Shared Wastewater Management Study
Towns of Bourne, Falmouth, Mashpee, Sandwich, and Joint Base Cape Cod

November 2017
Revised August 2019

Prepared for the
Town of Falmouth
(Fiscal Agent for Four Towns)
by

WRIGHT-PIERCE
Engineering a Better Environment

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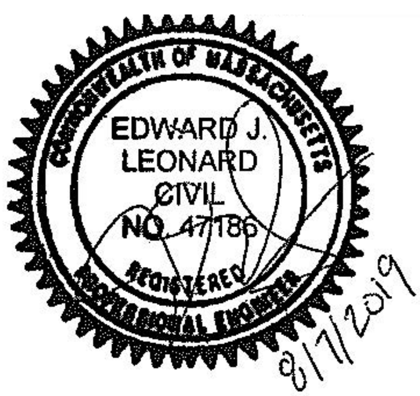

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SHARED WASTEWATER MANAGEMENT STUDY

TOWNS OF BOURNE, FALMOUTH, MASHPEE, SANDWICH AND JOINT BASE CAPE COD

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SHARED WASTEWATER MANAGEMENT STUDY
Towns of Bourne, Falmouth, Mashpee, Sandwich, and Joint Base Cape Cod
Executive Summary

The Towns of Bourne, Falmouth, Mashpee, and Sandwich were awarded two Community Compact Cabinet's Efficiency and Regionalization Grants for a Shared Wastewater Management Study. Subsequent to the second grant award, the Town of Barnstable expressed interest in the Shared Wastewater Management Study and separately funded the necessary study activities to "catch up" to the other four towns and to incorporate that content into this revised report. MassDevelopment also participated in the planning efforts. The purpose of the study is to prepare an engineering assessment for a potential partnership for shared wastewater management options among the towns, utilizing and expanding the Joint Base Cape Cod (JBCC) collection, treatment, transport, and effluent disposal systems for regional use.

The following items represent an executive summary of the key issues that need to be understood and resolved by participants, regulatory agencies, and stakeholders.

- The four Upper Cape towns (Bourne, Falmouth, Mashpee, and Sandwich) and Barnstable all have significant wastewater treatment and disposal needs in order to meet the water quality requirements issued in DEP Total Maximum Daily Load (TMDL) Reports and to meet other town wastewater management objectives. One potential way to address some or all these needs is through a significant expansion of JBCC wastewater treatment and disposal infrastructure to serve as a regional facility.
- As a part of this study, the Upper Cape towns provided estimates of wastewater management needs that could be addressed by a potential regional facility. As a part of a parallel study, Barnstable provided similar estimates. The total of the wastewater management needs provided by the five towns is 4,550,000 gallons per day (annual average basis) of sewage treatment and/or effluent disposal capacity. Refer to Sections 1.6 and 2.2 for additional information.
- The existing JBCC treatment and disposal system has approximately 75,000 to 100,000 gallons per day (annual average flow basis) of available capacity. <u>The available capacity at the existing JBCC treatment and disposal system addresses only 2% of the identified needs.</u> To serve the needs of the Upper Cape and Barnstable, a new significantly larger WWTF and effluent disposal system would need to be constructed. Refer to Section 1.4.9 for additional information.

- There appears to be more than adequate land available for a new regional WWTF within the Cantonment as described herein. Refer to Sections 2.5, 2.8 and 2.9 for additional information on the potential regional WWTF.
- Several methods of effluent disposal were evaluated as a part of this study. The most favorable methods include rapid infiltration basins, wicks, and surface water discharge to the Cape Cod Canal. Refer to Sections 2.7, 2.8, and 2.9 for additional information on the potential regional treatment facility.
- Although, JBCC consists of approximately 22,000 acres, there is limited land which could be utilized for expanded land-based effluent disposal without review and approval by others. Much of the JBCC land is protected by the Environmental Management Commission (EMC), is in nitrogen-sensitive watersheds, is in Zone II public water supply protection areas, and/or is impacted by historic groundwater contamination plumes under remediation. Significant expansion of effluent disposal capacity will require careful coordination with the military, ACOE, EPA, DEP, Environmental Management Commission, and the Commonwealth. Refer to Sections 2.7 and 4.2 for additional information.
- An "Effluent Disposal Workshop" was held at JBCC on May 9, 2019. The workshop was attended by over 24 individuals representing EPA, ACOE, DEP, Massachusetts Coastal Zone Management, Environmental Management Commission, Massachusetts Air National Guard - 102nd Intelligence Wing, Massachusetts Army National Guard, Cape Cod Commission, Upper Cape Regional Water Supply Cooperative, Buzzards Bay Coalition, Town of Falmouth, Town of Sandwich, and Town of Barnstable. During the workshop, several potential land-based disposal sites within the Upper Cape Water Supply Reserve and on land owned by the Army Corps of Engineers (ACOE) as well as one potential surface water discharge site to the Cape Cod Canal were discussed. At the conclusion of the meeting, all attendees agreed that there are numerous review processes that need to be undertaken (e.g., ACOE, Environmental Management Commission, NPDES permit application, etc.) and further agreed that there were no insurmountable issues associated effluent disposal siting and permitting that could be identified. Refer to Section 4.2 for additional information.

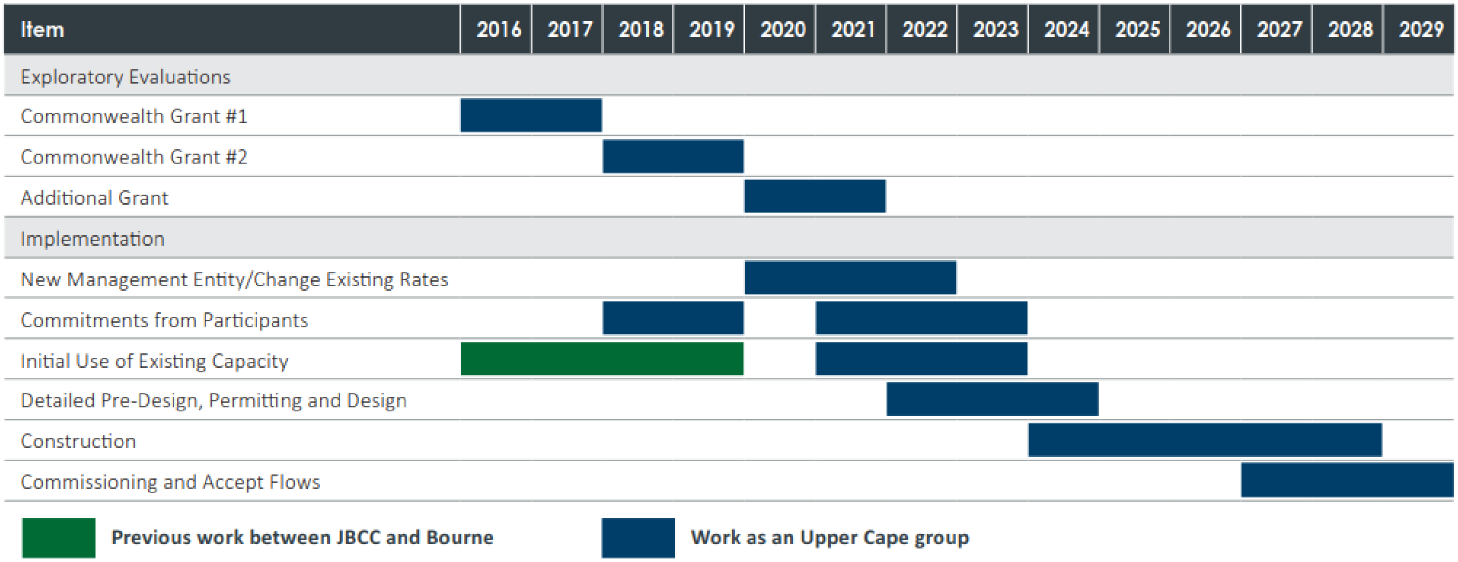
- To accommodate the regional flows identified by the Upper Cape towns, the estimated capital cost for the "candidate plan" is $154 million for the regional conveyance, treatment, transport, and disposal facilities (excluding any local collection system infrastructure within the towns). The annual operations and maintenance costs for these regional facilities are estimated at $3.1 million. These costs are presented in April 2019 dollars (ENR CCI 11228). Refer to Section 2.9 for additional information.
- If the additional flow identified by Barnstable was included, the estimated capital cost for the "candidate plan" is $229 million for the expanded regional facilities (again excluding the local collection system infrastructure within the towns). The annual operations and maintenance costs for these expanded regional facilities are estimated at $4.6 million. These costs are presented in April 2019 dollars (ENR CCI 11228). Refer to Section 2.9 for additional information.
- In terms of total equivalent annual cost (i.e., including capital cost and annual operating costs), the least expensive options are advanced wastewater treatment with biological nutrient removal, plus a combination of land-based and surface water-based disposal. An evaluation of non-financial factors results in similar conclusions regarding the most favorable options. Refer to Section 2.9 for additional information.
- A key factor in evaluating any regional solution is whether the regional solution is cost-effective when compared to other local options that a community may have. While a detailed assessment of the "non-JBCC alternatives" available to each of the towns was beyond the scope of this study, a broad assessment of cost-effectiveness was completed for the Upper Cape towns. Based on this broad assessment, there are sufficient advantages and cost-effectiveness for the participating municipalities to warrant continued planning efforts. Refer to Sections 2.9, 2.10 and 2.11 for additional information.
- Ultimately, each town needs to perform its own detailed assessment of the cost-effectiveness of a regional JBCC solution versus the other local options that they may have and then each town will need to commit to its desired level of participation. <u>It is important to recognize that when one participant changes its participation level (i.e., whether an increase or decrease), that</u>

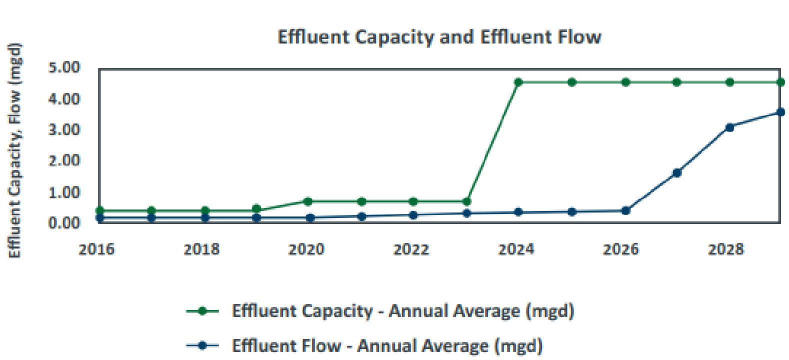
change impacts the cost-effectiveness for all the participants (i.e., better or worse). It may take several iterations in order to arrive at the final participation levels.

- Several management entity approaches were evaluated. Refer to Section 3 for additional information. The five towns currently favor a special purpose district or joint powers agreement to serve as the permanent management entity. Additional discussion among the participants on this topic is warranted.
- Implementation of regional facility will have many technical, permitting, and political challenges. The regional JBCC facility has several additional complex technical and legal issues associated with wastewater system ownership, land ownership, the desire of the military to divest ownership, the significant unfunded asset management and capital improvement needs and the resultant implications on sewer user rates. There is a need to facilitate a smooth transition from military ownership (USAF/ANG 102nd) to local municipal ownership (e.g., under a joint powers agreement). This may warrant or require technical and/or financial input from Federal, State, and local government. Refer to Section 5 for additional information.
- Based on the analyses conducted to date, the regional system would be most cost-effective under the future scenario once all participants are on-board and are responsible for their allocated share of debt service, operating costs, reserves, and asset management associated with the committed capacity. The regional system would be least cost-effective under the current situation (i.e., without municipal participants) once rates are raised to a point that is sufficient to fund reserves, asset management, and necessary capital improvements (i.e., relatively few users and relatively large unfunded liabilities associated with reserves, asset management, and capital improvements).
- If a regional JBCC wastewater system is to come to fruition, it will require a concerted, focused, and multi-track effort from Federal, State, and local government officials. An implementation plan, focused mainly on the key complicating issues, is outlined in Section 6. Resolution of these items is essential to reaching a conclusion on whether this concept is viable and cost-effective.

- If the participants desire to continue planning efforts, an initial Inter-Municipal Agreement should be considered. Refer to Section 3.1.7 for additional information. In addition, the participants will need to secure additional funding to make progress on key issues. These funds can be from local appropriations processes or through a State or Federal grant.
- An implementation timeline, including a graphical depiction of the conceptual effluent disposal capacity, effluent flow rate, planning-level cumulative costs, and planning-level annual budget including debt service is included as Figure ES-1/ 6-1 on the following pages. An implementation action items list is included as Figure ES-2/ 6-2 on the following pages. Refer to Section 6 for additional information.

FIGURE ES-1/ 6-1: IMPLEMENTATION TIMELINE





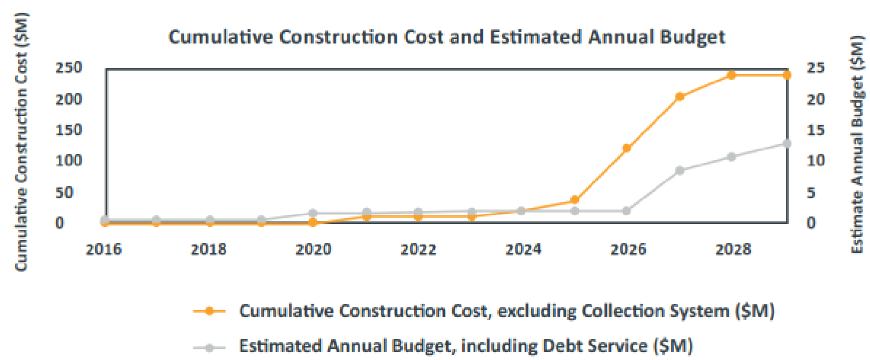


FIGURE ES-2/ 6-2: IMPLEMENTATION ACTION ITEMS

Key Issue	**Action Item**
Effluent Disposal Capacity	• Meet with EPA, DEP, CZM, ACOE and EMC staff to discuss surface water disposal. • Meet with DEP, ACOE and EMC staff to discuss land-based disposal. • Implement scientific and engineering studies associated with land-based and surface water-based effluent disposal on a dual-track. • Update cost estimates for the "candidate plan" based on the findings of the effluent disposal studies.
Cost-Effectiveness of Regional Approach	• Update town determinations of cost-effectiveness. • Reassess cost-effectiveness after next round of effluent disposal capacity analysis.
Facility Ownership, Management Entity and Sewer Rates	• Facilitate a decision on ownership transfer of the existing facilities including grants, as applicable and appropriate. • Transition to a new management entity. • Raise rates to properly fund reserve accounts, asset management and capital improvements for the existing wastewater infrastructure. • Determine whether to make interim upgrades to accept flow early to existing facilities or to wait for new facilities.
Timeline and Commitments from Participants	• Execute an IMA between/among participating municipalities to continue planning collaboratively and to fund additional planning activities. • Secure grant funds or local funds to explore effluent disposal capacity and cost-effectiveness items noted above. • Agree upon a timeline for the above implementation items.

SECTION 1

PRELIMINARY STRATEGY

1.1 INTRODUCTION

The Towns of Bourne, Falmouth, Mashpee, and Sandwich were awarded two Community Compact Cabinet's Efficiency and Regionalization Grants for a Shared Wastewater Management Study. Subsequent to the second grant award, the Town of Barnstable expressed interest in the Shared Wastewater Management Study and separately funded the necessary study activities to "catch up" to the other four towns and to incorporate that content into this revised report. MassDevelopment also participated in the planning efforts. The purpose of the study is to prepare an engineering assessment for a potential partnership for shared wastewater management options among the towns to utilize and expand the Joint Base Cape Cod (JBCC) collection, treatment, transport, and effluent disposal systems for regional use. A list of commonly used acronyms and abbreviations is included in Table 1-1.

1.2 JOINT STATEMENT AND PROJECT PREMISE

The Upper Cape towns have a long and proud history of active cooperation and collaboration with their neighbors at JBCC, including such items as solid waste management (Upper Cape Regional Transfer Station) planning/contracting, groundwater contamination clean-up, Upper Cape Regional Water Supply Cooperative management, Upper Cape Water Supply Reserve Community Advisory Council, and the Cape Cod Commission's Joint Land Use Study planning. The towns are each in various stages of wastewater management planning and implementation; however, the towns and JBCC are interested in actively and collaboratively exploring a shared wastewater solution utilizing the JBCC wastewater facilities. This is evidenced by the joint application for the Efficiency and Regionalization Grant. The towns, JBCC, and MassDevelopment jointly developed the following project premise to guide the preparation and review of this document:

> *The potential transfer of the JBCC wastewater facilities from the federal government to a local entity represents a significant opportunity for regional use by the surrounding towns; however, there are legal, political, and financial issues to work through. The existing wastewater facilities will require short-term upgrades and will likely require significant expansion to serve the anticipated mid-term to long-term Upper Cape needs. The purpose of this study is to develop a framework for regionalization based on a phased implementation approach with both short-term and long-term goals in mind.*

TABLE 1-1
LIST OF COMMONLY USED ACRONYMS AND ABBREVIATIONS

ACEC	Area of Critical Environmental Concern
ANG	Air National Guard, Massachusetts (102nd Intelligence Wing)
BOD_5	Biochemical Oxygen Demand
CCC	Cape Cod Commission
Current	Representing present conditions as applied to population, wastewater flow or nitrogen load
CWMP	Comprehensive Wastewater Management Plan
CWNMP	Comprehensive Watershed Nitrogen Management Plan
CWRMP	Comprehensive Water Resources Management Plan
D/B/O	Design/Build/Operate contract delivery method
DEIR	Draft Environmental Impact Report
DEP	Department of Environmental Protection
DRI	Developments of Regional Impact
EIR	Environmental Impact Report
EENF	Expanded Environmental Notification Form
EOEEA	Executive Office of Energy and Environmental Affairs
ESA	Environmentally Sensitive Area
FEIR/SEIR	Final Environmental Impact Report/ Single Environmental Impact Report
Future	Referring to population, wastewater flows or nitrogen loads, expected in the future
GIS	Geographic Information System
gpd	Gallons Per Day
gpd/sf	Gallons Per Day Per Square Foot
I/I	Infiltration and Inflow
IMA	Inter-Municipal Agreement
hp	Horsepower
JBCC	Joint Base Cape Cod (aka Massachusetts Military Reservations)
kg/day	Kilograms Per Day
lb/yr	Pounds Per Year
MEP	Massachusetts Estuaries Project
MCL	Maximum Contaminant Level
MEPA	Massachusetts Environmental Policy Act
Mgal	Million gallons
Mgal/yr	Million gallons per year
mgd	Million gallons per day
mg/l	Milligrams per liter
MOU	Memorandum of Understanding
NHESP	Natural Heritage and Endangered Species Program
NPV	Net Present Value
O&M	Operations and Maintenance
RIB	Rapid Infiltration Basin
SCADA	Supervisory Control and Data Acquisition system (computer control system)
SMAST	School of Marine Science and Technology, University of Massachusetts at Dartmouth
SRF	State Revolving Fund (administered by Massachusetts Department of Environmental Protection)
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TSS	Total Suspended Solids
TWMP	Targeted Watershed Management Plan
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
USGS	United States Geologic Survey
VOC	Volatile Organic Compound
WWTF	Wastewater Treatment Facility

1.3 SUMMARY OF PREVIOUS WASTEWATER PLANNING EFFORTS

The towns and JBCC/MassDevelopment have been engaged in wastewater management planning over the past decade. This section summarizes the relevant components of the previous wastewater planning efforts undertaken by each town.

1.3.1 Bourne

Bourne completed its initial town-wide Wastewater Management Study in 2007. The 2007 plan estimated current and future wastewater flows and septage volumes town-wide, but focused on alternatives and solutions for the most pressing wastewater management needs on the north side of the Cape Cod Canal, including on-going discussions and negotiations with Wareham regarding its wastewater treatment inter-municipal agreement (IMA) and siting of supplemental treatment and disposal facilities on the north side of the Canal. Bourne has also been focused on addressing landfill leachate needs on the south side of the Canal. In the future, it is expected that Bourne will need to address nutrient-related wastewater management drivers (based on the Massachusetts Estuaries Project work) and density-of-development-related wastewater management drivers on the north and south sides of the Canal.

1.3.2 Falmouth

Falmouth most recently completed its Targeted Watershed Management Plan (TWMP) for the Little Pond, Great Pond, Green Pond, Bournes Pond, Eel Pond, and Waquoit Bay watersheds in 2013. The TWMP proposes a sewer extension to serve Little Pond, upgrades to the Blacksmith Shop Road WWTF, an additional effluent disposal site (outside of the West Falmouth Harbor watershed), a number of demonstration projects (including aquaculture, inlet widening at Bournes Pond, eco-toilets, permeable reactive barriers, and stormwater management), and an adaptive management plan. This project received its EOEEA Certificate in 2014 and is currently being implemented. Falmouth is currently preparing its updated CWMP for submittal to the DEP by December 2019.

1.3.3 Mashpee

Mashpee completed a town-wide Comprehensive Watershed Nitrogen Management Plan (CWNMP) in 2015. The CWNMP identifies a regional approach with a proposed aquaculture program, a connection to the JBCC wastewater facilities, two or three small, decentralized WWTFs located in Mashpee, expansion/upgrades to several small existing public and private WWTFs in Mashpee, and a preliminary agreement to review nitrogen trading with Sandwich, Barnstable and potentially Falmouth. The 2015 CWNMP Final Environmental Impact Report received a MEPA Certificate from the Secretary of Energy and Environmental Affairs on July 31, 2015. The Cape Cod Commission DRI review of the 2015 CWNMP has been completed. Town-wide wastewater flows were identified in the Needs Assessment Report (2007) and are summarized in the 2015 CWNMP.

1.3.4 Sandwich

Sandwich completed its town-wide Comprehensive Water Resources Management Plan (CWRMP) in December 2017. The CWRMP identifies a regional approach with two proposed small decentralized WWTFs located in Sandwich, a proposed connection to the JBCC wastewater facilities, and a nitrogen trading program with Mashpee, Barnstable, and potentially Falmouth. The CWRMP has received a 208 Consistency Determination from the Cape Cod Commission and has been endorsed by the Board of Selectmen. The Town implemented a Water Infrastructure Investment Fund financial mechanism at its November 2018 Special Town Meeting and May 2019 ballot vote. In anticipation of a possible JBCC regional solution, the Town secured approval from the voters to negotiate sewer line easements over specific town roadways with Barnstable and/or Mashpee at its May 2019 Town Meeting.

1.3.5 Barnstable

Barnstable is currently finalizing its Comprehensive Wastewater Management Plan (CWMP). The CWMP identifies a mix of traditional and nontraditional approaches to address the Town's wastewater management needs and leverages its existing treatment infrastructure to accomplish much of the traditional approach. However, the CWMP also allows for the possibility of regional cooperation, especially regarding effluent disposal (and treatment, if it makes sense as part of regional effluent disposal requirements). The final draft plan is expected to be presented to the Town Council in early Fall 2019 and to DEP and the Cape Cod Commission for approval in late Fall 2019.

1.3.6 MassDevelopment

MassDevelopment, on behalf of JBCC, completed several wastewater planning efforts – one in 2012 (CH2M-Hill) and another in 2014 (Wright-Pierce). These studies concluded that the JBCC military needs a fairly small capacity allowance for the planning period and that excess capacity could be made available to municipalities. Both planning efforts were performed looking at a potential transfer of ownership of the wastewater facilities from JBCC to MassDevelopment. MassDevelopment is not currently considering taking ownership of the JBCC facilities.

1.3.7 JBCC/ Massachusetts ANG 102nd Intelligence Wing

JBCC via the Massachusetts Air National Guard 102nd Intelligence Wing has been actively working with a consultant to facilitate ownership transfer to any responsible party, including non-municipal entities.

1.3.8 Cape Cod Commission

The Cape Cod Commission completed a Joint Land Use Study (JLUS) for JBCC in 2005 and completed the JLUS Update in 2013. The JLUS Update affirmed the potential for a military/municipal partnership through shared facilities and recommended that the excess capacity at the JBCC wastewater facilities be used for military and municipal needs.

The JLUS Update identified a potential Upper Cape wastewater and effluent capacity need of 454,000 gpd to 3,270,000 gpd within a 20-year planning period (Executive Summary, Table 5). This table cites the 2012 CH2M-Hill study which was prepared for MassDevelopment, as described above.

The Cape Cod Commission completed its 208 Plan Update (Cape Cod Area Wide Water Quality Management Plan Update) in 2015. One general outcome of the 208 Plan Update is that it provides a technical framework for municipalities to incorporate non-traditional nitrogen control methods into wastewater management planning. Each of the towns is exploring non-traditional nitrogen control methods to varying degrees in accordance with the framework provided by the 208 Plan Update which, if successful, may postpone or eliminate the need for traditional wastewater infrastructure in certain portions of the respective towns. This will likely result in a longer planning period to reach the upper limit flow projections previously identified in the 2012 CH2M-Hill study and JLUS Update study (i.e., 40 to 50 years, rather than the 20 years used in the 2012 report).

Lastly, the 208 Plan Update has two specific recommendations regarding the JBCC wastewater facilities (Section 7):

- Recommendation S7.1 – "The Cape Cod Commission shall continue discussion and coordination with JBCC and MassDevelopment regarding wastewater allocation policy for the base."
- Recommendation S7.1 – "The Military should ensure that future development within the cantonment area be connected to the JBCC wastewater treatment plant wherever feasible."

The Cape Cod Commission completed an analysis of septage disposal need in 2016. The study estimated the volume of septage generated on Cape Cod (i.e., 52.8 Mgal/year) as well as the septage treatment capacity on Cape Cod (i.e., 53.3 Mgal/year, which excludes the recently closed Tri-Town Septage Treatment Plant). This analysis did not identify the volume of septage generated by each town on Cape Cod. [CCC/AECOM Task Order #12D Technical Memorandum on Barnstable County Septage Analysis, Table 2-2 and 3-1 (Rev Sept 30, 2016)]

1.3.9 Summary of Key Data for Wastewater Planning

A summary of key data for each town is presented in Table 1-2, including "current wastewater flow" and "future wastewater flow." The following definitions are applicable to the information in this table:

- Current Wastewater Flow is the estimated or known wastewater flow for pre-2017 conditions, based on town documentation or input. These flows are intended to represent the general population, level of commercial activity, and wastewater generation rates that exist today.
- Theoretical Build-Out is the population, commercial activity, and wastewater flow associated with the ultimate development in each town to the fullest extent possible under current zoning and other regulation, regardless of economic issues.
- Practical Build-Out is the population, commercial activity, and wastewater flow associated with more realistic assumptions on the extent of build-out, factoring in such concerns as economic realities, other limitations on growth (such as infrastructure capacity), land protection efforts, and retention of estate properties.
- Planning Horizon is the population, commercial activity, and wastewater flow that will serve as the basis for this planning effort. The planning horizon for this study is 20 years.

For the purposes of this report, the term “Future Wastewater Flow” represents the estimated wastewater flow at the “planning-horizon” as identified in town documentation.

TABLE 1-2: KEY DATA FOR PARTICIPATING TOWNS AND JBCC

	Bourne	Falmouth	Mashpee	Sandwich	JBCC	Barnstable
Population (2010)	19,754	31,531	14,006	20,675	~3,500	45,193
Area of Land and Water (TW)	52.9 sq mi.	48.8 sq mi.	27.2 sq mi.	44.2 sq mi.	~22,000 ac	59.8 sq mi.
Current Wastewater Flow (TW, AA)	2,200,000 gpd	4,000,000 gpd	1,136,000 gpd	1,667,000 gpd	140,000 gpd	5,600,000 gpd
Current Wastewater Flow to WWTFs (TW, AA)	110,000 gpd (Wareham)	440,000 gpd (Falmouth)	180,000 gpd	0 gpd	140,000 gpd (JBCC)	1,550,000 gpd (Hyannis)
Current Septage Volume (TW, AA)	4.1 Mgal/yr	8.0 Mgal/yr	2.7 Mgal/yr	3.9 Mgal/yr	0 Mgal/yr	12 Mgal/yr
Future Wastewater Flow (TW, AA)	3,751,000 gpd	4,000,000 gpd	2,007,000 gpd	2,164,000 gpd	152,000 gpd	8,780,000 gpd
Future Wastewater Flow to WWTFs (TW, AA)	1,061,000 to 1,782,000 gpd	750,000 to 2,200,000 gpd	1,076,000 to 1,776,000 gpd	540,000 to 900,000 gpd	152,000 gpd	4,020,000 gpd
Future Septage Volume (TW, AA)	6.2 Mgal/yr	9.5 Mgal/yr	1.5 Mgal/yr	5.1 Mgal/yr	0 Mgal/yr	12 Mgal/yr
Town-Wide Wastewater Planning Year Completed, Firm	2007 Tighe & Bond	2013 GHD	2015 GHD	2017 Wright-Pierce	2012 CH2M-Hill 2014 Wright-Pierce	Town, on-going

Notes:
1.) See report text on previous page for definitions.
2.) 2010 Population – 2010 US Census (municipalities) and 2009 JBCC Base population survey.
3.) Area of land and water based on Wikipedia.
4.) TW = all town-wide whether to an on-site system or a WWTF.
5.) AA = annual average basis
6.) Falmouth's Little Pond Sewer Service Area flow will increase the existing annual average flow to WWTFs to 710,000 gpd when completed.

1.4 DESCRIPTION OF EXISTING JBCC WASTEWATER FACILITIES

This section of the report describes the existing JBCC wastewater system, the current wastewater flows and loadings, and the overall facility condition assessment for the JBCC wastewater system.

1.4.1 Overall System

The existing JBCC wastewater system provides service for on-base facilities. It is currently owned by the United States Air Force (USAF) and is currently operated and maintained by the Massachusetts Air National Guard 102nd Intelligence Wing (ANG). The existing JBCC wastewater system is shown on Figure 1-1. The major components of the existing wastewater treatment system are summarized in Table 1-3.

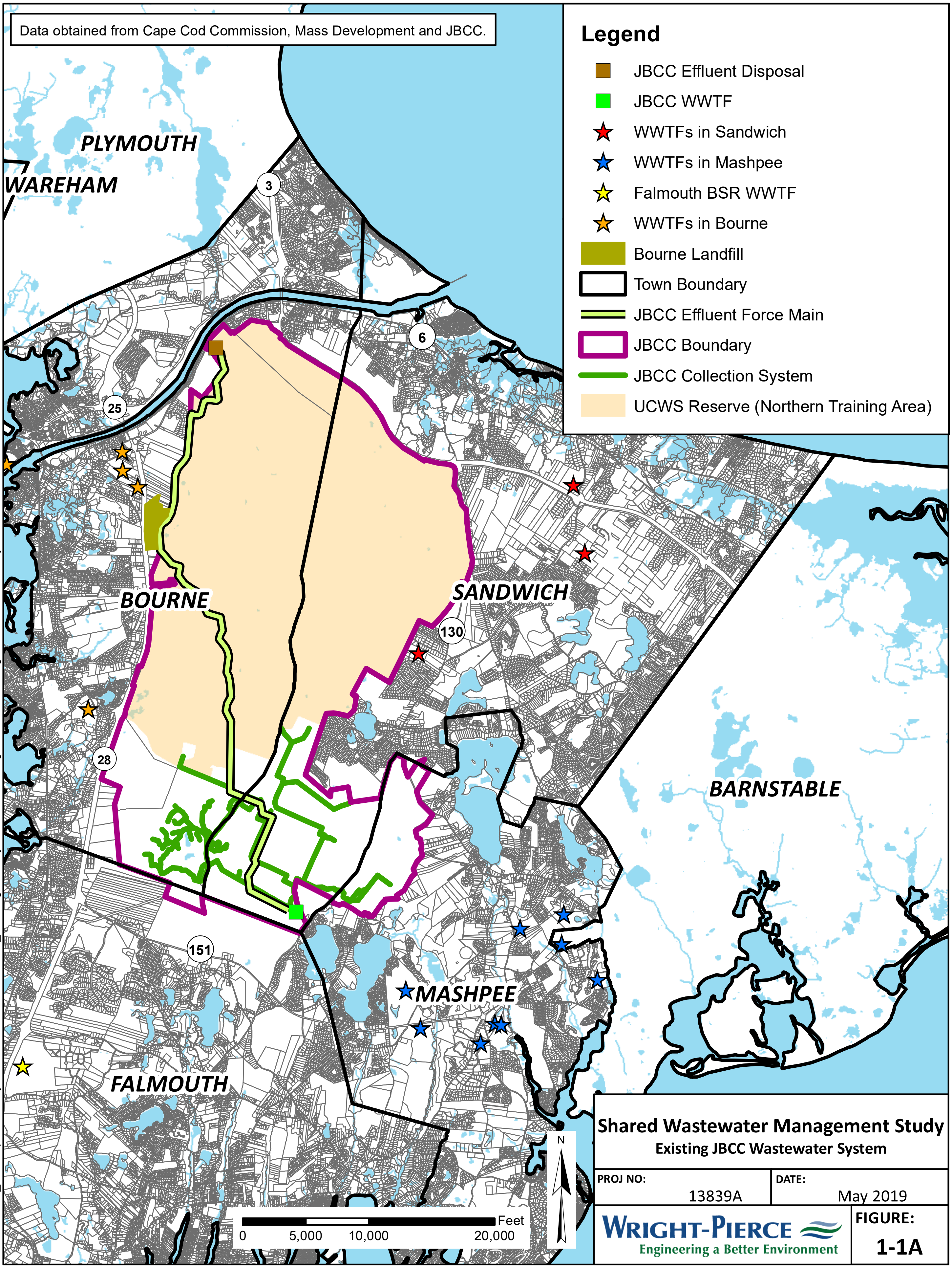
The WWTF and all the collection system are located within the Cantonment Area, which comprises approximately 25% of JBCC. Most of the effluent forcemain and the entire effluent disposal system are located in the Upper Cape Water Supply Reserve (also referred to as the "Northern Training Area"), which comprises the northerly 75% of JBCC.

1.4.2 Wastewater Flows and Loads

The wastewater flows and loads for the period 2008 to 2012 and for the period 2012 to 2014 are summarized in Table 1-4. Based on this information, the WWTF is operating at just under 50% of its design capacity.

1.4.3 Collection System

The collection system was built when the population served was approximately 70,000; whereas, there is currently a population served of approximately 3,500 (JBCC Base Population Survey, 2009). The collection system includes 11 pumping stations and approximately 30.5 miles of sewers ranging in size from 6-inch to 24-inch diameter including several pipe materials. The collection system was constructed between the 1940s and present.



Shared Wastewater Management Study

Existing JBCC Wastewater System

PROJ NO:	DATE:
13839A	May 2019

WRIGHT-PIERCE Engineering a Better Environment

FIGURE: 1-1A

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TABLE 1-3
WASTEWATER SYSTEM COMPONENTS

Component	Quantity
Collection & Conveyance	161,000 linear feet sewers, 595 manholes
Pump Stations	11
Wastewater Treatment Facility	360,000 gpd
Effluent Forcemain	55,280 linear feet
Rapid Infiltration Disposal Beds (RIBs)	4 cells, 6 acres
Monitoring Wells for RIB Compliance:	4
Composting Facilities (abandoned)	25,290 square feet

TABLE 1-4
CURRENT WWTF FLOWS AND LOADINGS

Parameter	Condition	Design Rating	Permit Value	Current 2008 to 2012	Current 2012 to 2014
Flow (gpd)	Annual Average	300,000	360,000 (1)	143,000	131,000
	Maximum Month	430,000	-	248,500	210,000
	Maximum Day	800,000	840,000	555,600	390,000
	Peak Hourly	1,380,000	-	-	-
BOD Load (lb/day)	Annual Average	690	-	337	-
	Maximum Month	990	-	548	-
	Maximum Week	1840	-	948	-
TSS Load (lb/day)	Annual Average	550	-	272	-
	Maximum Month	790	-	453	-
	Maximum Week	1470	-	884	-
TKN Load (lb/day)	Annual Average	125	-	60	-
	Maximum Month	180	-	104	-
	Maximum Week	335	-	233	-
Ammonia Load (lb/day)	Annual Average	90	-	43	-
	Maximum Month	125	-	76	-
	Maximum Week	235	-	163	-

Notes:
1) 12-month rolling average flow.
2) Data in “Design Rating” and “Current 2008 to 2012” columns are from CH2M-Hill, 2012.

1.4.4 Wastewater Treatment Facility

The WWTF is an extended aeration activated sludge facility (biological nitrogen removal) with disinfection that was constructed in 1995. The WWTF was constructed with a capacity of 300,000 gpd (annual average); however, when the Barnstable County Jail was constructed in the early 2000s, the WWTF was upgraded to a design capacity of 360,000 gpd (annual average). The WWTF design maximum day flow is 840,000 gpd. Major unit processes at the WWTF include:

- Preliminary Treatment (screening and grit removal)
- Advanced secondary treatment (biological nutrient removal)
- Disinfection
- Effluent Pumping
- Sludge Holding and Aeration
- Sludge Decanting
- Biosolids hauling (for off-site processing and disposal)

1.4.5 Effluent Forcemain

The existing effluent forcemain is a 12-inch diameter ductile iron pipe that runs approximately 10.5 miles from the WWTF, through the Reserve, to the Rapid Infiltration Basins (located at the northwest edge of JBCC). There is a short section of 8-inch diameter ductile iron pipe (at 5.5% slope) between Static Head Structure No.1 and the Hydraulic Distribution Structure. The forcemain is shown on the design drawings entitled “Effluent Forcemain and Infiltration Basins” (CDM/SAIC, 1993). The forcemain is hydraulically complex and has approximately 20 air and/or vacuum relief valves. Based on the existing pumping system design, the effluent disposal forcemain has a design capacity of 950 gpm on a peak rate basis (i.e., 2.8 feet per second).

1.4.6 Rapid Infiltration Basins

The existing effluent disposal facility consists of four rapid infiltration basins (RIBs), with a total surface area of 259,160 square feet. The RIBs were constructed on the basis of design drawings entitled “Effluent Forcemain and Infiltration Basins” (CDM/SAIC, 1993) as well as a *Hydrogeologic Investigation and Design Effluent Infiltration Basins* technical memorandum (CDM/SAIC, 1993). The existing RIBs are in very good condition with the only reported operational challenge being the control of vegetation growth. There are no reports of “effluent breakout" occurring downgradient of the RIBs. DEP has not identified the Cape Cod Canal as nitrogen-sensitive. A preliminary review of the design surficial loading rates and the groundwater mound elevations indicates that the sizing of the RIBs is conservative. Additional capacity can likely be obtained through a re-permitting and re-rating process with DEP. This will need to reviewed closely with DEP.

1.4.7 Groundwater Discharge Permit Requirements

The WWTF effluent quality requirements are contained in a Groundwater Discharge Permit (GWDP) which is issued by the Massachusetts Department of Environmental Protection (DEP). The GWDP (Application/Permit No. 41-3) allows for disposal of suitable quality effluent up to 360,000 gpd on a 12-month rolling average basis and up to a maximum of 840,000 gpd on any given day (so-called "maximum day flow"). The GWDP is included in Appendix A and its requirements for the WWTF effluent are summarized in Table 1-5. The GWDP requirements for groundwater monitoring at the RIB site are summarized in Table 1-6. The current permit expires in May 2023.

1.4.8 Facility Condition

The JBCC WWTF was operational in 1995 and is now approximately 24 years old. A comprehensive upgrade for the facility should be expected within the next 5 years. In the interim, the facility will require modest upgrades and investments in order to maintain reliability of treatment performance and permit compliance, to better utilize its existing available capacity and to reduce annual operations and maintenance costs. Several baseline improvements were identified for this purpose in the 2014 JBCC Water and Wastewater System Evaluation, including:

- Provide off-line influent equalization tank and a pump station to aid in peak flow management. Set equalization volume at 100,000 gallons.
- Install a small supplemental carbon system (e.g., methanol, glycerin) including 500-gallon storage tank, one chemical feed pump, instrumentation interface with SCADA and electrical feeds.
- Install a rotary disc or drum thickener over the existing Sludge Storage Tanks and enclose it in a small building. Automate sludge wasting and polymer feed system to pre-thicken waste sludge prior to storage.

TABLE 1-5
GWDP – WWTF EFFLUENT LIMITS AND MONITORING REQUIREMENTS

Parameter	Discharge Limitation	Minimum Frequency
Flow, 12-month moving average	360,000 gpd	Daily
Flow, maximum day	840,000 gpd	Daily
Oil and grease	15 mg/l	Monthly
Total Suspended Solids (TSS)	30 mg/l	Monthly
Total Nitrogen (NO2-N + NO3-N + TKN)	10 mg/l	Monthly
Nitrate-Nitrogen (NO3-N)	10 mg/l	Monthly
Biochemical Oxygen Demand, 5-day at 20°C (BOD_5)	30 mg/l	Monthly
Fecal Coliform	200 colonies/ 100 ml	Monthly
pH	6.5 to 8.5	Daily
Total Solids	Report	Monthly
Total Phosphorus (as P)	Report	Monthly
Orthophosphate (as P)	Report	Monthly
Volatile Organic Compounds	Report	Monthly

TABLE 1-6
GWDP – GROUNDWATER MONITORING REQUIREMENTS

Parameter	Discharge Limitation	Minimum Frequency
Static Water Level	Report	Monthly
Specific Conductance	Report	Monthly
pH	Report	Monthly
Total Nitrogen (NO2-N + NO3-N + TKN)	Report	Quarterly
Nitrate-Nitrogen (NO3-N)	Report	Quarterly
Total Phosphorus (as P)	Report	Quarterly
Orthophosphate (as P)	Report	Quarterly
Volatile Organic Compounds	Report	Quarterly

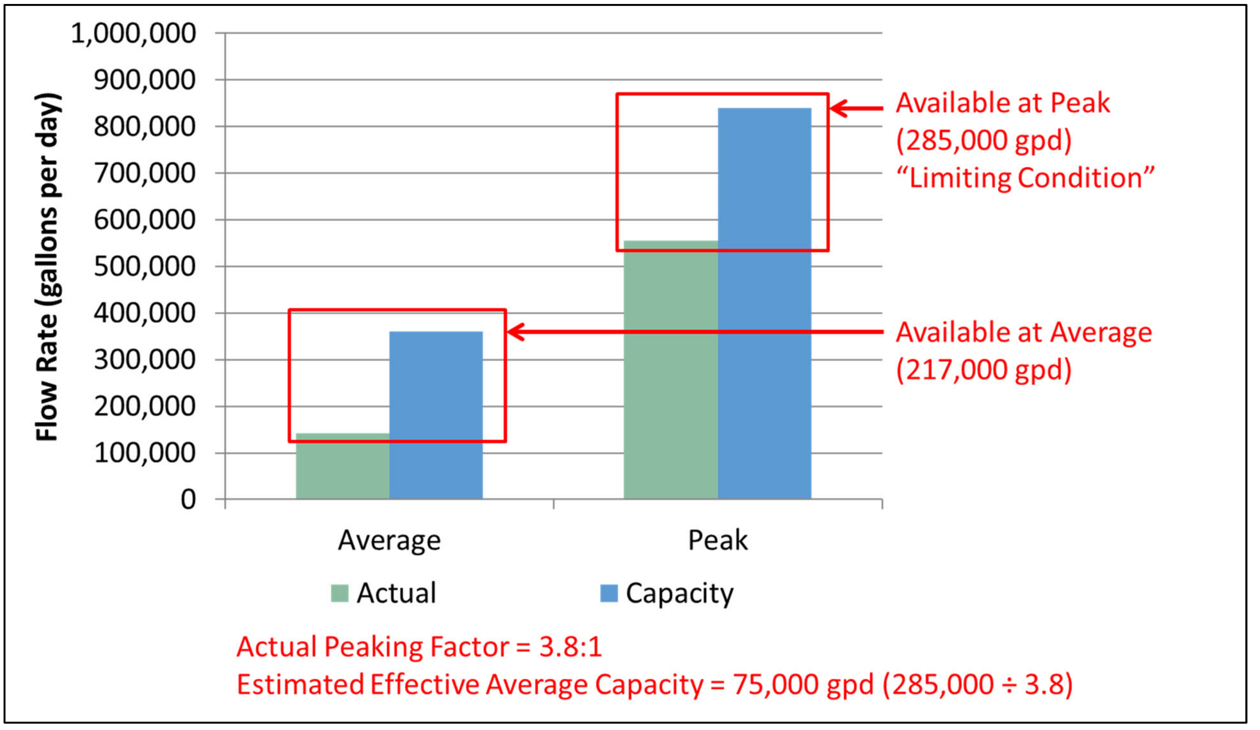
- Replace existing sludge feed pumps (progressing cavity) with higher-rate sludge feed pumps (rotary lobe) to convey thickened sludge to a tanker truck at high rate (say 200 gpm) to allow for shorter truck fill times. Add new truck fill piping with quick-connect to building exterior.
- Upgrade components of the effluent forcemain. Increase the diameter of 180 feet of pipe from 8-inch to 18-inch between Static Head Structure No. 1 to Hydraulic Distribution Structure at the RIB site (the remainder of the forcemain is 12-inch diameter). Replace all existing air/vacuum release valves along alignment. Replace Static Head Manhole No. 2 (at Frank Perkins Road) with a new pressure-rated manhole with a new controlled venting sewage vacuum relief valve mounted on top of the manhole. Refer to Appendix D for additional information.

1.4.9 Estimate of Existing Available Capacity

Based on the WWTF design capacity and the 2008 to 2012 flows and loads, the WWTF has approximately **157,000 gpd (annual average)** of residual capacity which can be made available to neighboring communities or users on the base.

On an annual average basis, the effluent disposal system also has approximately 157,000 gpd of additional capacity. On a peak day basis (due to the impacts of inflow), the effluent disposal system has approximately 285,000 gpd of additional capacity. Given that the existing peaking factor for peak-to-average flows is 3.8:1 (again, due primarily to the impacts of inflow), the *effective available capacity* is approximately **75,000 gpd (annual average basis)**. It is important to note this *effective capacity* is less than that available at the WWTF. Without inflow control, available treatment capacity will go unused due to the limitations inherent in the GWDP. The capacity and effective capacity are illustrated on Figure 1-2.

FIGURE 1-2
ESTIMATE OF EXISTING AVAILABLE CAPACITY



This existing available capacity can be made available to neighboring communities or to new users which may be located on JBCC. From a regionalization perspective, it is very important to maximize the available capacity. This available capacity can be maximized by one or more of the following methods:

- Aggressively investigating and removing collection system inflow sources;
- Securing customers with low wastewater flow "peaking factors" (i.e., customers with a peak flow that is similar to the average flow);
- Seeking opportunities for beneficial reuse of effluent;
- Providing influent flow equalization at the WWTF;
- Addressing the effluent forcemain capacity limitation; and/or
- Increasing the capacity of the disposal system by re-rating the RIBs and revising the GWDP with DEP review and approval.

1.5 REGULATORY FRAMEWORK

1.5.1 Effluent Disposal

The existing GWDP is focused primarily on addressing conventional parameters (BOD, TSS, bacteria) as well as nutrients (nitrogen, phosphorus). Over time, additional parameters or more stringent effluent limits may be imposed.

- Nitrogen – DEP has indicated that there is no intention to revise the effluent nitrogen limits for the JBCC GWDP at this time. DEP has also indicated that there is no Total Maximum Daily Load (TMDL) Study completed or planned because the effluent disposal site is not located in a nitrogen-sensitive watershed. Given that the RIBs are located in a non-nitrogen-sensitive watershed (Canal South), the imposition of a more stringent nitrogen limit is unlikely.
- Phosphorus – DEP has not indicated any intention to add a phosphorus limit at this time. Given the location of the discharge, the imposition of a phosphorus limit is very unlikely.
- Compounds of emerging concern (CECs) – CECs encompass a wide variety of compounds including endocrine disrupting compounds, pharmaceuticals, flame retardants, hormones, industrial solvents and surfactants, metals, pesticides, and personal care products. CECs have been found in wastewater for decades; however, they have recently reached the forefront of regulatory and public concern, and there is currently a great deal of research on CECs. One of the difficulties associated with addressing this topic is the large number, and wide array of, substances that can be classified as CECs. Given that the location of the discharge is outside water supply recharge areas, the short-term imposition of CEC limits is unlikely. DEP has developed regulatory limits for Total Organic Carbon (an indicator of CEC's) for groundwater discharges within a Zone II of a public water supply. There is no indication that limits will be extended to other groundwater categories.

Future effluent limits will be dictated by the disposal location and by potential changes in environmental policy over time. While capital upgrades would be required if the GWDP requirements were made more stringent, this eventuality appears unlikely within a 10- to 20-year timeframe. Refer to Section 2 for additional description of permit considers based on alternative effluent disposal methods.

To the extent that sufficient capacity can be obtained via RIB expansion, DEP will consider this a better environmental solution than a surface water discharge to the Cape Cod Canal and should be achievable at less cost and regulatory complexity. If sufficient capacity cannot be obtained via the existing or expanded RIBs, then alternative methods will need to be considered (e.g., surface outfall to the Cape Cod Canal, etc.).

1.5.2 Total Maximum Daily Loads for Nitrogen

The DEP and the Massachusetts Estuaries Project (MEP) have no plans to study the Cape Cod Canal at this time; however, the DEP and MEP have studied many of the Upper Cape watersheds and have developed Total Maximum Daily Load (TMDL) Studies on many of the studied watersheds. TMDLs may require that towns consider off-site wastewater management at more locations than currently considered or at greater flow rates than currently anticipated in this or previous studies. The elimination of private septic systems will increase the amount of wastewater flow requiring off-site wastewater management at WWTFs.

1.5.3 Municipal Reviews

Each municipality needs to review and approve its participation in a regional solution. The review would occur at a technical level (department heads and review boards) and an executive level (boards of selectmen and town meeting).

1.5.4 Cape Cod Commission

The Cape Cod Commission will need to review and approve any proposed regional project of the nature described in this document for consistency with the 208 Plan Update.

1.5.5 Massachusetts DEP and United States EPA

The DEP will need to review and approve proposed/requested capacity increases for the JBCC wastewater facilities. DEP will also need to address the issue of multiple permittees and effluent sources discharging to a single effluent disposal location (e.g., joint and several responsibilities related to monitoring requirements, maintenance requirements, etc.). EPA involvement is not anticipated unless there is a proposed surface water discharge to the Cape Cod Canal.

1.5.6 Upper Cape Water Supply Reserve/ Northern Training Area

The Upper Cape Water Supply Reserve (the "Reserve," also known as the "Northern Training Area") is located in the northern portion JBCC and is approximately 15,000 acres. The Reserve was created in 2001 to 2002 to protect the drinking water supply and wildlife habitat. The Reserve is governed by the Environmental Management Commission (3 members) and is advised by the Community Advisory Council (15 members). All activities in the Reserve are subject to Environmental Performance Standards and the approval of the Environmental Management Commission. The effluent forcemain and the RIBs are both within the Reserve. Also, the proposed effluent pipe connections from Bourne and Falmouth would cross the Reserve.

1.6 PRELIMINARY STRATEGY FOR REGIONAL APPROACH

1.6.1 Project Planning Horizon

The project planning horizon was agreed to be 20 years; however, the conceptual alternatives identified and evaluated in this report will also consider future expansion potential beyond the 20-year time frame.

1.6.2 Potential Opportunities, Challenges and Logistical Issues

There are many opportunities associated with regional wastewater facilities at the JBCC location. There are also a number of legal, political, and financial challenges to overcome for the wastewater facilities to be shared. These opportunities and challenges are summarized in **Figure 1-3**.

FIGURE 1-3 OPPORTUNITIES AND CHALLENGES

FOR SHARED WASTEWATER FACILITIES AT JBCC

Opportunities

- Central location in Upper Cape
- History of collaboration among Bourne, Falmouth, Mashpee, Sandwich and JBCC
- Existing wastewater collection, treatment, and disposal facilities
- Disposal in non-nitrogen-sensitive watershed
- Potential regional solution for septage and potential source of operating revenue
- Easement across the UCWSR for effluent connection from Bourne is almost approved
- Rail spur on JBCC, existing contract with SEMASS
- Preservation of military mission
- Preservation/protection of federally designated sole-source aquifer
- Extensive land area, lack of abutters
- Consensus from JBCC, municipalities, DEP and CCC on benefits
- Potential future regional solutions for biosolids and/or source-separated organics digestion
- Potential capital and O&M cost savings due to efficiencies gained by economies of scale

Challenges

- Complicated land ownership/lease arrangements
- Different needs, goals, and implementation timelines among towns and JBCC
- Shared military/ civilian facilities
- Capacity limitations of existing wastewater infrastructure
- Identification of mutually agreeable successor management entity to run facilities
- Land use restrictions in the Upper Cape Water Supply Reserve area
- Inconsistent WWTF performance
- Re-permitting of RIBs to receive different types of flow (e.g., municipal sewage vs treated landfill leachate) and flow from different communities
- Development of sustainable cost structure for future operations.
- Future changes in effluent limits or regulatory drivers (e.g., phosphorus, CECs)
- Potential third-party or non-governmental entity influence on the proposed project based on increased effluent flows and loadings to the Cape Cod Canal, Cape Cod Bay and Buzzards Bay.

1.6.3 Requested Capacity by Wastewater Type

Each of the towns and JBCC have provided capacity requests by wastewater type to address wastewater management needs including nitrogen TMDL compliance. For the purposes of this study, the following terms will be used for this study for the wastewater types:

- ***Sewage*** is residential/commercial/light industrial wastewater collected and conveyed to the JBCC WWTF for treatment and disposal.
- ***Effluent*** is treated wastewater. References to "effluent disposal only" mean that the wastewater will be treated elsewhere (e.g., the Bourne Integrated Solids Waste Management or "ISWM" WWTF) and the effluent will be conveyed to the JBCC disposal system via the existing forcemain (i.e., not treated at the JBCC WWTF).
- ***Leachate*** is from the Bourne ISWM landfill.
- ***Leachate effluent*** is leachate treated at the proposed Bourne ISWM WWTF.
- ***Septage*** is the liquid/sludge mixture pumped from septic tanks.

At the project kick-off meeting, all towns agreed that including an allocation for receiving and treating septage at the JBCC WWTF is appropriate for this study. Accordingly, the "current condition" septage flows indicated in Table 1-2 will be used in the analysis moving forward, as it is anticipated that increase in septage volume from non-sewered growth will offset the reduction in septage volume from current structures being connected to sewer.

<u>Bourne</u>

- <u>Study Basis</u>: The study basis includes the following key assumptions:
    1. Wastewater flow would not cross the Cape Cod Canal.
    2. Leachate effluent from the Bourne ISWM WWTF would be discharged to the JBCC effluent forcemain and disposal system (i.e., 100,000 gpd) in the short-term.
    3. Wastewater flow from Bourne wastewater planning areas 8, 9, 10, 12, 13, and 14 would go to the ISWM WWTF for co-treatment with landfill leachate and the effluent is directed to the JBCC effluent forcemain and disposal system in the mid-term and long-term. The ISWM WWTF would need to be designed for co-treatment under this approach.

4. Wastewater flow from Bourne wastewater planning areas 15 through 20 would go to the JBCC WWTF location and is treated as sewage in the mid-term and long-term.
5. Wastewater flow from Bourne wastewater planning area 11 (MacArthur Boulevard/Route 28) would be split equally between the ISWM WWTF and the JBCC WWTF.
6. Wastewater flows connected to sewer were estimated based on the priority assigned to the wastewater planning areas in the 2007 Tighe & Bond study
7. Septage treatment capacity would be provided at the JBCC WWTF.

- Low End: The low end estimate includes the following assumptions:
    1. Leachate effluent from the Bourne "ISWM WWTF" would be connected to the JBCC effluent forcemain and disposal system (i.e., 100,000 gpd) in the short-term.
    2. A maximum of 100,000 gpd of wastewater flow from Bourne wastewater planning areas 8, 9, 10, 12, 13, and 14 would go to the ISWM WWTF for co-treatment with landfill leachate and the effluent is directed to the JBCC effluent forcemain and disposal system in the long-term.
    3. Septage treatment capacity would be provided at the JBCC WWTF.
- High End: Same elements/flows/volumes as the study basis.

Falmouth

- Study Basis: The study basis includes the following key assumptions:
    1. Some/most of the effluent from the existing Blacksmith Shop Road WWTF would be directed to the JBCC effluent forcemain and disposal system. Specifically, in the mid-term, the BSR WWTF is assumed to receive and treat 1,200,000 gpd, of which 710,000 gpd of effluent would go to the existing BSR WWTF RIBs and 490,000 gpd of effluent would go to the JBCC effluent disposal system. In the long-term, the BSR WWTF is assumed to receive and treat 2,200,000 gpd, of which 710,000 gpd of effluent would go to the existing BSR WWTF RIBs and 1,490,000 gpd of effluent will go to the JBCC effluent disposal system.
    2. Septage treatment capacity could be provided at the JBCC WWTF [Note: this is a conceptual scenario; Falmouth does not have any plans to terminate septage receiving at the BSR WWTF at this time].

- Low End: Same elements; however, less effluent would be directed to the JBCC effluent forcemain and disposal system in the mid-term and the long-term.
- High End: The high end assumes that all effluent flow would go to the JBCC effluent disposal system in the mid-term and that the BSR WWTF would eventually be abandoned and all Falmouth wastewater flow would be directed to the JBCC WWTF in the long-term. Septage would also go to the JBCC WWTF.

Mashpee

- Study Basis: The study basis includes the following key assumptions:
    1. A specified amount of sewage from Mashpee would be directed to the JBCC WWTF
    2. Septage treatment capacity would be provided at the JBCC WWTF.
- Low End: Same elements/flows/volumes as the study basis.
- High End: Same elements; however, more sewage would be directed to the JBCC WWTF.

Sandwich

- Study Basis: The study basis includes the following key assumptions:
    1. A specified amount of sewage from Sandwich would be directed to the JBCC WWTF. For the study basis, the amount of capacity requested is equivalent to the capacity identified for the JBCC WWTF and the proposed so-called "IWS WWTF" in CWRMP Plan B.
    2. Septage treatment capacity would be provided at the JBCC WWTF.
- Low End: Same elements, however, the amount of capacity would be reduced to just the amount identified for the JBCC WWTF in CWRMP Plan B.
- High End: Same elements, however, the amount of capacity would be increased to the amount identified in for the JBCC WWTF, the proposed "IWS WWTF" and the proposed "CS WWTF" in CWRMP Plan A (fully traditional backup plan).

JBCC

- Study Basis: Future flow from military and non-military users was estimated to be 7,000 gpd (CH2M-Hill, 2012). This future flow is utilized herein.
- Low End/ High End: Same elements as the study basis.

Barnstable

- Study Basis: The study basis includes a specified amount of sewage from Barnstable that may be directed to the JBCC WWTF. For the study basis, the amount of capacity requested is intended to serve the village of Cotuit plus western portions of Barnstable Phases 1, 2, and 3.
- Low End: Same elements, however, for the mid-term, the identified capacity is reduced to just the amount required for Stages 1, 2, and 3 in the Popponesset Bay watershed and, for the long-term, the identified capacity is reduced to just the amount required for the village of Cotuit.
- High End: Same as the study basis, however, for the mid-term, the identified capacity is increased to include western portions of Phases 1 and 2 (for sewage) and, for the long-term, includes effluent flow allocation from the eastern portions of Barnstable following treatment at the Barnstable WPCF.

A summary of the capacity requests is provided in Table 1-7.

1.6.4 Capacity Needs at Planning Horizon

Based on our review of the towns and JBCC wastewater needs, we have developed a summary of the capacity needs by entity of the 20-year planning horizon in Table 1-8. All flows are presented on an annual average flow basis.

- The short-term capacity needs can be met with no increase in treatment capacity and a 28% increase in disposal capacity.
- The mid-term capacity needs will require a 250% increase in treatment capacity and a 511% increase in disposal capacity.
- The long-term capacity needs will require a 567% increase in treatment capacity and a 1164% increase in disposal capacity.

TABLE 1-7A: REQUESTED CAPACITY BY WASTEWATER TYPE

	Capacity Requested – Annual Average Basis		
	Low End (gpd)	Study Basis (gpd)	High End (gpd)
BOURNE			
Short-term (2017 to 2020)			
Sewage Treatment	0	0	0
Effluent Disposal Only	100,000	100,000	100,000
Septage Treatment	0	0	0
Mid-term (2020 to 2040)			
Sewage Treatment	0	259,000	259,000
Effluent Disposal Only	100,000	444,000	444,000
Septage Treatment	11,000	11,000	11,000
Long-term (2040+)			
Sewage Treatment	0	456,000	456,000
Effluent Disposal Only	200,000	651,000	651,000
Septage Treatment	11,000	11,000	11,000
FALMOUTH			
Short-term (2017 to 2020)			
Sewage Treatment	0	0	0
Effluent Disposal Only	0	0	0
Septage Treatment	0	0	0
Mid-term (2020 to 2040)			
Sewage Treatment	0	0	0
Effluent Disposal Only	300,000	490,000	1,200,000
Septage Treatment	22,000	22,000	22,000
Long-term (2040+)			
Sewage Treatment	0	0	2,200,000
Effluent Disposal Only	490,000	1,490,000	0
Septage Treatment	22,000	22,000	22,000
MASHPEE			
Short-term (2017 to 2020)			
Sewage Treatment	200,000	200,000	200,000
Effluent Disposal Only	0	0	0
Septage Treatment	0	0	0
Mid-term (2020 to 2040)			
Sewage Treatment	200,000	200,000	370,000
Effluent Disposal Only	0	0	0
Septage Treatment	0	3,000	7,000
Long-term (2040+)			
Sewage Treatment	200,000	200,000	850,000
Effluent Disposal Only	0	0	0
Septage Treatment	1,000	3,000	4,000

TABLE 1-7A: REQUESTED CAPACITY BY WASTEWATER TYPE (Continued)

	Capacity Requested – Annual Average Basis		
	Low End (gpd)	Study Basis (gpd)	High End (gpd)
SANDWICH			
Short-term (2017 to 2020)			
Sewage Treatment	0	0	300,000
Effluent Disposal Only	0	0	0
Septage Treatment	0	0	0
Mid-term (2020 to 2040)			
Sewage Treatment	0	100,000	340,000
Effluent Disposal Only	0	0	0
Septage Treatment	10,000	10,000	10,000
Long-term (2040+)			
Sewage Treatment	40,000	340,000	900,000
Effluent Disposal Only	0	0	0
Septage Treatment	10,000	10,000	10,000
JBCC			
Short-term (2017 to 2020)			
Sewage Treatment	140,000	140,000	140,000
Effluent Disposal Only	0	0	0
Mid-term (2020 to 2040)			
Sewage Treatment	147,000	147,000	147,000
Effluent Disposal Only	0	0	0
Long-term (2040+)			
Sewage Treatment	147,000	147,000	147,000
Effluent Disposal Only	0	0	0
BARNSTABLE			
Short-term (Year 0 to Year 3)			
Sewage Treatment	0	0	0
Effluent Disposal Only	0	0	0
Septage Treatment	0	0	0
Mid-term (Year 5 to Year 20)			
Sewage Treatment	100,000	500,000	800,000
Effluent Disposal Only	0	0	0
Septage Treatment	10,000	10,000	10,000
Long-term (Years 20+)			
Sewage Treatment	500,000	1,200,000	1,200,000
Effluent Disposal Only	0	0	900,000
Septage Treatment	10,000	10,000	10,000

TABLE 1-8A: SUMMARY OF CAPACITY REQUESTS USED IN ENGINEERING ASSESSMENT

	Capacity Requested - "Study Basis" Annual Average Flows (gpd)								
	JBCC	**Bourne**	**Falmouth**	**Mashpee**	**Sandwich**	**Barnstable**	**Total**	**Capacity Provided**	**% Increase Existing Capacity**
Existing									
Sewage Treatment	140,000	0	0	0	0	0	140,000	**360,000**	n/a
Septage Treatment	0	0	0	0	0	0	0		
Effluent Disposal Only	0	0	0	0	0	0	0		
Effluent Disposal	140,000	0	0	0	0	0	140,000	**360,000**	n/a
Short-Term (5-year)									
Sewage Treatment	147,000	0	0	200,000	0	0	347,000	**360,000**	0%
Septage Treatment	0	0	0	0	0	0	0		
Effluent Disposal Only	0	100,000	0	0	0	0	100,000		
Effluent Disposal	147,000	100,000	0	200,000	0	0	447,000	**460,000**	28%
Mid-Term (10 year)									
Sewage Treatment	147,000	259,000	0	200,000	100,000	500,000	1,206,000	**1,260,000**	250%
Septage Treatment	0	11,000	22,000	3,000	10,000	10,000	56,000		
Effluent Disposal Only	0	444,000	490,000	0	0	0	934,000		
Effluent Disposal	147,000	714,000	512,000	203,000	110,000	510,000	2,196,000	**2,200,000**	511%
Long-Term (20 year)									
Sewage Treatment	147,000	456,000	0	200,000	340,000	1,200,000	2,343,000	**2,400,000**	567%
Septage Treatment	0	11,000	22,000	3,000	10,000	10,000	56,000		
Effluent Disposal Only	0	651,000	1,490,000	0	0	0	2,141,000		
Effluent Disposal	147,000	1,118,000	1,512,000	203,000	350,000	1,210,000	4,540,000	**4,550,000**	1164%
Notes	1	1	1	1	1			2, 4	3

1) Refer to Table 1-7 for additional information.
2) Existing Capacity based on WP 2014, GWDP and WWTF O&M.
3) Capacity for Short-Term, Mid-Term and Long-Term conditions are increases over the existing capacity.
4) Organic loading treatment capacity will need to account for concentrated nature of septage.

SECTION 2

ENGINEERING ASSESSMENT

2.1 INTRODUCTION

Section 1 of this report summarizes the previous wastewater planning efforts and capacity needs for each of the participating entities. This section of the report identifies and evaluates the technical factors, costs and management considerations associated with potential shared wastewater facilities at JBCC.

2.2 WASTEWATER FLOWS USED IN THE ENGINEERING ASSESSMENT

Different components of a wastewater system are designed based on different process conditions (e.g., minimum day, annual average, maximum month, maximum multi-day, maximum day and peak instantaneous, etc.). In the absence of existing data on short-term peak flows, peaking factors are typically utilized to establish the other conditions. For the purposes of this study:

- Sewage peaking factors were established using the TR-16 Guides for the Design of Wastewater Treatment Works curves entitled "Relation of Extreme Discharges on Maximum and Minimum Days to the Average Daily Discharge of Domestic Sewage" (New England Interstate Water Pollution Control Commission, 2016) and were adjusted upward by 0.2 to account for seasonal population/flow variations on Cape Cod. Septage peaking factors were set assuming that equalization tanks would be provided.
- Effluent-only peaking factors were estimated by assuming that the remote facilities (i.e., Falmouth BSR WWTF and Bourne ISWM WWTF) have, or will have, effluent equalization tanks sized to meet these peaking factor limitations or will utilize existing or new effluent disposal systems local to the ISWM and BSR WWTFs to manage peak flows.

Table 2-1 summarizes the peaking factors which have been used for this project. The peaking factors from Table 2-1 were applied to the annual average flows from Table 1-8 in order to establish the wastewater flows that will be used for this engineering assessment. Table 2-2 summarizes the annual average, maximum 3-day flows and the peak conveyance flows for the existing, short-term, mid-term and long-term conditions. The flows in Table 2-2 have been used for the conceptual sizing and costing of proposed wastewater system components.

TABLE 2-1: PEAKING FACTORS FOR MIMIMUM AND MAXIMUM FLOW CONDITIONS

Ratio to Annual Average	Sewage	Septage	Effluent Only
Minimum Day	0.40	0.50	0.50
Minimum Month	0.75	0.75	0.75
Annual Average	1.00	1.00	1.00
Maximum Month	1.25	1.50	1.25
Maximum 3-Day	2.2 (LT) to 2.7 (ST)	1.75	1.25
Peak Instantaneous	3.5 (LT) to 4.7 (ST)	1.75	1.25

Note: LT = Long term; ST = Short term

TABLE 2-2: FLOWS USED IN ENGINEERING ASSESSMENT

Flows in gpd	Annual Average	Maximum 3-Day	Peak Conveyance
Existing	140,000	386,000	1,400,000
Short-Term	460,000	1,080,000	1,750,000
Mid-Term	2,200,000	4,160,000	6,090,000
Long-Term	4,550,000	7,930,000	10,980,000

Note: Refer to Appendix A for a breakdown of flows by category. Rounded to nearest 10,000 gpd.

2.3 IDENTIFICATION OF FUTURE WASTEWATER SYSTEM COMPONENTS

This section identifies the components of the future wastewater system to address future wastewater needs at shared facilities. The analysis and costs are presented in these categories.

2.3.1 Conveyance

Each community will have a collection system that transports flow to the location of the regional conveyance facilities. This report addresses the conveyance system costs but will not address the collection system costs.

2.3.2 Treatment

The JBCC WWTF will require upgrade/replacement to serve the regional needs. This report considers the costs for WWTF upgrade/replacement at the current WWTF location or at the former WWTF location (immediately adjacent to the current location). Any potential future WWTF expansions to include more regional flow and/or regional biosolids processing and/or regional source-separated organics digestion is beyond the scope of this study.

2.3.3 Transport to Effluent Disposal

WWTF effluent is conveyed to the existing RIBs via the existing 11-mile long, 12-inch diameter forcemain. This report considers the costs for upgrades to this forcemain as well as supplemental forcemain(s) to the supplemental or replacement effluent disposal methods.

2.3.4 Effluent Disposal

The JBCC RIBs will need to be supplemented or replaced in order to serve the regional needs. This report considers the costs for additional RIBs as well as other supplemental/replacement effluent disposal methods.

2.4 CONVEYANCE

This section identifies the options for wastewater conveyance systems required to support shared wastewater management opportunities for Bourne, Falmouth, Mashpee, Sandwich, Barnstable and JBCC. The objectives of the conveyance study include the following:

- Identify alignments for conveyance of sewage from Bourne's southern section, Mashpee, and Sandwich to JBCC WWTF for treatment and disposal;
- Identify alignments for conveyance of treated wastewater ("effluent") from the JBCC WWTF, the Bourne ISWM WWTF and the Falmouth BSR WWTF to the JBCC treated effluent conveyance system and disposal areas;
- Identify rehabilitation of sections of the JBCC gravity sewer system where shorter alignments and capital cost savings are available;

- Review conceptual profiles of each force main alignment to evaluate conceptual static and dynamic head on the pumping system;
- Develop preliminary hydraulic calculations to determine conceptual forcemain sizes; and
- Determine conceptual number and size of required pump stations.

2.4.1 Concept Design Criteria

The following key assumptions are used in this analysis:

- Elevation data were obtained from topographic information within Google Earth.
- Conceptual forcemain piping and wastewater lift station sizing are based on the conveyance flows in Table 2-2.
- Raw wastewater concept design criteria:
    - Peaking factor used for lift station flow: 4.0
    - Peaking factor used for Barnstable lift station flow: 3.6
    - Minimum force main velocity: 3 fps
    - Maximum force main design pressure: 275 ft (120 psi)
- Treated effluent concept design criteria:
    - Peaking factor used for pump station flow: 1.25
    - Minimum force main velocity: none
    - Maximum force main design pressure: 275 ft (120 psi)
- Force main materials:
    - Existing effluent force main: ductile iron
    - Proposed force mains: C900/C905 DR 18 PVC (235 psi) or HDPE (200 to 255 psi)
- Medium wastewater/effluent lift stations:
    - Flow: up to 1200 gpm
    - Pumps: wetwell installation, submersible, up to 75 hp
    - Generator and control panel in pump house
    - Conceptual construction cost: $1M each
- Large wastewater/effluent lift stations:

- Flow: 1200gpm to 2000 gpd
  - Pumps: drywell installation, greater than 75 hp
  - Generator and control panel in pump building over wetpit/drypit installation
  - Conceptual construction cost: $2.5M each

- Very large wastewater/effluent lift stations:
  - Flow: 2000 gpd or more
  - Pumps: drywell installation
  - Horsepower: up to 200hp
  - Generator and control panel in pump building over wetpit/drypit installation
  - Conceptual construction cost: $5M each
  - For pumps greater than 300hp, add an additional $1M

- Conveyance routes utilizing existing JBCC gravity conveyance systems assume the rehabilitation of those sections through trenchless methods. Rehabilitation costs are assumed to be $150 per foot.
- Forcemain costs vary depending on the conditions of the route and are shown below in Table 2-3. A route within a public way with heavy traffic volumes or dense development has a higher cost than a route along routes with little traffic or adjacent development. Unit costs are intended to cover full-depth trench paving with full-width mill and overlay.

TABLE 2-3: FORCEMAIN COSTS PER FOOT

Forcemain Diameter	Route Characteristics		
	Public Way/ Dense	Public Way Less Dense	Railroad Right of Way
8-inch	$200	$180	$300
10-inch	$215	$195	$320
12-inch	$230	$210	$340
16-inch	$260	$240	$360
18-inch	$280	$250	$380
20-inch	$300	$260	$400

2.4.2 Summary of Preferred Conveyance Options

Multiple alternatives for each town were evaluated and the details of this evaluation are found in Appendix A. Current preferred conveyance routes are shown on **Figure 2-1A** and identified as follows:

- Bourne North (effluent) – Proposed lift station at ISWM WWTF connected to existing JBCC effluent forcemain, via a new 8" Bourne forcemain.
- Bourne South (sewage) – Proposed lift station at the intersection of Valley Bars and County Roads to JBCC WWTF via a new 12" Bourne forcemain and rehabilitated gravity sewer (shared with Sandwich).
- Falmouth (effluent) – Proposed lift station at BSR WWTF connected to the JBCC effluent forcemain(s) via a new 18-inch Falmouth forcemain in Routes 28 and 151.
- Mashpee (sewage) – Proposed lift station on Back Road Site 1 (Town lot) to JBCC WWTF via new 8" Mashpee forcemain.
- Sandwich (sewage) – Proposed lift station on portion of Lot-06-236 at 40 Route 130 to JBCC WWTF via Sandwich forcemain, and rehabilitated gravity sewers (shared with Bourne).

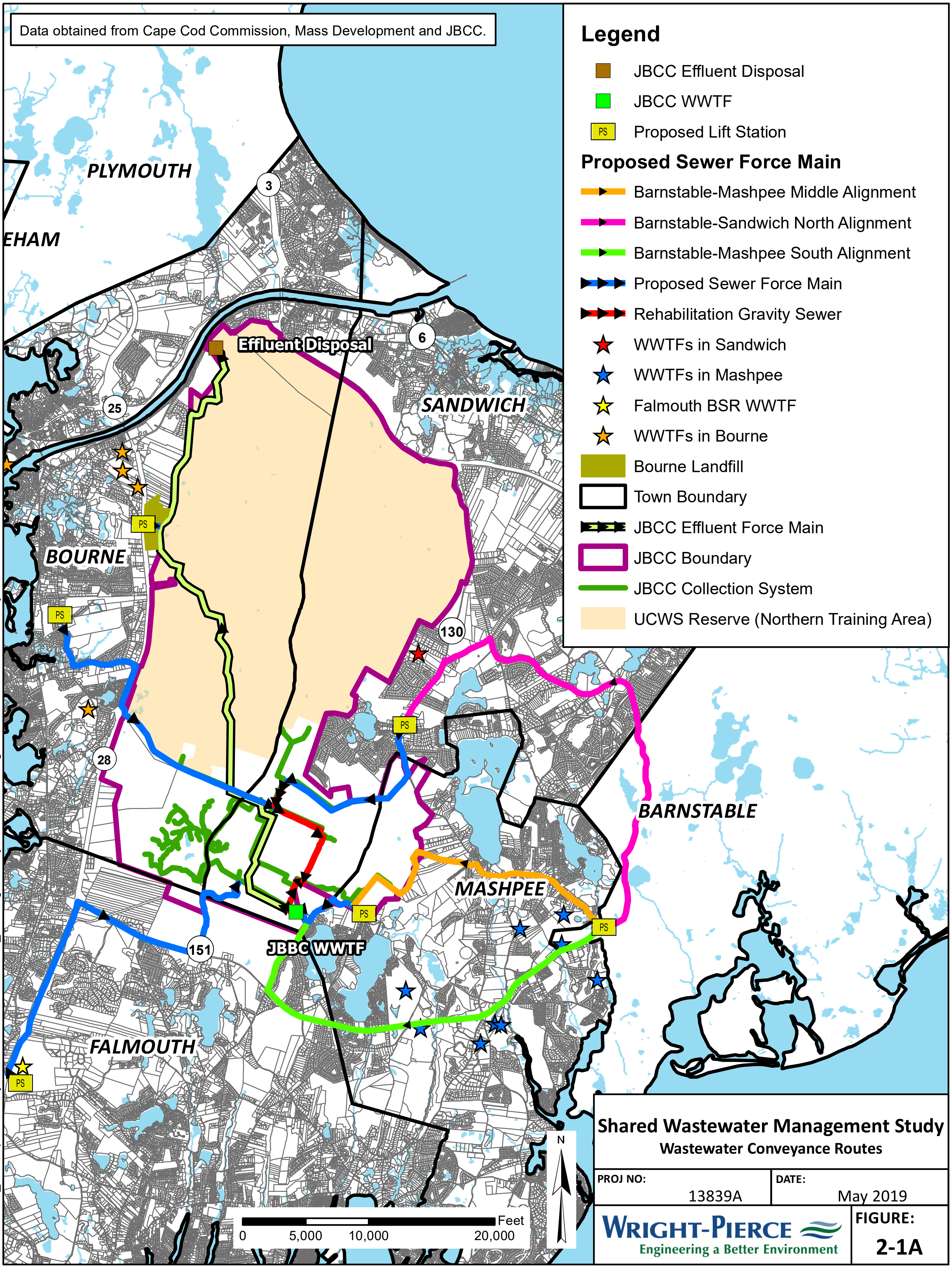
2.4.2.1 Preferred Bourne Alignment Details

One alignment was investigated for Bourne effluent flow from the ISWM WWTF to the JBCC effluent forcemain.

- 1 medium lift station, 570 gpm, 50 hp, velocity 1.7 fps
- 8" forcemain, 100 feet

Option 1 was selected, which has the shortest route through the JBCC base, utilizing rehabilitated existing JBCC gravity sewer.

- 1 large lift station, 1250 gpm, 150 hp
- 12" force main, velocity 3.6 fps, 5.1 miles
- JBCC rehabilitated gravity sewer, 2.3 miles
- Total route length: 7.4 miles



TAH W:\GIS_Development\Projects\MA\Falmouth\13839A_WW-MgmtStudy-JBCC\MXDs\Figure-2-1A-WastewaterConveyanceRoutes-v3-8x11-P.mxd

- Advantages - Least expensive (by $4.1M); shortest route by 2.1 miles; least amount in public ways and along dense development.
- Disadvantages - Uncertainty of obtaining construction easements within federal lands for forcemains; and uncertainty of the level of rehabilitation required for JBCC gravity sewers

2.4.2.2 Preferred Falmouth Alignment Details

Option 1 was selected, which has the shortest route in public way.

- 1 large lift station, 1300 gpm, 150 hp
- 18” Falmouth effluent forcemain, velocity 1.7 fps, 6.7 miles
- Total route length, 6.7 miles
- Advantages - Least expensive (by $0.1M).
- Disadvantages – Longer length in public way.
- Note: The route along the JBCC rail spur and right-of-way is approximately 1.4 miles shorter; however, the cost premium associated with constructing within the railroad right-of-way is significant. If Falmouth can negotiate fewer constraints than would typically be required by a railroad owner, then this shorter alignment may become less expensive and more favorable.

2.4.2.3 Preferred Mashpee Alignment Details

Option 1 was selected, which is the shortest route.

- 1 medium lift station, 560 gpm, 75 ft TDH, 20 hp
- 8” Mashpee forcemain, velocity 3.5 fps, 1.4 miles
- Total route length: 1.4 miles
- Advantages – Least expensive ($1.7M); shortest forcemain route by 3.4 miles
- Disadvantages – None identified.

2.4.2.4 Preferred Sandwich Alignment Details

Option 1 was selected, which has a shared rehabilitated gravity main with Bourne

- 1 large lift station, 1050 gpm, 40 hp

- 12” dedicated Sandwich forcemain, velocity 3.0 fps, 2.9 miles
- JBCC rehabilitated gravity sewer, 0.4 miles (Sandwich) and 2.3 miles (shared with Bourne)
- Total route length: 5.6 miles
- Advantages - Least expensive- by $0.8M; shortest forcemain route by 0.9 miles
- Disadvantages - Uncertainty of obtaining construction easements within federal lands for forcemains; and uncertainty of the level of rehabilitation required for JBCC gravity sewers.

2.4.2.5 Preferred Barnstable Alignment Details

Three candidate alignments were identified by the Town via email dated March 15, 2019. These alignments consist of a central alignment through Mashpee (Option 1), a southern alignment through Mashpee (Option 2), and a northern alignment through Sandwich (Option 3). The cost basis, advantages, and disadvantages of each alignment are described in a memorandum entitled *“JBCC Shared Wastewater Management Study, Evaluation of Conveyance Options”* (Wright-Pierce, May 13, 2019). Option 3 is carried forward in the costs presented herein at a placeholder value of $27.7M (ENR CCI 11228, April 2019) because it is the highest cost and most conservative of the three alignments.

2.5 TREATMENT

This section identifies the treatment components of the future wastewater system, including the preliminary criteria used for sizing components. The primary factors which contribute to the selection of wastewater treatment processes are: wastewater flow and characteristics (domestic, commercial, industrial, septage, etc.); and effluent disposal method. Each of these factors is described below.

2.5.1 Wastewater Flow and Characteristics

The Upper Cape regional sewage treatment needs exceed the available capacity at the existing JBCC WWTF. As noted in Table 1-8, the targeted treatment capacity for sewage and septage flows are (annual average flow basis):

- Existing: 140,000 gpd
- Short-Term: 360,000 gpd
- Long-Term: 2,400,000 gpd

The existing collection system serves the Cantonment, which includes domestic, food preparation and light industrial activities for the military population. The future collection system identified in Section 1 includes a higher volume of 'more conventional' sewage flows. The flow values above include 46,000 gpd of septage flow for mid-term and long-term. Septage is very concentrated and, in simplistic terms, has an 'equivalent load' of an additional 500,000 gpd of sewage, resulting in higher cost for treatment on a 'per gallon basis'.

Given the order of magnitude increase in design flow, the existing treatment tank sizes and arrangement on the site will not be suitable for the necessary amount of expansion. Accordingly, we have assumed the WWTF will be replaced and will be constructed on the original WWTF site (i.e., adjacent to the current WWTF site). Portions of the existing WWTF will be rehabilitated for continued use, as described later in this section. There are many types of wastewater treatment processes which are applicable to this wastewater flow range (e.g., conventional activated sludge, sequencing batch reactors, oxidation ditches, membrane bioreactors, etc.); however, comparison of the advantages/disadvantages and costs of the various type of wastewater treatment process is beyond the scope and objectives of this study. For the purposes of this report, sequencing batch reactor and membrane bioreactor activated sludge systems are considered.

2.5.2 Effluent Disposal Methods and WWTF Effluent Limits

The existing JBCC wastewater facilities have a Groundwater Discharge Permit (GWDP No 41-3) which is issued by the Department of Environmental Protection (DEP). The effluent limits imposed by DEP in GWDPs are common and well-established for rapid infiltration basins (RIBs), which do not discharge to watersheds of impaired waters or zones of contribution to drinking water wells (which is the case for the JBCC GWDP). Since the wastewater treatment and disposal needs defined herein are significantly greater than the existing GWDP, additional effluent disposal capacity will be needed. As noted in Table 1-8, the targeted effluent disposal capacity is 4,550,000 gpd (annual average flow basis).

This additional capacity will come in the form of additional land-based discharge (regulated by DEP) and/ or surface water discharge (regulated by EPA with input from DEP). The effluent disposal methods that were identified for consideration in this evaluation consist of: rapid infiltration; wicks; deep well injection; spray irrigation; effluent reuse; and outfall to surface water. The effluent disposal methods that were selected for more detailed evaluation consist of: rapid infiltration; wicks; deep well injection; and outfall to surface water. Each of these methods and the justification for keeping/eliminating methods is described in Section 2.7.

The anticipated WWTF effluent limits for each of the effluent disposal methods are presented in **Table 2-4**. The contents of this table should be reviewed with state and federal regulators at the appropriate time.

2.5.3 Concept Design Criteria

Treatment processes were selected to achieve the WWTF effluent limits associated with each effluent disposal method. These treatment processes are also summarized in Table 2-4. For example, in order to achieve the criteria for wicks, the new WWTF would need to include preliminary, primary, conventional nitrogen removal, sand filtration, disinfection, and chlorine residual unit processes.

2.5.3.1 Existing WWTF

The existing WWTF will require some limited upgrades in the short-term in order to maintain reliability. These items were identified in the JBCC Water and Wastewater System Evaluation report (Wright-Pierce, 2014, Alternative 1A) and were summarized in Section 1.4.8 of this report. Once the new WWTF is constructed, the existing WWTF buildings and tankage will be upgraded and repurposed for continued use as administrative facilities, laboratory, shop, garages and septage receiving facilities.

TABLE 2-4 ANTICIPATED MONTHLY AVERAGE WWTF EFFLUENT PERMIT LIMITS AND ASSOCIATED TREATMENT PROCESSES

Parameter	Rapid Infiltration	Wicks	Deep Well Injection	Outfall (Class SB)
Current				
BOD_5, mg/l	30	30	10	30
TSS, mg/l	30	30/ 5 (1)	5	30
Total Nitrogen, mg/l	10	10	5	3 (2)
Nitrate-Nitrogen, mg/l	10	10	5	n/a
Ammonia-Nitrogen, mg/l	n/a	n/a	n/a	n/a(4)
Oil & Grease, mg/l	15	15	n/a	n/a
Fecal Coliform, #/100 ml	200	200	14	88
Enterococci, #/100 ml	n/a	n/a	n/a	104
Total Residual Chorine, mg/l	n/a	n/a (1)	n/a (1)	n/a (3)
Total Recoverable Metals, mg/l	n/a	n/a	n/a	n/a (4)
Total Organic Carbon, mg/l	n/a	n/a	1	n/a
Turbidity, NTU	n/a	n/a	2	n/a
Virus Removal, log removal	n/a	n/a	5	n/a
Potential Future at Planning Horizon				
Total Phosphorus	unlikely	unlikely	unlikely	unlikely
Total Organic Carbon	unlikely	unlikely	applicable	unlikely
Unit Process				
Preliminary (Screening/Grit)	Yes	Yes	Yes	Yes
Primary	Yes	Yes	Yes	Yes
Conventional Nitrogen (TN <8 mg/l)	Yes	Yes	Yes	Yes
Enhanced Nitrogen (TN <5 mg/l)	No	No	Yes	Yes
Sand Filtration	No	Yes	No	No
Reverse Osmosis	No	No	Yes	No
Advanced Oxidation	No	No	Yes	No
Disinfection (Ultraviolet Light)	Yes	Yes	Yes	Yes
Chlorine Residual	No	Yes	Yes	No

Notes:

1.) Recommended for fouling control. DEP would likely limit the chlorine residual to 4 mg/l.
2.) Presumed based on input from EPA and Buzzards Bay Coalition.
3.) Use ultraviolet disinfection.
4.) Assume dilution factors of greater than 30:1 can be obtained which would preclude the need for metals or other toxics limits. Ammonia limits not needed since TN limit governs.

2.5.3.2 Enhanced Nitrogen Removal/Sequencing Batch Reactor

The new WWTF will consist of an enhanced nitrogen removal (ENR) activated sludge treatment system targeting less than 5-mg/l effluent total nitrogen using a sequencing batch reactor (SBR) for the RIB, Wick, and Canal Outfall disposal scenarios. The new WWTF will include the following additional items:

- Headworks Building (preliminary treatment).
- Process Building, to include process equipment (e.g., pumps, blowers, etc.), control room, sludge thickening/dewatering activities.
- Exterior primary treatment, SBR, sludge storage, and disinfection tankage.
- Odor control facilities.
- Standby power generator.
- Effluent pump station.

2.5.3.3 Enhanced Nitrogen Removal/ Membrane Bioreactor

The new WWTF will consist of an ENR activated sludge treatment system targeting less than 5-mg/l effluent total nitrogen using a membrane bioreactor (MBR) for the Deep Well Injection disposal scenarios. The new WWTF will include all the same elements as the ENR/SBR facility except that the MBR activated sludge tankage will also be enclosed in a building.

2.5.3.4 Sand Filtration

Conventional sand filtration will be included for the Wick effluent disposal option in order to keep the effluent total suspended solids well below the target criteria. The sand filtration system and appurtenant equipment will be in a building.

2.5.3.5 Reverse Osmosis/ Advanced Oxidation

As noted in Section 2.7.3, reverse osmosis (RO) treatment will be used as the supplemental treatment method required to achieve the effluent limits specified for Deep Well Injection. It is presumed that Falmouth and Bourne effluent would not meet the necessary effluent limits for DWI without supplemental treatment. The ENR/MBR process will need to be sized for the full effluent disposal flow rate (depending on which composite scenario is applicable). In addition, RO produces reject water at approximately 10% to 20% of forward flow. For the purposes of this report, a reject rate of 15% has been utilized. This reject water has high concentrations of nutrients and organics and may have high concentrations of minerals (e.g., calcium, magnesium, sulfates, chlorides, etc.). This reject water will be recycled through the WWTF; accordingly, the WWTF needs to be upsized in order to treat the reject water. A reject water equalization storage tank, sized at 1 day of reject flow volume, is included in order to minimize any peaks or shock loadings. The reject water will also be treated via advanced oxidation to further breakdown TOC compounds prior to recycling through the WWTF.

An effluent storage tank will also be included for the purpose of storing effluent that does meet the criteria for DWI. This tank will be sized for 1-day effluent flow (3.3 Mgal) to allow for the process to be remedied. Any liquid pumped to this tank will be disposed of via the RIBs or will be re-treated through the WWTF.

2.6 TRANSPORT TO EFFLUENT DISPOSAL

The concept design criteria for the effluent disposal piping are the same as was defined in Section 2.4.1 above. The following phased implementation approach was used for the transport to effluent disposal.

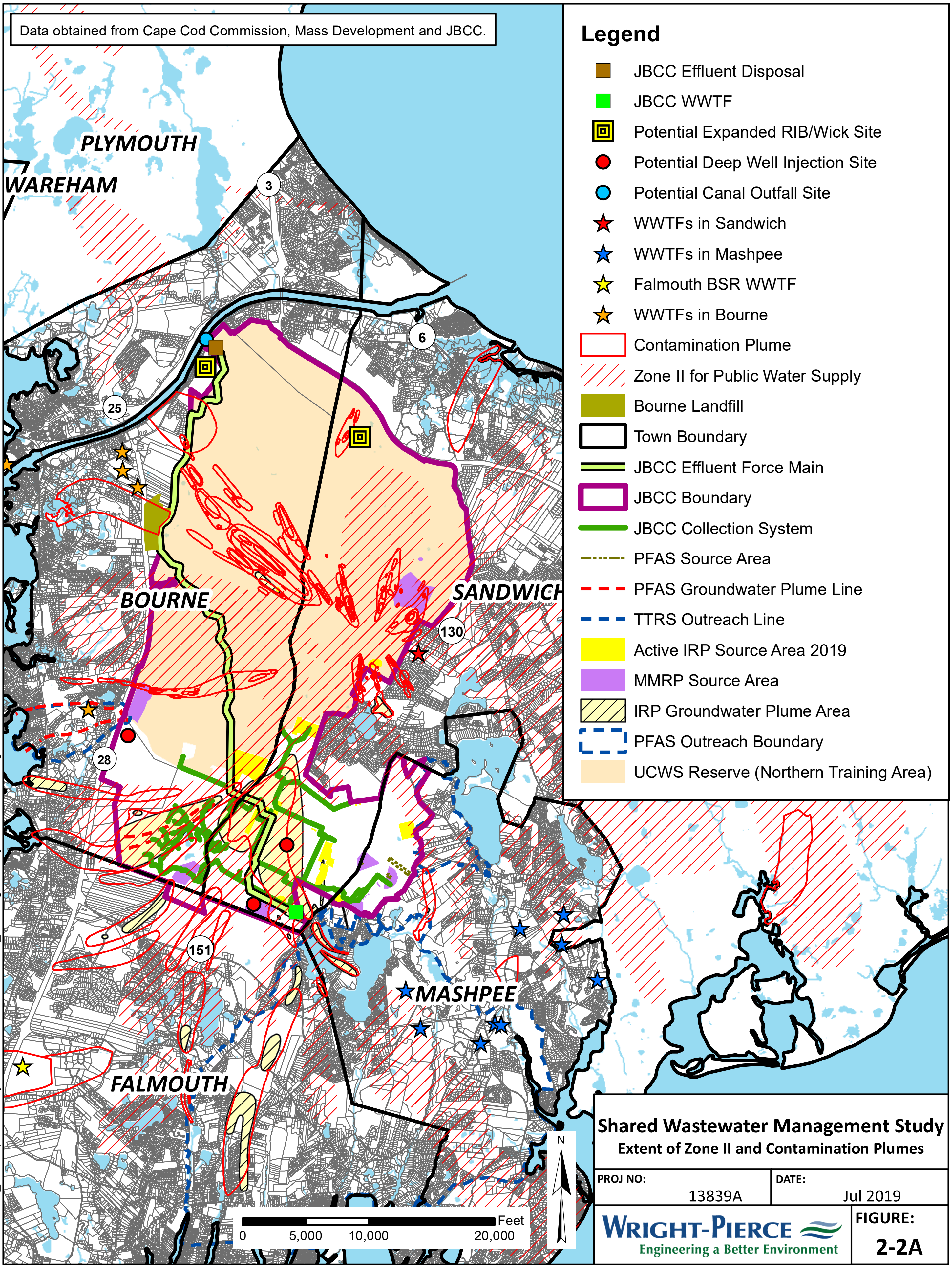
- Short-term
    - Connect Bourne ISWM WWTF (effluent) to existing forcemain.
    - Connect Mashpee (sewage) to the JBCC collection system.
    - Continue to operate existing effluent pump station and existing effluent forcemains.
- Long-term
    - Add flow from Bourne ISWM WWTF (effluent), Mashpee (sewage), Bourne-South (sewage), Falmouth BSR WWTF (effluent), and Sandwich (sewage).
    - Connect Falmouth BSR WWTF (effluent) to the JBCC effluent forcemains.
    - Construct new effluent force mains and valving interconnection with existing 12-inch force main.
    - Operate new effluent pump station and existing/new effluent forcemains.

2.7 EFFLUENT DISPOSAL

This section identifies the effluent disposal components of the future wastewater system, including the preliminary criteria used for sizing components. As noted above, the projected annual average effluent flows are 4,550,000-gpd. The needed additional capacity will come in the form of additional land-based discharge (regulated by DEP and in some cases by EPA as well) and/ or surface water discharge (regulated by EPA with input from DEP). The following effluent disposal methods are considered most applicable for this WWTF:

- Rapid infiltration
- Wicks
- Deep well injection
- Spray irrigation
- Effluent reuse
- Outfall to surface water

Subsurface leaching was not considered due to the relatively low application rates and large land area requirement. A brief description of each effluent disposal method is presented below to provide context for the implications on the treatment unit processes required at the WWTF presented in Section 2.5 of this report. The locations of existing Zone II water supply protection areas and current/former contamination plumes are shown on Figure 2-2. Plume mapping has been updated based on information provided by the Massachusetts Army National Guard in June 2019. The locations of MEP watersheds and TMDL status of each watershed are shown on Figure 2-3.



Shared Wastewater Management Study

Extent of Zone II and Contamination Plumes

PROJ NO:	DATE:
13839A	Jul 2019

WRIGHT-PIERCE
Engineering a Better Environment

FIGURE: 2-2A

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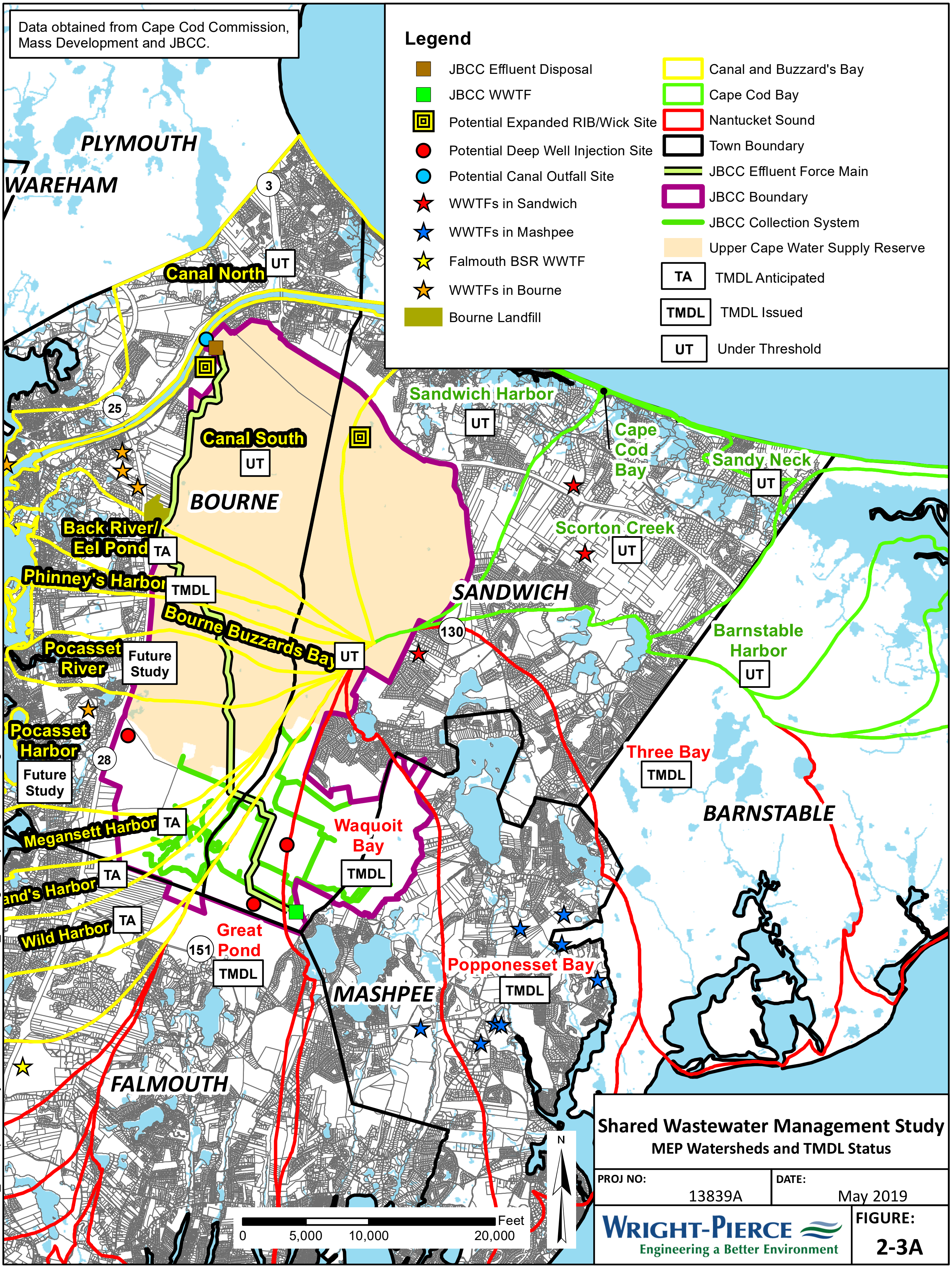

Shared Wastewater Management Study

MEP Watersheds and TMDL Status

PROJ NO: 13839A

DATE: May 2019

WRIGHT-PIERCE
Engineering a Better Environment

FIGURE: 2-3A

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2.7.1 Rapid Infiltration

Rapid infiltration, also referred to as open sand beds or rapid infiltration basins (RIBs), can operate at high loading rates on sites with good permeability and significant depth to groundwater. Year-round application is routine. The reduced footprint compared with subsurface disposal often outweighs the drawback that the selected site can only be used for effluent disposal and that the effluent must be disinfected. A smaller disposal footprint also broadens the number of parcels that can be used as effluent disposal sites. Rapid infiltration systems require fencing around the perimeter to keep out wildlife and humans. The maintenance of the system includes periodic solids removal from the application surface (scarifying) and infrequent weeding. The existing RIBs are shown in the inset photograph. The existing RIBs have 28 "hydraulic continuity measures" installed as a part of the original construction; these hydraulic continuity measures are functionally equivalent to a "wick", as described in Section 2.7.2.

2.7.1.1 Re-Rating Existing RIBs

In order to maximize the capacity of the existing RIBs, the following upgrades are recommended:

- Changing the GWDP to allow the 840,000 gpd value to represent the "Maximum 3-Day Peak Flow, moving average" instead of the current "Maximum Day";
- Segmenting the RIBs such that the site functions as 8 RIBs vs the existing 4 RIBs (which would allow the reserve area to represent 12% of the total infiltrative surface instead of the existing 25% of the total infiltrative surface); and
- Increasing the permitted loaded rate of the RIBs from 4.4 gpd/sf to a significantly higher rate (assumed to be 7 gpd/sf for this analysis) through large-scale loading tests, coordinated and approved with DEP.

In combination, these re-rating measures are anticipated to increase the permitted capacity up to 1,550,000 gpd (short-term peak). These items will need to be closely coordinated with DEP.

2.7.1.2 Sizing of New RIBs

For the purposes of this report, rapid infiltration at or near the existing RIB site will be sized based on 7 gpd/sf and requires a total site footprint based on two times the calculated infiltration area (3-day max flow basis) to account for site buffers/setbacks, roadways, etc. We have assumed the subsurface conditions in the immediate vicinity of the existing RIB site will have similar hydrogeologic properties and that the resulting groundwater mounds will be consistent with the existing groundwater mound.

2.7.2 Wicks

A wick is a vertical cylinder of highly permeable material that provides an efficient path for effluent to travel from the surface point of discharge to the soil in the vadose (unsaturated) zone. Effluent from a wick receives soil aquifer treatment (SAT) through the vadose zone. Wicks allow for very high loading rates on a small footprint because they disperse effluent both horizontally and vertically. Another advantage to wicks is the ability to bypass less permeable material. Wicks are not very intrusive; the only above-grade components include an access vault and cover.

This technology is relatively new and therefore DEP has stringent permitting requirements. First, the design must include standby wicks to provide more than 100 percent redundant disposal capacity, so that if a wick were to fail or be overloaded, another wick can be brought on-line immediately. Second, there must be another permitted disposal location that could be developed with a traditional system if the wicks fail prematurely. Extensive hydrogeologic evaluations are required to determine the suitability of the soil for wicks. WWTF effluent must be filtered to maintain a total suspended solids concentration of 5 mg/l or less. The use of chlorine to manage biofouling have the potential to create trihalomethanes (THMs) in groundwater due to elevated background concentrations of chloroform in the groundwater on Cape Cod. This should be considered in permitting/design.

This technology has been permitted at three locations in Massachusetts (i.e., Hingham, Tisbury, and West Island in Fairhaven) and is being considered for implementation in at least one other location in Massachusetts (i.e., Orleans). For the purposes of this report, each wick will be sized to handled 100,000 gpd of effluent (3-day max flow basis).

2.7.3 Deep Well Injection

Deep well injection (DWI) involves a special-purpose well designed for the disposal of effluent into the groundwater in the saturated zone. The groundwater in the Upper Cape is designated as a Sole Source Aquifer (Sagamore Lens). DWI would be regulated by the DEP under the Groundwater Discharge regulations (314 CMR 5.00) and by the EPA under the Underground Injection Control (UIC) program and the Sole Source Aquifer (SSA) program. As of the date of this report, "aquifer storage and recovery" (ASR) and indirect potable water reuse have been implemented in water-strained areas of the United States (e.g., California, Florida, Arizona). There are no full-scale DWI applications for effluent disposal in Massachusetts at this time; however, there are numerous groundwater treatment systems on JBCC that use a pump/treat/disposal approach similar to DWI. A DWI pilot test was conducted at the Hyannis WPCF in 2003 (*Pilot Test for Using Injection Wells for Reclaiming Treated Municipal Wastewater, Town of Barnstable, MA*, Stearn & Wheler, 2003). The pilot test report recommended filtration (<10 micron, to prevent fouling), maintaining a chlorine residual (to prevent biofouling), and additional pilot-scale and full-scale testing prior to further consideration of use on Cape Cod. DWI will have similar concerns regarding potential THM formation as wicks. This should be considered in permitting/design.

Based on the requirements outlined in 314 CMR 5.10, the treatment limits summarized below are applicable for discharge within a Zone II, for a discharge within a Zone II and with less than a 2-year travel time to a water supply well, and for any groundwater discharge "without the benefit of treatment in the unsaturated zone".

	Column A Within Zone II	**Column B Within Zone II and Less than 2-Year Travel Time**	**Column C Any GW Discharge without Treatment in Unsaturated Zone**
TSS	<10 mg/l	<5 mg/l	<5 mg/l
Turbidity	<5 NTU	<2 NTU	<2 NTU
TOC	<3 mg/l	<1 mg/l	<1 mg/l
Total Nitrogen and Nitrate-Nitrogen	<10 mg/l	<5 mg/l	<5 mg/l
Fecal Coliform	<200/ 100ml	<14/ 100ml	<14/ 100ml
Viruses	n/a	>5 log removal	>5 log removal

The primary regulatory focus for deep well injection applications is the impact on drinking water (i.e., TOC, fecal coliform, and virus removal). As noted in the table above, there is no difference in the effluent limits between Column B and Column C. This means that the regulations provide no relief in treatment standards for the DWI approach even if located remote from water supply wells.

In order to achieve the criteria for discharge within a Zone II and less than a 2-year travel time to a water supply well (Column B) or for any discharge "without the benefit of treatment in the unsaturated zone" (Column C), a reverse osmosis (RO) treatment system will be required primarily related to the TOC limits of <1 mg/l. For the purposes of this report, the approach is to inject highly treated effluent into the Sole Source Aquifer very deep in the aquifer (i.e., between approximately EL -100 to EL -200, or approximately 300 feet below ground surface) and substantially below the lowest elevation of the deepest drinking water supply wells. The typical screened interval in the Bourne and Falmouth water supply wells is EL 5.0 to EL -46.6 (USGS, SIR-2004-5181, Table 1-3). The premise is that water is returned to the local hydrologic cycle by replenishing the water levels in the Sagamore Lens at the bottom of the aquifer. At this depth, it is presumed that all DWI effluent will emerge beyond all nitrogen sensitive embayments/watersheds. The DWI will not include any concentrated reject water. For the purposes of this report, each DWI well is assumed to convey 750,000 gpd effluent flow (3-day max flow basis).

If the criteria for discharge within a Zone II (Column A) were applicable, a granular activated carbon (GAC) filtration system would likely be sufficient primarily based on its presumed ability to achieve <3 mg/l TOC. A GAC filtration system would be much less costly and less complicated to operate than the other treatment options and may be sufficiently conservative for permitting, given the following considerations:

- Much of the water to be disposed of via DWI already recharges the Sagamore Lens in a decentralized manner through individual septic systems.
- The DWI effluent would be treated to a substantially higher level than the existing decentralized treatment levels.
- The proposed DWI volume represents an estimated 2.3% of the annual average precipitation recharge to the Sagamore Lens with an assumed 4.55-mgd DWI recharge and an estimated 190-mgd annual average precipitation recharge (USGS, 2000).
- The DWI effluent would be injected approximately 50 to 100 feet below the bottom of the deepest drinking water well in the Sagamore Lens.

2.7.4 Spray Irrigation

Landscape spray irrigation is an example of technology that can be used at site with a dual use (e.g., effluent can be applied to parks, sports fields, golf courses, or landscaping. All of these activities are associated with human activity and require meeting the effluent reuse guidelines (DEP reclaimed water regulations and US EPA Reclaimed Water Guidelines), which usually adds to the cost of wastewater treatment. Irrigation is certainly restricted to seasonal operation which requires either winter storage or a complementary effluent disposal system. This technique uses moderate application rates.

Based on an assumed application rate of 1.5 inches of wastewater per week, and an assumed total site area at 1.5 times the area required for spray fields (to account for site buffers/setbacks, roadways, etc), the mid-term site area needs are 55 acres total and the long-term site area needs are 146 acres total. Based on the presumption that this amount of land would likely need to be within in the UCWS Reserve/ Northern Training area and would likely be in or around existing Zone II water supply protection areas and existing contamination plumes, this approach is determined to be not viable for the full effluent flow. However, it could be considered for possible seasonal application for a portion of the effluent flow.

2.7.5 Effluent Reuse

DEP uses the term "reclaimed water" which it defined as wastewater that has been treated at a wastewater treatment facility to an advanced degree and used again for various applications. The fundamental premise behind effluent reuse is the recognition of the value of water and the nutrients it may carry, tempered by the public health aspects of public contact with wastewater-derived material.

A good way to contrast "effluent disposal" and "use of reclaimed water" is to consider spray irrigation. A spray irrigation site that receives typical treatment plant effluent must include fencing or other means of preventing public access, as well as significant vegetated buffers to control spray drift (i.e., effluent disposal). If a higher level of treatment is provided, DEP allows for spray irrigation on golf courses where the public has access (i.e., reclaimed water).

The artificial recharging of aquifers is only permitted in watershed basins and sub-basins which are stressed water resource areas where it is necessary to replenish stream flow, enhance the productivity and capacity of an aquifer, and/or improve upon or mitigate water quality problems. The water quality criteria for the treated wastewater are extremely rigorous, requiring that reclaimed water be virtually pathogen- and contaminant-free, and are dependent on which “class” of effluent reuse is proposed. Based on the requirements outlined in 314 CMR 20.17, the treatment limits summarized below are applicable for the various classes of reclaimed water use.

	Class A Reuse	Class B Reuse	Class C Reuse
BOD_5, mg/l	10	30	30
TSS, mg/l	5	10	30
Total Nitrogen, mg/l	-	-	-
Nitrate-Nitrogen, mg/l	10	10	10
Turbidity, NTU Average Maximum	 2 10	 - -	 - -
Fecal Coliform, #/100ml Median Maximum	 0 14	 14 100	 0 200
Potential Uses	Public contact Irrigation Toilet flushing Agriculture Industrial use Car washes Fire protection Recreational Impoundments	No public contact likely Irrigation Concrete mix Aggregate washing Street cleaning	No public contact Irrigation of non-edibles Industrial use

The primary regulatory focus for effluent reuse applications is the impact on human health from incidental contact (i.e., fecal coliform). The effluent limits for reuse are less stringent than for deep well injection with the exception of fecal coliform, which is substantially more stringent.

There are a number of potential effluent reuse applications at JBCC, including golf course irrigation, vehicle washing, toilet flushing, and fire protection. There are several other golf courses in the vicinity of JBCC that could be considered for irrigation by effluent. Each of these potential uses is intermittent and will not represent a disposal source for all, or even a large portion of, the effluent flow. A potential year-round application could power plant cooling water; however, this would require a public private partnership and several additional miles of effluent forcemain. Accordingly, this approach is considered viable but as a supplemental method in the future. This approach has not been incorporated into the cost analysis.

2.7.6 Outfall to Surface Water

A new effluent discharge to surface water in Massachusetts must meet the requirements of Massachusetts Ocean Sanctuaries Act MGL Ch.132A, Sec.16G (OSA). The OSA requires that the following 10 items must be met (*italics indicate text from MGL*):

1) *The new or modified discharge shall be consistent with the intent and purpose of the act. Any discharge shall meet the water quality standards of the receiving water body and the standards of the act to protect the appearance, ecology, and marine resources of the waters of the sanctuary.*
2) *The new or modified discharge shall meet the United States Environmental Protection Agency's approved TMDL, if any, on the receiving water body.*
3) *The applicant shall have adopted and implemented a plan approved by the department requiring the pretreatment of all commercial and industrial wastes discharged to the POTW.*
4) *The applicant shall have adopted and implemented a program for water conservation according to the guidelines established by the water resources commission.*
5) *The applicant shall have adopted and implemented a plan, approved by the department, to control and minimize inflow and infiltration.*
6) *The applicant shall have adopted and implemented a plan, approved by the department, to control any combined sewer overflows.*
7) *The new or modified discharge shall not significantly affect the quality or quantity of existing or proposed water supplies by reducing ground or surface water replenishment.*
8) *The new or modified discharge is consistent with the policies and plans of the Massachusetts coastal zone management program.*
9) *The new or modified discharge and treatment plans are consistent with all applicable federal, state, and local laws, ordinances, by-laws, rules, and regulations protecting the environment, including but not limited to, the requirements of chapters 21, 91, 130, and 131.*
10) *The proposed discharge and outfall structure will not adversely impact marine fisheries or interfere with fishing grounds or the normal operation of fishing vessels.*

If the above can be met, then a surface water discharge could be permitted by DEP and EPA. The JBCC effluent discharge would need to meet standards set forth in state and federal water quality legislation. These standards establish minimum effluent discharge requirements which must always be satisfied . In accordance with Section 402 of the Clean Water Act, the WWTF's effluent quality requirements would be stipulated in a National Pollutant Discharge Elimination System (NPDES) permit which would be issued by the EPA. For the purposes of this report, we have presumed that a permit for surface water discharge to the Cape Cod Canal, which is designated as a Class SB waterway by the Massachusetts DEP (SWQ Standards) and is not designated as an Outstanding Resource Water or an Area of Critical Environmental Concern, can be obtained.

MADEP Implementation Policy for Mixing Zone (January 1993) defines how a mixing zone is established for a surface water outfall. A "mixing zone" is an area or volume of a waterbody in the immediate vicinity of a discharge where the initial dilution of the discharge occurs. Within a mixing zone, excursions from certain water quality criteria may be tolerable, provided this does not interfere with the existing or designated uses of the segment. Water quality criteria apply at the boundary of the mixing zone. The mixing zone is a function of the proposed outfall flow rate versus the minimum flow of the receiving water. In the case where there is tidal flow, there is a significant amount of judgement used by the permit writer in calculating the appropriate dilution factor and sizing the mixing zone. The following physical parameters were used in our evaluation:

- Minimum channel width at the channel bottom of 450 feet.
- Minimum channel width at the water surface of 670 feet.
- Minimum water depth of 32 feet.
- Estimated westward flow of 22,000 Mgal per tide cycle and an estimated eastward flow of 19,000 Mgal per tide cycle, with a net 8,500 Mgal per tide cycle to the west (Sandwich Draft Environmental Impact Statement, 1981).

- Canal water velocity between 3 to 5 fps between high and low tide and a minimum net velocity of 0.26 fps at slack tide.
- Minimum depth of water over diffusers of 40 feet.
- The use of multi-port diffusers oriented perpendicular to receiving water flow, with a discharge velocity of approximately 10 fps per port, in order to maximize dispersion and mixing of effluent with the receiving water.

In the case of a simple single-directional flow (i.e., river), the dilution factor is calculated by the formula: (River flow + WWTF flow) / WWTF flow; however, given that this application would be for tidal, dual-directional flow, the actual permitting calculations are more complicated. We recommend a minimum dilution factor of 50:1 in order to avoid the toxics criteria. Based on our experience with tidal outfalls, we anticipate that it will be possible to achieve a dilution factor of at least 50:1 with an overall diffuser length of 100 feet. Given that the Canal is a heavily used commercial shipping channel, heavily used recreational fishing location, and has a strong current, construction and maintenance of an outfall will be expensive.

It is important to note the following considerations related to a surface water outfall:

- Site-specific data collection and modeling will be required in order to determine actual dilution factor at this location.
- Long-term water quality monitoring will be needed to establish existing conditions for MADEP to make an anti-degradation determination.
- A "parallel to shore diffuser" or a "sidebank outfall" would be preferred based on the existing uses of the Canal and the construction/maintenance aspects of this application
- Numerous other factors go into siting and permitting a surface water outfall, including evaluation of existing water quality, completion of an anti-degredation review, and evaluation of existing uses (including human and aquatic life uses).
- The application and review process for a new surface water discharges should be expected to take 5 to 7 years and the successful conclusion is not assured.

2.7.7 Summary of Land-Based Effluent Disposal Alternatives

The hydrogeologic aspects of the effluent disposal options have been reviewed by GeoHydroCycle (GHC). GHC's analysis is presented in Appendix B and summarized here.

2.7.7.1 Rapid Infiltration Beds

The existing 4 RIBs, once upgraded and loaded at the projected 1.55-mgd rate, will produce a groundwater mound of approximately 10 to 15 feet above the seasonal high water table. That mound is expected to dissipate in a down-gradient direction sufficiently to prevent any breakout of effluent-impacted groundwater. All of the effluent-impacted groundwater will emerge in the Cape Cod Canal over several hundred feet of its length without impacting drinking water wells.

The new RIBs, located immediately west of the existing RIBs, are expected to exhibit similar surficial loading rates and mound heights when those RIBs are loaded due to being located in a very similar hydrogeologic setting. While there may be some superposition of the mounds of the existing and new RIBs, the additional mound is relatively minor compared to the significant unsaturated zone at this location. No break-out or well impacts are expected.

2.7.7.2 Wicks

Wicks are a relatively new disposal technology for Massachusetts. The significant depth-to-water table and glacial outwash soils at JBCC provide the conditions where wicks can be successful. Wicks would best be located outside of nitrogen-sensitive watersheds and downgradient from water supply wells. The location, design and capacity of wicks can only be determined through large-scale testing.

2.7.7.3 Deep Well Injection

Deep injection wells could be located in an area near the military cemetery at the southwest corner of JBCC and near the existing WWTF at the southeast corner of JBCC. There are no existing contaminant plumes or Zone IIs in either location. With screens located near bedrock, the injection wells would discharge approximately 100 feet to 150 feet <u>below</u> the intake screens at the deepest water supply wells. The near-bedrock discharges would allow the effluent-impacted groundwater to emerge in Buzzards Bay (westerly injection wells) or in Nantucket Sound (easterly injection wells), with little to no expected impact on coastal embayments. The travel time from the injection wells to the point of emergence is expected to be 2 or more decades.

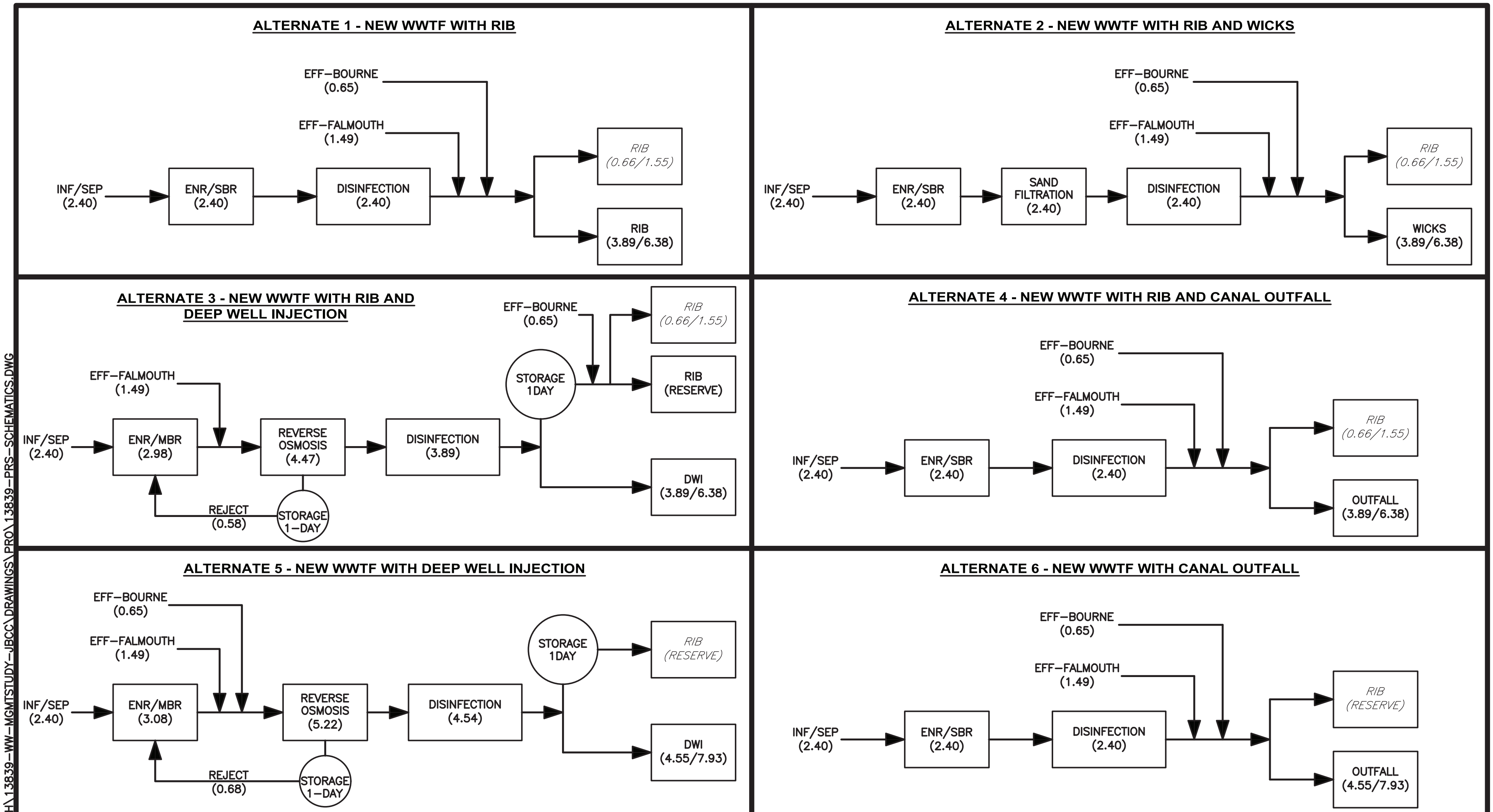
Injection wells are a new technology for Cape Cod and the location, design, and capacity of the wells would be determined only through large-scale testing. The ability to bypass coastal embayments would need to be further demonstrated through detailed groundwater modeling.

2.8 IDENTIFICATION OF COMPOSITE ALTERNATIVES

This section identifies and describes the following alternatives for the treatment and disposal aspects of the future wastewater system:

1) New WWTF with RIBs
2) New WWTF with RIBs and Wicks
3) New WWTF with RIBs and Deep Well Injection
4) New WWTF with RIBs and Canal Outfall
5) New WWTF with Deep Well Injection
6) New WWTF with Canal Outfall

Treatment process schematics for each alternative are shown on Figure 2-4A. Each of the alternatives includes limited upgrades to the existing JBCC wastewater facilities in order to maintain permit compliance and capacity in the short-term to mid-term. All flow rates indicated in Section 2.8 reference the 3-day peak flow. Each of the alternatives includes a description of the anticipated phasing requirements. A summary of the upgraded and new facilities for each of the composite alternatives is presented on the following pages. The project phasing and management entity boundaries which are included in the planning-level cost estimates are shown on Figure 2-5A.



NOTES:

(#.##/#.##) = LONG–TERM FLOW IN MGD. FIRST NUMBER IS ANNUAL AVERAGE FLOW BASIS. SECOND NUMBER IS 3–DAY MAXIMUM FLOW BASIS.

EXISTING = EXISTING PROCESS

PROPOSED = PROPOSED PROCESS

WITH BARNSTABLE

SHARED WASTEWATER MANAGEMENT STUDY
JBCC WASTEWATER SYSTEM
TREATMENT PROCESS SCHEMATICS

PROJ NO:	DATE:	FIGURE:
13839A	MARCH 2019	2-4A

WRIGHT-PIERCE
Engineering a Better Environment

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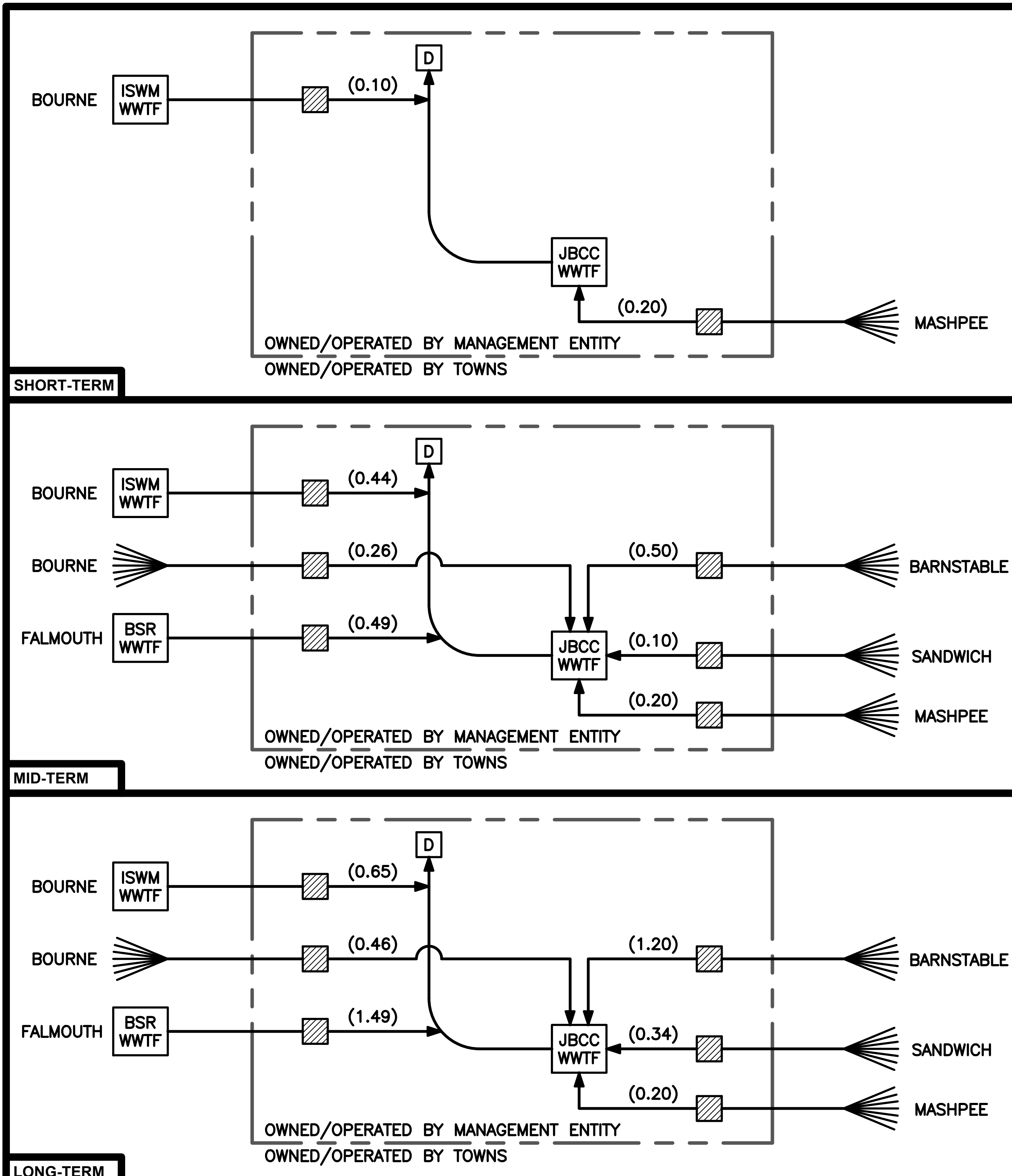

LEGEND

D DISPOSAL

LIFT STATION

COLLECTION SYSTEM

MANAGEMENT BOUNDARY

SHARED WASTEWATER MANAGEMENT STUDY
JBCC WASTEWATER SYSTEM
PHASING AND MANAGEMENT ENTITY SCHEMATIC

PROJ NO:	DATE:	FIGURE:
13839A	MARCH 2019	2-5A

WRIGHT-PIERCE
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2.8.1 New WWTF with RIBs

Short-Term: • Upgrades to existing JBCC wastewater facilities. • Upgrades to existing RIBs to achieve 1.55-mgd capacity. • Connect Bourne ISWM WWTF (effluent) and Mashpee (sewage).
Long-Term: • New ENR/SBR WWTF plus disinfection. • 16 new RIBs on the adjacent US Government parcel (ACOE) or in the Reserve to achieve an additional 6.38-mgd capacity. • 2 new effluent forcemains (11.0 miles) located parallel to existing (3 total forcemains). • Connect Falmouth BSR WWTF (effluent); Bourne, Sandwich, and Barnstable (sewage).

2.8.2 New WWTF with RIBs and Wicks

Short-Term: • Upgrades to existing JBCC wastewater facilities. • Upgrades to existing RIBs to achieve 1.55-mgd capacity. • Connect Bourne ISWM WWTF (effluent) and Mashpee (sewage).
Long-Term: • New ENR/SBR WWTF plus sand filtration and disinfection. • Assume that Bourne ISWM WWTF and Falmouth BSR WWTF can meet the effluent TSS and turbidity requirements for wicks (i.e., no cost included herein). • 30 to 65 new wicks to achieve an additional 6.38-mgd capacity (63 based on 100,000 gpd per wick). • 2 new effluent forcemains (11.0 miles) located parallel to existing (3 total forcemains). • Connect Falmouth BSR WWTF (effluent); Bourne, Sandwich, and Barnstable (sewage).

2.8.3 New WWTF with RIBs and Deep Well Injection

Short-Term: • Upgrades to existing JBCC wastewater facilities. • Upgrades to existing RIBs to achieve 1.55-mgd capacity. • Connect Bourne ISWM WWTF (effluent) and Mashpee (sewage).
Long-Term: • New ENR/MBR WWTF plus RO/Storage and disinfection. • 8 to 10 new DWI wells in the Cantonment or the Reserve to achieve an additional 6.38-mgd capacity (9 based on 750,000 gpd per DWI well). • Add RIBs or wicks to serve as reserve disposal (1.55 mgd) • 2 new effluent forcemains (2.3 miles) located parallel to existing (3 total forcemains). • Connect Falmouth BSR WWTF (effluent); Bourne, Sandwich, and Barnstable (sewage).

2.8.4 New WWTF with RIBs and Canal Outfall

Short-Term: • Upgrades to existing JBCC wastewater facilities. • Upgrades to existing RIBs to achieve 1.55-mgd capacity. • Connect Bourne ISWM WWTF (effluent) and Mashpee (sewage).
Long-Term: • New ENR/SBR WWTF plus disinfection. • Assume that Falmouth BSR WWTF and Bourne ISWM WWTF can meet the effluent requirements for a Canal outfall (i.e., no cost included herein). • New Canal outfall sized for an additional 6.38-mgd capacity. • 2 new effluent forcemains (11.5 miles) located parallel to existing (3 total forcemains). • Connect Falmouth BSR WWTF (effluent); Bourne, Sandwich, and Barnstable (sewage).

2.8.5 New WWTF with Deep Well Injection

Short-Term: • Upgrades to existing JBCC wastewater facilities. • Upgrades to existing RIBs to achieve 1.55-mgd capacity. Maintain existing RIBs to serve as reserve disposal. • Connect Bourne ISWM WWTF (effluent) and Mashpee (sewage).
Long-Term: • New ENR/MBR WWTF plus RO/Storage and disinfection. All Falmouth and Bourne effluent flow brought to JBCC WWTF site. • 10 to 12 new DWI wells in the Cantonment to achieve an additional 7.93-mgd capacity (11 based on 750,000 gpd per DWI well). • 2 new effluent forcemains (2.3 miles) located parallel to existing (3 total forcemains). • Connect Falmouth BSR WWTF (effluent); Bourne, Sandwich, and Barnstable (sewage).

2.8.6 New WWTF with Canal Outfall

Short-Term: • Upgrades to existing JBCC wastewater facilities. • Upgrades to existing RIBs to achieve 1.55-mgd capacity. • Maintain existing RIBs to serve as reserve disposal. • Connect Bourne ISWM WWTF (effluent) and Mashpee (sewage).
Long-Term: • New ENR/SBR WWTF plus UV disinfection. • Assume that Bourne ISWM WWTF and Falmouth BSR WWTF can meet the effluent requirements for a Canal outfall (i.e., no cost included herein). • New Canal outfall sized for an additional 7.93-mgd capacity. • 2 new effluent forcemains (11.5 miles) located parallel to existing (3 total forcemains). • Connect Falmouth BSR WWTF (effluent); Bourne, Sandwich, and Barnstable (sewage).

2.9 EVALUATION OF COMPOSITE ALTERNATIVES

This section evaluates the composite alternatives for the future wastewater system for cost and non-cost factors. Planning-level cost estimates for the long-term flows are summarized in Table 2-5 (for the Upper Cape towns) and Table 2-5A (for the Upper Cape town plus Barnstable). The cost information presented herein is in current dollars and is based on ENR Index 11228. Backup information and additional assumptions are identified in Appendix A.

2.9.1 Planning-Level Capital Costs

Planning-level capital cost estimates were developed using cost estimating procedures consistent with industry standards utilizing concept layouts, unit cost information, and planning-level cost curves, as necessary. The capital costs include the following key components: wastewater collection, transport-to-treatment, wastewater treatment, transport-to-disposal, effluent disposal, land acquisition, and technical services and contingencies. Key technical data were compiled for all plans, based on conceptual designs. Next, typical "unit costs" were applied (e.g., dollars per foot of pipe, or dollars per pump station) using recent experience from publicly-bid wastewater projects across New England. Unit costs for “baseline” treatment and disposal facilities (i.e., ENR/SBR and disinfection) were taken from the Barnstable County Cost Report (“*Comparison of Costs for Wastewater Management Systems Applicable to Cape Cod*,” April 2010). Once basic construction costs were estimated, allowances were added for contingencies and technical services (40% of construction subtotal) and financing/legal/administration expenses (3% of construction subtotal). Land costs were excluded from this analysis.

TABLE 2-5: PLANNING-LEVEL COST ESTIMATES FOR UPPER CAPE TOWNS (ENR CCI 11228, April 2019)

Option	1	2	3	4	5	6
Description of Effluent Disposal	**RIB**	**RIB & Wicks**	**RIB & DWI**	**RIB & Outfall**	**DWI**	**Outfall**
Capital Cost						
Construction - Conveyance	$29,030,000	$29,030,000	$29,030,000	$29,030,000	$29,030,000	$29,030,000
Construction - Treatment	$38,900,000	$41,300,000	$72,000,000	$41,300,000	$78,700,000	$41,300,000
Construction - Transport to Disposal	$22,900,000	$22,900,000	$5,160,000	$23,950,000	$5,160,000	$23,950,000
Construction - Disposal	$11,700,000	$11,400,000	$13,400,000	$11,900,000	$14,200,000	$13,400,000
Contingency, Technical, Legal/Admin/Finance	$44,090,000	$44,990,000	$51,420,000	$45,660,000	$54,650,000	$46,300,000
Total Capital Cost	**$146,620,000**	**$149,620,000**	**$171,010,000**	**$151,840,000**	**$181,740,000**	**$153,980,000**
Ratio to Lowest - Total Capital Cost	1.00	1.02	1.17	1.04	1.24	1.05
Ratio to Lowest - Capital Cost, excl. Conveyance	1.00	1.03	1.23	1.05	1.33	1.07
Annual Operation & Maintenance Cost	**$2,910,000**	**$3,010,000**	**$6,040,000**	**$3,110,000**	**$7,300,000**	**$3,110,000**
Ratio to Lowest - Annual O&M	1.00	1.03	2.08	1.07	2.51	1.07
Total Annual Debt Service on Capital Cost	$8,970,000	$9,150,000	$10,460,000	$9,290,000	$11,110,000	$9,420,000
Total Equivalent Annual Cost (Note 3)	**$11,880,000**	**$12,160,000**	**$16,500,000**	**$12,400,000**	**$18,410,000**	**$12,530,000**
Ratio to Lowest - Equivalent Annual Cost	1.00	1.02	1.39	1.04	1.55	1.05
EAC per thousand gallons of disposal capacity	$9.72	$9.94	$13.49	$10.14	$15.06	$10.25

Notes:

1) Costs are presented in current dollars based on Engineering News Record Construction Cost Index 11228 (April 2019).
2) Refer to Appendix A for supporting information.
3) Equivalent Annual Cost equals Annual O&M Cost plus the Annual Debt Service on Capital Cost.
4) Allocation for Conveyance is 100% to each town. Allocation for treatment/transport/disposal is pro-rated based on flow capacity requested.
5) Blue indicates lowest cost option, green indicates second lowest cost option and orange indicates third lowest cost option.

TABLE 2-5A: PLANNING-LEVEL COST ESTIMATES FOR UPPER CAPE TOWNS PLUS BARNSTABLE (ENR CCI 11228, April 2019)

Option	**1**	**2**	**3**	**4**	**5**	**6**
Description of Effluent Disposal	**RIB**	**RIB & Wicks**	**RIB & DWI**	**RIB & Outfall**	**DWI**	**Outfall**
Capital Cost						
Construction - Conveyance	$56,730,000	$56,730,000	$56,730,000	$56,730,000	$56,730,000	$56,730,000
Construction - Treatment	$58,000,000	$61,700,000	$92,800,000	$61,700,000	$98,800,000	$61,700,000
Construction - Transport to Disposal	$25,720,000	$25,720,000	$5,760,000	$26,910,000	$5,760,000	$26,910,000
Construction - Disposal	$13,200,000	$12,900,000	$16,600,000	$13,400,000	$18,400,000	$14,800,000
Contingency, Technical, Legal/Admin/Finance	$66,070,000	$67,530,000	$73,910,000	$68,260,000	$77,270,000	$68,860,000
Total Capital Cost	**$219,720,000**	**$224,580,000**	**$245,800,000**	**$227,000,000**	**$256,960,000**	**$229,000,000**
Ratio to Lowest - Total Capital Cost	1.00	1.02	1.12	1.03	1.17	1.04
Ratio to Lowest - Capital Cost, excl. Conveyance	1.00	1.04	1.19	1.05	1.27	1.07
Annual Operation & Maintenance Cost	**$4,290,000**	**$4,450,000**	**$7,100,000**	**$4,620,000**	**$8,150,000**	**$4,620,000**
Ratio to Lowest - Annual O&M	1.00	1.04	1.66	1.08	1.90	1.08
Total Annual Debt Service on Capital Cost	$13,440,000	$13,730,000	$15,030,000	$13,880,000	$15,710,000	$14,000,000
Total Equivalent Annual Cost (Note 3)	**$17,730,000**	**$18,180,000**	**$22,130,000**	**$18,500,000**	**$23,860,000**	**$18,620,000**
Ratio to Lowest - Equivalent Annual Cost	1.00	1.03	1.25	1.04	1.35	1.05
EAC per thousand gallons of disposal capacity	$14.50	$14.87	$18.10	$15.13	$19.51	$15.23

Notes:

1) Costs are presented in current dollars based on Engineering News Record Construction Cost Index 11228 (April 2019).
2) Refer to Appendix A for supporting information.
3) Equivalent Annual Cost equals Annual O&M Cost plus the Annual Debt Service on Capital Cost.
4) Allocation for Conveyance is 100% to each town. Allocation for treatment/transport/disposal is pro-rated based on flow capacity requested.
5) Blue indicates lowest cost option, green indicates second lowest cost option and orange indicates third lowest cost option.

2.9.2 Planning-Level Operation and Maintenance Costs

Annual operation and maintenance (O&M) costs were developed for each plan for the purposes of comparison among the plans. These planning-level O&M costs were developed using the anticipated wastewater flow rates for each plan. Unit O&M costs were taken from the Barnstable County Cost Report (April 2014). These O&M estimated include the following types of expenses: labor, including fringe benefits; electrical energy for powering pumps and treatment equipment; fuel for building heating and vehicular use; chemicals; disposal of dewatered sludge; laboratory testing and other permit compliance costs; administrative costs such as insurance; and equipment maintenance and replacement.

2.9.3 Equivalent Annual Cost

The “equivalent annual cost" (EAC) is a standard economic tool that allows for the calculation of a single "cost" to represent the combination of capital costs and annual expenses for O&M. The equivalent annual cost is the sum of the annual O&M cost plus the annualized debt service on the capital costs. For the purposes of this study, the present worth has been computed assuming a 2% interest rate and a 20-year loan based on presumed DEP CWSRF (Clean Water State Revolving Fund) loan financing.

2.9.4 Considerations for Composite Alternatives

- This analysis represents a complex matrix of alternatives and considerations. There may be other combinations of composite alternatives which are determined to be of interest based on this analysis.
- Each alternative represents a scenario that requires a number of technical, political, permitting, and logistical matters to fall into place.
- Laboratory testing should be conducted for a suite of primary and secondary drinking water parameters on the existing WWTF effluent in order to better assess implications to RO treatment through-put and reject water production.
- Pilot testing should be completed on WWTF effluent with potential MBR and RO treatment processes to better assess sizing implications for this project.

- Each alternative includes two new forcemains plus the existing forcemain to the disposal locations (i.e., 3 total forcemains). The reasons for this include increased operational flexibility and redundancy and decreased capital cost for mid-term phasing. This approach could be modified to reduce the long-term capital costs. For example, for Alternatives 1, 2, 4, and 6, a single large effluent forcemain could be installed (i.e., 2 total forcemains) which would save approximately $16M but reduce piping redundancy and would increase the mid-term costs.
- The costs associated with "transport-to-disposal" are significant due to the distance from the WWTF site. Based on a review of Figure 2-2 (Zone II and Contamination Plumes) and Figure 2-3 (MEP Watersheds and TMDL Status), it does not appear that additional RIB sites or wick sites near the existing effluent forcemain would be feasible or recommended until the Canal South watershed is reached, which is approximately 60% of the distance to the existing RIB location and which is within the Reserve/Northern Training Area.
- By selecting disposal sites closer to the WWTF via the use of deep well injection, the transport-to-disposal cost is significantly reduced; however, this savings is more than offset by the additional cost and complexity of the treatment processes required.
- The deep well injection alternatives use RO treatment to achieve the stringent DEP standard related to TOC removal. It may be possible to implement a granular activated carbon (GAC) filtration process but it would likely require changes in the DEP regulations following a detailed pilot testing protocol. A GAC filtration approach would lower the capital, annual O&M, and equivalent annual cost for deep well injection.
- Assuming the towns have relatively few effluent disposal sites which are outside of nitrogen-sensitive MEP watersheds, then the use of the JBCC wastewater facilities will save the towns costs associated with additional sewering required to offset effluent disposal within a nitrogen sensitive area.
- Alternative 1 (New WWTF with RIBs) is the lowest cost alternative for long-term and mid-term conditions. The cost premium associated with Alternatives 2, 4 and 6 are relatively small (i.e., less than 5%) for the long-term (refer to the "ratio rows" in Table 2-5). For this level of analysis, it is reasonable to consider Alternatives 1, 2, 4, and 6 as equivalent from a cost perspective. Alternatives 3 and 5 are considerably higher cost.
- Costs associated with phased implementation have not been considered. These costs will be considered for the recommended plan.

2.9.5 Evaluative Criteria

This section of the report describes the evaluative criteria that were used for this project and resulting ratings. Each alternative was rated as “advantageous,” “neutral,” or “disadvantageous” for each of the evaluative criteria. Each criterion and the basis for the rating is summarized below.

- Capital cost: This is an objective measure and is the planning-level cost for the project, including technical services and contingency. “Advantageous” is indicated for the lowest cost alternative and any alternatives within 5% of the lowest cost. “Neutral” is indicated for other alternatives that are between 5% and 10% higher than the lowest cost alternative. “Disadvantageous” is indicated for alternatives that are 10% or more higher than the lowest cost alternative.
- Equivalent annual cost: This is an objective measure and is the planning-level equivalent annual cost for the project, including debt service on the capital cost and the annual O&M costs. “Advantageous” is indicated for the lowest cost alternative and any alternatives within 5% of the lowest cost. “Neutral” is indicated for other alternatives that are between 5% and10% higher than the lowest cost alternative. “Disadvantageous” is indicated for alternatives that are 10% or more higher than the lowest cost alternative.
- Technical viability: This is a subjective measure of viability. “Advantageous” is indicated for alternatives approved and in use in Massachusetts.
- Land area required: This is an objective/relative measure and represents total land area needed outside of the Cantonment for treatment and disposal.
- Availability of required land: This is a subjective measure and represents the ease with which land can be obtained. “Advantageous” is indicated for land within the Cantonment or the site currently “owned” by the 102nd ANG. “Neutral” is indicated for land in the Reserve/Northern Training Area. “Disadvantageous” is indicated for land owned by Federal agencies or the public.
- Permitting challenges: This is a subjective measure and represents the effort associated with obtaining the necessary regulatory permits. “Advantageous” is indicated for approaches currently approved in Massachusetts (RIBs and wicks). “Neutral” is indicated for approaches used elsewhere in Massachusetts but with significant technical hurdles at this location. “Disadvantageous” is indicated for approaches not currently approved in Massachusetts.

- Time required for implementation: This is a subjective measure and represents the time necessary to secure land and permits. This is a measure of availability of necessary land (ANL) and permitting challenges (PC). "Advantageous" is indicated only if ANL and PC are both advantageous. "Disadvantageous" is indicated if ANL and PC are both disadvantageous. "Neutral" is indicated for all others.
- Regulatory requirements/short-term: This is a subjective measure and represents the immediate/short-term regulatory framework. "Advantageous" is indicated for groundwater discharges outside of Zone II and with soil aquifer treatment in the unsaturated zone. "Neutral" is indicated for all others.
- Regulatory requirements/long-term: This is a subjective measure and represents the potential for additional effluent treatment parameters in the long-term. "Advantageous" is indicated for land-based discharges to the unsaturated zone and outside of Zone II. "Neutral" is indicated for surface water discharges and land-based discharges into the saturated.
- Operational flexibility: This is a subjective measure and represents the how much flexibility and redundancy is built into the treatment and disposal processes. All alternatives are intended to provide the same relative flexibility and redundancy.
- Operational complexity: This is an objective measure and represents the complexity of the overall treatment and disposal schematic. "Advantageous" is indicated for alternatives with no additional unit processes/disposal types. "Neutral" is indicated for alternatives with one or two additional unit processes/disposal types. "Disadvantageous" is indicated for alternatives with three or more additional unit processes/disposal types.
- Expandability: This is a subjective/relative measure and represents the ability of the alternative to be expanded in the future. "Disadvantageous" is indicated for RIBs because of the relatively large land footprint required for additional disposal capacity. "Neutral" is indicated for all other alternatives.
- Public perception: This is a subjective measure and represents the perception of the general public on the various alternatives. "Advantageous" is indicated for alternatives that would have no or very limited public profile. "Neutral" is indicated for alternatives that impact surface water. "Disadvantageous" is indicated for alternatives that impact drinking water.
- Non-Governmental Organization (NGO) perception: This is a subjective measure and represents the perception of non-governmental organizations on the various alternatives.

"Advantageous" is indicated for no or very limited public profile. "Disadvantageous" is indicated for alternatives that impact surface water or drinking water.

- Sustainability/ groundwater supply: This is an objective measure based on whether the alternative recharges the drinking water supply. "Advantageous" is indicated for alternatives that do recharge the Zone II. "Disadvantageous" is indicated for alternatives that do not.
- Sustainability/ chemical use: This is an objective measure and represents whether chemical use will increase. "Advantageous" is indicated for alternatives that do not increase chemical use. "Neutral" is indicated for alternatives that add one chemical process. "Disadvantageous" is indicated for alternatives that add two or more chemical processes.
- Sustainability/ greenhouse gas emissions: This is a subjective/relative measure and represents the increase in energy use. "Advantageous" is indicated for alternatives that are substantially the same energy use. "Neutral" is indicated for alternatives that have a minor increase in energy use. "Disadvantageous" is indicated for alternatives that have a significant increase in energy use.

A summary of the evaluative criteria is presented in Table 2-6 and indicates the following:

- 1 – New WWTF with RIBs has the most Advantageous (10) and least Neutral (3) scores.
- 2 – New WWTF with RIB/Wick has the most "Advantageous plus Neutral" (16) and the least Disadvantageous (1) scores.
- 3 – New WWTF with RIB/DWI is tied for the most Disadvantageous (8) scores.
- Alternative 4 – New WWTF with RIB/Outfall has the second highest "Advantageous plus Neutral" (14) scores.
- 5 – New WWTF with DWI is tied for the most Disadvantageous (8) scores.
- 6 – New WWTF with Outfall has the third highest "Advantageous plus Neutral" (13) scores.

This matrix of alternatives identifies four alternatives with essentially equivalent costs (with the RIB alternative being the lowest cost) and two alternatives with higher costs (both alternatives being DWI). All of these alternatives each have fairly challenging hurdles related to permitting, public perception, non-governmental organization perception, or all three.

TABLE 2-6: SUMMARY OF EVALUATIVE CRITERIA

Criteria A = Advantageous; N = Neutral; D = Disadvantageous	**1** **RIB**	**2** **RIB/Wick**	**3** **RIB/DWI**	**4** **RIB/Outfall**	**5** **DWI**	**6** **Outfall**
Capital Cost	A	A	D	A	D	A
Equivalent Annual Cost	A	A	D	A	D	A
Technical Viability	A	N	N	N	N	N
Land Area Required	D	A	A	N	A	N
Availability of Necessary Land	D	N	A	D	A	D
Permitting Challenges	N	N	D	N	D	N
Time Required for Implementation	N	N	N	N	N	N
Regulatory/ Short-Term	A	A	N	N	N	N
Regulatory/ Long-Term	A	A	N	N	N	N
Operational Flexibility	N	N	N	N	N	N
Operational Complexity	A	N	D	N	D	N
Expandability	D	N	N	A	N	A
Public Perception	A	A	D	N	D	D
Non-Governmental Organization Perception	A	A	D	D	D	D
Sustainability/ Groundwater Supply	D	D	A	D	A	D
Sustainability/ Chemical Use	A	N	D	A	D	A
Sustainability/ Greenhouse Gas Emissions	A	N	D	A	D	A
Number of Advantageous Ratings	**10**	**7**	**3**	**5**	**3**	**5**
Number of Neutral Ratings	**3**	**9**	**6**	**9**	**6**	**8**
Number of Disadvantageous Ratings	**4**	**1**	**8**	**3**	**8**	**4**
Number of Advantageous and Neutral Ratings	**13**	**16**	**9**	**14**	**9**	**13**

2.9.6 Cost Breakdown by Phase

The cost breakdown is based on Alternative 6 (Outfall) because it is the most conservative (i.e., most expensive) of the four composite alternatives that have relatively equivalent cost (i.e., Alternatives 1, 2, 4 and 6). Cost breakdown is provided as follows:

- Short-Term Costs – These costs consist of the items identified in Section 1.4 of this report as well as the conveyance costs for Bourne ISWM WWTF and Mashpee sewage.
- Long-Term Costs – These costs consist of the remainder of the treatment, transport to disposal and disposal costs necessary to provide the requested capacity for the "study basis" flows.

The cost breakdown by phase is presented in Table 2-7. Additional information is provided in Appendix A.

2.9.7 Cost Allocation Among Participants

Costs for the various wastewater system components were allocated in the following ways:

- Conveyance – Costs were attributed to the individual towns, except where new or rehabilitated infrastructure is shared and except for baseline inflow removal at JBCC. When shared, the costs are split on a pro-rata flow basis among affected individual towns. Inflow removal costs associated with the existing system are the responsibility of JBCC. Conveyance costs include the cost of the lift station to convey flow to the JBCC system.
- Treatment – Costs were attributed to the individual towns and JBCC on a pro-rata flow basis, in accordance with the requested sewage treatment capacity indicated in Section 1.
- Transport and Disposal – Costs were attributed to the individual towns and JBCC on a pro-rata flow basis, in accordance with the requested effluent disposal capacity indicated in Section 1.
- Contingency/Technical/Legal/Administration/Finance – Costs were attributed to the individual towns and JBCC pro-rata based on the subtotal of the construction costs.

The percentage of total effluent flow by phase is presented in Table 2-8. These percentages are used to allocate O&M costs. The basis for allocation of capital costs is presented in Table 2-9. This allocation was used for the mid-term and long-term conditions. The allocations of capital cost, annual O&M, and equivalent cost are presented in Tables 2-10, 2-11 and 2-12, respectively.

TABLE 2-7: CAPITAL COST BY PHASE (ENR CCI 11228, April 2019)

	Short-Term	Long-Term Upper Cape Towns	Long-Term Upper Cape Towns plus Barnstable
Conveyance	$3.6M	$29.0M	$56.7M
Treatment	$1.9M	$41.3M	$61.7M
Transport	$0.3M	$24.0M	$26.9M
Disposal	$0.4M	$13.4M	$14.8M
Contingency, Technical, Legal, Admin., Finance	$2.7M	$46.3M	$68.9M
Total	$8.9M	$154.0M	$229.0M

Note:
1) For the illustrative purposes, costs are allocated pro-rata based on flow, as described in Section 2.9.7.

TABLE 2-8: PERCENTAGE OF TOTAL EFFLUENT FLOW BY PHASE

	Short-Term	Long-Term Upper Cape Towns	Long-Term Upper Cape Towns plus Barnstable
JBCC	33%	4%	3%
Bourne	22%	34%	25%
Falmouth	0%	45%	33%
Mashpee	45%	6%	4%
Sandwich	0%	11%	8%
Barnstable	0%	0%	27%
Total	100%	100%	100%

TABLE 2-9: BASIS FOR CAPITAL COST ALLOCATION (LONG-TERM FLOW)

	% of Total Upper Cape Towns		% of Total Upper Cape Towns plus Barnstable	
	Treatment	Transport/ Disposal	Treatment	Transport/ Disposal
JBCC	12%	4%	6%	3%
Bourne	39%	34%	19%	25%
Falmouth	2%	45%	1%	33%
Mashpee	17%	6%	8%	4%
Sandwich	29%	11%	15%	8%
Barnstable	0%	0%	50%	27%
Total	100%	100%	100%	100%

TABLE 2-10: CAPITAL COST ALLOCATION (ENR CCI 11228, April 2019)

	Short-Term	Long-Term Upper Cape Towns	Long-Term Upper Cape Towns plus Barnstable
JBCC	$1.5M	$10.8M	$8.7M
Bourne	$1.8M	$54.1M	$45.6M
Falmouth	$0M	$41.5M	$37.0M
Mashpee	$5.6M	$18.4M	$15.5M
Sandwich	$0M	$29.2M	$24.2M
Barnstable	$0M	$0M	$98.0M
Total	$8.9M	$154.0M	$229.0M

Note:
1) For the illustrative purposes, costs are allocated pro-rata based on flow, as described in Section 2.9.7.

TABLE 2-11: ANNUAL O&M ALLOCATION (ENR CCI 11228, April 2019)

	Short-Term	Long-Term Upper Cape Towns	Long-Term Upper Cape Towns plus Barnstable
JBCC	$0.49M	$0.26M	$0.22M
Bourne	$0.33M	$1.14M	$1.02M
Falmouth	$0.00M	$0.74M	$0.79M
Mashpee	$0.66M	$0.36M	$0.30M
Sandwich	$0.00M	$0.62M	$0.52M
Barnstable	$0.00M	$0.00M	$1.77M
Total	$1.48M	$3.12M	$4.62M

Note:
1) For the illustrative purposes, costs are allocated pro-rata based on flow, as described in Section 2.9.7.
2) This table includes asset management, capital improvements and management entity administrative costs associated with the take-over of the existing JBCC wastewater systems.

TABLE 2-12: EQUIV. ANNUAL COST ALLOCATION (ENR CCI 11228, April 2019)

	Short-Term	Long-Term Upper Cape Towns	Long-Term Upper Cape Towns plus Barnstable
JBCC	$0.58M	$0.83M	$0.65M
Bourne	$0.44M	$4.33M	$3.70M
Falmouth	$0.00M	$3.28M	$3.06M
Mashpee	$1.00M	$1.14M	$0.90M
Sandwich	$0.00M	$2.41M	$2.00M
Barnstable	$0.00M	$0.00M	$7.77M
Total	$2.02M	$11.99M	$18.08M

Note:
1) For the illustrative purposes, costs are allocated pro-rata based on flow, as described in Section 2.9.7.
2) Annual debt services on capital costs is calculated based on a CWSRF at 2% interest for 20 years (CRF 16.35).
3) This table includes asset management, capital improvements and management entity administrative costs associated with the take-over of the existing JBCC wastewater systems.

It is important to note that cost allocations per entity will change if not all entities ultimately elect to participate, or if entities elect to participate at higher or lower flow rates than indicated in Section 1 of this report. Cost allocations will also change if different allocation assumptions are utilized.

Based on the equivalent annual cost allocation presented in **Table 2-12**, each town and JBCC would have a reduction in equivalent annual cost if Barnstable were to participate. The amount of the reduction ranges from 21% to 27% for JBCC, Mashpee and Sandwich (sewage users), to 17% for Bourne (sewage and effluent user) to 7% for Falmouth (effluent user). Note that the additional costs for JBCC wastewater system, asset management, capital improvements and management entity administrative cost allowances would need to be allocated among the participants.

2.9.8 Comparison of Costs to Previous Town Planning Documents

This section of the report compares the capital cost allocation to cost estimates prepared as a part of previous planning documents prepared for each entity. This review is described below for each entity. The metric that will be used is "capital cost per thousand gallons of effluent in one year" (i.e., total costs divided by one year of effluent flow). For Alternative 6 (Outfall) in this report, the overall capital cost per thousand gallons of effluent per year is approximately $127 (ENR CCI 11228, April 2019). Additional supporting information is provided in **Appendices A and C**.

JBCC

Currently, JBCC has a small customer base which results in relatively high unit costs for treatment and debt allocation. Bringing additional customers (i.e., other towns) will significantly reduce this cost burden in the short-term, mid-term, and long-term. There is no sewer service expansion for JBCC, so there is no need to calculate or compare the cost metrics. The current operating budget for the JBCC facilities is estimated at approximately $0.59M per year (2019 dollars), as compared to an estimated equivalent annual cost of $0.58M to $0.65M (2019 dollars) as shown on **Table 2-12**. Given that JBCC's existing operating budget does not include any debt service (and the projected herein do include debt service) or any budget for asset management, this shows an economy of scale for JBCC.

Bourne

Bourne completed wastewater planning for the portion of town north of the Cape Cod Canal in 2007 (as noted in Section 1) but has not completed wastewater planning for the portion of town south of the Cape Cod Canal. Using the Phase 1 wastewater flows and planning-level costs from the Bourne Wastewater Management Study (Tighe & Bond, 2007) and adjusting the costs to 2019 dollars, the Bourne WMS indicates a capital cost per thousand gallons of effluent per year at approximately $169. This is 1.27 times Bourne's share of the JBCC SWMS which is $133 in current dollars (see Appendix A). This shows an economy of scale for Bourne.

Falmouth

As a part of this project, Falmouth's wastewater planning consultant (GHD) was retained to develop a comparison of Falmouth costs under previous planning efforts to the Falmouth costs projected as a part of this evaluation. A technical memorandum from GHD is included in Appendix C. In short, the previous planning efforts indicate a capital cost per thousand gallons of effluent per year at approximately $107 to $170 in 2017 dollars (or $111 and $177, respectively, in 2019 dollars). As presented in Appendix C, Falmouth's projected share of the JBCC SWMS is $75 for long-term. The JBCC SWMS is projected to cost Falmouth less in the long-term than it planned in the DCWMP. Regionalization is expected to be a benefit to Falmouth.

Mashpee

As a part of this project, Mashpee's wastewater planning consultant (GHD) was retained to develop a comparison of Mashpee costs under previous planning efforts to the Mashpee costs projected as a part of this evaluation. A technical memorandum from GHD is included in Appendix C. In short, the previous planning efforts indicate a capital cost per thousand gallons of effluent per year at approximately $78 for the recommended plan (i.e., connecting to JBCC with a smaller regional approach) and at approximately $207 for the backup plan (i.e., constructing a WWTF in Mashpee to treat and disposal of the same effluent volume), both in 2017 dollars (or $81 and $215, respectively, in 2019 dollars). As presented in Appendix A, Mashpee's projected share of the JBCC SWMS is $77 in the short-term and $229 in the long-term. The JBCC SWMS is projected to cost Mashpee slightly less in the short-term than was anticipated in the WNMP and slightly more in the long-term than was anticipated in the WNMP; however, even at a higher cost, participating in a regional solution at JBCC is projected to cost less than Mashpee providing equivalent facilities on its own (i.e., working separately under the "backup plan").

Sandwich

Sandwich completed town-wide wastewater planning in 2017. The Sandwich plan calls for two WWTFs, one near the Cape Cod Canal and one near the Sandwich Industrial Park. Using the wastewater flows and planning-level costs from the Sandwich draft Comprehensive Water Resources Management Plan (Wright-Pierce, 2017) and adjusting the costs to 2019 dollars, the Sandwich CWRMP indicates a capital cost per thousand gallons of effluent per year at approximately $298. This is 1.30 times than Sandwich's share of the JBCC SWMS which is $229 in current dollars (see Appendix A). This shows a strong economy of scale for Sandwich.

Summary

As described on the previous pages, a regional approach appears to be generally favorable for the communities and JBCC and warrants continued consideration. A summary of the cost comparisons described on the previous pages is presented below in the units of "capital cost per thousand gallons of effluent capacity per year."

ENR CCI 11228 (April 2019)	**JBCC Shared Wastewater Management Study**	**Previous Planning Documents**
Bourne (sewage)	$133 (LT)	$169 (LT)
Bourne (leachate)	-	No information received
Falmouth	$75 (LT)	$111 to $177 (LT)
Mashpee	$77 (ST) to $229 (LT)	$81 (RP LT) to $215 (BP LT)
Sandwich	$229 (LT)	$298 (LT)

1. Refer to Appendix A for additional details regarding Bourne and Sandwich.
2. Refer to Appendix C for additional details regarding Falmouth and Mashpee.
3. Cost metrics are based on April 2019 dollars (ENR CCI 11228).

It is important to note that these cost estimates are based on numerous key assumptions as described in this report, specifically including: the number of participants identified in **Section 1.6**; the capacity requests and timing of flows identified in **Section 1.6**; the phasing approach described in **Section 2.8**; and the loan financing terms identified in **Section 2.9**. Changes in these assumptions will result in adjustments to costs and cost allocations and may result in changes in cost comparisons. As more detailed cost information becomes available, these cost allocation comparisons should be refined.

2.10 SUMMARY OF SENSITIVITY ANALYSES

Sensitivity analyses were developed for two scenarios:

- Costs with Granular Activated Carbon (GAC) treatment instead of Reverse Osmosis (RO) treatment for Deep Well Injection (DWI) alternatives
- Costs for one new effluent forcemain instead of two new effluent forcemains.

The analyses were conducted by starting with the original cost model developed for the "base case," as presented in the 2017 Report, and modifying it to address the key differences associated with each of the three scenarios. Key assumptions and conclusions are summarized below for each of the sensitivity analysis scenarios. The results of the sensitivity analysis are presented in **Table 2-13**.

TABLE 2-13: CAPITAL COST SENSITIVITY ANALYSIS (ENR CCI 11228, April 2019)

	Base Case Upper Cape Towns Alternative 6	Scenario 1 Upper Cape Towns Alternative 3 with GAC Treatment	Scenario 2 Upper Cape Towns Alternative 6 with One Forcemain
JBCC	$10.8M	-	$10.6M
Bourne	$54.1M	-	$52.6M
Falmouth	$41.5M	-	$39.6M
Mashpee	$18.4M	-	$18.2M
Sandwich	$29.2M	-	$28.8M
Barnstable	Not Included	-	Not Included
Total	$154.0M	**$155.4M**	**$149.8M**

Note:
1) For the illustrative purposes, costs are allocated pro-rata based on flow, as described in Section 2.9.7.

Scenario 1 – Costs for GAC Treatment for DWI Alternatives

Key assumptions:

- Provide granular activated carbon treatment system (instead of reverse osmosis treatment). The capital cost and operating cost were reduced from the reverse osmosis alternative. The frequency of replacement of granular activated carbon will be a function of the amount of total organic carbon in the effluent, which would need to be confirmed via pilot testing. The annual operation and maintenance cost of this alternative is sensitive to this assumption. This scenario is applicable to Alternative 3 (RIB and DWI) and Alternative 5 (DWI only).

Conclusions:

- Based on the assumptions noted above, this scenario reduces the capital cost associated with the deep well injection alternatives (Alternatives 3 and 5) by approximately $7M to $9M (approximately 5% reduction) and the equivalent annual cost by approximately $800,000 to $1,000,000 per year (approximately 6% reduction).

- Alternative 3/Scenario 1 and Alternative 5/Scenario 1 continue to represent a significant cost premium over the "Candidate Plan"; however, there is a lesser premium than under the Base Case. Since the costs for Scenario 1 exceed the costs for the Candidate Plan, no cost allocation is provided for this Scenario.
- As shown on **Table 2-13**, the total difference between Alternative 6 (base case) and Alternative 3/ Scenario 1 is approximately 1%. It is important to note that the treatment cost is remains significantly higher and the transport to disposal cost remains significantly lower in Alternative 3/ Scenario 1 (refer to Table 2-5 for additional information).

Scenario 2 – Costs for One New Effluent Forcemain

Key assumptions:

- For the Upper Cape towns, provide one new 24" diameter forcemain (instead of two new 18" diameter forcemains) to the disposal locations. For the Upper Cape towns plus Barnstable flows, provide one new 30" diameter forcemain (instead of two new 20" diameter forcemains). For the purposes of this sensitivity analysis, these cost reductions for the Upper Cape towns with and without Barnstable are considered equivalent.

Observation:

- Another alternative that has been identified, but was not costed out, is an alternate alignment for a portion of the forcemain route to avoid the highest grade elevations and save pumping cost and pipe diameter. This would involve running the forcemain west from Frank Perkins Road along Snake Pond Road and then north along the power easement to the RIB site. See inset figure (orange is the existing forcemain alignment and purple is the alternate forcemain alignment).

Conclusion:

- Based on the assumptions noted above, this scenario reduces the capital cost associated with each alternative by approximately $4.2M for the Candidate Plan (approximately 3% reduction). Given the level of redundancy that the additional pipeline provides for this very long forcemain, it would be appropriate to be carefully consider the advantages/disadvantages and cost-benefit of this scenario.

2.11 PRELIMINARY CONCLUSIONS

Based on our evaluations, we offer the following conclusions regarding the potential for expanding the JBCC wastewater system to serve as a regional facility:

- There is a regional need on the Upper Cape for wastewater treatment and disposal facilities (short-term, mid-term, and long-term).
- Regionalizing the JBCC wastewater system provides economies of scale and provides apparent cost savings to the potential participating communities (based on capacity requests described herein).
- From a technical perspective, the advantages of regionalizing the JBCC wastewater system exceed the disadvantages. The municipalities will need to evaluate the advantages and disadvantages from political and policy perspectives.
- Six composite alternatives were identified to provide regional facilities for wastewater treatment of the capacities requested by each municipality and JBCC. The composite alternatives are differentiated primarily by the effluent disposal method that is utilized.
  - Four of the six composite alternatives have essentially equal costs and collectively represent the lowest cost alternatives. These four composite alternatives are Rapid Infiltration Basins (Alternative 1), Rapid Infiltration Basins plus Wicks (Alternative 2), Rapid Infiltration Basins plus a Cape Cod Canal Outfall (Alternative 4), and a Cape Cod Canal Outfall (Alternative 6).
  - The SWMS Group should advance discussions with regulators and stakeholders regarding additional effluent disposal via land-based and/or surface water discharge.

  - Disposal via deep well injection should be reserved for potential future use.
- Each of the effluent disposal alternatives described herein is allowed under Massachusetts law and regulation; however, each of the disposal alternatives has site-specific challenges related securing permit approvals. These challenges are related to both technical factors and public perception. These challenges should be explored with DEP and EPA as a part of continued planning efforts.
- The cost allocation methodology presented herein is a flow-based allocation model. Other methods of cost allocation could be developed. If some communities choose not to participate, now or later, the capital costs and the cost allocation will change.
- As more detailed cost information becomes available, these cost allocation comparisons should be updated and refined.

Based on our evaluations and based on the input of all participants, there are sufficient advantages to the participating municipalities and to JBCC to warrant continued planning efforts.

SECTION 3

MANAGEMENT AND POLICY ISSUES

3.1 MANAGEMENT ENTITY

3.1.1 Duties of the Management Entity

A publicly owned treatment works requires a management entity which must be able to fulfill the following common functions:

- **Planning.** Quantifying wastewater management needs; estimating wastewater flows; determining the necessary level of treatment; evaluating options for collection, treatment, and disposal; identifying and evaluating sites; estimating project costs; and obtaining public input.
- **Land Acquisition.** Obtaining fee simple interest or easement rights for land for collection, treatment, and disposal functions.
- **Permitting.** Obtaining all the permits and regulatory approvals to allow the proposed wastewater facilities to be built and operated.
- **Design.** Selecting and contracting with design professionals to prepare plans and specifications for the facilities to be built.
- **Construction.** Bidding and issuing contracts for the construction of wastewater facilities and overseeing the construction of those facilities.
- **Operation.** Operating and maintaining the wastewater facilities including periodic replacement of failed equipment.
- **Managing/Allocating Capacity.** Managing and allocating available capacity including securing appropriate capital commitments to reserve capacity and to support the necessary infrastructure upgrades.
- **Monitoring.** Monitoring the performance of the wastewater facilities, reviewing the performance of the wastewater facilities against the permit requirements and conditions, and taking appropriate action in the event of noncompliance.

- **Funding.** Incurring debt to construct facilities, incurring cost to operate the facilities, collecting revenue to pay the debt and operating costs, and accepting grant funds which may become available are separate but related functions of the management entity.

Each of the necessary functions should be accomplished without undue cost or complexity.

3.1.2 Potential Management Entity Approaches

Several potential management entity approaches have been identified for the participants to consider, as follows:

- **Single Host Town with Customer Agreements.** Ownership of the JBCC wastewater system could be transferred to one of the five towns, which in turn could enter into customer agreements with the other towns and the JBCC sewer users. This could make sense if one of the towns had the desire to undertake this significant responsibility. There may also be legal issues to address related to the fact that the WWTF is located in Sandwich and the effluent disposal system is located in Bourne.
- **Creation of a New Special Purpose District.** This approach would require an act of the Legislature to create a new special purpose district. This new district would presumably be established with a governing board representing each of the towns and JBCC. A new special purpose district seems to have significant merit because several towns may benefit from a regional facility, and the JBCC infrastructure is centrally located with respect to Bourne, Falmouth, Mashpee, and Sandwich. A new special purpose district would require a number of implementation steps related to establishing a charter, hiring staff, securing office space, developing billing protocols, etc.
- **Modification of an Existing Special Purpose District.** This approach would modify the charter of an existing special purpose to undertake ownership responsibilities for the existing JBCC wastewater systems. A logical example of this approach is the Upper Cape Regional Water Supply Cooperative (UCRWSC), which was established by an act of the Massachusetts Legislature in 2000 and is governed by a Board of Managers with representatives from the Bourne Water District, Town of Falmouth, Sandwich Water District, and Mashpee Water

District. This approach may be less logistically and administratively challenging than to create a new special purpose district.

- **Creation of a Joint Powers Agreement.** This approach would involve crafting a multi-town agreement pursuant to the authority of Massachusetts General Laws Chapter 40, Section 4A-1/2. A joint powers agreement (JPA) would establish a "joint powers entity" that would have the authorities and responsibilities outlined in Section 3.1.1 and would commit the towns together to own and operate the shared facilities. Town meeting approval is not required to enter into a JPA. This approach would establish a Board of Directors with membership from each participating town. This topic was discussed at a project meeting attended by the participating towns and a municipal law attorney. It was discussed and agreed that, in order for the entity to function properly, the financial obligations under a JPA for shared wastewater management could not be subject to appropriation (e.g., operating costs allocated to towns could not be subject to a town meeting appropriation, etc.). For this reason, Bourne, Falmouth, Mashpee, and Sandwich all agreed that, given the nature of the commitment, they would want to take a draft JPA to the voters for approval prior to entering into such an agreement.
- **Quasi-State Agency Serving as an Initial Management Entity.** MassDevelopment was in discussions with the Air Force and the Massachusetts Air National Guard for several years regarding potentially acquiring ownership of the JBCC water and wastewater systems. MassDevelopment has successfully implemented a similar arrangement in Devens, Massachusetts (formerly Fort Devens). As of the date of this report, MassDevelopment has decided that it cannot fulfill this role.

3.1.3 Evaluative Criteria

Each of the management options described above has advantages and disadvantages which can be identified by considering the following evaluative criteria:

- **Ease in implementation**. If a new management structure is difficult to implement, there is less chance of success and higher cost to bring it to fruition.
- **Political acceptability.** The status quo would constitute an impediment to a new entity.
- **First costs to implement.** The ideal option would carry low costs for formation. It would also use existing public employees wherever possible.

- **Potential for long-term cost savings**. The more functions that can be handled regionally, the greater the potential for savings due to economies of scale.
- **Ability to raise money**. The principal means of financing wastewater projects has traditionally been through property taxation and betterment assessments. An effective entity should have access to funds through both means, and others if possible.
- **Loss of local control.** A regional entity will suffer from a real or perceived loss of local control. To the extent that decisions impacting cost, growth and environmental quality are made by someone other than the towns (and town meetings), there could be some opposition.
- **Ability to obtain grants and loans.** A regional entity would need to be carefully established such that the entity would be eligible for grants and loans for environmental infrastructure.

These criteria cover a broad range of issues. Individual towns or interest groups may have other criteria to add to this list, and may place differing emphasis on these criteria.

3.1.4 Ownership of Wastewater System Components

The management entity will need to consider the geographic boundaries of the service area. The Towns will have shared facilities as well as individually owned and operated facilities. The table below shows the suggested management entity approaches for the components of the wastewater facilities. These components are also depicted schematically on Figure 2-5A. Refer to Section 5 for identification of likely easement requirements.

TABLE 3-1: SUGGESTED OWNERSHIP TYPE BY SYSTEM COMPONENT

System Component	Suggested Ownership
Wastewater Collection	Town
Wastewater Conveyance	Town, JPA, or SPD
Wastewater Treatment	JPA or SPD
Effluent Transport to Disposal	JPA or SPD
Effluent Disposal	JPA or SPD
JPA = joint powers agreement; SPD = special purpose district	

3.1.5 Selection of Management Entity Approach

Given the options and factors described above, the formation of a new (or modified) special purpose district or the signing of a joint powers agreement would likely provide the most advantages to the customer communities and entities for ownership of the shared facilities. Ultimately, the selection of the management entity approach will require input from technical staff, management staff, elected officials and legal counsel for each participating town as well as JBCC.

3.1.6 Key Factors to Facilitate Ownership Transfer

Ownership transfer of the wastewater facilities (assets) and the necessary rights to access the facilities (land and/or easements) is a complicated process. JBCC has a strong desire to transfer ownership of all wastewater and water facilities at the same time. Since the towns have little to no interest in the water facilities, this JBCC desire adds additional complexity to the process. The following items represent the key factors that will impact the timing of ownership transfer. Focusing on these factors will facilitate the decision-making process.

- **Timing of Facilities Transfer.** JBCC has indicated a strong desire to transfer ownership of all water and wastewater facilities in the *very near-term*. The Towns have indicated a clear desire to complete additional study in order to determine the value and cost-effectiveness prior to making a firm decision regarding potentially taking over any facilities. All parties agree that firming up a timeline for decision-making will be beneficial. It is also generally agreed that defining the management entity approach would be beneficial.
- **Scope and Value of Wastewater Facilities Transfer.** The existing JBCC wastewater facilities have some value to some Upper Cape towns under existing conditions. The existing JBCC wastewater facilities have more value to some Upper Cape town if the existing Groundwater Discharge (GWD) permit can be revised to obtain additional capacity. The existing JBCC wastewater facilities have the most value to all the Upper Cape town only with significantly more effluent disposal capacity (i.e., increase from current permitted flow of 0.36-mgd annual average to a future permitted flow of say 3.5-mgd to 5.0-mgd annual average. In the absence of significant additional disposal capacity, the existing facilities have negative value due to a lack of consistent asset management and impending capital improvement needs.

Obtaining significant additional permitted disposal capacity will require concerted input from the participants, the Commonwealth (DEP, State Legislators, Massachusetts Congressional delegation) and the US Air Force/ Air National Guard.

- **Scope and Value of Water Facilities Transfer.** Regional planning for the water facilities is outside the scope of the current Commonwealth Grant funded project; however, the water facilities has similar "value concerns."
- **Facilitating Revenue Generation by Allocating Existing Capacity.** As documented in previous reports regarding JBCC wastewater facilities (Wright-Pierce, 2014; Wright-Pierce, 2017), there is limited existing capacity which is immediately available if certain inter-municipal/inter-governmental hurdles can be overcome. This would require construction of conveyance infrastructure to the JBCC wastewater facilities. This would also require some capital improvements for the JBCC wastewater facilities themselves. The amount of capacity available and the permitting needs vary depending on whether the new flow is treated effluent (e.g., Bourne Integrated Solid Waste Management WWTF effluent or Falmouth Blacksmith Shop Road WWTF effluent) or sewage (e.g., from Mashpee, Sandwich, or Barnstable).

3.1.7 Multi-Step Approach to Inter-Municipal and Inter-Governmental Agreements

This project represents a potential regional approach to address the Upper Cape's wastewater management needs. It is expected that the remaining planning could take several years and may require one or more iterations to the cost model identified herein. It will be important that each participant clearly indicate its intentions to the other participants in order to converge on an acceptable solution. It is anticipated that one or more inter-municipal agreement (IMA) and inter-governmental agreements (IGA) may be necessary in order to implement the project.

- An initial IMA could be used to commit the towns to collaboratively complete planning phase activities (including securing effluent disposal capacity), to confirm capacity commitments, to confirm the cost allocation approach, and to select the management entity. The initial IMA should include all potential participating municipalities.

- An initial IGA could be used to commit one or more towns, the Commonwealth, and JBCC to a multi-step process with a specified timeline to complete evaluations and make determinations on ownership transfer.
- A subsequent IGA or series of IGAs could be used to commit the various military entities to the regulations imposed by the management entity (e.g., flow neutral regulations, sewer use regulations, sewer user charges, capital cost contributions, etc.).
- Subsequent IMA(s) or IGA(s) may be needed depending on the management entity approach that is selected.

3.2 MULTIPLE PERMITTEES FOR EFFLUENT DISCHARGE PERMIT

This evaluation considers regional treatment at the existing or upgraded JBCC WWTF as well as shared disposal facilities for effluent treated at the JBCC WWTF, the Bourne ISWM WWTF and the Falmouth BSR WWTF. While the use of a single effluent disposal system for multiple WWTFs has been done before, it is far from common and requires that EPA and/or DEP consider the following important permitting factors:

- Sources of wastewater to the individual WWTFs (i.e., residential, commercial, industrial, septage, leachate);
- Treatment processes used at the individual WWTFs;
- Average and peak flow rates, jointly and severally;
- Effluent limits, monitoring requirements, and monitoring locations for the individual WWTFs;
- Effluent limits, monitoring requirements, and monitoring locations for the common disposal method;
- Legal and financial assurances for meeting effluent limits and groundwater quality standards; and
- Legal and financial assurance for asset management.

The management entity must have the ability to monitor effluent quality from the individual WWTFs and enforce effluent quality standards, or must have the other individual municipalities named as “co-permittees” on the permit. Discussions with DEP regarding the specifics of how the permit will be written should occur as soon as possible.

3.3 ALLOCATION OF AVAILABLE CAPACITY

In the long-term, each participating entity will secure the desired amount of capacity by committing an appropriate amount of the capital cost to the management entity. In the short-term, there is less capacity available than has been requested. It may be necessary to establish a method to allocate the available capacity until such time as the JBCC wastewater system is upgraded in the mid-term. There are numerous potential methods to allocate capacity. A listing of potential methods is provided below.

- Highest bidder
- Highest environmental benefit
- Quickest environmental benefit
- Highest economic benefit to communities
- Equalize economic benefit to communities
- First-come, first-served or "shovel-ready" projects

Each of these methods has some technical, political, and financial trade-offs that should be discussed among the participants looking for short-term capacity.

3.4 PRE-REQUISITES TO CAPITAL IMPROVEMENTS

The following is a general list of pre-requisites to implementing any capital improvements related to providing capacity to regional participants beyond the existing system users.

- Develop initial IMA and IGA
- Complete planning, including confirming conceptual capacity commitments and developing consensus regarding allocation of capacity in the short-term.
- Confirm the management entity approach
- Establish the new management entity, develop subsequent IMA and IGA (as necessary) and complete the ownership transfer including land and/or easements for existing conveyance, treatment, transport, and disposal
- Obtain increase in existing GWDP capacity (prior to short-term improvements)

- Obtain permit approvals from EPA and/or DEP for the selected disposal alternative (prior to mid-term improvements)
- Develop sewer regulations (all) and flow neutral regulations (towns), including coordination with local Boards of Health
- Develop sewer user charge system
- Develop a specific procurement and financing plan
- Secure commitments for the allocated capital costs, including design and permitting, via town meeting authorizations
- Secure commitments for the O&M rate structure
- Enact any special legislation necessary to implement the selected plan
- Acquire land and/or easements for new conveyance, treatment, transport, and disposal
- Conduct Massachusetts Environmental Policy Act (MEPA) review
- Coordinate with Cape Cod Commission regarding the "208 Plan Update Consistency Review" [Note, the Commission has issued "Guidance on Section 208 Plan Update Consistency Review". The initial management entity would need to facilitate this review in coordination and collaboration with the four towns. The majority of the criteria for the consistency review are geared towards municipal planning by the designated Waste Treatment Management Agency (WMA). A proposed regional use of the JBCC wastewater system for the benefits of municipalities which are addressing water quality needs is consistent with the Commission's recommendations contained in Section 7 of the 208 Plan Update.]
- Complete design and obtain permitting for remainder of the project elements from EPA, DEP, local Town boards (Planning, Conservation, Historic District, etc.)
- Apply for grants and loans.

Figure 3-1 presents key pre-requisite activities by project phase.

FIGURE 3-1: DECISION FLOW CHART BY PROJECT PHASE

Pre-Requisites to Capital Improvements (Year 0 to Year 2)

- Confirm capacity requests and allocation approach
- Confirm management entity
- Complete initial IMA and IGA for continued planning
- Obtain increase in existing GWDP effluent disposal capacity for RIBs
- Obtain expanded effluent disposal capacity
- Complete ownership transfer from JBCC to management entity
- Develop sewer regulations, flow neutral regulations, user charge system and financing plan
- Complete MEPA review for full plan
- Coordinate with CCC for 208 Plan Update Consistency Review
- Apply for grants and loans

Short-Term Improvements (Year 3 to Year 8)

- Complete agreements and funding commitments for new flows
- Obtain permits for wastewater conveyance, treatment, transport and disposal facilities
- Complete design/construction of JBCC short-term improvements
- Complete design/construction of municipal collection and conveyance items and connect customers
- Apply for grants and loans

Mid-Term and Long-Term Improvements (Year 8 to Year 20+)

- Complete agreements and funding commitments for new flows
- Obtain permits for additional wastewater conveyance, treatment, transport and disposal facilities
- Complete design/construction of JBCC long-term improvements
- Complete design/construction of additional municipal collection and conveyance item and connect customers
- Apply for grants and loans

SECTION 4

FURTHER INVESTIGATION OF EFFLUENT DISPOSAL AND FORCEMAIN

Given the importance of effluent disposal capacity and effluent transport capacity to the overall plan, further investigations were conducted on both elements. This section of the report describes those investigations.

4.1 RE-RATING EXISTING RAPID INFILTRATION BEDS

The original DEP groundwater discharge (GWD) permit for the new facilities was issued in February of 1994 and the new facilities began operation about that time. The permitted disposal capacity was increased in 2003 to accommodate the new Barnstable County Jail. The current GWD permit (Permit 41-4) expires in May 2023. The GWD permit allows a maximum-day flow of up to 840,000 gallons per day (gpd) and restricts the annual average flow to 360,000 gpd. Refer to **Section 1.4.6** and **Appendix F** for additional information.

It appears that the existing RIBs are conservatively sized and could potentially be re-rated to allow for a higher permitted flow rate. As a part of this project, a February 15, 2019 memorandum was developed to outline the existing situation and general approach to rerating and a June 10, 2019 memorandum outlines the specific proposed steps for rerating, which consist of: 1) redefining the short term peak flow; 2) segmenting the RIBs so that there is less infiltrative surface required for reserve and more available for active disposal; and 3) increasing the application rate based on field testing and hydrogeologic modeling. These memoranda are included as **Appendix A**.

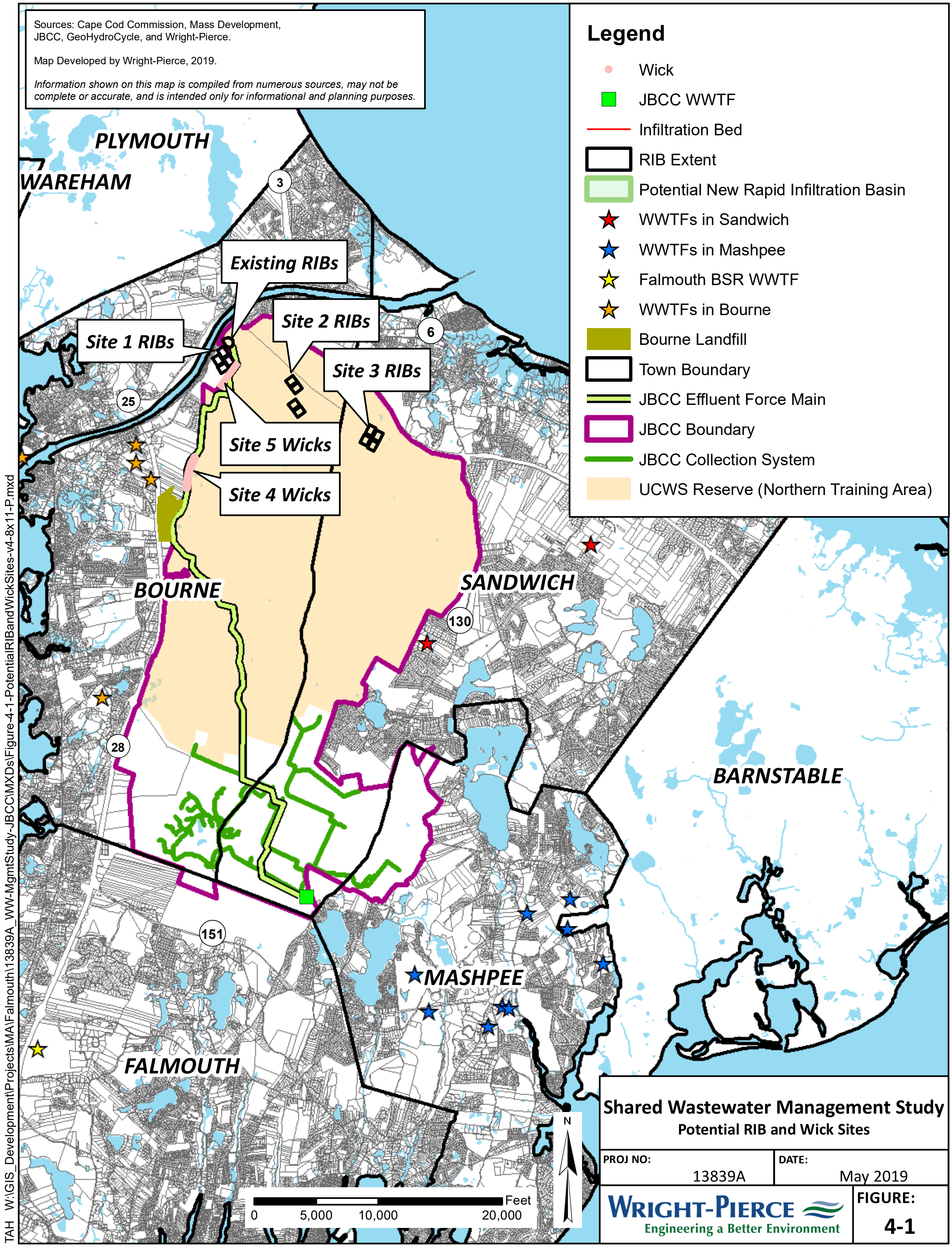
4.2 FUTURE EFFLUENT DISPOSAL PERMITTING

An "Effluent Disposal Workshop" was held at JBCC on May 9, 2019. The workshop was attended by over 24 individuals representing EPA, ACOE, DEP, Massachusetts Coastal Zone Management, Environmental Management Commission, Massachusetts Air National Guard, Massachusetts Army National Guard, Cape Cod Commission, Upper Cape Regional Water Supply Cooperative, Buzzards Bay Coalition, and the Towns of Falmouth, Sandwich, and Barnstable.

During the workshop, the following items were presented:

- Available locations for land-based disposal sites are very limited given the presence of numerous groundwater contamination plumes due to historic military activities, numerous Zone II public water supply protection areas, numerous nitrogen-sensitive watersheds identified by DEP/ Massachusetts Estuaries Project, as well as the Upper Cape Water Supply Reserve overlay.
- Several potential land-based disposal sites and one surface water disposal site were discussed. Site 1 is located on land owned by the Army Corps of Engineers (ACOE). Sites 2, 3, 4, and 5 are on JBCC land within the Upper Cape Water Supply Reserve. These locations are shown on **Figure 4-1** and were selected based on a desktop evaluation to be outside of Zone II water supply protection areas, known contamination plumes, wetlands, and wetlands setbacks. Site 3 was eliminated due to the potential for effluent impacted groundwater to recharge the Shawme Ponds in Sandwich. Site 4 was eliminated due to the potential for effluent impacted groundwater to recharge Great Pond and Deep Bottom Pond in Bourne. A conceptual arrangement for Sites 1 and 5 are shown on **Figure 4-2**.
- One surface water disposal site was discussed in the Cape Cod Canal (Site 6). This location is shown on **Figure 4-3**.
- There is no preferred site location at this time.
- Follow-up discussions are needed with the ACOE, the Environmental Management Commission, DEP, EPA, and interested stakeholders in order to undertake additional study on disposal site locations.

At the conclusion of the meeting, all attendees agreed that there are numerous review processes that need to be undertaken (e.g., ACOE proposed use and acquisition process, Environmental Management Commission proposed use and land acquisition process, Groundwater Discharge permit application, NPDES permit application, etc.), but that there are no apparent insurmountable issues associated with effluent disposal siting and permitting that could be identified. DEP provided a letter indicating their support and confidence in the ability to site effluent disposal capacity sufficient for the regional facility. Refer to **Appendix F** for additional information.



Shared Wastewater Management Study
Potential RIB and Wick Sites

PROJ NO:	DATE:
13839A	May 2019

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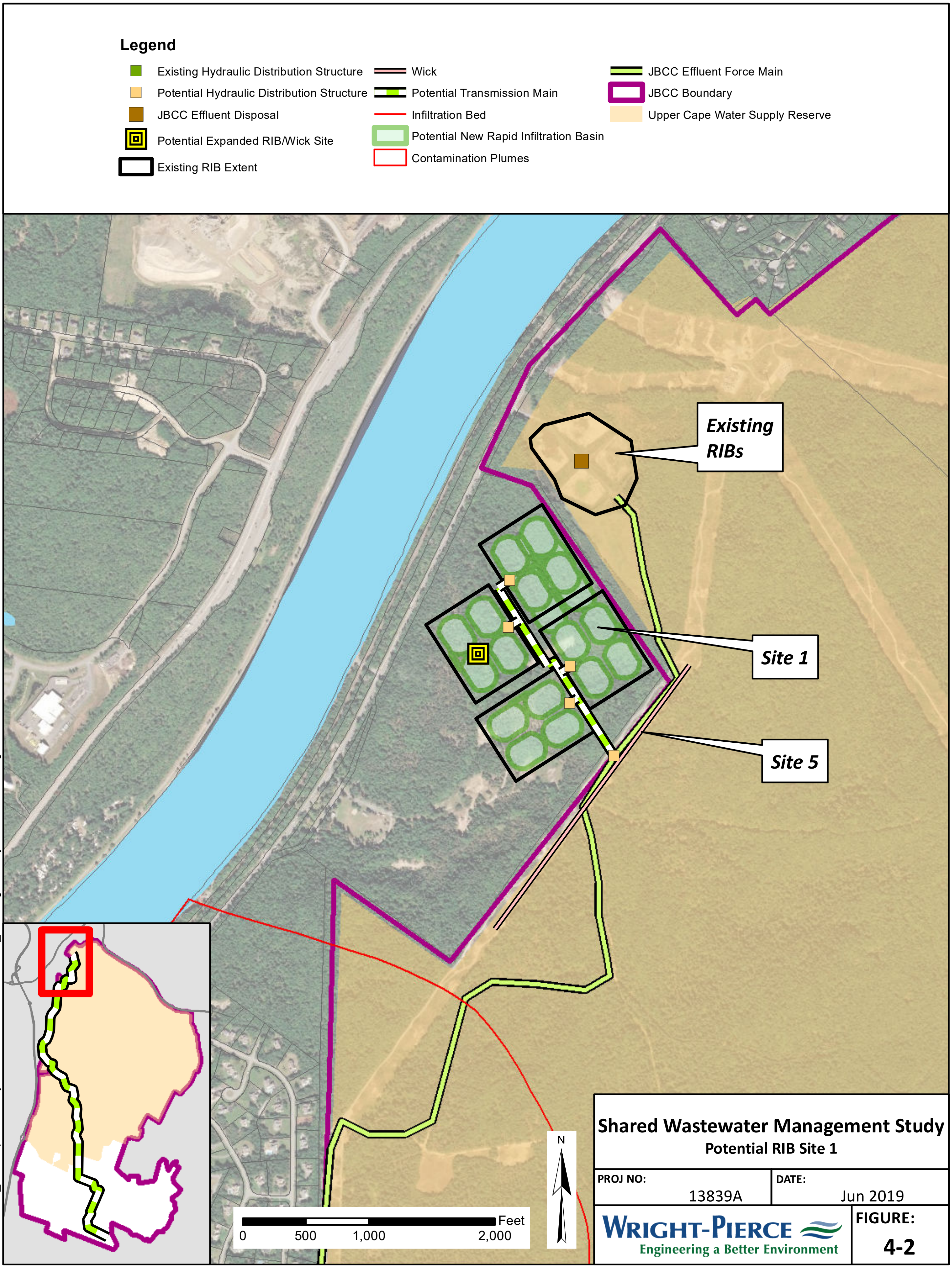
FIGURE: 4-1



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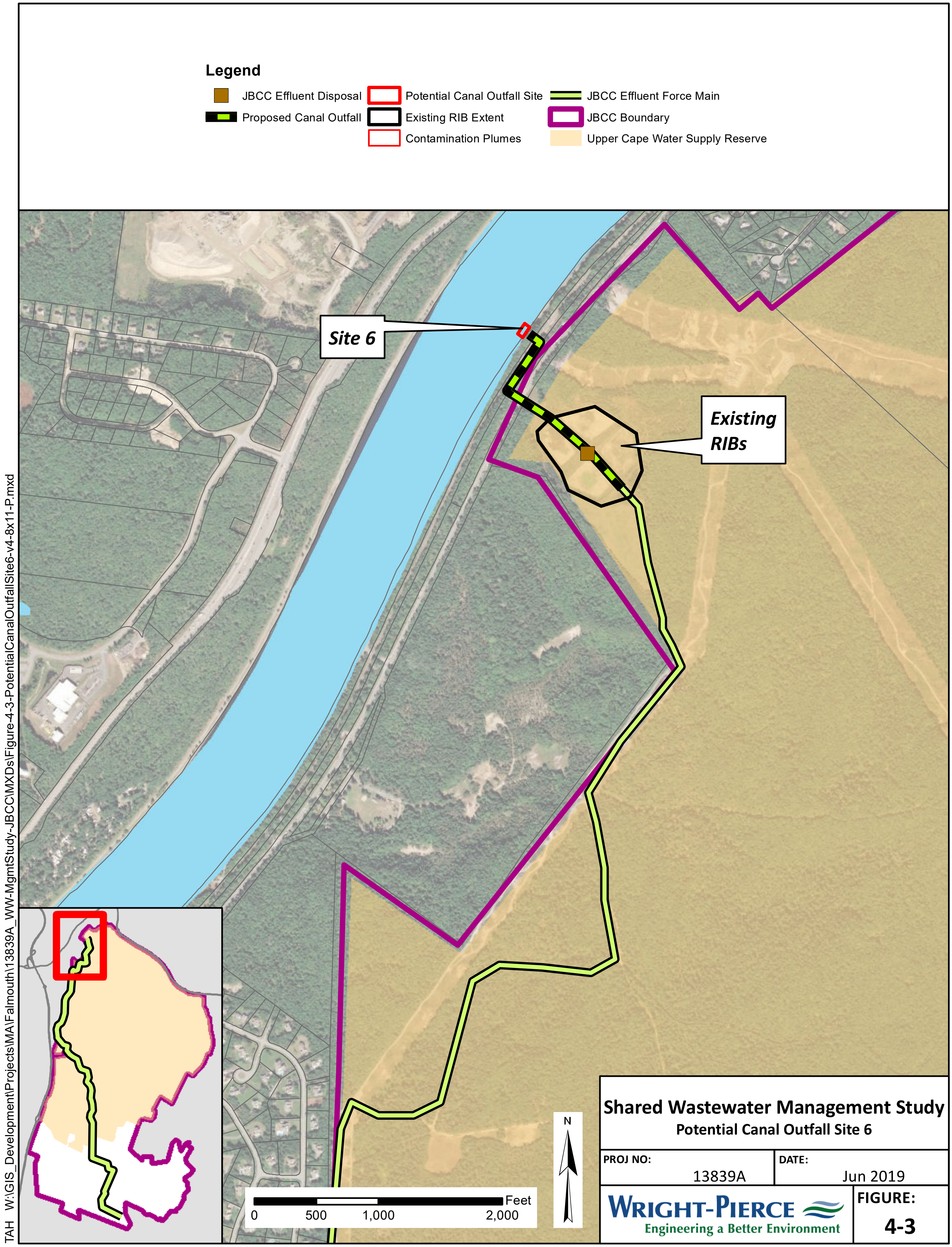


Shared Wastewater Management Study

Potential Canal Outfall Site 6

PROJ NO:	DATE:
13839A	Jun 2019

WRIGHT-PIERCE
Engineering a Better Environment

FIGURE: 4-3

4.3 EXISTING FORCEMAIN HYDRAULIC ISSUES

As noted in Section 1, WWTF operations staff identified capacity limitations to the existing effluent forcemain when two pumps are running. Two potential theories were put forward: 1) hydraulic transients are limiting capacity until steady state conditions can be achieved; and/or 2) solids settling within the 10.6-mile effluent forcemain over the 20-plus years of operation is limiting conveyance capacity between Static Head Manhole No. 1 and Static Head Manhole No. 2. As a part of this project, a hydraulic transient analysis model was developed to assess the theories. The findings of this review are as follows:

- System modeling indicates that settled solids are likely present in the line. This conclusion is probable given the relatively low system flows and the relatively long forcemain. This can be remedied by a maintenance procedure referred to as “pigging the line.” Concerns with a “pig” getting stuck in the forcemain can be mitigated through the use of “ice pigs” for the reach between the effluent lift station and Static Head Manhole No. 2. Water flushing could also be used, but would require maintaining pipeline scour velocities in the pipeline long enough to move any collected solids the full length of the main.
- If pigging or line flushing cannot be accomplished, Static Head Manhole No. 2 could be converted to a pressure manhole with a controlled venting/ vacuum relief valve mounted to the cover. Since Static Head Manhole No. 2 is located in Frank Perkins Road, this would require the slight relocation of the manhole or the road.
- If the effluent lift station pumps were upgraded, the existing forcemain could likely be increased (from 950 gpm) to 1,100 gpm to 1,450 gpm on a peak-rate basis. This would require additional analysis during the design phase to correctly size the piping, air release valves, vacuum relief valves, and surge tank settings. This would also require that the solids deposition issue described above be addressed.

The technical report prepared on this topic is included as **Appendix D**.

4.4 RARE SPECIES DUE DILIGENCE

In order to better assess the viability of significantly expanded effluent disposal, a rare species due diligence review was conducted for the northern portion of the Reserve as well as for the Cape Cod Canal. The findings of this review are as follows:

- There are numerous state-listed species (special concern, threatened, and endangered) and several federal-listed species (threatened and endangered) in the project area.
- Additional due diligence is recommended once conceptual site plans have been established to refine the species of concern and the anticipated permitting requirements.
- Early coordination with the Massachusetts Natural Heritage and Endangered Species Program (NHESP), Massachusetts Coastal Zone Management (CZM), and US Fish and Wildlife Service (FWS) is strongly recommended in order to refine the required permitting requirements.

The technical memorandum prepared on this topic is included as Appendix E.

SECTION 5

PERMITTING, APPROVALS AND FUNDING

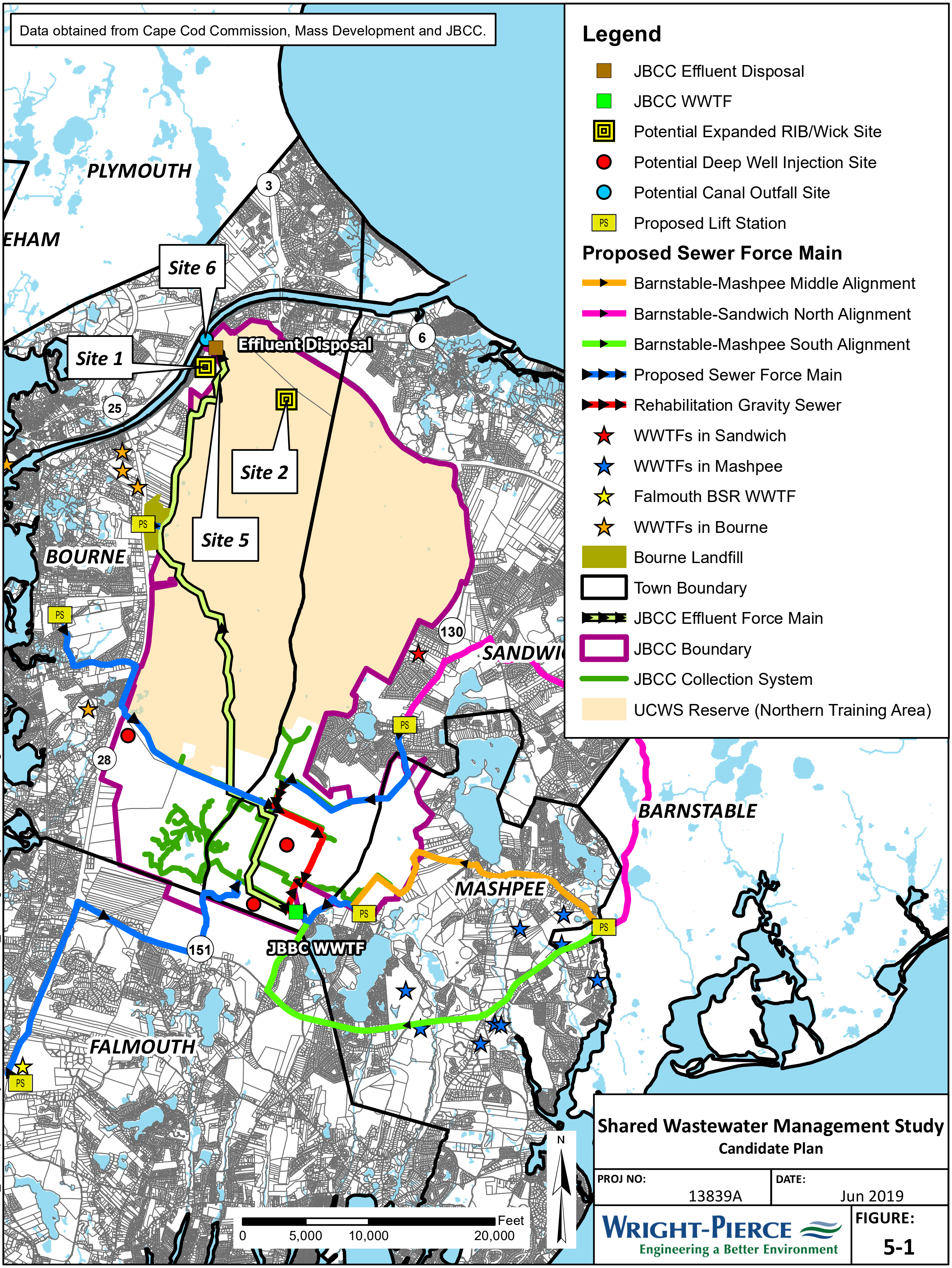
5.1 CANDIDATE PLAN

The "candidate plan" represents the current thinking of the five towns for a conceptual regional wastewater system located at JBCC. The candidate plan is summarized below and is shown on **Figure 5-1**. It should be expected that the components of this candidate plan may evolve over time, as the participants work through the implementation action items. Note that planning, design, and construction of the individual town collection systems would be completed by the participating communities and that the costs for that work is not included herein.

5.1.1 Conveyance

Each participating community would have one new conveyance lift station and associated piping to and through JBCC as described below. Refer to Section 2 for additional details.

- Bourne Effluent: A lift station would convey landfill leachate effluent from the future Integrated Solid Waste Management WWTF to the existing JBCC effluent forcemain.
- Bourne Sewage: A lift station would convey sewage from Bourne along the Shining Sea Bike Corridor, crossing Route 28, along Connery Avenue to the existing sewer system at Shelton Road.
- Falmouth Effluent: A lift station would convey municipal effluent from the Blacksmith Shop Road WWTF along Route 28, along the Shining Sea Bike Corridor, along Route 28 to rail right of way, to the existing JBCC effluent forcemain.
- Mashpee Sewage: A lift station would convey sewage along Falmouth-Sandwich Road, connection to existing gravity sewer system at South Outer Road.
- Sandwich Sewage: A lift station would convey sewage along Route 130, along Snake Pond Road to existing sewer system at Shelton Road.
- Barnstable Sewage: A lift station would convey sewage along one of three alignments (i.e., northern, central, or southern), as described in Section 2. No final decision has been made on this at this time.



Shared Wastewater Management Study
Candidate Plan

PROJ NO:	DATE:
13839A	Jun 2019

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FIGURE: 5-1

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5.1.2 Treatment

There would be one new WWTF located adjacent to the existing WWTF on land provided by JBCC (estimated 20 to 25 acres). The WWTF would include preliminary treatment, primary treatment, nutrient removal activated sludge, disinfection, effluent pumping, and conventional solids handling processes. While JBCC would be a good candidate site for other regional services (e.g., anaerobic digestion, nutrient recovery, etc.), no costs have been incorporated in this analysis for such items.

5.1.3 Transport to Disposal

Two new effluent transmission forcemains (and associated below-grade structures) would be constructed through the Cantonment Area, through the Reserve, to the existing RIB site. Extensions to these new forcemains (and associated below-grade structures) would be needed to the expanded effluent disposal sites, either across ACOE land and/or across the Reserve and/or across the Sandwich Road, across the Cape Cod Line, across the Canal Service Road and into the Cape Cod Canal.

5.1.4 Disposal

The existing RIBs would remain in service and the expanded effluent disposal facilities would be constructed at one or more of the following: expansion of RIBs in the Reserve, expansion of RIBs on Army Corps of Engineers land outside the Reserve, addition of wicks in the Reserve, addition of a Canal outfall. No decisions have been made at this time regarding which of these methods are desired or are most appropriate. Deep well injection wells in the Cantonment will be reserved as an option for the distant future.

5.2 ANTICIPATED PERMITS AND APPROVALS

A list of anticipated permits and approvals has been developed based on the “candidate plan” described above. Depending on the charter of the “management entity,” some of the permits, approvals, and easements identified below may not be applicable.

5.2.1 Federal

- Impacts to JBCC military operations
- Authority to enter premises to review compliance with sewer use regulations
- Excavation Permits for construction of conveyance infrastructure in the Cantonment area
- Crossing of railroad tracks on JBCC
- ACOE (easement and permit to construct at/in Canal)
- ACOE (easement and permit to construct on ACOE land including access roads)
- EPA NPDES permit (if Canal outfall)
- Federal Environmental Impact Report/ Environmental Impact Statement (potentially)
- EPA UIC permit and Federal Sole Source Aquifer designation (if well injection)

5.2.2 State

- Site Assignment under MGL Chapter 83, Section 6 (for treatment and disposal)
- MA EOEEA MEPA review, including subsequent permits related to identified historical, archaeological, natural heritage, environmental, and wetlands considerations)
- MA Environmental Management Commission review and conditions (for work in the Reserve)
- MADEP NPDES permit certification (if Canal outfall)
- MADEP Groundwater Discharge Permit (if RIB and/or wick and/or well injection)
- MADOT Excavation Permits for construction of conveyance infrastructure within/ along/ across State roads or rights-of-way (i.e., piping, subsurface structures, etc.)
- MADOT for crossing of Cape Cod Line railroad (at Sandwich Road) with disposal piping

5.2.3 County

- 208 Plan Consistency Review
- Development of Regional Impact (potentially for water supplies, traffic considerations, etc.)

5.2.4 Local

- Planning Boards and Historical Commissions in Bourne, Falmouth, Mashpee, Sandwich, and Barnstable for conveyance lift stations in each community

- Planning Boards in Bourne, Mashpee, and Sandwich for WWTF construction on JBCC (likely)
- Conservation Commission in Bourne (potentially for construction at/in Canal)

5.2.5 Utility

- JBCC (or Eversource) for power service
- JBCC (or “Management Entity”) for water service

5.3 ANTICIPATED EASEMENTS AND LAND ACQUISITION

Participating towns may or will need to install wastewater conveyance infrastructure (i.e., piping, pump stations, etc.) within neighboring towns in order to connect to the JBCC wastewater facilities. The inset table below shows the inter-municipal/inter-governmental easements that would potentially be required for the infrastructure.

TABLE 5-1: POTENTIAL EASEMENTS AND LAND ACQUISITION

Grantee	Possible Grantor	For
Each town	Private Parties	Sewage Pump Stations and potentially Sewage Conveyance
Bourne	Army Corps of Engineers	Effluent Forcemain
Bourne	JBCC/Sandwich	Effluent Forcemain
Falmouth	JBCC/Bourne, JBCC/Sandwich	Effluent Forcemain
Mashpee	Sandwich, JBCC/Sandwich	Sewage Conveyance
Mashpee	JBCC/Bourne, JBCC/Sandwich	Effluent Forcemain
Sandwich	Mashpee	Sewage Conveyance
Sandwich	JBCC/Bourne	Effluent Forcemain
Barnstable	Sandwich and/or Mashpee	Sewage Conveyance
Barnstable	JBCC/Bourne, JBCC/Sandwich	Effluent Forcemain
Management Entity	All of the above	All of the above
Management Entity	JBCC/Sandwich	WWTF

There are numerous “layers of easements” on JBCC. It may be possible for JBCC to declare some land as “excess property,” which would reportedly revert ownership of the land to the Commonwealth (DCAM). In this instance, the management entity would still need an easement for the land. This list will need to be further developed as a pre-design task based on the finalized scope of the candidate plan. This list should also be reviewed by legal counsel for additional items that may be appropriate for a project of this scale.

5.4 POTENTIAL FUNDING SOURCES

This section of the report identifies potential grant and loan sources which may be applicable to fund implementation of a shared regional wastewater management system as well as a few additional funding sources that may be applicable to the individual towns for the planning, design and/or construction of their collection systems.

5.4.1 Massachusetts Efficiency and Regionalization Grants

Massachusetts Executive Office for Administration and Finance, Community Compact Cabinet offers Efficiency and Regionalization (E&R) grants. The purpose of the E&R competitive grant program is to provide financial support for governmental entities interested in implementing regionalization and other efficiency initiatives that allow for long-term sustainability. This is the program under which the current study is funded.

5.4.2 Massachusetts Environmental Trust Grants

The Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) administers the Massachusetts Environmental Trust (MET). EOEEA issues a request for responses (RFR) annually in the fall and applications are due in the winter. The MET accepts proposals from municipalities and non-profit organizations for projects that will restore, protect, and improve water and water-related resources in Massachusetts. The MET is a competitive grant program that typically awards $500,000 per year, generally in grants of $10,000 to $40,000 per award. Eligible projects include those projects that address concerns such as: point- and non-point source pollution (including runoff, bacterial, chemical, and nutrient); water conservation and enhancing recharge and flow; river and estuary continuity and restoration; monitoring marine, estuarine, and freshwater systems; habitat protection and restoration for endangered and threatened species and habitat; human health issues that result from degraded water resources; environmental education projects pertaining to water resources; and/ or research on emerging environmental issues.

5.4.3 Cape Cod and Islands Water Protection Fund

In December 2018, the Massachusetts legislature expanded the room occupancy excise tax to include short-term property rentals beginning July 1, 2019. Detailed guidance is currently being developed by the Department of Revenue. For Cape Cod and the Islands, the legislation calls for a 2.75% excise tax in member towns as well as the creation of the *Cape Cod and Islands Water Protection Fund* (the "Fund"). Each municipality in Barnstable County will automatically be a member in part because they are covered by the Cape Cod Commission 208 Water Quality Plan Update. Any municipality will have the ability to withdraw membership by a two-thirds majority vote of its legislative body.

A Cape Cod and Islands Water Protection Fund Management Board will be established that will consist of one person (appointed by each board of selectmen or town council) from each municipality that is a member of the Cape Cod and Islands Water Protection Fund. The executive director of the Cape Cod Commission, the executive director of the Martha's Vineyard Commission and the town manager of Nantucket will also serve as non-voting, ex-officio members of the Board. Board members will be appointed to serve a 3-year term. The Board's duties include determining the method for subsidy allocation and ensuring that money from the Cape Cod and Islands Water Protection Fund is spent only for water pollution abatement purposes. The monies collected shall be held separate from other funds. The fund is expected to generate $34 million in state revenues and $25 million in local revenues annually based on a Senate Ways and Means Fiscal Impact Report (CapeCod.com, 26 December 2018).

5.4.4 MassWorks Infrastructure Grants

The Massachusetts Executive Office of Housing and Economic Development (EOHED) administers the MassWorks Infrastructure program. EOHED issues a request for proposals annually in the spring and applications are due in the summer. The program accepts proposals from municipalities and public agencies. MassWorks is a competitive grant program and the amount of funding available is variable. Eligible projects include those projects that provide public infrastructure to: support economic development or housing opportunities; complement existing centers of development; include a mix of commercial and residential development; include an emphasis on multi-family or small lot single-family residential development; are consistent with regional land use and development plans; and provide for transportation improvements which enhance roadway safety.

5.4.5 Community Development Block Grants

The Massachusetts Executive Office of Housing and Economic Development (EOHED) administers the Community Development Block Grant (CDBG) program with funds allocated by the U.S. Department of Housing and Urban Development. Grants are available in several different categories, including public facilities implementation grants for water and wastewater projects. Grant funds of up to $500,000 are available for eligible projects; however, these grants are very competitive.

5.4.6 U.S. Department of Agriculture Grants

The U.S. Department of Agriculture also has a grant and loan program, administered by Rural Development, that is available for the planning, design, and construction of municipal wastewater infrastructure projects for communities with a population of less than 10,000; however, USDA is currently re-evaluating this population threshold (and may increase it to 50,000 based on the 2018 Farm Bill). The main eligibility criterion is median household income (MHI). If a municipality has an MHI that is below the State average, then it may qualify for up to 45% grant funding; however, if a municipality has an MHI that is below 80% of the State average, then it may qualify for up to 75% grant funding and lower interest rates. Data from American Fact Finder (www.factfinder.census.gov).

TABLE 5-2: POPULATION AND MEDIAN HOUSEHOLD INCOME BY TOWN

Town	Population (2010 Census)	Median Household Income (2017 American Fact Finder)
State	-	$74,167
Bourne	19,754	$73,000
Falmouth	31,531	$70,918
Mashpee	14,006	$73,841
Sandwich	20,675	$88,870
Barnstable	45,193	$66,864

5.4.7 U.S. Economic Development Administration Grants

The U.S. Economic Development Administration (EDA) has a grant program for municipal infrastructure construction necessary to attract or increase commercial and/or industrial development. Grants of 50% of project cost, up to a maximum of $5,000,000, are available. One of the primary eligibility criteria is that the project must create or maintain employment opportunities. EDA also considers MHI when awarding grants. Municipalities need to present a compelling case that jobs would be created or maintained by the candidate project.

5.4.8 U.S. Environmental Protection Agency Grants

The U.S. Environmental Protection Agency administers the Southeast New England Program (SNEP), in association with Restore America's Estuaries, which is focused on promoting a resilient ecosystem of clean water, healthy diverse habitats, and sustainable communities in Southeast New England's coastal watersheds. JBCC is located within the focus area. "SNEP Watershed Grants" are awarded annually on a competitive basis. Typical awards range in size from $100,000 to $500,000 and require local matching funds.

5.4.9 U.S. Department of Transportation Grants

The U.S. Department of Transportation administers the Transportation Investment Generating Economic Recovery (TIGER) grant program. The TIGER grant program is a competitive grant program that accepts proposals from municipalities and public agencies. This program could potentially be utilized to address transportation challenges related to the development and redevelopment within the project service area at areas where conveyance infrastructure is installed.

5.4.10 U.S. National Defense Authorization Act and Congressional Appropriations

U.S. Congress appropriates defense funds each year and the National Defense Authorization Act sets policy and provides guidance on how the appropriations are to be used within the Department of Defense. This includes infrastructure at defense installations.

5.4.11 U.S. Department of Defense Community Infrastructure Program

Department of Defense budgets for on-base infrastructure upgrades and potentially for off-base infrastructure in "defense communities" (via a pilot program) to promote installation resiliency. Defense communities are those communities that are adjacent to active and closed defense installations. Defense Critical Infrastructure Protection (DCIP) focuses on systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters.

5.4.12 Massachusetts DEP State Revolving Fund Loan

The Massachusetts Department of Environmental Protection (MADEP) has the Clean Water State Revolving Fund (SRF) loan program available to municipalities for the planning and construction (i.e., not design) of water pollution abatement projects. The SRF loan program provides low-interest loans for eligible projects, which includes traditional wastewater infrastructure as well as landfill capping, upgrading septic systems and stormwater remediation. The program offers 20-year loans at 2% interest including potential principal forgiveness (in some cases 30-year loans can be obtained). Additional funds are available for designated "environmental justice" communities (applicable to small portions of Falmouth and Barnstable). The SRF program has a prescribed time table for submissions which must be followed in order to get proposed projects on the eligible and funded list.

DEP also has an "enhanced SRF loan program" to include 20-year loans at 0% interest for nutrient management projects (in some cases 30-year loans can be obtained). The legislation that establishes this financing program also extends the maximum allowable term for betterment assessments to 50 years. In order to qualify for the enhanced funding program, a municipality must: 1) have a project that is primarily intended to remediate or prevent nutrient enrichment of a surface water body or a source of water supply; 2) not be subject to any on-going enforcement action associated with nutrient management; 3) have a Comprehensive Wastewater Management Plan (CWMP) approved pursuant to regulations adopted by MassDEP; 4) receive a determination of consistency with the regional management plan (i.e., in this case the CCC 208 Plan Update); and 5) adopt land use controls to govern increases in nutrient loads due to growth ("flow neutral").

5.4.13 U.S. Department of Agriculture Loans

As noted above, the U.S. Department of Agriculture also has loan program, administered by Rural Development, that is available for the planning, design, and construction of municipal wastewater infrastructure projects. Generally, these loans are considered by municipalities if they get a USDA Rural Development grant or if they are not otherwise eligible for a State SRF loan.

5.4.14 Sewer Enterprise Funds

Wastewater infrastructure design, construction and operation are typically funded via municipal sewer enterprise funds. This approach ensures that the costs associated with the wastewater facilities are paid by the system users. This approach also ensures a sustainable revenue base to operate and maintain the infrastructure. Enterprise funds often include provisions for additional fees and surcharges, when applicable (e.g., connection/inspection fees; sewer service repair charges; emergency call-out charges; high-strength waste surcharges, etc.).

5.4.15 General Taxation Funds

A common method for funding on-going study, monitoring and planning activities related to nutrient management on Cape Cod is general municipal taxation. In some cases, portions of the design and construction are also covered through general taxation. The general fund covers a full range of municipal services and is subject to competing municipal demands. The general fund is also subject to the requirements of Massachusetts General Laws Chapter 59 § 21C (i.e., "Proposition 2½"). Certain activities related to implementation of the JBCC candidate plan could be funded via general taxation.

5.4.16 Municipal Water Infrastructure Investment Funds

Chapter 259/ Section 26 of the Acts of 2014 authorizes municipalities to impose a surcharge on real property at a rate of up to a 3 percent of the real estate tax levy. All monies collected from this surcharge shall be placed in a separate account to be named the Municipal Water Infrastructure Investment Fund. Expenditures from this fund shall only be used for municipal drinking water, wastewater, and stormwater infrastructure assets.

5.4.17 Tax Increment Financing (TIF) Funds

TIFs are financing mechanisms in which capital improvements within the TIF district are funded through increased property tax revenues resulting from private investment within the designated TIF district. When utilized, this financing mechanism is often used to fund infrastructure improvements to support the district.

5.4.18 Additional Potential Funding Sources Available for Town Collection Systems

The following additional sources are identified for individual town collection systems:

- Each of the sources listed above
- U.S. Department of Agriculture Preliminary Planning Grants
- FEMA/MEMA Hazard Mitigation Grants
- Massachusetts DEP Section 604b Water Quality Management Planning Grants
- Massachusetts DEP Asset Management Grants
- Massachusetts Coastal Zone Management Coastal Resiliency Grants
- Massachusetts Municipal Vulnerability Preparedness (MVP) Action Grants
- Betterment assessments

5.4.19 Most Likely External Funding Sources for the Candidate Plan

Based on the candidate plan, the inset table below identifies the external (i.e., non-local) funding sources which are considered the most likely sources of funding for the planning, design, and construction of the shared wastewater facilities.

TABLE 5-3: MOST LIKELY EXTERNAL FUNDING SOURCES

Source	Planning/ Pre-Design	Design	Construction
Efficiency and Regionalization Grant	X		
Cape Cod and Islands Water Protection Fund	X	X	X
MassWorks Infrastructure Grant			X
Economic Development Administration Grants			X
EPA SNEP Grants	X		
National Defense Authorization Act/ Congress			X
Department of Defense Community Infrastructure Program			X
DEP State Revolving Fund Loan	X		X

SECTION 6

IMPLEMENTATION PLAN

The concept of a regional WWTF located at JBCC has been a topic of discussion on the Upper Cape for more than 10 years; however, it has not advanced beyond the "discussion and pre-planning phase" due to the significant capital costs associated with a regional facility and due to a series of complicated and nested issues that are unique to JBCC and the Upper Cape.

This section of the report focuses on the key implementation items that are needed in order to confirm the cost-effectiveness of this potential regional system, to secure input from participants, regulatory agencies and stakeholders, as well as to secure the necessary approvals from the Towns to commit to moving forward. The key implementation categories are:

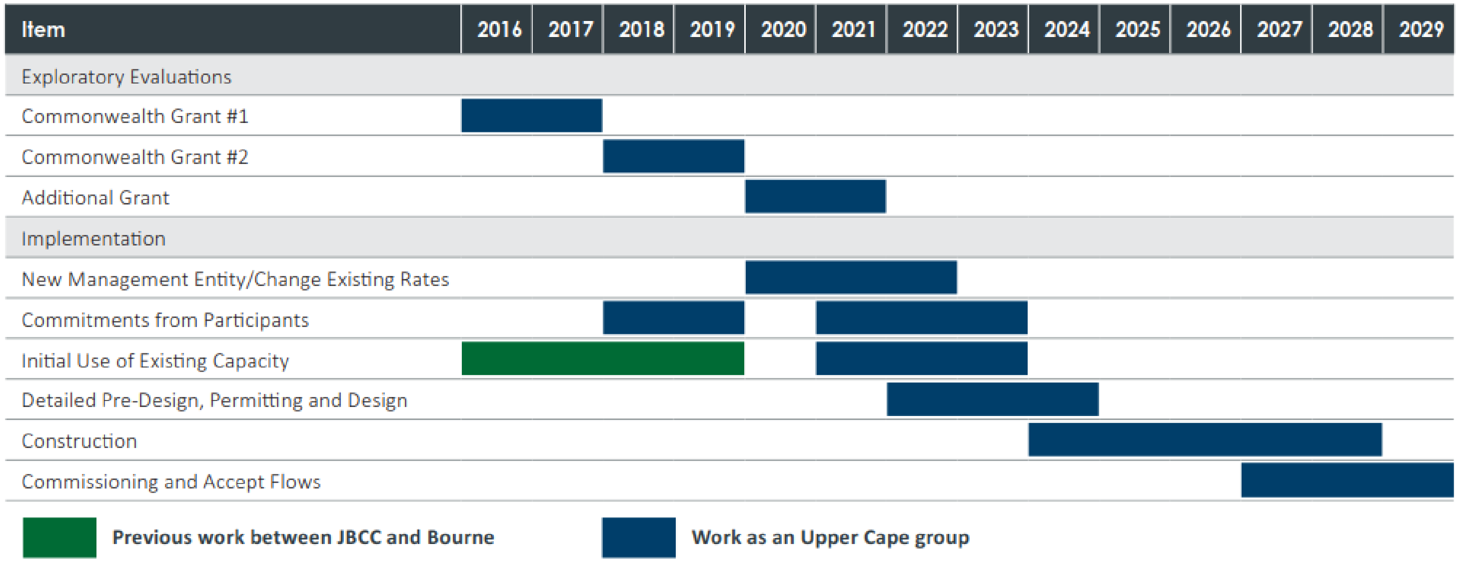
- Effluent disposal capacity
- Cost effectiveness of a regional solution
- Facility ownership, management entity and sewer rates
- Timeline and commitments for participating towns

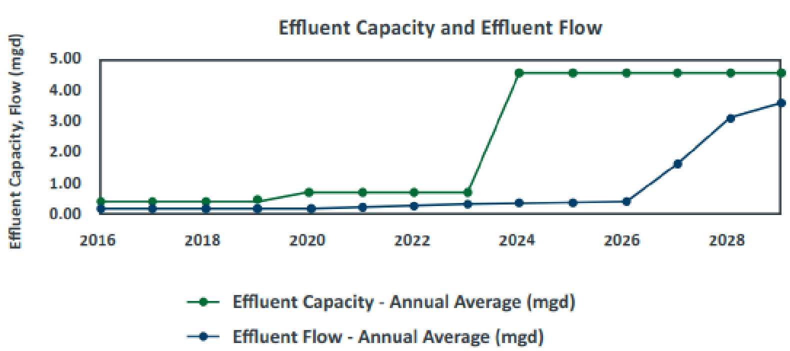
These items are presented in three panels on **Figure ES-1/ 6-1** at the end of this section. Panel 1 shows milestones and dates for major planning steps, from takeover of facilities through construction and acceptance of flows. Panel 2 shows the effluent disposal capacity versus the anticipated effluent flow over the implementation timeline. Panel 3 shows the cumulative construction cost expended (excluding costs for the collection systems needed in Bourne, Mashpee, Sandwich, and Barnstable) and the estimated annual budget to operate the system (including debt service on the construction costs, again excluding collection system costs) over the implementation timeline. Panels 2 and 3 are intended to illustrate one possible implementation scenario based on the schedule outlined in Panel 1 and based on assumed rates of construction cash flow and connected wastewater flow.

Based on the analyses conducted to date, the regional system would be most cost-effective once all participants are on-board and responsible for their allocated share of debt service, operating costs, reserves, and asset management associated with the committed capacity. The regional system would be least cost-effective in the current situation once rates are raised to a point that is sufficient to fund reserves, asset management, and necessary capital improvements (i.e., relatively few users and relatively large unfunded liabilities associated with reserves, asset management and capital improvements).

If a regional wastewater system at JBCC is to come to fruition, it will require a concerted, focused, and multi-track effort from Federal, State and local government officials. An action item list, organized by key issue, is outlined in **Figure ES-2/ 6-2**.

FIGURE ES-1/ 6-1: IMPLEMENTATION TIMELINE





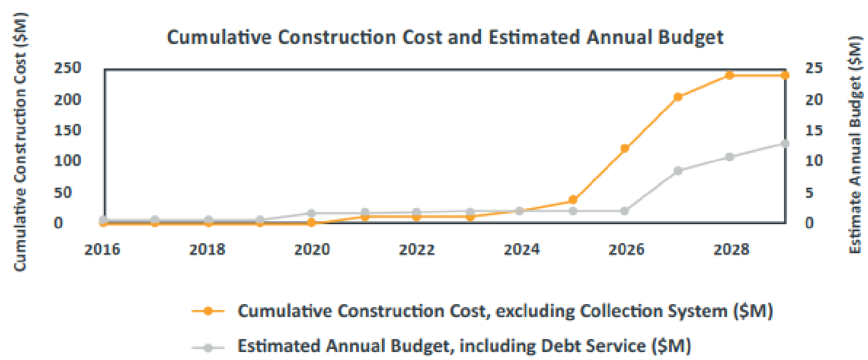


FIGURE ES-2/ 6-2: IMPLEMENTATION ACTION ITEMS

Key Issue	Action Item
Effluent Disposal Capacity	• Meet with EPA, DEP, CZM, ACOE and EMC staff to discuss surface water disposal. • Meet with DEP, ACOE and EMC staff to discuss land-based disposal. • Implement scientific and engineering studies associated with land-based and surface water-based effluent disposal on a dual-track. • Update wastewater facilities costs based on findings.
Cost-Effectiveness of Regional Approach	• Support town determinations of cost-effectiveness. • Reassess cost-effectiveness after next round of effluent disposal capacity analysis.
Facility Ownership, Management Entity and Sewer Rates	• Facilitate a decision on ownership of the existing facilities. • Transition to a new management entity. • Raise rates to properly fund reserve accounts, asset management and capital improvements for the existing wastewater infrastructure. • Determine whether to make interim upgrades to accept flow early to existing facilities or to wait for new facilities.
Timeline and Commitments from Participants	• Obtain letters of support from participating municipalities. • Execute an IMA between/among participating municipalities to fund additional planning activities. • Secure grant funds or local funds to explore effluent disposal capacity and cost-effectiveness items noted above. • Agree upon a timeline for the above implementation items.

SECTION 7

REFERENCES

The documents identified below were referenced in the development of this report.

WASTEWATER MANAGEMENT

Wastewater Management Study, Bourne, MA, Tighe & Bond, 2007.

Needs Assessment Report, Little Pond, Great Pond, Green Pond, Bournes Pond, Eel Pond, and Waquoit Bay Watersheds, Falmouth, MA, Stearns & Wheler, 2007.

Comprehensive Wastewater Management Plan and Final Environmental Impact report and Targeted Watershed Management Plan, Little Pond, Great Pond, Green Pond, Bournes Pond, Eel Pond, and Waquoit Bay Watersheds, Falmouth, MA, GHD, 2013.

Needs Assessment Report, Popponesset Bay and Waquoit Bay East Watersheds, Mashpee, MA, Stearns & Wheler, 2007

Comprehensive Watershed Nitrogen Management Plan, Final Recommended Plan/ Final Environmental Impact Report, Mashpee, MA, GHD, 2015

Comprehensive Water Resources Management Plan, Sandwich, MA, Wright-Pierce, Dec. 2017

Personal Correspondence with Barnstable Department Public Works, January to April 2019

EXISTING FACILITIES

Contract Drawings for Alteration of Wastewater Treatment Plant, CDM, 1993.

Contract Drawings for Effluent Forcemain and Infiltration Basins, CDM/SAIC Eng., 1993.

Hydrogeologic Investigation & Design Effluent Infiltration Basins, CDM/SAIC Eng., 1993.

Appraisal Consulting Services for the Wastewater Treatment System at the Massachusetts Military Reservation, CH2M-Hill, 2012

2013 Joint Land Use Study Update and Community-Military Partnerships Study Final Report, Cape Cod Commission, 2013

Joint Base Cape Cod, Water and Wastewater System Evaluation, Massachusetts Development Finance Agency, Wright-Pierce, Dec. 2014

Groundwater Discharge Permit No. 41-3, Massachusetts DEP, 2018

REGULATORY

314 CMR 5.00: Ground Water Discharge Permit Program

314 CMR 4.00: Massachusetts Surface Water Quality Standards

Implementation Procedures for the Anti-Degredation Provisions of the Massachusetts Surface Water Quality Standards, 314 CMR 4.00, Massachusetts DEP, October 21, 2009

Massachusetts Surface Water Quality Standards, Implementation Policy for Mixing Zones, January 8, 1993

314 CMR 20.00: Reclaimed Water Permit Program and Standards

Guidelines for Water Reuse 2012, Environmental Protection Agency, September 2012

208 Cape Cod Area Wide Water Quality Management Plan Update, Cape Cod Commission, 2015

208 *Cape Cod Area Wide Water Quality Management Plan Update – 2017 Implementation Report*, Cape Cod Commission, October 2017

An Act Establishing the Upper Cape Cod Regional Water Supply Cooperative (Acts of 2000, Chapter 532)

Executive Order No. 414: Establishing the Upper Cape Water Supply Reserve and Commission (1999)

TECHNICAL

Delineation of Ground-Water Recharge Areas, Western Cape Cod, Massachusetts, Water Resources Investigations Report 00-4000, United States Geological Survey, 2000

Simulated Water Sources and Effects of Pumping on Surface and Ground Water, Sagamore and Monomoy Flow Lenses, Cape Cod, Massachusetts, SIR 2004-5181, United States Geological Survey, 2004

Environmental Impact Statement - Draft, Wastewater Collection and Treatment Facilities, Sandwich, MA, Environmental Protection Agency, 1981.

Factors to Evaluate When Considering a Reverse Osmosis Concentrate Discharge to a Wastewater Treatment Facility, CH2M-Hill, Boe, Brubaker, 2016

Pilot Test for Using Injection Wells for Reclaiming Treated Municipal Wastewater, Barnstable, MA, Stearns & Wheler, 2003

Assessing the Impact of Increased Effluent Discharge into Cape Cod Canal, Churchill, Cowles, Rheuban, Woods Hole Oceanographic Institution and the University of Massachusetts at Dartmouth SMAST, February 2018.

APPENDIX A
Supplemental Materials – Wright-Pierce

WRIGHT-PIERCE
Engineering a Better Environment™

MEMORANDUM

TO:	File	**DATE:**	8/23/2017, Rev 11/27/2017 Rev 3/15/2019
FROM:	Ed Leonard	**PROJECT NO.:**	13839A
SUBJECT:	JBCC Shared Wastewater Management Study Flow Estimate Backup Materials		

Attached are the following flow estimate backup materials:

1. Basis for Bourne Flows to JBCC Wastewater Facilities
2. Bourne Wastewater Management Study, Figure 2-5
3. Correspondence from Barnstable (2019)
4. Supporting Information for Table 1-8 (Revised 2019)
5. TR-16 Flow Peaking Factor Chart (Revised 2019)
6. Supporting Information for Table 2-2 (Revised 2019)

Basis for Bourne Flows

The Bourne Wastewater Management Study (Tighe & Bond, 2007) included estimates of existing and future wastewater flow town-wide, as summarized in Table 3-4 of the Bourne WMS, and an assessment of "priority", as shown on Figure 2-5 (attached). The prioritization approach is presented in Section 2.5 of the Bourne WMS and includes consideration of: performance of existing on-site wastewater systems; location relative to 100-year flood plain; location relative to low permeability soils; and location relative to estuaries and coastal embayments.

The Bourne WMS did not assess or estimate off-site wastewater management needs; accordingly, a cursory assessment was conducted in order to support the JBCC SWMS effort. The wastewater flows are summarized on the attached table entitled "Basis for Bourne Flows to JBCC Wastewater Facilities" dated 22 Aug 2017. The following assumptions were utilized in preparing these estimates:

- Wastewater flow identified for off-site treatment and disposal was estimated by the following percentages using the information presented on Bourne WMS Figure 2-5: 25% for low priority (blue, green); 50% for medium priority (yellow, orange); and 75% for high priority (red).
- Wastewater flow does not cross the Cape Cod Canal.
- Wastewater flow from Areas 8 through 14 (except Area 11) goes to the ISWM WWTF location and is connected to the effluent forcemain along with the leachate flow. Area 11 (MacArthur Boulevard/Route 28) is split equally between the ISWM and JBCC WWTFs.
- Wastewater flow from Areas 15 to 20 goes to the JBCC WWTF location and is treated as sewage.
- Septage goes to the JBCC WWTF.

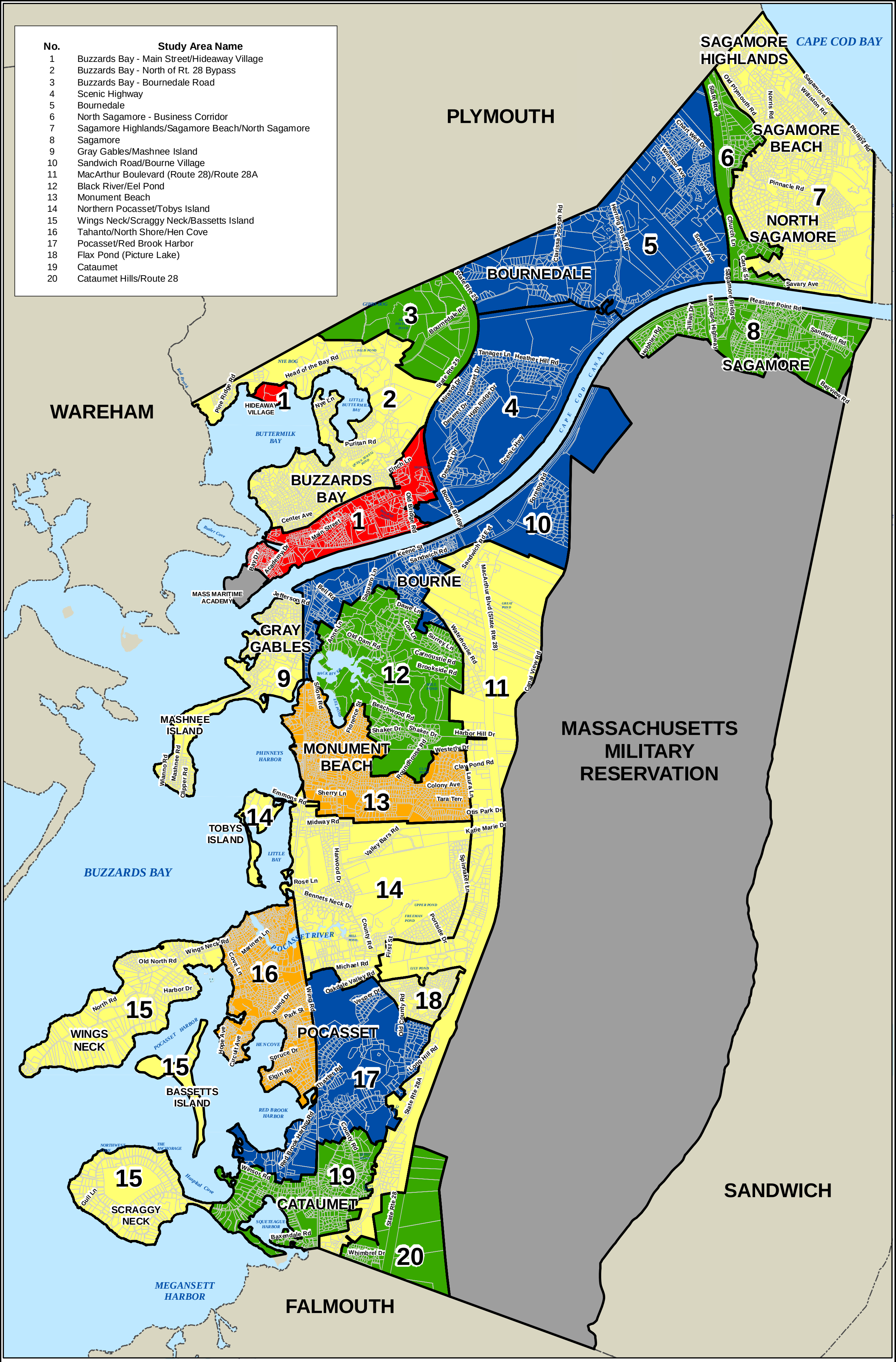
Bourne confirmed via email on 8/15/2017 and 8/23/2017 that the attached flow estimates were suitable for use in this planning effort. Bourne will need to develop a more detailed assessment of off-site wastewater management needs as a part of a town-wide or targeted watershed management planning effort.

WASTEWATER MANAGEMENT STUDY FOR TOWN OF BOURNE, FALMOUTH, MASHPEE, SANDWICH AND JBCC
BASIS FOR BOURNE FLOWS TO JBCC WASTEWATER FACILITIES
Wright-Pierce, 22 Aug 2017
Source of Data: 2007 Bourne Wastewater Management Study, Tighe & Bond

				Flows within WMS Planning Horizon					
				Flow to ISWM WWTF		Flow to JBCC WWTF		Flow to North WWTF	
Study Area	Existing Flows (gpd)	20-Year Future Flows (gpd)	% of Flow Used for JBCC Study	Existing Flows (gpd)	20-Year Future Flows (gpd)	Existing Flows (gpd)	20-Year Future Flows (gpd)	Existing Flows (gpd)	20-Year Future Flows (gpd)
1 Buzzards Bay - Main Street/Hideaway Village	106,000	386,000	75%	n/a	n/a	n/a	n/a	80,000	290,000
2 Buzzards Bay - North of Rt. 28 Bypass	202,000	243,000	50%	n/a	n/a	n/a	n/a	101,000	122,000
3 Buzzards Bay - Head of the Bay Road	1,000	24,000	25%	n/a	n/a	n/a	n/a	0	6,000
4 Scenic Highway	33,000	126,000	25%	n/a	n/a	n/a	n/a	8,000	32,000
5 Bournedale	80,000	115,000	25%	n/a	n/a	n/a	n/a	20,000	29,000
6 North Sagamore - Business Corridor	38,000	80,000	25%	n/a	n/a	n/a	n/a	10,000	20,000
7 Sagamore Highlands/Sagamore Beach/North Sagamore	278,000	352,000	50%	n/a	n/a	n/a	n/a	139,000	176,000
8 Sagamore	108,000	146,000	25%	27,000	37,000	n/a	n/a	n/a	n/a
9 Gray Gables/Mashnee Island	106,000	130,000	50%	53,000	65,000	n/a	n/a	n/a	n/a
10 Sandwich Road/Bourne Village	105,000	143,000	25%	26,000	36,000	n/a	n/a	n/a	n/a
11 MacArthur Boulevard/Route 28A	156,000	608,000	50%	39,000	152,000	39,000	152,000	n/a	n/a
12 Back River/Eel Pond	129,000	185,000	25%	32,000	46,000	n/a	n/a	n/a	n/a
13 Monument Beach	207,000	241,000	50%	104,000	121,000	n/a	n/a	n/a	n/a
14 Northern Pocasset/Tobys Island	125,000	188,000	50%	63,000	94,000	n/a	n/a	n/a	n/a
15 Wings Neck/Scraggy Neck/Bassetts Island	83,000	141,000	50%	n/a	n/a	42,000	71,000	n/a	n/a
16 Tahanto/North Shore/Hen Cove	240,000	274,000	50%	n/a	n/a	120,000	137,000	n/a	n/a
17 Pocasset/Red Brook Harbor	55,000	129,000	25%	n/a	n/a	14,000	32,000	n/a	n/a
18 Flax Pond (Picture Lake)	47,000	58,000	50%	n/a	n/a	24,000	29,000	n/a	n/a
19 Cataumet	72,000	99,000	25%	n/a	n/a	18,000	25,000	n/a	n/a
20 Cataumet Hills/Route 28	9,000	39,000	25%	n/a	n/a	2,000	10,000	n/a	n/a
Septage	12,000	17,000		n/a	n/a	see below	see below	n/a	n/a
Leachate	25,000	27,000		100,000	100,000	n/a	n/a	n/a	n/a
SUBTOTAL	2,217,000	3,751,000		444,000	651,000	259,000	456,000	358,000	675,000

TOTALS CAPACITY BY CATEGORY				Short-Term	Mid-Term	Long-Term
Total - Sewage Capacity				0	259,000	456,000
Total - Septage Capacity				0	11,000	11,000
Total - Effluent Disposal Only				100,000	444,000	651,000
Total - Effluent Disposal				100,000	714,000	1,118,000

NOTES:
1) Estimated flows based on Tighe & Bond Table 3-4 and 3-9. All flows presented as annual average flows.
2) Estimated flows based on Tighe & Bond Figure 2-5 using the following: blue and green = 25%, yellow and orange = 50%, red = 75%.
3) Estimated flows to ISWM WWTF will be for effluent disposal capacity and estimated flow to JBCC WWTF will be for sewage capacity.



Legend
- Imperative Need
- Near-Term Need
- Mid-Term Need
- Long-Term Need
- Low Need
- Parcel
- Town Boundary
- Rivers & Streams
- Lake, Pond, Stream or other Fresh/Salt Water Feature
- Fresh Water Wetlands
- Salt Water Wetlands

Source: MassGIS and Town of Bourne, October 2006

0 2,000 4,000 Feet
1 inch equals 4,000 feet

FIGURE 2-5 - STUDY AREA PRIORITIZATION BASED ON NEED FOR SEWER SERVICE
BOURNE WASTEWATER MANAGEMENT STUDY
BOURNE, MASSACHUSETTS

APRIL 2007

Tighe&Bond

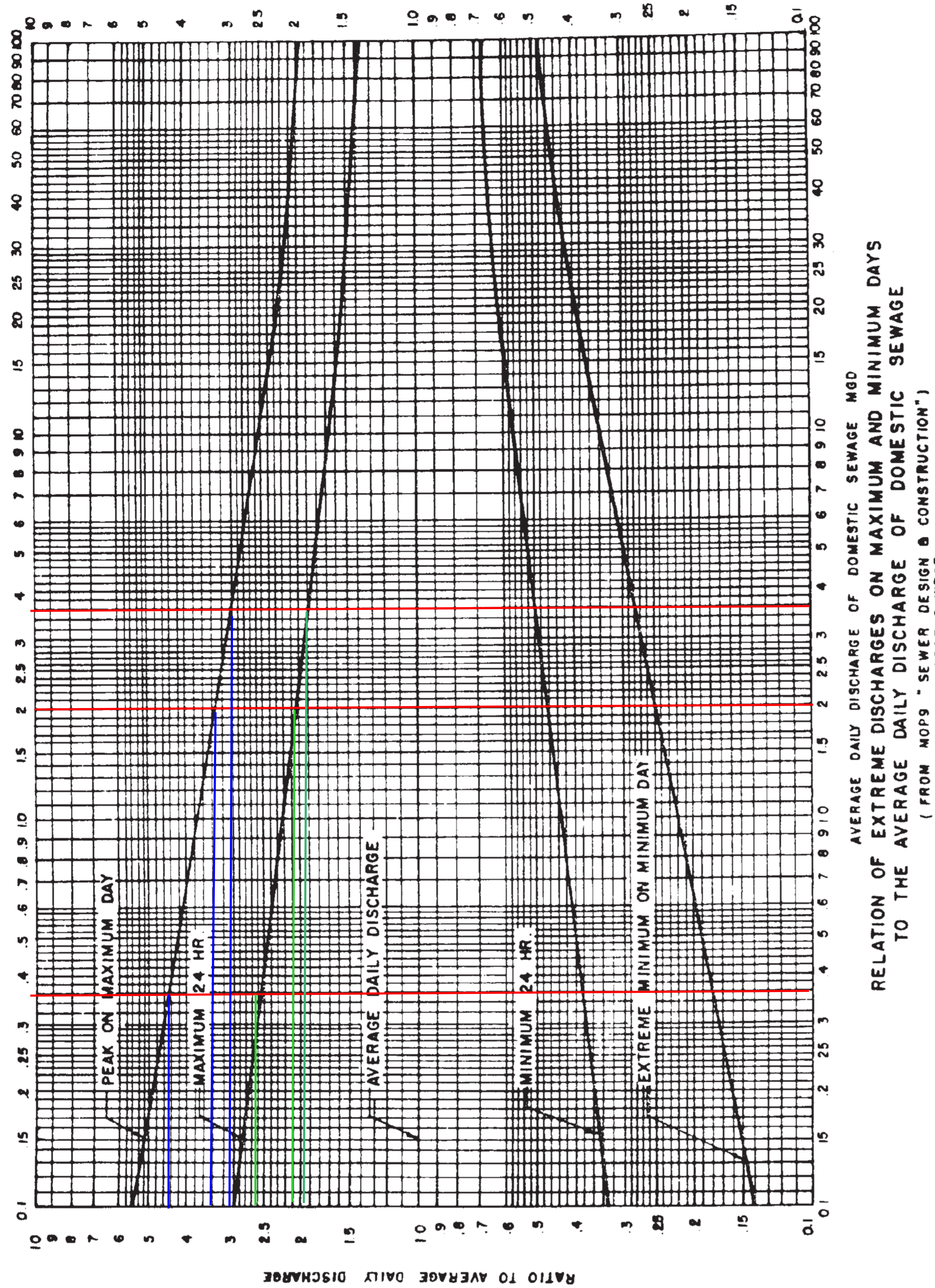
V:\Projects\B\B0403\Mapping\studyarea_prioritization_11x17.mxd

TABLE 1-8A: SUMMARY OF CAPACITY REQUESTS TO BE USED IN ENGINEERING ASSESSMENT

	Capacity Requested - "Study Basis" Annual Average Flows (gpd)								
	JBCC	**Bourne**	**Falmouth**	**Mashpee**	**Sandwich**	**Barnstable**	**Total**	**Capacity Provided**	**% Increase Existing Capacity**
Existing									
Sewage Treatment	140,000	0	0	0	0	0	140,000	**360,000**	n/a
Septage Treatment	0	0	0	0	0	0	0		
Effluent Disposal Only	0	0	0	0	0	0	0		
Effluent Disposal	140,000	0	0	0	0	0	140,000	**360,000**	n/a
Short-Term (5-year)									
Sewage Treatment	147,000	0	0	200,000	0	0	347,000	**360,000**	0%
Septage Treatment	0	0	0	0	0	0	0		
Effluent Disposal Only	0	100,000	0	0	0	0	100,000		
Effluent Disposal	147,000	100,000	0	200,000	0	0	447,000	**460,000**	28%
Mid-Term (10 year)									
Sewage Treatment	147,000	259,000	0	200,000	100,000	500,000	1,206,000	**1,260,000**	250%
Septage Treatment	0	11,000	22,000	3,000	10,000	10,000	56,000		
Effluent Disposal Only	0	444,000	490,000	0	0	0	934,000		
Effluent Disposal	147,000	714,000	512,000	203,000	110,000	510,000	2,196,000	**2,200,000**	511%
Long-Term (20 year)									
Sewage Treatment	147,000	456,000	0	200,000	340,000	1,200,000	2,343,000	**2,400,000**	567%
Septage Treatment	0	11,000	22,000	3,000	10,000	10,000	56,000		
Effluent Disposal Only	0	651,000	1,490,000	0	0	0	2,141,000		
Effluent Disposal	147,000	1,118,000	1,512,000	203,000	350,000	1,210,000	4,540,000	**4,550,000**	1164%
Notes	1	1	1	1	1			2, 4	3

1) Refer to Table 1-7 for additional information.
2) Existing Capacity based on WP 2014, GWDP and WWTF O&M.
3) Capacity for Short-Term, Mid-Term and Long-Term conditions are increases over the existing capacity.
4) Organic loading treatment capacity will need to account for concentrated nature of septage.

Figure 2-1 **Ratio of Extreme Flow to Average Daily Flow**



BACKUP FOR TABLE 2-2: WASTEWATER FLOWS USED IN ENGINEERING ASSESSMENT

			Capacity - Maximum 3 Day Flow (gpd)			Capacity - Peak Instan. Flow (gpd)		
	Annual Average Flow (gpd)	Treatment Capacity	Peaking Factor (M3D:AA)	Maximum 3 Day Flow	Effluent Disposal Capacity	Peaking Factor (PI:AA)	Peak Instan. Flow	Conveyance Capacity
Existing								
Sewage Treatment	140,000	**360,000**	2.75	386,000		10.0	1,400,000	
Septage Treatment	0		2.0	0		2.0	0	
Effluent Disposal Only	0		1.5	0		1.5	0	
Effluent Disposal	140,000	**360,000**			**386,000**			**1,400,000**
Short-Term (5-year)								
Sewage Treatment	347,000	**360,000**	2.75	955,000		4.7	1,625,000	
Septage Treatment	0		1.75	0		1.75	0	
Effluent Disposal Only	100,000		1.25	125,000		1.25	125,000	
Effluent Disposal	447,000	**460,000**			**1,080,000**			**1,750,000**
Mid-Term (10 year)								
Sewage Treatment	1,206,000	**1,260,000**	2.4	2,890,000		4.0	4,820,000	
Septage Treatment	56,000		1.75	100,000		1.75	100,000	
Effluent Disposal Only	934,000		1.25	1,170,000		1.25	1,170,000	
Effluent Disposal	2,196,000	**2,200,000**			**4,160,000**			**6,090,000**
Long-Term (20 year)								
Sewage Treatment	2,343,000	**2,400,000**	2.2	5,150,000		3.5	8,200,000	
Septage Treatment	56,000		1.75	100,000		1.75	100,000	
Effluent Disposal Only	2,141,000		1.25	2,680,000		1.25	2,680,000	
Effluent Disposal	4,540,000	**4,550,000**			**7,930,000**			**10,980,000**

1) Peaking factors for sewage taken from TR-16, New England Interstate Water Pollution Control Commission, 2016.
Peaking factors for sewage were adjusted upward by 0.2 to account for Cape Cod seasonality.

2) Peaking factors for septage and "effluent disposal only" are input values and will address via design controls.

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MEMORANDUM

TO:	File	**DATE:**	5/13/2019
FROM:	E. Whatley, J. Ducharme, J. Srey	**PROJECT NO.:**	13839/20008A
SUBJECT:	JBCC Shared Wastewater Management Study Evaluation of Conveyance Options		

This memorandum identifies the options for wastewater conveyance systems required to support shared wastewater management opportunities for the towns of Bourne, Falmouth, Mashpee, Sandwich, Joint Base Cape Cod (JBCC), and Barnstable. Supplemental information is included in the following attachments:

- Conveyance Option Worksheet with plan and profile figures
- Conveyance Options Costs
- JBCC Conveyance Improvement Worksheet

1.1 OBJECTIVES

The objectives of the conveyance study include the following:

- Identify alignments for conveyance of sewage from Barnstable, Bourne's southern section, Mashpee and Sandwich to JBCC WWTF for treatment and disposal;
- Identify alignments for conveyance of treated wastewater ("effluent") from the JBCC WWTF, the Bourne ISWM WWTF and the Falmouth BSR WWTF to the JBCC treated effluent conveyance system and disposal areas;
- Identify rehabilitation of sections of the JBCC gravity sewer system where shorter alignments and capital cost savings are available;
- Review conceptual profiles of each forcemain alignment to evaluate conceptual static and dynamic head on the pumping system;
- Develop preliminary hydraulic calculations to determine conceptual forcemain sizes; and
- Determine conceptual number and size of required lift stations.

1.1.1 Concept Design Criteria

The following key assumptions are used in this analysis:

- Elevation data was obtained from topographic information within Google Earth.
- Conceptual forcemain piping and wastewater lift station sizing are based on the conveyance flows in Tables 1 and 2.

TABLE 1: RAW WASTEWATER CONVEYANCE FLOWS

(Raw Wastewater Lift Station Peaking Factor: 4)
(Barnstable Raw Wastewater Lift Station Peaking Factor: 3.6)

Flow Source	Existing Flows		Short-Term Flows		Mid-Term Flows		Long-Term Flows	
	Avg.	Peak	Avg.	Peak	Avg.	Peak	Avg.	Peak
	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)
JBCC	140,000	389	152,000	422	152,000	422	152,000	422
Sandwich	-	-	-	-	100,000	278	340,000	944
Mashpee	-	-	200,000	556	200,000	556	200,000	556
Bourne-S	-	-	-	-	259,000	719	456,000	1,267
Barnstable	-	-	-	-	500,000	1,250	1,200,000	3,000
Subtotal- Raw WW to WWTF	**140,000**	**389**	**352,000**	**978**	**1,211,000**	**3,225**	**2,348,000**	**6,522**

TABLE 2: EFFLUENT CONVEYANCE FLOWS

(Effluent Lift Station Peaking Factor: 1.25)

Flow Source	Existing Flows		Short-Term Flows		Mid-Term Flows		Long-Term Flows	
	Avg.	Peak	Avg.	Peak	Avg.	Peak	Avg.	Peak
	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)
JBCC	140,000	122	152,000	132	152,000	132	152,000	132
Bourne Effluent	-	-	100,000	87	444,000	385	651,000	565
Bourne-S	-	-	-	-	270,000	234	467,000	405
Falmouth	-	-	-	-	512,000	444	1,512,000	1,313
Mashpee	-	-	200,000	174	203,000	176	203,000	176
Sandwich	-	-	-	-	110,000	95	350,000	304
Barnstable	-	-	-	-	500,000	434	1,200,000	1,042
Total Effluent Disposal	**140,000**	**122**	**452 ,000**	**392**	**2,191,000**	**1,902**	**4,535,000**	**3,937**

- Raw wastewater concept design criteria:
  - Peaking factor used for lift station flow: 4.0
  - Peaking factor used for Barnstable lift station flow: 3.6
  - Minimum forcemain velocity: 3 fps
  - Maximum forcemain design pressure: 275 ft (120 psi)
- Effluent concept design criteria:
  - Peaking factor used for lift station flow: 1.25
  - Minimum forcemain velocity: none
  - Maximum forcemain design pressure: 275 ft (120 psi)
- Forcemain materials:
  - Existing effluent forcemain: ductile iron
  - Proposed forcemains: C900/C905 DR 18 PVC (235 psi) or HDPE (200 to 255 psi)
- Pump calculations:
  - Method: Hazen-Williams with friction value of 130
  - Pump Horsepower approximation per Hydraulic Institute method
  - Assumed pump efficiency for sewage: 50%
  - Assumed pump efficiency for effluent: 65%
- Medium-sized wastewater and effluent lift stations:
  - Flow: up to 1200 gpm
  - Pumps: submersible, up to 75 hp
  - Wetwell and valve vault
  - Generator and control panel in pump house
  - Conceptual construction cost: $1M each

- Large-sized wastewater and effluent lift stations:
  - Flow: 1200 gpm to 2000 gpm
  - Pumps: drypit installation, greater than 75 hp
  - Generator and control panel in pump building over wetpit/drypit installation
  - Conceptual construction cost: $2.5M each
- Very large-sized wastewater and effluent lift stations:
  - Flow: 2000 gpm or more
  - Pumps: drypit installation
  - Horsepower: up to 200 hp
  - Generator and control panel in pump building over wetpit/drypit installation
  - Conceptual construction cost: $5M each
  - For pumps requiring 300 hp, add an additional $1M.
- Air release structures
  - Located at high points
  - Conceptual construction costs: $25,000 each
- Conveyance routes utilizing existing JBCC gravity conveyance systems assume the rehabilitation of those sections through trenchless methods for options that do not include Barnstable. Rehabilitation costs are assumed to be $150 per foot. For options that include Barnstable, new gravity sewers required accommodate large flows are assumed to be $300 per foot.
- Forcemain costs vary depending on the conditions of the route and are shown below in Table 3. "Public Way/Dense" refers to a route within a public way with heavy traffic volumes or dense development and has a higher cost than a route referred to as "Public Way/Less Dense" which includes routes within a public way with little traffic. Force main costs assume full-depth trench paving and full-width mill and overlay.
- For the large-diameter effluent force main routes through JBCC, the costs for 18-inch and 20-inch force mains are approximates $200 /LF and $210 / LF, respectively.

TABLE 3: FORCEMAIN UNIT COSTS

Forcemain Diameter	Route Characteristics		
	Public Way/Dense (Cost/ft)	Public Way/ Less Dense (cost/ft)	Railroad Right of Way (cost/ft)
8-inch	$200	$180	$300
10-inch	$215	$195	$320
12-inch	$230	$210	$340
14-inch	$245	$225	$360
16-inch	$260	$240	$360
18-inch	$280	$250	$380
20-inch	$300	$260	$400

1.2 SUMMARY OF PREFERRED CONVEYANCE OPTIONS

Current preferred conveyance routes are shown on **Figure 2-1A** and identified as follows:

- Bourne North (effluent) – Proposed lift station at ISWM WWTF connected to existing JBCC effluent forcemain, via a new 8” Bourne forcemain.
- Bourne South – Proposed lift station at the intersection of Valley Bars and County Roads to JBCC WWTF via a new 12” Bourne forcemain and rehabilitated gravity sewer (shared with Sandwich).
- Falmouth (effluent) – Proposed lift station at BSR WWTF connected to the JBCC effluent forcemain(s) via a new 18” Falmouth forcemain in Routes 28 and 151.
- Mashpee – Proposed lift station on Back Road Site 1 (Town lot) to JBCC WWTF via new 8” Mashpee forcemain.
- Sandwich – Proposed lift station on portion of Lot-06-236 at 40 Route 130 to JBCC WWTF via 12” Sandwich forcemain, and rehabilitated gravity sewers (shared with Bourne).
- Barnstable – Proposed lift station at intersection of Route 130 and Falmouth Road to JBCC WWTF via a new 20” Barnstable forcemain through Newton Road to a shared Sandwich forcemain and new gravity sewers (shared with Sandwich and Bourne).

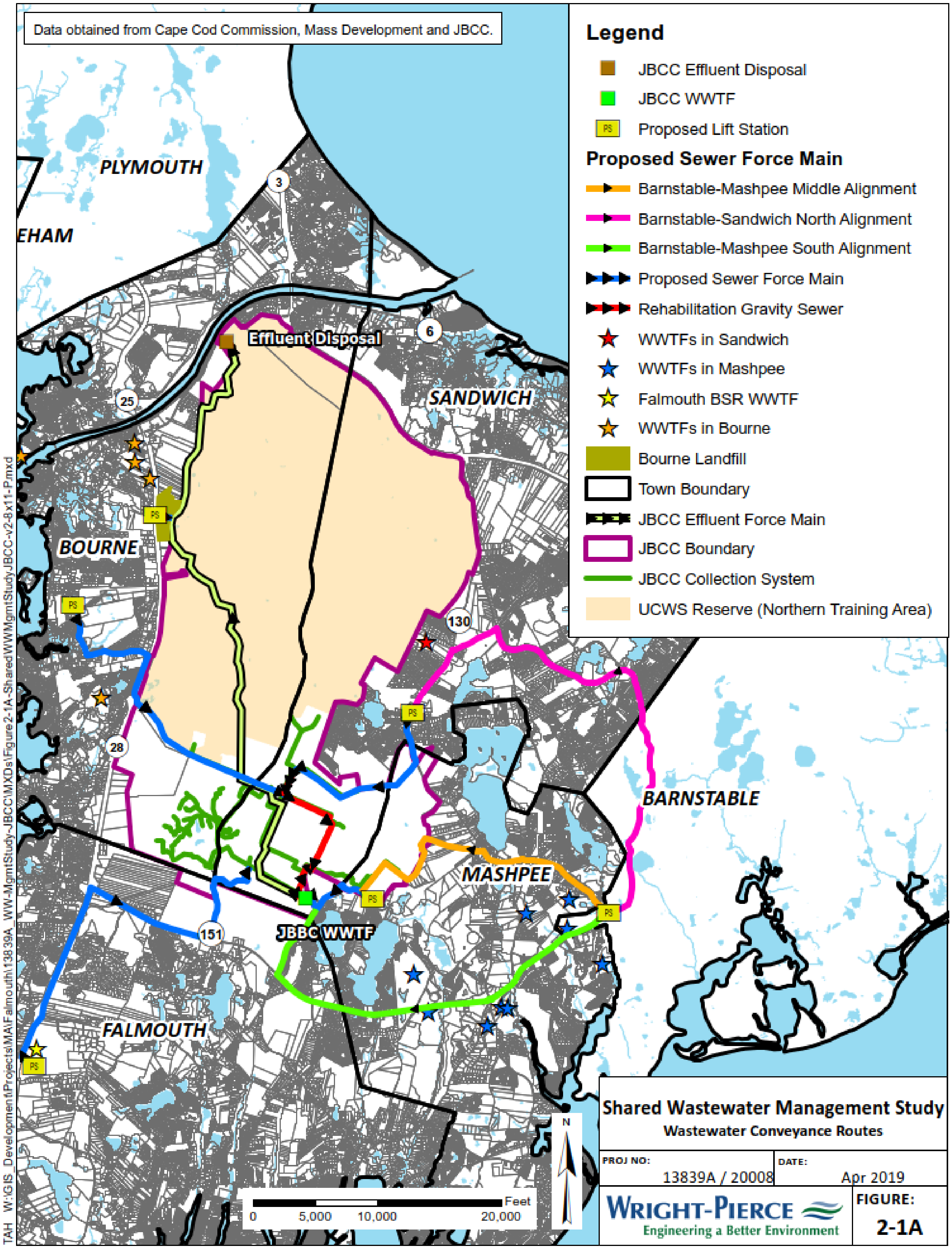
Data obtained from Cape Cod Commission, Mass Development and JBCC.
Legend
JBCC Effluent Disposal
JBCC WWTF
Proposed Lift Station
Proposed Sewer Force Main
Barnstable-Mashpee Middle Alignment
Barnstable-Sandwich North Alignment
Barnstable-Mashpee South Alignment
Proposed Sewer Force Main
Rehabilitation Gravity Sewer
WWTFs in Sandwich
WWTFs in Mashpee
Falmouth BSR WWTF
WWTFs in Bourne
Bourne Landfill
Town Boundary
JBCC Effluent Force Main
JBCC Boundary
JBCC Collection System
UCWS Reserve (Northern Training Area)
PLYMOUTH
EHAM
SANDWICH
BOURNE
BARNSTABLE
MASHPEE
FALMOUTH
Effluent Disposal
JBBC WWTF
Feet
0 5,000 10,000 20,000
N
Shared Wastewater Management Study
Wastewater Conveyance Routes
PROJ NO:
13839A / 20008
DATE:
Apr 2019
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FIGURE:
2-1A
TAH W:\GIS_Development\Projects\MA\Falmouth\13839A_WW-MgmtStudy-JBCC\MXDs\Figure2-1A-SharedWWMgmtStudyJBCC-v2-8x11-P.mxd

1.3 CONVEYANCE ALIGNMENTS EVALUATED

1.3.1 Bourne Alignments

The following alignments were investigated for Bourne sewage flow from the southern sections of town. This piping is required in the mid-term.

- Option 1. Shortest route through the JBCC base, utilizing existing JBCC gravity sewer
  - 1 large lift station, 1250 gpm, 235 ft TDH, 150 hp
  - 12” forcemain, velocity 3.6 fps, 5.1 miles
  - JBCC rehabilitated gravity sewer, 2.3 miles
  - Total route length: 7.4 miles
  - Advantages
    - Least expensive - by $4.1M
    - Shortest route by 2.1 miles
    - Shortest length within public way / dense route
  - Disadvantages
    - Uncertainty of obtaining construction easements within federal lands for forcemains
    - Uncertainty of the level of rehabilitation required for JBCC gravity sewers
- Option 2A. Route utilizing the Shining Sea bike corridor, 1 lift station
  - 1 large lift station, 1400 gpm, 250 ft TDH, 175 hp
  - 14” forcemain, velocity 3.0 fps, 9.5 miles
  - Total route length, 9.5 miles
- Option 2B. Route utilizing the Shining Sea bike corridor, 2 lift stations
  - 2 large lift stations, 1250 gpm, 175 ft TDH, 100 hp
  - 12” forcemain, velocity 3.6 fps, 9.5 miles
  - Total route length, 9.5 miles
- Option 3A. Route primarily in public way
  - 1 large lift station, 1400 gpm, 250ft TDH, 175 hp

- 14" forcemain, velocity 3.0 fps, 9.9 miles
- Total route length, 9.9 miles

- Option 3B. Route primarily in public way
  - 2 large lift stations, 1250 gpm, 175 ft TDH, 120 hp
  - 12" forcemain, velocity 3.6 fps, 9.9 miles
  - Total route length, 9.9 miles

Bourne Option 2A, 2B, 3A and 3B appear to be less favorable option based on the following:

- Advantage
  - Avoids having to obtain extensive construction easements within federal lands for forcemains
  - Avoids concern over the level of rehabilitation required for JBCC gravity sewers
- Disadvantage
  - High costs

One alignment was investigated for Bourne effluent flow from the ISWM WWTF to the JBCC effluent forcemain. We assumed the construction of a medium sized lift station to accommodate long-term conditions.

- 1 medium lift stations, 570 gpm, 180 ft TDH, 50 hp, Velocity 1.7 fps
- Existing 8" Forcemain, 100 feet

A summary of the Bourne-South Options is shown below.

TABLE 4: BOURNE CONVEYANCE ALTERNATIVES COMPARISON

Conveyance Feature		Option 1	Option 2A	Option 2B	Option 3A	Option 3B
Cost (2019 Dollars)	$M	10.5	15.2	17.0	16.1	17.8
Rehabilitated JBCC sewer (50% Share)	1000 ft	12.3	0.0	0.0	0.0	0.0
Medium PS (Bourne – North)	Each	1	1	1	1	1
Large PS	Each	1	1	2	1	2
Forcemain - public way/dense	1000 ft	12.7	17.8	17.8	38.5	38.5
Forcemain – public way/ less dense	1000 ft	14.5	32.2	32.2	13.5	13.5

1.3.2 Falmouth Alignments

The following alignments were investigated for Falmouth effluent flow from the BSR WWTF to the JBCC WWTF effluent forcemain. This piping is required in the mid-term.

- Option 1. Route in public way
  - 1 Large lift station, 1300 gpm, 220 ft TDH, 150 hp
  - 18” Falmouth effluent forcemain, velocity 1.7 fps, 6.7 miles
  - Total route length, 6.7 miles
  - Advantages
    - Least expensive by $100,000
    - Eliminates potentially expensive railroad coordination costs in Option 3
  - Disadvantage
    - Lengthy section of the route is in right of way
- Option 2. Route in public way, with semi-utilization of the Shining Sea bike corridor
  - 1 Large lift station, 1300 gpm, 220 ft TDH, 150 hp
  - 18” Falmouth effluent forcemain, velocity 1.7 fps, 8.1 miles
  - Total route length. 8.1 miles
  - Advantages
    - Shorter section of the route is in right of way
    - Eliminates potentially expensive railroad coordination costs in Option 3
  - Disadvantage
    - More expensive than Option 1 by $1M
- Option 3. Route in public way and rail right of way
  - 1 Large lift station, 1300 gpm, 220 ft TDH, 150 hp
  - 18” Falmouth effluent forcemain, velocity 1.7 fps, 5.3 miles
  - Total route length, 5.3 miles
  - Advantages
    - Shortest route
    - Potential to be less expensive with favorable railroad coordination costs

- Disadvantages
  - Costs associated with railroad safety and flagmen expenses during construction and regular operation
  - Efficient access to the rail corridor during and after construction
  - Potential damage from vibration caused by rail traffic

A summary of the Falmouth Conveyance Options is shown below.

TABLE 5: FALMOUTH CONVEYANCE ALTERNATIVES COMPARISON

Conveyance Feature		Option 1	Option 2	Option 3
Cost (2019 Dollars)	$M	12.1	13.8	11.8
Large PS	Each	1	1	1
Forcemain - public way/dense	1000 ft	25.9	20.1	13.8
Forcemain - railroad right of way	1000 ft	0.0	0.0	14.2
Forcemain -public way/less dense	1000 ft	9.5	22.6	0.0

1.3.3 Mashpee Alignments

The following alignments were investigated for Mashpee sewage flow to the JBCC WWTF. This piping is required in the short-term.

- Option 1. Mashpee forcemain to connect directly to JBCC WWTF
  - Medium lift station, 560 gpm, 75 ft TDH, 20 hp
  - 8” Dedicated Mashpee forcemain, velocity 3.5 fps, 1.4 miles
  - Total route length: 1.4 miles
  - Advantages
    - Least expensive by $1.7M
    - Shortest forcemain route by 3.4 miles
    - Reduced lift station size
    - Smaller diameter force main
  - Disadvantages
    - None

- Option 2. Mashpee forcemain to shared rehabilitated gravity main with Sandwich and Bourne
    - Medium lift station, 1040 gpm, 140 ft TDH, 70 hp
    - 12" Dedicated Mashpee forcemain, velocity 3.0 fps, 4.2 miles
    - JBCC rehabilitated gravity sewer, 0.6 miles, shared with Bourne and Sandwich
    - Total route length: 4.8 miles
    - If the existing 10-inch JBCC forcemain serving JBCC lift stations at Rocket Storage, Central Heating Plant and Hanger was rehabilitated or decommissioned, there could be cost advantages for Mashpee.
    - Advantages
        - Forcemain would be dedicated to Mashpee and maintaining correct operating conditions would be easier for Mashpee.
        - If the existing 10-inch JBCC forcemain serving JBCC lift stations at Rocket Storage, Central Heating Plant and Hanger was rehabilitated or decommissioned, there could be cost advantages for Mashpee.
    - Disadvantages
        - More expensive than Option 1 by $2.4M. (Note: Mashpee Option 3 requires Sandwich to choose Option 2 which is $0.8M more expensive for Sandwich).
- Option 3. Mashpee forcemain to forcemain shared with Sandwich and rehabilitated gravity main shared with Sandwich and Bourne
    - Medium lift station, 1040 gpm, 140 ft TDH, 70 hp
    - 12" Dedicated Mashpee forcemain, velocity 3.0 fps, 2.4 miles
    - 12" S Outer Road forcemain, 0.7 miles, shared with Sandwich
    - 12" Reilly Rd/Grandville Ave forcemain, 1.1 miles, shared with Sandwich
    - JBCC rehabilitated gravity sewer, 0.6 miles, shared with Bourne and Sandwich
    - Total route length: 4.8 miles

- Advantages
  - If the existing 10-inch JBCC forcemain serving JBCC lift stations at Rocket Storage, Central Heating Plant and Hanger was rehabilitated or decommissioned, there could be additional cost advantages.
- Disadvantages
  - More expensive than Option 1 by $1.7M.

A summary of the Mashpee options is shown below.

TABLE 6: MASHPEE CONVEYANCE ALTERNATIVES COMPARISON

Conveyance Feature		Option 1	Option 2	Option 3
Cost (2019 Dollars)	$M	2.5	5.8	5.0
Rehabilitated JBCC sewer (33% Share)	1000 ft	0	3.4	3.4
Medium PS	Each	1	1	1
Forcemain - public way/dense	1000 ft	7.5	3.0	3.0
Forcemain – public way/less dense	1000 ft	0	18.9	9.7
Forcemain – public way/less dense - 50% share with Sandwich	1000 ft	0	0.0	9.3

1.3.4 Sandwich Alignments

The following alignments were investigated for Sandwich sewage flow to the JBCC WWTF. The conveyance system is required in the mid-term.

- Option 1. Sandwich forcemain to connect to shared rehabilitated gravity main with Bourne
  - Medium lift station, 1050 gpm, 75 ft TDH, 40 hp
  - 12” Dedicated Sandwich forcemain, velocity 3.0 fps, 2.9 miles
  - JBCC rehabilitated gravity sewer, 0.4 miles
  - JBCC rehabilitated gravity sewer, 1.7 miles, shared with Bourne
  - JBCC rehabilitated gravity sewer, 0.6 miles, shared with Bourne
  - Total route length: 5.7 miles
  - Advantages

        - Least expensive by $0.8M
    - Disadvantages
        - Uncertainty of obtaining construction easements within federal lands for forcemains
        - Uncertainty of the level of rehabilitation required for JBCC gravity sewer mains.

- Option 2. Sandwich forcemain to connect shared forcemain with Mashpee (Mashpee Option 2) and shared rehabilitated gravity main with Bourne and Mashpee
    - Medium lift station, 1050 gpm, 140 ft TDH, 60 hp
    - 12” Dedicated Sandwich forcemain, velocity 3.0 fps, 4.2 miles
    - 12” S Outer Road forcemain, 0.7 miles, shared with Mashpee
    - 12” Reilly Rd/Grandville Ave forcemain, 1.1 miles, shared with Mashpee
    - JBCC rehabilitated gravity sewer, 0.6 miles, shared with Bourne and Sandwich
    - Total route length: 6.6 miles
    - Advantages
        - If Mashpee implements Option 2, there would be cost savings with implementation of Sandwich Option 2.
        - Shortest forcemain route by 0.9 miles
    - Disadvantages
        - More expensive by $0.8M
- Option 3: Sandwich forcemain to connect to Snake Pond Road, then to rehabilitated gravity
    - Medium lift station, 1050 gpm, 105 ft TDH, 60 hp
    - 12” Dedicated Sandwich forcemain, velocity 3.0 fps, 2.4 miles
    - JBCC rehabilitated gravity sewer, 0.4 miles
    - JBCC rehabilitated gravity sewer, 1.7 miles, shared with Bourne
    - JBCC rehabilitated gravity sewer, 0.6 miles, shared with Bourne
    - Total Route length: 5.1 miles
    - Advantages
        - Utilize public way, rather than federal lands
        - Shortest route

- Disadvantages
  - Uncertainty of obtaining construction easements within federal lands for forcemains
  - Uncertainty of the level of rehabilitation required for JBCC gravity sewer mains.

TABLE 7: SANDWICH CONVEYANCE ALTERNATIVES COMPARISON

Conveyance Feature		Option 1	Option 2	Option 3
Cost (2019 Dollars)	$M	5.6	6.9	5.2
Rehabilitated JBCC sewer (100% Share)	1000 ft	2.2	0.0	2.2
Rehabilitated JBCC sewer (50% Share)	1000 ft	12.3	3.4	12.1
Medium PS	Each	1	1	1
Forcemain - public way/dense	1000 ft	3.5	3.5	12.7
Forcemain – public way/less dense	1000 ft	11.9	18.3	0.0
Forcemain – public way/less dense – share with Mashpee	1000 ft	0.0	9.3	0.0

1.3.5 Barnstable Alignments

The following alignments were investigated for Barnstable sewage flow to the JBCC WWTF. Options 1A, 2A and 3A include cost sharing while Options 1B, 2B and 3B do not include cost sharing. Cost sharing is pro-rated based on flow. Barnstable represents 80% of flow when combined with Sandwich and represents 70% of the flow when combined with both Sandwich and Bourne.

- Option 1: Central Alignment through Mashpee
  - 1 very large lift station, 3000 gpm, 70 TDH, 200 hp, located at the intersection of Route 130 and Falmouth Road.
  - 20” forcemain, velocity 3.1 fps, 6.2 miles
    - 2.3 miles on Route 130
    - 0.9 miles on Ashumet Road
    - 1.8 miles on Riley St and Grandville Ave (JBCC roads)

        - 1.2 miles shared with Mashpee (19% of total length)
    - Advantages
        - Shortest route
        - Potential shared costs with Mashpee
        - Fewer major terrain changes
    - Disadvantages
        - Only 19% of route is shared
        - Uncertainty of obtaining construction easements within federal lands for forcemains
- Option 2: Southern Alignment through Mashpee
    - 1 very large lift station, 3000 gpm, 70 TDH, 200 hp, located at the intersection of Route 130 and Falmouth Road.
    - 20” forcemain, velocity 3.1 fps, 7.2 miles
        - 2.3 miles on Falmouth Road (Route 28)
        - 3.4 miles on Nathan Ellis Road (Route 151)
        - 1.2 miles on Sandwich Road
        - 0.3 miles on Simkins Road shared with Mashpee (4% of the route)
    - Advantages
        - Mid-length route
    - Disadvantages
        - Little potential for shared costs (4% of the route is shared with Mashpee)
        - Most of construction route in state highway on areas of high density (Route 28 and Route 151)
        - Terrain requires the installation of at least 6 air release structures.
- Option 3: Northern Alignment through Sandwich
    - 1 large lift station, 3000 gpm, 70 TDH, 300 hp, located at the intersection of Route 130 and Falmouth Road.
    - 20” forcemain, velocity 3.1 fps, 11.6 miles
        - 0.3 miles in Falmouth Road (Route 28)

        - 3.7 miles in Santuit/Newtown Rd
        - 2.3 miles in Farmersville Rd
        - 0.5 miles in Cotuit Road
        - 0.5 miles in Quaker Meeting House Road
        - 1.3 miles in Route 130
        - 3.0 miles shared with Sandwich (21% of the force main route)
    - JBCC new gravity sewer, 0.6 miles shared with Sandwich (4% of the total route)
    - JBCC new gravity sewer, 2.1 miles shared with Sandwich and Bourne (15% of the total route)
    - Total route length: 14.3 miles
    - Advantages
        - 40% of total route length is shared
        - Potential shared route with Sandwich and Bourne
        - Most shared cost
    - Disadvantages
        - Longest route compared to shortest route by 8 miles.
        - Uncertainty of obtaining construction easements within federal lands for forcemains
        - Uncertainty of the level of rehabilitation or replacement required for JBCC gravity sewer mains.
        - Highest costs

TABLE 8: BARNSTABLE CONVEYANCE ALTERNATIVES COMPARISON WITH COST SHARING

Conveyance Feature – With Shared Casts		Option 1A	Option 2A	Option 3A
Cost (2019 Dollars)	$M	13.9	16.2	25.7
Rehabilitated JBCC sewer (80% Share with Sandwich)	1000 ft	0.0	0.0	3.2
Rehabilitated JBCC sewer (70% Share with Sandwich and Bourne)	1000 ft	0.0	0.0	11.1
Very Large PS	Each	1	1	1
Forcemain - public way/dense	1000 ft	14.3	30.1	31.2
Forcemain – public way/less dense	1000 ft	12.1	6.3	14.3
Forcemain – public way/less dense (80% shared with Sandwich)	1000 ft	0.0	0.0	15.8
Forcemain – public way/less dense (80% shared with Mashpee)	1000 ft	6.4	1.6	0.0

TABLE 9: BARNSTABLE CONVEYANCE ALTERNATIVES COMPARISON WITHOUT COST SHARING

Conveyance Feature – With No Shared Casts		Option 1B	Option 2B	Option 3B
Cost (2019 Dollars)	$M	14.2	16.3	27.7
Rehabilitated JBCC sewer (80% Share with Sandwich)	1000 ft	0.0	0.0	3.2
Rehabilitated JBCC sewer (70% Share with Sandwich and Bourne)	1000 ft	0.0	0.0	11.1
Very Large PS	Each	1	1	1
Forcemain - public way/dense	1000 ft	14.3	30.1	31.2
Forcemain – public way/less dense	1000 ft	12.1	6.3	14.3
Forcemain – public way/less dense (80% shared with Sandwich)	1000 ft	0.0	0.0	15.8
Forcemain – public way/less dense (80% shared with Mashpee)	1000 ft	6.4	1.6	0.0

1.3.6 Effluent Conveyance Systems

The effluent conveyance system will require improvements to accommodate anticipated flow increases in each phase.

- Existing Conveyance System Data

  The existing effluent forcemain will remain in service until dual forcemains and associated pumping capacity are constructed. Characteristics of the existing forcemain are listed below.
  - Existing forcemain
    - 12-inch diameter
    - 10.8 miles
    - Ductile iron
    - Design friction factor, C, 130
    - Distance to high point, 5.8 miles (30,600 feet)
    - Static head: 210 feet
  - Existing system design assumptions
    - Conveyance main operates as a forcemain to the high point and forcemain friction calculations are based on 5.8 miles.
    - From the high point, around 150 feet of head is available to drive flow to the RIB's. A flow of about 1500 gpm uses up the available head.
    - With one pump running at the JBCC WWTF, there is available capacity in the short term for Bourne to discharge treated effluent into the JBCC forcemain at the ISWM.
- Proposed Effluent Forcemains

  In the long-term, the design effluent pumping and conveyance system will be required to handle a flow of approximately 4,000 gpm. The construction of a single large-diameter forcemain will provide increased capacity and valuable redundancy in the event that the 12-inch force main experiences a failure. The construction of the second large-diameter force main will allow the existing 12-inch forcemain to be abandoned or maintained for capacity redundancy. Two alternate routes were identified as outlined below, a match of the existing route and an alternate route with a lower static head and associated reduced pumping horsepower requirements and related operating costs.

- Proposed 20-inch forcemain (Following existing route)
    - Following existing route (parallel to existing 12-inch forcemain)
    - 20-inch diameter
    - 10.8 miles
    - Distance to high point, 5.8 miles (30,600 feet)
    - Static head: 210 feet
    - 160 HP required for pump station
- Proposed 18-inch forcemains (Alternate route with lower static head)
    - Following improved route with lower static head and TDH
    - 18-inch diameter
    - 10.9 miles
    - Distance to high point, 5.0 miles (26,400 feet)
    - Static head: 95 feet
    - 100 HP required for pump station

1.4 SCHEDULE OF IMPROVEMENTS

1.4.1 Short-term improvements:

- JBCC / All Participants
  - Maintain operation of existing lift station and forcemain
  - Accommodate flows from JBCC and Mashpee arriving at the effluent lift station (252,000 gpd / peaked pump flow of 320 gpm)
- Bourne
  - At the ISWM, install a lift station designed to accommodate mid-term and long-term flows
  - Make connection to existing JBCC forcemain
  - Install additional valves and stubs to make a future connection to new effluent forcemains without disrupting service.
- Falmouth – no changes
- Mashpee
  - Construct Mashpee lift station and forcemain conveying flow to the WWTF.
- Sandwich – no changes
- Barnstable – no changes

1.4.2 Mid-term improvements:

- JBCC / All Participants
  - Maintain operation of existing lift station and forcemain.
  - Accommodate effluent from JBCC, Bourne-South, Mashpee and Sandwich .in the existing effluent forcemain (peaked pump flow of 640 gpm).
  - Construct new 18-inch forcemain from Falmouth connection to the RIB's with interconnection valving with existing 12-inch forcemain.
- Bourne
  - Connect ISWM forcemain into new 18-inch forcemain (peaked flows increase from 87 to 385 gpm).

    - Construct Bourne Option 1 including lift station, forcemain and JBCC gravity sewer rehabilitation.
- Falmouth
    - Construct Falmouth 18-inch forcemain to valving interconnection with existing 12-inch forcemain and new 18-inch forcemain.
    - Direct Falmouth flow to new 18-inch forcemain (peaked pump flow of 444 gpm).
    - Make future provisions for future 18-inch effluent forcemain
- Mashpee – no changes
- Sandwich
    - Construct Sandwich lift station, forcemain and JBCC gravity sewer rehabilitation.

- Barnstable
    - Construct Barnstable lift station, forcemain, and new JBCC gravity sewers.

1.4.3 Long-term improvements

- JBCC / All Participants
    - Construct second 18-inch effluent forcemain and interconnections and connect Bourne and Falmouth to the second forcemain.

ATTACHMENT A

Conveyance Options Worksheets

LIST OF FIGURES

Bourne-N Option 1 Preferred

Option 1. Bourne force main to existing JBCC effluent force main

Site Conditions:

Single Pump Station

Length (miles), (ft)	-	100 total length — Run friction calc only to high point
Average C	130	
Low point (ft)	108	(Existing grade at pump station minus 25 feet)
High point(ft)	285	(Existing grade at pump station minus 5 feet)
Static Head(ft)	177	

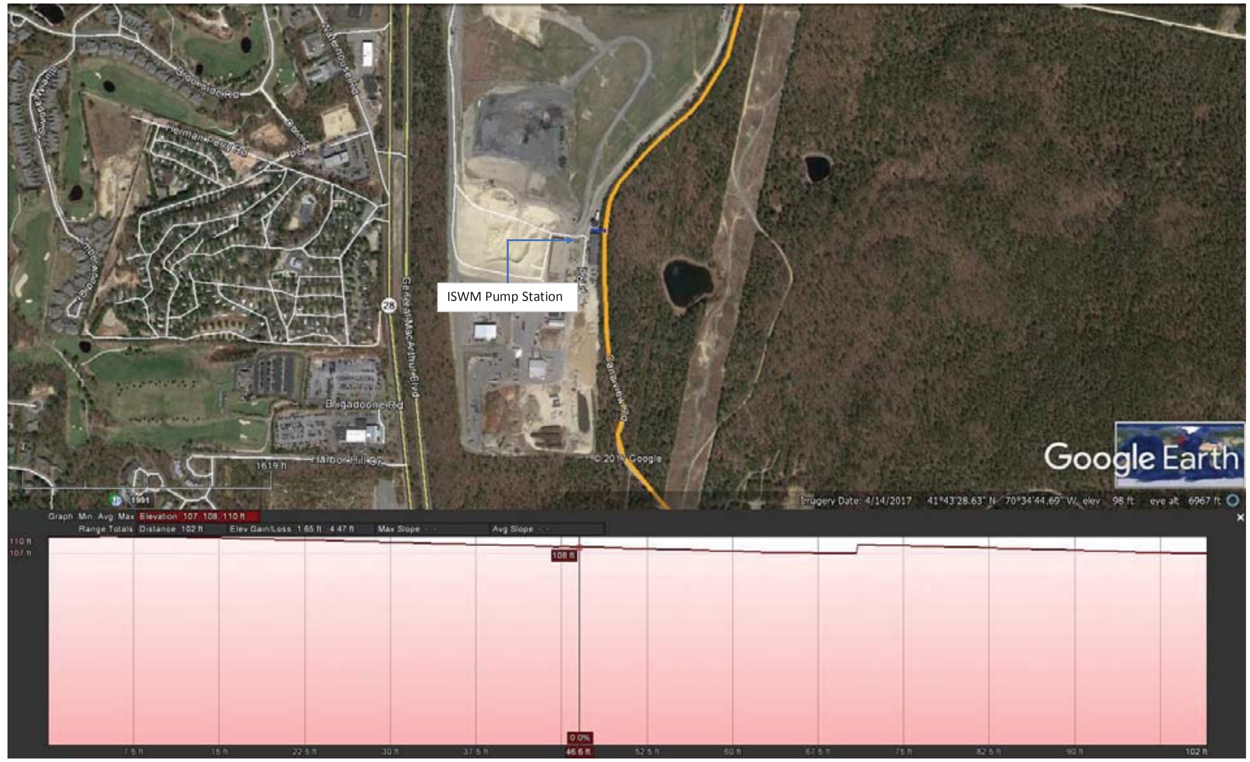
Flow Conditions:

Flow Source	Existing		Near-Term		Mid-Term		Long-Term	
	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q
	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)
Bourne-N	-	-	100,000	87	444,000	385	651,000	565
Add'l flow for min v	-	-	-	-	-	-	-	-
Total	-	-	100,000	87	444,000	385	651,000	565
Flow(cfs)		0.00		0.19		0.86		1.26

Segment 1 Pipe Diameter Analysis:

FM Dia (in)	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
3	0.0	177	3.9	179	17.5	214	25.7	253
4	0.0	177	2.2	178	9.8	186	14.4	196
6	0.0	177	1.0	177	4.4	178	6.4	180
8	0.0	177	0.6	177	2.5	177	3.6	178
10	0.0	177	0.4	177	1.6	177	2.3	177
12	0.0	177	0.2	177	1.1	177	1.6	177

Figure 1-1



Bourne Option 1 **Preferred**

Option 1. Bourne force main to shared rehabilitated gravity main with Sandwich and Mashpee

Site Conditions:

Single Pump Station **Preferred**

Length (miles), (ft)	3.23	17054.4 total length — Run friction calc only to high point
Average C	130	
Low point (ft)	5	(Existing grade at pump station minus 25 feet)
High point(ft)	175	(Existing grade at pump station minus 5 feet)
Static Head(ft)	170	

Flow Conditions:

Flow Source	Existing		Near-Term		Mid-Term		Long-Term	
	Avg Q (gpd)	Peak Q (gpm)	Avg Q (gpd)	Peak Q (gpm)	Avg Q (gpd)	Peak Q (gpm)	Avg Q (gpd)	Peak Q (gpm)
Bourne-S	-	-	-	-	259,000	719	456,000	1,267
Add'l flow for min v	-	-	-	-	-	-	-	-
Total	-	-	-	-	259,000	719	456,000	1,267
Flow(cfs)		0.00		0.00		1.60		2.82

Single FM Pipe Diameter Analysis:

FM Dia (in)	Velocity (ft/s)	Headloss (ft)	Velocity (ft/s)	Headloss (ft)	Velocity (ft/s)	Headloss (ft)	Velocity (ft/s)	Headloss (ft)
6	0.0	170	0.0	170	8.2	861	14.4	2137
8	0.0	170	0.0	170	4.6	340	8.1	655
10	0.0	170	0.0	170	2.9	227	5.2	334
12	0.0	170	0.0	170	2.0	194	3.6	237
14	0.0	170	0.0	170	1.5	181	2.6	202

Figure 2-1

Figure 2-2

Bourne Option 2
Description: Bourne Raw Wastewater Forcemain-Shining Sea Alternate Path.

Option 2A Single Pump Station Option

Length (miles), (ft)	9.48	50054.4
Average C	130	
Low point (ft)	5	
High Point (ft)	135	
Static Head(ft)	130	

Option 2B Two Pump Station Option

Segment 1 9.48 total length

Length (miles), (ft)	5.1	26928
Average C	130	
Low point (ft)	5	(Existing grade at pump station minus 25 feet)
High point(ft)	75	(Existing grade at pump station minus 5 feet)
Static Head(ft)	70	

$$H.L. = 3.02LD^{(-1.167)}(V/C_h)^{1.85}$$

Segment 2

Length (miles), (ft)	4.38	23126.4
Average C	130	
Low point (ft)	55	(Existing grade at pump station minus 25 feet)
High point(ft)	135	(Existing grade at pump station minus 5 feet)
Static Head(ft)	80	

Flow Conditions:

Flow Source	Existing		Near-Term		Mid-Term		Long-Term	
	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q
	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)
Bourne-S	-	-	-	-	259,000	719	456,000	1,267
Add'l flow for min v	-	-	-	-	-	-	-	153
Total	-	-	-	-	259,000	719	456,000	1,420
Flow(cfs) - 14" FM		0.00		0.00		1.60		3.16
Flow(cfs) - 12" FM								2.82

Option 2A-Single Pump Station

Single Force Main Pipe Diameter Analysis:

FM Dia (in)	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
12	0.0	130	0.0	130	2.0	199	4.0	374
14	0.0	130	0.0	130	1.5	163	3.0	245

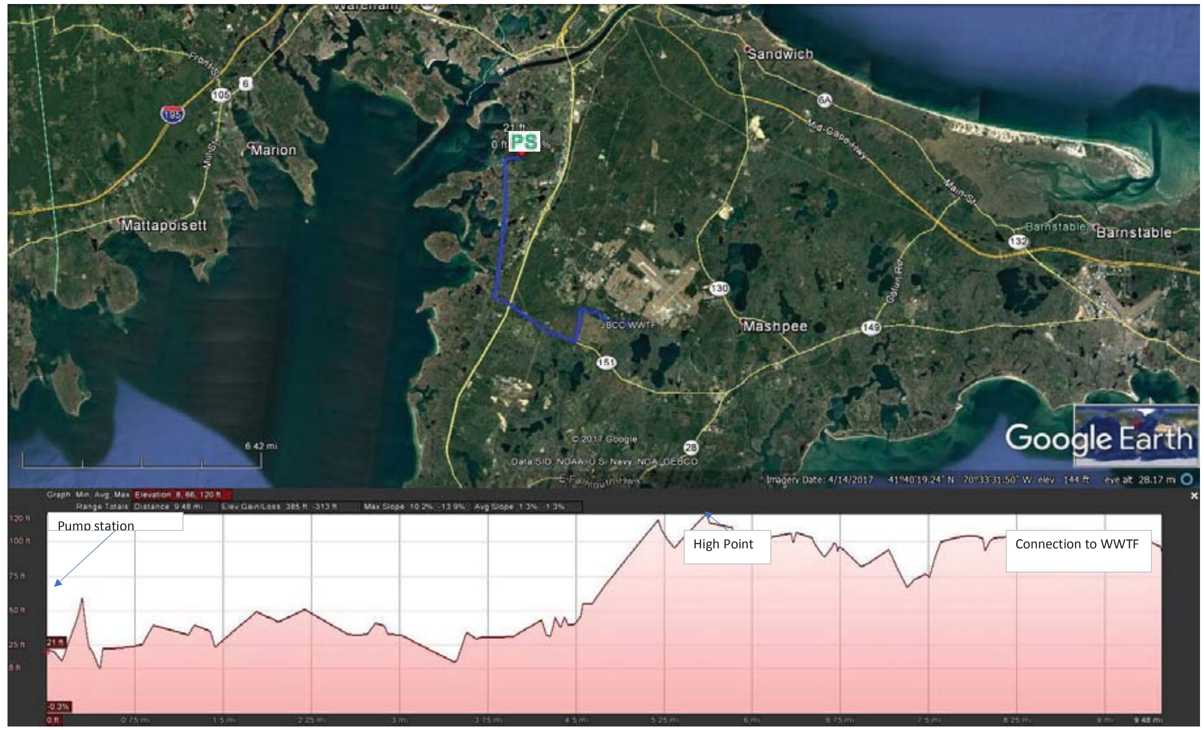
Option 2B- Two Pump Stations

Segment 1: Pipe Diameter Analysis:

FM Dia (in)	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
12	0.0	70	0.0	70	2.0	107	3.6	176
14	0.0	70	0.0	70	1.5	88	2.6	120

Segment 2: Pipe Diameter Analysis:

FM Dia (in)	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
12	0.0	80	0.0	80	2.0	112	3.6	171
14	0.0	80	0.0	80	1.5	95	2.6	123



Bourne Option 3

Description: Force main dedicated to future Bourne Raw Wastewater pump flow.

Site Conditions:

Option 3A - Single Pump Station

Length (miles), (ft)	9.85	52008	5.5
Average C	130		
Low point (ft)	5	(Existing grade at pump station minus 25 feet)	
High point(ft)	135	(Existing grade at pum	100
Static Head(ft)	130		

$$H.L. = 3.02LD^{(-1.167)}(V/C_h)^{1.85}$$

Option 3B- Two Pump Stations

Segment 1

	9.85	total length
Length (miles), (ft)	5.5	29040
Average C	130	
Low point (ft)	5	(Existing grade at pump station minus 25 feet)
High point(ft)	100	(Existing grade at pump station minus 5 feet)
Static Head(ft)	95	

$$H.L. = 3.02LD^{(-1.167)}(V/C_h)^{1.85}$$

Segment 2

Length (miles), (ft)	4.35	22968
Average C	130	
Low point (ft)	80	(Existing grade at pump station minus 25 feet)
High point(ft)	135	(Existing grade at pump station minus 5 feet)
Static Head(ft)	55	

Flow Conditions

Flow Source	Existing		Near-Term		Mid-Term		Long-Term	
	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q
	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)
Bourne-S	-	-	-	-	259,000	719	456,000	1,267
Add'l flow for min v	-	-	-	-	-	-	-	153
Total	-	-	-	-	259,000	719	456,000	1,420
Flow(cfs)		0.00		0.00		1.60		3.16
Flow(cfs) - 12" FM								2.82

Option 3A -Single FM Pipe Diameter Analysis:

FM Dia (in)	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
12	0.0	130	0.0	130	2.0	202	4.0	384
14	0.0	130	0.0	130	1.5	164	3.0	250

Option 3B- Two Pump Stations Option

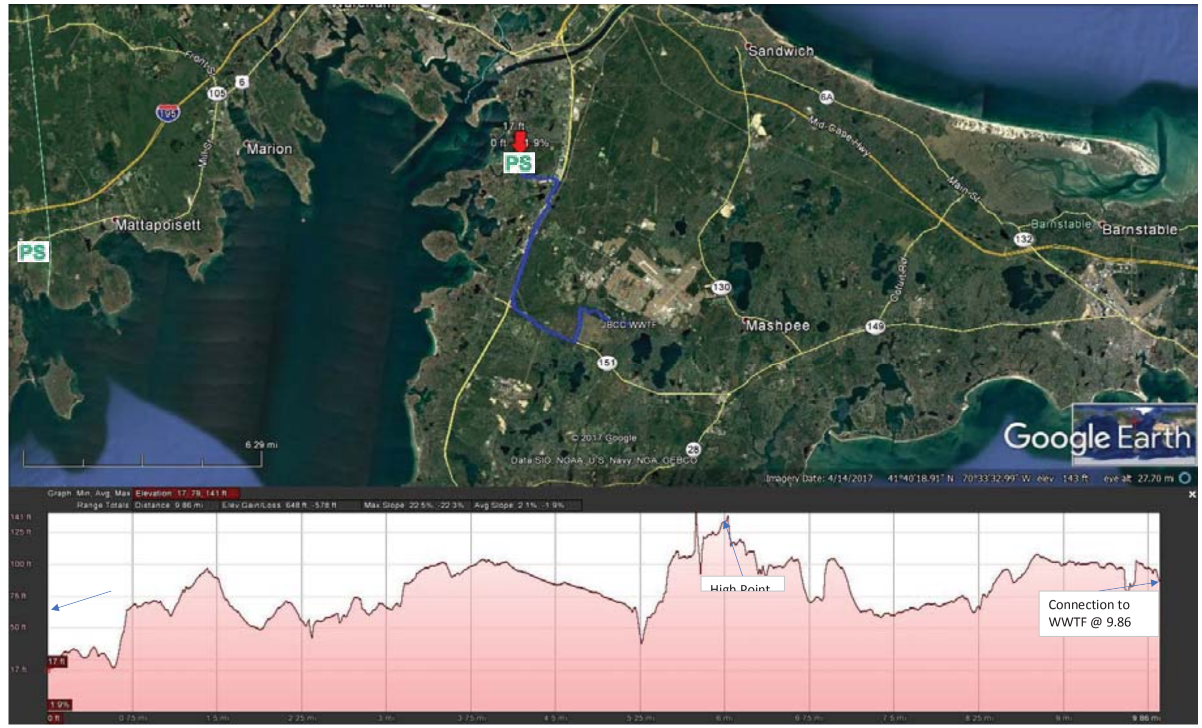
Segment 1: Pipe Diameter Analysis:

FM Dia (in)	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
12	0.0	95	0.0	95	2.0	135	3.6	210
14	0.0	95	0.0	95	1.5	114	2.6	149

Segment 2: Pipe Diameter Analysis:

FM Dia (in)	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
12	0.0	55	0.0	55	2.0	87	3.6	146
14	0.0	55	0.0	55	1.5	70	2.6	98

Figure 2-3



Falmouth Option 1 Preferred

Description: Force main dedicated to future Falmouth pump flow.

Site Conditions:

Length (miles), (ft)		
Falmouth	6.67	35217.6
JBBC to High Point	5.8	30624
Total Length	12.47	65841.6
Average C	130	
Low point (ft)	110	(Existing grade at pump station minus 10 feet)
High point(ft)	286	(effluent force main Highpoint)
Static Head(ft)	176	

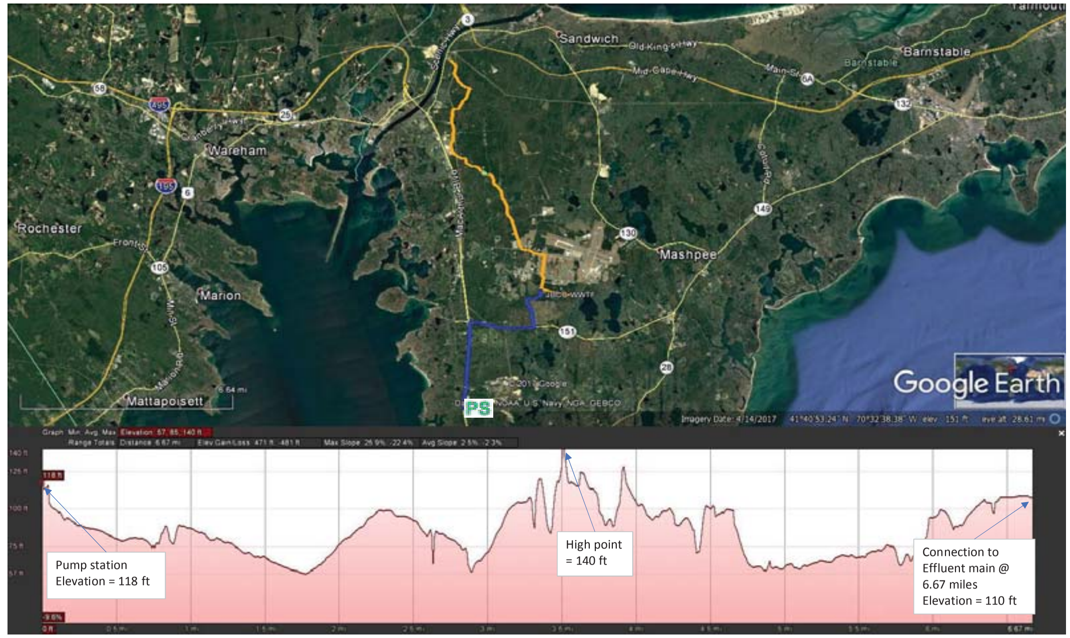
Flow Condtions:

Flow Source	Existing		Near-Term		Mid-Term		Long-Term	
	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q
	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)
Falmouth	-	-	-	-	512,000	444	1,512,000	1,313
Add'l flow for min v	-	-	-	-	-	-	-	-
Total	-	-	-	-	512,000	444	1,512,000	1,313
Flow(cfs)		0.00		0.00		0.99		2.92

Pipe Diameter Analysis:

FM Dia (in)	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
8	0.0	176	0.0	176	2.8	446	8.4	2176
10	0.0	176	0.0	176	1.8	267	5.4	851
12	0.0	176	0.0	176	1.3	213	3.7	454
14	0.0	176	0.0	176	0.9	194	2.7	307
16	0.0	176	0.0	176	0.7	185	2.1	245
18	0.0	176	0.0	176	0.6	181	1.7	215
20	0.0	176	0.0	176	0.5	179	1.3	199
22	0.0	176	0.0	176	0.4	178	1.1	191
24	0.0	176	0.0	176	0.3	177	0.9	186

Figure 3-1



Falmouth Option 2

Description: Force main dedicated to future Falmouth disposal to JBCC using existing shining sea bikeway

Site Conditions:

Length (miles), (ft)		
Falmouth	8.09	42715.2
JBBC to High Point	5.8	30624
Total Length	13.89	73339.2 For TDH Calc
Average C	130	
Low point (ft)	110	(Existing grade at pump station minus 10 feet)
High point(ft)	286	(effluent force main Highpoint)
Static Head(ft)	176	

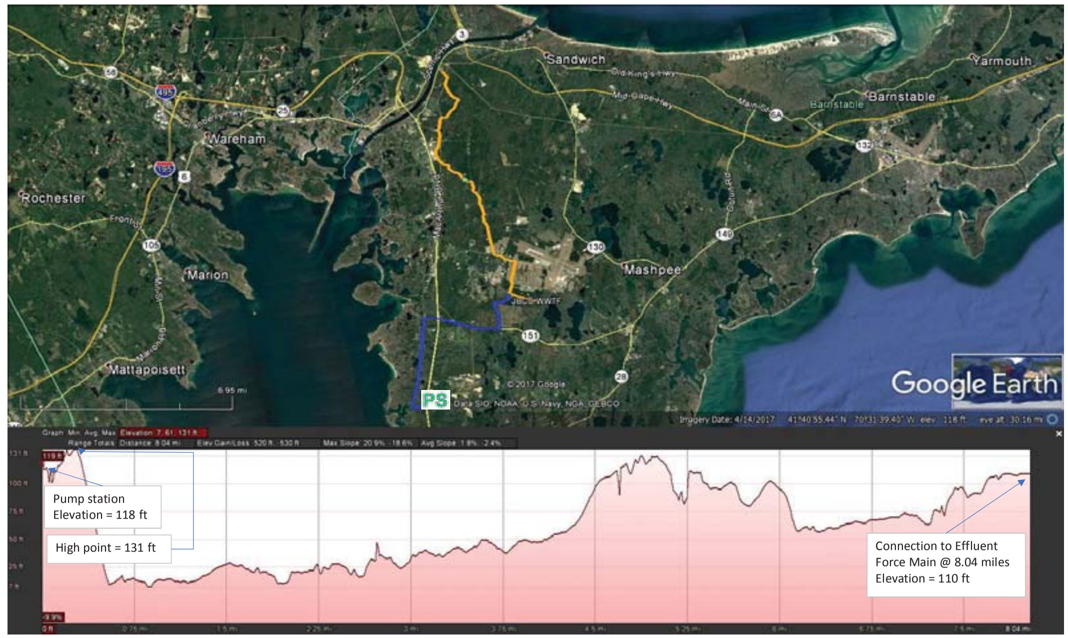
Flow Conditions:

Flow Source	Existing		Near-Term		Mid-Term		Long-Term	
	Avg Q (gpd)	Peak Q (gpm)	Avg Q (gpd)	Peak Q (gpm)	Avg Q (gpd)	Peak Q (gpm)	Avg Q (gpd)	Peak Q (gpm)
Falmouth	-	-	-	-	512,000.00	444.44	1,512,000.00	1,312.50
Add'l flow for min v	-	-	-	-	-	-	-	-
Total	-	-	-	-	512,000.00	444.44	1,512,000.00	1,312.50
Flow(cfs)		0.00		0.00		0.99		2.92

Pipe Diamter Anaylsis:

FM Dia (in)	Velocity (ft/s)	Headloss (ft)	Velocity (ft/s)	Headloss (ft)	Velocity (ft/s)	Headloss (ft)	Velocity (ft/s)	Headloss (ft)
8	0.0	176	0.0	176	2.8	476	8.4	2404
10	0.0	176	0.0	176	1.8	277	5.4	928
12	0.0	176	0.0	176	1.3	218	3.7	486
14	0.0	176	0.0	176	0.9	196	2.7	322
16	0.0	176	0.0	176	0.7	186	2.1	252
18	0.0	176	0.0	176	0.6	182	1.7	219
20	0.0	176	0.0	176	0.5	179	1.3	202
22	0.0	176	0.0	176	0.4	178	1.1	192
24	0.0	176	0.0	176	0.3	177	0.9	187

Figure 3-2



Falmouth Option 3

Description: Force main dedicated to future Falmouth disposal to JBCC WWTF, routed along JBCC rail line

Site Conditions:

Length (miles), (ft)		
Falmouth	5.3	27984
JBBC to High Point	5.8	30624
Total Length	11.1	58608 For TDH Calc
Average C	130	
Low point (ft)	110	(Existing grade at pump station minus 10 feet)
High point(ft)	286	(effluent force main Highpoint)
Static Head(ft)	176	

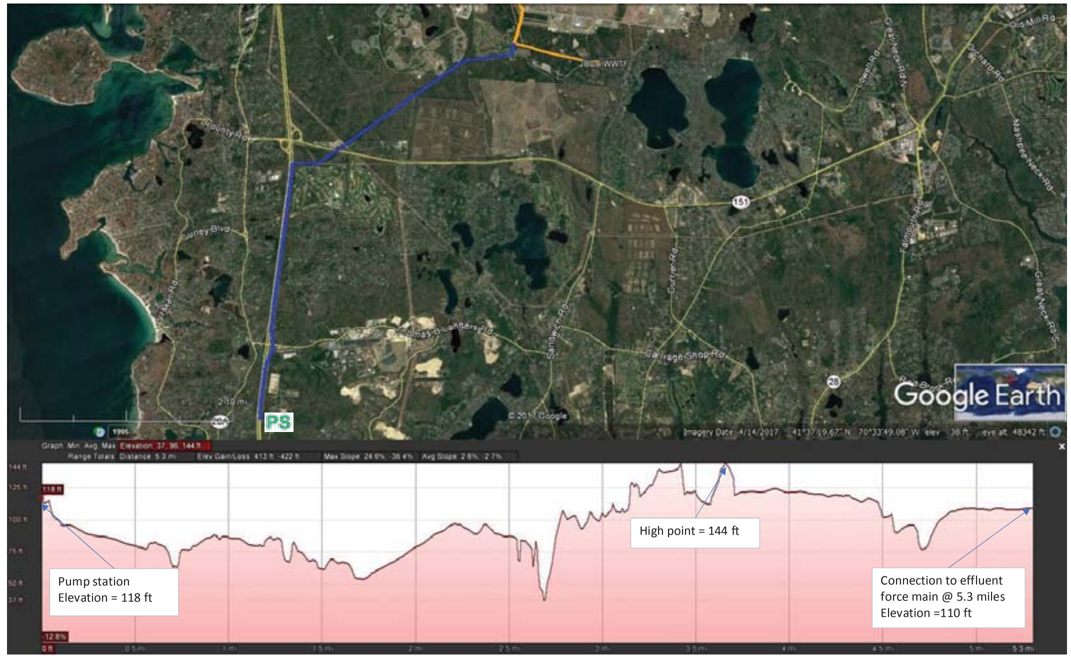
Flow Conditions:

Flow Source	Existing		Near-Term		Mid-Term		Long-Term	
	Avg Q (gpd)	Peak Q (gpm)	Avg Q (gpd)	Peak Q (gpm)	Avg Q (gpd)	Peak Q (gpm)	Avg Q (gpd)	Peak Q (gpm)
Falmouth	-	-	-	-	512,000.00	444.44	1,512,000.00	1,312.50
Add'l flow for min v	-	-	-	-	-	-	-	-
Total	-	-	-	-	512,000.00	444.44	1,512,000.00	1,312.50
Flow(cfs)		0.00		0.00		0.99		2.92

Pipe Diamter Anaylsis:

FM Dia (in)	Velocity (ft/s)	Headloss (ft)	Velocity (ft/s)	Headloss (ft)	Velocity (ft/s)	Headloss (ft)	Velocity (ft/s)	Headloss (ft)
8	0.0	176	0.0	176	2.8	416	8.4	1956
10	0.0	176	0.0	176	1.8	257	5.4	777
12	0.0	176	0.0	176	1.3	209	3.7	423
14	0.0	176	0.0	176	0.9	192	2.7	293
16	0.0	176	0.0	176	0.7	184	2.1	237
18	0.0	176	0.0	176	0.6	181	1.7	210
20	0.0	176	0.0	176	0.5	179	1.3	197
22	0.0	176	0.0	176	0.4	178	1.1	189
24	0.0	176	0.0	176	0.3	177	0.9	184

Figure 3-3



Mashpee Option 1 **Preferred**
Mashpee force main to JBCC WWTF
Site Conditions:

Length (miles), (ft)		
Mashpee	1.42	7497.6
Average C	130	
Low point (ft)	72	(Existing grade at pump station minus 25 feet)
High point(ft)	102	
Static Head(ft)	30	

Flow Conditions:

Flow Source	Existing		Near-Term		Mid-Term		Long-Term	
	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q
	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)
Mashpee	-	-	200,000	556	200,000	556	200,000	556
Total	-	-	200,000	556	200,000	556	200,000	556
Flow(cfs)		0.00		1.24		1.24		1.24

Pipe Diameter Analysis:

FM Dia (in)	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
8	0.0	30	3.5	76	3.5	76	3.5	76
10	0.0	30	2.3	46	2.3	46	2.3	46
12	0.0	30	1.6	36	1.6	36	1.6	36

Figure 4-1

Mashpee Option 2

Mashpee force main to shared force main and rehabilitated gravity main with Sandwich and Bourne

Site Conditions:

Length (miles), (ft)			
Mashpee	2.4	12672	
Mashpee-Sandich FM	1.77	9345.6	
Total Length	4.17	22017.6	
Average C	130		
Low point (ft)	26	(Existing grade at pump station minus 25 feet)	
High point(ft)	101		
Static Head(ft)	75		

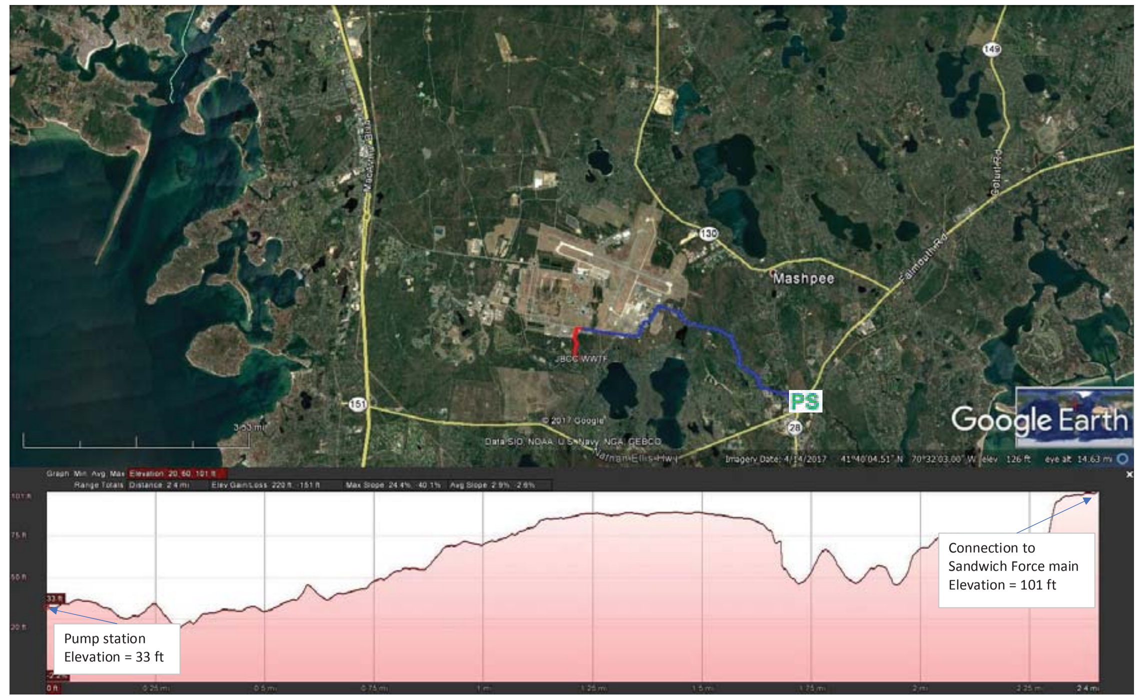
Flow Conditions:

Flow Source	Existing		Near-Term		Mid-Term		Long-Term	
	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q
	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)
Mashpee	-	-	200,000	556	200,000	556	200,000	556
Add'l flow for min v	-	-	-	-	-	-	175,000	486
Total	-	-	200,000	556	200,000	556	375,000	1,042
Flow(cfs)		0.00		1.24		1.24		2.32

Pipe Diameter Analysis:

FM Dia (in)	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
10	0.0	75	2.3	121	2.3	121	4.3	222
12	0.0	75	1.6	94	1.6	94	3.0	136

Figure 4-2



Mashpee Option 3

Mashpee force mains to shared rehabilitated gravity main with Sandwich and Bourne

Site Conditions:

Length (miles), (ft)			
Mashpee	3.4	17952	
Mashpee to Gravity	0.74	3907.2	
Total Length	4.14	21859.2	
Average C	130		
Low point (ft)	26	(Existing grade at pump station minus 25 feet)	
High point(ft)	101		
Static Head(ft)	75		

Flow Conditions:

Flow Source	Existing		Near-Term		Mid-Term		Long-Term	
	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q
	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)
Mashpee	-	-	200,000	556	200,000	556	200,000	556
Add'l flow for min v	-	-	-	-	-	-	175,000	486
Total	-	-	200,000	556	200,000	556	375,000	1,042
Flow(cfs)		0.00		1.24		1.24		2.32

Pipe Diameter Analysis:

FM Dia (in)	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
10	0.0	75	2.3	121	2.3	121	4.3	221
12	0.0	75	1.6	94	1.6	94	3.0	135

Figure 4-3

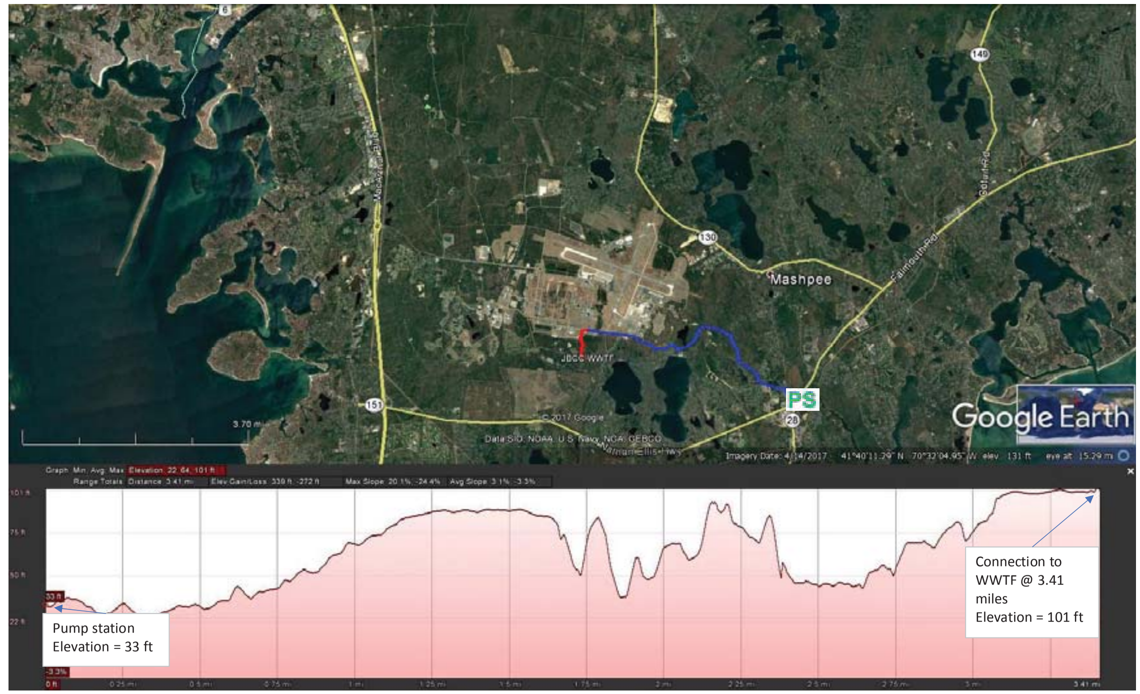


Figure 5-1

Sandwich Option 1 **Preferred**

Description: Force main for Sandwich raw wastewater connection to existing system

Site Conditions:

Length (miles), (ft)	2.92	15417.6
Average C	130	
Low point (ft)	107	(Existing grade at pump station minus 25 feet)
High point(ft)	140	
Static Head(ft)	33	

Flow Conditions:

Flow Source	Existing		Near-Term		Mid-Term		Long-Term	
	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q
	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)
Sandwich	-	-	-	-	100,000	278	340,000	944
Add'l flow for min v								100
Total	-	-	-	-	100,000	278	340,000	1,044
Flow(cfs)		0.00		0.00		0.62		2.33

Pipe Diameter Analysis

FM Dia (in)	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
6	0.0	33	0.0	33	3.2	140	11.9	1278
8	0.0	33	0.0	33	1.8	59	6.7	340
10	0.0	33	0.0	33	1.1	42	4.3	137
12	0.0	33	0.0	33	0.8	37	3.0	76

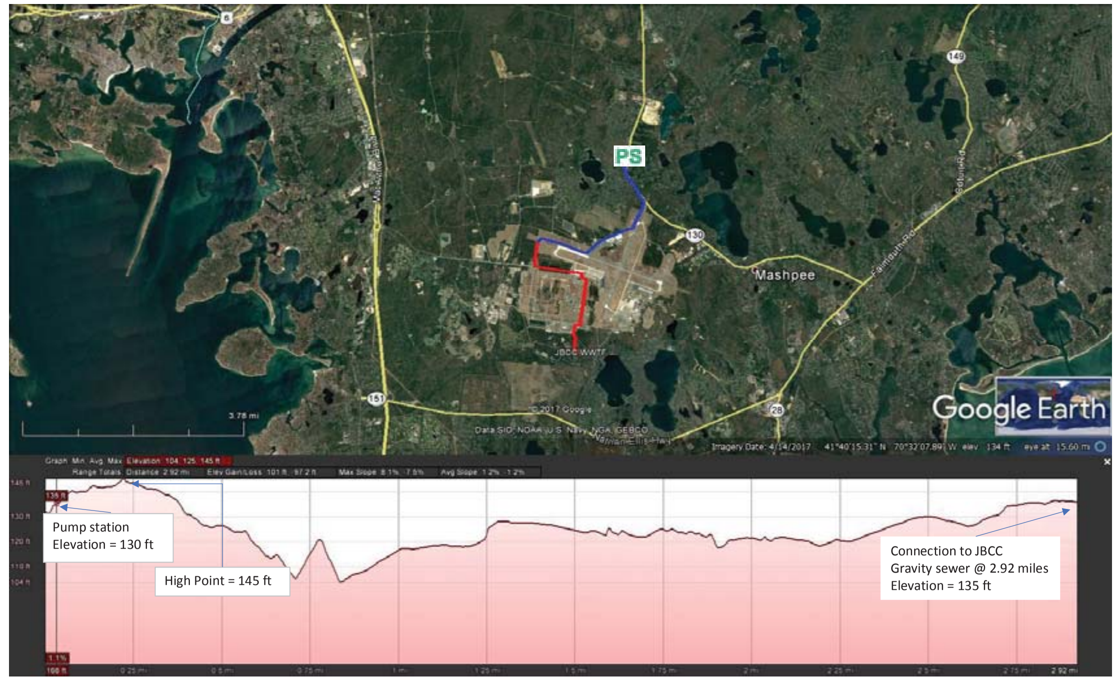


Figure 5-2

Sandwich Option 2

Description: Sandwich force main for shared force main with Mashpee and shared gravity main with Mashpee and Bourne

Site Conditions:

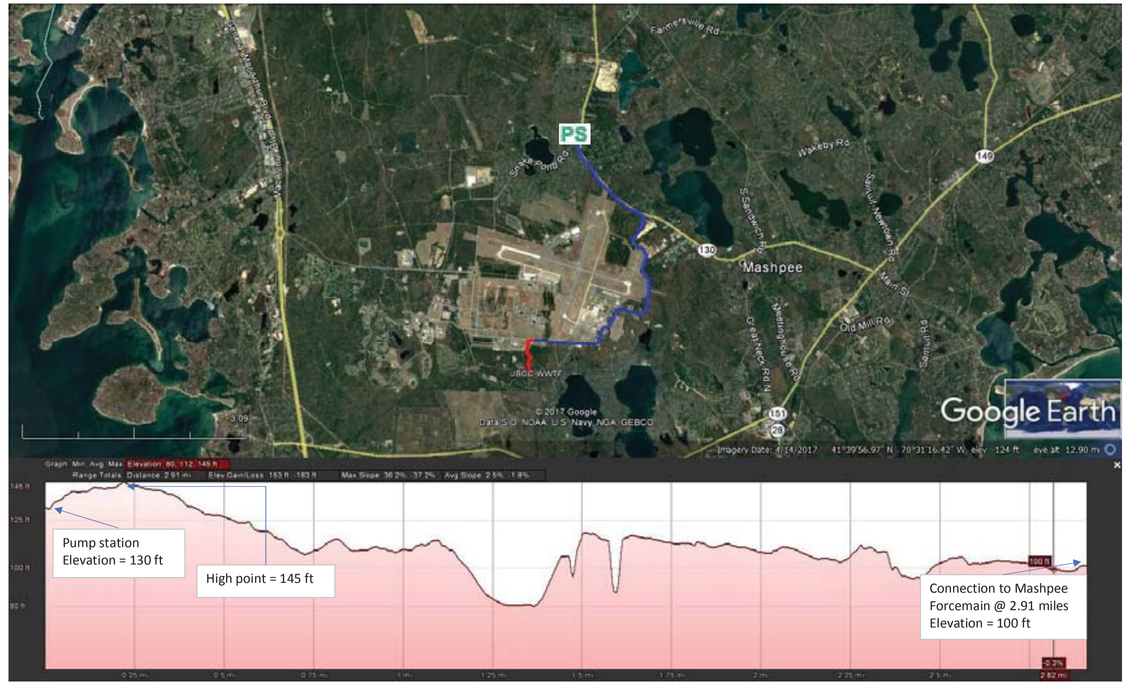
Length (miles), (ft)			
Sandwich	2.9	15312	
Mashpee-Sandich FM	1.77	9345.6	
Total Length	4.67	24657.6	
Average C	130		
Low point (ft)	110	(Existing grade at pump station minus 25 feet)	
High point(ft)	145	(Existing grade minus 5 feet)	
Static Head(ft)	35		

Flow Conditions:

Flow Source	Existing		Near-Term		Mid-Term		Long-Term	
	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q
	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)
Sandwich	-	-	-	-	100,000	278	340,000	944
Add'l flow for min v	-	-	-	-	-	0	-	100
Total	-	-	-	-	100,000	278	340,000	1,044
Flow(cfs)		0.00		0.00		0.62		2.33

Pipe Diameter Analysis:

FM Dia (in)	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
6	0.0	35	0.0	35	3.2	207	11.9	2026
8	0.0	35	0.0	35	1.8	77	6.7	526
10	0.0	35	0.0	35	1.1	49	4.3	201
12	0.0	35	0.0	35	0.8	41	3.0	103



JBCC Effluent Disposal Force Main

Description: Existing force main for JBCC Effluent pumped flow.

	Miles	Ft	1000 ft	
Length	10.8	57,024	57.0	
Length	5.8	30,624	30.6	(Headloss Calc)
Average C	130			
Low point (ft)	75	(Existing grade at pump station minus 25 feet)		
High point(ft)	286			
Static Head(ft)	211			

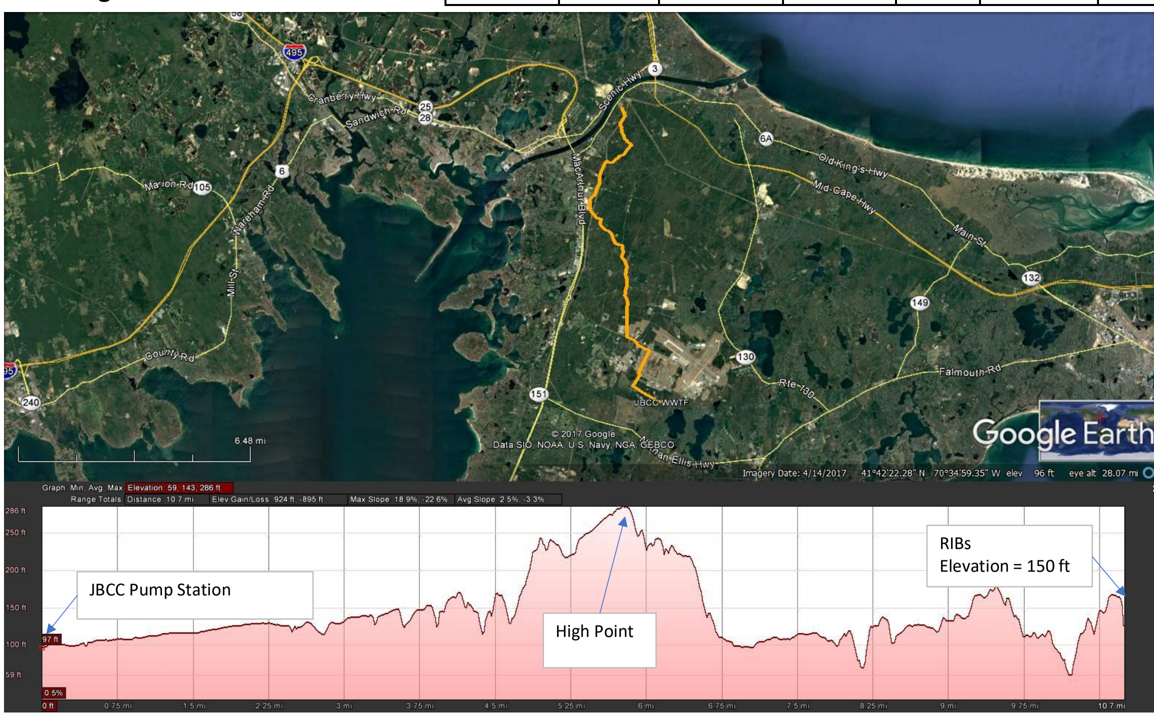
Flow Conditions:

Flow Source	Existing		Near-Term		Mid-Term		Long-Term	
	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q
	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)
JBCC	140,000	122	152,000	132	152,000	132	152,000	132
Bourne-Effl	-	-	-	-	-	-	-	-
Bourne-S	-	-	-	-	270,000	234	467,000	405
Falmouth	-	-	-	-	512,000	444	1,512,000	1,313
Mashpee	-	-	200,000	174	203,000	176	203,000	176
Sandwich	-	-	-	-	110,000	95	350,000	304
Barnstable			-	-	500,000	434	1,200,000	1,042
Total Effluent	140,000	122	352,000	306	1,747,000	1,516	3,884,000	3,372
Additional								183
Total Effluent	140,000	122	352,000	306	1,747,000	1,516	3,884,000	3,555
50% Total Eff	70,000	61	176,000	153	873,500	758	1,942,000	1,777
Flow (cfs)		0.14		0.34		1.69		3.96

Pipe Diameter Analysis:

FM Dia (in)	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
16	0.1	211	0.2	212	1.2	223	2.8	267
18	0.1	211	0.2	211	1.0	218	2.2	242
20	0.1	211	0.2	211	0.8	215	1.8	230
24	0.0	211	0.1	211	0.5	213	1.3	219

Figure 6-1



JBCC Effluent Disposal Force Main

Description: Existing force main for JBCC Effluent pumped flow.

	Miles	Ft	1000 ft	
Length (miles), (f	10.9	57,552	57.6	
Length (miles), (f	10.7	56,496	56.5	(Headloss Calc)
Average C	130			
Low point (ft)	75	(Existing grade at pump station minus 25 feet)		
High point(ft)	170			
Static Head(ft)	95			

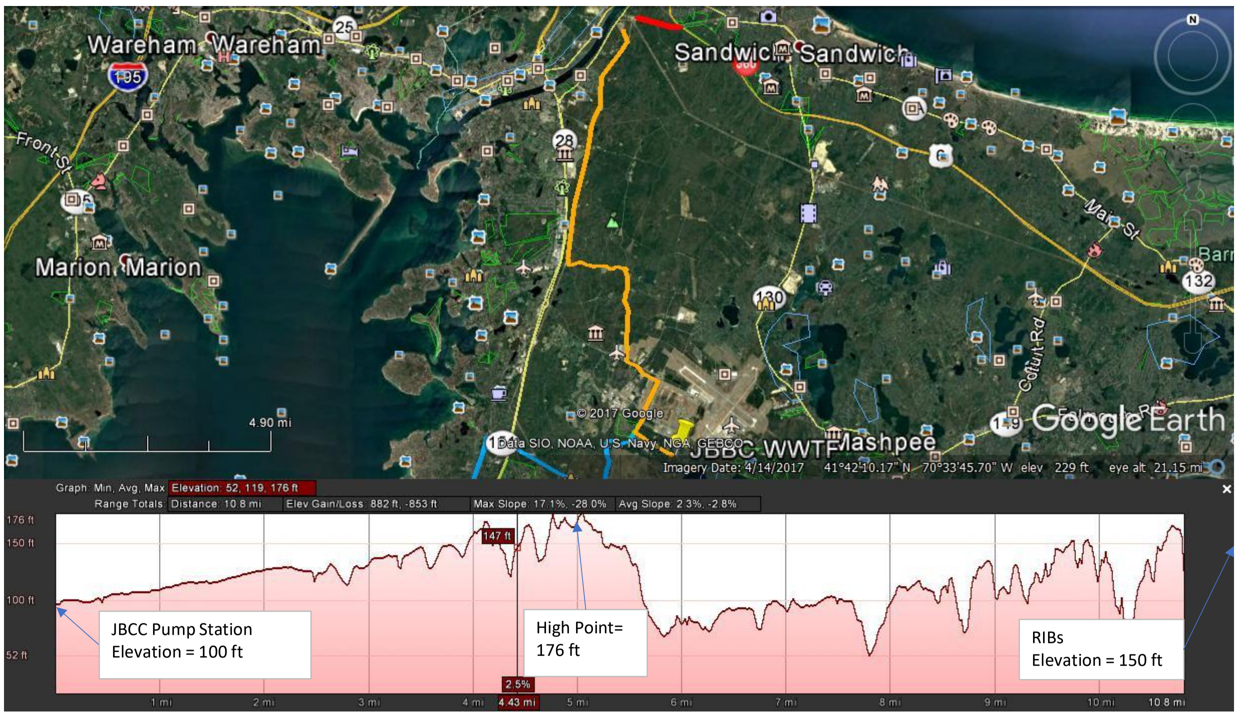
Flow Conditions:

Flow Source	Existing		Near-Term		Mid-Term		Long-Term	
	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q
	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)
JBCC	140,000	122	152,000	132	152,000	132	152,000	132
Bourne-Effl	-	-	-	-	-	-	-	-
Bourne-S	-	-	-	-	270,000	234	467,000	405
Falmouth	-	-	-	-	512,000	444	1,512,000	1,313
Mashpee	-	-	200,000	174	203,000	176	203,000	176
Sandwich	-	-	-	-	110,000	95	350,000	304
Barnstable			-	-	500,000	434	1,200,000	1,042
Total Effluent I	140,000	122	352,000	306	1,747,000	1,516	3,884,000	3,372
Additional								183
Total Effluent I	140,000	122	352,000	306	1,747,000	1,516	3,884,000	3,555
50% Total Eff	70,000	61	176,000	153	873,500	758	1,942,000	1,777
Flow (cfs)		0.14		0.34		1.69		3.96

Pipe Diameter Analysis:

FM Dia (in)	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
16	0.1	95	0.2	96	1.2	116	2.8	198
18	0.1	95	0.2	96	1.0	107	2.2	153
20	0.1	95	0.2	95	0.8	102	1.8	130

Figure 6-2



Barnstable Option 1

Central Alignment through Mashpee

Site Conditions:

Length (miles), (ft)	Miles	1000 ft	
Barnstable FM	2.7	14.3	Public Way/Dense
Barnstable FM	2.3	12.1	Less Dense
Barnstable-Mashpee FI	1.2	6.3	Less Dense
Barnstable + mashpee	6.2	32.7	Length use for Calculation

Average C	130
Low point (ft)	35
High point(ft)	106
Static Head(ft)	71

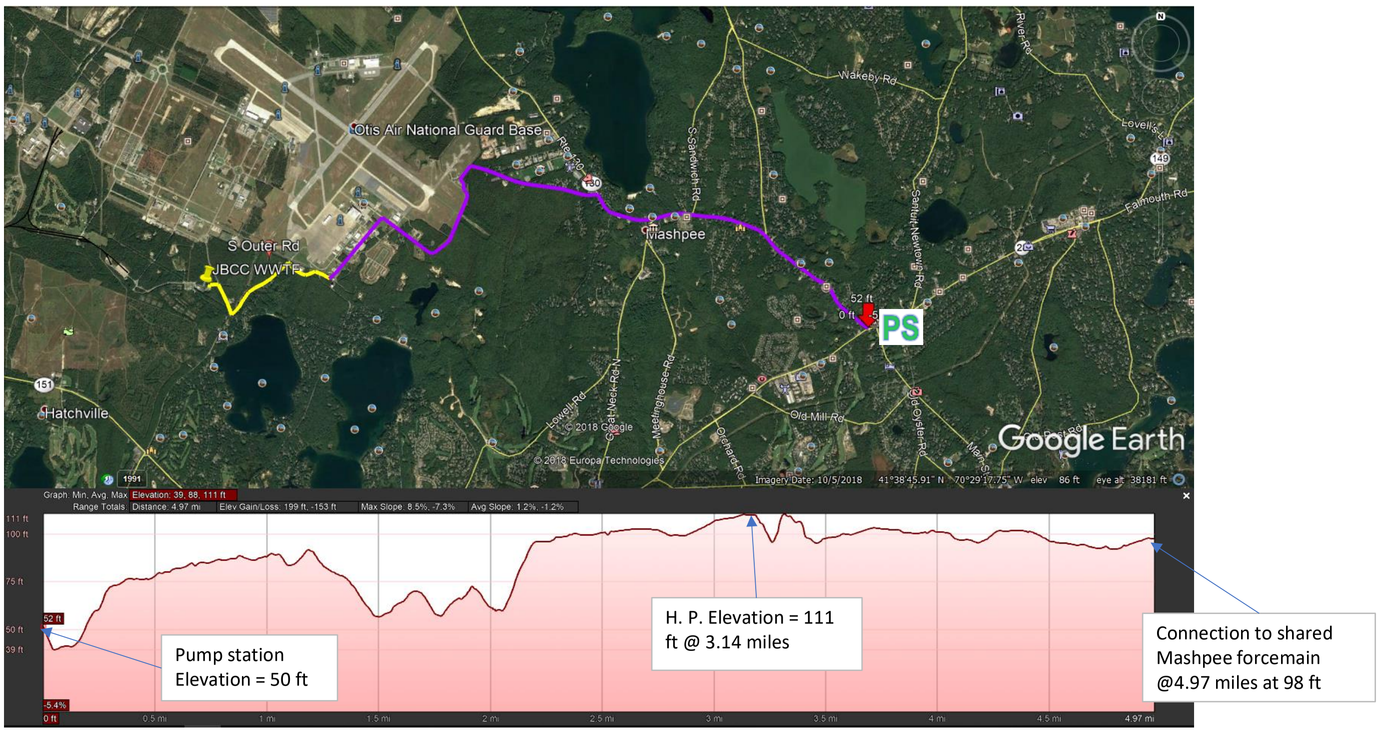
Flow Conditions:

Flow Sourc	Existing		Near-Term		Mid-Term		Long-Term	
	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q
	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)
Barnstable	-	-	-	-	500,000	1,250	1,200,000	3,000
Total	-	-	-	-	500,000	1,250	1,200,000	3,000
Flow(cfs)		0.00		0.00		2.79		6.68

Pipe Diameter Analysis:

FM Dia (in)	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
8	0.0	71	0.0	71	8.0	72	19.1	76
10	0.0	71	0.0	71	5.1	71	12.3	73
12	0.0	71	0.0	71	3.5	71	8.5	72
14	0.0	71	0.0	71	2.6	71	6.3	71
16	0.0	71	0.0	71	2.0	71	4.8	71
18	0.0	71	0.0	71	1.6	71	3.8	71
20	0.0	71	0.0		1.3	71	3.1	71
24	0.0	71	0.0	71	0.9	71	2.1	71

Figure 7-1



Barnstable Option 2

Southern Alignment through Mashpee

Site Conditions:

Length (miles), (ft)	Miles	1000 ft	
Barnstable FM	5.7	30.1	Public Way/Dense
Barnstable FM	1.2	6.3	Less Dense
Barnstable-Mashpee FI	0.3	1.6	Less Dense
Barnstable + mashpee	7.2	38.0	Length use for Calculation

Average C	130
Low point (ft)	33
High point(ft)	85
Static Head(ft)	70

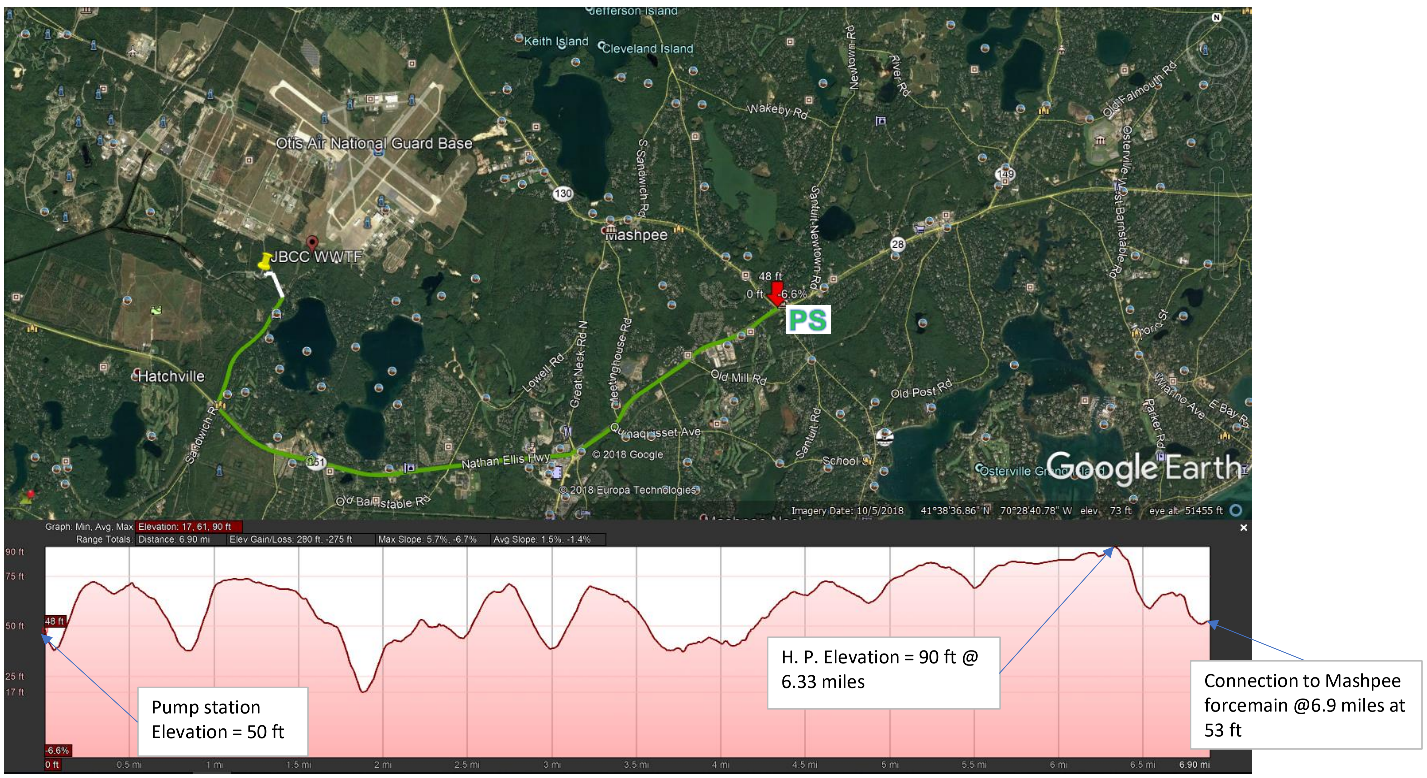
Flow Conditions:

Flow Sourc	Existing		Near-Term		Mid-Term		Long-Term	
	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q
	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)
Barnstable	-	-	-	-	500,000	1,250	1,200,000	3,000
Add'l flow	-	-	-	-	-	-	-	-
Total	-	-	-	-	500,000	1,250	1,200,000	3,000
Flow(cfs)		0.00		0.00		2.79		6.68

Pipe Diameter Analysis:

FM Dia (in)	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
10	0.0	70	0.0	70	5.1	70	12.3	72
12	0.0	70	0.0	70	3.5	70	8.5	71
14	0.0	70	0.0	70	2.6	70	6.3	70
16	0.0	70	0.0	70	2.0	70	4.8	70
18	0.0	70	0.0	70	1.6	70	3.8	70
20	0.0	70	0.0	70	1.3	70	3.1	70
24	0.0	70	0.0	70	0.9	70	2.1	70

Figure 7-2



Barnstable Option 3

Northern Alignment through Sandwich/Mashpee

Site Conditions:

Length (miles), (ft)	Miles	1000 ft	
Barnstable	5.9	31.2	Public Way/Dense
Barnstable	2.7	14.3	Less Dense
Barnstable to Gravity	3.0	15.8	Shared with Sandwich
Total FM Length	11.6	61.2	Length use for Calculation
gravity to wwtf	0.6	3.2	Shared with Sandwich
gravity to wwtf	2.1	11.1	Shared with Sandwich and Bourne
Total Route Length	14.3	75.5	

Average C	130
Low point (ft)	35
High point(ft)	151
Static Head(ft)	70

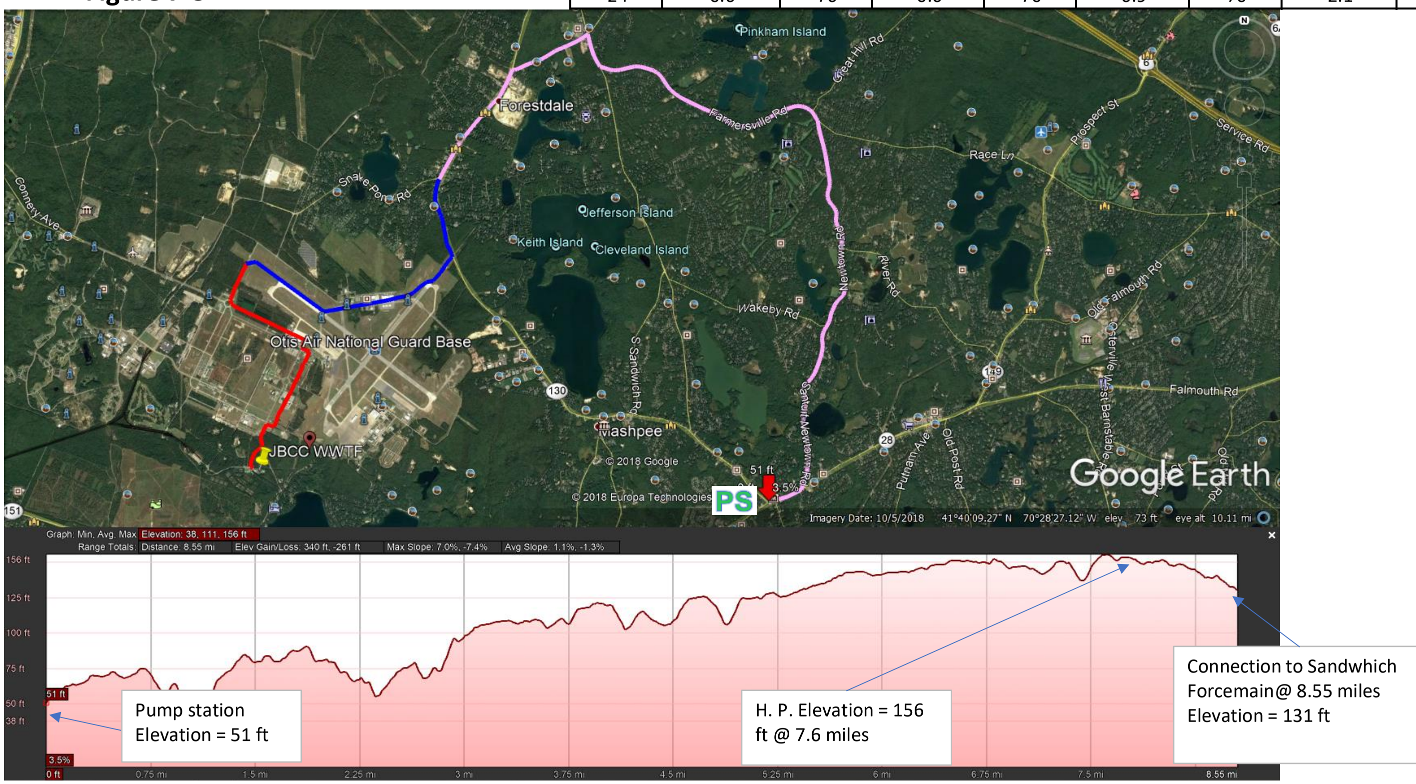
Flow Conditions:

Flow Sourc	Existing		Near-Term		Mid-Term		Long-Term	
	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q	Avg Q	Peak Q
	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)	(gpd)	(gpm)
Barnstable	-	-	-	-	500,000	1,250	1,200,000	3,000
Add'l flow	-	-	-	-	-	-	-	-
Total	-	-	-	-	500,000	1,250	1,200,000	3,000
Flow(cfs)		0.00		0.00		2.79		6.68

Pipe Diameter Analysis:

FM Dia (in)	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss	Velocity	Headloss
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
10	0.0	70	0.0	70	5.1	71	12.3	73
12	0.0	70	0.0	70	3.5	70	8.5	71
14	0.0	70	0.0	70	2.6	70	6.3	71
16	0.0	70	0.0	70	2.0	70	4.8	70
18	0.0	70	0.0	70	1.6	70	3.8	70
20	0.0	70	0.0	70	1.3	70	3.1	70
24	0.0	70	0.0	70	0.9	70	2.1	70

Figure 7-3



ATTACHMENT B

Conveyance Options Costs

JBCC SHARED WASTEWATER MANAGEMENT STUDY

ENGINEERING ASESSEMENT | ENR CCI | 11228 | Apr-19

Wright-Pierce, 13 May 2019 - Preliminary Draft for Review

COSTS FOR CONVEYANCE ALTERNATIVES | **Projected to October 2019 dollars**

Capital Costs for Conveyance and Transport to Disposal

Conveyance

Conveyance-Bourne	Alt 1	Alt 2A	Alt 2B	Alt 3A	Alt 3B
Sewers - Bourne - 50% Share with Sandwich					
Distance, 1000 ft	12.3				
Distance, miles	2.3				
Cost per foot - Rehabilitation	75				
Construction cost	920,000				
Pump Stations - Bourne					
Medium PS (200-1200 gpm)	1	1	1	1	1
Unit Cost	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Large PS (1200+ gpm)	1	1	2	1	2
Unit Cost	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000
Construction cost, pump stations	3,500,000	3,500,000	6,000,000	3,500,000	6,000,000
Transport to Treatment - Public Way/Dense	12"	14"	12"	14"	12"
Distance, 1000 ft	12.7	17.8	17.8	38.5	38.5
Distance, miles	2.4	3.4	3.4	7.3	7.3
Cost per foot	230	245	230	245	230
Construction cost	2,920,000	4,360,000	4,090,000	9,433,000	8,855,000
Transport to Treatment - Public Way/Less Dense	12"	14"	12"	14"	12"
Distance, 1000 ft	14.5	32.2	32.2	13.5	13.5
Distance, miles	2.7	6.1	6.1	2.6	2.6
Cost per foot	210	225	210	225	210
Construction cost	3,050,000	7,250,000	6,760,000	3,038,000	2,835,000
ISWM Connection to Effluent Forcemain (LS)	100,000	100,000	100,000	100,000	100,000
Construction cost, Total Conveyance- Bourne	10,490,000	15,210,000	16,950,000	16,071,000	17,790,000
Total Route Distance, mile	7.4	9.5	9.5	9.9	9.9

Bourne Conveyance

JBCC SHARED WASTEWATER MANAGEMENT STUDY

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Wright-Pierce, 13 May 2019 - Preliminary Draft for Review

COSTS FOR CONVEYANCE ALTERNATIVES **Projected to October 2019 dollars**

Falmouth Conveyance

Conveyance-Falmouth	Alt 1	Alt 2	Alt 3
Pump Stations-Falmouth			
Large PS (1200+ gpm)	1	1	1
Unit Cost	2,500,000	2,500,000	2,500,000
Construction cost, pump stations	2,500,000	2,500,000	2,500,000
Transport to Disposal - Public Way/Dense	18"	18"	18"
Distance, 1000 ft	25.9	20.1	13.8
Distance, miles	4.9	3.8	2.6
Cost per foot	280	280	280
Construction cost	7,250,000	5,630,000	3,860,000
Transport to Disposal - Railroad ROW			18"
Distance, 1000 ft			14.2
Distance, miles			2.7
Cost per foot			380
Construction cost			5,400,000
Transport to Treatment - Public Way/Less Dense	18"	18"	
Distance, 1000 ft	9.5	22.6	
Distance, miles	1.8	4.3	
Cost per foot	250	250	
Construction cost	2,380,000	5,650,000	
Construction cost, Total Conveyance-Falmouth	12,130,000	13,780,000	11,760,000
Total Route Distance, mile	6.7	8.1	5.3

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COSTS FOR CONVEYANCE ALTERNATIVES — **Projected to October 2019 dollars**

Conveyance-Mashpee	Alt 1	Alt 2	Alt 3
Sewers - Mashpee 33% Rehab			
Distance, 1000 ft		3.4	3.4
Distance, miles		0.6	0.6
Cost per foot (33% of 150)		50	50
Construction cost		170,000	170,000
Pump Stations-Mashpee			
Medium PS (200-1200 gpm)	1	1	1
Unit Cost	1,000,000	1,000,000	1,000,000
Construction cost, pump stations	1,000,000	1,000,000	1,000,000
Transport to Treatment - Public Way/Dense	8"	12"	12"
Distance, 1000 ft	7.5	3.0	3.0
Distance, miles	1.4	0.6	0.6
Cost per foot	200	230	230
Construction cost	1,500,000	690,000	690,000
Transport to Treatment - Public Way/Less Dense		12"	12"
Distance, 1000 ft		18.9	9.7
Distance, miles		3.6	1.8
Cost per foot		210	210
Construction cost		3,970,000	2,040,000
Transport to Treatment - Public Way/Less Dense - 50% Share with Sandwich			12"
Distance, 1000 ft			9.3
Distance, miles			1.8
Cost per foot			115
Construction cost			1,070,000
Construction cost, Total Conveyance-Mashpee	2,500,000	5,830,000	4,970,000
Total Route Distance, mile	1.4	4.8	4.8

Mashpee Conveyance

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Wright-Pierce, 13 May 2019 - Preliminary Draft for Review
COSTS FOR CONVEYANCE ALTERNATIVES **Projected to October 2019 dollars**

Sandwich Conveyance

Conveyance-Sandwich	Alt 1	Alt 2	Alt 3
Sewers - Sandwich - Dedicated			
Distance, 1000 ft	2.2		2.2
Distance, miles	0.4		0.4
Cost per foot	150		150
Construction cost	330,000		330,000
Sewers - Sandwich - 50% Share with Bourne			
Distance, 1000 ft	12.30	3.40	12.14
Distance, miles	2.3	0.6	2.3
Cost per foot	75	75	75
Construction cost	920,000	260,000	910,000
Pump Stations-Sandwich			
Medium PS (200-1200 gpm)	1	1	1
Unit Cost	1,000,000	1,000,000	1,000,000
Construction cost, pump stations	1,000,000	1,000,000	1,000,000
Transport to Treatment - Public Way/Dense	12"	12"	12"
Distance, 1000 ft	3.50	3.50	12.67
Distance, miles	0.7	0.7	2.4
Cost per foot	230	230	230
Construction cost	810,000	810,000	2,910,000
Transport to Treatment - Public Way/Less Dense	12"	12"	
Distance, 1000 ft	11.9	18.3	
Distance, miles	2.3	3.5	
Cost per foot	210	210	
Construction cost	2,500,000	3,840,000	
Transport to Treatment - Public Way/Less Dense - 50% Share with Mashpee		12"	
Distance, 1000 ft		9.3	
Distance, miles		1.8	
Cost per foot		105	
Construction cost		980,000	
Construction cost, Total Conveyance-Sandwich	5,560,000	6,890,000	5,150,000
Total Route Distance, mile	5.7	6.6	5.1

JBCC SHARED WASTEWATER MANAGEMENT STUDY

ENGINEERING ASESSEMENT — ENR CCI 11228 — Apr-19

Wright-Pierce, 13 May 2019 - Preliminary Draft for Review

COSTS FOR CONVEYANCE ALTERNATIVES — **Projected to October 2019 dollars**

Conveyance-Barnstable	Alt 1A	Alt 2A	Alt 3A	Alt 1B	Alt 2B	Alt 3B
Sewers - Barnstable - New - 80% shared with Sandwich						
Distance, 1000 ft			3.2			3.2
Distance, miles			0.6			0.6
Cost per foot (80% of 300 for option 3)			240			300
Construction cost			770,000			960,000
Sewers - Barnstable - New 70% shared with Sandwich and Bourne						
Distance, 1000 ft			11.1			11.1
Distance, miles			2.1			2.1
Cost per foot (70% of 300 for option 3)			210			300
Construction cost			2,330,000			3,330,000
Pump Stations-Barnstable						
Very Large PS (>2500 gpm)	1	1	1	1	1	1
Unit Cost	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000
Additional cost for 300 hp requirement (Option 3)			1,000,000			1,000,000
Construction cost, pump stations	5,000,000	5,000,000	6,000,000	5,000,000	5,000,000	6,000,000
Transport to Treatment - Public Way/Dense	20"	20"	20"	20"	20"	20"
Distance, 1000 ft	14.3	30.1	31.2	14.3	30.1	31.2
Distance, miles	2.7	5.7	5.9	2.7	5.7	5.9
Cost per foot	300	300	300	300	300	300
Construction cost	4,290,000	9,030,000	9,360,000	4,290,000	9,030,000	9,360,000
Transport to Treatment - Public Way/Less Dense	20"	20"	20"	20"	20"	20"
Distance, 1000 ft	12.1	6.3	14.3	12.1	6.3	14.3
Distance, miles	2.3	1.2	2.7	2.3	1.2	2.7
Cost per foot	260	260	260	260	260	260
Construction cost	3,150,000	1,640,000	3,720,000	3,150,000	1,640,000	3,720,000
Transport to Treatment - Public Way/Less Dense -80% Shared with Sandwich			20"			20"
Distance, 1000 ft			15.80			15.80
Distance, miles			3.0			3.0
Cost per foot (80% of 260 for option 3)			208			260
Construction cost			3,290,000			4,110,000
Transport to Treatment - Public Way/Less Dense - 80% Shared with Mashpee	20"	20"		20"	20"	
Distance, 1000 ft	6.4	1.6		6.4	1.6	
Distance, miles	1.2	0.3		1.2	0.3	
Cost per foot (80% of 260 for option 3)	208	208		260	260	
Construction cost	1,330,000	340,000		1,660,000	430,000	
Air Release Manholes	5	6	10	5	6	10
Unit Cost	25,000	25,000	25,000	25,000	25,000	25,000
Construction cost, Air Release Valves	130,000	150,000	250,000	130,000	150,000	250,000
Construction cost, Total Conveyance-Barnstable	13,900,000	16,160,000	25,720,000	14,230,000	16,250,000	27,730,000
Total Route Distance, mile	6.2	7.2	14.3	6.2	7.2	14.3

Barnstable Conveyance

JBCC SHARED WASTEWATER MANAGEMENT STUDY

ENGINEERING ASESSEMENT — ENR CCI 11228, Apr-19

Wright-Pierce, 13 May 2019 - Preliminary Draft for Review

COSTS FOR CONVEYANCE ALTERNATIVES — **Projected to October 2019 dollars**

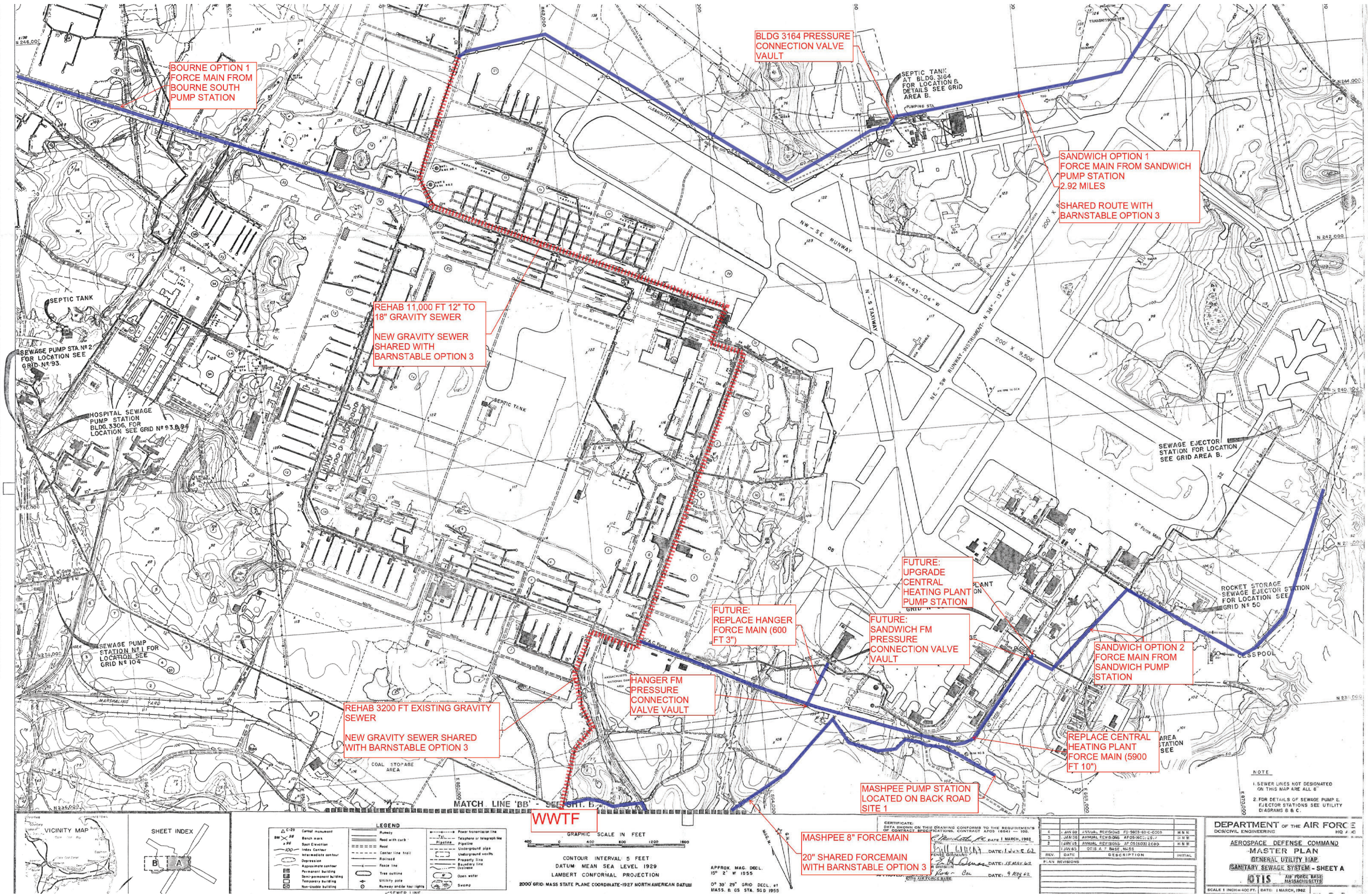
SUMMARY

Conveyance Cost Summary	
Sewers	
Construction cost	5,270,000
Pump Stations	
Construction cost, pump stations	14,000,000
Transport to Treatment	
Construction cost	37,130,000
Construction Cost, Total Conveyance	56,400,000
Cross Check	56,400,000

ATTACHMENT C

JBBC Conveyance

Improvements Worksheet


BOURNE OPTION 1
FORCE MAIN FROM
BOURNE SOUTH
PUMP STATION
BLDG 3164 PRESSURE
CONNECTION VALVE
VAULT
SEPTIC TANK
AT BLDG. 3164
FOR LOCATION & DETAILS SEE GRID
AREA B.
SANDWICH OPTION 1
FORCE MAIN FROM SANDWICH
PUMP STATION
2.92 MILES
SHARED ROUTE WITH
BARNSTABLE OPTION 3
NW - SE RUNWAY
N-S TAXIWAY
NE - SW RUNWAY - INSTRUMENT
200' X 9,500'
SEPTIC TANK
REHAB 11,000 FT 12" TO
18" GRAVITY SEWER
NEW GRAVITY SEWER
SHARED WITH
BARNSTABLE OPTION 3
SEWAGE PUMP STA. Nº 2
FOR LOCATION SEE
GRID Nº 93.
HOSPITAL SEWAGE
PUMP STATION
BLDG. 3306, FOR
LOCATION SEE GRID Nº 93 & 94
SEWAGE EJECTOR
STATION FOR LOCATION
SEE GRID AREA B.
FUTURE:
UPGRADE
CENTRAL
HEATING PLANT
PUMP STATION
ROCKET STORAGE
SEWAGE EJECTOR STATION
FOR LOCATION SEE
GRID Nº 50
FUTURE:
REPLACE HANGER
FORCE MAIN (600
FT 3")
FUTURE:
SANDWICH FM
PRESSURE
CONNECTION VALVE
VAULT
SANDWICH OPTION 2
FORCE MAIN FROM
SANDWICH PUMP
STATION
CESSPOOL
SEWAGE PUMP
STATION Nº 1 FOR
LOCATION SEE
GRID Nº 104
HANGER FM
PRESSURE
CONNECTION
VALVE VAULT
REHAB 3200 FT EXISTING GRAVITY
SEWER
NEW GRAVITY SEWER SHARED
WITH BARNSTABLE OPTION 3
COAL STORAGE
AREA
REPLACE CENTRAL
HEATING PLANT
FORCE MAIN (5900
FT 10")
MASHPEE PUMP STATION
LOCATED ON BACK ROAD
SITE 1
MATCH LINE 'BB' - SEE SHT. B
WWTF
MASHPEE 8" FORCEMAIN
20" SHARED FORCEMAIN
WITH BARNSTABLE OPTION 3
NOTE
1. SEWER LINES NOT DESIGNATED ON THIS MAP ARE ALL 6"
2. FOR DETAILS OF SEWAGE PUMP & EJECTOR STATIONS SEE UTILITY DIAGRAMS B & C.
VICINITY MAP
SHEET INDEX
LEGEND
GRAPHIC SCALE IN FEET
CONTOUR INTERVAL 5 FEET
DATUM MEAN SEA LEVEL 1929
LAMBERT CONFORMAL PROJECTION
2000' GRID: MASS STATE PLANE COORDINATE-1927 NORTH AMERICAN DATUM
APPROX. MAG. DECL. 15° 2' W 1955
DEPARTMENT OF THE AIR FORCE
DCS/CIVIL ENGINEERING
AEROSPACE DEFENSE COMMAND
MASTER PLAN
GENERAL UTILITY MAP
SANITARY SEWAGE SYSTEM - SHEET A
OTIS AIR FORCE BASE MASSACHUSETTS
SCALE 1 INCH = 400 FT. DATE: 1 MARCH, 1962

WRIGHT-PIERCE
Engineering a Better Environment

MEMORANDUM

TO:	File	**DATE:**	11/27/2017, Rev. 5/13/2019
FROM:	Ed Leonard	**PROJECT NO.:**	13839A
SUBJECT:	JBCC Shared Wastewater Management Study Cost Estimate Backup Materials		

Attached are the following cost estimate backup materials:

1. Baseline – All Participants without Barnstable (6 pages)
   a. Costs for Treatment, Transport-to-Disposal and Disposal Alternatives (Long-Term)
   b. Summary of Planning-Level Cost Estimates and Cost Allocation (Long-Term)
   c. Cost Allocation for Composite Wastewater Alternative, Option 6 (All Phases)
2. Sensitivity Analysis Scenario 1 (GAC vs Reverse Osmosis) (6 pages)
   a. Costs for Treatment, Transport-to-Disposal and Disposal Alternatives (Long-Term)
   b. Summary of Planning-Level Cost Estimates and Cost Allocation (Long-Term)
   c. Cost Allocation for Composite Wastewater Alternative, Option 6 (All Phases)
3. Scenario 2 Sensitivity Analysis (One forcemain vs two forcemains) (6 pages)
   a. Costs for Treatment, Transport-to-Disposal and Disposal Alternatives (Long-Term)
   b. Summary of Planning-Level Cost Estimates and Cost Allocation (Long-Term)
   c. Cost Allocation for Composite Wastewater Alternative, Option 6 (All Phases)
4. Step 3A – JBCC and Barnstable Only (6 pages)
   a. Costs for Treatment, Transport-to-Disposal and Disposal Alternatives (Long-Term)
   b. Summary of Planning-Level Cost Estimates and Cost Allocation (Long-Term)
   c. Cost Allocation for Composite Wastewater Alternative, Option 6 (All Phases)
5. Step 3B – All Participants with Barnstable (6 pages)
   a. Costs for Treatment, Transport-to-Disposal and Disposal Alternatives (Long-Term)
   b. Summary of Planning-Level Cost Estimates and Cost Allocation (Long-Term)
   c. Cost Allocation for Composite Wastewater Alternative, Option 6 (All Phases)
6. Cost Comparison for Bourne and Sandwich (1 page)

BASELINE

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ENGINEERING ASSESSMENT
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019 — ENR CCI (10/2017) — 10800

Scenario 1
Scenario 2
Scenario 3

COSTS FOR TREATMENT, TRANSPORT-TO-DISPOSAL AND DISPOSAL ALTERNATIVES
LONG-TERM

Projected to April 2019 dollars

		1	2	3	4	5	6
Items		**RIB**	**RIB/WICK**	**RIB/DWI**	**RIB/OUTFALL**	**DWI**	**OUTFALL**
CAPITAL COSTS							
Unit Costs							
Cost, ENR/SBR, Disinfection	1.00	$30.00	$30.00	$30.00	$32.00	$30.00	$32.00
Cost, ENR/MBR, Disinfection	10%			$3.00		$3.00	
Cost, Sand Filtration	1.00		$1.90				
Cost, RO/Reject/Storage	1.00			$4.50		$4.50	
Cost, GAC/Reject/Storage	1.00						
Effluent PS, at 200'TDH	1.00	$2.25	$2.25	$1.50	$2.25	$1.50	$2.25
Flow (gpd, annual average basis)							
ENR/SBR/UV		1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000
ENR/MBR-Adder				400,000		500,000	
Sand Filtration	5%		1,270,000				
RO/AO/Storage				3,100,000		3,850,000	
GAC/Reject/Storage				3,100,000		3,850,000	
Effluent PS		1,210,000	1,210,000	2,700,000	1,210,000	3,350,000	1,210,000
Cost - Treatment-Baseline							
Existing WWTF Upgrades		$2,570,000	$2,570,000	$2,570,000	$2,570,000	$2,570,000	$2,570,000
ENR Baseline		$36,300,000	$36,300,000	$36,300,000	$38,720,000	$36,300,000	$38,720,000
Subtotal - Treatment		**$38,900,000**	**$38,900,000**	**$38,900,000**	**$41,300,000**	**$38,900,000**	**$41,300,000**
Cost - Treatment-Supplemental							
ENR/MBR Adder		$0	$0	$13,200,000	$0	$16,500,000	$0
Sand Filtration		$0	$2,413,000	$0	$0	$0	$0
RO/AO/Storage		$0	$0	$13,950,000	$0	$17,325,000	$0
GAC/Reject/Storage		$0	$0	$0	$0	$0	$0
Subtotal - Treatment		**$0**	**$2,400,000**	**$27,200,000**	**$0**	**$33,800,000**	**$0**
Cost - Transport to Disposal							
Existing Forcemain Upgrades		$300,000	$300,000	$300,000	$300,000	$300,000	$300,000
New Forcemains		$22,600,000	$22,600,000	$4,860,000	$23,650,000	$4,860,000	$23,650,000
Length	mi	10.7	10.7	2.3	11.2	2.3	11.2
Number		2	2	2	2	2	2
Length	ft	112,992	112,992	24,288	118,272	24,288	118,272
Cost per Foot		200	200	200	200	200	200
Subtotal - Transport to Disposal		**$22,900,000**	**$22,900,000**	**$5,160,000**	**$23,950,000**	**$5,160,000**	**$23,950,000**

BASELINE

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ENGINEERING ASSESSMENT
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019 ENR CCI (10/2017) 10800

Scenario 1
Scenario 2
Scenario 3

COSTS FOR TREATMENT, TRANSPORT-TO-DISPOSAL AND DISPOSAL ALTERNATIVES **Projected to April 2019 dollars**
LONG-TERM

			1	2	3	4	5	6
Items			**RIB**	**RIB/WICK**	**RIB/DWI**	**RIB/OUTFALL**	**DWI**	**OUTFALL**
	Cost - Disposal							
	Existing RIB Upgrades		$400,000	$400,000	$400,000	$400,000	$400,000	$400,000
	Effluent PS		$2,720,000	$2,720,000	$4,050,000	$2,720,000	$5,030,000	$2,720,000
	New RIBs		$8,600,000		$2,640,000			
	New Wicks			$8,300,000				
	New DWI				$6,300,000		$8,800,000	
	New Outfall					$8,800,000		$10,290,000
	Subtotal - Disposal		**$11,700,000**	**$11,400,000**	**$13,400,000**	**$11,900,000**	**$14,200,000**	**$13,400,000**
	TOTAL		**$73,500,000**	**$75,600,000**	**$84,660,000**	**$77,150,000**	**$92,060,000**	**$78,650,000**
	Lowest plus +% higher for other Options		$73,500,000	3%	15%	5%	25%	7%
ANNUAL O&M								
	Basis flow		1,210,000	1,210,000	2,700,000	1,210,000	3,350,000	1,210,000
	Baseline, April 2014 (ENR CCI 9750)	1.00	$1.50	$1.50	$1.25	$1.50	$1.25	$1.50
	Baseline, Current (ENR CCI 10800)		$1.66	$1.66	$1.38	$1.66	$1.38	$1.66
	Baseline Costs		$2,010,000	$2,010,000	$3,740,000	$2,010,000	$4,640,000	$2,010,000
	Adder for Existing Collection O&M		$800,000	$800,000	$800,000	$800,000	$800,000	$800,000
	Adder for Filtration	5%		$100,500				
	Adder for SW Discharge	10%				$201,000.00		$201,000.00
	Adder for ENR/MBR	10%			$374,000		$464,000	
	Adder for RO/Storage	25%			$935,000		$1,160,000	
	Adder for GAC/Storage	0%			$0		$0	
	Adder for Effluent Pumping	5%	$100,500	$100,500	$187,000	$100,500	$232,000	$100,500
	Annual O&M		$2,910,000	$3,010,000	$6,040,000	$3,110,000	$7,300,000	$3,110,000
	Lowest plus +% higher for other Options		$2,910,000	3%	108%	7%	151%	7%
	O&M Allocated to Sewage/Septage, %		50%	50%	50%	50%	50%	50%
	O&M Allocated to Effluent, %		50%	50%	50%	50%	50%	50%
	O&M Allocated to Sewage/Septage, $$		$1,460,000	$1,510,000	$3,020,000	$1,560,000	$3,650,000	$1,560,000
	O&M Allocated to Effluent, $$		$1,460,000	$1,510,000	$3,020,000	$1,560,000	$3,650,000	$1,560,000

BASELINE

TABLE 2-5: SUMMARY OF PLANNING-LEVEL COST ESTIMATES AND COST ALLOCATION (BASED ON LONG-TERM, CONSTRUCTED AS A SINGLE PROJECT) (ENR CCI 11228, April 2019)

Option	**1**	**2**	**3**	**4**	**5**	**6**
Description of Effluent Disposal	**RIB**	**RIB & Wicks**	**RIB & DWI**	**RIB & Outfall**	**DWI**	**Outfall**
Capital Cost						
Construction - Conveyance	$29,030,000	$29,030,000	$29,030,000	$29,030,000	$29,030,000	$29,030,000
Construction - Treatment	$38,900,000	$41,300,000	$66,100,000	$41,300,000	$72,700,000	$41,300,000
Construction - Transport to Disposal	$22,900,000	$22,900,000	$5,160,000	$23,950,000	$5,160,000	$23,950,000
Construction - Disposal	$11,700,000	$11,400,000	$13,400,000	$11,900,000	$14,200,000	$13,400,000
Contingency, Technical, Legal/Admin/Finance	$44,090,000	$44,990,000	$48,890,000	$45,660,000	$52,070,000	$46,300,000
Total Capital Cost	**$146,620,000**	**$149,620,000**	**$162,580,000**	**$151,840,000**	**$173,160,000**	**$153,980,000**
Ratio to Lowest - Total Capital Cost	1.00	1.02	1.11	1.04	1.18	1.05
Ratio to Lowest - Capital Cost, excl. Conveyance	1.00	1.03	1.15	1.05	1.25	1.07
Annual Operation & Maintenance Cost	**$2,910,000**	**$3,010,000**	**$6,040,000**	**$3,110,000**	**$7,300,000**	**$3,110,000**
Ratio to Lowest - Annual O&M	1.00	1.03	2.08	1.07	2.51	1.07
Total Annual Debt Service on Capital Cost	$8,970,000	$9,150,000	$9,940,000	$9,290,000	$10,590,000	$9,420,000
Total Equivalent Annual Cost (Note 3)	**$11,880,000**	**$12,160,000**	**$15,980,000**	**$12,400,000**	**$17,890,000**	**$12,530,000**
Ratio to Lowest - Equivalent Annual Cost	1.00	1.02	1.35	1.04	1.51	1.05
EAC per thousand gallons of disposal capacity	$9.72	$9.94	$13.07	$10.14	$14.63	$10.25

Notes:

1) Costs are presented in current dollars based on Engineering News Record Construction Cost Index 11228 (April 2019).
2) Refer to Appendix A for supporting information.
3) Equivalent Annual Cost equals Annual O&M Cost plus the Annual Debt Service on Capital Cost.
4) Allocation for Conveyance is 100% to each town. Allocation for treatment/transport/disposal is pro-rated based on flow capacity requested.
5) Blue indicates lowest cost option, green indicates second lowest cost option and orange indicates third lowest cost option.

BASELINE

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ALTERNATIVES ANALYSIS
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019

File Name: CostAnalysis-20171127-BARN-20190327

ENR CCI 11228 (April 2019)

COST ALLOCATION OF "CANDIDATE PLAN" BY PHASE

USE COSTS FOR OPTION 6 (OUTFALL), AS THE MOST CONSERVATIVE OF "FOUR ESSENTIALLY EQUIVALENT COST OPTIONS" (OPTIONS 1/2/4/6)

	COSTS ($MILLION)			CHECK	ALLOCATION, % OF FLOW			ALLOCATION OF FLOW		
	Existing	Short-Term	Long-Term	TOTAL	Ex	ST	LT	Ex	ST	LT
Conveyance	$0	$3,600,000	$25,430,000	$29,030,000				140,000	347,000	1,189,000
JBCC	$0	$0	$0	$0				140,000	147,000	147,000
Bourne	$0	$1,100,000	$8,790,000	$9,890,000				0	0	467,000
Falmouth	$0	$0	$11,650,000	$11,650,000				0	0	22,000
Mashpee	$0	$2,500,000	$0	$2,500,000				0	200,000	203,000
Sandwich	$0	$0	$4,990,000	$4,990,000				0	0	350,000
Barnstable	$0	$0		$0				0	0	
Treatment-BASELINE	$0	$1,920,000	$39,380,000	$41,300,000	100%	100%	100%	140,000	347,000	1,189,000
JBCC	$0	$813,000	$4,869,000	$5,682,000	100%	42%	12%	140,000	147,000	147,000
Bourne	$0	$0	$15,467,000	$15,467,000	0%	0%	39%	0	0	467,000
Falmouth	$0	$0	$729,000	$729,000	0%	0%	2%	0	0	22,000
Mashpee	$0	$1,107,000	$6,723,000	$7,830,000	0%	58%	17%	0	200,000	203,000
Sandwich	$0	$0	$11,592,000	$11,592,000	0%	0%	29%	0	0	350,000
Barnstable	$0	$0	$0	$0	0%	0%	0%	0	0	0
Treatment-SUPPLEMENT	$0	$0	$0	$0	100%	100%	100%	140,000	347,000	1,189,000
JBCC	$0	$0	$0	$0	100%	42%	12%	140,000	147,000	147,000
Bourne	$0	$0	$0	$0	0%	0%	39%	0	0	467,000
Falmouth	$0	$0	$0	$0	0%	0%	2%	0	0	22,000
Mashpee	$0	$0	$0	$0	0%	58%	17%	0	200,000	203,000
Sandwich	$0	$0	$0	$0	0%	0%	29%	0	0	350,000
Barnstable	$0	$0	$0	$0	0%	0%	0%	0	0	0
Transport to Disposal	$0	$300,000	$23,650,000	$23,950,000	100%	100%	100%	140,000	447,000	3,330,000
JBCC	$0	$99,000	$1,044,000	$1,143,000	100%	33%	4%	140,000	147,000	147,000
Bourne	$0	$67,000	$7,940,000	$8,007,000	0%	22%	34%	0	100,000	1,118,000
Falmouth	$0	$0	$10,738,000	$10,738,000	0%	0%	45%	0	0	1,512,000
Mashpee	$0	$134,000	$1,442,000	$1,576,000	0%	45%	6%	0	200,000	203,000
Sandwich	$0	$0	$2,486,000	$2,486,000	0%	0%	11%	0	0	350,000
Barnstable	$0	$0	$0	$0	0%	0%	0%	0	0	0
Disposal	$0	$400,000	$13,000,000	$13,400,000	100%	100%	100%	140,000	447,000	3,330,000
JBCC	$0	$132,000	$574,000	$706,000	100%	33%	4%	140,000	147,000	147,000
Bourne	$0	$89,000	$4,365,000	$4,454,000	0%	22%	34%	0	100,000	1,118,000
Falmouth	$0	$0	$5,903,000	$5,903,000	0%	0%	45%	0	0	1,512,000
Mashpee	$0	$179,000	$792,000	$971,000	0%	45%	6%	0	200,000	203,000
Sandwich	$0	$0	$1,366,000	$1,366,000	0%	0%	11%	0	0	350,000
Barnstable	$0	$0	$0	$0	0%	0%	0%	0	0	0

BASELINE

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ALTERNATIVES ANALYSIS
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019

File Name: CostAnalysis-20171127-BARN-20190327

ENR CCI 11228 (April 2019)

COST ALLOCATION OF "CANDIDATE PLAN" BY PHASE
USE COSTS FOR OPTION 6 (OUTFALL), AS THE MOST CONSERVATIVE OF "FOUR ESSENTIALLY EQUIVALENT COST OPTIONS" (OPTIONS 1/2/4/6)

	COSTS ($MILLION)			CHECK	ALLOCATION, % OF FLOW			ALLOCATION OF FLOW		
	Existing	Short-Term	Long-Term	TOTAL	Ex	ST	LT	Ex	ST	LT
Conting/Tech/Legal/etc	$0	$2,675,000	$43,628,000	$46,300,000	100%	100%	100%	Pro-rata based on construction subtotal		
JBCC	$0	$449,000	$2,789,000	$3,238,000	100%	17%	6%	Pro-rata based on construction subtotal		
Bourne	$0	$540,000	$15,722,000	$16,262,000	0%	20%	36%	Pro-rata based on construction subtotal		
Falmouth	$0	$0	$12,479,000	$12,479,000	0%	0%	29%	Pro-rata based on construction subtotal		
Mashpee	$0	$1,686,000	$3,852,000	$5,538,000	0%	63%	9%	Pro-rata based on construction subtotal		
Sandwich	$0	$0	$8,787,000	$8,787,000	0%	0%	20%	Pro-rata based on construction subtotal		
Barnstable	$0	$0	$0	$0	0%	0%	0%			
Check										
TOTAL	$0	$8,900,000	$145,090,000	$153,990,000						
JBCC	$0	$1,490,000	$9,280,000	$10,770,000						
Bourne	$0	$1,800,000	$52,280,000	$54,080,000						
Falmouth	$0	$0	$41,500,000	$41,500,000						
Mashpee	$0	$5,610,000	$12,810,000	$18,420,000						
Sandwich	$0	$0	$29,220,000	$29,220,000						
Barnstable	$0	$0	$0	$0						
Check	$0	$8,900,000	$145,090,000	$153,990,000						
ANNUAL O&M-SEW/SEPT	$0	$739,500	$1,560,000		100%	100%	100%	140,000	447,000	1,189,000
JBCC	$0.00	$0.24	$0.19		100%	33%	12%	140,000	147,000	147,000
Bourne	$0.00	$0.17	$0.61		0%	22%	39%	0	100,000	467,000
Falmouth	$0.00	$0.00	$0.03		0%	0%	2%	0	0	22,000
Mashpee	$0.00	$0.33	$0.27		0%	45%	17%	0	200,000	203,000
Sandwich	$0.00	$0.00	$0.46		0%	0%	29%	0	0	350,000
Barnstable	$0.00	$0.00	$0.00		0%	0%	0%	0	0	0
Check	$0.00	$0.74	$1.56							
ANNUAL O&M-EFF	$510,000	$739,500	$1,560,000		100%	100%	100%	140,000	447,000	3,330,000
JBCC	$0.51	$0.24	$0.07		100%	33%	4%	140,000	147,000	147,000
Bourne	$0.00	$0.17	$0.52		0%	22%	34%	0	100,000	1,118,000
Falmouth	$0.00	$0.00	$0.71		0%	0%	45%	0	0	1,512,000
Mashpee	$0.00	$0.33	$0.10		0%	45%	6%	0	200,000	203,000
Sandwich	$0.00	$0.00	$0.16		0%	0%	11%	0	0	350,000
Barnstable	$0.00	$0.00	$0.00		0%	0%	0%	0	0	0
Check	$0.51	$0.74	$1.56							
ANNUAL O&M-TOTAL	$510,000	$1,479,000	$3,120,000		100%	100%	100%	140,000	447,000	3,330,000
JBCC	$0.51	$0.49	$0.26		100%	33%	4%	140,000	147,000	147,000
Bourne	$0.00	$0.33	$1.14		0%	22%	34%	0	100,000	1,118,000
Falmouth	$0.00	$0.00	$0.74		0%	0%	45%	0	0	1,512,000

BASELINE

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ALTERNATIVES ANALYSIS
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019

File Name: CostAnalysis-20171127-BARN-20190327

ENR CCI 11228 (April 2019)

COST ALLOCATION OF "CANDIDATE PLAN" BY PHASE
USE COSTS FOR OPTION 6 (OUTFALL), AS THE MOST CONSERVATIVE OF "FOUR ESSENTIALLY EQUIVALENT COST OPTIONS" (OPTIONS 1/2/4/6)

	COSTS ($MILLION)			CHECK	ALLOCATION, % OF FLOW			ALLOCATION OF FLOW		
	Existing	Short-Term	Long-Term	TOTAL	Ex	ST	LT	Ex	ST	LT
Mashpee	$0.00	$0.66	$0.36		0%	45%	6%	0	200,000	203,000
Sandwich	$0.00	$0.00	$0.62		0%	0%	11%	0	0	350,000
Barnstable	$0.00	$0.00	$0.00		0%	0%	0%	0	0	0
Check	$0.51	$1.48	$3.12							

DEBT SERVICE	CRF >>	16.35		
JBCC	$0.00	$0.09	$0.57	$0.66
Bourne	$0.00	$0.11	$3.20	$3.31
Falmouth	$0.00	$0.00	$2.54	$2.54
Mashpee	$0.00	$0.34	$0.78	$1.13
Sandwich	$0.00	$0.00	$1.79	$1.79
Barnstable	$0.00	$0.00	$0.00	$0.00
Check	$0.00	$0.54	$8.87	$9.42

EQUIVALENT ANNUAL COST			
JBCC	$0.51	$0.58	$0.83
Bourne	$0.00	$0.44	$4.33
Falmouth	$0.00	$0.00	$3.28
Mashpee	$0.00	$1.00	$1.14
Sandwich	$0.00	$0.00	$2.41
Barnstable	$0.00	$0.00	$0.00
Check	$0.51	$2.02	$11.99

CAPITAL COST PER KGAL (DISPOSAL CAPACITY)					DISPOSAL CAPACITY		
JBCC	$0	$28	$173	$201	140,000	147,000	147,000
Bourne		$49	$128	$133	0	100,000	1,118,000
Falmouth		$0	$75	$75	0	0	1,512,000
Mashpee		$77	$173	$249	0	200,000	203,000
Sandwich		$0	$229	$229	0	0	350,000
Barnstable		$0	#DIV/0!	#DIV/0!		0	0
TOTAL		$55	$119	$127		447,000	3,330,000

SCENARIO 1

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ENGINEERING ASSESSMENT
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019 ENR CCI (10/2017) 10800

Scenario 1
Scenario 2
Scenario 3

COSTS FOR TREATMENT, TRANSPORT-TO-DISPOSAL AND DISPOSAL ALTERNATIVES **Projected to April 2019 dollars**
LONG-TERM

			1	2	3	4	5	6
Items			**RIB**	**RIB/WICK**	**RIB/DWI**	**RIB/OUTFALL**	**DWI**	**OUTFALL**
CAPITAL COSTS								
	Unit Costs							
	Cost, ENR/SBR, Disinfection	1.00	$30.00	$30.00	$30.00	$32.00	$30.00	$32.00
	Cost, ENR/MBR, Disinfection	10%			$3.00		$3.00	
	Cost, Sand Filtration	1.00		$1.90				
	Cost, RO/Reject/Storage	1.00						
	Cost, GAC/Reject/Storage	1.00			$2.90		$2.90	
	Effluent PS, at 200'TDH	1.00	$2.25	$2.25	$1.50	$2.25	$1.50	$2.25
	Flow (gpd, annual average basis)							
	ENR/SBR/UV		1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000
	ENR/MBR-Adder				400,000		500,000	
	Sand Filtration	5%		1,270,000				
	RO/AO/Storage				3,100,000		3,850,000	
	GAC/Reject/Storage				3,100,000		3,850,000	
	Effluent PS		1,210,000	1,210,000	2,700,000	1,210,000	3,350,000	1,210,000
	Cost - Treatment-Baseline							
	Existing WWTF Upgrades		$2,570,000	$2,570,000	$2,570,000	$2,570,000	$2,570,000	$2,570,000
	ENR Baseline		$36,300,000	$36,300,000	$36,300,000	$38,720,000	$36,300,000	$38,720,000
	Subtotal - Treatment		**$38,900,000**	**$38,900,000**	**$38,900,000**	**$41,300,000**	**$38,900,000**	**$41,300,000**
	Cost - Treatment-Supplemental							
	ENR/MBR Adder		$0	$0	$13,200,000	$0	$16,500,000	$0
	Sand Filtration		$0	$2,413,000	$0	$0	$0	$0
	RO/AO/Storage		$0	$0	$0	$0	$0	$0
	GAC/Reject/Storage		$0	$0	$8,990,000	$0	$11,165,000	$0
	Subtotal - Treatment		**$0**	**$2,400,000**	**$22,200,000**	**$0**	**$27,700,000**	**$0**
	Cost - Transport to Disposal							
	Existing Forcemain Upgrades		$300,000	$300,000	$300,000	$300,000	$300,000	$300,000
	New Forcemains		$22,600,000	$22,600,000	$4,860,000	$23,650,000	$4,860,000	$23,650,000
	Length	mi	10.7	10.7	2.3	11.2	2.3	11.2
	Number		2	2	2	2	2	2
	Length	ft	112,992	112,992	24,288	118,272	24,288	118,272
	Cost per Foot		200	200	200	200	200	200
	Subtotal - Transport to Disposal		**$22,900,000**	**$22,900,000**	**$5,160,000**	**$23,950,000**	**$5,160,000**	**$23,950,000**

SCENARIO 1

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ENGINEERING ASSESSMENT
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019 ENR CCI (10/2017) 10800

Scenario 1
Scenario 2
Scenario 3

COSTS FOR TREATMENT, TRANSPORT-TO-DISPOSAL AND DISPOSAL ALTERNATIVES **Projected to April 2019 dollars**
LONG-TERM

			1	2	3	4	5	6
Items			**RIB**	**RIB/WICK**	**RIB/DWI**	**RIB/OUTFALL**	**DWI**	**OUTFALL**
	Cost - Disposal							
	Existing RIB Upgrades		$400,000	$400,000	$400,000	$400,000	$400,000	$400,000
	Effluent PS		$2,720,000	$2,720,000	$4,050,000	$2,720,000	$5,030,000	$2,720,000
	New RIBs		$8,600,000		$2,640,000			
	New Wicks			$8,300,000				
	New DWI				$6,300,000		$8,800,000	
	New Outfall					$8,800,000		$10,290,000
	Subtotal - Disposal		**$11,700,000**	**$11,400,000**	**$13,400,000**	**$11,900,000**	**$14,200,000**	**$13,400,000**
	TOTAL		**$73,500,000**	**$75,600,000**	**$79,660,000**	**$77,150,000**	**$85,960,000**	**$78,650,000**
	Lowest plus +% higher for other Options		$73,500,000	3%	8%	5%	17%	7%
ANNUAL O&M								
	Basis flow		1,210,000	1,210,000	2,700,000	1,210,000	3,350,000	1,210,000
	Baseline, April 2014 (ENR CCI 9750)	1.00	$1.50	$1.50	$1.25	$1.50	$1.25	$1.50
	Baseline, Current (ENR CCI 10800)		$1.66	$1.66	$1.38	$1.66	$1.38	$1.66
	Baseline Costs		$2,010,000	$2,010,000	$3,740,000	$2,010,000	$4,640,000	$2,010,000
	Adder for Existing Collection O&M		$800,000	$800,000	$800,000	$800,000	$800,000	$800,000
	Adder for Filtration	5%		$100,500				
	Adder for SW Discharge	10%				$201,000.00		$201,000.00
	Adder for ENR/MBR	10%			$374,000		$464,000	
	Adder for RO/Storage	0%			$0		$0	
	Adder for GAC/Storage	15%			$561,000		$696,000	
	Adder for Effluent Pumping	5%	$100,500	$100,500	$187,000	$100,500	$232,000	$100,500
	Annual O&M		$2,910,000	$3,010,000	$5,660,000	$3,110,000	$6,830,000	$3,110,000
	Lowest plus +% higher for other Options		$2,910,000	3%	95%	7%	135%	7%
	O&M Allocated to Sewage/Septage, %		50%	50%	50%	50%	50%	50%
	O&M Allocated to Effluent, %		50%	50%	50%	50%	50%	50%
	O&M Allocated to Sewage/Septage, $$		$1,460,000	$1,510,000	$2,830,000	$1,560,000	$3,420,000	$1,560,000
	O&M Allocated to Effluent, $$		$1,460,000	$1,510,000	$2,830,000	$1,560,000	$3,420,000	$1,560,000

SCENARIO 1

TABLE 2-5: SUMMARY OF PLANNING-LEVEL COST ESTIMATES AND COST ALLOCATION
(BASED ON LONG-TERM, CONSTRUCTED AS A SINGLE PROJECT) (ENR CCI 11228, April 2019)

Option	**1**	**2**	**3**	**4**	**5**	**6**
Description of Effluent Disposal	**RIB**	**RIB & Wicks**	**RIB & DWI**	**RIB & Outfall**	**DWI**	**Outfall**
Capital Cost						
Construction - Conveyance	$29,030,000	$29,030,000	$29,030,000	$29,030,000	$29,030,000	$29,030,000
Construction - Treatment	$38,900,000	$41,300,000	$61,100,000	$41,300,000	$66,600,000	$41,300,000
Construction - Transport to Disposal	$22,900,000	$22,900,000	$5,160,000	$23,950,000	$5,160,000	$23,950,000
Construction - Disposal	$11,700,000	$11,400,000	$13,400,000	$11,900,000	$14,200,000	$13,400,000
Contingency, Technical, Legal/Admin/Finance	$44,090,000	$44,990,000	$46,740,000	$45,660,000	$49,450,000	$46,300,000
Total Capital Cost	**$146,620,000**	**$149,620,000**	**$155,430,000**	**$151,840,000**	**$164,440,000**	**$153,980,000**
Ratio to Lowest - Total Capital Cost	1.00	1.02	1.06	1.04	1.12	1.05
Ratio to Lowest - Capital Cost, excl. Conveyance	1.00	1.03	1.08	1.05	1.17	1.07
Annual Operation & Maintenance Cost	**$2,910,000**	**$3,010,000**	**$5,660,000**	**$3,110,000**	**$6,830,000**	**$3,110,000**
Ratio to Lowest - Annual O&M	1.00	1.03	1.95	1.07	2.35	1.07
Total Annual Debt Service on Capital Cost	$8,970,000	$9,150,000	$9,510,000	$9,290,000	$10,060,000	$9,420,000
Total Equivalent Annual Cost (Note 3)	**$11,880,000**	**$12,160,000**	**$15,170,000**	**$12,400,000**	**$16,890,000**	**$12,530,000**
Ratio to Lowest - Equivalent Annual Cost	1.00	1.02	1.28	1.04	1.42	1.05
EAC per thousand gallons of disposal capacity	$9.72	$9.94	$12.41	$10.14	$13.81	$10.25

Notes:

1) Costs are presented in current dollars based on Engineering News Record Construction Cost Index 11228 (April 2019).
2) Refer to Appendix A for supporting information.
3) Equivalent Annual Cost equals Annual O&M Cost plus the Annual Debt Service on Capital Cost.
4) Allocation for Conveyance is 100% to each town. Allocation for treatment/transport/disposal is pro-rated based on flow capacity requested.
5) Blue indicates lowest cost option, green indicates second lowest cost option and orange indicates third lowest cost option.

SCENARIO 1

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ALTERNATIVES ANALYSIS
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019

File Name: CostAnalysis-20171127-BARN-20190327

ENR CCI 11228 (April 2019)

COST ALLOCATION OF "CANDIDATE PLAN" BY PHASE
USE COSTS FOR OPTION 6 (OUTFALL), AS THE MOST CONSERVATIVE OF "FOUR ESSENTIALLY EQUIVALENT COST OPTIONS" (OPTIONS 1/2/4/6)

	COSTS ($MILLION)			CHECK	ALLOCATION, % OF FLOW			ALLOCATION OF FLOW		
	Existing	Short-Term	Long-Term	TOTAL	Ex	ST	LT	Ex	ST	LT
Conveyance	$0	$3,600,000	$25,430,000	$29,030,000				140,000	347,000	1,189,000
JBCC	$0	$0	$0	$0				140,000	147,000	147,000
Bourne	$0	$1,100,000	$8,790,000	$9,890,000				0	0	467,000
Falmouth	$0	$0	$11,650,000	$11,650,000				0	0	22,000
Mashpee	$0	$2,500,000	$0	$2,500,000				0	200,000	203,000
Sandwich	$0	$0	$4,990,000	$4,990,000				0	0	350,000
Barnstable	$0	$0		$0				0	0	
Treatment-BASELINE	$0	$1,920,000	$39,380,000	$41,300,000	100%	100%	100%	140,000	347,000	1,189,000
JBCC	$0	$813,000	$4,869,000	$5,682,000	100%	42%	12%	140,000	147,000	147,000
Bourne	$0	$0	$15,467,000	$15,467,000	0%	0%	39%	0	0	467,000
Falmouth	$0	$0	$729,000	$729,000	0%	0%	2%	0	0	22,000
Mashpee	$0	$1,107,000	$6,723,000	$7,830,000	0%	58%	17%	0	200,000	203,000
Sandwich	$0	$0	$11,592,000	$11,592,000	0%	0%	29%	0	0	350,000
Barnstable	$0	$0	$0	$0	0%	0%	0%	0	0	0
Treatment-SUPPLEMENT	$0	$0	$0	$0	100%	100%	100%	140,000	347,000	1,189,000
JBCC	$0	$0	$0	$0	100%	42%	12%	140,000	147,000	147,000
Bourne	$0	$0	$0	$0	0%	0%	39%	0	0	467,000
Falmouth	$0	$0	$0	$0	0%	0%	2%	0	0	22,000
Mashpee	$0	$0	$0	$0	0%	58%	17%	0	200,000	203,000
Sandwich	$0	$0	$0	$0	0%	0%	29%	0	0	350,000
Barnstable	$0	$0	$0	$0	0%	0%	0%	0	0	0
Transport to Disposal	$0	$300,000	$23,650,000	$23,950,000	100%	100%	100%	140,000	447,000	3,330,000
JBCC	$0	$99,000	$1,044,000	$1,143,000	100%	33%	4%	140,000	147,000	147,000
Bourne	$0	$67,000	$7,940,000	$8,007,000	0%	22%	34%	0	100,000	1,118,000
Falmouth	$0	$0	$10,738,000	$10,738,000	0%	0%	45%	0	0	1,512,000
Mashpee	$0	$134,000	$1,442,000	$1,576,000	0%	45%	6%	0	200,000	203,000
Sandwich	$0	$0	$2,486,000	$2,486,000	0%	0%	11%	0	0	350,000
Barnstable	$0	$0	$0	$0	0%	0%	0%	0	0	0
Disposal	$0	$400,000	$13,000,000	$13,400,000	100%	100%	100%	140,000	447,000	3,330,000
JBCC	$0	$132,000	$574,000	$706,000	100%	33%	4%	140,000	147,000	147,000
Bourne	$0	$89,000	$4,365,000	$4,454,000	0%	22%	34%	0	100,000	1,118,000
Falmouth	$0	$0	$5,903,000	$5,903,000	0%	0%	45%	0	0	1,512,000
Mashpee	$0	$179,000	$792,000	$971,000	0%	45%	6%	0	200,000	203,000
Sandwich	$0	$0	$1,366,000	$1,366,000	0%	0%	11%	0	0	350,000
Barnstable	$0	$0	$0	$0	0%	0%	0%	0	0	0

SCENARIO 1

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ALTERNATIVES ANALYSIS
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019

File Name: CostAnalysis-20171127-BARN-20190327

ENR CCI 11228 (April 2019)

COST ALLOCATION OF "CANDIDATE PLAN" BY PHASE
USE COSTS FOR OPTION 6 (OUTFALL), AS THE MOST CONSERVATIVE OF "FOUR ESSENTIALLY EQUIVALENT COST OPTIONS" (OPTIONS 1/2/4/6)

	COSTS ($MILLION)			CHECK	ALLOCATION, % OF FLOW			ALLOCATION OF FLOW		
	Existing	Short-Term	Long-Term	TOTAL	Ex	ST	LT	Ex	ST	LT
Conting/Tech/Legal/etc	$0	$2,675,000	$43,628,000	$46,300,000	100%	100%	100%	Pro-rata based on construction subtotal		
JBCC	$0	$449,000	$2,789,000	$3,238,000	100%	17%	6%	Pro-rata based on construction subtotal		
Bourne	$0	$540,000	$15,722,000	$16,262,000	0%	20%	36%	Pro-rata based on construction subtotal		
Falmouth	$0	$0	$12,479,000	$12,479,000	0%	0%	29%	Pro-rata based on construction subtotal		
Mashpee	$0	$1,686,000	$3,852,000	$5,538,000	0%	63%	9%	Pro-rata based on construction subtotal		
Sandwich	$0	$0	$8,787,000	$8,787,000	0%	0%	20%	Pro-rata based on construction subtotal		
Barnstable	$0	$0	$0	$0	0%	0%	0%			
Check										
TOTAL	$0	$8,900,000	$145,090,000	$153,990,000						
JBCC	$0	$1,490,000	$9,280,000	$10,770,000						
Bourne	$0	$1,800,000	$52,280,000	$54,080,000						
Falmouth	$0	$0	$41,500,000	$41,500,000						
Mashpee	$0	$5,610,000	$12,810,000	$18,420,000						
Sandwich	$0	$0	$29,220,000	$29,220,000						
Barnstable	$0	$0	$0	$0						
Check	$0	$8,900,000	$145,090,000	$153,990,000						
ANNUAL O&M-SEW/SEPT	$0	$739,500	$1,560,000		100%	100%	100%	140,000	447,000	1,189,000
JBCC	$0.00	$0.24	$0.19		100%	33%	12%	140,000	147,000	147,000
Bourne	$0.00	$0.17	$0.61		0%	22%	39%	0	100,000	467,000
Falmouth	$0.00	$0.00	$0.03		0%	0%	2%	0	0	22,000
Mashpee	$0.00	$0.33	$0.27		0%	45%	17%	0	200,000	203,000
Sandwich	$0.00	$0.00	$0.46		0%	0%	29%	0	0	350,000
Barnstable	$0.00	$0.00	$0.00		0%	0%	0%	0	0	0
Check	$0.00	$0.74	$1.56							
ANNUAL O&M-EFF	$510,000	$739,500	$1,560,000		100%	100%	100%	140,000	447,000	3,330,000
JBCC	$0.51	$0.24	$0.07		100%	33%	4%	140,000	147,000	147,000
Bourne	$0.00	$0.17	$0.52		0%	22%	34%	0	100,000	1,118,000
Falmouth	$0.00	$0.00	$0.71		0%	0%	45%	0	0	1,512,000
Mashpee	$0.00	$0.33	$0.10		0%	45%	6%	0	200,000	203,000
Sandwich	$0.00	$0.00	$0.16		0%	0%	11%	0	0	350,000
Barnstable	$0.00	$0.00	$0.00		0%	0%	0%	0	0	0
Check	$0.51	$0.74	$1.56							
ANNUAL O&M-TOTAL	$510,000	$1,479,000	$3,120,000		100%	100%	100%	140,000	447,000	3,330,000
JBCC	$0.51	$0.49	$0.26		100%	33%	4%	140,000	147,000	147,000
Bourne	$0.00	$0.33	$1.14		0%	22%	34%	0	100,000	1,118,000
Falmouth	$0.00	$0.00	$0.74		0%	0%	45%	0	0	1,512,000

SCENARIO 1

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ALTERNATIVES ANALYSIS
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019

File Name: CostAnalysis-20171127-BARN-20190327

ENR CCI 11228 (April 2019)

COST ALLOCATION OF "CANDIDATE PLAN" BY PHASE

USE COSTS FOR OPTION 6 (OUTFALL), AS THE MOST CONSERVATIVE OF "FOUR ESSENTIALLY EQUIVALENT COST OPTIONS" (OPTIONS 1/2/4/6)

	COSTS ($MILLION)			CHECK	ALLOCATION, % OF FLOW			ALLOCATION OF FLOW		
	Existing	Short-Term	Long-Term	TOTAL	Ex	ST	LT	Ex	ST	LT
Mashpee	$0.00	$0.66	$0.36		0%	45%	6%	0	200,000	203,000
Sandwich	$0.00	$0.00	$0.62		0%	0%	11%	0	0	350,000
Barnstable	$0.00	$0.00	$0.00		0%	0%	0%	0	0	0
Check	$0.51	$1.48	$3.12							

DEBT SERVICE	CRF >>	16.35		
JBCC	$0.00	$0.09	$0.57	$0.66
Bourne	$0.00	$0.11	$3.20	$3.31
Falmouth	$0.00	$0.00	$2.54	$2.54
Mashpee	$0.00	$0.34	$0.78	$1.13
Sandwich	$0.00	$0.00	$1.79	$1.79
Barnstable	$0.00	$0.00	$0.00	$0.00
Check	$0.00	$0.54	$8.87	$9.42

EQUIVALENT ANNUAL COST			
JBCC	$0.51	$0.58	$0.83
Bourne	$0.00	$0.44	$4.33
Falmouth	$0.00	$0.00	$3.28
Mashpee	$0.00	$1.00	$1.14
Sandwich	$0.00	$0.00	$2.41
Barnstable	$0.00	$0.00	$0.00
Check	$0.51	$2.02	$11.99

CAPITAL COST PER KGAL (DISPOSAL CAPACITY)					DISPOSAL CAPACITY		
JBCC	$0	$28	$173	$201	140,000	147,000	147,000
Bourne		$49	$128	$133	0	100,000	1,118,000
Falmouth		$0	$75	$75	0	0	1,512,000
Mashpee		$77	$173	$249	0	200,000	203,000
Sandwich		$0	$229	$229	0	0	350,000
Barnstable		$0	#DIV/0!	#DIV/0!		0	0
TOTAL		$55	$119	$127		447,000	3,330,000

SCENARIO 2

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ENGINEERING ASSESSMENT
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019 ENR CCI (10/2017) 10800

Scenario 1
Scenario 2
Scenario 3

COSTS FOR TREATMENT, TRANSPORT-TO-DISPOSAL AND DISPOSAL ALTERNATIVES **Projected to April 2019 dollars**
LONG-TERM

			1	2	3	4	5	6
Items			**RIB**	**RIB/WICK**	**RIB/DWI**	**RIB/OUTFALL**	**DWI**	**OUTFALL**
CAPITAL COSTS								
	Unit Costs							
	Cost, ENR/SBR, Disinfection	1.00	$30.00	$30.00	$30.00	$32.00	$30.00	$32.00
	Cost, ENR/MBR, Disinfection	10%			$3.00		$3.00	
	Cost, Sand Filtration	1.00		$1.90				
	Cost, RO/Reject/Storage	1.00			$4.50		$4.50	
	Cost, GAC/Reject/Storage	1.00						
	Effluent PS, at 200'TDH	1.00	$2.25	$2.25	$1.50	$2.25	$1.50	$2.25
	Flow (gpd, annual average basis)							
	ENR/SBR/UV		1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000
	ENR/MBR-Adder				400,000		500,000	
	Sand Filtration	5%		1,270,000				
	RO/AO/Storage				3,100,000		3,850,000	
	GAC/Reject/Storage				3,100,000		3,850,000	
	Effluent PS		1,210,000	1,210,000	2,700,000	1,210,000	3,350,000	1,210,000
	Cost - Treatment-Baseline							
	Existing WWTF Upgrades		$2,570,000	$2,570,000	$2,570,000	$2,570,000	$2,570,000	$2,570,000
	ENR Baseline		$36,300,000	$36,300,000	$36,300,000	$38,720,000	$36,300,000	$38,720,000
	Subtotal - Treatment		**$38,900,000**	**$38,900,000**	**$38,900,000**	**$41,300,000**	**$38,900,000**	**$41,300,000**
	Cost - Treatment-Supplemental							
	ENR/MBR Adder		$0	$0	$13,200,000	$0	$16,500,000	$0
	Sand Filtration		$0	$2,413,000	$0	$0	$0	$0
	RO/AO/Storage		$0	$0	$13,950,000	$0	$17,325,000	$0
	GAC/Reject/Storage		$0	$0	$0	$0	$0	$0
	Subtotal - Treatment		**$0**	**$2,400,000**	**$27,200,000**	**$0**	**$33,800,000**	**$0**
	Cost - Transport to Disposal							
	Existing Forcemain Upgrades		$300,000	$300,000	$300,000	$300,000	$300,000	$300,000
	New Forcemains		$19,770,000	$19,770,000	$4,250,000	$20,700,000	$4,250,000	$20,700,000
	Length	mi	10.7	10.7	2.3	11.2	2.3	11.2
	Number		1	1	1	1	1	1
	Length	ft	56,496	56,496	12,144	59,136	12,144	59,136
	Cost per Foot		350	350	350	350	350	350
	Subtotal - Transport to Disposal		**$20,070,000**	**$20,070,000**	**$4,550,000**	**$21,000,000**	**$4,550,000**	**$21,000,000**

SCENARIO 2

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ENGINEERING ASSESSMENT
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019 ENR CCI (10/2017) 10800

Scenario 1
Scenario 2
Scenario 3

COSTS FOR TREATMENT, TRANSPORT-TO-DISPOSAL AND DISPOSAL ALTERNATIVES **Projected to April 2019 dollars**
LONG-TERM

			1	2	3	4	5	6
Items			**RIB**	**RIB/WICK**	**RIB/DWI**	**RIB/OUTFALL**	**DWI**	**OUTFALL**
	Cost - Disposal							
	Existing RIB Upgrades		$400,000	$400,000	$400,000	$400,000	$400,000	$400,000
	Effluent PS		$2,720,000	$2,720,000	$4,050,000	$2,720,000	$5,030,000	$2,720,000
	New RIBs		$8,600,000		$2,640,000			
	New Wicks			$8,300,000				
	New DWI				$6,300,000		$8,800,000	
	New Outfall					$8,800,000		$10,290,000
	Subtotal - Disposal		**$11,700,000**	**$11,400,000**	**$13,400,000**	**$11,900,000**	**$14,200,000**	**$13,400,000**
	TOTAL		**$70,670,000**	**$72,770,000**	**$84,050,000**	**$74,200,000**	**$91,450,000**	**$75,700,000**
	Lowest plus +% higher for other Options		$70,670,000	3%	19%	5%	29%	7%
ANNUAL O&M								
	Basis flow		1,210,000	1,210,000	2,700,000	1,210,000	3,350,000	1,210,000
	Baseline, April 2014 (ENR CCI 9750)	1.00	$1.50	$1.50	$1.25	$1.50	$1.25	$1.50
	Baseline, Current (ENR CCI 10800)		$1.66	$1.66	$1.38	$1.66	$1.38	$1.66
	Baseline Costs		$2,010,000	$2,010,000	$3,740,000	$2,010,000	$4,640,000	$2,010,000
	Adder for Existing Collection O&M		$800,000	$800,000	$800,000	$800,000	$800,000	$800,000
	Adder for Filtration	5%		$100,500				
	Adder for SW Discharge	10%				$201,000.00		$201,000.00
	Adder for ENR/MBR	10%			$374,000		$464,000	
	Adder for RO/Storage	25%			$935,000		$1,160,000	
	Adder for GAC/Storage	0%			$0		$0	
	Adder for Effluent Pumping	5%	$100,500	$100,500	$187,000	$100,500	$232,000	$100,500
	Annual O&M		$2,910,000	$3,010,000	$6,040,000	$3,110,000	$7,300,000	$3,110,000
	Lowest plus +% higher for other Options		$2,910,000	3%	108%	7%	151%	7%
	O&M Allocated to Sewage/Septage, %		50%	50%	50%	50%	50%	50%
	O&M Allocated to Effluent, %		50%	50%	50%	50%	50%	50%
	O&M Allocated to Sewage/Septage, $$		$1,460,000	$1,510,000	$3,020,000	$1,560,000	$3,650,000	$1,560,000
	O&M Allocated to Effluent, $$		$1,460,000	$1,510,000	$3,020,000	$1,560,000	$3,650,000	$1,560,000

SCENARIO 2

TABLE 2-5: SUMMARY OF PLANNING-LEVEL COST ESTIMATES AND COST ALLOCATION (BASED ON LONG-TERM, CONSTRUCTED AS A SINGLE PROJECT) (ENR CCI 11228, April 2019)

Option	**1**	**2**	**3**	**4**	**5**	**6**
Description of Effluent Disposal	**RIB**	**RIB & Wicks**	**RIB & DWI**	**RIB & Outfall**	**DWI**	**Outfall**
Capital Cost						
Construction - Conveyance	$29,030,000	$29,030,000	$29,030,000	$29,030,000	$29,030,000	$29,030,000
Construction - Treatment	$38,900,000	$41,300,000	$66,100,000	$41,300,000	$72,700,000	$41,300,000
Construction - Transport to Disposal	$20,070,000	$20,070,000	$4,550,000	$21,000,000	$4,550,000	$21,000,000
Construction - Disposal	$11,700,000	$11,400,000	$13,400,000	$11,900,000	$14,200,000	$13,400,000
Contingency, Technical, Legal/Admin/Finance	$42,870,000	$43,770,000	$48,620,000	$44,390,000	$51,810,000	$45,030,000
Total Capital Cost	**$142,570,000**	**$145,570,000**	**$161,700,000**	**$147,620,000**	**$172,290,000**	**$149,760,000**
Ratio to Lowest - Total Capital Cost	1.00	1.02	1.13	1.04	1.21	1.05
Ratio to Lowest - Capital Cost, excl. Conveyance	1.00	1.03	1.19	1.05	1.29	1.07
Annual Operation & Maintenance Cost	**$2,910,000**	**$3,010,000**	**$6,040,000**	**$3,110,000**	**$7,300,000**	**$3,110,000**
Ratio to Lowest - Annual O&M	1.00	1.03	2.08	1.07	2.51	1.07
Total Annual Debt Service on Capital Cost	$8,720,000	$8,900,000	$9,890,000	$9,030,000	$10,540,000	$9,160,000
Total Equivalent Annual Cost (Note 3)	**$11,630,000**	**$11,910,000**	**$15,930,000**	**$12,140,000**	**$17,840,000**	**$12,270,000**
Ratio to Lowest - Equivalent Annual Cost	1.00	1.02	1.37	1.04	1.53	1.06
EAC per thousand gallons of disposal capacity	$9.51	$9.74	$13.03	$9.93	$14.59	$10.03

Notes:

1) Costs are presented in current dollars based on Engineering News Record Construction Cost Index 11228 (April 2019).
2) Refer to Appendix A for supporting information.
3) Equivalent Annual Cost equals Annual O&M Cost plus the Annual Debt Service on Capital Cost.
4) Allocation for Conveyance is 100% to each town. Allocation for treatment/transport/disposal is pro-rated based on flow capacity requested.
5) Blue indicates lowest cost option, green indicates second lowest cost option and orange indicates third lowest cost option.

SCENARIO 2

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ALTERNATIVES ANALYSIS
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019

File Name: CostAnalysis-20171127-BARN-20190327

ENR CCI 11228 (April 2019)

COST ALLOCATION OF "CANDIDATE PLAN" BY PHASE
USE COSTS FOR OPTION 6 (OUTFALL), AS THE MOST CONSERVATIVE OF "FOUR ESSENTIALLY EQUIVALENT COST OPTIONS" (OPTIONS 1/2/4/6)

	COSTS ($MILLION)			CHECK	ALLOCATION, % OF FLOW			ALLOCATION OF FLOW		
	Existing	Short-Term	Long-Term	TOTAL	Ex	ST	LT	Ex	ST	LT
Conveyance	$0	$3,600,000	$25,430,000	$29,030,000				140,000	347,000	1,189,000
JBCC	$0	$0	$0	$0				140,000	147,000	147,000
Bourne	$0	$1,100,000	$8,790,000	$9,890,000				0	0	467,000
Falmouth	$0	$0	$11,650,000	$11,650,000				0	0	22,000
Mashpee	$0	$2,500,000	$0	$2,500,000				0	200,000	203,000
Sandwich	$0	$0	$4,990,000	$4,990,000				0	0	350,000
Barnstable	$0	$0		$0				0	0	
Treatment-BASELINE	$0	$1,920,000	$39,380,000	$41,300,000	100%	100%	100%	140,000	347,000	1,189,000
JBCC	$0	$813,000	$4,869,000	$5,682,000	100%	42%	12%	140,000	147,000	147,000
Bourne	$0	$0	$15,467,000	$15,467,000	0%	0%	39%	0	0	467,000
Falmouth	$0	$0	$729,000	$729,000	0%	0%	2%	0	0	22,000
Mashpee	$0	$1,107,000	$6,723,000	$7,830,000	0%	58%	17%	0	200,000	203,000
Sandwich	$0	$0	$11,592,000	$11,592,000	0%	0%	29%	0	0	350,000
Barnstable	$0	$0	$0	$0	0%	0%	0%	0	0	0
Treatment-SUPPLEMENT	$0	$0	$0	$0	100%	100%	100%	140,000	347,000	1,189,000
JBCC	$0	$0	$0	$0	100%	42%	12%	140,000	147,000	147,000
Bourne	$0	$0	$0	$0	0%	0%	39%	0	0	467,000
Falmouth	$0	$0	$0	$0	0%	0%	2%	0	0	22,000
Mashpee	$0	$0	$0	$0	0%	58%	17%	0	200,000	203,000
Sandwich	$0	$0	$0	$0	0%	0%	29%	0	0	350,000
Barnstable	$0	$0	$0	$0	0%	0%	0%	0	0	0
Transport to Disposal	$0	$300,000	$20,700,000	$21,000,000	100%	100%	100%	140,000	447,000	3,330,000
JBCC	$0	$99,000	$914,000	$1,013,000	100%	33%	4%	140,000	147,000	147,000
Bourne	$0	$67,000	$6,950,000	$7,017,000	0%	22%	34%	0	100,000	1,118,000
Falmouth	$0	$0	$9,399,000	$9,399,000	0%	0%	45%	0	0	1,512,000
Mashpee	$0	$134,000	$1,262,000	$1,396,000	0%	45%	6%	0	200,000	203,000
Sandwich	$0	$0	$2,176,000	$2,176,000	0%	0%	11%	0	0	350,000
Barnstable	$0	$0	$0	$0	0%	0%	0%	0	0	0
Disposal	$0	$400,000	$13,000,000	$13,400,000	100%	100%	100%	140,000	447,000	3,330,000
JBCC	$0	$132,000	$574,000	$706,000	100%	33%	4%	140,000	147,000	147,000
Bourne	$0	$89,000	$4,365,000	$4,454,000	0%	22%	34%	0	100,000	1,118,000
Falmouth	$0	$0	$5,903,000	$5,903,000	0%	0%	45%	0	0	1,512,000
Mashpee	$0	$179,000	$792,000	$971,000	0%	45%	6%	0	200,000	203,000
Sandwich	$0	$0	$1,366,000	$1,366,000	0%	0%	11%	0	0	350,000
Barnstable	$0	$0	$0	$0	0%	0%	0%	0	0	0

SCENARIO 2

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ALTERNATIVES ANALYSIS
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019

File Name: CostAnalysis-20171127-BARN-20190327

ENR CCI 11228 (April 2019)

COST ALLOCATION OF "CANDIDATE PLAN" BY PHASE

USE COSTS FOR OPTION 6 (OUTFALL), AS THE MOST CONSERVATIVE OF "FOUR ESSENTIALLY EQUIVALENT COST OPTIONS" (OPTIONS 1/2/4/6)

	COSTS ($MILLION)			CHECK	ALLOCATION, % OF FLOW			ALLOCATION OF FLOW		
	Existing	Short-Term	Long-Term	TOTAL	Ex	ST	LT	Ex	ST	LT
Conting/Tech/Legal/etc	$0	$2,675,000	$42,359,000	$45,030,000	100%	100%	100%	Pro-rata based on construction subtotal		
JBCC	$0	$449,000	$2,733,000	$3,182,000	100%	17%	6%	Pro-rata based on construction subtotal		
Bourne	$0	$540,000	$15,296,000	$15,836,000	0%	20%	36%	Pro-rata based on construction subtotal		
Falmouth	$0	$0	$11,903,000	$11,903,000	0%	0%	28%	Pro-rata based on construction subtotal		
Mashpee	$0	$1,686,000	$3,774,000	$5,460,000	0%	63%	9%	Pro-rata based on construction subtotal		
Sandwich	$0	$0	$8,653,000	$8,653,000	0%	0%	20%	Pro-rata based on construction subtotal		
Barnstable	$0	$0	$0	$0	0%	0%	0%			
Check										
TOTAL	$0	$8,900,000	$140,870,000	$149,770,000						
JBCC	$0	$1,490,000	$9,090,000	$10,580,000						
Bourne	$0	$1,800,000	$50,870,000	$52,670,000						
Falmouth	$0	$0	$39,580,000	$39,580,000						
Mashpee	$0	$5,610,000	$12,550,000	$18,160,000						
Sandwich	$0	$0	$28,780,000	$28,780,000						
Barnstable	$0	$0	$0	$0						
Check	$0	$8,900,000	$140,870,000	$149,770,000						
ANNUAL O&M-SEW/SEPT	$0	$739,500	$1,560,000		100%	100%	100%	140,000	447,000	1,189,000
JBCC	$0.00	$0.24	$0.19		100%	33%	12%	140,000	147,000	147,000
Bourne	$0.00	$0.17	$0.61		0%	22%	39%	0	100,000	467,000
Falmouth	$0.00	$0.00	$0.03		0%	0%	2%	0	0	22,000
Mashpee	$0.00	$0.33	$0.27		0%	45%	17%	0	200,000	203,000
Sandwich	$0.00	$0.00	$0.46		0%	0%	29%	0	0	350,000
Barnstable	$0.00	$0.00	$0.00		0%	0%	0%	0	0	0
Check	$0.00	$0.74	$1.56							
ANNUAL O&M-EFF	$510,000	$739,500	$1,560,000		100%	100%	100%	140,000	447,000	3,330,000
JBCC	$0.51	$0.24	$0.07		100%	33%	4%	140,000	147,000	147,000
Bourne	$0.00	$0.17	$0.52		0%	22%	34%	0	100,000	1,118,000
Falmouth	$0.00	$0.00	$0.71		0%	0%	45%	0	0	1,512,000
Mashpee	$0.00	$0.33	$0.10		0%	45%	6%	0	200,000	203,000
Sandwich	$0.00	$0.00	$0.16		0%	0%	11%	0	0	350,000
Barnstable	$0.00	$0.00	$0.00		0%	0%	0%	0	0	0
Check	$0.51	$0.74	$1.56							
ANNUAL O&M-TOTAL	$510,000	$1,479,000	$3,120,000		100%	100%	100%	140,000	447,000	3,330,000
JBCC	$0.51	$0.49	$0.26		100%	33%	4%	140,000	147,000	147,000
Bourne	$0.00	$0.33	$1.14		0%	22%	34%	0	100,000	1,118,000
Falmouth	$0.00	$0.00	$0.74		0%	0%	45%	0	0	1,512,000

SCENARIO 2

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ALTERNATIVES ANALYSIS
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019

File Name: CostAnalysis-20171127-BARN-20190327

ENR CCI 11228 (April 2019)

COST ALLOCATION OF "CANDIDATE PLAN" BY PHASE

USE COSTS FOR OPTION 6 (OUTFALL), AS THE MOST CONSERVATIVE OF "FOUR ESSENTIALLY EQUIVALENT COST OPTIONS" (OPTIONS 1/2/4/6)

	COSTS ($MILLION)			CHECK	ALLOCATION, % OF FLOW			ALLOCATION OF FLOW		
	Existing	Short-Term	Long-Term	TOTAL	Ex	ST	LT	Ex	ST	LT
Mashpee	$0.00	$0.66	$0.36		0%	45%	6%	0	200,000	203,000
Sandwich	$0.00	$0.00	$0.62		0%	0%	11%	0	0	350,000
Barnstable	$0.00	$0.00	$0.00		0%	0%	0%	0	0	0
Check	$0.51	$1.48	$3.12							

DEBT SERVICE	CRF >>	16.35		
JBCC	$0.00	$0.09	$0.56	$0.65
Bourne	$0.00	$0.11	$3.11	$3.22
Falmouth	$0.00	$0.00	$2.42	$2.42
Mashpee	$0.00	$0.34	$0.77	$1.11
Sandwich	$0.00	$0.00	$1.76	$1.76
Barnstable	$0.00	$0.00	$0.00	$0.00
Check	$0.00	$0.54	$8.62	$9.16

EQUIVALENT ANNUAL COST			
JBCC	$0.51	$0.58	$0.82
Bourne	$0.00	$0.44	$4.25
Falmouth	$0.00	$0.00	$3.16
Mashpee	$0.00	$1.00	$1.13
Sandwich	$0.00	$0.00	$2.38
Barnstable	$0.00	$0.00	$0.00
Check	$0.51	$2.02	$11.74

CAPITAL COST PER KGAL (DISPOSAL CAPACITY)					DISPOSAL CAPACITY		
JBCC	$0	$28	$169	$197	140,000	147,000	147,000
Bourne		$49	$125	$129	0	100,000	1,118,000
Falmouth		$0	$72	$72	0	0	1,512,000
Mashpee		$77	$169	$245	0	200,000	203,000
Sandwich		$0	$225	$225	0	0	350,000
Barnstable		$0	#DIV/0!	#DIV/0!		0	0
TOTAL		$55	$116	$123		447,000	3,330,000

STEP 3A

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ENGINEERING ASSESSMENT
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019 ENR CCI (10/2017) 10800

Scenario 1
Scenario 2
Scenario 3

COSTS FOR TREATMENT, TRANSPORT-TO-DISPOSAL AND DISPOSAL ALTERNATIVES **Projected to April 2019 dollars**
LONG-TERM

		1	2	3	4	5	6
Items		**RIB**	**RIB/WICK**	**RIB/DWI**	**RIB/OUTFALL**	**DWI**	**OUTFALL**
CAPITAL COSTS							
Unit Costs							
Cost, ENR/SBR, Disinfection	1.00	$30.00	$30.00	$30.00	$32.00	$30.00	$32.00
Cost, ENR/MBR, Disinfection	10%			$3.00		$3.00	
Cost, Sand Filtration	1.00		$1.90				
Cost, RO/Reject/Storage	1.00			$4.50		$4.50	
Cost, GAC/Reject/Storage	1.00						
Effluent PS, at 200'TDH	1.00	$2.25	$2.25	$1.50	$2.25	$1.50	$2.25
Flow (gpd, annual average basis)							
ENR/SBR/UV		1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000
ENR/MBR-Adder				400,000		500,000	
Sand Filtration	5%		1,270,000				
RO/AO/Storage				3,100,000		3,850,000	
GAC/Reject/Storage				3,100,000		3,850,000	
Effluent PS		1,210,000	1,210,000	2,700,000	1,210,000	3,350,000	1,210,000
Cost - Treatment-Baseline							
Existing WWTF Upgrades		$2,570,000	$2,570,000	$2,570,000	$2,570,000	$2,570,000	$2,570,000
ENR Baseline		$36,300,000	$36,300,000	$36,300,000	$38,720,000	$36,300,000	$38,720,000
Subtotal - Treatment		**$38,900,000**	**$38,900,000**	**$38,900,000**	**$41,300,000**	**$38,900,000**	**$41,300,000**
Cost - Treatment-Supplemental							
ENR/MBR Adder		$0	$0	$13,200,000	$0	$16,500,000	$0
Sand Filtration		$0	$2,413,000	$0	$0	$0	$0
RO/AO/Storage		$0	$0	$13,950,000	$0	$17,325,000	$0
GAC/Reject/Storage		$0	$0	$0	$0	$0	$0
Subtotal - Treatment		**$0**	**$2,400,000**	**$27,200,000**	**$0**	**$33,800,000**	**$0**
Cost - Transport to Disposal							
Existing Forcemain Upgrades		$300,000	$300,000	$300,000	$300,000	$300,000	$300,000
New Forcemains		$22,600,000	$22,600,000	$4,860,000	$23,650,000	$4,860,000	$23,650,000
Length	mi	10.7	10.7	2.3	11.2	2.3	11.2
Number		2	2	2	2	2	2
Length	ft	112,992	112,992	24,288	118,272	24,288	118,272
Cost per Foot		200	200	200	200	200	200
Subtotal - Transport to Disposal		**$22,900,000**	**$22,900,000**	**$5,160,000**	**$23,950,000**	**$5,160,000**	**$23,950,000**

STEP 3A

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ENGINEERING ASSESSMENT
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019 ENR CCI (10/2017) 10800

Scenario 1
Scenario 2
Scenario 3

COSTS FOR TREATMENT, TRANSPORT-TO-DISPOSAL AND DISPOSAL ALTERNATIVES **Projected to April 2019 dollars**
LONG-TERM

			1	2	3	4	5	6
Items			**RIB**	**RIB/WICK**	**RIB/DWI**	**RIB/OUTFALL**	**DWI**	**OUTFALL**
	Cost - Disposal							
	Existing RIB Upgrades		$400,000	$400,000	$400,000	$400,000	$400,000	$400,000
	Effluent PS		$2,720,000	$2,720,000	$4,050,000	$2,720,000	$5,030,000	$2,720,000
	New RIBs		$8,600,000		$2,640,000			
	New Wicks			$8,300,000				
	New DWI				$6,300,000		$8,800,000	
	New Outfall					$8,800,000		$10,290,000
	Subtotal - Disposal		**$11,700,000**	**$11,400,000**	**$13,400,000**	**$11,900,000**	**$14,200,000**	**$13,400,000**
	TOTAL		**$73,500,000**	**$75,600,000**	**$84,660,000**	**$77,150,000**	**$92,060,000**	**$78,650,000**
	Lowest plus +% higher for other Options		$73,500,000	3%	15%	5%	25%	7%
ANNUAL O&M								
	Basis flow		1,210,000	1,210,000	2,700,000	1,210,000	3,350,000	1,210,000
	Baseline, April 2014 (ENR CCI 9750)	1.00	$1.50	$1.50	$1.25	$1.50	$1.25	$1.50
	Baseline, Current (ENR CCI 10800)		$1.66	$1.66	$1.38	$1.66	$1.38	$1.66
	Baseline Costs		$2,010,000	$2,010,000	$3,740,000	$2,010,000	$4,640,000	$2,010,000
	Adder for Existing Collection O&M		$800,000	$800,000	$800,000	$800,000	$800,000	$800,000
	Adder for Filtration	5%		$100,500				
	Adder for SW Discharge	10%				$201,000.00		$201,000.00
	Adder for ENR/MBR	10%			$374,000		$464,000	
	Adder for RO/Storage	25%			$935,000		$1,160,000	
	Adder for GAC/Storage	0%			$0		$0	
	Adder for Effluent Pumping	5%	$100,500	$100,500	$187,000	$100,500	$232,000	$100,500
	Annual O&M		$2,910,000	$3,010,000	$6,040,000	$3,110,000	$7,300,000	$3,110,000
	Lowest plus +% higher for other Options		$2,910,000	3%	108%	7%	151%	7%
	O&M Allocated to Sewage/Septage, %		50%	50%	50%	50%	50%	50%
	O&M Allocated to Effluent, %		50%	50%	50%	50%	50%	50%
	O&M Allocated to Sewage/Septage, $$		$1,460,000	$1,510,000	$3,020,000	$1,560,000	$3,650,000	$1,560,000
	O&M Allocated to Effluent, $$		$1,460,000	$1,510,000	$3,020,000	$1,560,000	$3,650,000	$1,560,000

STEP 3A

TABLE 2-5: SUMMARY OF PLANNING-LEVEL COST ESTIMATES AND COST ALLOCATION
(BASED ON LONG-TERM, CONSTRUCTED AS A SINGLE PROJECT) (ENR CCI 11228, April 2019)

Option	**1**	**2**	**3**	**4**	**5**	**6**
Description of Effluent Disposal	**RIB**	**RIB & Wicks**	**RIB & DWI**	**RIB & Outfall**	**DWI**	**Outfall**
Capital Cost						
Construction - Conveyance	$27,700,000	$27,700,000	$27,700,000	$27,700,000	$27,700,000	$27,700,000
Construction - Treatment	$38,900,000	$41,300,000	$66,100,000	$41,300,000	$72,700,000	$41,300,000
Construction - Transport to Disposal	$22,900,000	$22,900,000	$5,160,000	$23,950,000	$5,160,000	$23,950,000
Construction - Disposal	$11,700,000	$11,400,000	$13,400,000	$11,900,000	$14,200,000	$13,400,000
Contingency, Technical, Legal/Admin/Finance	$43,520,000	$44,420,000	$48,310,000	$45,090,000	$51,500,000	$45,730,000
Total Capital Cost	**$144,720,000**	**$147,720,000**	**$160,670,000**	**$149,940,000**	**$171,260,000**	**$152,080,000**
Ratio to Lowest - Total Capital Cost	1.00	1.02	1.11	1.04	1.18	1.05
Ratio to Lowest - Capital Cost, excl. Conveyance	1.00	1.03	1.15	1.05	1.25	1.07
Annual Operation & Maintenance Cost	**$2,910,000**	**$3,010,000**	**$6,040,000**	**$3,110,000**	**$7,300,000**	**$3,110,000**
Ratio to Lowest - Annual O&M	1.00	1.03	2.08	1.07	2.51	1.07
Total Annual Debt Service on Capital Cost	$8,850,000	$9,030,000	$9,830,000	$9,170,000	$10,470,000	$9,300,000
Total Equivalent Annual Cost (Note 3)	**$11,760,000**	**$12,040,000**	**$15,870,000**	**$12,280,000**	**$17,770,000**	**$12,410,000**
Ratio to Lowest - Equivalent Annual Cost	1.00	1.02	1.35	1.04	1.51	1.06
EAC per thousand gallons of disposal capacity	$9.62	$9.85	$12.98	$10.04	$14.53	$10.15

Notes:

1) Costs are presented in current dollars based on Engineering News Record Construction Cost Index 11228 (April 2019).
2) Refer to Appendix A for supporting information.
3) Equivalent Annual Cost equals Annual O&M Cost plus the Annual Debt Service on Capital Cost.
4) Allocation for Conveyance is 100% to each town. Allocation for treatment/transport/disposal is pro-rated based on flow capacity requested.
5) Blue indicates lowest cost option, green indicates second lowest cost option and orange indicates third lowest cost option.

STEP 3A

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ALTERNATIVES ANALYSIS
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019

File Name: CostAnalysis-20171127-BARN-20190327

ENR CCI 11228 (April 2019)

COST ALLOCATION OF "CANDIDATE PLAN" BY PHASE
USE COSTS FOR OPTION 6 (OUTFALL), AS THE MOST CONSERVATIVE OF "FOUR ESSENTIALLY EQUIVALENT COST OPTIONS" (OPTIONS 1/2/4/6)

	COSTS ($MILLION)			CHECK	ALLOCATION, % OF FLOW			ALLOCATION OF FLOW		
	Existing	Short-Term	Long-Term	TOTAL	Ex	ST	LT	Ex	ST	LT
Conveyance	$0	$3,600,000	$53,130,000	$56,730,000				140,000	347,000	1,347,000
JBCC	$0	$0	$0	$0				140,000	147,000	147,000
Bourne	$0	$1,100,000	$8,790,000	$9,890,000				0	0	
Falmouth	$0	$0	$11,650,000	$11,650,000				0	0	
Mashpee	$0	$2,500,000	$0	$2,500,000				0	200,000	
Sandwich	$0	$0	$4,990,000	$4,990,000				0	0	
Barnstable	$0	$0	$27,700,000	$27,700,000				0	0	1,200,000
Treatment-BASELINE	$0	$1,920,000	$39,380,000	$41,300,000	100%	100%	100%	140,000	347,000	1,347,000
JBCC	$0	$813,000	$4,298,000	$5,111,000	100%	42%	11%	140,000	147,000	147,000
Bourne	$0	$0	$0	$0	0%	0%	0%	0	0	
Falmouth	$0	$0	$0	$0	0%	0%	0%	0	0	
Mashpee	$0	$1,107,000	$0	$1,107,000	0%	58%	0%	0	200,000	
Sandwich	$0	$0	$0	$0	0%	0%	0%	0	0	
Barnstable	$0	$0	$35,082,000	$35,082,000	0%	0%	89%	0	0	1,200,000
Treatment-SUPPLEMENT	$0	$0	$0	$0	100%	100%	100%	140,000	347,000	1,347,000
JBCC	$0	$0	$0	$0	100%	42%	11%	140,000	147,000	147,000
Bourne	$0	$0	$0	$0	0%	0%	0%	0	0	
Falmouth	$0	$0	$0	$0	0%	0%	0%	0	0	
Mashpee	$0	$0	$0	$0	0%	58%	0%	0	200,000	
Sandwich	$0	$0	$0	$0	0%	0%	0%	0	0	
Barnstable	$0	$0	$0	$0	0%	0%	89%	0	0	1,200,000
Transport to Disposal	$0	$300,000	$23,650,000	$23,950,000	100%	100%	100%	140,000	447,000	1,347,000
JBCC	$0	$99,000	$2,581,000	$2,680,000	100%	33%	11%	140,000	147,000	147,000
Bourne	$0	$67,000	$0	$67,000	0%	22%	0%	0	100,000	
Falmouth	$0	$0	$0	$0	0%	0%	0%	0	0	
Mashpee	$0	$134,000	$0	$134,000	0%	45%	0%	0	200,000	
Sandwich	$0	$0	$0	$0	0%	0%	0%	0	0	
Barnstable	$0	$0	$21,069,000	$21,069,000	0%	0%	89%	0	0	1,200,000
Disposal	$0	$400,000	$13,000,000	$13,400,000	100%	100%	100%	140,000	447,000	1,347,000
JBCC	$0	$132,000	$1,419,000	$1,551,000	100%	33%	11%	140,000	147,000	147,000
Bourne	$0	$89,000	$0	$89,000	0%	22%	0%	0	100,000	
Falmouth	$0	$0	$0	$0	0%	0%	0%	0	0	
Mashpee	$0	$179,000	$0	$179,000	0%	45%	0%	0	200,000	
Sandwich	$0	$0	$0	$0	0%	0%	0%	0	0	
Barnstable	$0	$0	$11,581,000	$11,581,000	0%	0%	89%	0	0	1,200,000

STEP 3A

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ALTERNATIVES ANALYSIS
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019

File Name: CostAnalysis-20171127-BARN-20190327

ENR CCI 11228 (April 2019)

COST ALLOCATION OF "CANDIDATE PLAN" BY PHASE

USE COSTS FOR OPTION 6 (OUTFALL), AS THE MOST CONSERVATIVE OF "FOUR ESSENTIALLY EQUIVALENT COST OPTIONS" (OPTIONS 1/2/4/6)

	COSTS ($MILLION)			CHECK	ALLOCATION, % OF FLOW			ALLOCATION OF FLOW		
	Existing	Short-Term	Long-Term	TOTAL	Ex	ST	LT	Ex	ST	LT
Conting/Tech/Legal/etc	$0	$2,675,000	$55,539,000	$58,210,000	100%	100%	100%	Pro-rata based on construction subtotal		
JBCC	$0	$449,000	$3,568,000	$4,017,000	100%	17%	6%	Pro-rata based on construction subtotal		
Bourne	$0	$540,000	$3,780,000	$4,320,000	0%	20%	7%	Pro-rata based on construction subtotal		
Falmouth	$0	$0	$5,010,000	$5,010,000	0%	0%	9%	Pro-rata based on construction subtotal		
Mashpee	$0	$1,686,000	$0	$1,686,000	0%	63%	0%	Pro-rata based on construction subtotal		
Sandwich	$0	$0	$2,146,000	$2,146,000	0%	0%	4%	Pro-rata based on construction subtotal		
Barnstable	$0	$0	$41,036,000	$41,036,000	0%	0%	74%			
Check										
TOTAL	$0	$8,900,000	$184,700,000	$193,600,000						
JBCC	$0	$1,490,000	$11,870,000	$13,360,000						
Bourne	$0	$1,800,000	$12,570,000	$14,370,000						
Falmouth	$0	$0	$16,660,000	$16,660,000						
Mashpee	$0	$5,610,000	$0	$5,610,000						
Sandwich	$0	$0	$7,140,000	$7,140,000						
Barnstable	$0	$0	$136,470,000	$136,470,000						
Check	$0	$8,900,000	$184,710,000	$193,610,000						
ANNUAL O&M-SEW/SEPT	$0	$739,500	$1,560,000		100%	100%	100%	140,000	447,000	1,347,000
JBCC	$0.00	$0.24	$0.17		100%	33%	11%	140,000	147,000	147,000
Bourne	$0.00	$0.17	$0.00		0%	22%	0%	0	100,000	
Falmouth	$0.00	$0.00	$0.00		0%	0%	0%	0	0	
Mashpee	$0.00	$0.33	$0.00		0%	45%	0%	0	200,000	
Sandwich	$0.00	$0.00	$0.00		0%	0%	0%	0	0	
Barnstable	$0.00	$0.00	$1.39		0%	0%	89%	0	0	1,200,000
Check	$0.00	$0.74	$1.56							
ANNUAL O&M-EFF	$510,000	$739,500	$1,560,000		100%	100%	100%	140,000	447,000	1,347,000
JBCC	$0.51	$0.24	$0.17		100%	33%	11%	140,000	147,000	147,000
Bourne	$0.00	$0.17	$0.00		0%	22%	0%	0	100,000	
Falmouth	$0.00	$0.00	$0.00		0%	0%	0%	0	0	
Mashpee	$0.00	$0.33	$0.00		0%	45%	0%	0	200,000	
Sandwich	$0.00	$0.00	$0.00		0%	0%	0%	0	0	
Barnstable	$0.00	$0.00	$1.39		0%	0%	89%	0	0	1,200,000
Check	$0.51	$0.74	$1.56							
ANNUAL O&M-TOTAL	$510,000	$1,479,000	$3,120,000		100%	100%	100%	140,000	447,000	1,347,000
JBCC	$0.51	$0.49	$0.34		100%	33%	11%	140,000	147,000	147,000
Bourne	$0.00	$0.33	$0.00		0%	22%	0%	0	100,000	
Falmouth	$0.00	$0.00	$0.00		0%	0%	0%	0	0	

STEP 3A

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ALTERNATIVES ANALYSIS
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019

File Name: CostAnalysis-20171127-BARN-20190327

ENR CCI 11228 (April 2019)

COST ALLOCATION OF "CANDIDATE PLAN" BY PHASE

USE COSTS FOR OPTION 6 (OUTFALL), AS THE MOST CONSERVATIVE OF "FOUR ESSENTIALLY EQUIVALENT COST OPTIONS" (OPTIONS 1/2/4/6)

	COSTS ($MILLION)			CHECK	ALLOCATION, % OF FLOW			ALLOCATION OF FLOW		
	Existing	Short-Term	Long-Term	TOTAL	Ex	ST	LT	Ex	ST	LT
Mashpee	$0.00	$0.66	$0.00		0%	45%	0%	0	200,000	
Sandwich	$0.00	$0.00	$0.00		0%	0%	0%	0	0	
Barnstable	$0.00	$0.00	$2.78		0%	0%	89%	0	0	1,200,000
Check	$0.51	$1.48	$3.12							

DEBT SERVICE	CRF >>	16.35		
JBCC	$0.00	$0.09	$0.73	$0.82
Bourne	$0.00	$0.11	$0.77	$0.88
Falmouth	$0.00	$0.00	$1.02	$1.02
Mashpee	$0.00	$0.34	$0.00	$0.34
Sandwich	$0.00	$0.00	$0.44	$0.44
Barnstable	$0.00	$0.00	$8.35	$8.35
Check	$0.00	$0.54	$11.30	$11.84

EQUIVALENT ANNUAL COST			
JBCC	$0.51	$0.58	$1.07
Bourne	$0.00	$0.44	$0.77
Falmouth	$0.00	$0.00	$1.02
Mashpee	$0.00	$1.00	$0.00
Sandwich	$0.00	$0.00	$0.44
Barnstable	$0.00	$0.00	$11.13
Check	$0.51	$2.02	$14.42

CAPITAL COST PER KGAL (DISPOSAL CAPACITY)					DISPOSAL CAPACITY		
JBCC	$0	$28	$221	$249	140,000	147,000	147,000
Bourne		$49	#DIV/0!	#DIV/0!	0	100,000	
Falmouth		$0	#DIV/0!	#DIV/0!	0	0	
Mashpee		$77	#DIV/0!	#DIV/0!	0	200,000	
Sandwich		$0	#DIV/0!	#DIV/0!	0	0	
Barnstable		$0	$312	$312		0	1,200,000
TOTAL		$55	$376	$394		447,000	1,347,000

STEP 3B

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ENGINEERING ASSESSMENT
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019 ENR CCI (10/2017) 10800

Scenario 1
Scenario 2
Scenario 3

COSTS FOR TREATMENT, TRANSPORT-TO-DISPOSAL AND DISPOSAL ALTERNATIVES
LONG-TERM

Projected to April 2019 dollars

		1	2	3	4	5	6
Items		**RIB**	**RIB/WICK**	**RIB/DWI**	**RIB/OUTFALL**	**DWI**	**OUTFALL**
CAPITAL COSTS							
Unit Costs							
Cost, ENR/SBR, Disinfection	1.30	$23.08	$23.08	$23.08	$24.62	$23.08	$24.62
Cost, ENR/MBR, Disinfection	10%			$2.31		$2.31	
Cost, Sand Filtration	1.30		$1.46				
Cost, RO/Reject/Storage	1.30			$4.50		$4.50	
Cost, GAC/Reject/Storage	1.30						
Effluent PS, at 200'TDH	1.30	$1.73	$1.73	$1.15	$1.73	$1.15	$1.73
Flow (gpd, annual average basis)							
ENR/SBR/UV		2,400,000	2,400,000	2,400,000	2,400,000	2,400,000	2,400,000
ENR/MBR-Adder				580,000		680,000	
Sand Filtration	5%		2,520,000				
RO/AO/Storage				4,470,000		5,220,000	
GAC/Reject/Storage				4,470,000		5,220,000	
Effluent PS		2,400,000	2,400,000	3,900,000	2,400,000	4,550,000	2,400,000
Cost - Treatment-Baseline							
Existing WWTF Upgrades		$2,570,000	$2,570,000	$2,570,000	$2,570,000	$2,570,000	$2,570,000
ENR Baseline		$55,380,000	$55,380,000	$55,380,000	$59,080,000	$55,380,000	$59,080,000
Subtotal - Treatment		**$58,000,000**	**$58,000,000**	**$58,000,000**	**$61,700,000**	**$58,000,000**	**$61,700,000**
Cost - Treatment-Supplemental							
ENR/MBR Adder		$0	$0	$14,723,077	$0	$17,261,538	$0
Sand Filtration		$0	$3,683,077	$0	$0	$0	$0
RO/AO/Storage		$0	$0	$20,115,000	$0	$23,490,000	$0
GAC/Reject/Storage		$0	$0	$0	$0	$0	$0
Subtotal - Treatment		**$0**	**$3,700,000**	**$34,800,000**	**$0**	**$40,800,000**	**$0**
Cost - Transport to Disposal							
Existing Forcemain Upgrades		$300,000	$300,000	$300,000	$300,000	$300,000	$300,000
New Forcemains		$25,420,000	$25,420,000	$5,460,000	$26,610,000	$5,460,000	$26,610,000
Length	mi	10.7	10.7	2.3	11.2	2.3	11.2
Number		2	2	2	2	2	2
Length	ft	112,992	112,992	24,288	118,272	24,288	118,272
Cost per Foot		225	225	225	225	225	225
Subtotal - Transport to Disposal		**$25,720,000**	**$25,720,000**	**$5,760,000**	**$26,910,000**	**$5,760,000**	**$26,910,000**

STEP 3B

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ENGINEERING ASSESSMENT
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019 ENR CCI (10/2017) 10800

Scenario 1
Scenario 2
Scenario 3

COSTS FOR TREATMENT, TRANSPORT-TO-DISPOSAL AND DISPOSAL ALTERNATIVES
LONG-TERM

Projected to April 2019 dollars

		1	2	3	4	5	6
Items		**RIB**	**RIB/WICK**	**RIB/DWI**	**RIB/OUTFALL**	**DWI**	**OUTFALL**
Cost - Disposal							
Existing RIB Upgrades		$400,000	$400,000	$400,000	$400,000	$400,000	$400,000
Effluent PS		$4,150,000	$4,150,000	$4,500,000	$4,150,000	$5,250,000	$4,150,000
New RIBs		$8,600,000		$2,640,000			
New Wicks			$8,300,000				
New DWI				$9,100,000		$12,700,000	
New Outfall					$8,800,000		$10,290,000
Subtotal - Disposal		**$13,200,000**	**$12,900,000**	**$16,600,000**	**$13,400,000**	**$18,400,000**	**$14,800,000**
TOTAL		**$96,920,000**	**$100,320,000**	**$115,160,000**	**$102,010,000**	**$122,960,000**	**$103,410,000**
Lowest plus +% higher for other Options		$96,920,000	4%	19%	5%	27%	7%
ANNUAL O&M							
Basis flow		2,400,000	2,400,000	3,900,000	2,400,000	4,550,000	2,400,000
Baseline, April 2014 (ENR CCI 9750)	1.20	$1.25	$1.25	$1.04	$1.25	$1.04	$1.25
Baseline, Current (ENR CCI 10800)		$1.38	$1.38	$1.15	$1.38	$1.15	$1.38
Baseline Costs		$3,320,000	$3,320,000	$4,500,000	$3,320,000	$5,250,000	$3,320,000
Adder for Existing Collection O&M		$800,000	$800,000	$800,000	$800,000	$800,000	$800,000
Adder for Filtration	5%		$166,000				
Adder for SW Discharge	10%				$332,000.00		$332,000.00
Adder for ENR/MBR	10%			$450,000		$525,000	
Adder for RO/Storage	25%			$1,125,000		$1,312,500	
Adder for GAC/Storage	0%			$0		$0	
Adder for Effluent Pumping	5%	$166,000	$166,000	$225,000	$166,000	$262,500	$166,000
Annual O&M		$4,290,000	$4,450,000	$7,100,000	$4,620,000	$8,150,000	$4,620,000
Lowest plus +% higher for other Options		$4,290,000	4%	66%	8%	90%	8%
O&M Allocated to Sewage/Septage, %		50%	50%	50%	50%	50%	50%
O&M Allocated to Effluent, %		50%	50%	50%	50%	50%	50%
O&M Allocated to Sewage/Septage, $$		$2,150,000	$2,230,000	$3,550,000	$2,310,000	$4,080,000	$2,310,000
O&M Allocated to Effluent, $$		$2,150,000	$2,230,000	$3,550,000	$2,310,000	$4,080,000	$2,310,000

STEP 3B

TABLE 2-5: SUMMARY OF PLANNING-LEVEL COST ESTIMATES AND COST ALLOCATION (BASED ON LONG-TERM, CONSTRUCTED AS A SINGLE PROJECT) (ENR CCI 11228, April 2019)

Option	**1**	**2**	**3**	**4**	**5**	**6**
Description of Effluent Disposal	**RIB**	**RIB & Wicks**	**RIB & DWI**	**RIB & Outfall**	**DWI**	**Outfall**
Capital Cost						
Construction - Conveyance	$56,730,000	$56,730,000	$56,730,000	$56,730,000	$56,730,000	$56,730,000
Construction - Treatment	$58,000,000	$61,700,000	$92,800,000	$61,700,000	$98,800,000	$61,700,000
Construction - Transport to Disposal	$25,720,000	$25,720,000	$5,760,000	$26,910,000	$5,760,000	$26,910,000
Construction - Disposal	$13,200,000	$12,900,000	$16,600,000	$13,400,000	$18,400,000	$14,800,000
Contingency, Technical, Legal/Admin/Finance	$66,070,000	$67,530,000	$73,910,000	$68,260,000	$77,270,000	$68,860,000
Total Capital Cost	**$219,720,000**	**$224,580,000**	**$245,800,000**	**$227,000,000**	**$256,960,000**	**$229,000,000**
Ratio to Lowest - Total Capital Cost	1.00	1.02	1.12	1.03	1.17	1.04
Ratio to Lowest - Capital Cost, excl. Conveyance	1.00	1.04	1.19	1.05	1.27	1.07
Annual Operation & Maintenance Cost	**$4,290,000**	**$4,450,000**	**$7,100,000**	**$4,620,000**	**$8,150,000**	**$4,620,000**
Ratio to Lowest - Annual O&M	1.00	1.04	1.66	1.08	1.90	1.08
Total Annual Debt Service on Capital Cost	$13,440,000	$13,730,000	$15,030,000	$13,880,000	$15,710,000	$14,000,000
Total Equivalent Annual Cost (Note 3)	**$17,730,000**	**$18,180,000**	**$22,130,000**	**$18,500,000**	**$23,860,000**	**$18,620,000**
Ratio to Lowest - Equivalent Annual Cost	1.00	1.03	1.25	1.04	1.35	1.05
EAC per thousand gallons of disposal capacity	$14.50	$14.87	$18.10	$15.13	$19.51	$15.23

Notes:

1) Costs are presented in current dollars based on Engineering News Record Construction Cost Index 11228 (April 2019).
2) Refer to Appendix A for supporting information.
3) Equivalent Annual Cost equals Annual O&M Cost plus the Annual Debt Service on Capital Cost.
4) Allocation for Conveyance is 100% to each town. Allocation for treatment/transport/disposal is pro-rated based on flow capacity requested.
5) Blue indicates lowest cost option, green indicates second lowest cost option and orange indicates third lowest cost option.

STEP 3B

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ALTERNATIVES ANALYSIS
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019

File Name: CostAnalysis-20171127-BARN-20190327

ENR CCI 11228 (April 2019)

COST ALLOCATION OF "CANDIDATE PLAN" BY PHASE
USE COSTS FOR OPTION 6 (OUTFALL), AS THE MOST CONSERVATIVE OF "FOUR ESSENTIALLY EQUIVALENT COST OPTIONS" (OPTIONS 1/2/4/6)

	COSTS ($MILLION)			CHECK	ALLOCATION, % OF FLOW			ALLOCATION OF FLOW		
	Existing	Short-Term	Long-Term	TOTAL	Ex	ST	LT	Ex	ST	LT
Conveyance	$0	$3,600,000	$53,130,000	$56,730,000				140,000	347,000	2,389,000
JBCC	$0	$0	$0	$0				140,000	147,000	147,000
Bourne	$0	$1,100,000	$8,790,000	$9,890,000				0	0	467,000
Falmouth	$0	$0	$11,650,000	$11,650,000				0	0	22,000
Mashpee	$0	$2,500,000	$0	$2,500,000				0	200,000	203,000
Sandwich	$0	$0	$4,990,000	$4,990,000				0	0	350,000
Barnstable	$0	$0	$27,700,000	$27,700,000				0	0	1,200,000
Treatment-BASELINE	$0	$1,920,000	$59,780,000	$61,700,000	100%	100%	100%	140,000	347,000	2,389,000
JBCC	$0	$813,000	$3,678,000	$4,491,000	100%	42%	6%	140,000	147,000	147,000
Bourne	$0	$0	$11,686,000	$11,686,000	0%	0%	20%	0	0	467,000
Falmouth	$0	$0	$551,000	$551,000	0%	0%	1%	0	0	22,000
Mashpee	$0	$1,107,000	$5,080,000	$6,187,000	0%	58%	8%	0	200,000	203,000
Sandwich	$0	$0	$8,758,000	$8,758,000	0%	0%	15%	0	0	350,000
Barnstable	$0	$0	$30,028,000	$30,028,000	0%	0%	50%	0	0	1,200,000
Treatment-SUPPLEMENT	$0	$0	$0	$0	100%	100%	100%	140,000	347,000	2,389,000
JBCC	$0	$0	$0	$0	100%	42%	6%	140,000	147,000	147,000
Bourne	$0	$0	$0	$0	0%	0%	20%	0	0	467,000
Falmouth	$0	$0	$0	$0	0%	0%	1%	0	0	22,000
Mashpee	$0	$0	$0	$0	0%	58%	8%	0	200,000	203,000
Sandwich	$0	$0	$0	$0	0%	0%	15%	0	0	350,000
Barnstable	$0	$0	$0	$0	0%	0%	50%	0	0	1,200,000
Transport to Disposal	$0	$300,000	$26,610,000	$26,910,000	100%	100%	100%	140,000	447,000	4,530,000
JBCC	$0	$99,000	$864,000	$963,000	100%	33%	3%	140,000	147,000	147,000
Bourne	$0	$67,000	$6,567,000	$6,634,000	0%	22%	25%	0	100,000	1,118,000
Falmouth	$0	$0	$8,882,000	$8,882,000	0%	0%	33%	0	0	1,512,000
Mashpee	$0	$134,000	$1,192,000	$1,326,000	0%	45%	4%	0	200,000	203,000
Sandwich	$0	$0	$2,056,000	$2,056,000	0%	0%	8%	0	0	350,000
Barnstable	$0	$0	$7,049,000	$7,049,000	0%	0%	26%	0	0	1,200,000
Disposal	$0	$400,000	$14,400,000	$14,800,000	100%	100%	100%	140,000	447,000	4,530,000
JBCC	$0	$132,000	$467,000	$599,000	100%	33%	3%	140,000	147,000	147,000
Bourne	$0	$89,000	$3,554,000	$3,643,000	0%	22%	25%	0	100,000	1,118,000
Falmouth	$0	$0	$4,806,000	$4,806,000	0%	0%	33%	0	0	1,512,000
Mashpee	$0	$179,000	$645,000	$824,000	0%	45%	4%	0	200,000	203,000
Sandwich	$0	$0	$1,113,000	$1,113,000	0%	0%	8%	0	0	350,000
Barnstable	$0	$0	$3,815,000	$3,815,000	0%	0%	26%	0	0	1,200,000

STEP 3B

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ALTERNATIVES ANALYSIS
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019

File Name: CostAnalysis-20171127-BARN-20190327

ENR CCI 11228 (April 2019)

COST ALLOCATION OF "CANDIDATE PLAN" BY PHASE
USE COSTS FOR OPTION 6 (OUTFALL), AS THE MOST CONSERVATIVE OF "FOUR ESSENTIALLY EQUIVALENT COST OPTIONS" (OPTIONS 1/2/4/6)

	COSTS ($MILLION)			CHECK	ALLOCATION, % OF FLOW			ALLOCATION OF FLOW		
	Existing	Short-Term	Long-Term	TOTAL	Ex	ST	LT	Ex	ST	LT
Conting/Tech/Legal/etc	$0	$2,675,000	$66,186,000	$68,860,000	100%	100%	100%	Pro-rata based on construction subtotal		
JBCC	$0	$449,000	$2,154,000	$2,603,000	100%	17%	3%	Pro-rata based on construction subtotal		
Bourne	$0	$540,000	$13,157,000	$13,697,000	0%	20%	20%	Pro-rata based on construction subtotal		
Falmouth	$0	$0	$11,132,000	$11,132,000	0%	0%	17%	Pro-rata based on construction subtotal		
Mashpee	$0	$1,686,000	$2,974,000	$4,660,000	0%	63%	4%	Pro-rata based on construction subtotal		
Sandwich	$0	$0	$7,274,000	$7,274,000	0%	0%	11%	Pro-rata based on construction subtotal		
Barnstable	$0	$0	$29,495,000	$29,495,000	0%	0%	45%			
Check										
TOTAL	$0	$8,900,000	$220,110,000	$229,010,000						
JBCC	$0	$1,490,000	$7,160,000	$8,650,000						
Bourne	$0	$1,800,000	$43,750,000	$45,550,000						
Falmouth	$0	$0	$37,020,000	$37,020,000						
Mashpee	$0	$5,610,000	$9,890,000	$15,500,000						
Sandwich	$0	$0	$24,190,000	$24,190,000						
Barnstable	$0	$0	$98,090,000	$98,090,000						
Check	$0	$8,900,000	$220,100,000	$229,000,000						
ANNUAL O&M-SEW/SEPT	$0	$739,500	$2,310,000		100%	100%	100%	140,000	447,000	2,389,000
JBCC	$0.00	$0.24	$0.14		100%	33%	6%	140,000	147,000	147,000
Bourne	$0.00	$0.17	$0.45		0%	22%	20%	0	100,000	467,000
Falmouth	$0.00	$0.00	$0.02		0%	0%	1%	0	0	22,000
Mashpee	$0.00	$0.33	$0.20		0%	45%	8%	0	200,000	203,000
Sandwich	$0.00	$0.00	$0.34		0%	0%	15%	0	0	350,000
Barnstable	$0.00	$0.00	$1.16		0%	0%	50%	0	0	1,200,000
Check	$0.00	$0.74	$2.31							
ANNUAL O&M-EFF	$510,000	$739,500	$2,310,000		100%	100%	100%	140,000	447,000	4,530,000
JBCC	$0.51	$0.24	$0.07		100%	33%	3%	140,000	147,000	147,000
Bourne	$0.00	$0.17	$0.57		0%	22%	25%	0	100,000	1,118,000
Falmouth	$0.00	$0.00	$0.77		0%	0%	33%	0	0	1,512,000
Mashpee	$0.00	$0.33	$0.10		0%	45%	4%	0	200,000	203,000
Sandwich	$0.00	$0.00	$0.18		0%	0%	8%	0	0	350,000
Barnstable	$0.00	$0.00	$0.61		0%	0%	26%	0	0	1,200,000
Check	$0.51	$0.74	$2.31							
ANNUAL O&M-TOTAL	$510,000	$1,479,000	$4,620,000		100%	100%	100%	140,000	447,000	4,530,000
JBCC	$0.51	$0.49	$0.22		100%	33%	3%	140,000	147,000	147,000
Bourne	$0.00	$0.33	$1.02		0%	22%	25%	0	100,000	1,118,000
Falmouth	$0.00	$0.00	$0.79		0%	0%	33%	0	0	1,512,000

STEP 3B

JBCC SHARED WASTEWATER MANAGEMENT STUDY
ALTERNATIVES ANALYSIS
Wright-Pierce, 27 Nov 2017, REV 27 Mar 2019

File Name: CostAnalysis-20171127-BARN-20190327

ENR CCI 11228 (April 2019)

COST ALLOCATION OF "CANDIDATE PLAN" BY PHASE
USE COSTS FOR OPTION 6 (OUTFALL), AS THE MOST CONSERVATIVE OF "FOUR ESSENTIALLY EQUIVALENT COST OPTIONS" (OPTIONS 1/2/4/6)

	COSTS ($MILLION)			CHECK	ALLOCATION, % OF FLOW			ALLOCATION OF FLOW		
	Existing	Short-Term	Long-Term	TOTAL	Ex	ST	LT	Ex	ST	LT
Mashpee	$0.00	$0.66	$0.30		0%	45%	4%	0	200,000	203,000
Sandwich	$0.00	$0.00	$0.52		0%	0%	8%	0	0	350,000
Barnstable	$0.00	$0.00	$1.77		0%	0%	26%	0	0	1,200,000
Check	$0.51	$1.48	$4.62							

DEBT SERVICE	CRF >>	16.35		
JBCC	$0.00	$0.09	$0.44	$0.53
Bourne	$0.00	$0.11	$2.68	$2.79
Falmouth	$0.00	$0.00	$2.26	$2.26
Mashpee	$0.00	$0.34	$0.60	$0.95
Sandwich	$0.00	$0.00	$1.48	$1.48
Barnstable	$0.00	$0.00	$6.00	$6.00
Check	$0.00	$0.54	$13.46	$14.00

EQUIVALENT ANNUAL COST			
JBCC	$0.51	$0.58	$0.65
Bourne	$0.00	$0.44	$3.70
Falmouth	$0.00	$0.00	$3.06
Mashpee	$0.00	$1.00	$0.90
Sandwich	$0.00	$0.00	$2.00
Barnstable	$0.00	$0.00	$7.77
Check	$0.51	$2.02	$18.08

CAPITAL COST PER KGAL (DISPOSAL CAPACITY)					DISPOSAL CAPACITY		
JBCC	$0	$28	$133	$161	140,000	147,000	147,000
Bourne		$49	$107	$112	0	100,000	1,118,000
Falmouth		$0	$67	$67	0	0	1,512,000
Mashpee		$77	$133	$209	0	200,000	203,000
Sandwich		$0	$189	$189	0	0	350,000
Barnstable		$0	$224	$224		0	1,200,000
TOTAL		$55	$133	$138		447,000	4,530,000

JBCC SHARED WASTEWATER MANAGEMENT STUDY
COMPARISON TO PREVIOUS PLANNING EFFORTS
Wright-Pierce, 27 Nov 2017, Rev 13 May 2019

BOURNE

WASTEWATER MANAGEMENT STUDY, TIGHE & BOND, OCT 2007
RECOMMENDED PLAN >> 1B
INCLUDES 35% CONTINGENCY AND TECHNICAL SERVICES

		TOTAL	WWTF	DISPOSAL	T/D			T/D	T/D	
PHASE	**20YR FLOW**	**COSTS**	**COSTS**	**COSTS**	**COSTS**	**ENR CCI**	**ENR CCI**	**COSTS**	**COST/KGAL/YR**	**RATIO**
	YEAR >>	**2007**	**2007**	**2007**	**2007**	**2007**	**2019**	**2019**	**2019**	
1	449,000	$47.1	$18.1	$4.1	$22.2	9000	11228	$27.6	**$169**	1.27
2	352,000	$56.2	$12.6	$3.2	$15.8	9000	11228	$19.8	$154	1.2
3	104,000	$17.0	$7.3	$0.8	$8.1	9000	11228	$10.1	$267	2.0
4	541,000	$50.0	$11.2	$2.4	$13.6	9000	11228	$17.0	$86	0.6
	1,446,000	$170.3	$49.2	$10.5	$59.7			$74.5	$141	1.1
				Compare with JBCC Option 6 Allocation to Bourne					**$133**	

SANDWICH

COMPREHENSIVE WATER RESOURCES MANAGEMENT PLAN, WRIGHT-PIERCE, AUG 2017
RECOMMENDED PLAN >> PLAN B
INCLUDES 35% CONTINGENCY AND TECHNICAL SERVICES

		TOTAL	WWTF	DISPOSAL	T/D			T/D	T/D	
PHASE	**20YR FLOW**	**COSTS**	**COSTS**	**COSTS**	**COSTS**	**ENR CCI**	**ENR CCI**	**COSTS**	**COST/KGAL/YR**	**RATIO**
	YEAR >>	**2017**	**2017**	**2017**	**2017**	**2017**	**2019**	**2019**	**2019**	
1	340,000	$70.0	$33.9	in wwtf	$33.9	10300	11228	$36.94	**$298**	1.30
TOTAL	340,000									
				Compare with JBCC Option 6 Allocation to Sandwich					**$229**	

WRIGHT-PIERCE
Engineering a Better Environment

MEMORANDUM

TO:	File	**DATE:**	2/15/2019
FROM:	Mike Giggey, Ed Leonard	**PROJECT NO.:**	13839B
SUBJECT:	JBCC SWMS – Plan for Effluent Disposal Re-Permitting		

PURPOSE

Effluent from the wastewater treatment facility (WWTF) at JBCC is now disposed of at rapid infiltration basins (RIBs) 10 miles north of the WWTF near the Cape Cod Canal. The RIBs' rated capacity may impose a constraint on the full utilization of the WWTF's treatment capacity, and those RIBs will need expansion if the WWTF is enlarged in the future. Accordingly, a work plan has been developed to lay out an approach to determining if the existing RIBs can accept greater flows and to evaluate options for modifying them or adding to them to increase the overall capacity. ***This memorandum was updated and adapted from work previously completed in 2015.***

BACKGROUND

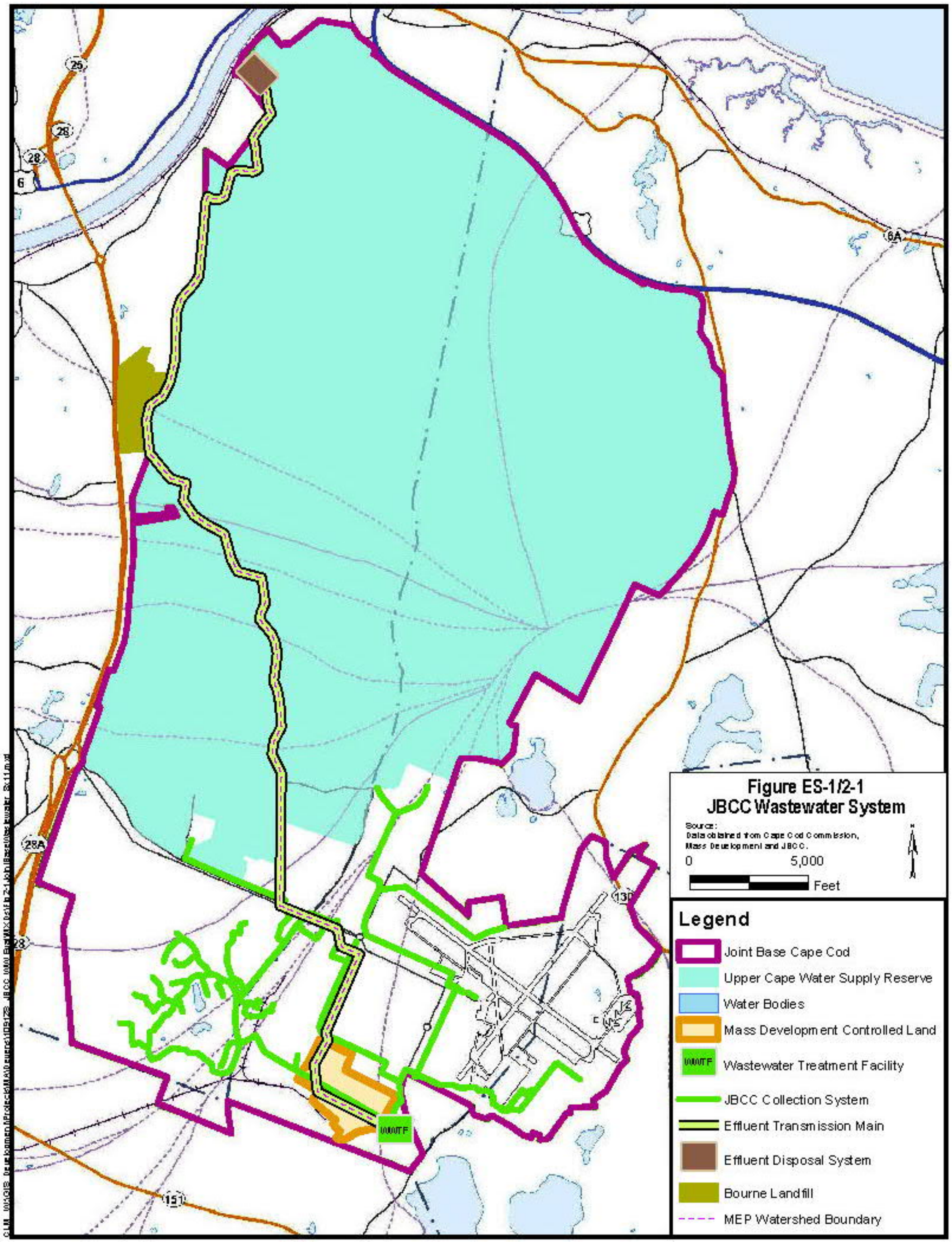
The wastewater treatment facilities at JBCC were upgraded in the 1990s, replacing the old trickling filter plant with new oxidation ditches. The then-existing effluent disposal beds south of the WWTF had caused considerable down-gradient impacts and were replaced by new RIBs near the Cape Cod Canal and a connecting 10.5-mile pipeline. As shown in Figure 1, the new RIBs are located near the northwest corner of the JBCC property, within the Upper Cape Water Supply Reserve, an area of enhanced environmental concern.

The design engineer for the WWTF was CDM Federal Programs. The hydrogeologic evaluation and design of the RIBs were completed by SAIC Engineering under contract to CDM Federal Programs.

The DEP groundwater discharge (GWD) permit for the new facilities was issued in February of 1994 and the new facilities began operation about that time. The permitted disposal capacity was increased in 2003 to accommodate the new Barnstable County Jail. The current GWD permit (Permit 41-4) expires in May 2023.

The GWD permit allows a maximum-day flow of up to 840,000 gallons per day (gpd), and also restricts the annual average flow to 360,000 gpd. During the period of September 2003 to May 2015 (slightly more than 11.5 years), flows from the WWTF were 143,700 gpd as an annual average and 633,100 gpd on the highest day. The actual effluent flows have a maximum-day peaking factor of 4.40, much higher than the design peaking factor of 2.33. This phenomenon is due the presence of significant amounts of extraneous wet-weather flow reaching the WWTF.

Figure 1. JBCC Wastewater System



Unless steps are taken to reduce those high peak flows, the RIBs will reach their peak-flow capacity before reaching their average-flow capacity. It is estimated that as much as 40% of the average flow capacity at the WWTF will not be available due to the high peak flows unless those peaks are corrected.

The JBCC treatment and disposal facilities have been identified as a potential regional resource that could facilitate new development on and near JBCC and also solve wastewater management problems faced by nearby towns. In one scenario, the JBCC treatment plant could be significantly enlarged, putting even more emphasis on determining and increasing the capacity of the RIBs.

INITIAL EVALUATION

To find the best approach to re-rating, we must consider some basic facts about the existing facilities and operation. Data from the following sources are available for this evaluation:

1. 1993 hydrogeologic evaluation prepared by SAIC Engineering
2. 1993 design data prepared by CDM Federal Programs
3. The GWD permit application submitted to DEP in 1993
4. The current GWD permit which expires in 2018.
5. Record drawings of the RIBs prepared by SAIC and dated 6 August 1993
6. WWTF flow records for the period of late 2003 to early 2015
7. Data from the 4 monitoring wells surrounding the RIBs, including depth to groundwater and contaminant concentrations in the groundwater.
8. Long-term groundwater elevation data from nearby USGS monitoring wells
9. Land use mapping of the area within one mile of the site

Potential Limitations on Effluent Disposal Rate

In general terms, any effluent recharge site may be limited hydraulically in one or more of the following ways:

1. Inability of the surficial soils to accept the effluent without excessive ponding.
2. The creation of a groundwater mound that rises too close to the ground surface. (The minimum depth of unsaturated soil above the mound is 4 feet in Massachusetts.)
3. Nearby impacts of the groundwater mound, such as breakout at down-gradient slopes, basement flooding, or impacts on nearby water supply wells.
4. Impacts of nutrients on down-gradient surface waters (such as Cape Cod’s nitrogen-sensitive coastal embayments).

One of the goals of this memorandum is to identify which of these factors may limit the JBCC RIBs and to explore ways to address those limitations.

1. Surficial Loading

The following facts apply:

- There are four RIBs with a combined bottom area of 259,160 square feet (sf). The largest RIB has a bottom area of 67,000 sf, or about 26% of the total. See Figure 2.
- The GWD permit allows discharge up to 840,000 gpd in any one day.
- With the largest RIB out of service (say for cleaning or repair), the design surface loading rate is apparently 4.4 gpd/sf. (840,000 gpd divided by 192,160 sf).
- The JBCC staff uses one RIB at a time. The average and maximum-day loading rates have been 2.3 gpd/sf and 9.7 gpd/sf, respectively.
- The existing RIBs have not been loaded at their design rate under average conditions, but have been loaded much higher than the design rate when all of the peak flow has been loaded to one bed. The WWTF operators are not aware of any significant ponding, even under those peak conditions.
- Other Cape Cod RIBs have been shown to accept 5 gpd/sf and above.

2. Mounding

The existing RIBs have bottom elevations of:

Bed #1 and Bed #2	90 ft MSL
Bed #3	106 ft MSL
Bed #4	116 ft MSL

Average water table elevation is generally about 20 ft MSL, leaving an unsaturated zone of 70 feet or more. Generally, at surficial loading rates in the range of 4 to 6 gpd/sf, in these soils, it is expected that the mound will be less than 10 or 15 feet. Hence mounding is very unlikely to be a limiting factor at this site.

3. Nearby Impacts of Higher Groundwater

There are no reports of breakout down-gradient from this site and the down-gradient area is bereft of any development. Potential impacts in this category are quite unlikely.

4. Nutrient Enrichment of Surface Waters

Prior groundwater modeling, both regionally by USGS, and for the purposes of the JBCC GWD permit application, have shown that effluent-impacted groundwater will reach the Cape Cod Canal and not impact any coastal embayments. Hence, nutrient impacts will not be limiting.

In summary, providing increased capacity for effluent disposal will hinge on demonstrating that the existing soils can handle a higher surficial loading rate.

Figure 2. Existing JBCC Rapid Infiltration Basins (from CH2M/Hill, 2012)

Analysis of WWTF Discharge Records

Data characterizing the WWTF discharge have been compiled and reviewed for the period of late 2003 to early 2015. Moving averages of effluent flow were computed for 2-day, 3-day, 4-day, 5-day, 7-day, and 10-day periods, in addition to monthly and annual averages, with the following results:

Length of Short-Term Peak	Short-Term Peak Flow, gpd	Ratio to Long-Term Average	Ratio to One-Day Peak
1 day	633,100	4.40	1.00
2 days	444,600	3.09	0.702
3 days	385,800	2.68	0.609
4 days	340,600	2.37	0.538
5 days	313,100	2.18	0.495
7 days	291,400	2.03	0.460
10 days	267,400	1.86	0.423
30 days (max month)	219,700	1.53	0.357
Long-term average	143,700	1.00	0.227

The very high flow that occurred on 7 Jun 2006 (633,100 gpd) exceeds the second highest flow (555,600 gpd) by nearly 80,000 gpd, and exceeded the third highest flow by 226,000 gpd. If equalization could be provided to damp the peak-day flow over 2 or 3 days, the resulting peak flow would be 30% to 40% less than the recorded one-day peak. Four days of equalization would bring the short-term peaking factor down to 2.37, very close to the design basis of the RIBs (840,000 gpd divided by 360,000 gpd).

The attached graphs illustrate the difference between the daily flow and the multi-day average flows. Figure 3 is a plot of daily flow data over the 11+-year period of record. It is apparent that there have been two isolated high peak flows of 663,100 gpd in 2006 and 555,600 gpd in 2011. These are two readings out of over 4,200 recorded daily flows. Figure 3 shows that all but these two data points are less than about 410,000 gpd.

Figure 4 shows the maximum-day, maximum-3-day and annual average flows for the 11+ years of record. Other than 2006 and 2011, the maximum-day flows have been less than about 410,000 gpd and the maximum 3-day-flows have been a little less than about 300,000 gpd. Figures 3 and 4 clearly illustrate a fairly uniform pattern in flow variation, except for the two outliers.

From Figure 4 it is apparent that annual average flows (blue bars) were higher in the period of 2005 to 2010 than they have been since 2010.

A discussion with WWTF Operators on February 8, 2019 indicates that flows over the past few years have been consistent with the flows shown in Figures 3 and 4.

Summary of Current Operational Procedures

The WWTF staff was interviewed in May 2015 to determine standard operational and maintenance procedures related to the RIBs. Those procedures are as follows:

- One RIB is loaded at a time while the other three sit idle.
- Ponding of the applied effluent typically extends outward from the center distribution pipe to a radius of approximately 20 feet and is typically 1 inch to 2 inches deep. (This roughly circular area represent only about 2% of the total bottom area—an indication that the RIB soils can quickly accept the flow at current application rates.)
- A given RIB is loaded for one week before the flow is diverted to the next RIB.
- No routine maintenance is performed after each rotation.
- Every 3 to 5 years, the staff undertakes major maintenance work, which consists of using earth-moving equipment to re-work the bottom of each RIB. Over the life of the RIBs, there has been no need to remove and replace the sand in the bottoms of the RIBs.
- Vegetation grows on the wetted bottom area of each RIB. That vegetation is removed as part of the major maintenance. No chemicals are used to control the vegetation.
- There is no record of any break-out of effluent-impacted groundwater down-gradient of the RIBs.

Figure 3. Daily Effluent Flows: 2003 to 2015

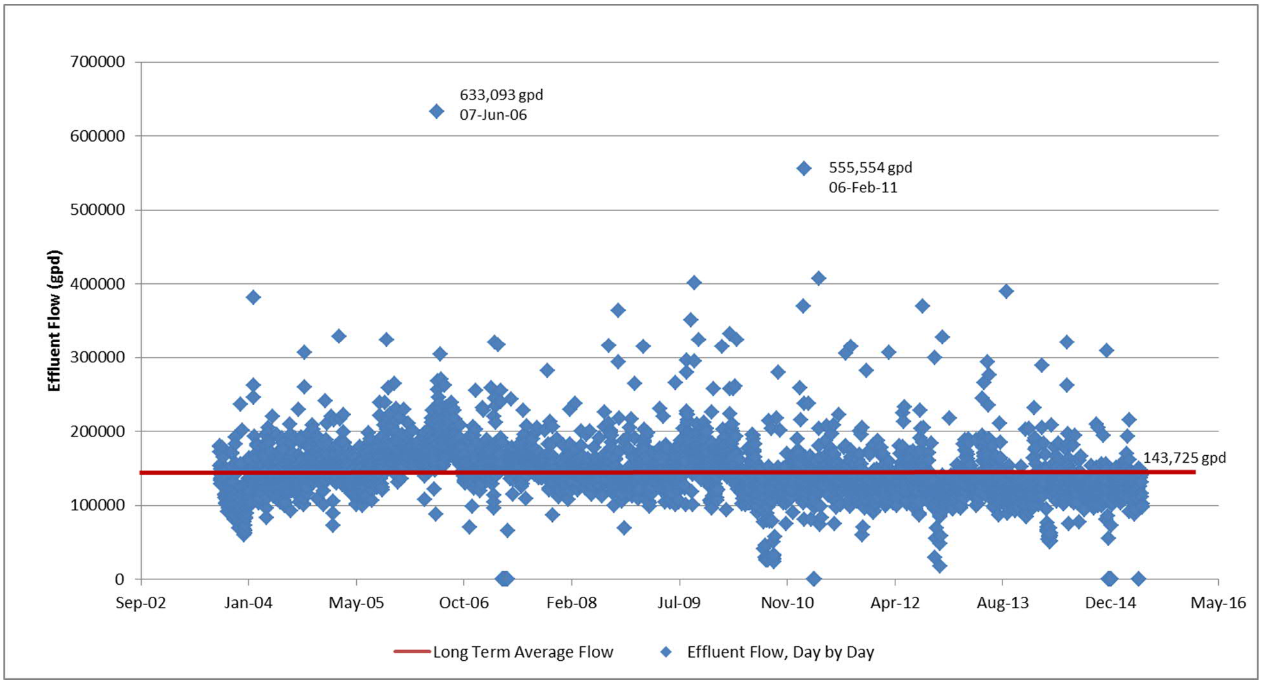
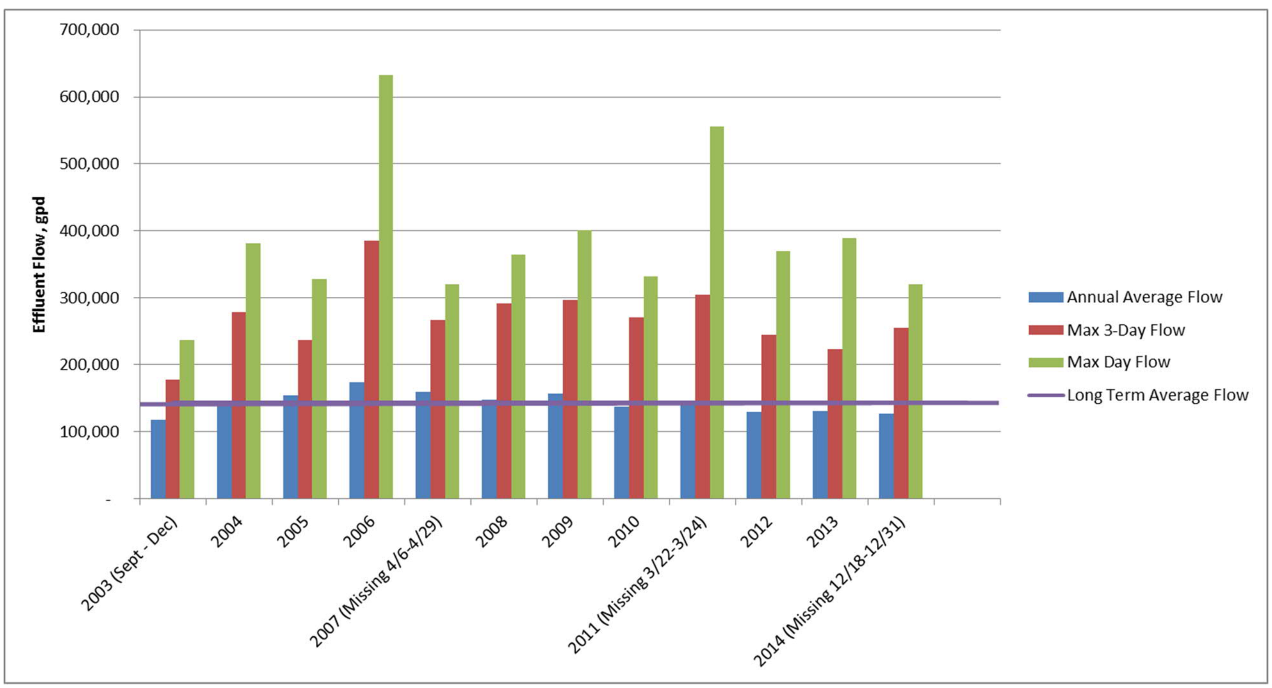


Figure 4. Peak Effluent Flows: 2003 to 2015



Review of Groundwater Impacts

Data from the four existing monitoring wells (MWs) at the RIBs were analyzed and graphed to determine:

- Average and seasonal variations in groundwater elevation at the site
- Trends in groundwater specific conductance and concentrations of nitrogen and phosphorus species

This analysis is based on the JBCC-supplied data for the period of 2007 to 2015. The start of this period of analysis is 13 years later than the start of operation of the RIBs.

It is instructive to compare average contaminant concentrations between up-gradient and down-gradient MWs to assess the impact of the effluent disposal operation:

Parameter	Up-Gradient Average	Down-Gradient Average
Depth to Water Table, ft	163	84 to 89
Specific Conductance, µmhos/cm	96	278 to 310
Total Nitrogen, mg/l	1.0	3.9 to 5.2
Total Phosphorus, mg/l	0.4	1.1 to 4.8

These groundwater concentrations are consistent with the contaminant levels in the effluent and with groundwater concentrations seen at other Cape Cod RIB sites.

No data were found on pre-construction concentrations of contaminants in the groundwater. Such information may exist in the application for the Groundwater Discharge Permit and should be reviewed if available.

Benefits of Redefining the Short-Term Peak Flow

The current GWD permit uses the single-day maximum flow to define the highest quantity that can be discharged. The long record of effluent flow data, summarized above, has been used to explore the possibility of redefining the peak flow used in the permit, using (say) a 3-day peak flow.

Due to the significant freeboard that is present in the existing RIBs (in all cases in excess of 6 feet), there is "built-in" equalization volume. If the soils can accept only a fixed amount in one day, flows in excess of that amount will pond and eventually percolate. The difference between the 1-day maximum flow and the 3-day maximum flow is 248,000 gallons per day. Storing that daily amount for 3 days would consume about 750,000 gallons of volume. The average-sized RIB is 65,000 square feet. Ponding to a depth of about 18 inches would provide all of the needed equalization volume, ignoring the infiltration that would occur during the period. Therefore, a strong case can be made to restrict the use of the RIBs to only a 3-day peak flow instead of the more stringent one-day peak flow. Such a change would be part of a requested modification of the GWD permit at the time of permit renewal, or earlier if appropriate. If the permit were changed to redefine the short-term peak flow using a 3-day average, a 39% increase in capacity would result, based on the flow data presented above.

Evaluation of Segmentation Options

With four RIBs, one should be considered a reserve. If the largest RIB were to be out of service, its area represents 26% of the total area and 35% of the area of the remaining RIBs in operation. Current DEP guidelines acknowledge the possibility of a lower percentage of reserve area when there is a highly-treated effluent and independently configured segments in the disposal system. It would be a fairly easy matter to subdivide the existing RIBs to have smaller segments and less of the overall area considered reserve.

The following chart summarizes three scenarios. The first scenario represents the original design that provides 35% reserve in the form of the largest RIB.

Scenario	Number of RIBs	Active Area (with Largest RIB out of Service), sf	Design Loading Rate, gpd/sf	Allowable Flow to Active Area, gpd	Reserve Area, % of Active Area
1	4	192,160	4.4	840,000	35
2	8	225,660	4.4	993.000	15
3	16	242,410	4.4	1,067,000	7

Scenario 2 assumes that each of the four RIBs would be split in two through the construction of shallow concrete dividing walls. With one half of the largest modified RIB off-line, the remaining 7 modified RIBs could accept 993,000 gpd at the design loading rate of 4.4 gpd/sf. The un-used RIB would represent 15% of the active area. The segmenting would allow an 18% increase in capacity.

In Scenario 3, it is assumed that each of the exiting RIBs would be split into quarters. With one quarter of the largest modified RIB off-line, the remaining 15 modified RIBs could accept 1,067,000 gpd at the design loading rate of 4.4 gpd/sf. The un-used RIB would represent 7% of the active area. The segmenting would allow a 27% increase in capacity.

A reduction in the amount of reserve area is a topic that should be discussed with DEP, and considered in concert with other re-permitting concepts presented herein.

Loading Tests to Increase Design Loading Rate

The most effective way to determine the actual surficial capacity of the soils at the RIB site is to load one RIB (or a portion of an RIB) at a high rate over a sustained period, say 30 or 45 days. It is difficult to project the outcome of such tests. On the premise that the design loading rate is 4.4

gpd/sf, higher RIB capacity would be as follows for hypothetical higher loading rates that might be demonstrated through large-scale testing:

Hypothetical Testing Result	Loading Rate, gpd/sf	Capacity, gpd, with Largest RIB out of Service
Current design rate	4.37	840,000
20% higher than current	5.25	1,008,000
40% higher than current	6.12	1,176,000
60% higher than current	7.00	1,344,000

The use of large-scale loading tests is accepted by DEP as a means to establish design loading rates for facilities like these. It is important that the test utilize actual effluent and be of sufficient duration to reach equilibrium. It is also important to monitor the mound height below the basin being tested to ascertain the reduction in unsaturated zone associated with the higher loading. The details of the test must be reviewed and approved by DEP to ensure that the results are considered.

Utilization of Wicks

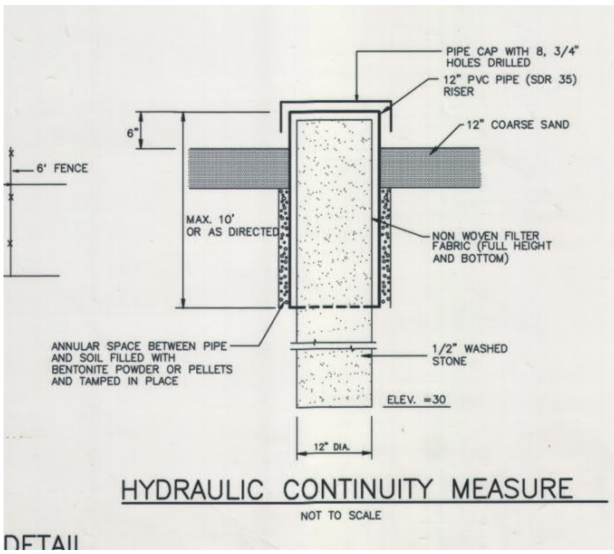
Wicks are vertical conduits of gravel or crushed stone that allow applied effluent to quickly reach deep soil strata. They have the most potential at sites with very permeable soils and deep groundwater, or where semi-permeable lenses impede downward effluent flow.

The "as-built" drawing of the JBCC RIBs show 28 "hydraulic continuity measures" located along the northwest sides of the bottoms of the RIBs (six in RIBs 1, 2, and 4, and ten in the RIB 3). Figure 5 presents key information on the "hydraulic continuity measures", which are essentially 12-inch-diameter wicks. The design includes a perforated cap on the top of the casing which extends 6 inches above the bottom of the RIB. With this configuration, the wicks act as an "overflow", in that they are inactive unless the effluent ponds more than 6 inches. Given the operators' recollections of minimal ponding, it is unlikely that these wicks have ever been used. By cutting off the top 6 to 12 inches of casing, however, they could be used whenever the flow extends to the periphery of the RIB, and may provide a currently-unused means of added capacity.

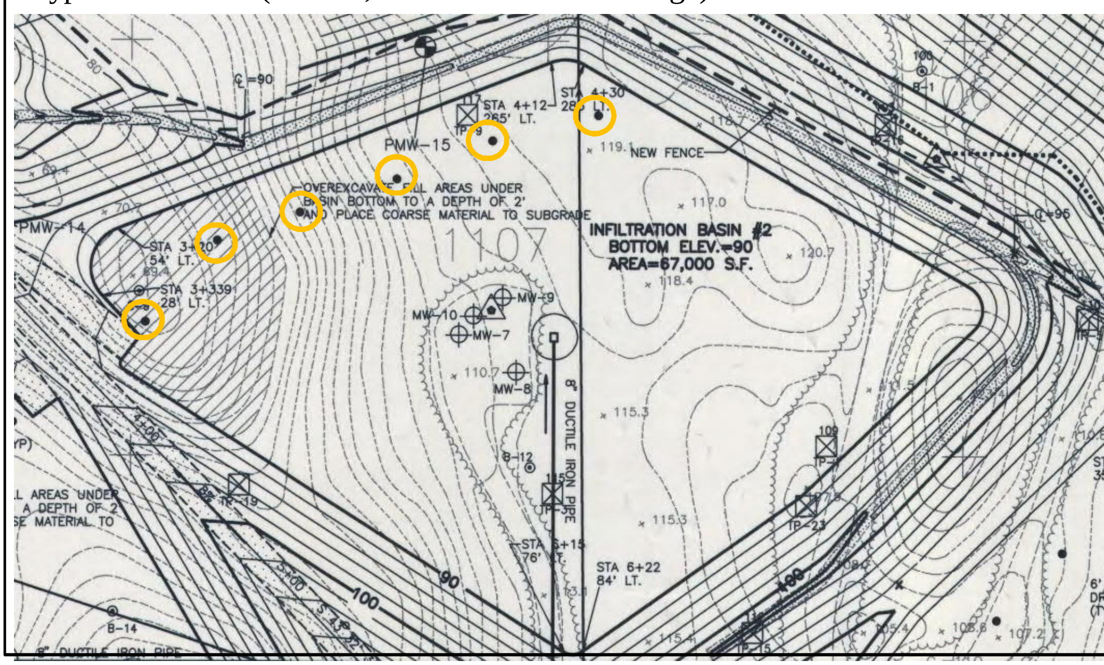
Figure 5. Key Information on Existing Wicks

Infiltration Basin No.	Surface Elevation, ft	Wick Length, ft	Number of Wicks
1	90	60	6
2	90	60	6
3	106	76	10
4	116	86	6

Typical Wick Cross Section



Typical RIB Plan (RIB #2, Wicks Circled in Orange)



Combination of Options

While several options have been explored for demonstrating or creating additional effluent disposal capacity, none of them precludes the others. For example, redefining the short-term peak flow using a 3-day average would add 39% to the RIB capacity. In conjunction with that administrative step, the basins could be segmented by dividing them in halves. The segmentation on its own could add 18% to the capacity, but the two steps taken together would result in a 64% increase. If load test were also successful in demonstrating a higher design loading rate of (say) 5.5 gpd/sf, the aggregate benefit of all three steps would be a 100% increase in capacity.

It would be wise to further develop these options in a phased approach because each option has different implementation costs and different potential for increasing capacity. A logical order of implementation could be:

- Redefine the short-term peak flow
- Segment the basins and conduct a large-scale load test on a segmented basin
- Modify the wicks and retest the basins

Preliminary Conclusions

This preliminary evaluation indicates the potential to increase the effluent disposal capacity of the existing JBCC RIBs in four different ways. Through a redefinition of the short-term peak flow, segmentation of the basins and conducting a successful large-scale loading test, this preliminary review indicates the potential to approximately double the RIB capacity. Such an increase would be sufficient to accommodate the likely peak flows from a 50% expansion of the existing WWTF. Use of the existing wicks also holds promise in increasing the RIB capacity an indeterminate amount at a much lower cost than new construction of RIBs. Additional study is needed to further develop these concepts and to provide soils and groundwater data to support a new groundwater discharge permit. The principal steps are outlined in the following section of this memo.

Next Steps

The following next steps are recommended:

- Meet with DEP to discuss: whether they are amenable to these concepts; the preliminary field test protocol for segmentation and re-rating; whether the effluent limits would remain the same; how multiple permittees would be addressed if there are new effluent disposal connections (e.g., Bourne treated landfill leachate, Falmouth treated effluent); how long the changes may take to implement; and whether Environmental Management Commission approval may be needed.. The meeting should be attended by Falmouth (as fiscal agent), JBCC personnel and Wright-Pierce.
- If DEP is amenable, write up suggested language and field test protocol for formal review and comment by DEP. Submit through Falmouth (as fiscal agent) and JBCC.

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MEMORANDUM

TO:	Brian Dudley – DEP; Col. Chris Hurley – JBCC; Ray Jack – Town of Falmouth	**DATE:**	5/13/2019, Rev 7/2/2019
FROM:	Mike Giggey, Ed Leonard	**PROJECT NO.:**	13839B
SUBJECT:	JBCC SWMS – Proposed Steps to Increase Existing RIB Capacity		

PURPOSE

As documented in the Wright-Pierce 2/15/2019 technical memorandum, our desk-top evaluations indicate the potential to increase the effluent disposal capacity of the existing JBCC RIBs through a redefinition of the short-term peak flow, segmentation of the basins and demonstrating that the surficial soil can accept more than the current design flow rate. Our initial analysis suggested the potential to approximately double the RIB capacity. This increase in capacity would be beneficial to JBCC and the four Towns in potentially establishing a shared wastewater management system.

Additional study is needed to further develop these concepts and to provide soils and groundwater data to support a new groundwater discharge permit (i.e., determine surficial infiltration rate, anticipated mound height, near-field mound impacts and ultimate fate of contaminants).

This memorandum is written to address Task 4 of the Commonwealth Efficiency and Regionalization Grant. The purpose of this memorandum is to summarize the specific action items that we believe are necessary to re-rate the existing Rapid Infiltration Basins (RIBs) for the Joint Base Cape Cod (JBCC) wastewater system, via a revised Groundwater Discharge (GWD) Permit. The initial memorandum was dated 5/13/2019 and was revised to address comments provided verbally by DEP staff. Refer to the 2/15/2019 memorandum for background information.

REDEFINITION OF SHORT-TERM PEAK

See attached excerpted pages from Groundwater Discharge Permit Number 41-4, marked up to reflect proposed changes. These changes could be made to the permit without field testing and would result in some additional effective capacity because of the annual average and peak flow limits in the permit. The essence of this item is to change the operative flow limitation from “maximum day” to “maximum 3-day moving average”.

SEGMENTATION

A conceptual segmentation plan is shown on Figure 1 at the end of this memorandum. For this current phase of the project, design and construction activities would be limited to the construction and subsequent removal of the test cell components.

CONDUCT FIELD TESTING AND CONFIRMATORY MODELING

A series of inter-related tasks should be completed in order to develop a firm estimate of the capacity of the existing RIBs and the existing "hydraulic continuity measures" (which are functionally equivalent to "wicks") to increase that permitted capacity if appropriate. Whatever options are implemented to increase RIB capacity, the target is the updating of the GWD permit to allow a higher flow.

Task 1—Coordination Kick-Off Meeting

A coordination kick-off meeting would be held with DEP and JBCC prior to initiating the testing program. Discussion topics would include site access, site security, data acquisition, reporting, etc.

Task 2—Design and Construct Test Cell

Generally, RIBs are sized and permitted using relatively small-scale and relatively short-duration tests which are conducted with potable water, which necessitates a 'scaling' (or derating) of the results in order to account for full-scale conditions using wastewater effluent. This testing program is intended to eliminate the need for scaling the results of the load testing to get to 'full-scale' results for the RIB testing. This will be accomplished by using a relatively large test cell, by using wastewater and by maximizing test duration. Preliminary modeling indicates that 7 to 10 days should be sufficient to establish a steady-state mound. That said, while this testing program will substantially increase the <u>surficial loading rate</u>, it will only increase to the <u>total loading</u> (total flow) to the site by a small amount during the test (i.e., by potable water flow added to the WWTF Effluent Pump Station). Given the significant depth to groundwater at this site, ground water mound height is not a principal concern.

Note that there is no power or water at this site, which is remote from the WWTF and which introduces additional complexity as noted below. This program will likely require full-time monitoring (24 hours per day) unless a temporary power service (120V/230V/460V) could be obtained from the adjacent substation site. Alternatively, a portable generator will be needed to power pumps; a backup portable generator would also be prudent.

Potable water should be used for the Wick testing to eliminate the potential for fouling the wick. Since there is no potable water on-site, three methods were identified and initial cost estimates were prepared:

- A temporary potable water service could potentially be obtained from the closest hydrant which is located on Sandwich Road approximately 500 feet north of the RIB site driveway with water piped across the Sandwich Road. MADOT would require the pipe be installed below the road surface, so a 50-foot long section of the road would need to be repaved.
- A temporary potable water service could potentially be obtained from the same hydrant on Sandwich Road with water trucked to the site. This would require 24 hour per day coverage with tanker trucks.

- A new 4-inch test well could be drilled near the RIB site gate and a new pump could be used for wick testing. A portable generator will be needed to power pumps; a backup portable generator would also be a worthwhile expense given the cost associated with obtaining the data.

Based on an initial cost analysis of the three options for the volume of potable water needed for wick testing, a new test well is the most cost-effective approach. If the costs for temporary power and water are too high, then loading tests would likely stop at Test 1 as outlined below.

Expected steps for design and construction of the RIB test cell and Wick test are:

- Select a portion of RIB#3 to construct a large-scale load test cell. Based on a minimum daily effluent flow of 80,000 gpd and a desired application rate of 8 gpd/sf, target a 10,000 sf test cell. Construct test cell partition walls out of interlocking concrete dividers with poly wrapping for water retention.
- Select and construct one of the following wastewater flow distribution methods for RIB testing:
  - A - Install a temporary pump and flow metering at the existing distribution box to convey wastewater flow to the test cell. This will require portable generators. This approach will provide for relatively consistent flow rates to the test cell but will warrant 24 hour per day coverage to make sure flow is maintained.
  - B – Set flow isolation gates in the distribution box at different heights such that an average of 80,000 gpd goes to the test cell via gravity and remainder of the flow to RIB#1 via gravity. With this method, install a gauge and data logger at the distribution box to measure water surface elevation as a means to estimate flow rate to the test cell. This will provide for somewhat variable flow rates to the test cell and will require that daily flows be averaged to determine the application rate over the test period.
- Install 4-inch test well, pump and flow metering on-site. This approach will provide for relatively consistent flow rates to the selected wick. The test well will be located as far away from the RIBs as possible, but within the fenceline, to minimize the influence on the water table.
- Install 2 monitoring wells, 1 monitoring well in the test cell and 1 immediately downgradient of the test cell (and very close to an existing wick in RIB#3) to supplement the existing well network. Final locations would be determined via preliminary model runs prior to test cell construction. At least one of the monitoring wells will be drilled with continuous split spoon samples in order to collect undisturbed samples.
- Install temporary rain gauge.
- Conduct limited topographic survey from RIB site down to the Canal (across State and ACOE land) in order to assess mounding impacts near the Canal. Conduct topographic survey on all monitoring wells used in the monitoring and sampling program.
- See additional test cell construction items noted in Task 3 below.
- Return the site to existing conditions following the testing.

Task 3—Conduct Loading Tests

While historical operations indicate that the RIBs and Wicks can accept a higher loading rate, the actual surficial capacity of the soils at the RIB site should be tested by loading to simulate steady-state conditions. The loading steps outlined below are recommended:

- Pre-Test. Install the new monitoring wells. Install data loggers at up to 6 monitoring wells (4 existing monitoring wells and 2 new monitoring wells) starting one month prior to testing. Collect data from a regional USGS monitoring well to assess seasonal influences.
- Test 0 – Assess Groundwater Mound Movement based on Application Location.
    - Direct all flow to RIB#4 (64,000 sf) for two weeks.
    - Direct all flow to RIB#1 (62,400 sf) for two weeks.
    - Direct all flow to RIB#2 (67,000 sf) for two weeks.
    - Monitor groundwater surface via data loggers for full pre-test duration. The purpose of this step is to assess the baseline movement of the mound based on the existing flows and application rates.
- Test 1 – RIB Infiltrative Surface Only.
    - Direct flow to the RIB#3 test cell (10,000 sf) for 10 days at a target of 8 gpd/sf. Increase application rate within the test cell until 6-inches of ponding occurs. Decrease the application rate if 12-inches of ponding occurs.
    - Excess flow higher than 100,000 gpd with be directed to RIB#1
    - Supplement WWTF flows with potable water only if WWTF daily flow drops below 60,000 gpd. Potable water can be added to the effluent pump station wetwell via a fire hose from the nearest fire hydrant at the WWTF site.
    - Provide one week of rest before starting Test 2.
- Test 2 – Wick (Hydraulic Continuity Measure) Testing Only.
    - Direct potable water to one existing 12-inch diameter wick for 10 days at up to 36,000 gpd. If water mounds to within 10-feet of ground surface in the wick or the immediate downgradient well, decrease the application rate.
    - During this test, all wastewater flow will be directed to RIB#1.
    - Provide two weeks of monitoring after wick test ends.

The duration of test and rest times would be confirmed via pre-modeling.

Water table elevations will be measured electronically at varying intervals (i.e., every 10 seconds to once an hour) during the test in five to six MWs (three to four existing and two new). The results of the testing will be evaluated so that a recommended higher loading can be used, if appropriate.

The horizontal locations of the existing monitoring wells, new monitoring wells and corners of the test cell will be confirmed using survey-grade, hand-held GPS equipment. The top-of-casing elevation for the existing and new monitoring wells will be established on a common datum by a surveyor.

Given the long-term water quality data record available, no new water quality samples would be collected for laboratory analysis; however, field specific conductivity testing would be performed to provide effluent presence/absence information for analysis.

Task 4—Develop a Groundwater Model and Hydrogeologic Report

Assemble all available data on soil characteristics and groundwater conditions in a computer model of groundwater flow that can simulate increased loading options and predict mounding and groundwater flow directions. Obtain, update and recalibrate the existing USGS groundwater model (based on MODFLOW and MODPATH). Refine the model based on the results from Test 0. Run the model for the proposed increased loading rates and document the results in a hydrogeologic evaluation report suitable to accompany a GWD permit application, including summary of application rates, mound heights, predicted emergence, travel time, etc.

Task 5—Prepare a Preliminary Engineering Report

An engineering report will be prepared to accompany the hydrogeologic evaluation. That report will focus on the RIB modifications needed to provide the recommended flow rate, including the location of any additional recommended monitoring wells. It will not address wastewater treatment, because no changes in those facilities are contemplated as part of this specific project.

Task 6---Apply for a GWD Permit Modification

Assuming that one or more of the options (redefinition of short peak flow, segmenting and loading test) demonstrates the expected additional capacity, permission to use that capacity must be obtained by way of a modification to the GWD permit. This task would involve preparing a GWD permit application based on the final hydrogeologic report and preliminary engineering report.

Future Tasks

If segmentation is determined to be a viable option, then plans and specifications would need to be developed for segmentation and flow distribution. After completion of the plans and specifications, a cost estimate would be prepared and the regulatory and permitting issues addressed. Contractor procurement and construction would follow.

SCHEDULE

Once funding is established, we anticipated that the schedule for this scope would be as follows:

Item	Description	Duration
1	Coordination Kick-Off Meeting	1 month
2	Design and Construct Test Cell	2 months
3	Conduct Loading Tests	3 months
4	Develop Groundwater Model	2 months
5	Prepare Preliminary Engineering Report	2 months
6	Apply for GWD Permit Modification	2 months
Total		***12 months***

PRELIMINARY BUDGET

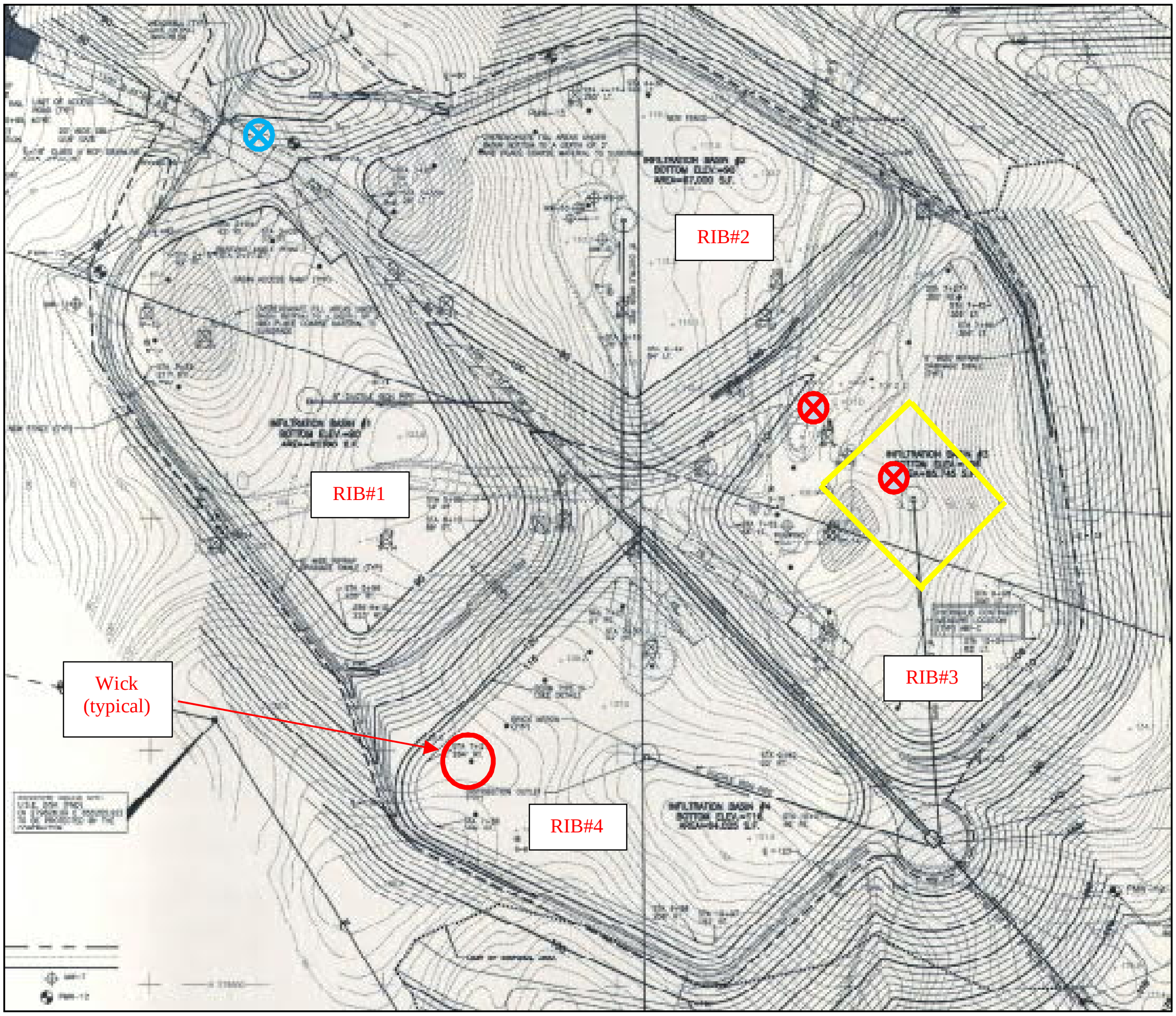
We suggest establishing a budget of $285,000 for this effort. This cost is higher than that of typical testing programs due in large part to the location of the RIB site relative to the WWTF and the lack of potable water and electricity at the RIB site.

FIGURE 1 – CONCEPTUAL SEGMENTATION PLAN

(Image Source: CH2M-Hill 2012). Segmentation added in yellow lines.

FIGURE 2 – TEST CELL LOCATION PLAN

(Image Source: CDM Federal -1993 Record Drawings).
Load cell added in yellow lines. Approximate monitoring well locations shown in red circles.
Approximate test well shown in blue circle. Actual locations to be confirmed by pre-modelling.



Proposed Text
Wright-Pierce 5/13/2019 memorandum attachment

MassDEP

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

Southeast Regional Office • 20 Riverside Drive, Lakeville MA 02347 • 508-946-2700

Charles D. Baker
Governor

Karyn E. Polito
Lieutenant Governor

Matthew A. Beaton
Secretary

Martin Suuberg
Commissioner

Individual Groundwater Discharge Permit
Fact Sheet

I. APPLICANT, FACILITY INFORMATION, and DISCHARGE LOCATION

Name and Address of Applicant:

102nd Intelligence Wing, 156 Reilly Street, Box 46, Otis Air National Guard Base, Massachusetts 02542

Name and Address of Facility where discharge occurs:

971 South Outer Road, Otis Air National Guard Base, MA 02542

Discharge Information:

Short-Term Peak Flow

Groundwater Discharge Permit Number: 41 - 4

The Groundwater Discharge Permit will allow the applicant to continue to discharge 12 month moving average flow 360,000 gallons per day of treated sanitary wastewater with a ~~Maximum Day Flow~~ 840,000 gallons per day to groundwaters of the Commonwealth. The discharge is not located in a sensitive area such as a Zone II wellhead protection area of a public water supply.

II. LIMITATIONS AND CONDITIONS

Discharge permit limitations are as listed in the ground water permit and are in conformance with 314 CMR 5.00, the Groundwater Discharge Permit Program.

III. PERMIT BASIS AND EXPLANATION OF EFFLUENT LIMITATIONS

An Individual Groundwater Discharge permit is required for this discharge in accordance with the Massachusetts Clean Water Act, M.G.L. c. 21, s. 26-53 and 314 CMR 5.03.

Effluent limitations are based upon the location of the discharge, the level of treatment, consideration of human health protection criteria and protection of the groundwaters of the Commonwealth.

IV. COMMENT PERIOD, HEARING REQUESTS, AND PROCEDURES FOR FINAL DECISIONS

The public comment period for this permit is thirty (30) days following public notice in *The Environmental Monitor*. The public notice for this Individual Groundwater Discharge Permit occurred on April 11, 2018..

Requests for an adjudicatory hearing must be submitted within thirty (30) days of the issuance/denial of the permit, by any person who is aggrieved by such issuance/denial.

A final decision on the issuance/denial of this permit will be made after the public notice period, and review of any comments received during this period.

V. STATE CONTACT INFORMATION

Additional information concerning the draft permit may be obtained between the hours of 9:00 a.m. and 5:00 p.m. Monday through Friday excluding holidays, from:

Christos Dimisioris
DEP /SERO
20 Riverside Drive
Lakeville, MA 02347
(508) 946-2736

Brian A. Dudley
Bureau of Water Resources

May 21, 2018
Date

P:\12\41 - 4 - Sandwich - Otis Air National Guard Fact Sheet.docx

Proposed Text
Wright-Pierce 5/13/2019 memorandum attachment

MassDEP
Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

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Commissioner

INDIVIDUAL GROUNDWATER DISCHARGE PERMIT

Name and Address of Applicant: ***102nd Intelligence Wing, 156 Reilly Street, Box 46, Otis Air National Guard Base, Massachusetts 02542.***

Date of Application: ***November 17, 2017***

Application/Permit No. ***41 - 4***

Date of Issuance: ***May 21, 2018***

Date of Expiration: ***May 21, 2023***

Effective Date: ***May 21, 2018***

AUTHORITY FOR ISSUANCE

Pursuant to authority granted by Chapter 21, Sections 26-53 of the Massachusetts General Laws, as amended, 314 CMR 2.00, and 314 CMR 5.00, the Massachusetts Department of Environmental Protection (the Department or MassDEP) hereby issues the following permit to: **102nd Intelligence Wing** (hereinafter called "the permittee") authorizing discharges to the ground from the on site wastewater treatment facility located at **971 South Outer Road, Otis Air National Guard Base, MA 02542** such authorization being expressly conditional on compliance by the permittee with all terms and conditions of the permit hereinafter set forth.

Brian A. Dudley
Bureau of Water Resources

May 21, 2018
Date

I. SPECIAL CONDITIONS

A. Effluent Limits

1) The permittee is authorized to discharge into the ground from the wastewater treatment facilities for which this permit is issued a treated effluent whose characteristics shall not exceed the following values:

Effluent Characteristics	Discharge Limitations
12 month moving average flow	360,000 GPD
~~Maximum Day Flow~~ Short-Term Peak Flow	840,000 GPD
Oil and grease	15 mg/l
Total Suspended Solids (TSS)	30 mg/l
Total Nitrogen ($NO_2 + NO_3$ + TKN)	10 mg/l
Nitrate-Nitrogen	10 mg/l
Biochemical Oxygen Demand, 5-day @20°C (BOD_5)	30 mg/l
Fecal Coliform	200 colonies / 100 ml

a) The pH of the effluent shall not be less than 6.5 nor greater than 8.5 at any time or not more than 0.2 standard units outside the naturally occurring range.

b) The discharge of the effluent shall not result in any demonstrable adverse effect on the groundwater or violate any water quality standards that have been promulgated.

c) The monthly average concentration of BOD and TSS in the discharge shall not exceed 15 percent of the monthly average concentrations of BOD and TSS in the influent into the permittee's wastewater treatment facility.

d) When the average annual flow exceeds 80 percent of the permitted flow limitations, the permittee shall submit a report to the Department describing what steps the permittee will take in order to remain in compliance with the permit limitations and conditions, inclusive of the flow limitations established in this permit.

e) Short-Term Peak Flow shall be computed as the highest 3-day moving average.

APPENDIX B
Supplemental Materials – GeoHydroCycle

GeoHydroCycle, Inc.

Hazardous Waste
Water Supply

Assessment
Remediation
Analyses
Permitting
Modeling
Software

October 5, 2017

Mr. Edward J. Leonard, P.E.
Wright-Pierce
75 Washington Avenue, Suite 202
Portland, ME 04101

re: JBCC
Shared Wastewater Management Study
Hydrogeologic Considerations
GHC #17017

Dear Mr. Leonard:

At Wright-Pierce's request, GeoHydroCycle, Inc. (GHC) looked into the geohydrologic considerations related to Rapid Infiltration Basins, Wicks, and Deep Injection Wells at Joint Base Cape Cod (JBCC).

Rapid Infiltration Basins

GeoHydroCycle, Inc. (GHC) conducted groundwater mounding for the existing 4 Rapid Infiltration Beds (RIBs) located in the northern portion of JBCC near the Cape Cod Canal. The goal of this work has been to estimate the effects of groundwater mounding under wastewater loading conditions greater than the permitted rate. Groundwater mounding was accomplished with the finite difference model MODFLOW following MassDEP guidelines[1]. Input data for the model came from available data and information at JBCC and other available online sources.

Based on the modeling results, the assessment showed that the existing RIBs have the capacity to receive treated wastewater at 1.55 million gallons per day without causing: 1) mounding that would exceed MassDEP design requirements; or 2) breakout along the land surface in the down gradient direction toward the Cape Cod Canal.

Figure 1 shows a cross-section through the JBCC RIB area starting at the Cape Cod Canal and extending approximately one mile south away from the Canal. As the figure shows, natural groundwater flows toward the Cape Cod Canal, and beneath the RIB area there is at least 70 feet separation between groundwater and the land surface. Even as groundwater approaches the Canal, the vertical separation remains between 5 and 10 feet below ground surface.

151B California Street
Newton, Massachusetts
02458

(617) 527-8074 (v)
(617) 527-8668 (f)

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1 Massachusetts DEP. November 2014. *Guidelines for the Design, Construction, Operation, and Maintenance of Small Wastewater Treatment Facilities with Land Disposal.*

GEOHYDROCYCLE, INC.

Figure 2 shows the results of a groundwater mounding simulation where wastewater was discharged into the 4 RIBs at a rate of 1.295 mgd, or 5 gpd/sf into all 4 beds. Because MassDEP allows the use of 80% of the daily maximum wastewater discharge in groundwater mounding models, the actual discharge would be 1.619 mgd, which is more than double the 0.800 mgd permitted for the RIBs. Figure 2 demonstrates that the discharge would only cause a 12 foot increase in groundwater levels beneath the 4 RIBs.

Figure 3 shows groundwater elevation contours that would result from adding the groundwater mound heights onto local groundwater. As Figure 3 shows, although the mounded groundwater is at elevation 30, it is still 60 feet below the land surface at the JBCC RIBs, and down gradient of the RIBs the mounded groundwater remains well below the land surface.

Existing information indicates that the hydrogeologic conditions beneath the adjacent property to the west is very similar to what exists beneath the JBCC RIBs. Based on this information, GHC would expect that additional sets of RIBs located on available property to the west of the existing RIBs would exhibit similar mound heights when the new RIBs are all loaded at 5.0 gpd/sf.

<u>Wicks</u>

Wicks, a relatively new technology in Massachusetts, provide a useful and cost effective disposal option. The significant depth to water table and glacial outwash soils at JBCC provide the conditions were wicks can be successful. Wicks can be thought of as large diameter wells that provide a vertical conduit transmitting wastewater down to the water table. For a given discharge, Wicks use less land area than conventional disposal technologies and can be used to transmit effluent vertically through tight soils to more conductive hydrogeologic formations.

<u>Deep Well Discharge</u>

GeoHydroCycle, Inc. compiled hydrogeologic information relative to three possible deep discharge well sites within the JBCC Cantonment Area. The goal of this work was to look at different types of hydrogeologic conditions that would either positively or negatively affect the placement of a deep well to discharge treated wastewater at a particular site. GHC downloaded and reviewed online USGS data to accomplish this goal.

Figure 4 shows JBCC in the western portion of Cape Cod and the five towns (Falmouth, Bourne, Sandwich, Barnstable and Mashpee) around the base. The Cantonment Area is located in the southern portion of JBCC, and Figure 4 shows the possible locations of three deep wells, DW-1, DW-2 and DW-3. Figures 5, 6 and 7 show the geologic makeup of the soils at the three deep well locations. Those figures also show the types of soil around the well, the hydraulic properties of the soils, and the depth range of the screened entrance for municipal wells in the vicinity of the deep well.

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GeoHydroCycle, Inc.

Soil types can be used to infer the general ability of the well to discharge water to groundwater. Typically, sands and gravels provide a much better media for discharge wells than do silts or clays. Soil hydraulic conductivity is also a good indicator of a well's ability to act as a discharge well. The greater the hydraulic conductivity, the greater the well's ability to discharge to groundwater. A municipal well's screen is where water is drawn into the well, and the greater the separation depth between the deep well's screen and the municipal well's screen, the less likely it is for the municipal well to draw in deep well wastewater.

The placement of the deep wells took into consideration the location of municipal well Zone IIs or wellhead protection areas. Wells DW-1 and DW-2 were located outside Zone IIs and well DW-3 was located within a Zone II. A Zone II is defined by state regulations as that land area that provides water to a municipal well under drought conditions, and the location of a deep well discharging treated wastewater in a Zone II would be considered negatively under current regulations even with a large vertical separation. On a technical basis there should be a large enough vertical separation to allow deep well injection without impacting municipal wells.

Figure 8 presents possible groundwater pathways from each deep well to the ocean. This figure is based on general groundwater contours published by the Cape Cod Commission. As Figure 8 shows groundwater in the area of deep well DW-2 flows to the west toward Buzzards Bay, and could be expected to travel 15,000 feet in groundwater before reaching the Bay. Deep wells DW-1 and DW-3 travel with groundwater to the south toward Vineyard Sound, but the travel path for both wells is much longer, 7.4 and 8.4 miles respectively. The further travel distances, and times, provide more opportunity for the wastewater to be drawn upward and end up discharging to one of the many ponds or estuaries instead of the ocean. The longer flow paths also adversely change the natural groundwater quality of a much larger volume of groundwater than do shorter pathways.

Injection wells are a new technology for Cape Cod and the location, design and capacity of the wells would be determined only through large-scale testing. The ability to bypass coastal embayments would need to be further demonstrated through detailed groundwater modeling.

If you have any questions, please feel free to call me.

Sincerely,
GeoHydroCycle, Inc.

Stephen W. Smith, P.E., P.HGW.

Enclosures: Figures 1 - 8

JBCC Hydrogeo.lwp

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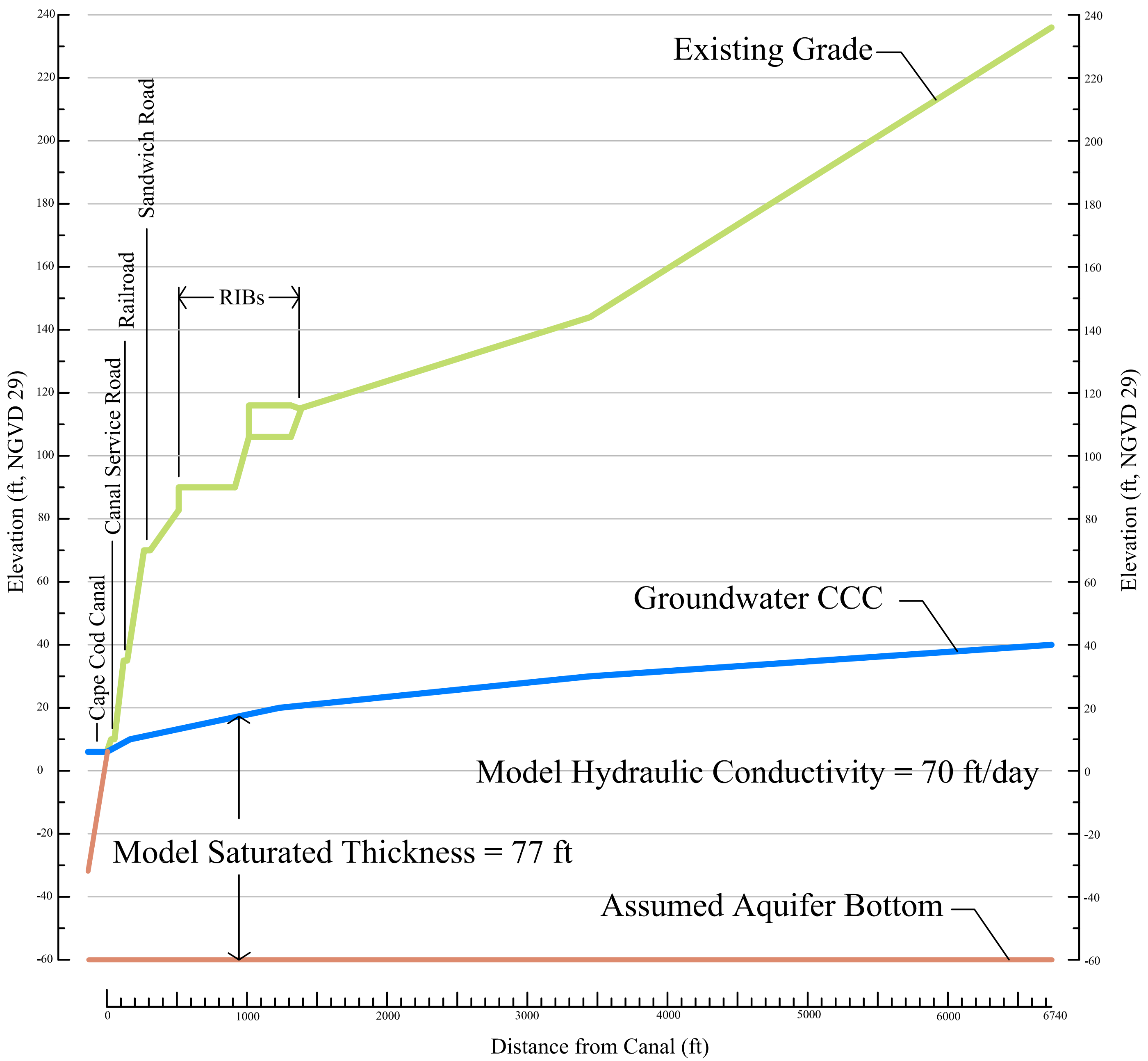

JBCC
Shared Wastewater Management Study Hydrogeologic Considerations

Figure 1. Hydrogeologic Cross-Section.

NOTES

1. Feature details obtained from Google Earth.

Vert/Horiz 22.5:1
Scales as Shown

Project No. GHC#17017

Drafted SWS Checked

Date 9/17/17 Rev 10/4/17

Base Map: None.

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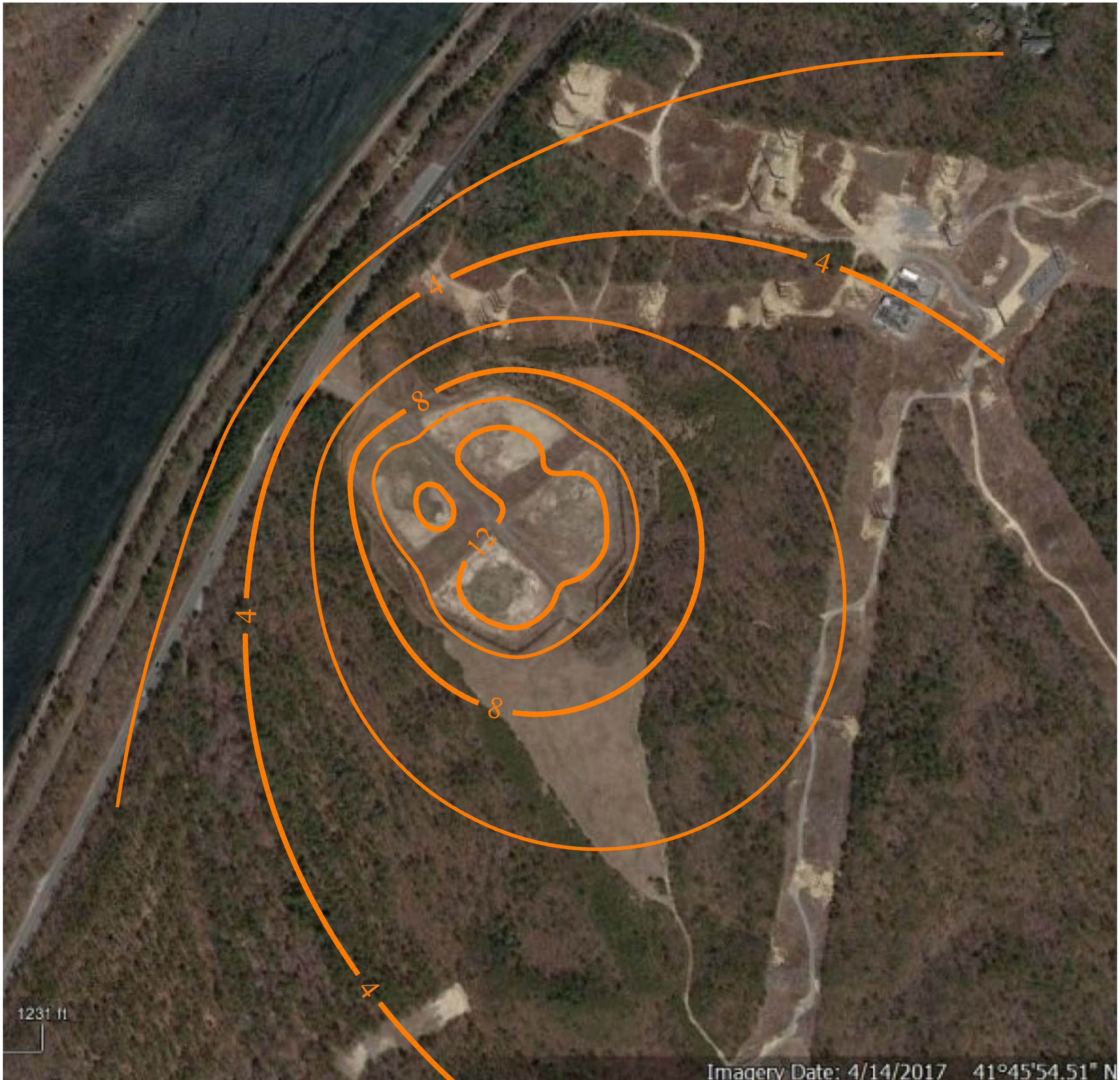

JBCC
Shared Wastewater Management Study Hydrogeologic Considerations

Figure 2. Simulated Groundwater Mound Height Contours, Loading at 5 gpd/sf* or 1,295,800 gpd.

Notes

* based on loading all 4 beds.

0 300

Scale in feet

Project No. GHC#17017
Drafted SWS Checked
Date 9/20/17 Rev 10/4/17
Base Map: Google Earth

GeoHydroCycle, Inc.

JBCC
Shared Wastewater
Management Study
Hydrogeologic
Considerations

Figure 3. Simulated Groundwater Elevation Contours, Loading at 5 gpd/sf* or 1,295,800 gpd.

Notes

* based on loading all 4 beds.

0 300

Scale in feet

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Project No. GHC#17017
Drafted SWS Checked
Date 9/20/17 Rev 10/4/17
Base Map: Google Earth

GeoHydroCycle, Inc.

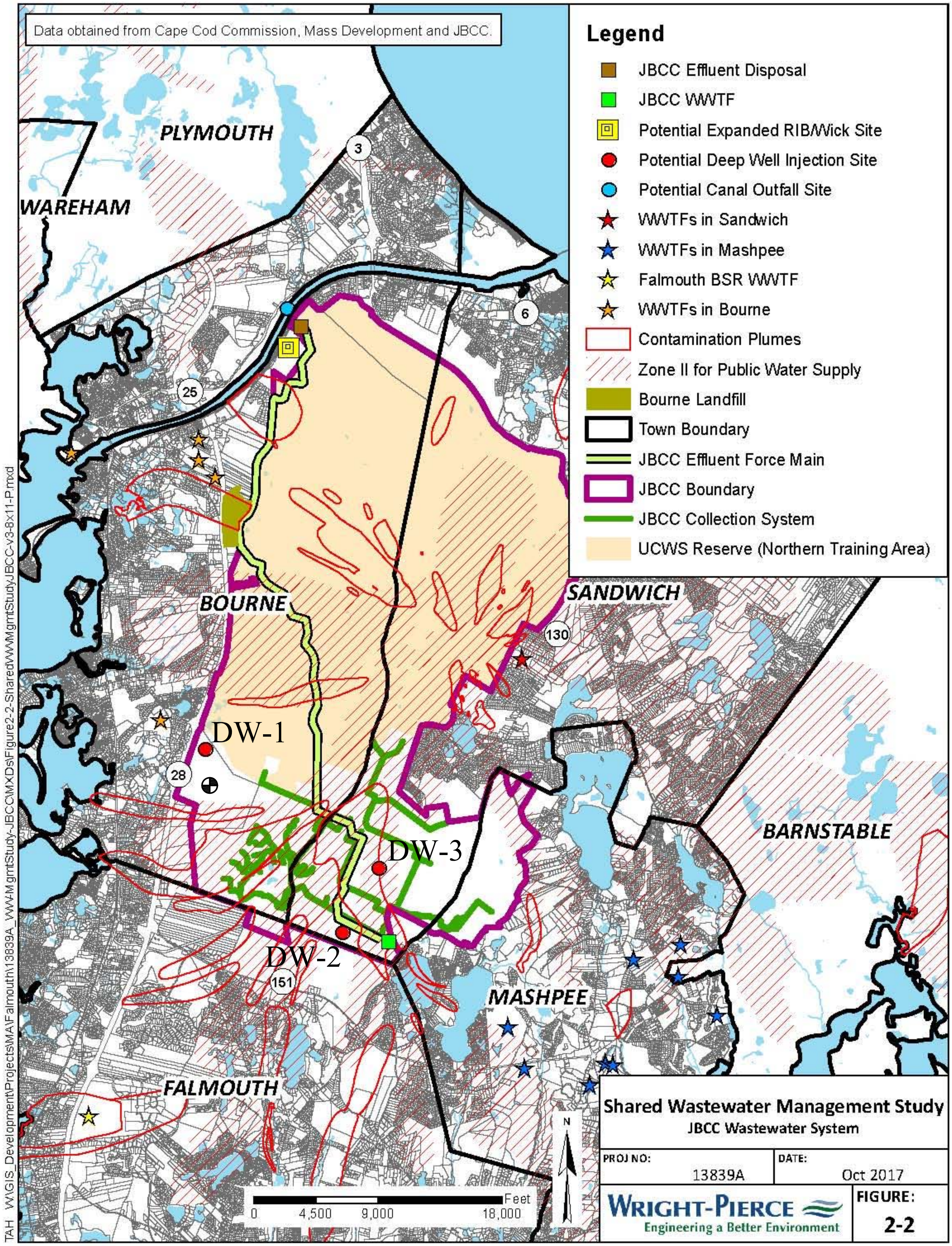
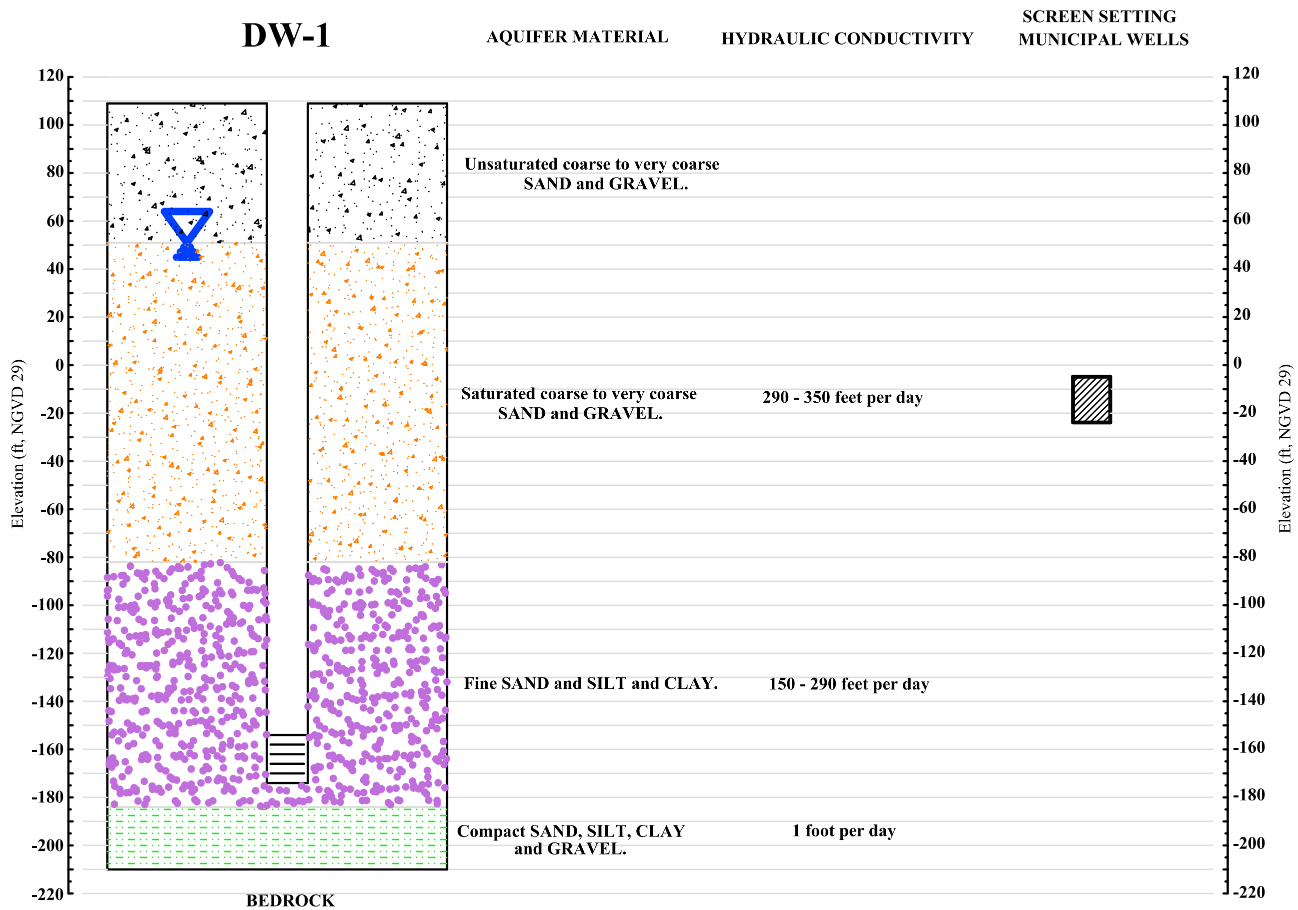


Figure 4. Potential Deep Well Locations.



JBCC
Shared Wastewater Management Study Hydrogeologic Considerations

Figure 5. Potential Deep Discharge Well, DW-1.

Scales as Shown

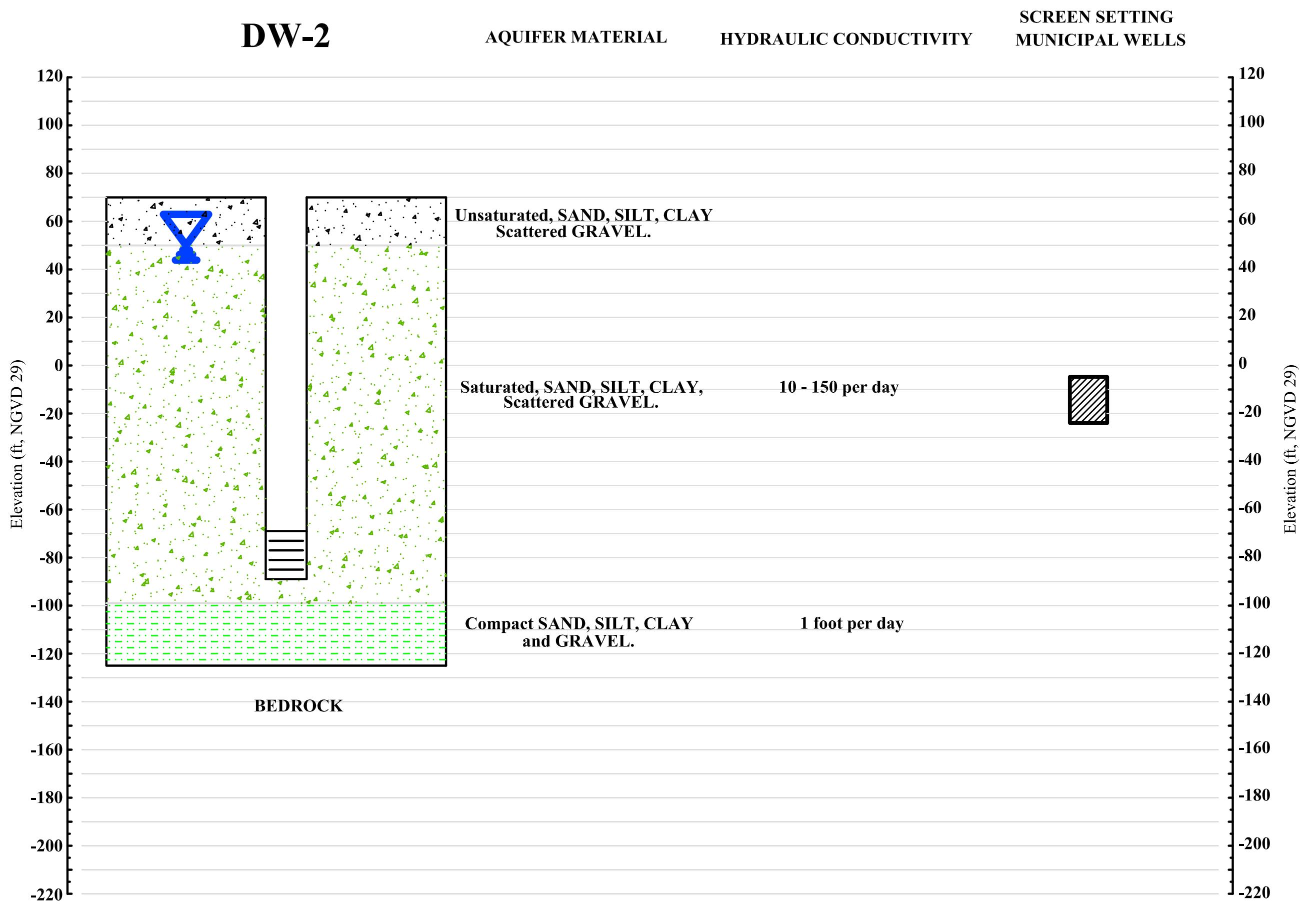
Project No. GHC#17017

Drafted SWS Checked

Date 9/27/17 Rev 10/4/17

Base Map: None.

GeoHydroCycle, Inc.



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Shared Wastewater Management Study Hydrogeologic Considerations

Figure 6. Potential Deep Discharge Well, DW-2.

Scales as Shown

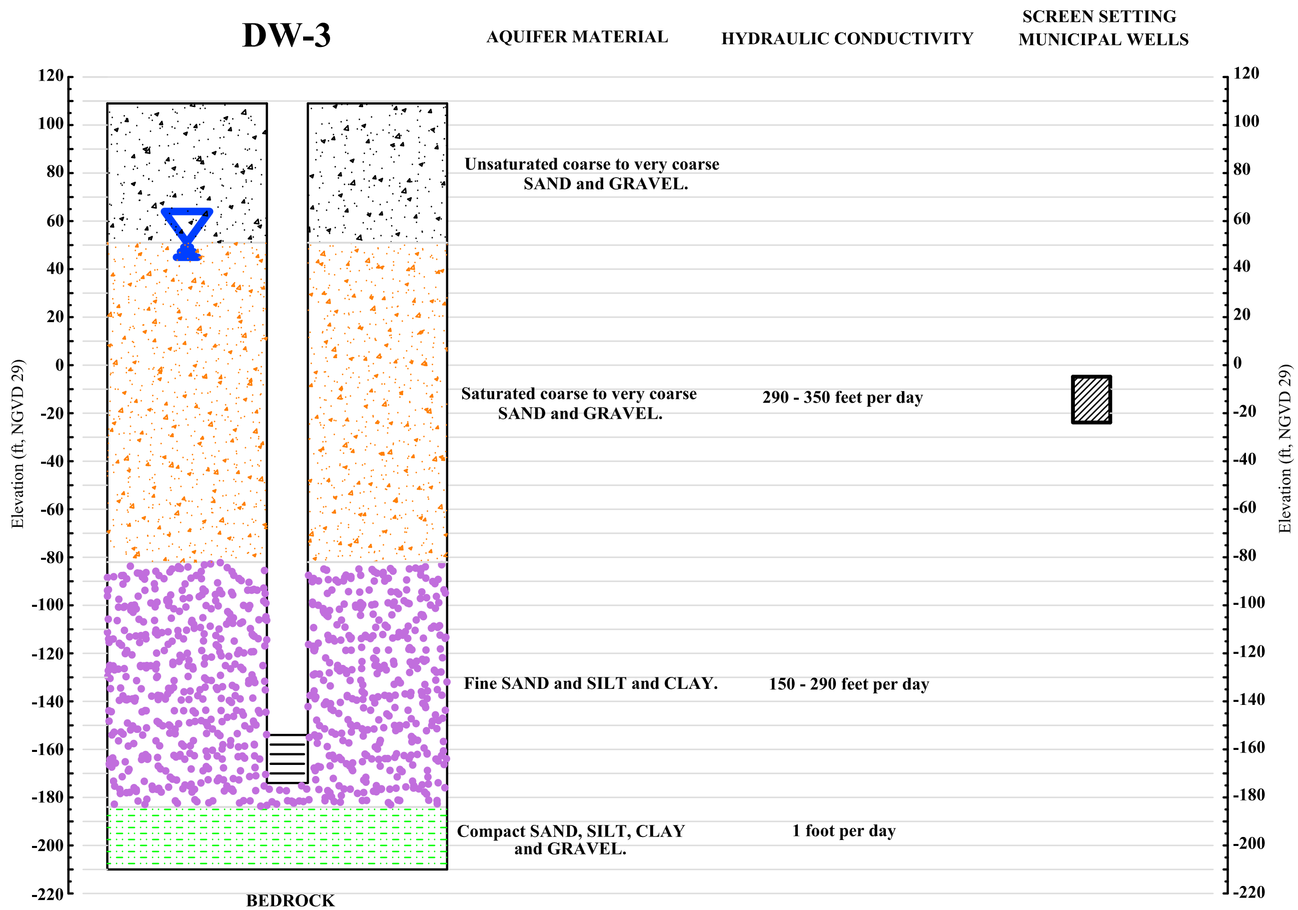
Project No. GHC#17017

Drafted SWS Checked

Date 9/27/17 Rev 10/4/17

Base Map: None.

GeoHydroCycle, Inc.



JBCC
Shared Wastewater Management Study Hydrogeologic Considerations

Figure 7. Potential Deep Discharge Well, DW-3.

Scales as Shown

Project No. GHC#17017

Drafted SWS Checked

Date 9/27/17 Rev 10/4/17

Base Map: None.

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JBCC
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Management Study
Hydrogeologic
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Figure 8. Groundwater Flow from Three Possible Deep Wells, DW-1, DW-2 and DW-3.

Project No. GHC#17017
Drafted SWS Checked
Date 9/24/17 Rev 10/4/17
Base Map: USGS Publication.

GeoHydroCycle, Inc.

APPENDIX C
Supplemental Materials – GHD

Memorandum

November 28, 2017

To:	Ed Leonard – Wright Pierce	Ref. No.:	11151818
From:	J. Jefferson Gregg, P.E., BCEE	Tel:	774-470-1640
CC:	Rodney Collins – Town of Mashpee, MA Amy Lowell – Town of Falmouth, MA		
Subject:	**Cost Review – JBCC Shared Wastewater Management Study** **Towns of Falmouth, MA and Mashpee, MA**		

1. Introduction

GHD Inc. was contracted by Wright Pierce for consulting services as part of their Joint Base Cape Cod (JBCC) Shared Wastewater Management Study through a grant received by the Town of Falmouth, MA. The data in this memorandum is provided subject to the limitations in Section 6.0.

GHD's tasks included review of draft documents provided by Wright Pierce related to their efforts on the project, attendance at a workshop held at the Mashpee Town Hall on October 18, 2017 with the other project participants, and then provide general comments on the draft documents and the costs presented. The general review of preliminary costs was done on behalf of the communities of Falmouth, MA and Mashpee, MA and would be based on existing planning documents developed by GHD for those two communities. No new costs were to be developed as part of this evaluation. Comparison was made following the Wright Pierce phasing framework of Short Term (2017 to 2020), Mid Term (2020 to 2040) and Long Term (2040+).

The existing planning documents referenced for comparison are as follows:

- "Shared Watershed Management Study: Towns of Bourne, Falmouth, Mashpee, Sandwich and Joint Base Cape Cod – Preliminary Strategy and Engineering Assessment Report – DRAFT", Town of Falmouth, Ma, October 2017, Wright Pierce. (JBCC Report)
- "Final Recommended Plan/ Final Environmental Impact Report", Town of Mashpee Sewer Commission, May 2015, GHD Inc. (WNMP)
- "Draft Comprehensive Wastewater Management Plan and Draft Environmental Impact Report, and Notice of Project Change – Little Pond, Great Pond, Green Pond, Bournes Pond, Eel Pond, and Waquoit Bay Watersheds and Recommendations for West Falmouth Harbor Watershed – Volume 1 and 2", Town of Falmouth, MA, July 2012, GHD Inc. (DCWMP/DEIR)

Supplemental information was also consulted as it related to the previous GHD planning efforts and past cost development for both Falmouth, MA and Mashpee, MA.

2. Task 3 General JBCC Report Review

On October 16, 2017, GHD was provided with the JBCC DRAFT Report for review and comment prior to the October 18, 2017 workshop. GHD identified the following comments summarized as follows: (Wright Pierce general responses are summarized in *italics*)

1. Section 1.3.3 "Mashpee" – GHD requested that reference to the July 31, 2015 Certificate of the Secretary of Energy and Environmental Affairs on the Final Environmental Impact Report be included in this section. *Reference will be included in final document.*

2. Section 1.4.8, last bullet – GHD suggested clarification be provided on where the 8-inch FM section is, as all other references to the effluent FMs at JBCC are of 12-inch pipe. *Clarification will be provided in final document.*

3. Section 1.6.3, first paragraph, 3rd sentence. Should read "advantageous", not "advantages". *Correction made in final document.*

4. Table 1-7 Requested Capacity By Wastewater Type, following discussions with the Town of Mashpee. Please revise two rows:

   a. Mid Term – High End (gpd) change from 200,000 gpd to 370,000 gpd

   b. Long Term – High End (gpd) change from 200,000 gpd to 850,000 gpd

   It is our understanding that these changes in values do not impact the Study Basis or Cost Estimations. *Table 1-7 will be modified per the request, and values do not impact Study Basis.*

5. Section 2.4.2, fourth bullet "Mashpee (sewage)"; Mashpee requested that the location of the lift station be made consistent with the approved WNMP. There is no lift station proposed at the Mashpee Rotary to convey wastewater to JBCC. GHD provided additional information during discussions with Wright Pierce regarding the location of the pumping station to JBCC. During that discussion, GHD suggested two potential options:. either at the "Back Road Site 1" location as shown on Figure 6-4, or at the proposed lift station location proposed for Subarea "L" off of Hooppole Road. *WP will show pumping station at Back Road Site 1.*

6. Section 2.4.2.3 – Preferred Mashpee Alignment Details. See Comment #5.

7. Table 2-4 Unit Processes – suggested that Deep Well Injection and Outfall would be the same for "Conventional Nitrogen" either both "yes" or both "no". *Correction made in final document.*

8. Sections 2.8.2, 2.84 and 2.8.6 – suggested that Mid-Term first bullet be clarified. Is the assumption that they currently meet these requirements, or that they will by the time of Mid-Term implementation. *Additional clarification will be provided in final document.*

9. GHD asked if there would be a table presenting the "Short-Term" breakdown. GHD suggested that a simple table of % contribution by each town under the Short-, Mid-, and Long-Term options be presented. *Updates provided by WP.*

10. Section 2.9.4 –"Conveyance", GHD asked if cost splitting by flow contribution was considered for shared infrastructure? *It was clarified that other methods were not considered for this report, but it is acknowledged that other methods could be used.*

11. Section 2.9.6 – Evaluation Criteria.

    a. Public perception – GHD asked why impact to surface water was considered "neutral", isn't there concern over ocean outfalls and the public perception – wouldn't this be the same as the "NGO" perception? *It was clarified that public perception was considered different than NGO perception on this topic, but that this is a subjective criteria.*

    b. Groundwater Protection – GHD suggested modifying this title or breaking into two categories, as it could be interpreted that "protection" and "sustainability" might be different relative to Zone IIs. *It was clarified that this would be changed to "Sustainability/Groundwater supply". Groundwater protection is covered by permitting.*

    c. Sustainability/chemical use – GHD asked if there was consideration of decrease in chemical use as the advantage. *It was clarified that chemical use was related to the number of processes, not chemical quantities*.

12. Appendix A – Evaluation Conveyance Options memo should be updated – see Comment #5. *Correction will be made in final document.*

3. Task 4 Mashpee Review

The following tables summarize the analysis used to look at capital costs for various options.

GHD has elected to evaluate the wastewater treatment and recharge option components at JBCC, and compare then to similar options identified as part of the Mashpee WNMP. As part of the Mashpee WNMP, JBCC was considered for treatment and recharge. In order to compare to the JBCC Report, the following considerations were made:

1. The WNMP considered treatment at JBCC using their existing facilities and presumed that only improvements to the existing WWTF would be necessary. Conveyance costs were included in their overall collection system costs and were not broken out separately. In addition, it was assumed for the JBCC option that the existing rapid infiltration basins (RIBs)/open sand beds would be sufficient to handle the flows recommended.
2. An alternative to the WNMP sending flow to JBCC was to construct new facilities at the "Back Road Site 1". This evaluation considers an MBR for treatment and recharge at open sand beds.
3. These WNMP options were then compared to the JBCC-Option 1 which included SBRs and RIBs.
4. Conveyance costs were not considered since they are considered each town's responsibility, thus these costs were not broken out in the WNMP..

5. Costs were then calculated on a dollars per thousand gallon treated ($/Kgal) per Wright-Pierce's request. Each component was calculated individually and then added up to consider those conditions where flow may change between what is being treated and what is being recharged.

Table 3.1 presents the summary of the Short-Term costs prepared by Wright-Pierce for the Treatment and Disposal options.

Table 3.2 presents the summary of the Mid-Term costs prepared by Wright-Pierce for the Treatment and Disposal options.

Table 3.3 presents the summary of the Long-Term costs prepared by Wright-Pierce for the Treatment and Disposal options.

Table 3.4 presents a summary of the WNMP costs prepared for the following three options:

1. Phase 2 (JBCC Option) – this option is the recommended plan, where 200,000 gpd would be sent to JBCC and treated using the existing facilities (expanded with a parallel oxidation ditch added), and recharged using the existing RIBs.
2. Phase 2 (Back Roads Site - MBR) – This option represents the "fall back" option presented in the Recommended Plan if the JBCC facility was not available to Mashpee. This would include a new WWTF and RIBs.

Table 3.5 presents the comparison between each option and identifies each option by high, medium, and lowest capital cost on a $/Kgal basis.

Table 3.1 Short-Term - Mashpee

Scenario	Flow (gpd)	Baseline Cost ($)	Contingency (43%)	Subtotal ($)	$/Kgal
Baseline Treatment Only					
WP-Option 6	200,000	$1,090,000	$468,700	$1,558,700	$21
Supplemental Treatment Only					
WP-Option 6	200,000	$-	$-	$-	$-
Disposal (with Transport) Only					
WP-Option 6	200,000	$309,734	$133,186	$442,920	$6
Total					
WP-Option 6 - WWTF and Recharge (RIB)					$27

Notes:

1. Costs are based on values prepared by Wright-Pierce in their Draft October 2017 report and appendices.
2. Conveyance Costs Not included, because locations could vary when compared to each alternative (including CWMPs) and all Costs by Town only.
3. Contingency column represents "Contingencies/Fiscal, Legal, Engineering" (43%) differ from those for the WNMP (40% assumed in WNMP).

Table 3.2 Mid-Term - Mashpee

Scenario	Flow (gpd)	Baseline Cost ($)	Contingency (43%)	Subtotal ($)	$/Kgal
Baseline Treatment Only					
WP-Option 6	203,000	$5,443,338	$2,340,635	$7,783,973	$105
Supplemental Treatment Only					
WP-Option 6	203,000	$-	$-	$-	$-
Disposal (w/ Transport) Only					
WP-Option 6	203,000	$1,310,126	$563,354	$1,873,480	$25
Total					
WP-Option 6 - WWTF and Recharge (RIB)					$130

Notes:

1. Costs are based on values prepared by Wright-Pierce in their Draft October 2017 report and appendices.
2. Conveyance Costs Not included, because locations could vary when compared to each alternative (including CWMPs) and all Costs by Town only.
3. Contingency column represents “Contingencies/Fiscal, Legal, Engineering” (43%) differ from those for the WNMP (40% assumed in WNMP).

Table 3.2 Long-Term - Mashpee

Scenario	Flow (gpd)	Baseline Cost ($)	Contingency (43%)	Subtotal ($)	$/Kgal
Baseline Treatment Only					
WP-Option 6	203,000	$7,786,169	$3,348,053	$11,134,222	$150
Supplemental Treatment Only					
WP-Option 6	203,000	$-	$-	$-	$-
Disposal (w/ Transport) Only					
WP-Option 6	203,000	$2,236,257	$961,591	$3,197,848	$43
Total					
WP-Option 6 - WWTF and Recharge (RIB)					$193

Notes:

1. Costs are based on values prepared by Wright-Pierce in their Draft October 2017 report and appendices.
2. Conveyance Costs Not included, because locations could vary when compared to each alternative (including CWMPs) and all Costs by Town only.
3. Contingency column represents “Contingencies/Fiscal, Legal, Engineering” (43%) differ from those for the WNMP (40% assumed in WNMP).

Table 3.3 Mashpee WNMP (2015)

Scenario	Flow (gpd)	Baseline Cost ($)	Contingency (43%)	Subtotal ($)	$/Kgal
Treatment Only					
Phase 2 JBCC Option	200,000	$4,000,000	$1,720,000	$5,720,000	$78
Phase 2 Back Roads Site	200,000	$9,860,000	$4,240,000	$14,100,000	$193
Disposal (w/ Transport) Only					
Phase 2 JBCC Option	200,000	$-	$-	$-	$-
Phase 2 Back Roads Site	200,000	$720,000	$310,000	$1,030,000	$14
Total					
Phase 2 (JBCC Option)					$78
Phase 2 (Back Roads Site - MBR)					$207

Notes:
1. Contingency column represents "Contingency/Fiscal, Legal, Engineering" changed to 43% to match JBCC evaluation (40% assumed in WNMP).
2. Base line cost adjusted from 2015 values (ENR 9922) to 2017 Costs per JBCC ENR (10800).
3. Mashpee Alternative assumed no improvements needed to effluent recharge facilities at JBCC.
4. Mashpee Alternative assumed existing JBCC WWTF could be used and expanded vs. construction of a new WWTF.

Table 3.4 Mashpee Summary ($/Kgal)

Option	Mashpee WNMP (JBCC)	Mashpee WNMP (Back Roads - MBR)	JBCC Short-Term	JBCC Mid-Term	JBCC Long-Term
WW Treatment and Recharge (RIB)	$78	$207	$27	$130	$193

Notes:
1. RIB = Rapid Infiltration Basin/Open Sand Bed
2. Green = Lowest Cost
3. Orange = Mid Cost
4. Red = High Cost

As can be seen in Table 3.4, the Mashpee WNMP recommended plan presents the lowest capital cost option. This is primarily because it does not call for an entirely new WWTF and does not require construction of new

RIBs. O&M costs were not compared directly as there was no breakout by "process", "town", and "option" provided for the JBCC report.

4. Task 5 – Falmouth Review

The following tables summarize the analysis used to look at capital costs for various options. Comparisons are strictly made in an effort to compare cost development for this JBCC Report relative to previous planning efforts in Falmouth, MA and are not intended to represent any recommended plan for Falmouth, MA as they are currently still in the midst of Comprehensive Planning.

GHD has elected to evaluate the wastewater treatment and recharge option components at JBCC and compare then to similar options identified as part of the evaluations performed in developing the Falmouth Draft CWMP/DEIR. As part of the Falmouth Draft CWMP planning efforts, several alternatives for JBCC were considered for treatment and recharge. The Town of Falmouth is still in planning, has been working on addressing their TMDLs through multiple approaches, and has not finalized any recommendation regarding the use of JBCC; therefore comparisons are made based on evaluations performed as part of the Draft CWMP development back in 2009 and 2012. In order to compare to the JBCC Report, the following considerations were made:

1. Conveyance costs were included in their overall collection system costs and were not broken out separately.
2. Costs for Falmouth were based on those developed as part of the DCWMP/DEIR. It should be noted that these were not the final recommendations of the Town; however they were used as they provided a group of comparable scenarios.
3. Costs were then calculated on a dollars per thousand gallon treated ($/Kgal) per Wright-Pierce request. Each component was calculated individually and then added up to consider those conditions where flow may change between what is being treated and what is being recharged.
4. Option 6 (as outlined in Section 2 of the JBCC Report was used as the evaluation point) – New WWTF at JBCC and ocean outfall (OO) (Falmouth continues treatment at the existing BSR WWTF)
5. O&M costs were not compared directly as there was no breakout by "process", "town", and "option" provided for the JBCC report.

Table 4.1 presents the summary of the Mid-Term costs prepared by Wright-Pierce for the Treatment and Disposal options, plus upgrade costs for the BSR WWTF to continue treatment in the long-term. Upgrade costs represent the portion of the costs that would be sent to JBCC for effluent disposal (i.e., Falmouth would have additional upgrade costs for the effluent flow that would stay in Falmouth).

Table 4.2 presents the summary of the Long-Term costs prepared by Wright-Pierce for the Treatment and Disposal options, plus upgrade costs for the BSR WWTF to continue treatment in the long-term. Upgrade costs represent the portion of the costs that would be sent to JBCC for effluent disposal (i.e., Falmouth would have additional upgrade costs for the effluent flow that would stay in Falmouth).

Table 4.3 presents a summary of the DCWMP/DEIR costs prepared for the following three options:

1. 3A - JBCC WWTF with Recharge at the Falmouth County Club (FCC).
2. 3C - JBCC WWTF with RO and Well Injection.
3. 1D – Blacksmith Shop Road (BSR) WWTF with Ocean Outfall.

These options were considered the most comparable to the JBCC Report options, based on their treatment and discharge technologies.

Table 4.4 presents the comparison between each option and identifies each option by high, medium, and lowest capital cost on a $/Kgal basis.

Table 4.1 Mid Term – Falmouth

Scenario	Flow (gpd)	Baseline Cost ($)	Contingency (43%)	Subtotal ($)	$/Kgal
Baseline Treatment Only					
WP-Option 6	512,000	$6,297,248	$2,707,816	$9,005,064	$48
Supplemental Treatment Only					
WP-Option 6	512,000	$-	$-	$-	$-
Disposal (w/ Transport) Only					
WP-Option 6	512,000	$7,451,190	$3,204,012	$10,655,202	$56
Total					
WP - Option 6 - WWTF and Recharge (OO)					$104

Notes:

1. Costs are based on values prepared by Wright Pierce in their Draft October 2017 report and appendices.
2. Conveyance Costs Not included, because locations could vary when compared to each alternative (including CWMPs) and all Costs by Town only.
3. Contingency column represents "Contingencies/Fiscal, Legal, Engineering" (43%) differ from those for the CWMP (50% assumed in DCWMP/DEIR).
4. Treatment flows and costs adjusted to account for off-site (not at JBCC) wastewater treatment. Estimated $/Kgal used based on Option 1D of the DCWMP/DEIR for 490,000 gpd balance.

Table 4.2 Long Term - Falmouth

Scenario	Flow (gpd)	Baseline Cost ($)	Contingency (43%)	Subtotal ($)	$/Kgal
Baseline Treatment Only					
WP-Option 6	1,512,000	$18,440,041	$7,929,218	$26,369,259	$48
Supplemental Treatment Only					
WP-Option 6	1,512,000	$-	$-	$-	$-
Disposal (w/ Transport) Only					
WP-Option 6	1,512,000	$14,349,266	$6,170,184	$20,519,450	$37
Total					
WP - Option 6 - WWTF and Recharge (OO)					$85

Notes:

1. Costs are based on values prepared by Wright Pierce in their Draft October 2017 report and appendices.
2. Conveyance Costs Not included, because locations could vary when compared to each alternative (including CWMPs) and all Costs by Town only.
3. Contingency column represents “Contingencies/Fiscal, Legal, Engineering” (43%) differ from those for the CWMP (50% assumed in DCWMP/DEIR).
4. Treatment flows and costs adjusted to account for off-site (not at JBCC) wastewater treatment. Estimated $/Kgal used based on Option 1D of the DCWMP/DEIR for 1,490,000 gpd balance.

Table 4.3 Falmouth DCWMP/DEIR (2009/2012)

Scenario	Flow (gpd)	Baseline Cost ($)	Contingency (43%)	Subtotal ($)	$/Kgal
Treatment Only					
3A (Phase 1 and 2) Table 5-1	1,800,000	$32,700,000	$14,100,000	$46,800,000	$71
3C (Phase 1 and 2) Table 5-4	1,800,000	$68,000,000	$29,200,000	$97,200,000	$148
1D (Phase 1 and 2) - Table 5-5	1,800,000	$21,400,000	$9,200,000	$30,600,000	$47
Disposal (w/Transport) Only					
3A (Phase 1 and 2) Table 5-1	1,800,000	$16,400,000	$7,100,000	$23,500,000	$36
3C (Phase 1 and 2) Table 5-4	1,800,000	$10,100,000	$4,300,000	$14,400,000	$22
1D (Phase 1 and 2) - Table 5-5	1,800,000	$47,900,000	$20,600,000	$68,500,000	$104
Total					
3A (Phase 1 and 2) Table 5-1					$107
3C (Phase 1 and 2) Table 5-4					$170
1D (Phase 1 and 2) - Table 5-5					$151

Notes:

1. 3A - JBCC WWTF with Recharge at FCC
2. 3C - JBCC WWTF with RO and Well Injection
3. 1D - BSR WWTF with Ocean Outfall
4. Conveyance cost based on Major PS and FM cost row from spreadsheets
5. Contingency column represents “Contingency/Fiscal, Legal, Engineering” changed to 43% to match JBCC evaluation
6. Base line cost adjusted from July 2009 values (ENR 8570) to 2017 Costs per JBCC ENR (10800)

Scenario Flow (gpd)	Estimated $/Kgal
DCWMP WW Treatment and Recharge (RIB)	$107
DCWMP WW Treatment and Recharge (DWI)	$170
DCWMP WW Treatment and Recharge (OO)	$151
Option 6 – Mid-Term (JBCC Report)	$104
Option 6 – Long-Term (JBCC Report)	$85

Notes:

1. RIB = Rapid Infiltration Basin/Open Sand Bed
2. DWI = Deep Well Injection
3. OO = Ocean Outfall
4. Green = Lowest Cost
5. Orange = Mid Costs
6. Red = High Costs

5. Summary

Based on this initial review of the documents and costs:

- The Mashpee WNMP recommendations (i.e., to send 200,000 gpd of sewage to JBCC upgaded for a smaller scale regional use) still appear to be the most cost effective for that community, however, the Mashpee WNMP was not intended to consider a larger scale regional use of the JBCC facility. If all of the communities were in agreement and a larger effluent discharge option were presented, the Town of Mashpee may consider requesting additional sewage treatment capacity in order to alleviate stress on its existing embayments. At this time the short-term goals of Mashpee appear consistent with the short-term goals presented in the JBCC report.
- The Falmouth DCWMP/DEIR costs indicate that it is slightly less cost effective for Falmouth to work independently in the long term and essentially the same under mid-term conditions. Irrespective of the term, the Town is in the middle of its planning efforts and changes and alternatives identified during that process may show the JBCC alternatives more cost effective. The alternatives for Falmouth were much closer in cost than those presented for Mashpee.
- There are still a significant number of unknowns regarding the use of JBCC which would influence each of these communities and their future decision making process; however, the planning-level cost estimates are indicative of potential cost savings in the long-term due to regionalization. Mashpee and Falmouth should continue to stay engaged on the potential regional use of the JBCC wastewater facilities.

6. Limitations

GHD has not been involved in the direct preparation of the JBCC Report and makes no statement in the JBCC Report other than the contents of this memorandum.

The Cost Estimates are a preliminary estimate only. Actual prices, costs, and other variables may be different to those used to prepare the Cost Estimate and may change. No detailed quotation has been obtained for actions identified herein. GHD does not represent, warrant or guarantee that the works/project can or will be undertaken at a cost which is the same or less than the Cost Estimates presented.

No information provided as part of this memorandum shall be used for design or construction.

APPENDIX D
Supplemental Materials – Northwest Hydraulic Consultants

JOINT BASE CAPE COD
SHARED WASTEWATER MANAGEMENT SYSTEM
HYDRAULIC TRANSIENT ANALYSIS
TOWN OF FALMOUTH

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May 31, 2019

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EXECUTIVE SUMMARY

This report presents findings from a hydraulic transient analysis of the Joint Base Cape Cod (JBCC) Shared Wastewater Management System. A hydraulic transient analysis computer model was developed for the operation of the upgraded Effluent Pump Station (EPS) at the Otis Air National Guard Base Wastewater Treatment Facility (WWTF) and the associated existing effluent force main. The 12-inch diameter ductile iron pipe force main is approximately 10.5 miles in length and conveys up to 800 gpm (according to operations staff) of wastewater from a wet well to Static Head Manhole No. 1 (SHMH No. 1) where there is a transition from pressurized to gravity flow. The wastewater is then conveyed a short distance by a gravity sewer to infiltration basins. SHMH No. 2 is located at the force main high point and has been observed to surcharge and overflow when two pumps are operating at the WWTF EPS. The reduced voltage soft starters with which the pumps at the WWTF EPS were originally equipped are in the process of being replaced by variable frequency drives (VFD) by the operations staff. Northwest Hydraulic Consultants Inc. (NHC) performed power failure and start-up simulations for the pumps at the EPS. This report presents findings from the hydraulic transient analysis and operational recommendations for the system. The report also includes analyses and recommendations for the existing and future conveyance capacity of the force main.

Pump Power Failure, Shutdown and Start-up

The results of the hydraulic transient analyses show that the existing pressurized surge tank at the WWTF EPS is predicted to provide satisfactory surge protection for the force main following loss of power to or shutdown of the existing pumps at the WWTF EPS, and that additional surge control is not necessary. However, it is recommended that the WWTF EPS operators implement the following operational recommendations:

- The pressurized surge tank at the WWTF EPS should maintain an air volume of 45 percent of the total tank volume under steady state operating conditions at the pump station.

- If the WWTF EPS operators are observing check valve slam or valve seat damage following pump power failure at the pump station, it is recommended that the swing check valves at the WWTF EPS be equipped with oil mounted bottom buffers. The air cushion cylinder currently installed on each swing check valve at the WWTF EPS may not prevent the slam closure of the swing check valves following pump power failure.

- The pumps at the WWTF EPS should be ramped from idle (i.e., zero rpm) up to full speed (i.e., 1750 rpm) in 30 seconds or longer and should be started one at a time with at least a 30 second lag between each pump start.

The results of a sensitivity analysis show that the existing pressurized surge tank at the WWTF EPS will provide satisfactory surge protection for the force main with or without entrained air in the wastewater.

Force Main Conveyance Capacity

To restore force main conveyance capacity and help to prevent surcharging and overflowing SHMH No. 2, it is recommended that the force main be pigged to remove deposited solids from the low elevation segments of the force main. The results of steady state analyses predict force main conveyance capacities of between 942 gpm (low wet well level, high friction loss equivalent to Manning's n = 0.013) and 1162 gpm (high wet well level, low friction loss equivalent to Manning's n = 0.01) with two of the existing pumps in operation following force main pigging.

If pigging the force main is not possible, surcharging and overflowing of SHMH No. 2 could be prevented by replacing this static head manhole with a pressurized manhole and installing a minimum 4-inch diameter controlled venting sewage vacuum relief valve (e.g., APCO S-1500CS, Crispin SVR/SL20, CLA-VAL Series 38WW/ARBW, Golden Anderson Figure Number 993) on the top of the pressurized manhole. A single body valve (e.g., Vent-O-Mat RGX or equivalent) should not be installed because there is insufficient seating pressure at this location to prevent leakage from the valve. The controlled venting sewage vacuum relief valve may be duplicated to provide redundancy in case the valve fails to open, opens too slowly, or is removed for service. If needed, the sewage vacuum relief valve enclosure could be equipped with a vent that has an activated carbon filter to prevent release of odors. The vent should have a cross-sectional area equal to or greater than the total cross-sectional area of the sewage vacuum relief valve orifice in the vault. To prevent freezing, the sewage vacuum relief valves should be heat traced and the enclosures insulated. Regular maintenance should be performed on the valves to ensure that they are always in good working order. To simplify maintenance, spare controlled venting sewage vacuum relief valves could be stored in the shop and then installed on the force main in place of a working sewage vacuum relief valve when it is returned to the shop for cleaning.

As an alternative to replacing the SHMH No. 2 with a pressurized manhole, the WWTF EPS operators could raise the top elevation (currently about El. 286 ft) of the existing static head manhole. However, given the uncertainty associated with the capacity of the existing (non-pigged) force main, this alternative is not recommended by NHC because it is difficult to estimate with any certainty the necessary top elevation to which the SHMH No. 2 should be raised to prevent surcharging and overflowing the static manhole structure. Should this alternative be selected, the new top elevation of the SHMH No. 2 is estimated to be at least El. 300 ft (i.e., a 14 ft raise of the overflow elevation). Further evaluation of the future capacity of the pump station (e.g., the pump upgrades discussed below) and the force main (e.g., pigged capacity) would be required prior to implementation of this alternative.

In addition to restoring the conveyance capacity of the existing force main, Wright-Pierce expressed interest in the maximum capacity of the force main should the pumps at the WWTF EPS be replaced with larger capacity units in the future (note that the capacity of the future units was not finalized when the transient analysis was performed). Based on the steady state analyses performed by NHC with larger capacity pumps installed at the WWTF EPS, the maximum capacity of the pigged force main would be between 1132 gpm (assuming Manning's n = 0.013) and 1472 gpm (assuming Manning's n = 0.01) with two larger capacity pumps operating at the pump station (estimated hydraulic power required per duty pump is 191 hp). For this range of force main operating capacity, the results of a preliminary pump power failure simulation show that the existing pressurized surge tank will provide satisfactory protection for the force main if the initial steady state air volume is decreased to 35 percent (from 45 percent).

Note that if pigging the force main is not possible, the steady state analyses performed by NHC with larger capacity pumps installed at the WWF EPS, shows that the maximum capacity of the existing force main would be between 775 gpm (assuming Manning's n = 0.019) and 866 gpm (assuming Manning's n = 0.017) with two larger capacity pumps operating at the pump station. The existing pressurized surge tank will provide satisfactory surge protection for the force main under this range of force main conveyance rates.

It is recommended that additional transient analyses be performed once larger capacity pumps are selected for the WWF EPS and that the results and recommendations for surge control be checked with the larger capacity pumps installed in the transient computer model.

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1 INTRODUCTION

Wright-Pierce is providing engineering services associated with an evaluation of the wastewater facilities at Joint Base Cape Cod (JBCC). The work is being performed on behalf of the Town of Falmouth and Wright-Pierce has retained NHC to perform a hydraulic transient analyses for the project.

Constructed in the 1990s, the JBCC Shared Wastewater Management System consists of a 10.5 mile long, 12-inch diameter ductile iron pipe force main that conveys effluent wastewater to infiltration basins. The force main includes two Static Head Manholes (one at the high point of the force main and another at the terminus of the force main). The Wastewater Treatment Facility (WWTF) Effluent Pump Station (EPS) includes three (3) horizontal split case centrifugal pumps (2 duty, 1 standby) and conveys wastewater through the force main. The reduced voltage soft starters with which the pumps were originally equipped are in the process of being replaced by VFDs. The WWTF EPS also includes a pressurized surge tank. With two pumps in operation, the WWTF EPS operators estimate that the current maximum effluent pumping capacity of the force main is approximately 700 to 800 gpm. They also note that on some occasions when two effluent pumps have been operating simultaneously, the static head manhole at the force main high point has surcharged and overflowed.

The results of the hydraulic transient analysis performed by NHC are described in this report along with operational recommendations. Pump power failure and pump start-up simulations were performed for the WWTF EPS and the results of the most pertinent simulations are included in this report. Existing and future conveyance capacities of the force main were analyzed. Additionally, movies of the most pertinent transient analysis simulations are included on a CDROM as Appendix A and can be viewed with Microsoft Windows Media Player© or other comparable software.

The report also includes a description of the hydraulic transient analysis modeling approach, which is the focus of the next section.

2 UNSTEADY FLOW AND TRANSIENT ANALYSIS

Unsteady flow in pipelines can be represented by a set of one-dimensional hyperbolic partial differential equations. In their simplified hydraulic grade line form, the continuity and momentum equations are[1]

$$\frac{a^2}{g}\frac{\partial v}{\partial x}+\frac{\partial H}{\partial t}+v\frac{\partial H}{\partial x}=0 \tag{1}$$

$$\frac{\partial v}{\partial t}+v\frac{\partial v}{\partial x}+g\frac{\partial H}{\partial x}+\frac{4}{\rho D}\tau=0 \tag{2}$$

in which t = time; x = distance along the pipe centerline; H = piezometric head (i.e., elevation plus pressure head); a = acoustic wave speed; v = average fluid velocity; g = acceleration due to gravity; D = inside diameter of the pipe; ρ = mass density of the fluid; and τ = shear stress at the pipe wall. Line pressure (lb/ft^2) can be calculated as the product of the specific gravity (1.0 for water) and specific weight of water (i.e., 62.4 lb/ft^3), and the pipeline pressure head (ft). The wall shear stress can be approximated as $\tau = \rho f|v|v/8$ where f = Darcy-Weisbach friction factor for steady pipe flow.

The Method of Characteristics (MOC) is considered the most numerically efficient solution of the above continuity and momentum equations when modeling transient pressures in pipe systems[1,2]. Solving these equations using MOC yields a system of ordinary differential equations. Following integration, these equations may be written in their simplified form and solved for the head and flow at pipe junctions and boundary conditions using the approach of Karney and McInnis, 1992[2].

As shown in Figure 1, NHC constructed a hydraulic transient analysis model of the system and associated facilities using the TransAM hydraulic transient analysis software. This MOC based computer model has been used to perform both steady state and hydraulic transient analysis of pipelines with diameters as large as 22 ft and flow rates up to 1,485 cfs. TransAM has been extensively verified by comparison of computed transient pressures and flow with those measured in the field (e.g., Axworthy and Chabot, 2004[3]) and laboratory (e.g., Axworthy, et al., 2000[4]), and predicted by codes developed by others.

TransAM is unique in that it has one hydraulic computational engine that can perform hydraulic transient simulations, extended period simulations, and steady state simulations. This means that, unlike other transient computer models, TransAM does not require an external steady state numerical engine. Our experience shows that TransAM computes more stable numerical solutions in both the unsteady and steady flow regimes because the same hydraulic engine is used to perform both sets of

[1] Wylie, E.B., and Streeter, V.L. (1993). *Fluid Transients in Systems.* Prentice-Hall, Englewood Cliffs, NJ.

[2] Karney, B.W., and McInnis, D. (1992). "Efficient calculation of transient flow in simple pipe networks." *Journal of Hydraulic Engineering,* ASCE, 118(7), 1014-1030.

[3] Axworthy, D.H. and Chabot, N. (2004). "Pressure transients in a Canadian sewage force main." *Canadian Journal of Civil Engineering,* NRC, Canada, 31, 1039-1050

[4] Axworthy, D.H., Ghidaoui, M.S., and McInnis, D.A. (2000). "Extended thermodynamics derivation of energy dissipation in unsteady pipe flow." *Journal of Hydraulic Engineering,* ASCE, 126(4), 276-287

calculations. This attribute of TransAM is particularly beneficial when modeling flow and pressure regulating stations, which are notorious for not converging to stable solutions when modeled using conventional steady state solvers in combination with dedicated transient models.

The TransAM code, which was originally developed in 1984 and is co-authored by NHC's lead for hydraulic transient analysis, Dr. Axworthy, is compiled with the most recent version of FORTRAN to fully leverage the computing power of multi-core processors and is one of the first transient analysis programs to fully exploit the parallel processing capabilities of multi-core processors. The resulting fast computer execution time makes the transient analysis software ideal for performing analyses of large and complex pipeline systems.

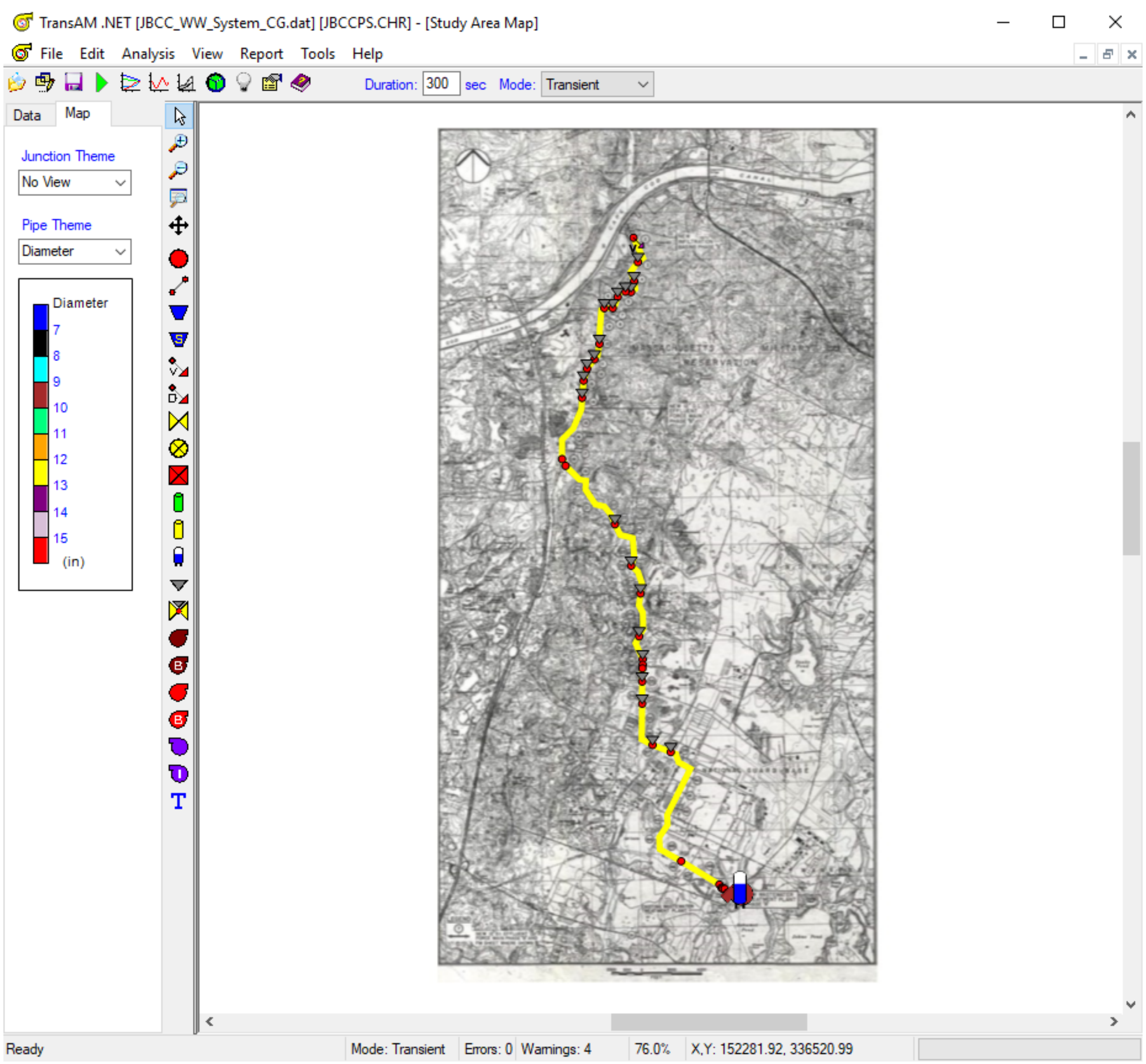


Figure 1: TransAM Transient Analysis Software showing JBCC Shared Wastewater Management System

3 SYSTEM FACILITIES AND CHARACTERISTICS

The facilities and characteristics associated with the JBCC Shared Wastewater Management System are presented in this section. Figure 2 shows a schematic of the force main alignment identifying the locations of the WWTF EPS and two static head manholes. The gravity sewer between SHMH No. 1 and the infiltration basins is not part of the transient analysis. The vertical profile of the force main is illustrated in the results of the hydraulic transient analyses that are shown in Section 4. Note that the force main elevations shown in Figure 2 are for the pipe crown.

The WWTF EPS conveys wastewater from a wet well to infiltration basins via an existing 10.5 mile long, 12-inch diameter ductile iron pipe (DIP) force main. The force main has double thickness cement mortar lining and a pressure class of 350 psi. The AWWA Standard specifies a surge allowance for DIP of 100 psi. The acoustic wavespeed for the DIP force main was calculated to be 4,043 ft/s.

The supplied alignment and elevation drawings show that there are several sewage air release valves on the force main to provide for release of air that comes out of solution during normal operation of the force main. The sewage air release valves do not provide for vacuum relief. Additionally, there are two Static Head Manholes on the force main. SHMH No. 1 is located at the terminus of the force main (i.e., STA 0+00) where the flow transitions to a gravity sewer. SHMH No. 2 is located at the force main high point (i.e., STA 247+47). The top elevation of SHMH No. 2 is about 286 ft.

The WWTF EPS includes three (3) Crane Deming Model 5062 horizontal split-case centrifugal pumps (2 duty, 1 standby). The operators of the WWTF EPS estimate that the force main currently conveys approximately 700 gpm to 800 gpm with two pumps operating at full speed. Table 1 lists the rated characteristics for the centrifugal pumps and the pump performance curve for full speed operation of a pump is shown in Figure 3. The total polar moment of inertia (WR^2) of the rotating parts of the pump motor combination was obtained from manufacturers' data for similarly sized pumps and motors. As part of an ongoing upgrade to the pump station undertaken by the operations staff, each pump will be equipped with a VFD in place of the existing reduced voltage soft starts (RVSS). A 6-inch diameter air cushioned swing check valve (Milliken Valve Company Series 9000) is installed on the discharge side of each pump to prevent reverse flow.

There is an existing 105 ft^3 pressurized surge tank installed at the WWTF EPS. The supplied drawings show that the pressurized surge tank is connected to the discharge header with a 6-inch diameter pipe and that the bottom elevation of the tank is approximately 77.5 ft. The pressurized surge tank has a pressure rating equal to 150 psi. The volume of air maintained in the pressurized surge tank under steady state operating conditions was not available from the operators.

For this analysis, we have relied on data (e.g., engineering drawings, pump performance curve, wet well levels, pipe material type, etc.) provided by Wright-Pierce. Should any component of this system be significantly modified relative to its current design as specified above, it would be necessary to update the hydraulic transient analyses with the modified design and check the results of the analysis and recommendations.

Table 1: Rated characteristics for pumps at WWTF EPS

Characteristic	*Crane Deming 5062*
No. of Pumps	2 duty, 1 standby
Rated Discharge/Pump (gpm)	700
Rated Head (ft)	260
Rated Speed (rpm)	1750
Rated Efficiency (%)	67
Motor Power (hp)	75
Inertia, WR^2 ($lb\text{-}ft^2$)	23.7
Check Valve Diameter (in)	6
Check Valve C_v (gpm/√ft)	500

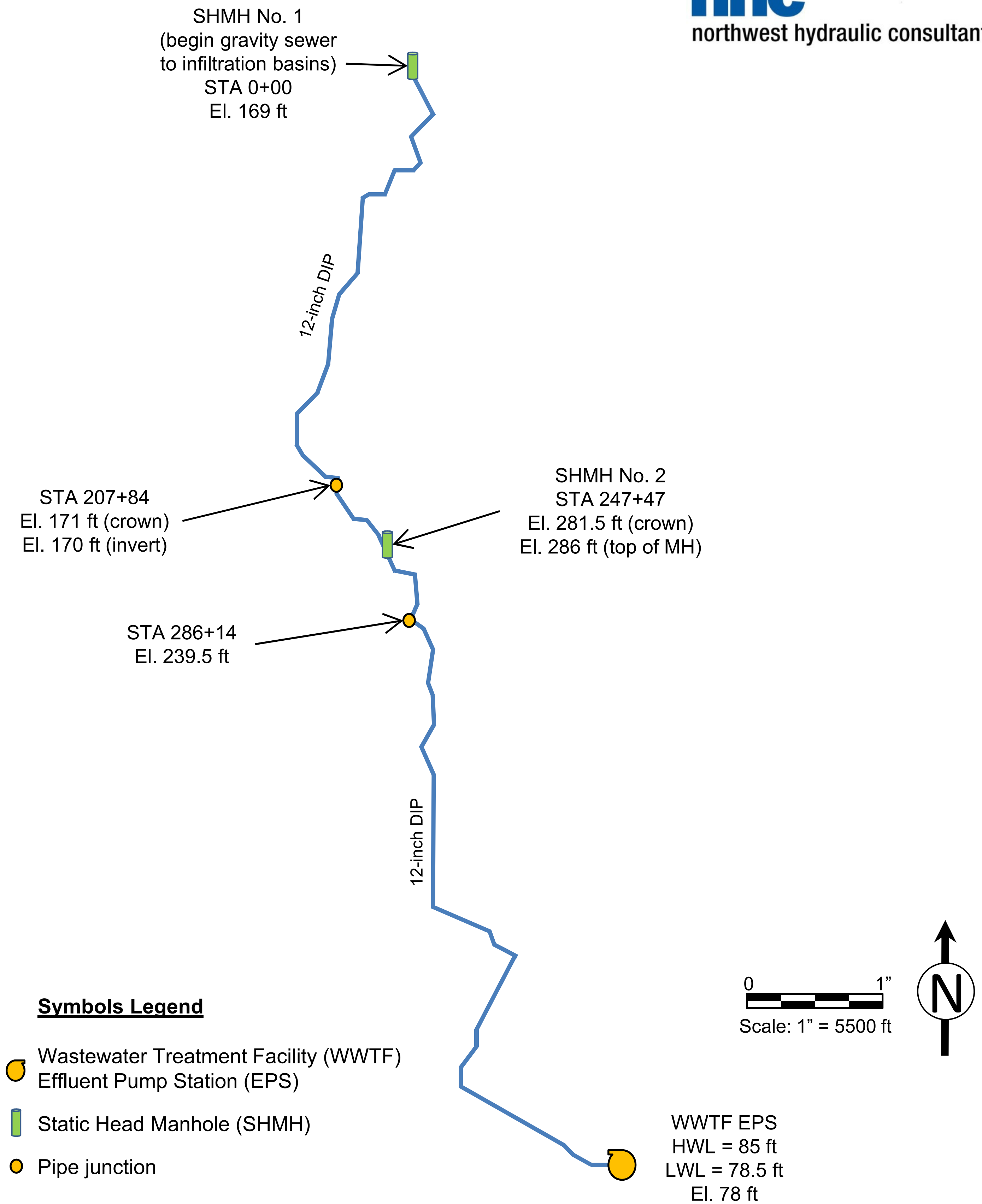


Figure 2: Schematic of the JBCC Shared Wastewater Management System

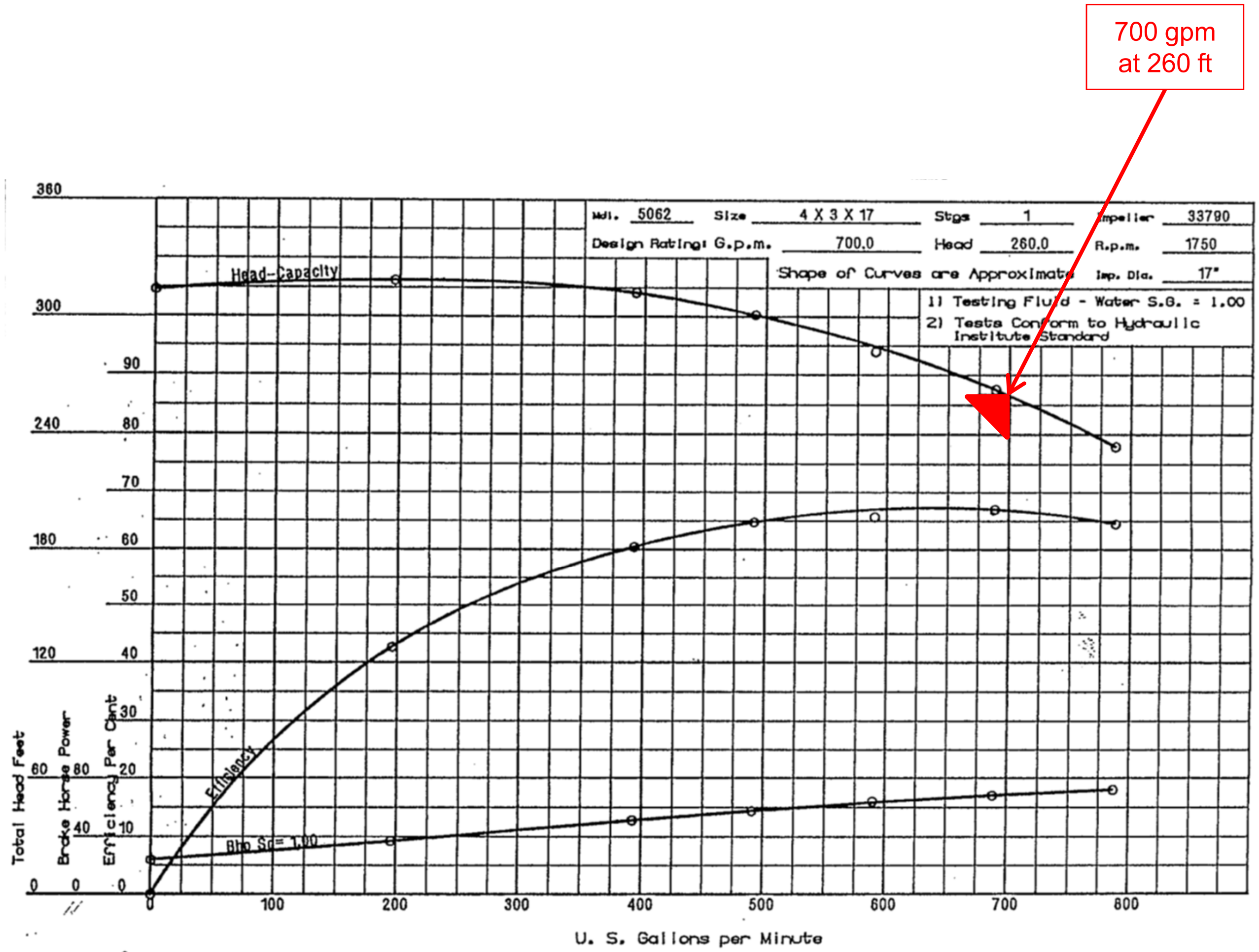


Figure 3: Head-discharge performance curve for the pumps at the WWTF EPS (Courtesy of Crane Deming Pump)

4 HYDRAULIC TRANSIENT ANALYSIS

This section presents the results of the hydraulic transient analyses for the JBCC Shared Wastewater Management System. Simulations were performed for pump power failure and pump start-up at WWTF EPS and are described in Sections 4.1 and 4.2. Operational recommendations, such as those for safely starting the pumps, are also provided. Section 4.3 describes analyses and recommendations for the existing and future conveyance capacity of the force main.

4.1 Pump Power Failure

Power failures are unpredictable and will therefore occur at the WWTF EPS without anticipation. Following a loss of power to the pumps in the WWTF, there will be a rapid drop in both the flow rate and discharge pressure at the pump station because the VFDs, once installed, will not function during a power failure and several seconds will elapse before backup power (if available) activates and restarts the pumps. The results of the pump power failure simulations show that a traveling low pressure (i.e., pressure drop) wave will be created by the drop in pressure at the pump station. The existing surge tank at the WWTF EPS significantly attenuates this pressure drop wave. This is because fluid will begin flowing from the pressurized surge tank into the force main to make up for the drop in flow at the pumps. The compressed air in the pressurized surge tank will expand as the water level in the tank drops. Because air is much more compressible than water, the corresponding drop in pressure in the pressurized surge tank will not be as large as at the pumps. Water will be delivered from the pressurized surge tank into the force main until the column of water comes to rest. The flow of water then reverses and flows back into the surge tank compressing the air and raising the pressure. The air is compressed until the reverse flow is halted. The air then expands as water is delivered back into the force main. The pressure and the flow continue to cycle in this manner until the oscillations are damped by pipe friction.

The results of the simulations for pump power failure that are presented in this section focus on the operation of the duty pumps (i.e., two pumps) at the WWTF EPS during times when there is a high water level in the wet well and high force main friction loss (e.g., old pipe condition) because these conditions are predicted to create some of the worst-case surge conditions in the system. For this condition, the maximum initial steady state operating flow rate at the WWTF EPS is predicted to be 966 gpm at a total dynamic head (TDH) of 301 ft. In the hydraulic transient analysis, a high Darcy-Weisbach friction factor is used to simulate high pipeline friction loss and is equivalent to a Manning's roughness value (n) of 0.013.[5]

With a high wet well level at the WWTF EPS and high force main friction loss, Figure 4 shows the results of the pump power failure analysis approximately 300 seconds after loss of power to the pumps when

[5] The hydraulic transient analysis was performed for both high (Manning's n = 0.013) and low (Manning's n = 0.01) force main friction losses to ensure that the force main is satisfactorily protected against adverse surge pressures for a range of possible system operating conditions.

the initial air volume in the pressurized surge tank is equal to 45 percent of the total tank volume[6]. This figure depicts: (a) the maximum/minimum hydraulic grade line (HGL) envelope predicted by the transient simulation, (b) the initial steady state HGL elevation, (c) the elevation profile for the force main, and (d) the rated HGL elevation (see Section 3) for the force main. Only the stations referenced in the report are noted on the figures.

Between the WWTF EPS and SHMH No. 2, the maximum HGL is predicted to be coincident with the steady state HGL and the minimum HGL elevation is predicted to remain above the crown elevation of the force main except at SHMH No. 2 where the force main is open to the atmosphere. At this location, the water level in the static head manhole is predicted to drop to the invert elevation of the force main. Also, the water level in SHMH No. 2 is predicted to not surcharge the manhole structure.

The maximum, minimum and steady state HGL are shown to be coincident between SHMH No. 1 and SHMH No. 2. In the real system, the force main will drain between SHMH No. 2 and STA 207+84 (approximate El. 170 ft, which is also the elevation of the force main terminus) following loss of power to the pumps.[7] As this segment of the force main drains, it will fill with air that is introduced through SHMH No. 2.

Figure 5 depicts the predicted pressure head records at the WWTF EPS (surge tank) and at STA 286+14 on the force main (see Figure 2). This figure shows that the amplitude of the pressure fluctuations is reduced with each successive pressure wave cycle.

With a steady state air volume equivalent to 45 percent of the total tank volume maintained in the pressurized surge tank prior to pump power failure, the pressure head at the pressurized surge tank is predicted to not exceed the rated pressure head of the pressurized surge tank (i.e., 346 ft or 150 psi). Although not illustrated in these figures, the results of the analysis show that a water seal, equivalent to at least 19 percent of the total surge tank volume is predicted to be maintained in the pressurized surge tank following pump power failure at the WWTF EPS.

The pressurized surge tank at the WWTF EPS causes the check valves at the pumps to close quickly following loss of power to the pumps. Because air is compressible, the air cushion cylinder currently installed on the swing check valves at the WWTF EPS may not prevent the slam closure of the swing check valves following pump power failure, which could damage the valve seats and create an audible slam. If the WWTF EPS operators are observing check valve slam or valve seat damage following pump power failure, it is recommended that the swing check valves be equipped with oil mounted bottom buffers.

[6] As noted in Section 3, the air volume of the surge tank was not available from the WWTF EPS operators. Based on the results of NHC's transient analysis, it is recommended that the surge tank maintain an air volume of 45% under steady state operating conditions.

[7] Note that transient analysis computer models do not simulate partly full flow in pipelines, which will be the condition in the real force main downstream of SHMH No. 2 following loss of power to the pumps at the EPS.

A movie of the simulation summarized in Figure 4 is provided on the CDROM enclosed as Appendix A. This movie (i.e., `Power-failure.avi`) shows the animation of the force main HGLs prior to and after loss of power to the pumps at the WWTF EPS with a high wet well level and high force main friction loss. The movie files can be viewed with Microsoft Windows Media Player© or comparable software.

A pump power failure simulation was also performed with a high wet well level at the WWTF EPS and low force main friction loss. For this operating condition, the predicted steady state flow rate at the WWTF EPS is 1162 gpm at a TDH of 286 ft. Figure 6 depicts the results of the pump power failure simulation with low force main friction loss and shows that the predicted maximum and minimum HGL elevations are predicted to be similar to those illustrated above in Figure 4. The predicted pressure head records at the WWTF EPS (surge tank) and at STA 286+14 on the force main are illustrated in Figure 7. In this case, the pressure head in the pressurized surge tank is predicted to exceed the steady state pressure head, but not the rated pressure head of the pressurized surge tank (i.e., 346 ft or 150 psi) when the pressurized surge tank initially contains an air volume equivalent to 45 percent of the total tank volume. A water seal, equivalent to at least 12 percent of the total surge tank volume is predicted to be maintained in the pressurized surge tank following pump power failure at the WWTF EPS.

Pump power failure analyses were also performed for an overflowing wet well and a low wet well level at the WWTF EPS. Analyses were also performed for the unlikely event that both the duty and standby pumps are operation prior to loss of power to the pumps. For brevity, the results of these analyses are not illustrated in this report but show that the existing pressurized surge tank will provide satisfactory surge protection for the system.

If the pumps at the WWTF EPS are ramped down (instead of tripped as analyzed previously), the existing pressurized surge tank with an initial air volume of 45% of the total tank volume will also provide satisfactory surge protection for the force main. Any pump ramp down time will be satisfactory.

Air Entrainment

In the above analyses, it was assumed that the wastewater was free of air entrainment. This condition was represented in the simulations by setting the acoustic wave speed of the force main to be 4,043 ft/s. However, in wastewater systems, air is frequently entrained in the fluid when the wastewater cascades into the wet well (e.g., when the wet well is at a low level). The propagation velocity of a pressure wave in the pipeline can be significantly reduced by the presence of even small quantities of air in the wastewater.[8] This is because at normal temperatures, air is more compressible than a liquid. In fact, research shows that as little as one (1) percent by volume air entrainment of a fluid can reduce the acoustic wave speed of a pressure wave by up to 75 percent of its non-air entrained value (see Page 10 of Wylie and Streeter, 1993[9] and page 279 of Chaudhry, 1979[10]). For this system, the presence of air in

[8] Elliot, R.C. and Axworthy, D.H. (2009). "Special considerations in pressure surge analysis and control for wastewater systems.'' 33rd IAHR Congress Water Engineering for a sustainable environment, Vancouver, British Columbia, Canada, August 9 to 14, 6512-6519.

[9] Wylie, E.B. and Streeter, V.L. (1993). Fluid Transients in Systems. Prentice Hall, Englewood Cliffs, NJ.

[10] Chaudhry, M.H. (1979). Applied Hydraulic Transients. Van Nostrand Reinhold, New York, NY.

the wastewater could reduce the acoustic wave speed of the DIP to as little as 1011 ft/s. For completeness, the above transient analysis was repeated with reduced wave speeds to study the sensitivity of the force main's response to air entrainment.

Figure 8 illustrates the results of the WWTP EPS pump power failure analysis with a high wet well level, low force main friction loss, an initial surge tank air volume equivalent to 45 percent of the total tank volume, and entrained air in the wastewater (acoustic wave speed is equivalent to 25% of its non-air entrained value for this simulation). Between the WWTF EPS and SHMH No. 2, this figure shows that the minimum HGL is predicted to remain above the crown elevation of the force main and the maximum HGL elevation is predicted to not exceed the rated HGL elevation. Downstream of SHMH No. 2, the maximum, minimum and steady state HGLs are predicted to be coincident, but as noted previously, the force main between SHMH No. 2 and STA 207+84 will drain following loss of power to the pumps. Figure 9 depicts the predicted pressure head histories at the the WWTF EPS (surge tank) and at STA 286+14 on the force main.

The pressure head in the pressurized surge tank is predicted to not exceed the rated pressure head of the pressurized surge tank (i.e., 346 ft or 150 psi) and a water seal, equivalent to at least 24 percent of the total surge tank volume is predicted to be maintained in the pressurized surge tank following pump power failure at the WWTF EPS with entrained air in the wastewater.

A movie of the simulation summarized in Figure 8 is provided on the CDROM enclosed as Appendix A. The movie (i.e., `Power-failure-ae.avi`) shows the animation of the force main HGL prior to and after loss of power to the pumps at the WWTF EPS with entrained air in the wastewater.

For brevity, the results of the transient analysis with a high force main friction loss and entrained air in the wastewater are not illustrated in this report. However, the results show that with an initial air volume equivalent to 45 percent of the total tank volume, the existing pressurized surge tank will also provide satisfactory surge protection for the system under these conditions.

4.2 Pump Start-Up

When a pump at the WWTF EPS is started, the pressure will increase rapidly and eventually exceed the static pressure in the force main between the pump station and SHMH No. 2. The swing check valve will open, and the pump will deliver water into the force main, which will be initially filled with fluid at rest. The opening of the check valve will create a traveling pressure upsurge wave that will propagate out from the pump station and be partly attenuated by the surge tank before entering the force main. Control of pressure surges that are created upon pump start-up is simply a matter of controlling the rate of fluid acceleration at the pump. Usually this is accomplished by adjusting the pump ramp up speed on the variable frequency drive.

It is recommended that the pumps at the WWTF EPS be ramped from idle (i.e., zero rpm) up to full speed (i.e., 1750 rpm) in 30 seconds or longer. The pumps should be started one at a time with at least a 30 second lag between each pump start.

Figure 10 depicts the predicted maximum and minimum HGL elevations for the force main after start-up of both the duty and standby pumps at the WWTF EPS. The results shown here are for a high wet well level and low force main friction loss. This figure shows that the maximum HGL elevation is predicted to not exceed the rated HGL and the minimum HGL is predicted to remain above the crown elevation of the force main between the WWTF EPS and SHMH No. 2. In the real system, the force main between SHMH No. 2 and STA 207+84 will initially be drained and then will slowly fill with wastewater following start up of the pumps at the WWTF EPS. Most of the air displaced by the wastewater in this segment of the force main will rise to SHMH No. 2 where it will be vented from the force main. Upwelling is likely to occur in the SHMH No. 2 as the air escapes from the force main, but the water level should not exceed the top elevation of SHMH No. 2 as long as the flow capacity of the force main is not diminished by solids deposition (see Section 4.3).

Figure 11 depicts the predicted pressure head histories at the WWTF EPS (surge tank) and at STA 286+14 on the force main. The pressure head in the pressurized surge tank is predicted to not exceed the rated pressure head of the pressurized surge tank (i.e., 346 ft or 150 psi) if the pumps are started as recommended above with an initial air volume in the surge tank equivalent to 45 percent of the total surge tank volume.

A movie of the simulation summarized in Figure 10 is provided on the CDROM enclosed as Appendix A. The movie (i.e., `Startup.avi`) shows the animation of the force main HGLs prior to and after start-up of the pumps at the WWTF EPS.

Between SHMH No. 2 and STA 207+84, the force main will be drained (i.e., contain air) prior to re-starting the pumps after a power failure or complete shutdown of the pump station. As recommended above, a pump should be ramped up to speed slowly so that the force main downstream of SHMH No. 2 gradually fills with water and slowly expels air through the SHMH No. 2.

Simulation results indicate that the above pump start-up recommendations are also applicable for low wet well levels, high force main friction loss, and when the wastewater is air entrained.

4.3 Force Main Conveyance Capacity

As noted in Section 3, the operators of the WWTF EPS estimate that the force main currently conveys approximately 700 gpm to 800 gpm with two pumps operating at full speed. This flow range is lower than the steady state conveyance rates predicted in Section 4.1 for the high force main friction loss condition (i.e., force main wall friction loss based on a Manning's n = 0.013). Additional steady state simulations performed by NHC predict conveyance rates between 700 gpm and 800 gpm when the force main Manning's n is between 0.017 and 0.019. This means that the head loss in the existing force main is significantly higher than the typical range of friction loss for a wastewater force main.

The undulating profile of this force main means that, even though this is an effluent force main, deposition of solids probably occurs when the force main is idle. Peak velocities during normal operation of the force main are low (e.g., approximately 2 ft/s or less) making it unlikely that the deposited solids would be re-suspended in the flow and conveyed to the infiltration basins. It is therefore likely that deposition of solids in the low segments of the force main have reduced the effective diameter of the force main in these locations, increased force main head loss, and reduced force main conveyance capacity.

The operators of the WWTF EPS have observed surcharging and overflowing wastewater from SHMH No. 2 when two pumps at the pump station are operating at full speed, which is likely due to the reduced conveyance capacity of the force main. To restore force main conveyance capacity and to help prevent spillage from SHMH No. 2, it is recommended that the force main be pigged to remove deposited solids from the low elevation segments of the force main. If pigging the force main removes sufficient solids to reduce the force main friction loss to levels equivalent to a Manning's n of between 0.01 and 0.013, the results of the steady state analyses performed in Section 4.1 predict force main conveyance capacities of between 942 gpm (low wet well level, high friction loss) and 1162 gpm (high wet well level, low friction loss) with two of the existing pumps in operation.

If pigging the force main is not possible, surcharging and overflowing of SHMH No. 2 could be prevented by replacing this static head manhole with a pressurized manhole and installing a minimum 4-inch diameter controlled venting sewage vacuum relief valve (e.g., APCO S-1500CS, Crispin SVR/SL20, CLA-VAL Series 38WW/ARBW, Golden Anderson Figure Number 993) on the top of the pressurized manhole. Several examples of controlled venting sewage vacuum relief valves are shown in Figure 12. A single body valve (e.g., Vent-O-Mat RGX or equivalent) should not be installed at this location because there is insufficient seating pressure at this location to prevent leakage from the valve. The controlled venting sewage vacuum relief valve may be duplicated to provide redundancy in case the valve fails to open, opens too slowly, or is removed for service. If needed, the sewage vacuum relief valve enclosure could be equipped with a vent that has an activated carbon filter to prevent release of odors. To prevent freezing, the sewage vacuum relief valves should be heat traced and the enclosures insulated. Additionally, the vent should have a cross-sectional area equal to or greater than the total cross-sectional area of the sewage vacuum relief valve orifice in the vault. Regular maintenance should be performed on the valves to ensure that they are always in good working order. To simplify maintenance, spare controlled venting sewage vacuum relief valves could be stored in the shop and then installed on the force main in place of a working sewage vacuum relief valve when it is returned to the shop for cleaning. As an alternative to replacing the SHMH No. 2 with a pressurized manhole, the WWTF EPS operators could raise the top elevation (currently about El. 286 ft) of the existing static head manhole. However, given the uncertainty associated with the capacity of the existing (non-pigged) force main, this alternative is not recommended by NHC because it is difficult to estimate with any certainty the necessary top elevation to which the SHMH No. 2 should be raised to prevent surcharging and overflowing the static manhole structure. Should this alternative be selected, the new top elevation of the SHMH No. 2 is estimated to be at least El. 300 ft (i.e., a 14 ft raise of the overflow elevation). Further evaluation of the future capacity of the pump station (e.g., the pump upgrades discussed below) and the force main (e.g., pigged capacity) would be required prior to implementation of this alternative.

In addition to restoring the conveyance capacity of the existing force main, Wright-Pierce expressed interest in the maximum capacity of the force main should the pumps at the WWTF EPS be replaced with larger capacity units in the future (note that the capacity of the future units was not finalized when the transient analysis was performed). Based on the steady state analyses performed by NHC with larger capacity pumps installed at the WWTF EPS, the maximum capacity of the pigged force main would be between 1132 gpm (assuming Manning's n = 0.013) and 1472 gpm (assuming Manning's n = 0.01) with two larger capacity pumps operating at the pump station (estimated hydraulic power required per duty pump is 191 hp). For this range of force main operating capacity, the results of a preliminary pump power failure simulation show that the existing pressurized surge tank will provide satisfactory protection for the force main if the initial steady state air volume is decreased to 35 percent (from 45 percent).

Note that if pigging the force main is not possible, the steady state analyses performed by NHC with larger capacity pumps installed at the WWF EPS, shows that the maximum capacity of the existing force main would be between 775 gpm (assuming Manning's n = 0.019) and 866 gpm (assuming Manning's n = 0.017) with two larger capacity pumps operating at the pump station. The existing pressurized surge tank will provide satisfactory surge protection for the force main under this range of force main conveyance rates.

It is recommended that additional transient analyses be performed once larger capacity pumps are selected for the WWF EPS and that the results and recommendations for surge control be checked with the larger capacity pumps installed in the transient computer model.

nhc northwest hydraulic consultants

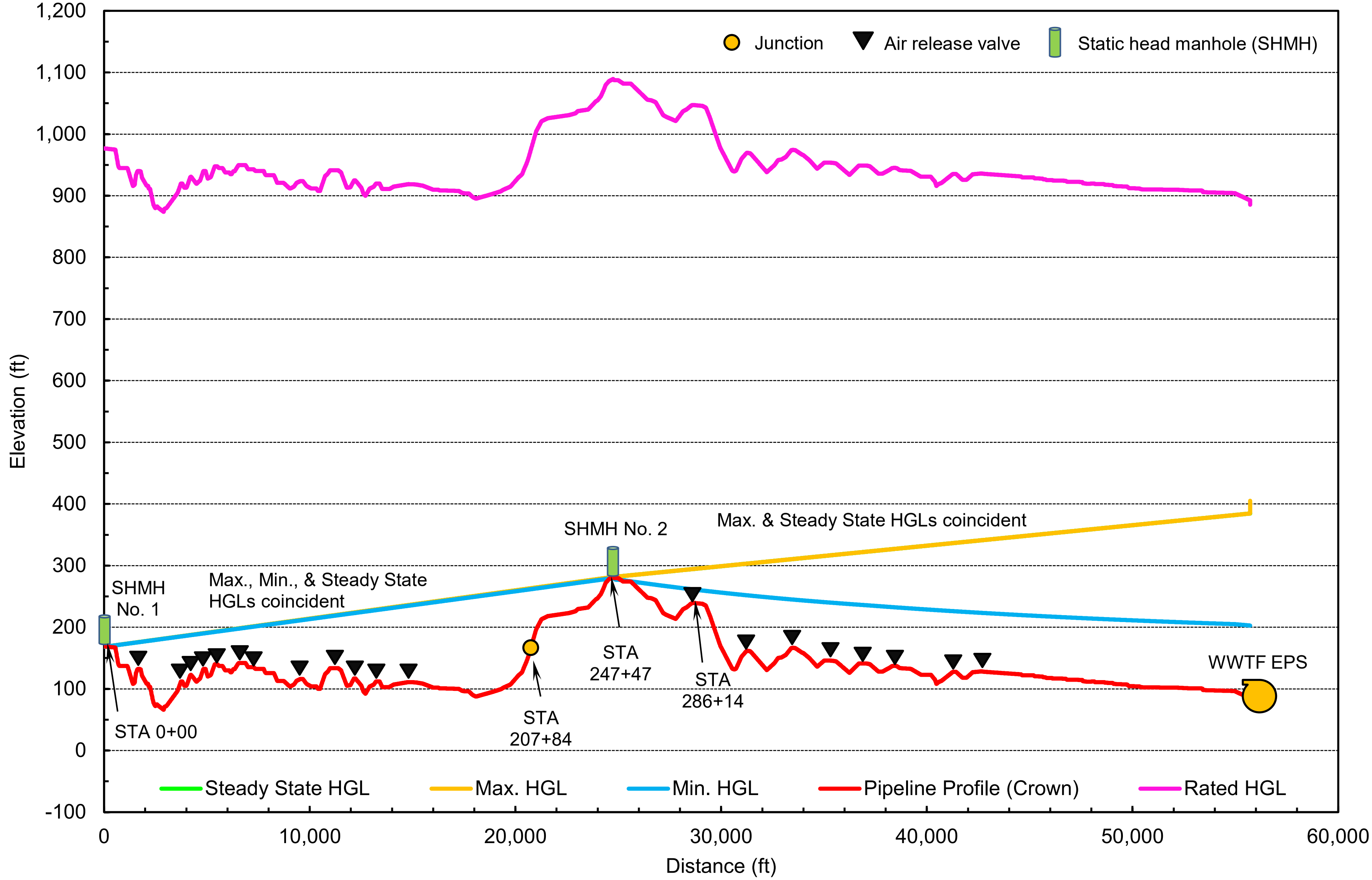


Figure 4: HGL elevations in JBCC force main about 300 seconds following loss of power to pumps at the Wastewater Treatment Facility EPS with high wet well and high force main friction loss

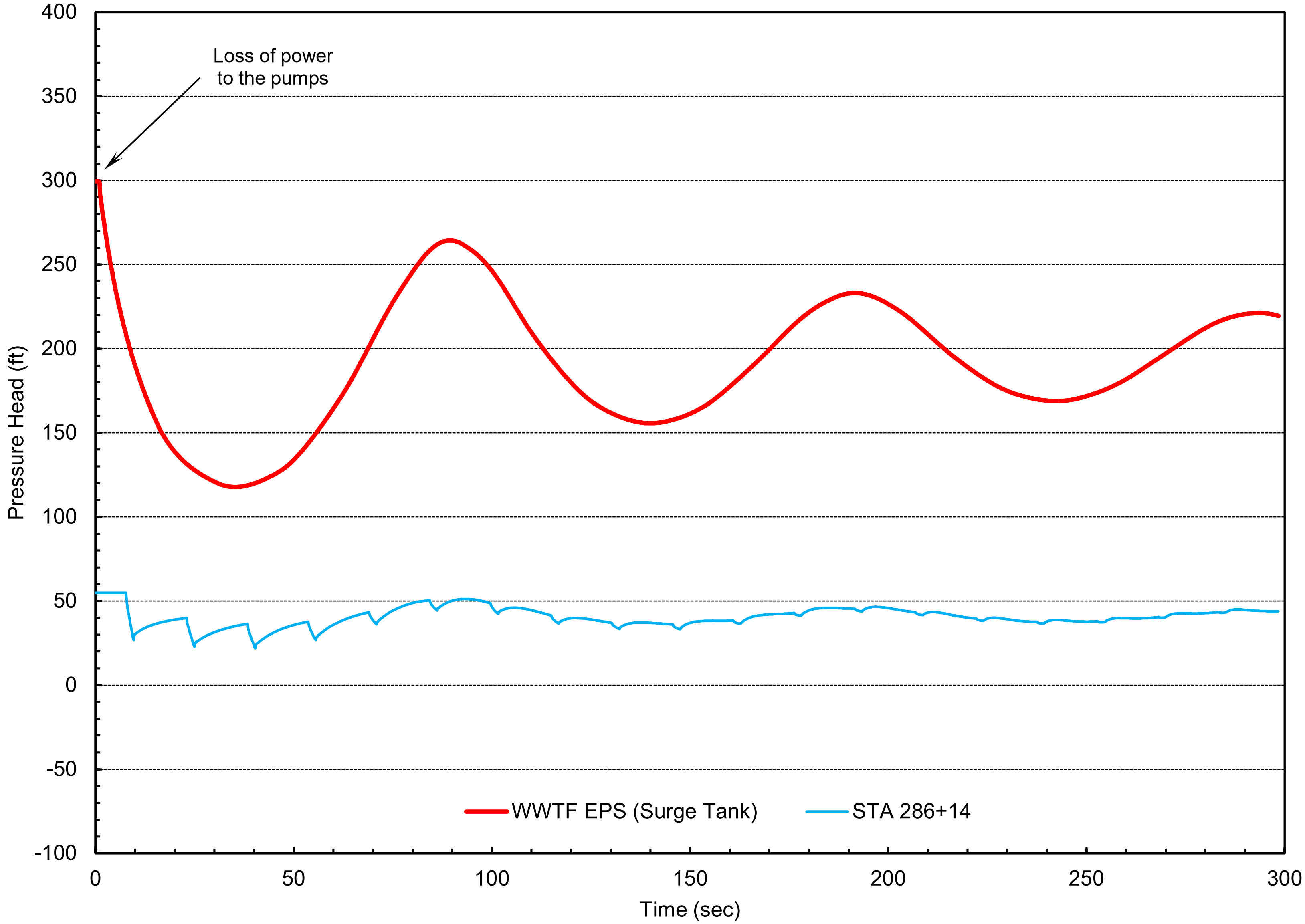


Figure 5: Pressure head records following loss of power to pumps at the Wastewater Treatment Facility EPS with high wet well and high force main friction loss

northwest hydraulic consultants

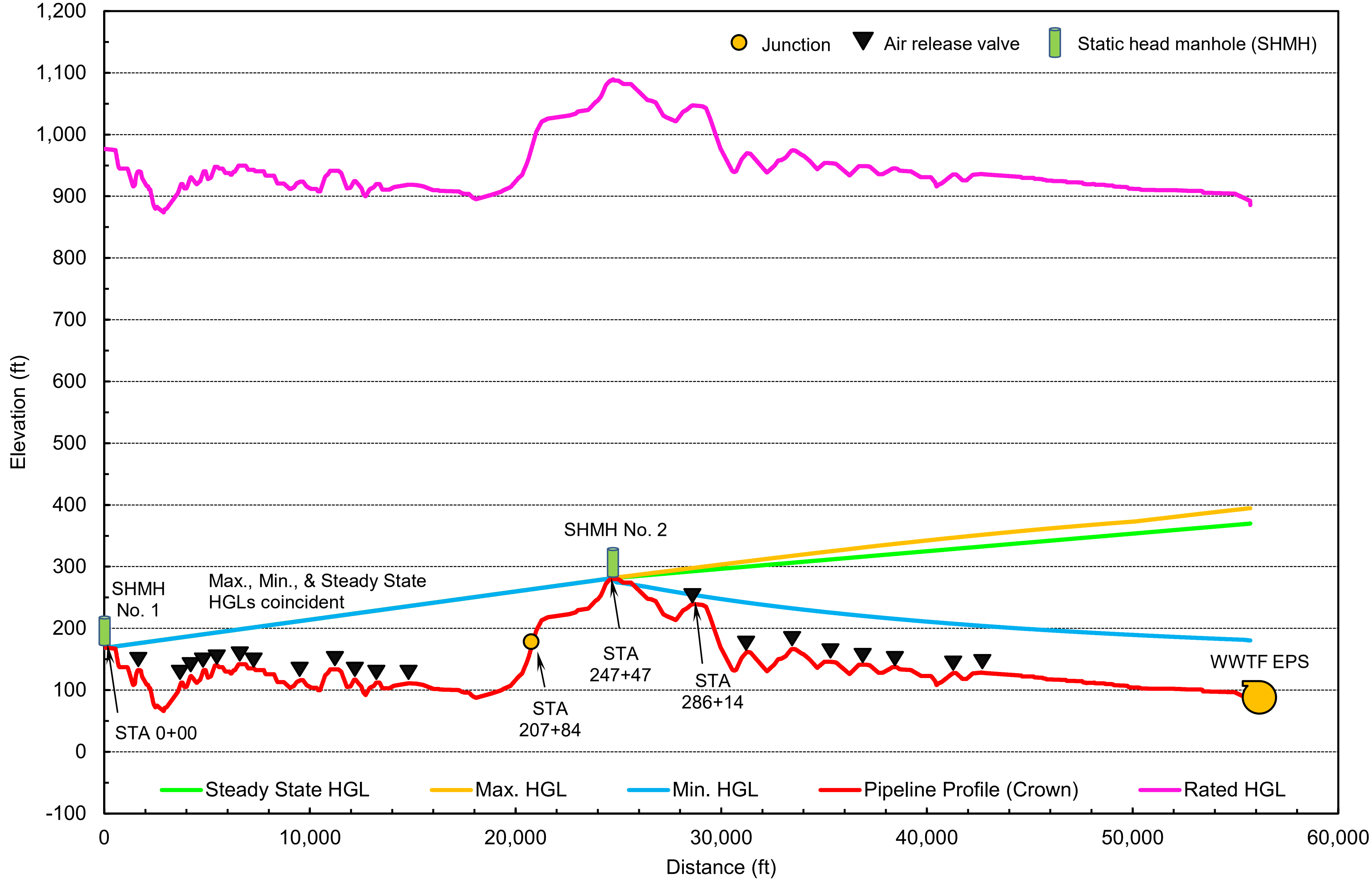


Figure 6: HGL elevations in JBCC force main about 300 seconds following loss of power to pumps at the Wastewater Treatment Facility EPS with high wet well and low force main friction loss

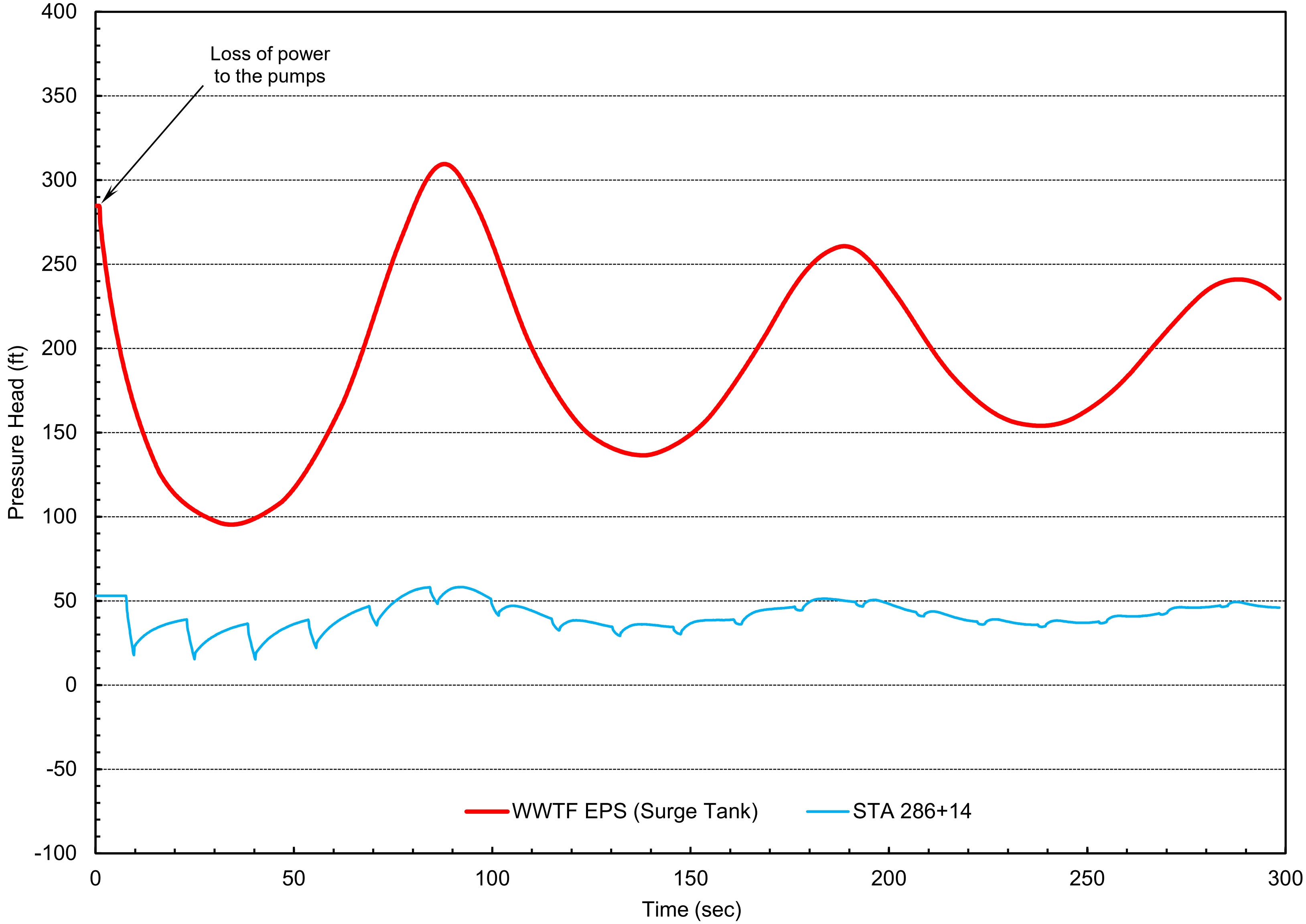


Figure 7: Pressure head records following loss of power to pumps at the Wastewater Treatment Facility EPS with high wet well and low force main friction loss

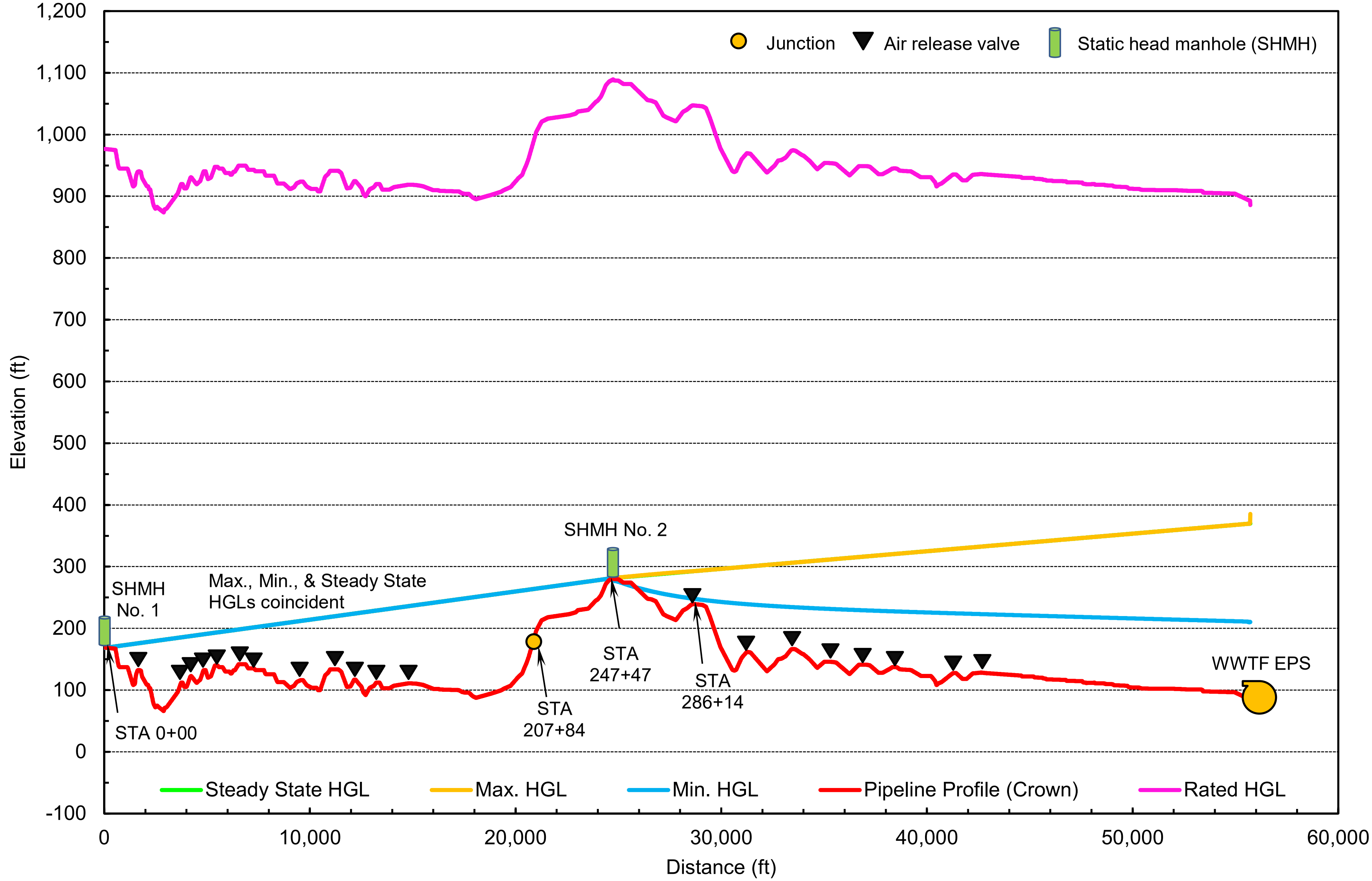


Figure 8: HGL elevations in JBCC force main about 300 seconds following loss of power to pumps at the Wastewater Treatment Facility EPS with high wet well level, low force main friction loss, and entrained air

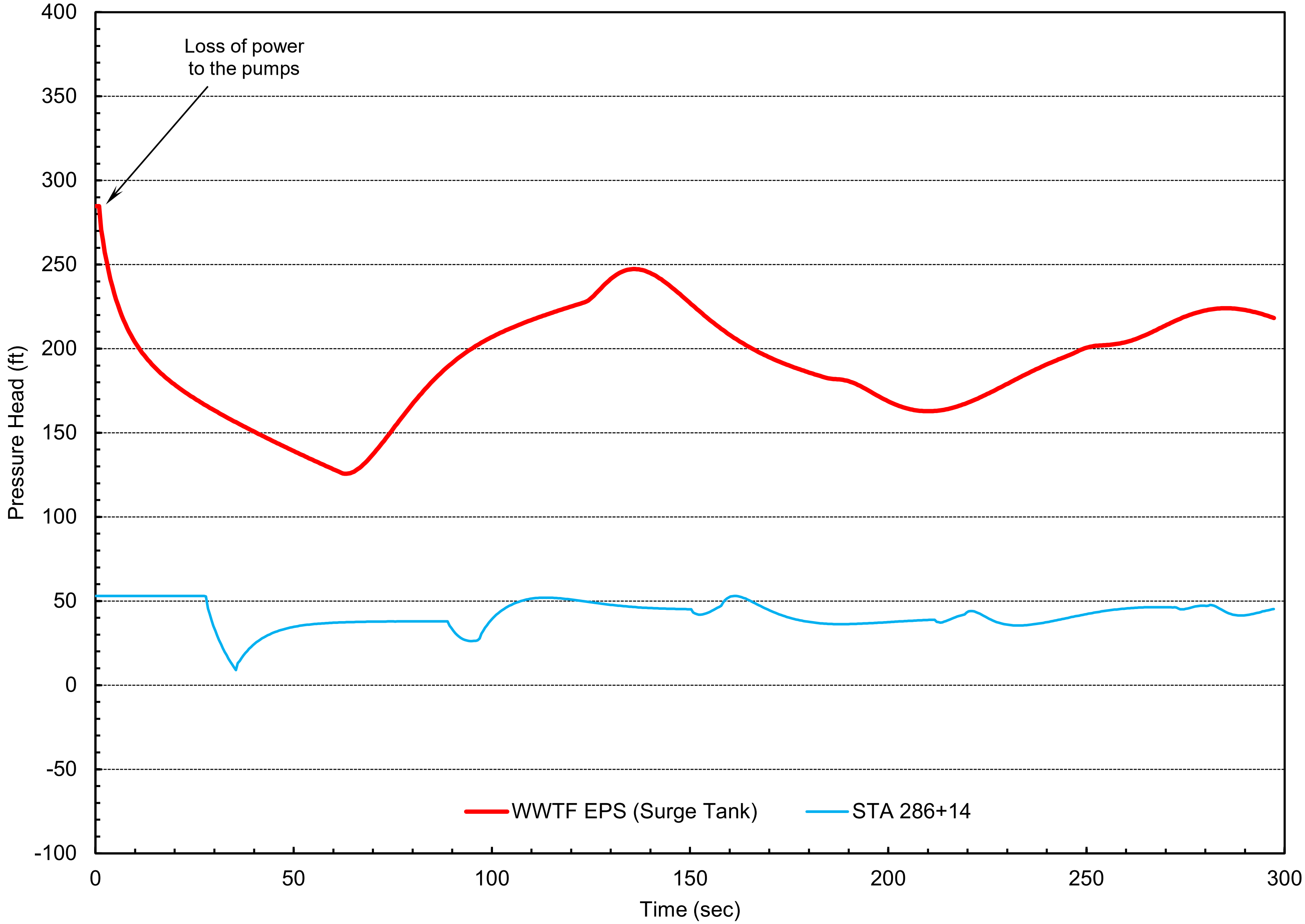


Figure 9: Pressure head records following loss of power to pumps at the Wastewater Treatment Facility EPS with high wet well level, low force main friction loss, and entrained air

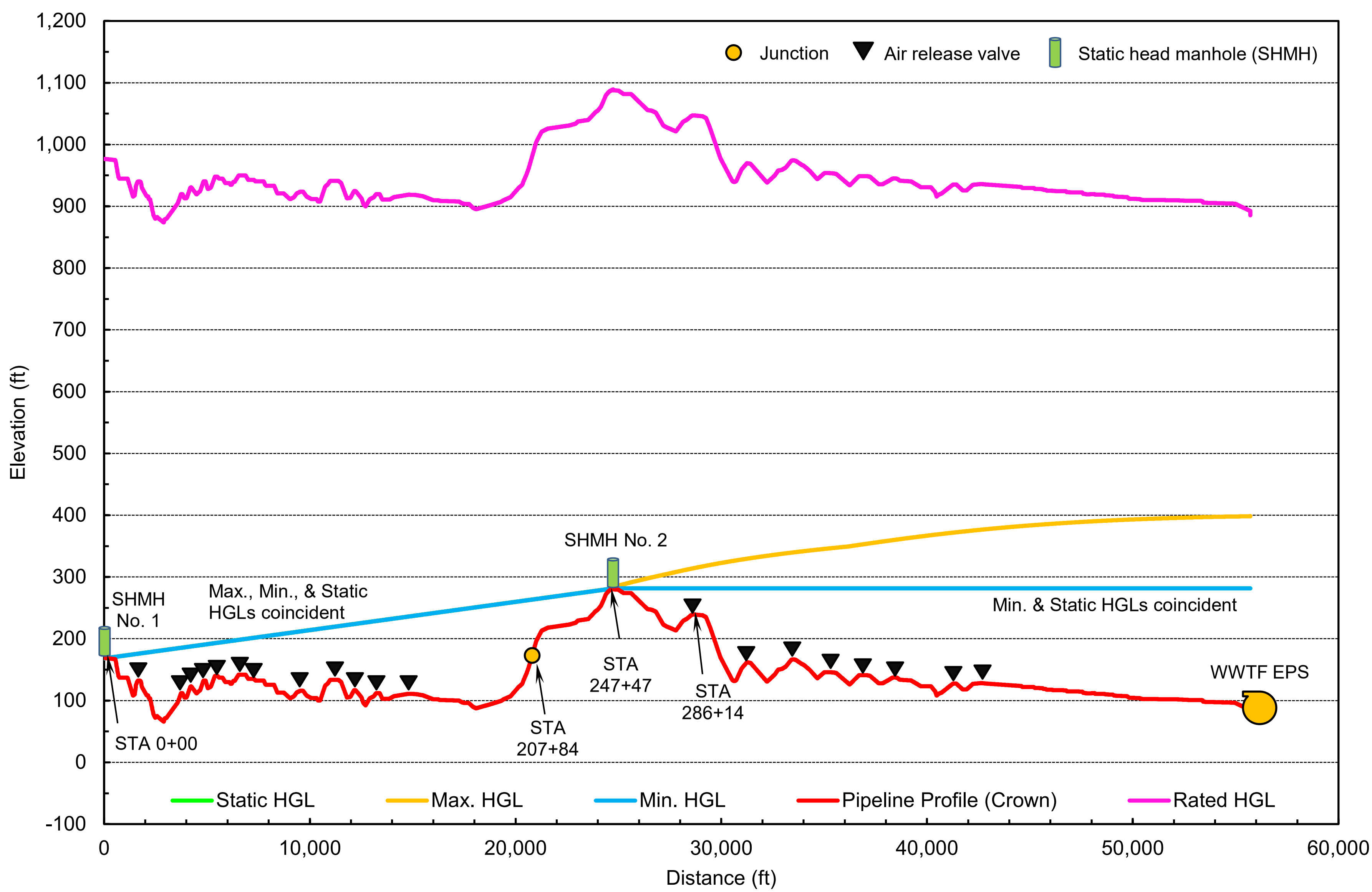


Figure 10: HGL elevations in JBCC force main after start-up of pumps at the Wastewater Treatment Facility EPS with high wet well and low force main friction loss

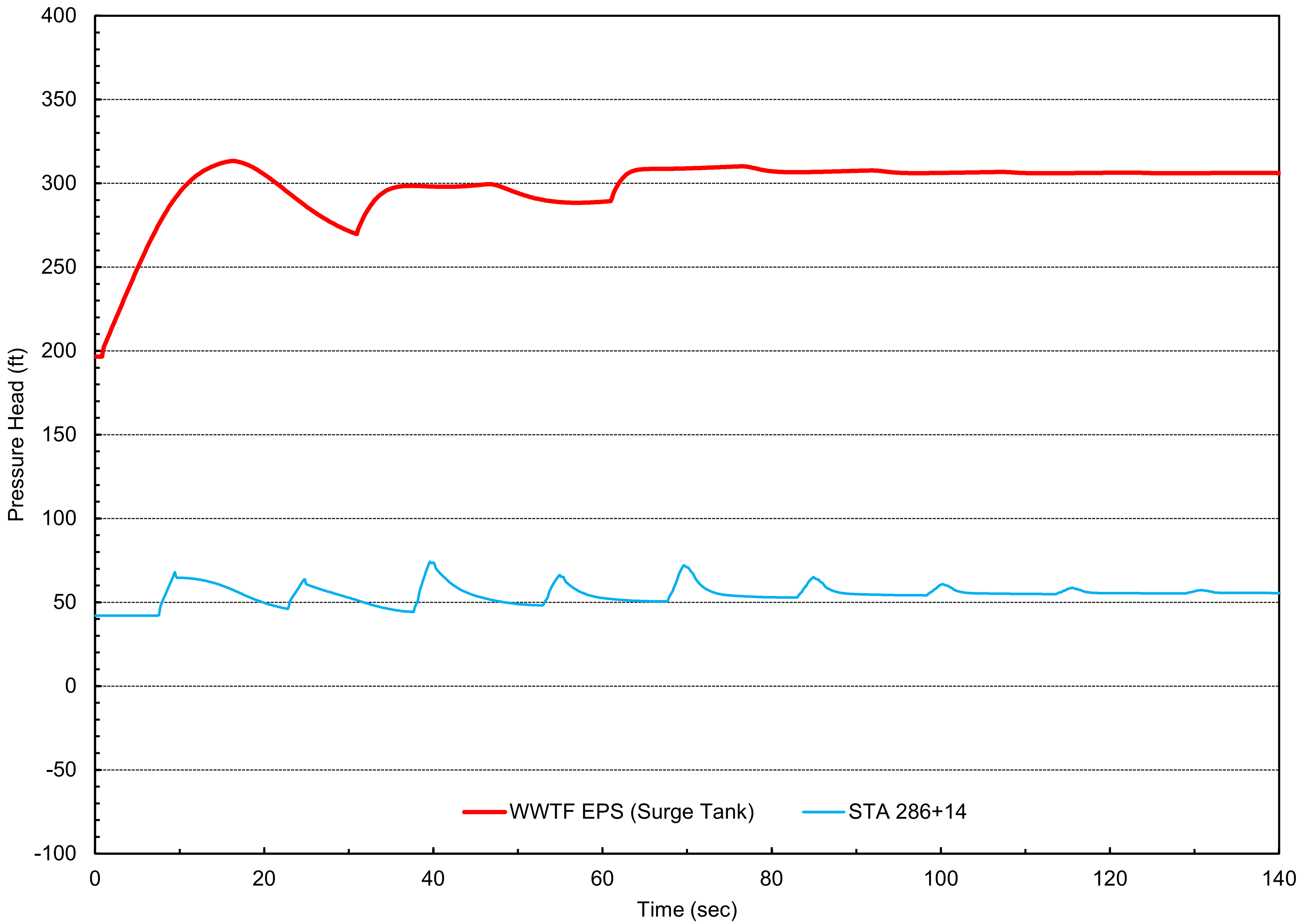
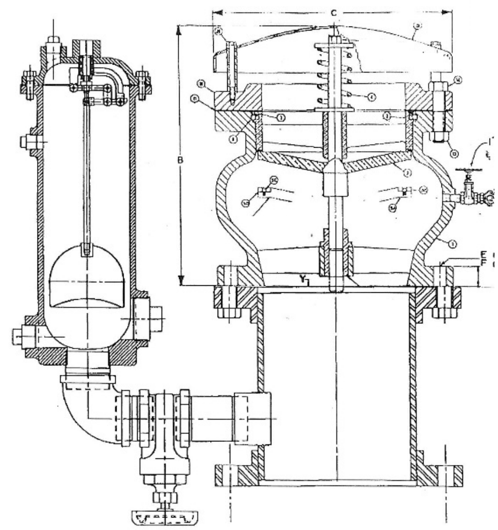
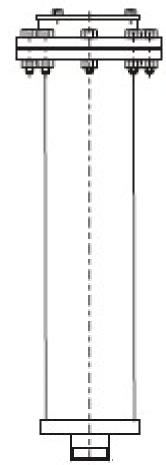


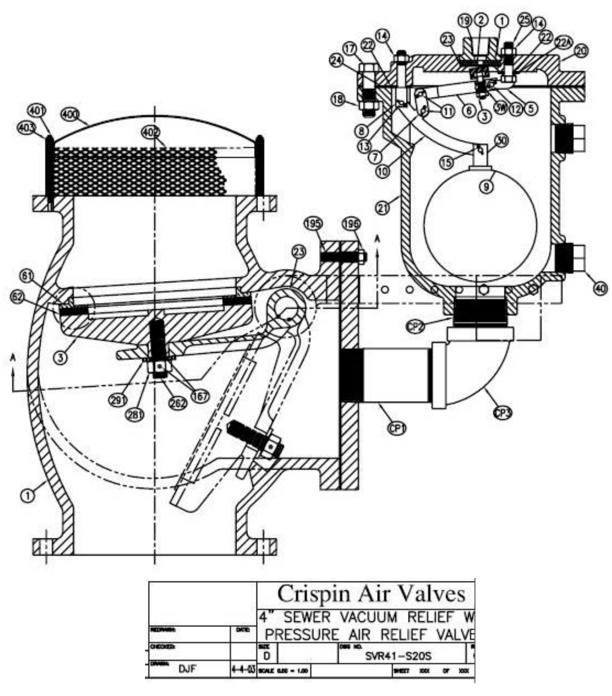
Figure 11: Pressure head records after start-up of pumps at the Wastewater Treatment Facility EPS with high wet well and low force main friction loss



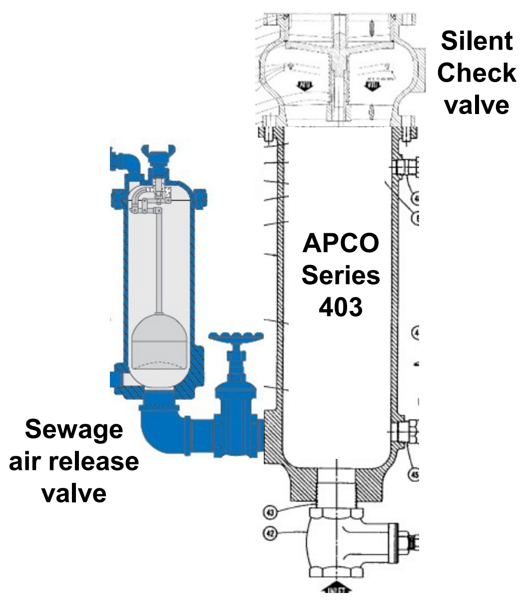
a) APCO S-1500CS (Courtesy of DeZurik)



b) Vent-O-Mat RGX
(Courtesy of Vent-O-Mat)



c) Crispin SVR/SL20 (Courtesy of Crispin)



d) APCO Series 403 with silent check valve and sewage air release valve
(Courtesy of APCO)

Figure 12: Controlled Venting Sewage Vacuum Relief Valves

5 CONCLUSIONS AND RECOMMENDATIONS

A hydraulic transient analysis has been completed for the Joint Base Cape Cod Shared Wastewater Management System. The system includes an approximately 10.5 mile long, 12-inch diameter ductile iron force main and an effluent pump station with two duty pumps that currently convey up to about 800 gpm (according to operations staff) of wastewater from the WWTF to infiltration basins. A pressurized surge tank is installed at the WWTF EPS and there are static head manholes located at the force main high point and terminus. Northwest Hydraulic Consultants constructed a hydraulic transient computer model of the system and performed pump power failure and pump start-up simulations for the WWTF EPS.

Pump Power Failure, Shutdown and Start-up

The results of the hydraulic transient analyses show that the existing pressurized surge tank at the WWTF EPS is predicted to provide satisfactory surge protection for the force main following loss of power to or shutdown of the existing pumps at the WWTF EPS, and that additional surge control is not necessary. However, it is recommended that the WWTF EPS operators implement the following operational recommendations:

- The pressurized surge tank at the WWTF EPS should maintain an air volume of 45 percent of the total tank volume under steady state operating conditions at the pump station.
- If the WWTF EPS operators are observing check valve slam or valve seat damage following pump power failure at the pump station, it is recommended that the swing check valves at the WWTF EPS be equipped with oil mounted bottom buffers. The air cushion cylinder currently installed on each swing check valve at the WWTF EPS may not prevent the slam closure of the swing check valves following pump power failure.
- The pumps at the WWTF EPS should be ramped from idle (i.e., zero rpm) up to full speed (i.e., 1750 rpm) in 30 seconds or longer and should be started one at a time with at least a 30 second lag between each pump start.

The results of a sensitivity analysis show that the existing pressurized surge tank at the WWTF EPS will provide satisfactory surge protection for the force main with or without entrained air in the wastewater.

Force Main Conveyance Capacity

To restore force main conveyance capacity and help to prevent surcharging and overflowing SHMH No. 2, it is recommended that the force main be pigged to remove deposited solids from the low elevation segments of the force main. The results of steady state analyses predict force main conveyance capacities of between 942 gpm (low wet well level, high friction loss equivalent to Manning's n = 0.013) and 1162 gpm (high wet well level, low friction loss equivalent to Manning's n = 0.01) with two of the existing pumps in operation following force main pigging.

If pigging the force main is not possible, surcharging and overflowing of SHMH No. 2 could be prevented by replacing this static head manhole with a pressurized manhole and installing a minimum 4-inch diameter controlled venting sewage vacuum relief valve (e.g., APCO S-1500CS, Crispin SVR/SL20, CLA-VAL Series 38WW/ARBW, Golden Anderson Figure Number 993) on the top of the pressurized manhole. A single body valve (e.g., Vent-O-Mat RGX or equivalent) should not be installed because there is insufficient seating pressure at this location to prevent leakage from the valve. The controlled venting sewage vacuum relief valve may be duplicated to provide redundancy in case the valve fails to open, opens too slowly, or is removed for service. If needed, the sewage vacuum relief valve enclosure could be equipped with a vent that has an activated carbon filter to prevent release of odors. The vent should have a cross-sectional area equal to or greater than the total cross-sectional area of the sewage vacuum relief valve orifice in the vault. To prevent freezing, the sewage vacuum relief valves should be heat traced and the enclosures insulated. Regular maintenance should be performed on the valves to ensure that they are always in good working order. To simplify maintenance, spare controlled venting sewage vacuum relief valves could be stored in the shop and then installed on the force main in place of a working sewage vacuum relief valve when it is returned to the shop for cleaning.

As an alternative to replacing the SHMH No. 2 with a pressurized manhole, the WWTF EPS operators could raise the top elevation (currently about El. 286 ft) of the existing static head manhole. However, given the uncertainty associated with the capacity of the existing (non-pigged) force main, this alternative is not recommended by NHC because it is difficult to estimate with any certainty the necessary top elevation to which the SHMH No. 2 should be raised to prevent surcharging and overflowing the static manhole structure. Should this alternative be selected, the new top elevation of the SHMH No. 2 is estimated to be at least El. 300 ft (i.e., a 14 ft raise of the overflow elevation). Further evaluation of the future capacity of the pump station (e.g., the pump upgrades discussed below) and the force main (e.g., pigged capacity) would be required prior to implementation of this alternative.

In addition to restoring the conveyance capacity of the existing force main, Wright-Pierce expressed interest in the maximum capacity of the force main should the pumps at the WWTF EPS be replaced with larger capacity units in the future (note that the capacity of the future units was not finalized when the transient analysis was performed). Based on the steady state analyses performed by NHC with larger capacity pumps installed at the WWTF EPS, the maximum capacity of the pigged force main would be between 1132 gpm (assuming Manning's n = 0.013) and 1472 gpm (assuming Manning's n = 0.01) with two larger capacity pumps operating at the pump station (estimated hydraulic power required per duty pump is 191 hp). For this range of force main operating capacity, the results of an approximate pump power failure simulation show that the existing pressurized surge tank will provide satisfactory protection for the force main if the initial steady state air volume is decreased to 35 percent (from 45 percent).

Note that if pigging the force main is not possible, the steady state analyses performed by NHC with larger capacity pumps installed at the WWF EPS, shows that the maximum capacity of the existing force main would be between 775 gpm (assuming Manning's n = 0.019) and 866 gpm (assuming Manning's n = 0.017) with two larger capacity pumps operating at the pump station. The existing pressurized surge tank will provide satisfactory surge protection for the force main under this range of force main conveyance rates.

It is recommended that additional transient analyses be performed once larger capacity pumps are selected for the WWF EPS and that the results and recommendations for surge control be checked with the larger capacity pumps installed in the transient computer model.

6 APPENDIX A - MOVIES

The enclosed CDROM contains movies of HGL elevation animations for pump power failure and pump start-up at the WWTF EPS. The movie files can be viewed with Microsoft Corporation's Windows Media Player© or other comparable software.

Table A1: Movie filenames and figure numbers

Filename	***Description***	***Figure #***
`Power-failure.avi`	Pump power failure at WWTF EPS with high wet well level and high force main friction loss	4
`Power-failure-ae.avi`	Pump power failure at WWTF EPS with high wet well level, low force main friction loss, and entrained air	8
`Startup.avi`	Pump start-up at WWTF EPS with high wet well level and low force main friction loss	10

CDROM here

APPENDIX E
Supplemental Materials – LEC Environmental Consultants

June 21, 2019

Email (ed.leonard@wright-pierce.com)

Mr. Edward J. Leonard, PE
Wright-Pierce
40 Shattuck Road, Suite 305
Andover, MA 01810

Re: Preliminary Rare Species Due Diligence [LEC File #WP\19-184.01]
Shared Wastewater Management Study
Joint Base Cape Cod
Sandwich & Bourne, Massachusetts

Dear Mr. Leonard:

As requested, LEC Environmental Consultants, Inc., is providing the following information on state and federally-listed rare species and associated regulatory implications for the evaluation of potential shared wastewater collection, treatment, transmission and disposal facilities at Joint Base Cape Cod (JBCC). Specifically, LEC evaluated Figure 4-1: *Potential RIB and Wick Sites*, prepared by Wright-Pierce, dated May 2019 and Figure 4-3: *Shared Wastewater Management Study Potential Canal Outfall Site 6*, prepared by Wright-Pierce, dated June 2019 (**Attachments A & B**). Figure 4-1 depicts the Sites 1, 2, and 3 RIBs (Rapid Infiltration Basins) and Sites 4 & 5 Wicks. Sites 1 & 2 RIBs and Sites 4 & 5 Wicks occur within Bourne, south of the Cape Cod Canal and Sandwich Road between the Bourne and Sagamore Bridges, while Site 3 RIB occurs within Sandwich south of Route 6 on the JBCC property. Potential Canal Outfall Site 6 is located at the Cape Cod Canal, nearly halfway between the Bourne and Sagamore Bridges.

For state-listed rare species, LEC performed a desktop review of MassGIS data layers and the 14th edition of the *Massachusetts Natural Heritage Atlas* (effective August 1, 2017) published by the Massachusetts Natural Heritage and Endangered Species Program (NHESP) to determine the extent of Priority/Estimated Habitat mapping. In addition to submitting an Information Request, NHESP's *BioMap2* was also reviewed to determine which state-listed rare species may occur within the vicinity of potential work areas.

The U.S. Fish & Wildlife Service's (FWS) Information for Planning and Consultation (IPaC) planning tool was utilized to determine whether federally-listed Threatened or Endangered Species, candidate species, or species proposed for listing and/or Critical Habitat may occur within the project area. The New England Field Office's Endangered Species Consultation guidelines were also reviewed to prepare this letter along with NHESP's current Northern Long-Eared Bat (*Myotis septentrionalis*) database to determine the proximity of the potential work areas to known hibernacula and maternity roost trees for the federally-Threatened species.

State-Listed Rare Species

According to the MassGIS NHESP data layers and 14th edition of the *Massachusetts Natural Heritage Atlas* (effective August 1, 2017), Sites 1, 2, and 3 RIBs and Sites 4 & 5 Wicks are located within a *Priority Habitat of Rare Species* or *Estimated Habitat of Rare Wildlife* mapped by NHESP (**Attachment C**). Priority/Estimated Habitat mapping does not extend northerly across Sandwich Road and therefore, Site 6 as depicted on Figure 4-3, does not occur within a Priority/Estimated Habitat.

BioMap2, developed by NHESP and The Nature Conservancy's Massachusetts Program to protect the state's biodiversity, identifies two complementary spatial layers related to plant and wildlife habitat. "Core Habitat" *identifies key areas that are critical for the long-term persistence of rare species and other Species of Special Concern, as well as a wide diversity of natural communities and intact ecosystems across the Commonwealth*. "Critical Natural Landscape" *identifies larger natural Landscape Blocks that are minimally impacted by development. If protected, these areas will provide habitat for wide-ranging native species, maintain connectivity among habitats, and enhance ecological resilience to natural and anthropogenic disturbances in a rapidly changing world. Areas delineated as Critical Natural Landscape also include buffering upland around wetland, coastal, and aquatic Core Habitats to help ensure their long-term integrity*.

According to MassGIS BioMap2 data layers, Sites 1, 2, and 3 RIBs and Sites 4 & 5 Wicks are located within a "Critical Natural Landscape" and primarily within "Core Habitat" (**Attachment D**). The Towns of Bourne and Sandwich's *BioMap 2* (2012) reports identify numerous state-listed species currently protected under the *Massachusetts Endangered Species Act* (M.G.L. c. 131A) and its implementing *Regulations* (321 CMR 10.00, collectively, "MESA"), within the expansive mapped Core Habitat (507) extending across JBCC. In response to an Information Request, NHESP issued a letter on June 13, 2019 (**Attachment E**), confirming that the following state-listed rare species (SC = Special Concern; T = Threatened; E = Endangered) have been documented within the vicinity of Sites 1, 2, and 3 RIBs and Sites 4 & 5 Wicks:

<u>*Birds*</u>
Eastern Whip-poor-will (*Caprimulgus vociferus*), SC
Northern Harrier (*Circus cyaneus*), T

<u>*Moths*</u>
Coastal Heathland Cutworm (*Abagrotis nefascia*), SC
Barrens Daggermoth (*Acronicta albarufa*), T
Gerhard's Underwing (*Catocala herodias gerhardi*), SC
Waxed Sallow Moth (*Chaetaglaea cerata*), SC
Melsheimer's Sack Bearer (*Cicinnus melsheimeri*), T

Chain Dot Geometer (*Cingilia catenaria*), SC
Sandplain Euchlaena (*Euchlaena madusaria*), SC
Slender Clearwing Sphinx (*Hemaris gracilis*), SC
Barrens Buckmoth (*Hemileuca maia*), SC
Pine Barrens Lycia (*Lycia ypsilon*), T
Coastal Swamp Metarranthis (*Metarranthis pilosaria*), SC
Water-willow Stem Borer (*Papaipema sulphurata*), T
Pink Sallow (*Psectraglaea carnosa*), SC
Pine Barrens Speranza (*Speranza exonerata*), SC
Pine Barrens Zale (*Zale lunifera*), SC

Plants
Adder′s-Tongue Fern (*Ophioglossum pusillum*), T
Broad Tinker′s-weed (*Triosteum perfoliatum*), E

Reptile
Eastern Box Turtle (*Terrapene carolina*), SC

Proposed activities associated with shared wastewater collection, treatment, transmission and disposal facilities will require NHESP review under MESA. NHESP recommends that potential state-listed rare species habitat concerns be reviewed with Staff during the early planning stages prior to formal design, as avoidance and minimization of impacts to rare species and their habitats is likely to expedite MESA regulatory review. NHESP may require seasonally-dependent field surveys to determine presence/absence of species and distribution, if present, to facilitate the MESA review process.

All proposed non-exempt activities within Priority Habitat will be evaluated by NHESP under MESA Project Review in the context of potential impacts to state-listed rare species habitat that may rise to the level of a "take". A "take", *in reference to animals, means to harass, harm, pursue, hunt, shoot, hound, kill, trap, capture, collect, process, disrupt the nesting, breeding, feeding or migratory activity or attempt to engage in any such conduct, or to assist such conduct…Disruption of nesting, breeding, feeding or migratory activity may result from, but is not limited to, the modification, degradation or destruction of Habitat.*

Should work activities result in a "take" of state-listed rare species, a MESA Conservation and Management Permit Application will be required, in addition to filing for MESA Project Review. In order to meet the Performance Standards for issuance of a MESA Conservation & Management Permit, an Applicant must demonstrate that impacts to state-listed species have been avoided, minimized, and mitigated, while adequately assessing alternatives to temporary and permanent impacts and confirming that an insignificant portion of the local population will be impacted. Furthermore, the Applicant must carry out a Conservation and Management Plan that provides a long-term Net Benefit to the impacted state-listed rare species and/or their habitat.

Federally-Listed Rare Species

LEC utilized IPaC to separately determine whether federally-listed Threatened or Endangered Species, candidate species, or species proposed for listing and/or Critical Habitat are associated with the Sites 1, 2, and 3 RIBs and Sites 4 & 5 Wicks on the JBCC property (terrestrial) and the Cape Cod Canal (in-water).

Based on information currently available to LEC from an IPaC desktop (online) review (**Attachment F**), there are no Critical Habitats on or surrounding Sites 1, 2, and 3 RIBs and Sites 4 & 5 Wicks. Additionally, there are no Critical Habitats associated with the Cape Cod Canal and Site 6 (**Attachment G**).

The federally-listed Northern Long-Eared Bat and American Chaffseed (*Schwalbea americana*) have been identified on the JBCC property. The Piping Plover (*Charadrius*), Red Knot (*Calidris canutus rufa*), and Roseate Tern (*Sterna dougallii dougallii*) are listed in association with the Cape Cod Canal. The Plymouth Redbelly Turtle (*Pseudemys rubiventris bangsi*) was also listed on the Cape Cod Canal IPaC; however, this freshwater species was likely only identified as it has been known to occur within portions of Bourne north of the Canal.

Northern Long-Eared Bat

The Threatened Northern Long-Eared Bat (NLEB) is listed statewide by FWS and subject to a Final 4(d) rule under the *Endangered Species Act* (16 U.S.C. § 1531 et seq.) and its implementing regulations (collectively, "ESA"), effective February 16, 2016. NLEB is also listed as Endangered under MESA.

Projects that result in tree removal activities shall comply with the Final 4(d) which states:

"Incidental take resulting from tree removal is prohibited if, 1) Occurs within 0.25 mile radius of known northern long-eared bat hibernacula or 2) cuts or destroys known occupied maternity roost trees, or any other trees within a 150-foot radius from the known maternity tree during the pup season (June 1 through July 31)."

LEC performed a "desktop" review of the online database maintained by MA NHESP last updated on June 4, 2019 (http://www.mass.gov/eea/agencies/dfg/dfw/natural-heritage/species-information-and-conservation/rare-mammals/northern-long-eared-bat.html) to confirm the closest known NLEB hibernacula and occupied maternity roost trees. Based on NHESP's current online database, Sites 1, 2, and 3 RIBs and Sites 4 & 5 Wicks are not located within 0.25 miles of a known hibernacula or 150 linear feet of a known maternity roost tree. The closest maternity roost tree has been documented slightly greater than 5,000 linear feet from Site 5, while no NLEB hibernacula have been documented on Cape Cod, as depicted on the *NLEB Map* (**Attachment H**). Please note that NHESP's database is routinely updated and based on documented hibernacula and maternity roost trees that do not represent a comprehensive inventory.

LEC

American Chaffseed

This Endangered plant is typically associated with sandplain grasslands, a habitat cover type that is found on JBCC. American Chaffseed is included within the 2019 MESA List Change Proposals, to be protected under MESA as an Endangered species.

Birds

Piping Plover (Threatened), Red Knot (Threatened), and/or Roseate Tern (Endangered) may seasonally forage along portions of Cape Cod Canal. LEC is aware that Piping Plover has been known to nest proximate to either end of the Canal on surrounding beaches. The Piping Plover and Roseate Tern are also listed under MESA as Threatened and Endangered, respectively. Both ends of the Canal are mapped as Priority/Estimated Habitat for state-listed rare tern foraging habitat (e.g., Common and Least Terns) and possibly also for Piping Plover.

Projects obtaining federal funding or authorization, including National Pollutant Discharge Elimination System (NPDES) authorization from the Environmental Protection Agency (EPA), and projects requiring Clean Water Act authorization from the U.S. Army Corps of Engineers (ACOE) necessitate Endangered Species Consultation (Section 7) under the ESA. Further consultation with the FWS New England Field Office would likely be required to understand ESA requirements for wastewater collection, treatment, transmission and disposal facilities at JBCC, including the proposed outfall to the Cape Cod Canal (Site 6). Coordination with the National Marine Fisheries Service (NMFS), Massachusetts Division of Marine Fisheries (DMF), EPA, ACOE, Massachusetts Department of Environmental Protection (MassDEP), and/or Massachusetts Office of Coastal Zone Management (CZM) is also likely required for the proposed outfall (Site 6).

Summary

Proposed wastewater collection, treatment, transmission and disposal facilities at JBCC, including Sites 1, 2, and 3 RIBs and Sites 4 & 5 Wicks and the proposed outfall to the Cape Cod Canal (Site 6), as depicted on Figures 4-1 and 4-3, will require review by NHESP in addition to FWS should proposed activities involve federal funding, authorization, and/or permitting. Early coordination with both agencies will enable a better understanding of potential rare species habitat concerns to avoid and/or minimize impacts to rare species and their habitats associated with shared wastewater management, in addition to streamlining the regulatory review process to the greatest extent feasible. Further consultation with DMF, EPA, ACOE, DEP, and/or CZM is recommended regarding the proposed Cape Cod Canal outfall (Site 6).

In conclusion:

- There are numerous state-listed species (Special Concern, Threatened, and Endangered) and several federal-listed species (Threatened and Endangered) documented within the vicinity of the project areas.

- Additional due diligence is recommended once conceptual site plans have been established to understand potential rare species habitat concerns and the anticipated permitting requirements.
- Early coordination with the NHESP and FWS, in addition to other agencies (see above), is strongly recommended in order to refine the required permitting requirements.

LEC is pleased to provide this Preliminary Rare Species Due Diligence review for the Shared Wastewater Management Study at JBCC. If you should you have any immediate questions or comments, feel free to contact me at 508-746-9491 or at bmadden@lecenvironmental.com.

Sincerely,

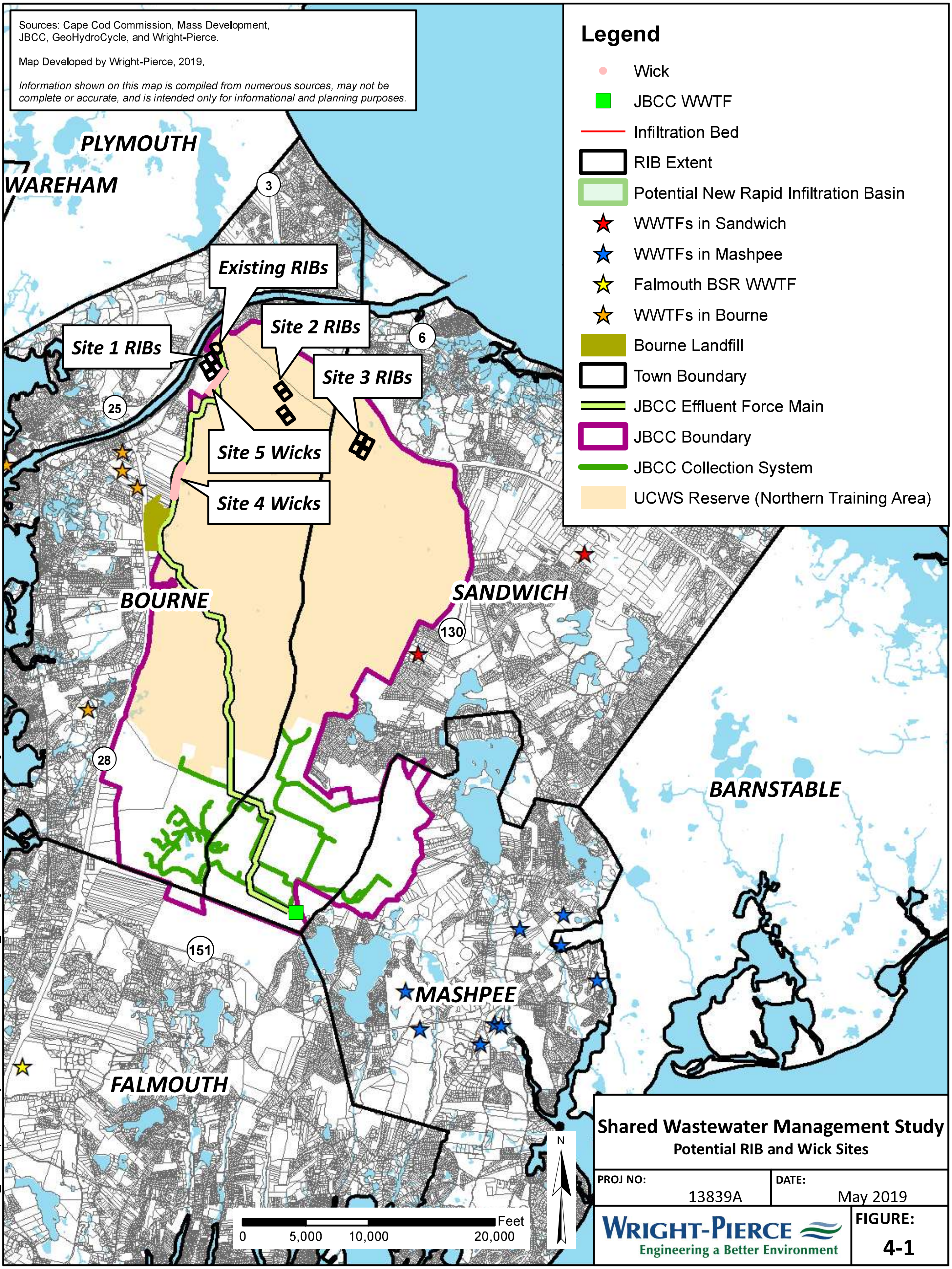
LEC Environmental Consultants, Inc.

Brian T. Madden
Wildlife Scientist

Attachments

Attachment A

Figure 4-1



Shared Wastewater Management Study

Potential RIB and Wick Sites

PROJ NO:	DATE:
13839A	May 2019

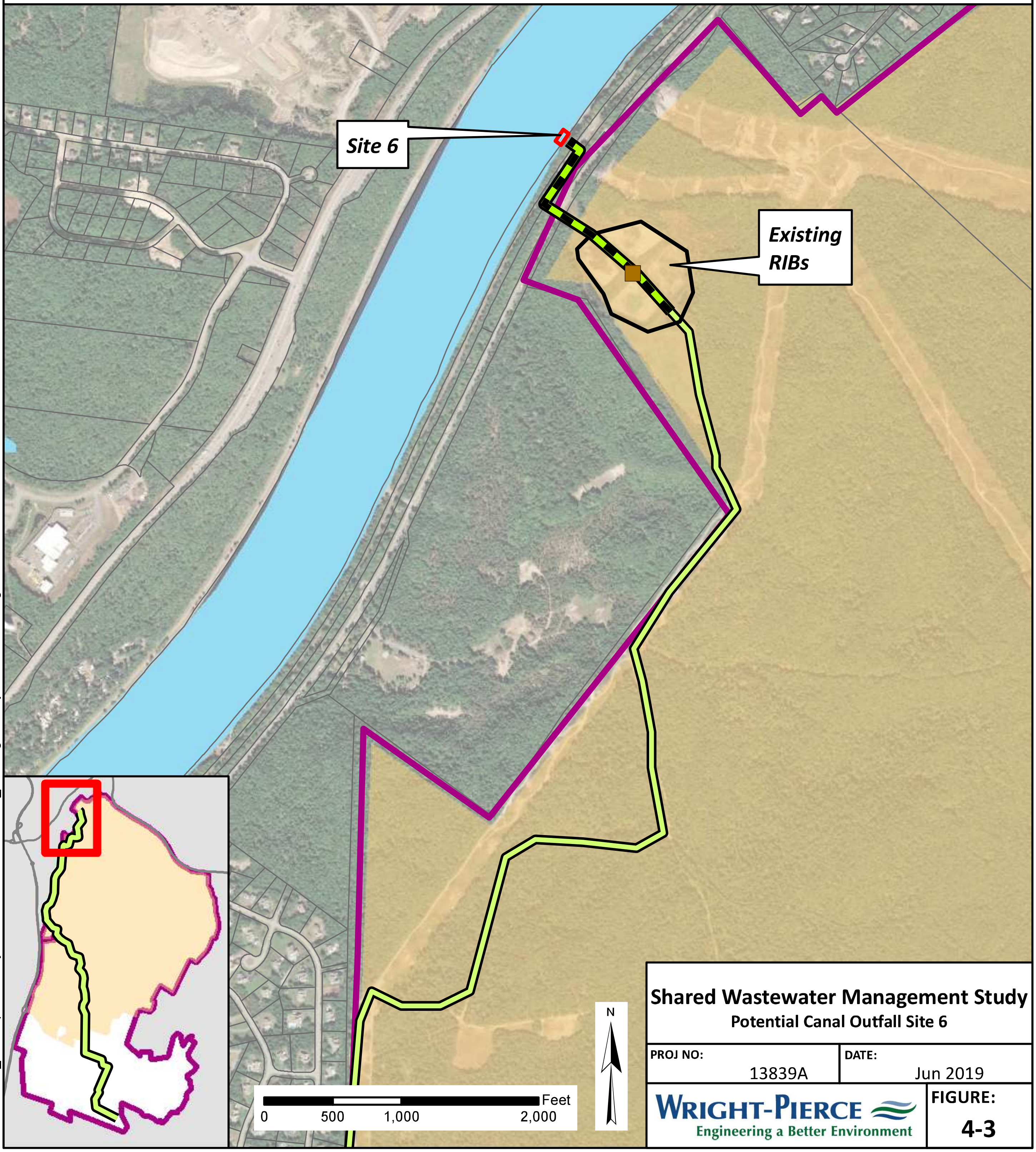
WRIGHT-PIERCE
Engineering a Better Environment

FIGURE: 4-1

Figure 4-3

Legend

- JBCC Effluent Disposal
- Potential Canal Outfall Site
- JBCC Effluent Force Main
- Proposed Canal Outfall
- Existing RIB Extent
- JBCC Boundary
- Contamination Plumes
- Upper Cape Water Supply Reserve



Shared Wastewater Management Study

Potential Canal Outfall Site 6

PROJ NO:	DATE:
13839A	Jun 2019

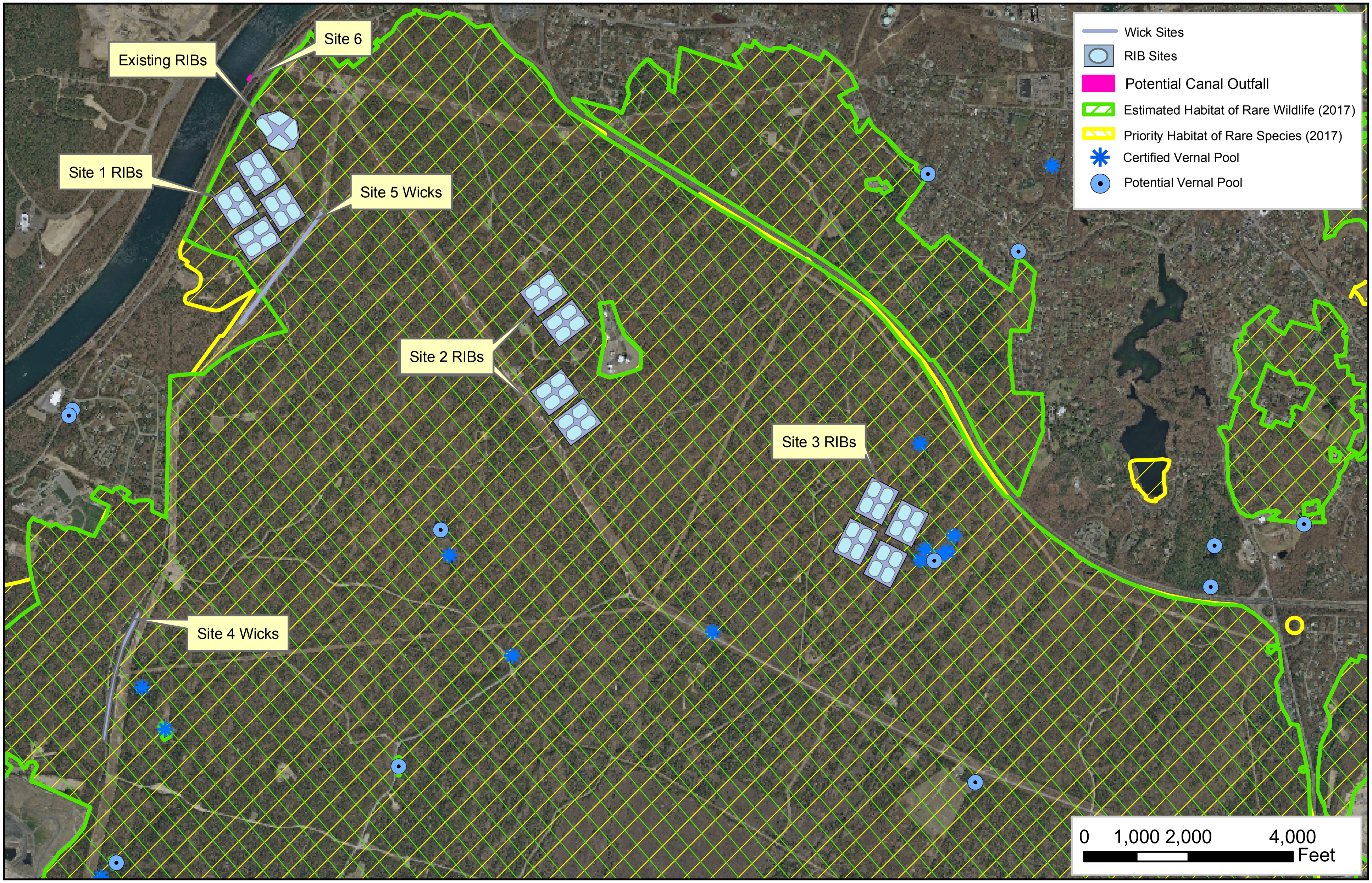
WRIGHT-PIERCE
Engineering a Better Environment

FIGURE: 4-3

TAH W:\GIS_Development\Projects\MA\Falmouth\13839A_WW-MgmtStudy-JBCC\MXDs\Figure-4-3-PotentialCanalOutfallSite6-v4-8x11-P.mxd

Attachment C

NHESP Map



LEC
LEC Environmental Consultants, Inc.
Plymouth, MA
508.746.9491
www.lecenvironmental.com

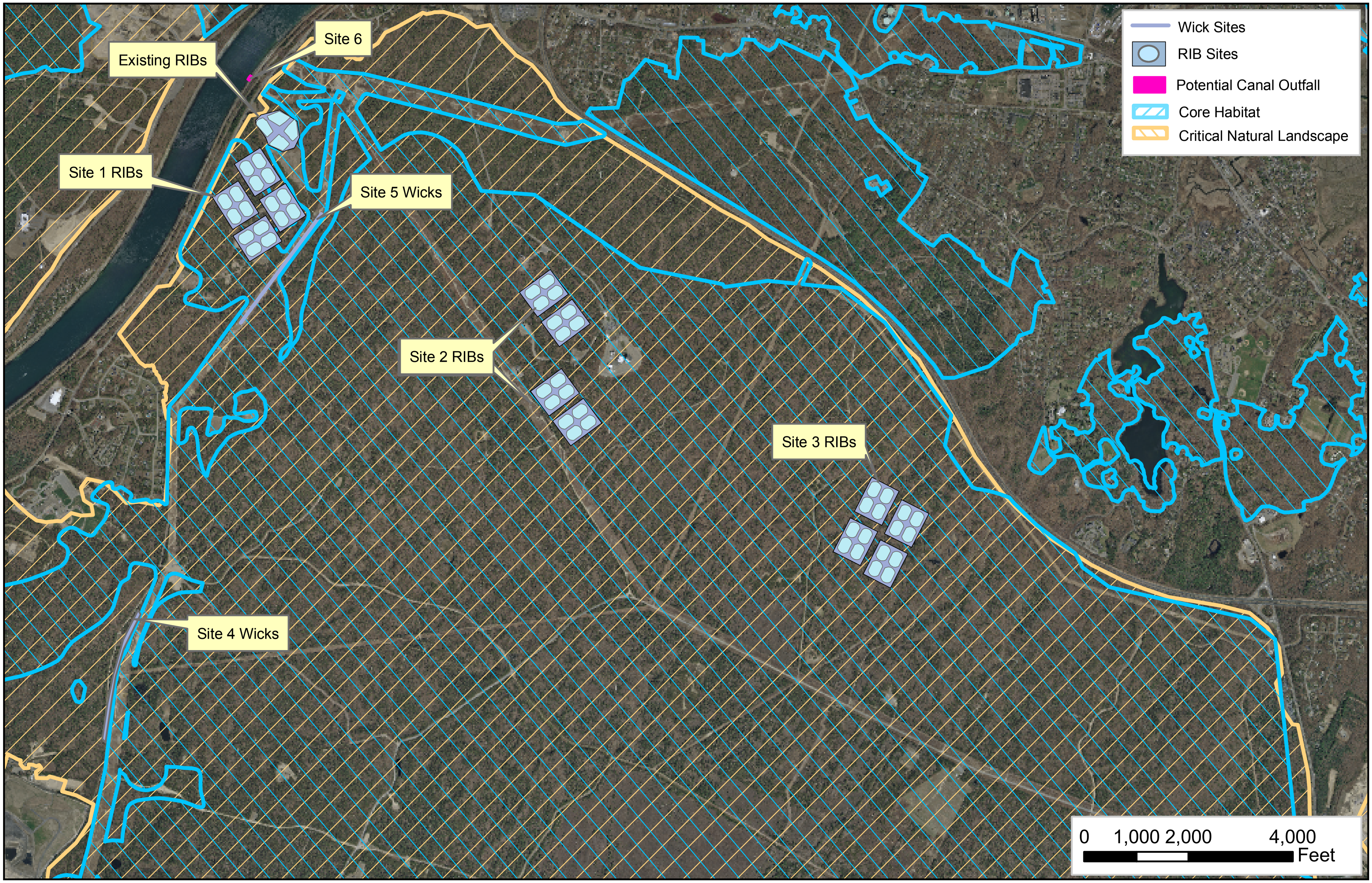
NHESP Map

Shared Wastewater Management Study
Joint Base Cape Cod
Bourne, Massachusetts

June 19, 2019

Attachment D

BioMap 2 Map



LEC Environmental Consultants, Inc.
Plymouth, MA
508.746.9491
www.lecenvironmental.com

BioMap 2 Map

Shared Wastewater Management Study
Joint Base Cape Cod
Bourne, Massachusetts

N

June 19, 2019

Attachment E

NHESP Letter, Dated June 13, 2019

June 13, 2019

Brian Madden
LEC Environmental Consultants, Inc
12 Resnik Road, Suite 1
Plymouth MA 02360

RE: Project Location: Joint Base Cape Cod
Town: SANDWICH, BOURNE
NHESP Tracking No.: 19-38702

To Whom It May Concern:

Thank you for contacting the Natural Heritage and Endangered Species Program of the MA Division of Fisheries & Wildlife (the "Division") for information regarding state-listed rare species in the vicinity of the above referenced site. Based on the information provided, this project site, or a portion thereof, is located **within** *Priority Habitat 490* (PH 490) and *Estimated Habitat 435* (EH 435) as indicated in the *Massachusetts Natural Heritage Atlas* (14th Edition) for the following state-listed rare species:

Scientific name	Common Name	Taxonomic Group	State Status
Caprimulgus vociferus	Eastern Whip-poor-will	Bird	Special Concern
Circus cyaneus	Northern Harrier	Bird	Threatened
Abagrotis nefascia	Coastal Heathland Cutworm	Butterflies and Moths	Special Concern
Acronicta albarufa	Barrens Dagger Moth	Butterflies and Moths	Threatened
Catocala herodias gerhardi	Gerhard's Underwing Moth	Butterflies and Moths	Special Concern
Chaetaglaea cerata	Waxed Sallow Moth	Butterflies and Moths	Special Concern
Cicinnus melsheimeri	Melsheimer's Sack Bearer	Butterflies and Moths	Threatened
Cingilia catenaria	Chain Dot Geometer	Butterflies and Moths	Special Concern
Euchlaena madusaria	Sandplain Euchlaena	Butterflies and Moths	Special Concern
Hemaris gracilis	Slender Clearwing Sphinx	Butterflies and Moths	Special Concern
Hemileuca maia	Barrens Buckmoth	Butterflies and Moths	Special Concern
Lycia ypsilon	Pine Barrens Lycia	Butterflies and Moths	Threatened
Metarranthis pilosaria	Coastal Swamp Metarranthis Moth	Butterflies and Moths	Special Concern
Papaipema sulphurata	Water-Willow Borer Moth	Butterflies and Moths	Threatened
Psectraglaea carnosa	Pink Sallow	Butterflies and Moths	Special Concern
Speranza exonerata	Pine Barrens Speranza	Butterflies and Moths	Special Concern
Zale lunifera	Pine Barrens Zale	Butterflies and Moths	Special Concern
Ophioglossum pusillum	Adder's-Tongue Fern	Plant	Threatened
Triosteum perfoliatum	Broad Tinker's-Weed	Plant	Endangered
Terrapene carolina	Eastern Box Turtle	Reptile	Special Concern

The species listed above are protected under the Massachusetts Endangered Species Act (MESA) (M.G.L. c. 131A) and its implementing regulations (321 CMR 10.00). State-listed wildlife are also protected under the state's Wetlands Protection Act (WPA) (M.G.L. c. 131, s. 40) and its implementing regulations (310 CMR 10.00). Fact sheets for most state-listed rare species can be found on our website (www.mass.gov/nhesp).

Please note that projects and activities located within Priority and/or Estimated Habitat **must** be reviewed by the Division for compliance with the state-listed rare species protection provisions of MESA (321 CMR 10.00) and/or the WPA (310 CMR 10.00).

Wetlands Protection Act (WPA)
If the project site is within Estimated Habitat and a Notice of Intent (NOI) is required, then a copy of the NOI must be submitted to the Division so that it is received at the same time as the local conservation commission. If the Division determines that the proposed project will adversely affect the actual Resource Area habitat of state-protected wildlife, then the proposed project may not be permitted (310 CMR 10.37, 10.58(4)(b) & 10.59). In such a case, the project proponent may request a consultation with the Division to discuss potential project design modifications that would avoid adverse effects to rare wildlife habitat.

A streamlined joint MESA/WPA review process is available. When filing a Notice of Intent (NOI), the applicant may file concurrently under the MESA on the same NOI form and qualify for a 30-day streamlined joint review. For a copy of the NOI form, please visit the MA Department of Environmental Protection's website: https://www.mass.gov/how-to/wpa-form-3-wetlands-notice-of-intent.

MA Endangered Species Act (MESA)
If the proposed project is located within Priority Habitat and is not exempt from review (see 321 CMR 10.14), then project plans, a fee, and other required materials must be sent to Natural Heritage Regulatory Review to determine whether a probable Take under the MA Endangered Species Act would occur (321 CMR 10.18). Please note that all proposed and anticipated development must be disclosed, as MESA does not allow project segmentation (321 CMR 10.16). For a MESA filing checklist and additional information please see our website: https://www.mass.gov/regulatory-review.

We recommend that rare species habitat concerns be addressed during the project design phase prior to submission of a formal MESA filing, as avoidance and minimization of impacts to rare species and their habitats is likely to expedite endangered species regulatory review.

This evaluation is based on the most recent information available in the Natural Heritage database, which is constantly being expanded and updated through ongoing research and inventory. If the purpose of your inquiry is to generate a species list to fulfill the federal Endangered Species Act (16 U.S.C. 1531 et seq.) information requirements for a permit, proposal, or authorization of any kind from a federal agency, we recommend that you contact the National Marine Fisheries Service at (978)281-9328 and use the U.S. Fish and Wildlife Service's Information for Planning and Conservation website (https://ecos.fws.gov/ipac). If you have any questions regarding this letter please contact Melany Cheeseman, Endangered Species Review Assistant, at (508) 389-6357.

Sincerely,

Everose Schlüter, Ph.D.
Assistant Director

Attachment F

Joint Base Cape Cod IPaC Resource List

IPaC **U.S. Fish & Wildlife Service**

IPaC resource list

This report is an automatically generated list of species and other resources such as critical habitat (collectively referred to as *trust resources*) under the U.S. Fish and Wildlife Service's (USFWS) jurisdiction that are known or expected to be on or near the project area referenced below. The list may also include trust resources that occur outside of the project area, but that could potentially be directly or indirectly affected by activities in the project area. However, determining the likelihood and extent of effects a project may have on trust resources typically requires gathering additional site-specific (e.g., vegetation/species surveys) and project-specific (e.g., magnitude and timing of proposed activities) information.

Below is a summary of the project information you provided and contact information for the USFWS office(s) with jurisdiction in the defined project area. Please read the introduction to each section that follows (Endangered Species, Migratory Birds, USFWS Facilities, and NWI Wetlands) for additional information applicable to the trust resources addressed in that section.

Location

Barnstable County, Massachusetts

Local office

New England Ecological Services Field Office

(603) 223-2541
(603) 223-0104

70 Commercial Street, Suite 300
Concord, NH 03301-5094

http://www.fws.gov/newengland

Endangered species

This resource list is for informational purposes only and does not constitute an analysis of project level impacts.

The primary information used to generate this list is the known or expected range of each species. Additional areas of influence (AOI) for species are also considered. An AOI includes areas outside of the species range if the species could be indirectly affected by activities in that area (e.g., placing a dam upstream of a fish population, even if that fish does not occur at the dam site, may indirectly impact the species by reducing or eliminating water flow downstream). Because species can move, and site conditions can change, the species on this list are not guaranteed to be found on or near the project area. To fully determine any potential effects to species, additional site-specific and project-specific information is often required.

Section 7 of the Endangered Species Act **requires** Federal agencies to "request of the Secretary information whether any species which is listed or proposed to be listed may be present in the area of such proposed action" for any project that is conducted, permitted, funded, or licensed by any Federal agency. A letter from the local office and a species list which fulfills this requirement can **only** be obtained by requesting an official species list from either the Regulatory Review section in IPaC (see directions below) or from the local field office directly.

For project evaluations that require USFWS concurrence/review, please return to the IPaC website and request an official species list by doing the following:

1. Draw the project location and click CONTINUE.
2. Click DEFINE PROJECT.
3. Log in (if directed to do so).
4. Provide a name and description for your project.
5. Click REQUEST SPECIES LIST.

Listed species[1] and their critical habitats are managed by the Ecological Services Program of the U.S. Fish and Wildlife Service (USFWS) and the fisheries division of the National Oceanic and Atmospheric Administration (NOAA Fisheries[2]).

Species and critical habitats under the sole responsibility of NOAA Fisheries are **not** shown on this list. Please contact NOAA Fisheries for species under their jurisdiction.

1. Species listed under the Endangered Species Act are threatened or endangered; IPaC also shows species that are candidates, or proposed, for listing. See the listing status page for more information.
2. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

The following species are potentially affected by activities in this location:

Mammals

NAME	STATUS
Northern Long-eared Bat *Myotis septentrionalis* No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/9045	Threatened

Flowering Plants

NAME	STATUS
American Chaffseed *Schwalbea americana* No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/1286	Endangered

Critical habitats

Potential effects to critical habitat(s) in this location must be analyzed along with the endangered species themselves.

THERE ARE NO CRITICAL HABITATS AT THIS LOCATION.

Migratory birds

Certain birds are protected under the Migratory Bird Treaty Act[1] and the Bald and Golden Eagle Protection Act[2].

Any person or organization who plans or conducts activities that may result in impacts to migratory birds, eagles, and their habitats should follow appropriate regulations and consider implementing appropriate conservation measures, as described below.

1. The Migratory Birds Treaty Act of 1918.
2. The Bald and Golden Eagle Protection Act of 1940.

Additional information can be found using the following links:

- Birds of Conservation Concern http://www.fws.gov/birds/management/managed-species/birds-of-conservation-concern.php
- Measures for avoiding and minimizing impacts to birds http://www.fws.gov/birds/management/project-assessment-tools-and-guidance/conservation-measures.php
- Nationwide conservation measures for birds http://www.fws.gov/migratorybirds/pdf/management/nationwidestandardconservationmeasures.pdf

The birds listed below are birds of particular concern either because they occur on the USFWS Birds of Conservation Concern (BCC) list or warrant special attention in your project location. To learn more about the levels of concern for birds on your list and how this list is generated, see the FAQ below. This is not a list of every bird you may find in this location, nor a guarantee that every bird on this list will be found in your project area. To see exact locations of where birders and the general public have sighted birds in and around your project area, visit the E-bird data mapping tool (Tip: enter your location, desired date range and a species on your list). For projects that occur off the Atlantic Coast, additional maps and models detailing the relative occurrence and abundance of bird species on your list are available. Links to additional information about Atlantic Coast birds, and other important information about your migratory bird list, including how to properly interpret and use your migratory bird report, can be found below.

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, click on the PROBABILITY OF PRESENCE SUMMARY at the top of your list to see when these birds are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON (IF A BREEDING SEASON IS INDICATED FOR A BIRD ON YOUR LIST, THE BIRD MAY BREED IN YOUR PROJECT AREA SOMETIME WITHIN THE

TIMEFRAME SPECIFIED, WHICH IS A VERY LIBERAL ESTIMATE OF THE DATES INSIDE WHICH THE BIRD BREEDS ACROSS ITS ENTIRE RANGE. "BREEDS ELSEWHERE" INDICATES THAT THE BIRD DOES NOT LIKELY BREED IN YOUR PROJECT AREA.)

American Oystercatcher Haematopus palliatus This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/8935	Breeds Apr 15 to Aug 31
Bald Eagle Haliaeetus leucocephalus This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities. https://ecos.fws.gov/ecp/species/1626	Breeds Oct 15 to Aug 31
Black-billed Cuckoo Coccyzus erythropthalmus This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9399	Breeds May 15 to Oct 10
Bobolink Dolichonyx oryzivorus This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds May 20 to Jul 31
Dunlin Calidris alpina arcticola This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA	Breeds elsewhere
Eastern Whip-poor-will Antrostomus vociferus This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds May 1 to Aug 20

Least Tern *Sterna antillarum* — Breeds Apr 20 to Sep 10

This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA

Lesser Yellowlegs *Tringa flavipes* — Breeds elsewhere

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.
https://ecos.fws.gov/ecp/species/9679

Nelson's Sparrow *Ammodramus nelsoni* — Breeds May 15 to Sep 5

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Prairie Warbler *Dendroica discolor* — Breeds May 1 to Jul 31

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Purple Sandpiper *Calidris maritima* — Breeds elsewhere

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Red-throated Loon *Gavia stellata* — Breeds elsewhere

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Ruddy Turnstone *Arenaria interpres morinella* — Breeds elsewhere

This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA

Rusty Blackbird *Euphagus carolinus* — Breeds elsewhere

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Seaside Sparrow Ammodramus maritimus — Breeds May 10 to Aug 20
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Semipalmated Sandpiper Calidris pusilla — Breeds elsewhere
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Short-billed Dowitcher Limnodromus griseus — Breeds elsewhere
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.
https://ecos.fws.gov/ecp/species/9480

Snowy Owl Bubo scandiacus — Breeds elsewhere
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Whimbrel Numenius phaeopus — Breeds elsewhere
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.
https://ecos.fws.gov/ecp/species/9483

Willet Tringa semipalmata — Breeds Apr 20 to Aug 5
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Wood Thrush Hylocichla mustelina — Breeds May 10 to Aug 31
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Probability of Presence Summary

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read and understand the FAQ "Proper Interpretation and Use of Your Migratory Bird Report" before using or attempting to interpret this report.

Probability of Presence (■)

Each green bar represents the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during a particular week of the year. (A year is represented as 12 4-week months.) A taller bar indicates a higher probability of species presence. The survey effort (see below) can be used to establish a level of confidence in the presence score. One can have higher confidence in the presence score if the corresponding survey effort is also high.

How is the probability of presence score calculated? The calculation is done in three steps:

1. The probability of presence for each week is calculated as the number of survey events in the week where the species was detected divided by the total number of survey events for that week. For example, if in week 12 there were 20 survey events and the Spotted Towhee was found in 5 of them, the probability of presence of the Spotted Towhee in week 12 is 0.25.
2. To properly present the pattern of presence across the year, the relative probability of presence is calculated. This is the probability of presence divided by the maximum probability of presence across all weeks. For example, imagine the probability of presence in week 20 for the Spotted Towhee is 0.05, and that the probability of presence at week 12 (0.25) is the maximum of any week of the year. The relative probability of presence on week 12 is 0.25/0.25 = 1; at week 20 it is 0.05/0.25 = 0.2.
3. The relative probability of presence calculated in the previous step undergoes a statistical conversion so that all possible values fall between 0 and 10, inclusive. This is the probability of presence score.

To see a bar's probability of presence score, simply hover your mouse cursor over the bar.

Breeding Season (■)
Yellow bars denote a very liberal estimate of the time-frame inside which the bird breeds across its entire range. If there are no yellow bars shown for a bird, it does not breed in your project area.

Survey Effort (|)
Vertical black lines superimposed on probability of presence bars indicate the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps. The number of surveys is expressed as a range, for example, 33 to 64 surveys.

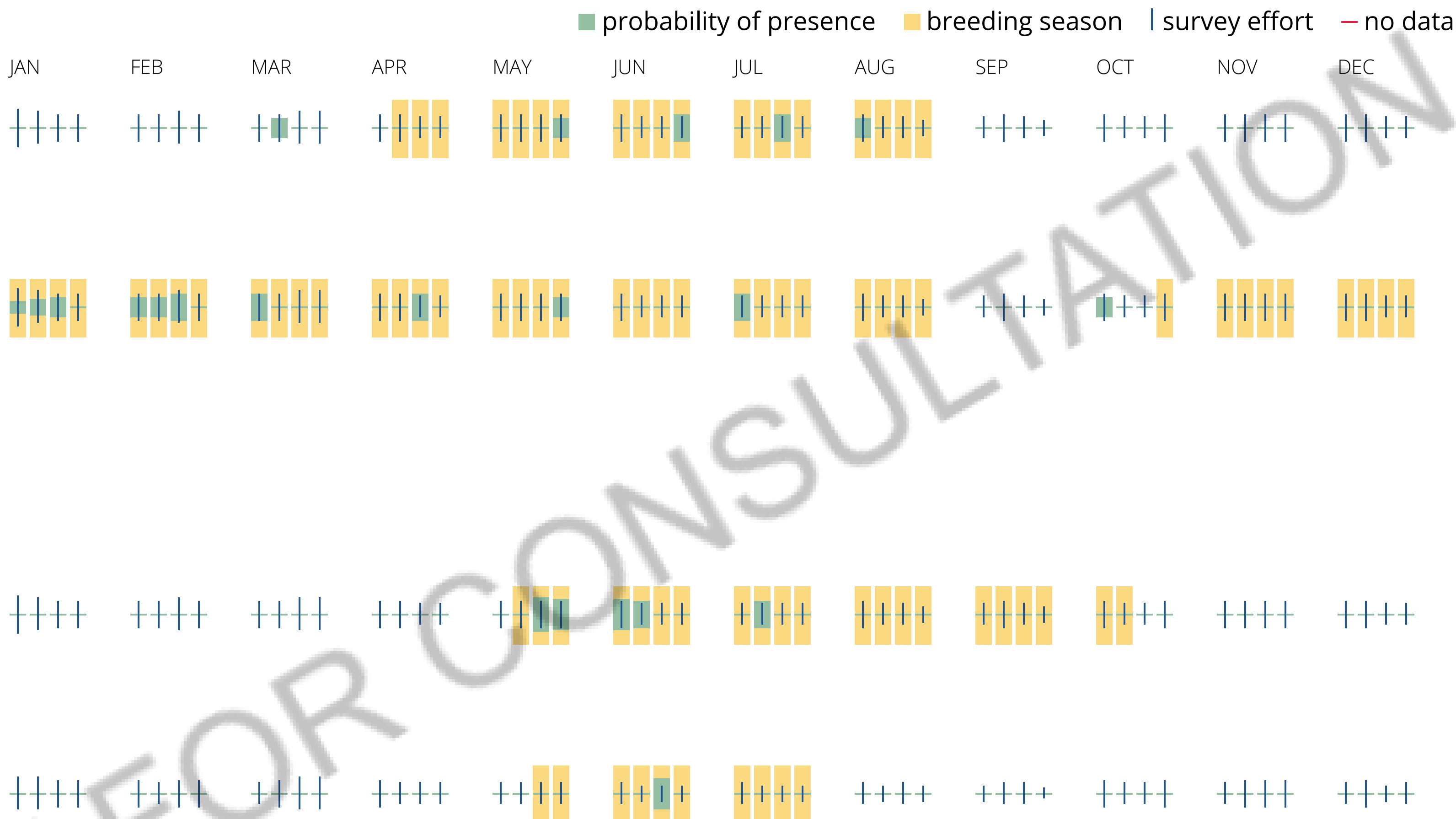
To see a bar's survey effort range, simply hover your mouse cursor over the bar.

No Data (–)

A week is marked as having no data if there were no survey events for that week.

Survey Timeframe

Surveys from only the last 10 years are used in order to ensure delivery of currently relevant information. The exception to this is areas off the Atlantic coast, where bird returns are based on all years of available data, since data in these areas is currently much more sparse.



SPECIES

American Oystercatcher
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Bald Eagle
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Black-billed Cuckoo
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Bobolink
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Dunlin
BCC - BCR (This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA)

Eastern Whip-poor-will
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

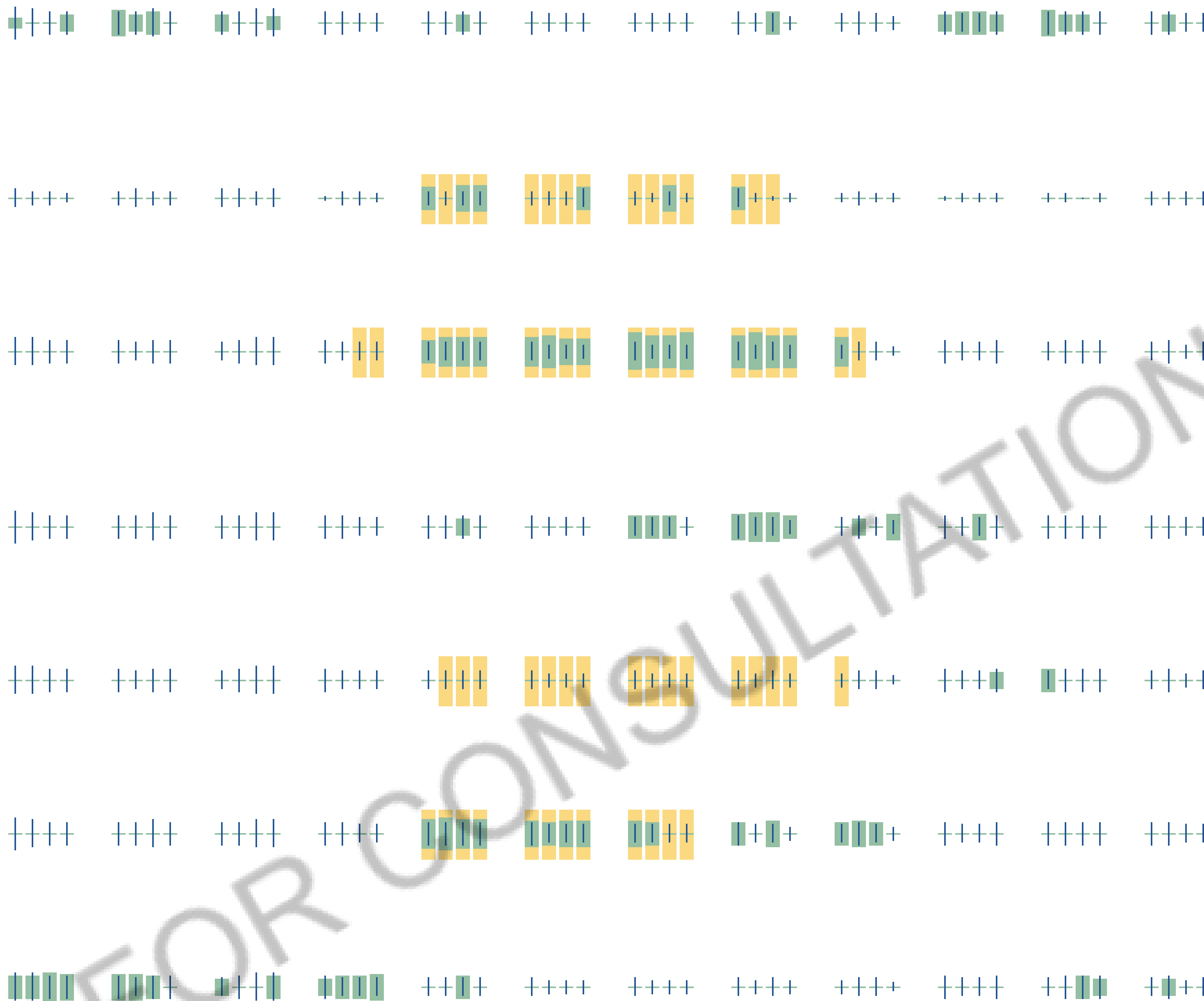
Least Tern
BCC - BCR (This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA)

Lesser Yellowlegs
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Nelson's Sparrow
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Prairie Warbler
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Purple Sandpiper
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)



SPECIES

Red-throated Loon
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

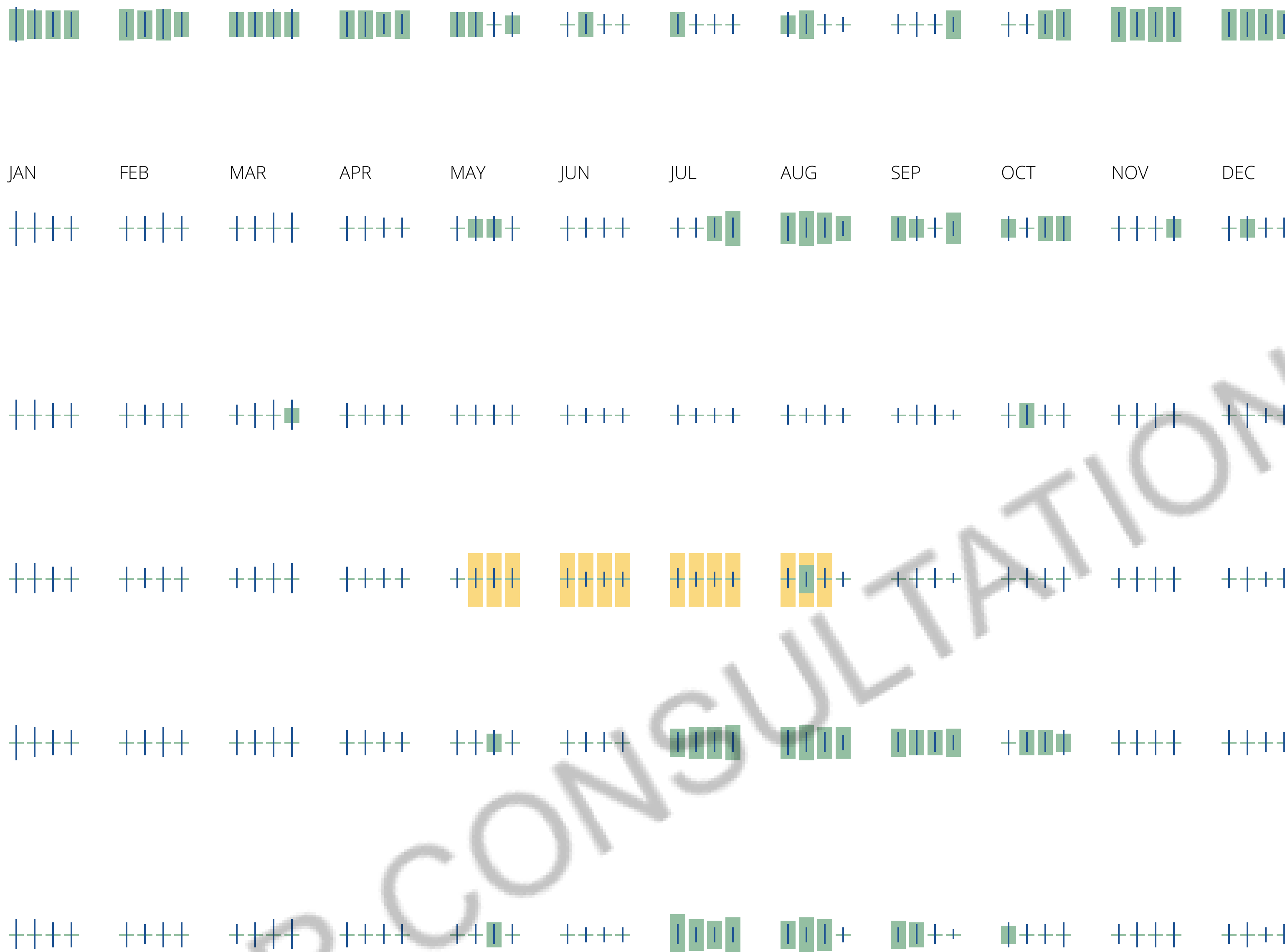
Ruddy Turnstone
BCC - BCR (This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA)

Rusty Blackbird
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Seaside Sparrow
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Semipalmated Sandpiper
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Short-billed Dowitcher
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

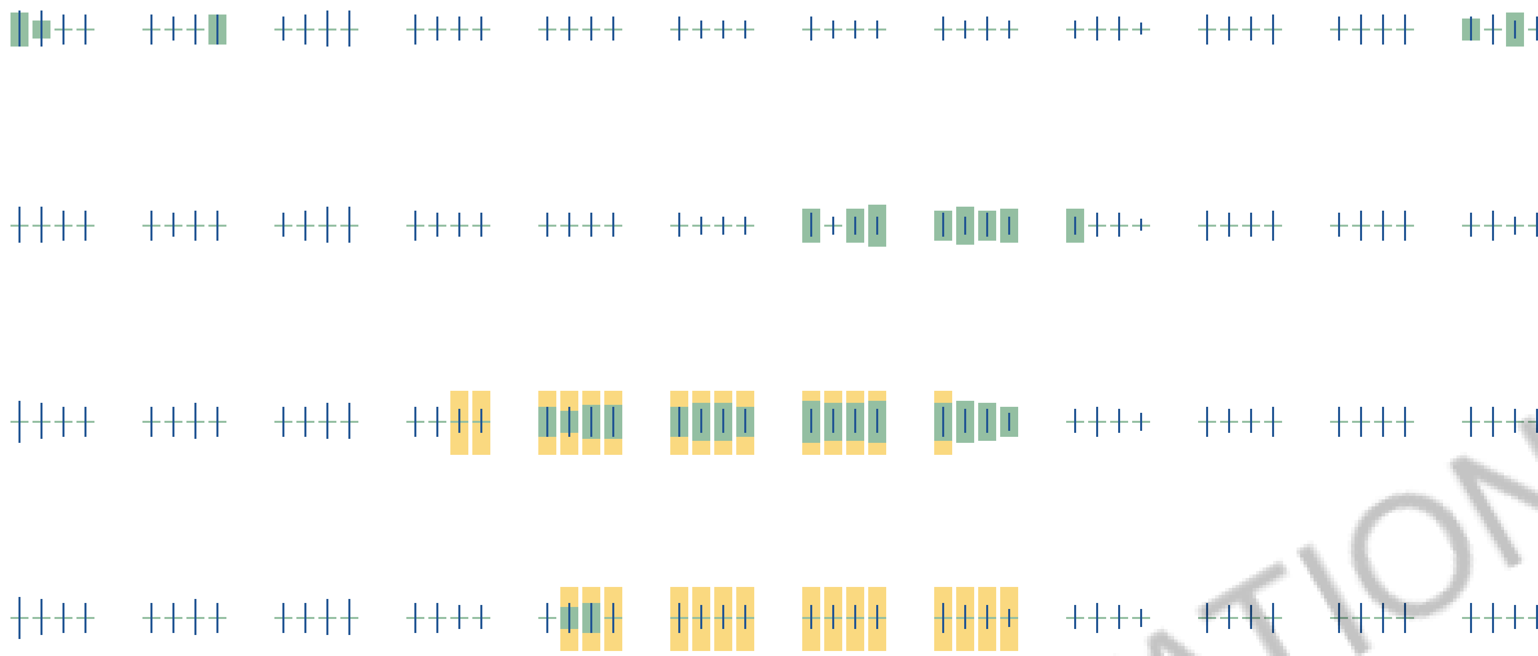


Snowy Owl
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Whimbrel
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Willet
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Wood Thrush
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)



Tell me more about conservation measures I can implement to avoid or minimize impacts to migratory birds.

Nationwide Conservation Measures describes measures that can help avoid and minimize impacts to all birds at any location year round. Implementation of these measures is particularly important when birds are most likely to occur in the project area. When birds may be breeding in the area, identifying the locations of any active nests and avoiding their destruction is a very helpful impact minimization measure. To see when birds are most likely to occur and be breeding in your project area, view the Probability of Presence Summary. Additional measures and/or permits may be advisable depending on the type of activity you are conducting and the type of infrastructure or bird species present on your project site.

What does IPaC use to generate the migratory birds potentially occurring in my specified location?

The Migratory Bird Resource List is comprised of USFWS Birds of Conservation Concern (BCC) and other species that may warrant special attention in your project location.

The migratory bird list generated for your project is derived from data provided by the Avian Knowledge Network (AKN). The AKN data is based on a growing collection of survey, banding, and citizen science datasets and is queried and filtered to return a list of those birds reported as occurring in the 10km grid cell(s) which your project intersects, and that have been identified as warranting special attention because they are a

BCC species in that area, an eagle (Eagle Act requirements may apply), or a species that has a particular vulnerability to offshore activities or development.

Again, the Migratory Bird Resource list includes only a subset of birds that may occur in your project area. It is not representative of all birds that may occur in your project area. To get a list of all birds potentially present in your project area, please visit the AKN Phenology Tool.

What does IPaC use to generate the probability of presence graphs for the migratory birds potentially occurring in my specified location?

The probability of presence graphs associated with your migratory bird list are based on data provided by the Avian Knowledge Network (AKN). This data is derived from a growing collection of survey, banding, and citizen science datasets .

Probability of presence data is continuously being updated as new and better information becomes available. To learn more about how the probability of presence graphs are produced and how to interpret them, go the Probability of Presence Summary and then click on the "Tell me about these graphs" link.

How do I know if a bird is breeding, wintering, migrating or present year-round in my project area?

To see what part of a particular bird's range your project area falls within (i.e. breeding, wintering, migrating or year-round), you may refer to the following resources: The Cornell Lab of Ornithology All About Birds Bird Guide, or (if you are unsuccessful in locating the bird of interest there), the Cornell Lab of Ornithology Neotropical Birds guide. If a bird on your migratory bird species list has a breeding season associated with it, if that bird does occur in your project area, there may be nests present at some point within the timeframe specified. If "Breeds elsewhere" is indicated, then the bird likely does not breed in your project area.

What are the levels of concern for migratory birds?

Migratory birds delivered through IPaC fall into the following distinct categories of concern:

1. "BCC Rangewide" birds are Birds of Conservation Concern (BCC) that are of concern throughout their range anywhere within the USA (including Hawaii, the Pacific Islands, Puerto Rico, and the Virgin Islands);
2. "BCC - BCR" birds are BCCs that are of concern only in particular Bird Conservation Regions (BCRs) in the continental USA; and
3. "Non-BCC - Vulnerable" birds are not BCC species in your project area, but appear on your list either because of the Eagle Act requirements (for eagles) or (for non-eagles) potential susceptibilities in offshore areas from certain types of development or activities (e.g. offshore energy development or longline fishing).

Although it is important to try to avoid and minimize impacts to all birds, efforts should be made, in particular, to avoid and minimize impacts to the birds on this list, especially eagles and BCC species of rangewide concern. For more information on conservation measures you can implement to help avoid and minimize migratory bird impacts and requirements for eagles, please see the FAQs for these topics.

Details about birds that are potentially affected by offshore projects

For additional details about the relative occurrence and abundance of both individual bird species and groups of bird species within your project area off the Atlantic Coast, please visit the Northeast Ocean Data Portal. The Portal also offers data and information about other taxa besides birds that may be helpful to you in your project review. Alternately, you may download the bird model results files underlying the portal maps through the NOAA NCCOS Integrative Statistical Modeling and Predictive Mapping of Marine Bird Distributions and Abundance on the Atlantic Outer Continental Shelf project webpage.

Bird tracking data can also provide additional details about occurrence and habitat use throughout the year, including migration. Models relying on survey data may not include this information. For additional information on marine bird tracking data, see the Diving Bird Study and the nanotag studies or contact Caleb Spiegel or Pam Loring.

What if I have eagles on my list?

If your project has the potential to disturb or kill eagles, you may need to obtain a permit to avoid violating the Eagle Act should such impacts occur.

Proper Interpretation and Use of Your Migratory Bird Report

The migratory bird list generated is not a list of all birds in your project area, only a subset of birds of priority concern. To learn more about how your list is generated, and see options for identifying what other birds may be in your project area, please see the FAQ "What does IPaC use to generate the migratory birds potentially occurring in my specified location". Please be aware this report provides the "probability of presence" of birds within the 10 km grid cell(s) that overlap your project; not your exact project footprint. On the graphs provided, please also look carefully at the survey effort (indicated by the black vertical bar) and for the existence of the "no data" indicator (a red horizontal bar). A high survey effort is the key component. If the survey effort is high, then the probability of presence score can be viewed as more dependable. In contrast, a low survey effort bar or no data bar means a lack of data and, therefore, a lack of certainty about presence of the species. This list is not perfect; it is simply a starting point for identifying what birds of concern have the potential to be in your project area, when they might be there, and if they might be breeding (which means nests might be present). The list helps you know what to look for to confirm presence, and helps guide you in knowing when to implement conservation measures to avoid or minimize potential impacts from your project activities, should presence be confirmed. To learn more about conservation measures, visit the FAQ "Tell me about conservation measures I can implement to avoid or minimize impacts to migratory birds" at the bottom of your migratory bird trust resources page.

Facilities

National Wildlife Refuge lands

Any activity proposed on lands managed by the National Wildlife Refuge system must undergo a 'Compatibility Determination' conducted by the Refuge. Please contact the individual Refuges to discuss any questions or concerns.

THERE ARE NO REFUGE LANDS AT THIS LOCATION.

Fish hatcheries

THERE ARE NO FISH HATCHERIES AT THIS LOCATION.

Wetlands in the National Wetlands Inventory

Impacts to NWI wetlands and other aquatic habitats may be subject to regulation under Section 404 of the Clean Water Act, or other State/Federal statutes.

For more information please contact the Regulatory Program of the local U.S. Army Corps of Engineers District.

Please note that the NWI data being shown may be out of date. We are currently working to update our NWI data set. We recommend you verify these results with a site visit to determine the actual extent of wetlands on site.

This location overlaps the following wetlands:

FRESHWATER FORESTED/SHRUB WETLAND
 PSS1E

FRESHWATER POND
 PABF

A full description for each wetland code can be found at the National Wetlands Inventory website

Data limitations

The Service's objective of mapping wetlands and deepwater habitats is to produce reconnaissance level information on the location, type and size of these resources. The maps are prepared from the analysis of high altitude imagery. Wetlands are identified based on vegetation, visible hydrology and geography. A margin of error is inherent in the use of imagery; thus, detailed on-the-ground inspection of any particular site may result in revision of the wetland boundaries or classification established through image analysis.

The accuracy of image interpretation depends on the quality of the imagery, the experience of the image analysts, the amount and quality of the collateral data and the amount of ground truth verification work conducted. Metadata should be consulted to determine the date of the source imagery used and any mapping problems.

Wetlands or other mapped features may have changed since the date of the imagery or field work. There may be occasional differences in polygon boundaries or classifications between the information depicted on the map and the actual conditions on site.

Data exclusions

Certain wetland habitats are excluded from the National mapping program because of the limitations of aerial imagery as the primary data source used to detect wetlands. These habitats include seagrasses or submerged aquatic vegetation that are found in the intertidal and subtidal zones of estuaries and nearshore coastal waters. Some deepwater reef communities (coral or tuberficid worm reefs) have also been excluded from the inventory. These habitats, because of their depth, go undetected by aerial imagery.

Data precautions

Federal, state, and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, in either the design or products of this inventory, to define the limits of proprietary jurisdiction of any Federal, state, or local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate federal, state, or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities.

Attachment G

Cape Cod Canal IPaC Resource List

IPaC **U.S. Fish & Wildlife Service**

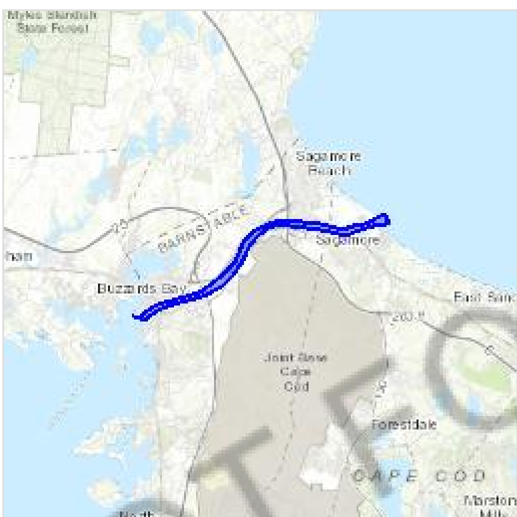
IPaC resource list

This report is an automatically generated list of species and other resources such as critical habitat (collectively referred to as *trust resources*) under the U.S. Fish and Wildlife Service's (USFWS) jurisdiction that are known or expected to be on or near the project area referenced below. The list may also include trust resources that occur outside of the project area, but that could potentially be directly or indirectly affected by activities in the project area. However, determining the likelihood and extent of effects a project may have on trust resources typically requires gathering additional site-specific (e.g., vegetation/species surveys) and project-specific (e.g., magnitude and timing of proposed activities) information.

Below is a summary of the project information you provided and contact information for the USFWS office(s) with jurisdiction in the defined project area. Please read the introduction to each section that follows (Endangered Species, Migratory Birds, USFWS Facilities, and NWI Wetlands) for additional information applicable to the trust resources addressed in that section.

Location

Barnstable County, Massachusetts



Local office

New England Ecological Services Field Office

(603) 223-2541
(603) 223-0104

70 Commercial Street, Suite 300
Concord, NH 03301-5094

http://www.fws.gov/newengland

Endangered species

This resource list is for informational purposes only and does not constitute an analysis of project level impacts.

The primary information used to generate this list is the known or expected range of each species. Additional areas of influence (AOI) for species are also considered. An AOI includes areas outside of the species range if the species could be indirectly affected by activities in that area (e.g., placing a dam upstream of a fish population, even if that fish does not occur at the dam site, may indirectly impact the species by reducing or eliminating water flow downstream). Because species can move, and site conditions can change, the species on this list are not guaranteed to be found on or near the project area. To fully determine any potential effects to species, additional site-specific and project-specific information is often required.

Section 7 of the Endangered Species Act **requires** Federal agencies to "request of the Secretary information whether any species which is listed or proposed to be listed may be present in the area of such proposed action" for any project that is conducted, permitted, funded, or licensed by any Federal agency. A letter from the local office and a species list which fulfills this requirement can **only** be obtained by requesting an official species list from either the Regulatory Review section in IPaC (see directions below) or from the local field office directly.

For project evaluations that require USFWS concurrence/review, please return to the IPaC website and request an official species list by doing the following:

1. Draw the project location and click CONTINUE.
2. Click DEFINE PROJECT.
3. Log in (if directed to do so).
4. Provide a name and description for your project.
5. Click REQUEST SPECIES LIST.

Listed species[1] and their critical habitats are managed by the Ecological Services Program of the U.S. Fish and Wildlife Service (USFWS) and the fisheries division of the National Oceanic and Atmospheric Administration (NOAA Fisheries[2]).

Species and critical habitats under the sole responsibility of NOAA Fisheries are **not** shown on this list. Please contact NOAA Fisheries for species under their jurisdiction.

1. Species listed under the Endangered Species Act are threatened or endangered; IPaC also shows species that are candidates, or proposed, for listing. See the listing status page for more information.
2. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

The following species are potentially affected by activities in this location:

Mammals

NAME	STATUS
Northern Long-eared Bat Myotis septentrionalis No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/9045	Threatened

Birds

NAME	STATUS
Piping Plover Charadrius melodus There is **final** critical habitat for this species. Your location is outside the critical habitat. https://ecos.fws.gov/ecp/species/6039	Threatened
Red Knot Calidris canutus rufa No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/1864	Threatened
Roseate Tern Sterna dougallii dougallii No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/2083	Endangered

Reptiles

NAME	STATUS

Plymouth Redbelly Turtle *Pseudemys rubriventris bangsi* There is **final** critical habitat for this species. Your location is outside the critical habitat. https://ecos.fws.gov/ecp/species/451	Endangered

Flowering Plants

NAME	STATUS
American Chaffseed *Schwalbea americana* No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/1286	Endangered

Critical habitats

Potential effects to critical habitat(s) in this location must be analyzed along with the endangered species themselves.

THERE ARE NO CRITICAL HABITATS AT THIS LOCATION.

Migratory birds

Certain birds are protected under the Migratory Bird Treaty Act[1] and the Bald and Golden Eagle Protection Act[2].

Any person or organization who plans or conducts activities that may result in impacts to migratory birds, eagles, and their habitats should follow appropriate regulations and consider implementing appropriate conservation measures, as described below.

1. The Migratory Birds Treaty Act of 1918.
2. The Bald and Golden Eagle Protection Act of 1940.

Additional information can be found using the following links:

- Birds of Conservation Concern http://www.fws.gov/birds/management/managed-species/birds-of-conservation-concern.php
- Measures for avoiding and minimizing impacts to birds http://www.fws.gov/birds/management/project-assessment-tools-and-guidance/conservation-measures.php
- Nationwide conservation measures for birds http://www.fws.gov/migratorybirds/pdf/management/nationwidestandardconservationmeasures.pdf

The birds listed below are birds of particular concern either because they occur on the USFWS Birds of Conservation Concern (BCC) list or warrant special attention in your project location. To learn more about the levels of concern for birds on your list and how this list is generated, see the FAQ below. This is not a list of every bird you may find in this location, nor a guarantee that every bird on this list will be found in your project area. To see exact locations of where birders and the general public have sighted birds in and around your project area, visit the E-bird data mapping tool (Tip: enter your location, desired date range and a species on your list). For projects that occur off the Atlantic Coast, additional maps and models detailing the relative occurrence and abundance of bird species on your list are available. Links to additional information about Atlantic Coast birds, and other important information about your migratory bird list, including how to properly interpret and use your migratory bird report, can be found below.

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, click on the PROBABILITY OF PRESENCE SUMMARY at the top of your list to see when these birds are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON (IF A BREEDING SEASON IS INDICATED FOR A BIRD ON YOUR LIST, THE BIRD MAY BREED IN YOUR PROJECT AREA SOMETIME WITHIN THE TIMEFRAME SPECIFIED, WHICH IS A VERY LIBERAL ESTIMATE OF THE DATES INSIDE WHICH THE BIRD BREEDS ACROSS ITS ENTIRE RANGE. "BREEDS ELSEWHERE" INDICATES THAT THE BIRD DOES NOT LIKELY BREED IN YOUR PROJECT AREA.)

American Oystercatcher Haematopus palliatus — Breeds Apr 15 to Aug 31

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.
https://ecos.fws.gov/ecp/species/8935

Bald Eagle Haliaeetus leucocephalus — Breeds Oct 15 to Aug 31

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.
https://ecos.fws.gov/ecp/species/1626

Black Guillemot Cepphus grylle — Breeds May 15 to Sep 10

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Black Scoter Melanitta nigra — Breeds elsewhere

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Black-billed Cuckoo Coccyzus erythropthalmus — Breeds May 15 to Oct 10

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.
https://ecos.fws.gov/ecp/species/9399

Black-legged Kittiwake Rissa tridactyla — Breeds elsewhere

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Bobolink Dolichonyx oryzivorus — Breeds May 20 to Jul 31

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Bonaparte's Gull Chroicocephalus philadelphia — Breeds elsewhere

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Common Eider Somateria mollissima — Breeds Jun 1 to Sep 30

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Common Loon gavia immer — Breeds Apr 15 to Oct 31

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.
https://ecos.fws.gov/ecp/species/4464

Common Murre Uria aalge — Breeds Apr 15 to Aug 15

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Common Tern Sterna hirundo — Breeds May 10 to Sep 10

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.
https://ecos.fws.gov/ecp/species/4963

Cory's Shearwater *Calonectris diomedea* — Breeds elsewhere

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Double-crested Cormorant *phalacrocorax auritus* — Breeds Apr 20 to Aug 31

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.
https://ecos.fws.gov/ecp/species/3478

Dovekie *Alle alle* — Breeds elsewhere

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.
https://ecos.fws.gov/ecp/species/6041

Dunlin *Calidris alpina arcticola* — Breeds elsewhere

This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA

Eastern Whip-poor-will *Antrostomus vociferus* — Breeds May 1 to Aug 20

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Great Black-backed Gull *Larus marinus* — Breeds Apr 15 to Aug 20

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Great Shearwater *Puffinus gravis* — Breeds elsewhere

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Herring Gull *Larus argentatus* — Breeds Apr 20 to Aug 31

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Leach's Storm-petrel *Oceanodroma leucorhoa* — Breeds May 15 to Nov 20

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Least Tern *Sterna antillarum* — Breeds Apr 20 to Sep 10

This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA

Lesser Yellowlegs *Tringa flavipes* — Breeds elsewhere

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.
https://ecos.fws.gov/ecp/species/9679

Long-tailed Duck *Clangula hyemalis* — Breeds elsewhere

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.
https://ecos.fws.gov/ecp/species/7238

Manx Shearwater Puffinus puffinus — Breeds Apr 15 to Oct 31

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Nelson's Sparrow Ammodramus nelsoni — Breeds May 15 to Sep 5

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Northern Fulmar Fulmarus glacialis — Breeds elsewhere

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Northern Gannet Morus bassanus — Breeds elsewhere

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Parasitic Jaeger Stercorarius parasiticus — Breeds elsewhere

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Prairie Warbler Dendroica discolor — Breeds May 1 to Jul 31

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Purple Sandpiper Calidris maritima — Breeds elsewhere

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Razorbill Alca torda — Breeds Jun 15 to Sep 10

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Red Phalarope Phalaropus fulicarius — Breeds elsewhere

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Red-breasted Merganser Mergus serrator — Breeds elsewhere

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Red-necked Phalarope Phalaropus lobatus — Breeds elsewhere

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Red-throated Loon Gavia stellata — Breeds elsewhere

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Ring-billed Gull Larus delawarensis — Breeds elsewhere

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Roseate Tern Sterna dougallii — Breeds May 10 to Aug 31

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Ruddy Turnstone Arenaria interpres morinella This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA	Breeds elsewhere
Rusty Blackbird Euphagus carolinus This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds elsewhere
Seaside Sparrow Ammodramus maritimus This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds May 10 to Aug 20
Semipalmated Sandpiper Calidris pusilla This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds elsewhere
Short-billed Dowitcher Limnodromus griseus This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9480	Breeds elsewhere
Snowy Owl Bubo scandiacus This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds elsewhere
Surf Scoter Melanitta perspicillata This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.	Breeds elsewhere

Thick-billed Murre Uria lomvia — Breeds Apr 15 to Aug 15

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Whimbrel Numenius phaeopus — Breeds elsewhere

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.
https://ecos.fws.gov/ecp/species/9483

White-winged Scoter Melanitta fusca — Breeds elsewhere

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Willet Tringa semipalmata — Breeds Apr 20 to Aug 5

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Wilson's Storm-petrel Oceanites oceanicus — Breeds elsewhere

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

Wood Thrush Hylocichla mustelina — Breeds May 10 to Aug 31

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Probability of Presence Summary

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read and understand the FAQ “Proper Interpretation and Use of Your Migratory Bird Report” before using or attempting to interpret this report.

Probability of Presence (■)

Each green bar represents the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during a particular week of the year. (A year is represented as 12 4-week months.) A taller bar indicates a higher probability of species presence. The survey effort (see below) can be used to establish a level of confidence in the presence score. One can have higher confidence in the presence score if the corresponding survey effort is also high.

How is the probability of presence score calculated? The calculation is done in three steps:

1. The probability of presence for each week is calculated as the number of survey events in the week where the species was detected divided by the total number of survey events for that week. For example, if in week 12 there were 20 survey events and the Spotted Towhee was found in 5 of them, the probability of presence of the Spotted Towhee in week 12 is 0.25.
2. To properly present the pattern of presence across the year, the relative probability of presence is calculated. This is the probability of presence divided by the maximum probability of presence across all weeks. For example, imagine the probability of presence in week 20 for the Spotted Towhee is 0.05, and that the probability of presence at week 12 (0.25) is the maximum of any week of the year. The relative probability of presence on week 12 is 0.25/0.25 = 1; at week 20 it is 0.05/0.25 = 0.2.
3. The relative probability of presence calculated in the previous step undergoes a statistical conversion so that all possible values fall between 0 and 10, inclusive. This is the probability of presence score.

To see a bar's probability of presence score, simply hover your mouse cursor over the bar.

Breeding Season (■)
Yellow bars denote a very liberal estimate of the time-frame inside which the bird breeds across its entire range. If there are no yellow bars shown for a bird, it does not breed in your project area.

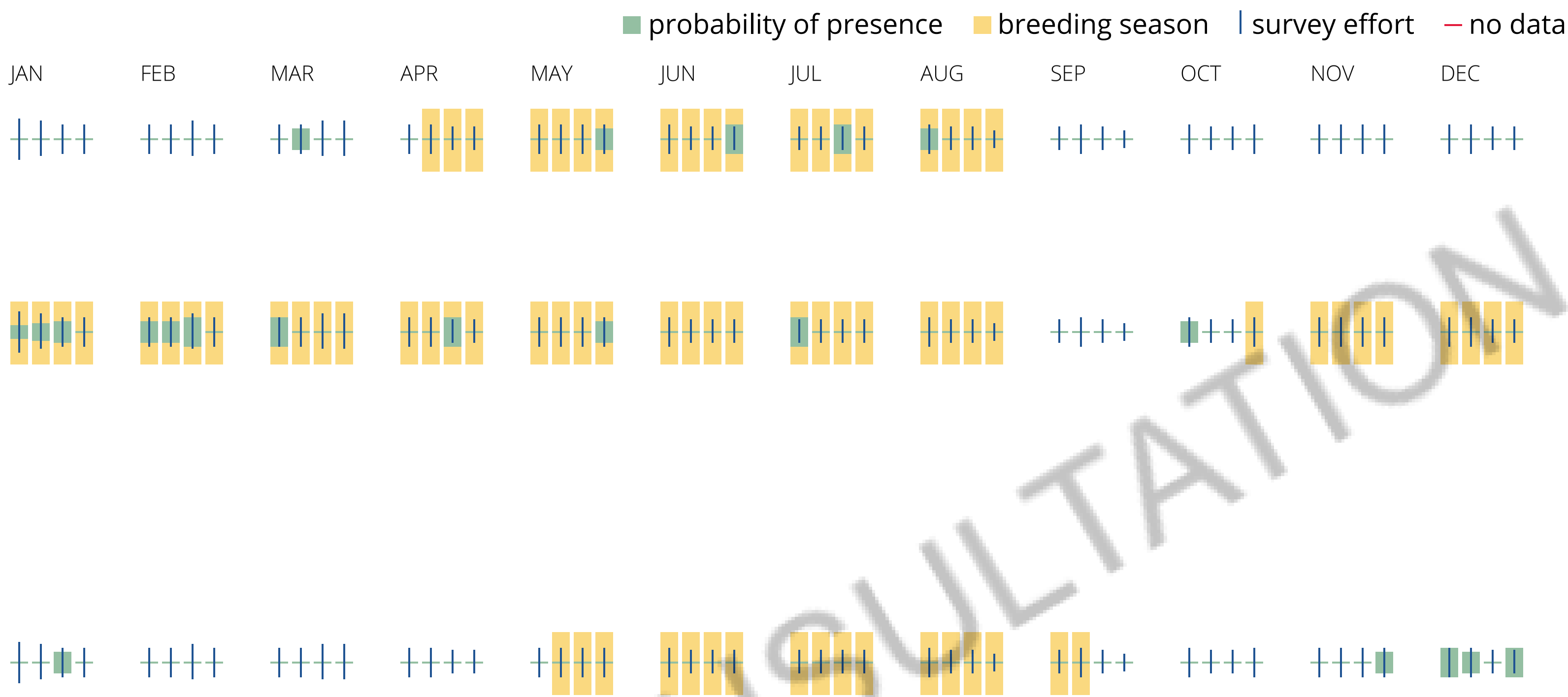
Survey Effort (|)
Vertical black lines superimposed on probability of presence bars indicate the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps. The number of surveys is expressed as a range, for example, 33 to 64 surveys.

To see a bar's survey effort range, simply hover your mouse cursor over the bar.

No Data (–)
A week is marked as having no data if there were no survey events for that week.

Survey Timeframe

Surveys from only the last 10 years are used in order to ensure delivery of currently relevant information. The exception to this is areas off the Atlantic coast, where bird returns are based on all years of available data, since data in these areas is currently much more sparse.

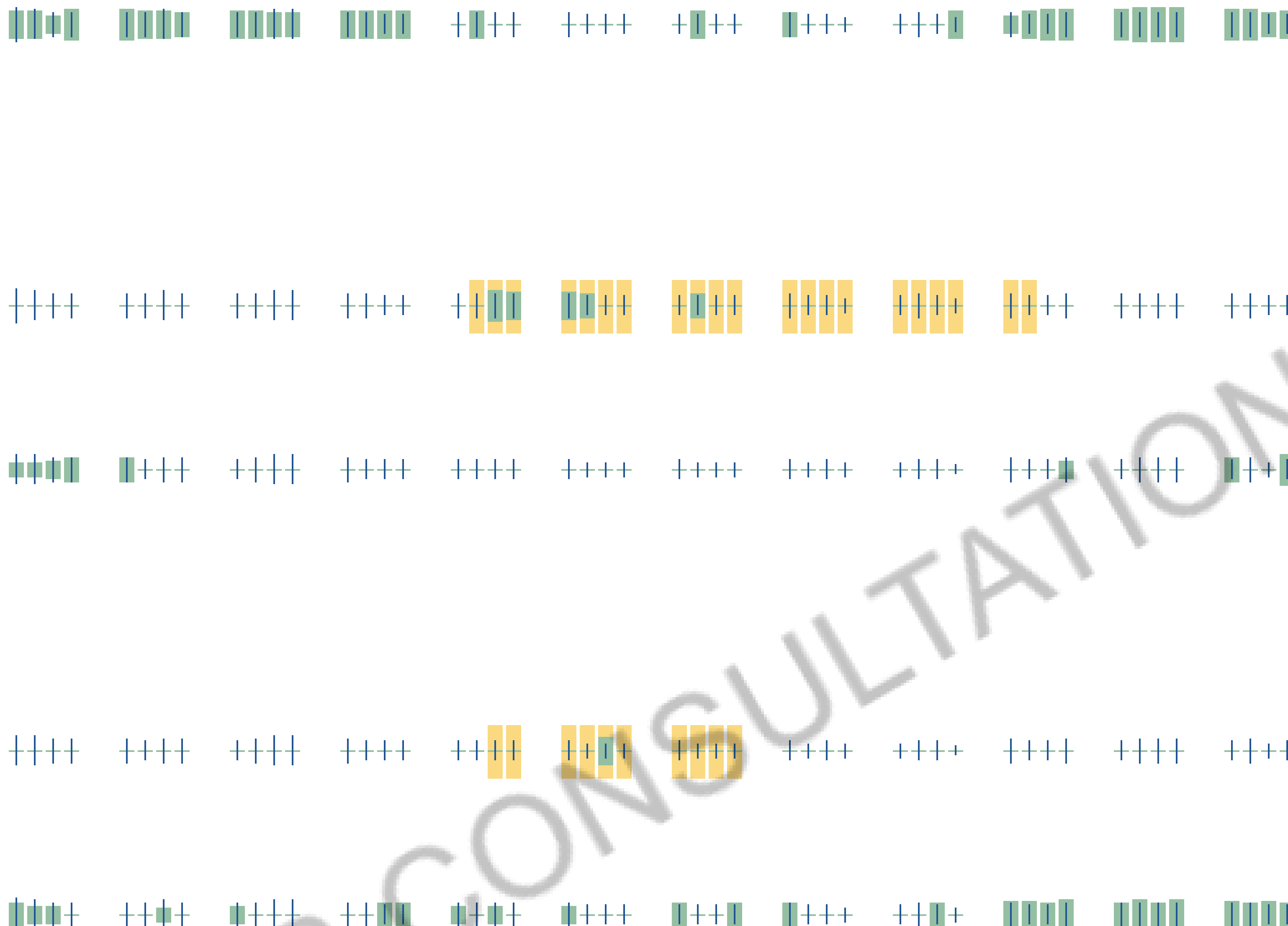


SPECIES

American Oystercatcher
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Bald Eagle
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Black Guillemot
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)



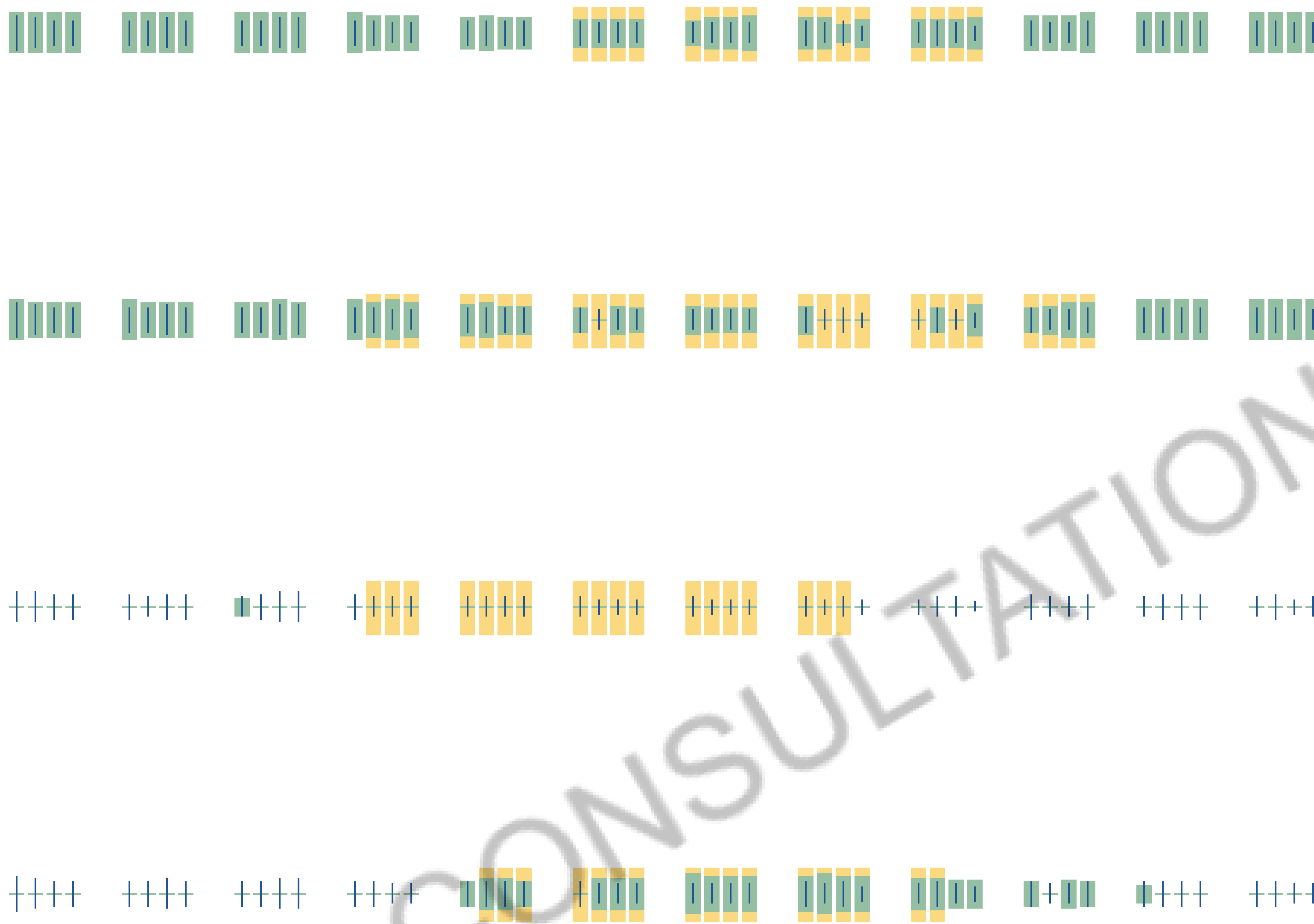
Black Scoter
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Black-billed Cuckoo
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Black-legged Kittiwake
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Bobolink
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Bonaparte's Gull
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)



Common Eider
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Common Loon
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Common Murre
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Common Tern
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

SPECIES JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Cory's Shearwater
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

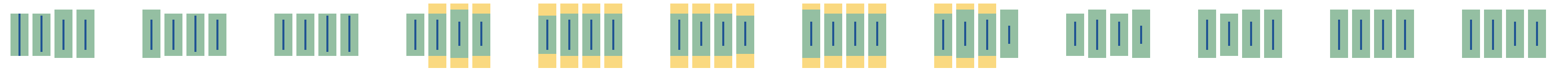
Double-crested Cormorant
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Dovekie
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Dunlin
BCC - BCR (This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA)

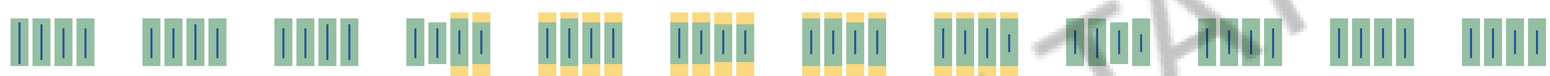
Eastern Whip-poor-will
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Great Black-backed Gull
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

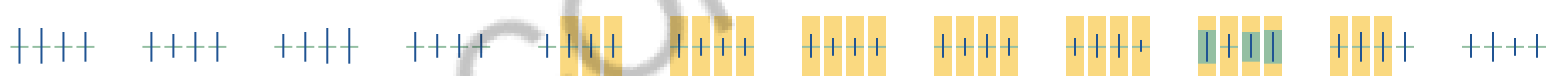


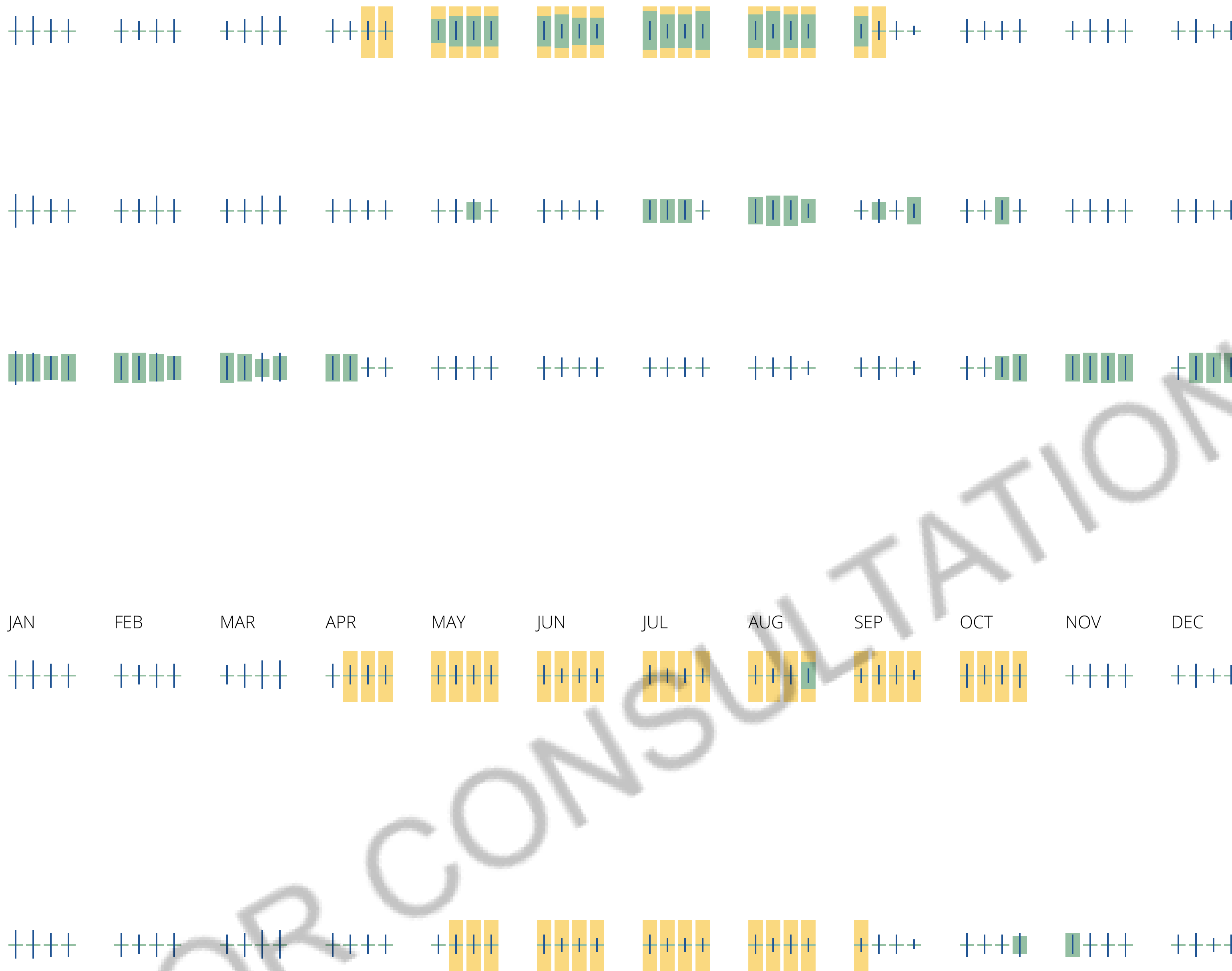
Great Shearwater
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Herring Gull
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)



Leach's Storm-petrel
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)





Least Tern
BCC - BCR (This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA)

Lesser Yellowlegs
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Long-tailed Duck
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Manx Shearwater
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Nelson's Sparrow
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

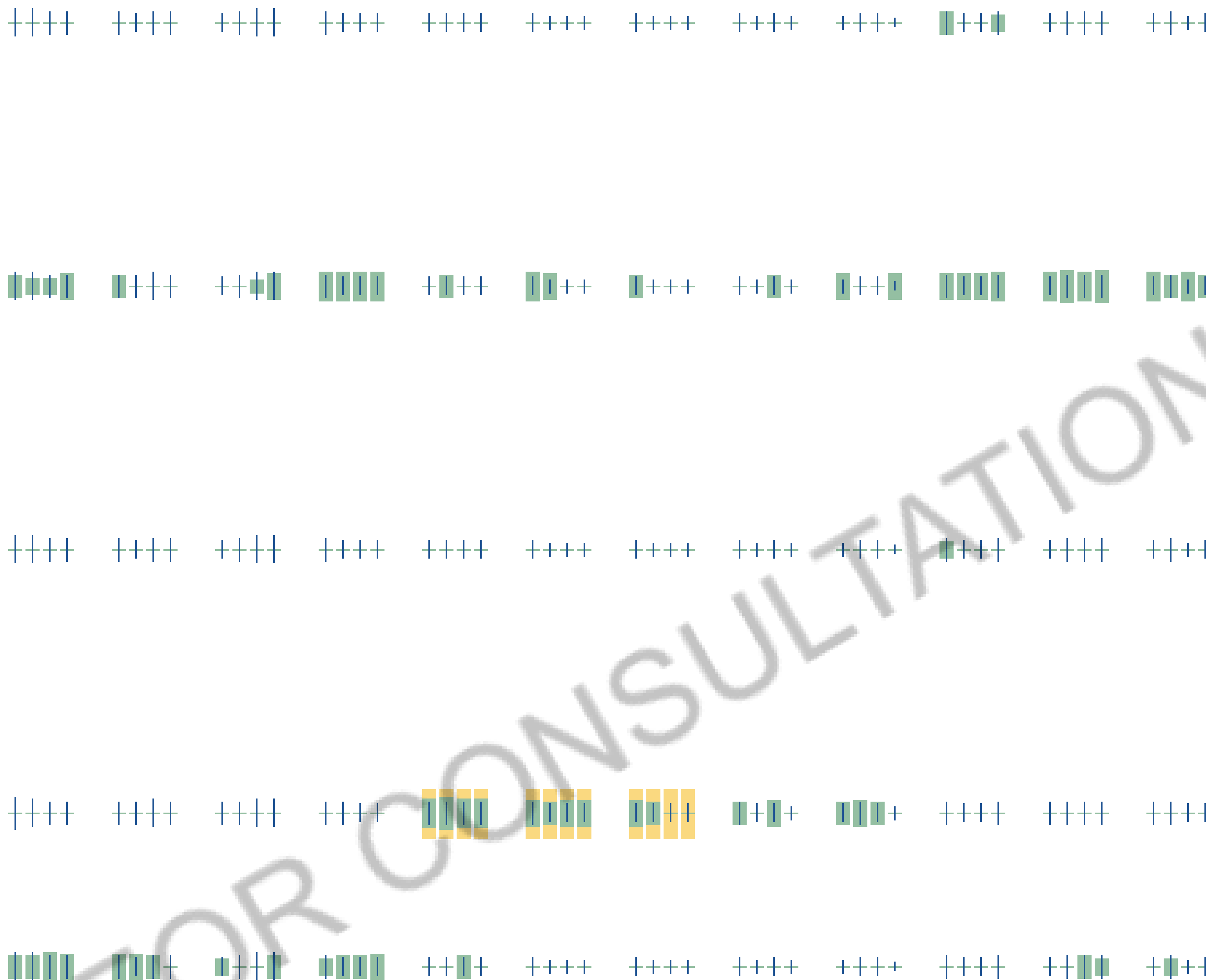
Northern Fulmar
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Northern Gannet
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

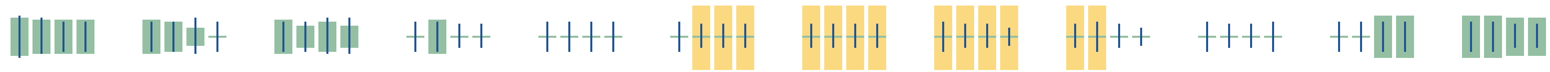
Parasitic Jaeger
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Prairie Warbler
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Purple Sandpiper
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)



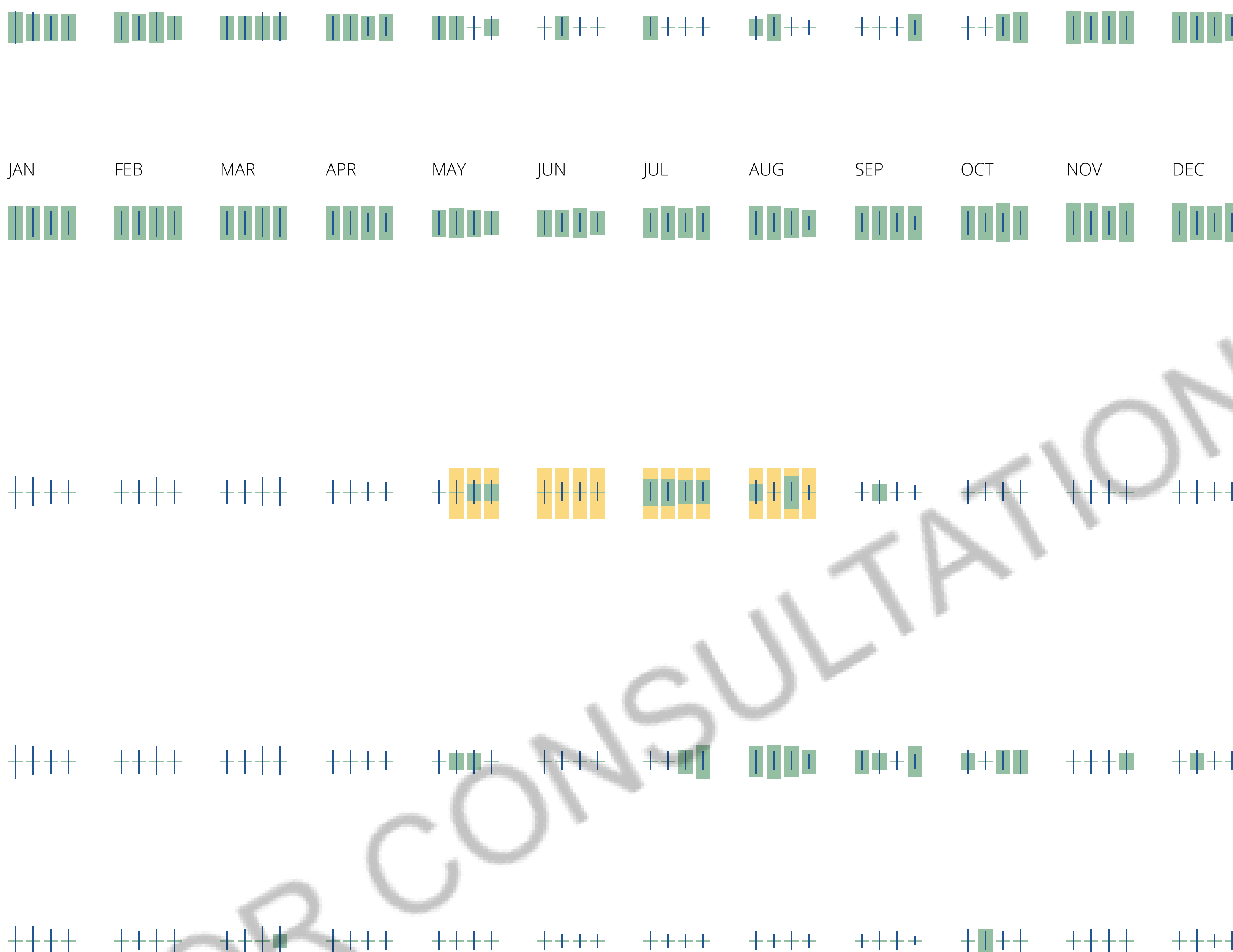
Razorbill
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)



Red Phalarope
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Red-breasted Merganser
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Red-necked Phalarope
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)



Red-throated Loon
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Ring-billed Gull
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Roseate Tern
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Ruddy Turnstone
BCC - BCR (This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA)

Rusty Blackbird
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

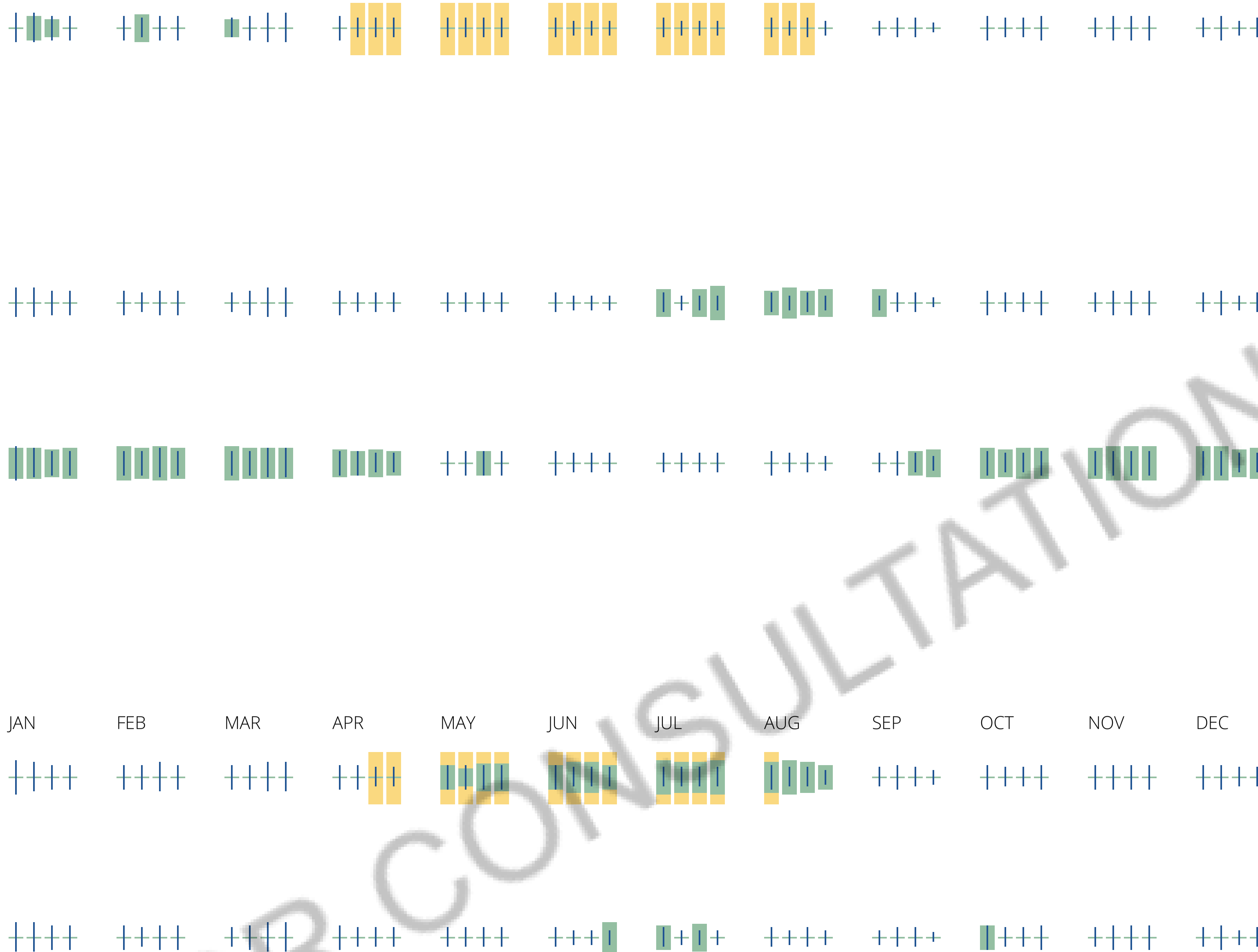
Seaside Sparrow
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Semipalmated Sandpiper
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Short-billed Dowitcher
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Snowy Owl
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Surf Scoter
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)



Thick-billed Murre
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Whimbrel
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

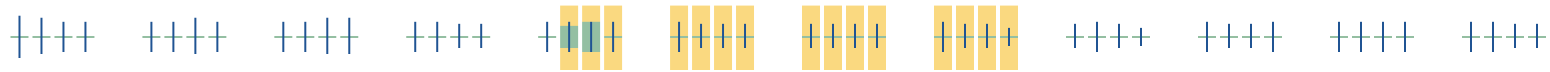
White-winged Scoter
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

SPECIES

Willet
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Wilson's Storm-petrel
Non-BCC Vulnerable (This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.)

Wood Thrush
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)



Tell me more about conservation measures I can implement to avoid or minimize impacts to migratory birds.

Nationwide Conservation Measures describes measures that can help avoid and minimize impacts to all birds at any location year round. Implementation of these measures is particularly important when birds are most likely to occur in the project area. When birds may be breeding in the area, identifying the locations of any active nests and avoiding their destruction is a very helpful impact minimization measure. To see when birds are most likely to occur and be breeding in your project area, view the Probability of Presence Summary. Additional measures and/or permits may be advisable depending on the type of activity you are conducting and the type of infrastructure or bird species present on your project site.

What does IPaC use to generate the migratory birds potentially occurring in my specified location?

The Migratory Bird Resource List is comprised of USFWS Birds of Conservation Concern (BCC) and other species that may warrant special attention in your project location.

The migratory bird list generated for your project is derived from data provided by the Avian Knowledge Network (AKN). The AKN data is based on a growing collection of survey, banding, and citizen science datasets and is queried and filtered to return a list of those birds reported as occurring in the 10km grid cell(s) which your project intersects, and that have been identified as warranting special attention because they are a BCC species in that area, an eagle (Eagle Act requirements may apply), or a species that has a particular vulnerability to offshore activities or development.

Again, the Migratory Bird Resource list includes only a subset of birds that may occur in your project area. It is not representative of all birds that may occur in your project area. To get a list of all birds potentially present in your project area, please visit the AKN Phenology Tool.

What does IPaC use to generate the probability of presence graphs for the migratory birds potentially occurring in my specified location?

The probability of presence graphs associated with your migratory bird list are based on data provided by the Avian Knowledge Network (AKN). This data is derived from a growing collection of survey, banding, and citizen science datasets .

Probability of presence data is continuously being updated as new and better information becomes available. To learn more about how the probability of presence graphs are produced and how to interpret them, go the Probability of Presence Summary and then click on the "Tell me about these graphs" link.

How do I know if a bird is breeding, wintering, migrating or present year-round in my project area?

To see what part of a particular bird's range your project area falls within (i.e. breeding, wintering, migrating or year-round), you may refer to the following resources: The Cornell Lab of Ornithology All About Birds Bird Guide, or (if you are unsuccessful in locating the bird of interest there), the Cornell Lab of Ornithology Neotropical Birds guide. If a bird on your migratory bird species list has a breeding season associated with it, if that bird does occur in your project area, there may be nests present at some point within the timeframe specified. If "Breeds elsewhere" is indicated, then the bird likely does not breed in your project area.

What are the levels of concern for migratory birds?

Migratory birds delivered through IPaC fall into the following distinct categories of concern:

1. "BCC Rangewide" birds are Birds of Conservation Concern (BCC) that are of concern throughout their range anywhere within the USA (including Hawaii, the Pacific Islands, Puerto Rico, and the Virgin Islands);
2. "BCC - BCR" birds are BCCs that are of concern only in particular Bird Conservation Regions (BCRs) in the continental USA; and
3. "Non-BCC - Vulnerable" birds are not BCC species in your project area, but appear on your list either because of the Eagle Act requirements (for eagles) or (for non-eagles) potential susceptibilities in offshore areas from certain types of development or activities (e.g. offshore energy development or longline fishing).

Although it is important to try to avoid and minimize impacts to all birds, efforts should be made, in particular, to avoid and minimize impacts to the birds on this list, especially eagles and BCC species of rangewide concern. For more information on conservation measures you can implement to help avoid and minimize migratory bird impacts and requirements for eagles, please see the FAQs for these topics.

Details about birds that are potentially affected by offshore projects

For additional details about the relative occurrence and abundance of both individual bird species and groups of bird species within your project area off the Atlantic Coast, please visit the Northeast Ocean Data Portal. The Portal also offers data and information about other taxa besides birds that may be helpful to you in your project review. Alternately, you may download the bird model results files underlying the portal maps through the NOAA NCCOS Integrative Statistical Modeling and Predictive Mapping of Marine Bird Distributions and Abundance on the Atlantic Outer Continental Shelf project webpage.

Bird tracking data can also provide additional details about occurrence and habitat use throughout the year, including migration. Models relying on survey data may not include this information. For additional information on marine bird tracking data, see the Diving Bird Study and the nanotag studies or contact Caleb Spiegel or Pam Loring.

What if I have eagles on my list?

If your project has the potential to disturb or kill eagles, you may need to obtain a permit to avoid violating the Eagle Act should such impacts occur.

Proper Interpretation and Use of Your Migratory Bird Report

The migratory bird list generated is not a list of all birds in your project area, only a subset of birds of priority concern. To learn more about how your list is generated, and see options for identifying what other birds may be in your project area, please see the FAQ "What does IPaC use to generate the migratory birds potentially occurring in my specified location". Please be aware this report provides the "probability of presence" of birds within the 10 km grid cell(s) that overlap your project; not your exact project footprint. On the graphs provided, please also look carefully at the survey effort (indicated by the black vertical bar) and for the existence of the "no data" indicator (a red horizontal bar). A high survey effort is the key component. If the survey effort is high, then the probability of presence score can be viewed as more dependable. In contrast, a low survey effort bar or no data bar means a lack of data and, therefore, a lack of certainty about presence of the species. This list is not perfect; it is simply a starting point for identifying what birds of concern have the potential to be in your project area, when they might be there, and if they might be breeding (which means nests might be present). The list helps you know what to look for to confirm presence, and helps guide you in knowing when to implement conservation measures to avoid or minimize potential impacts from your project activities, should presence be confirmed. To learn more about conservation measures, visit the FAQ "Tell me about conservation measures I can implement to avoid or minimize impacts to migratory birds" at the bottom of your migratory bird trust resources page.

Facilities

National Wildlife Refuge lands

Any activity proposed on lands managed by the National Wildlife Refuge system must undergo a 'Compatibility Determination' conducted by the Refuge. Please contact the individual Refuges to discuss any questions or concerns.

THERE ARE NO REFUGE LANDS AT THIS LOCATION.

Fish hatcheries

THERE ARE NO FISH HATCHERIES AT THIS LOCATION.

Wetlands in the National Wetlands Inventory

Impacts to NWI wetlands and other aquatic habitats may be subject to regulation under Section 404 of the Clean Water Act, or other State/Federal statutes.

For more information please contact the Regulatory Program of the local U.S. Army Corps of Engineers District.

Please note that the NWI data being shown may be out of date. We are currently working to update our NWI data set. We recommend you verify these results with a site visit to determine the actual extent of wetlands on site.

This location overlaps the following wetlands:

ESTUARINE AND MARINE DEEPWATER

- M1UBL
- E1UBLx

ESTUARINE AND MARINE WETLAND

- M2USP
- M2USM
- E2USN
- M2ABM

FRESHWATER FORESTED/SHRUB WETLAND

- PFO1E
- PFO1/4E
- PSS1E

RIVERINE

- R5UBH

A full description for each wetland code can be found at the National Wetlands Inventory website

Data limitations

The Service's objective of mapping wetlands and deepwater habitats is to produce reconnaissance level information on the location, type and size of these resources. The maps are prepared from the analysis of high altitude imagery. Wetlands are identified based on vegetation, visible hydrology and geography. A margin of error is inherent in the use of imagery; thus, detailed on-the-ground inspection of any particular site may result in revision of the wetland boundaries or classification established through image analysis.

The accuracy of image interpretation depends on the quality of the imagery, the experience of the image analysts, the amount and quality of the collateral data and the amount of ground truth verification work conducted. Metadata should be consulted to determine the date of the source imagery used and any mapping problems.

Wetlands or other mapped features may have changed since the date of the imagery or field work. There may be occasional differences in polygon boundaries or classifications between the information depicted on the map and the actual conditions on site.

Data exclusions

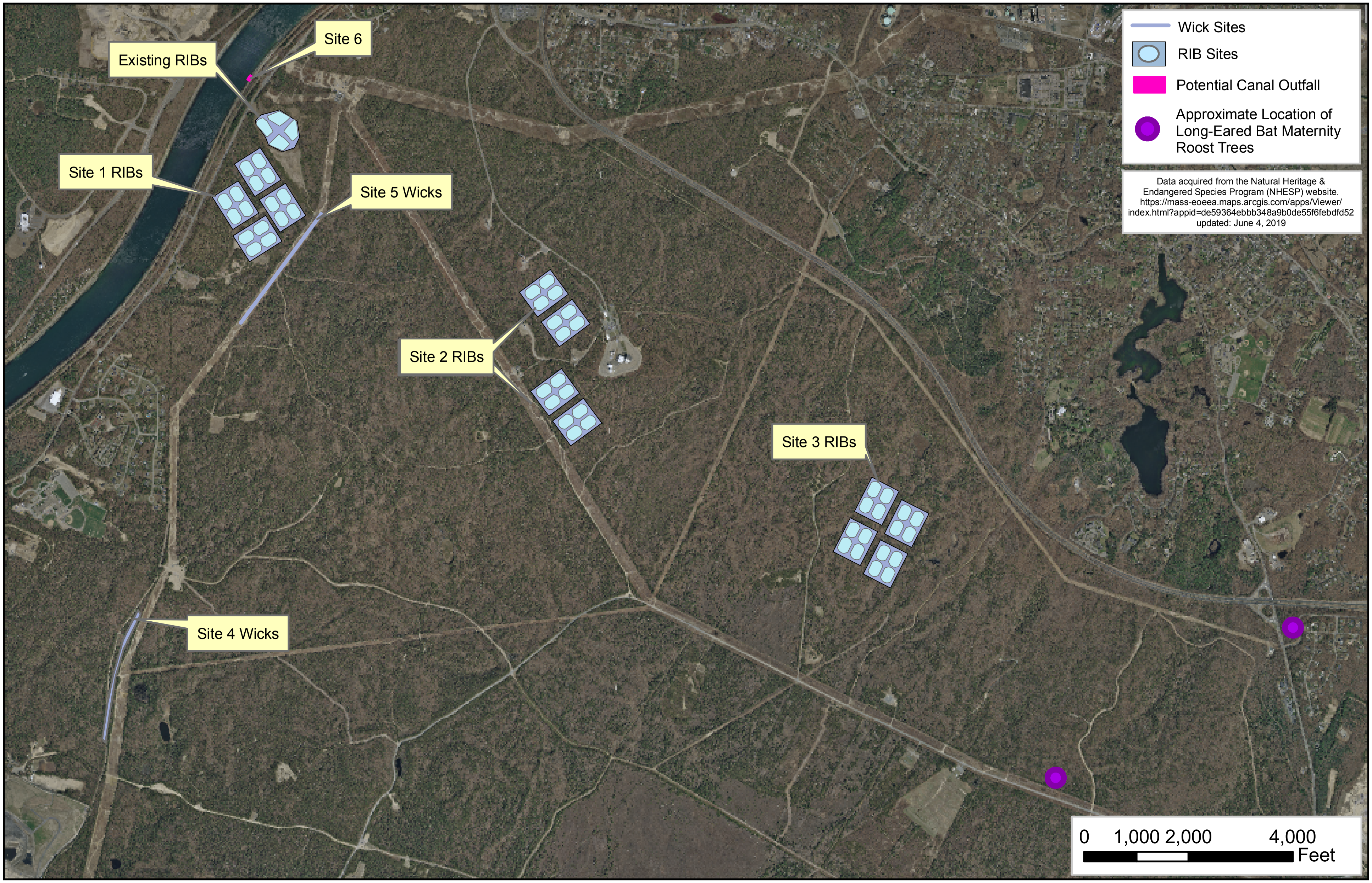
Certain wetland habitats are excluded from the National mapping program because of the limitations of aerial imagery as the primary data source used to detect wetlands. These habitats include seagrasses or submerged aquatic vegetation that are found in the intertidal and subtidal zones of estuaries and nearshore coastal waters. Some deepwater reef communities (coral or tuberficid worm reefs) have also been excluded from the inventory. These habitats, because of their depth, go undetected by aerial imagery.

Data precautions

Federal, state, and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, in either the design or products of this inventory, to define the limits of proprietary jurisdiction of any Federal, state, or local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate federal, state, or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities.

Attachment H

NLEB Map



LEC Environmental Consultants, Inc.
Plymouth, MA
508.746.9491
www.lecenvironmental.com

NLEB Map

Shared Wastewater Management Study
Joint Base Cape Cod
Bourne, Massachusetts

N

June 19, 2019

APPENDIX F
Supplemental Materials – Massachusetts DEP

MassDEP

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

Southeast Regional Office • 20 Riverside Drive, Lakeville MA 02347 • 508-946-2700

May 29, 2019

Mr. Michael Giggey
Wright-Pierce
11 Bowdoin Mill Island
Suite 140
Topsham, ME 04086

RE: BOURNE - Wastewater Regionalization for Joint Base Cape Cod

Dear Mr. Giggey:

MassDEP appreciated the opportunity to participate in the JBCC wastewater regionalization meeting on May 9, 2019. It is clear that there is significant interest from Barnstable, Bourne, Falmouth, Mashpee, Sandwich and JBBC in advancing the development of a community partnership utilizing existing and expanded infrastructure at JBCC.

While the meeting primarily focused on wastewater effluent recharge and disposal options at this time, MassDEP thanks you for devoting ample time to discuss issues that could either advance or limit this partnership effort. At the meeting, the communities that participated in the strategic discussion stressed that unless MassDEP agrees in principle that there is a recharge and disposal capacity for the approximately 8 million gallon per day (MGD) short term peak flow, the towns may not be able to commit any available funds to allow the partnership to move forward.

MassDEP staff listened intently to the presentation that your consulting firm, Wright-Pierce, offered on May 9th, including discussion of the reviewed recharge and disposal options and their proposed locations. This presentation was also offered to pertinent state and federal review agencies and interested parties. While some concerns were raised about details offered for some of the proposed options, no insurmountable objections seemed to be voiced.

Based on the presentation and subsequent technical discussions, MassDEP is of the opinion that either through a single effluent recharge or disposal option or a combination of the several options discussed on May 9th, there will be sufficient capacity to accommodate the projected short term peak effluent flow.

MassDEP hopes that this letter provides sufficient assurances to all involved parties that we have given this technical question a level of analysis deemed as substantive and meaningful planning and as such, our region is confident that next additional steps should proceed in order to forward and advance this important regional wastewater management effort.

If you have any questions, please feel free to contact me at (508) 946-2727 or Brian Dudley at (508) 946-2814.

Very truly yours,

Millie Garcia-Serrano, Regional Director

ecc: Town of Barnstable
Attn.: Mark Ells
Andrew Clyburn

Town of Bourne
Attn: Thomas Guerino

Town of Falmouth
Attn: Julian Suso
Raymond Jack

Town of Mashpee
Attn: Rodney Collins
Andrew Gottlieb

Town of Sandwich
Attn: George Dunham
David Mason

JBCC
Attn: Col. Virginia Gaglio
Col. Christopher Hurley

Wright-Pierce
Attn: Ed Leonard

MassDEP/Boston
Attn: Gary Moran
Bruce Bouck

MassDEP/SERO
Attn: David Johnston
Len Pinaud
Brian Dudley

MassDEP
Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

Southeast Regional Office • 20 Riverside Drive, Lakeville MA 02347 • 508-946-2700

Charles D. Baker
Governor

Karyn E. Polito
Lieutenant Governor

Matthew A. Beaton
Secretary

Martin Suuberg
Commissioner

May 21, 2018

Thurman Deane
102nd Intelligence Wing
156 Reilly Street, Box 46
Otis Air National Guard Base, MA 02542

RE: SANDWICH: BRPWP12, Otis ANG Base Wastewater Treatment Facility, Otis Air National Guard Base.
Permit No.: 41 - 4
Transmittal No. X276582

Dear Mr. Deane:

In response to your application for a permit to discharge into the ground a treated effluent from the treatment works at the above referenced location and after due public notice, I hereby issue the attached final permit.

Since no comments were received by the Department during the public comment period related to the terms of the permit, in accordance with 310 CMR 2.08, the permit becomes effective at issuance.

Parties aggrieved by the issuance of this permit are hereby advised of their right to request an Adjudicatory Hearing under the provisions of Chapter 30A of the Massachusetts General Laws and 314 CMR 1.00, Rules for the Conduct of Adjudicatory Proceedings. Unless the person requesting the adjudicatory hearing requests and is granted a stay of the terms and conditions of the permit, the permit shall remain fully effective.

If you should have any questions on any information provided with this letter please contact Christos Dimisioris at (508) 946-2736.

Sincerely,

Brian A. Dudley
Bureau of Water Resources

D/CD/
Enclosure

cc: David B. Mason
Sandwich Board of Health
16 Jan Sebastian Drive
Sandwich, Massachusetts 02563
(with enclosure)

Terri Guarino
Bourne Board of Health
24 Perry Avenue, Buzzards Bay
Bourne, Massachusetts 02532
(with enclosure)

Glen Harrington
Mashpee Board of Health
16 Great Neck Road North
Mashpee, Massachusetts 02649
(with enclosure)

David Carignan
Falmouth Health Department
59 Town Hall Square
Falmouth, Massachusetts 02540
(with enclosure)

ecc: DEP/Boston
DEP/SERO: Cheryl Bump

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MassDEP

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

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Secretary

Martin Suuberg
Commissioner

Individual Groundwater Discharge Permit
Fact Sheet

I. APPLICANT, FACILITY INFORMATION, and DISCHARGE LOCATION

Name and Address of Applicant:

102nd Intelligence Wing, 156 Reilly Street, Box 46, Otis Air National Guard Base, Massachusetts 02542

Name and Address of Facility where discharge occurs:

971 South Outer Road, Otis Air National Guard Base, MA 02542

Discharge Information:

Groundwater Discharge Permit Number: 41 - 4

The Groundwater Discharge Permit will allow the applicant to continue to discharge 12 month moving average flow 360,000 gallons per day of treated sanitary wastewater with a Maximum Day Flow 840,000 gallons per day to groundwaters of the Commonwealth. The discharge is not located in a sensitive area such as a Zone II wellhead protection area of a public water supply.

II. LIMITATIONS AND CONDITIONS

Discharge permit limitations are as listed in the ground water permit and are in conformance with 314 CMR 5.00, the Groundwater Discharge Permit Program.

III. PERMIT BASIS AND EXPLANATION OF EFFLUENT LIMITATIONS

An Individual Groundwater Discharge permit is required for this discharge in accordance with the Massachusetts Clean Water Act, M.G.L. c. 21, s. 26-53 and 314 CMR 5.03.

Effluent limitations are based upon the location of the discharge, the level of treatment, consideration of human health protection criteria and protection of the groundwaters of the Commonwealth.

IV. COMMENT PERIOD, HEARING REQUESTS, AND PROCEDURES FOR FINAL DECISIONS

The public comment period for this permit is thirty (30) days following public notice in *The Environmental Monitor.* The public notice for this Individual Groundwater Discharge Permit occurred on April 11, 2018..

Requests for an adjudicatory hearing must be submitted within thirty (30) days of the issuance/denial of the permit, by any person who is aggrieved by such issuance/denial.

A final decision on the issuance/denial of this permit will be made after the public notice period, and review of any comments received during this period.

V. STATE CONTACT INFORMATION

Additional information concerning the draft permit may be obtained between the hours of 9:00 a.m. and 5:00 p.m. Monday through Friday excluding holidays, from:

Christos Dimisioris
DEP /SERO
20 Riverside Drive
Lakeville, MA 02347
(508) 946-2736

[signature]
Brian A. Dudley
Bureau of Water Resources

May 21, 2018
Date

P:\12\41 - 4 - Sandwich - Otis Air National Guard Fact Sheet.docx

MassDEP

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Executive Office of Energy & Environmental Affairs

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Secretary

Martin Suuberg
Commissioner

INDIVIDUAL GROUNDWATER DISCHARGE PERMIT

Name and Address of Applicant: ***102nd Intelligence Wing, 156 Reilly Street, Box 46, Otis Air National Guard Base, Massachusetts 02542.***

Date of Application:	***November 17, 2017***
Application/Permit No.	***41 - 4***
Date of Issuance:	***May 21, 2018***
Date of Expiration:	***May 21, 2023***
Effective Date:	***May 21, 2018***

AUTHORITY FOR ISSUANCE

Pursuant to authority granted by Chapter 21, Sections 26-53 of the Massachusetts General Laws, as amended, 314 CMR 2.00, and 314 CMR 5.00, the Massachusetts Department of Environmental Protection (the Department or MassDEP) hereby issues the following permit to: **102nd Intelligence Wing** (hereinafter called "the permittee") authorizing discharges to the ground from the on site wastewater treatment facility located at **971 South Outer Road, Otis Air National Guard Base, MA 02542** such authorization being expressly conditional on compliance by the permittee with all terms and conditions of the permit hereinafter set forth.

Brian A. Dudley
Bureau of Water Resources

May 21, 2018
Date

I. SPECIAL CONDITIONS

A. Effluent Limits

1) The permittee is authorized to discharge into the ground from the wastewater treatment facilities for which this permit is issued a treated effluent whose characteristics shall not exceed the following values:

Effluent Characteristics	Discharge Limitations
12 month moving average flow	360,000 GPD
Maximum Day Flow	840,000 GPD
Oil and grease	15 mg/l
Total Suspended Solids (TSS)	30 mg/l
Total Nitrogen ($NO_2 + NO_3$ + TKN)	10 mg/l
Nitrate-Nitrogen	10 mg/l
Biochemical Oxygen Demand, 5-day @20°C (BOD_5)	30 mg/l
Fecal Coliform	200 colonies / 100 ml

a) The pH of the effluent shall not be less than 6.5 nor greater than 8.5 at any time or not more than 0.2 standard units outside the naturally occurring range.

b) The discharge of the effluent shall not result in any demonstrable adverse effect on the groundwater or violate any water quality standards that have been promulgated.

c) The monthly average concentration of BOD and TSS in the discharge shall not exceed 15 percent of the monthly average concentrations of BOD and TSS in the influent into the permittee's wastewater treatment facility.

d) When the average annual flow exceeds 80 percent of the permitted flow limitations, the permittee shall submit a report to the Department describing what steps the permittee will take in order to remain in compliance with the permit limitations and conditions, inclusive of the flow limitations established in this permit.

B. Monitoring and Reporting

1) The permittee shall monitor and record the quality of the **influent** and the quality and quantity of the **effluent** prior to discharge to the leaching facilities according to the following schedule and other provisions:

INFLUENT:

Parameter	Minimum Frequency of Analysis	Sample Type
BOD_5	Monthly	24-Hour Composite
Total Suspended Solids	Monthly	24-Hour Composite
Total Solids	Monthly	24-Hour Composite
Ammonia Nitrogen	Monthly	24-Hour Composite

EFFLUENT:

Parameter	Minimum Frequency of Analysis	Sample Type
Flow	Daily	Meter reading Report: Min – Max - Average
pH	Daily	Grab
Fecal Coliform	Monthly	Grab
Total Suspended Solids	Monthly	24-Hour Composite
Oil & Grease	Monthly	Grab
BOD_5	Monthly	24-Hour Composite
Nitrate Nitrogen	Monthly	24-Hour Composite
Total Nitrogen ($NO_2 + NO_3 +$ TKN)	Monthly	24-Hour Composite
Total Phosphorus (as P)	Quarterly	Grab

Parameter	Minimum Frequency of Analysis	Sample Type
Orthophosphate (as P)	Quarterly	Grab
Volatile Organic Compounds[1]	Monthly	Grab

[1]USEPA Method #624

a) After one full year of monitoring the Total Phosphorus and Orthophosphate results, the Department may determine, upon the request of the permittee, that the frequency of monitoring may be reduced if, in the judgment of the Department, the results of the sampling indicate that existing phosphorus levels will not adversely impact downgradient receptors. If the Department reduces the frequency of monitoring for Total Phosphorus and Orthophosphate, the Department reserves the right to resume more frequent monitoring if the Department determines that phosphorus levels are impacting downgradient receptors.

2) The permittee shall sample the upgradient monitoring well MW16 and the downgradient monitoring wells MW13, MW14 and MW15 as shown on a plan titled "Otis Air National Guard Effluent Force Main and Infiltration Basins" sheet 4 of 55, dated August 12, 1993. Labels identifying each monitoring well's identification in accordance with the above-referenced approved plans shall be affixed to the steel protective casing of each monitoring well.

The permittee shall monitor, record and report the quality of water in the approved monitoring wells according to the following schedule and other provisions:

Parameter	Minimum Frequency of Analysis
Static Water Level	Monthly
Specific Conductance	Monthly
pH	Monthly
Total Nitrogen (NO_2+NO_3+TKN)	Quarterly
Nitrate-Nitrogen	Quarterly
Total Phosphorus (as P)	Quarterly
Orthophosphate (as P)	Quarterly
Volatile Organic Compounds[1]	Annually

[1]USEPA Method #624

a) Static Water Level shall be expressed as an elevation and shall be referenced to the surveyed datum established for the site. It shall be calculated by subtracting the depth to the water table from the surveyed elevation of the top of the monitoring well's PVC well casing/riser.

b) After one full year of monitoring the Total Phosphorus and Orthophosphate results, the Department may determine, upon the request of the permittee, that the frequency of monitoring may be reduced if, in the judgment of the Department, the results of the sampling indicate that existing phosphorus levels will not adversely impact downgradient receptors. If the Department reduces the frequency of monitoring for Total Phosphorus and Orthophosphate, the Department reserves the right to resume more frequent monitoring if the Department determines that phosphorus levels are impacting downgradient receptors.

3) Any grab sample or composite sample required to be taken less frequently than daily shall be taken during the period of Monday through Friday inclusive. All composite samples shall be taken over the operating day.

4) The permittee shall submit all monitoring reports within 30 days of the last day of the reporting month. Reports shall be on an acceptable form, properly filled and signed and shall be sent to: the Deputy Regional Director, Bureau of Water Resources, Department of Environmental Protection, Southeast Regional Office, 20 Riverside Drive, Lakeville, MA 02347, and to the Department of Environmental Protection, Bureau of Water Resources, Wastewater Management Program, One Winter Street/5th Floor, Boston, MA 02108, and to the Bourne Board of Health, 24 Perry Avenue, Buzzards Bay, Bourne, MA 02532 and to the Mashpee Health Department, 16 Great Neck Road North, Mashpee, Massachusetts 02649 and to the Sandwich Board of Health, 16 Jan Sebastian Drive, Sandwich, Massachusetts 02563, and to the Falmouth Health Department, 59 Town Hall Square, Falmouth, MA 02540. .

a) Submission of monitoring reports in electronic format is available through eDEP and serves as data submission to both the Regional and Boston offices. Effective December 2, 2017, all discharge monitoring reports must be submitted through eDEP. To register for electronic submission go to: *http://www.mass.gov/edep-online-filing*

C. Supplemental Conditions

1) The permittee shall notify the Department at least thirty (30) days in advance of the proposed transfer of ownership of the facility for which this permit is written. Said notification shall include a written agreement between the existing and new permittees containing a specific date for transfer of permit, responsibility, coverage and liability between them.

2) A staffing plan for the facility shall be submitted to the Department once every two years and whenever there are staffing changes. The staffing plan shall include the following components:

a) The operator(s)'s name(s), operator grade(s) and operator license number(s);
b) The number of operational days per week;
c) The number of operational shifts per week;
d) The number of shifts per day;
e) The required personnel per shift;
f) Saturday, Sunday and holiday staff coverage;
g) Emergency operating personnel

3) The permittee is responsible for the operation and maintenance of all sewers, pump stations, and treatment units for the permitted facility, which shall be operated and maintained under the direction of a properly certified wastewater operator.

4) Operation and maintenance of the proposed facility must be in accordance with 314 CMR 12.00, "Operation and Maintenance and Pretreatment Standards for Wastewater Treatment Works and Indirect Discharges", and, 257 CMR 2.00, "Rules and Regulations for Certification of Operators of Wastewater Treatment Facilities".

a) The facility has been rated (in accordance with 257 CMR 2.00), to be a Grade **4** facility. Therefore, the permittee shall provide for oversight by a Massachusetts Certified Wastewater Treatment plant operator (Chief Operator) Grade **4** or higher. The permittee will also provide for a backup operator who shall possess at least a valid Grade **3** license.

b) The date and time of the operator's inspection along with the operator's name and certification shall be recorded in the log book on location at the treatment facility. All daily inspection logs consistent with the O&M Manual requirements shall be kept at the facility for a period of three (3) years.

c) Records of operation of wastewater treatment facilities or disposal systems required by the Department shall be submitted on forms supplied by the Department or on other forms approved by the Department for such use. Monthly reports shall be certified by the wastewater treatment plant operator in charge and shall be included in the discharge monitoring reports submitted each month.

5) If the operation and maintenance of the facility is contracted to a private concern, the permittee shall submit a copy of the contract, consistent with what is required by the approved Operation & Maintenance manual and signed only by the contractor, to the appropriate MassDEP Regional Office within thirty (30) days of permit issuance. Along with the contract, a detailed listing of all contract operation obligations of the proposed contractor at other facilities shall also be submitted.

6) Any additional connections to the sewer system, of the facility of this permit shall be approved by MassDEP and the local Board of Health prior to the connection.

7) All tests or analytical determinations to determine compliance with permit standards and requirements shall be done using tests and procedures found in the most recent version of

Standard Methods for the Examination of Water and Wastewater and shall be performed by a Massachusetts Certified laboratory.

8) The permittee shall notify the appropriate MassDEP Regional Office, in writing, within thirty (30) days of the following events:

   a) Any interruption of the treatment system operation, other than routine maintenance.
   b) Final shutdown of the treatment system.

9) The permittee shall contract to have any and all solids and sludges generated by the treatment system for which this permit is issued removed off site by a properly licensed waste hauler for disposal at an EPA/MassDEP approved facility. The name and license number of the hauler along with the quantity of wastes removed and the date(s) of removal shall be reported by the permittee in writing to the appropriate MassDEP Regional Office.

10) Simultaneously with the permit renewal application at year fifteen (2038) following the initiation of plant operations, the permittee shall submit two reports to the Department for its review and approval:

   a) An engineering report, prepared by a registered professional engineer, that outlines in sufficient detail what modifications (if any) to the facility or other changes are required to insure that the facility can remain in compliance with its GWDP and other applicable requirements through the next 5 year permit term (year 2043) and beyond.

   b) A financial plan that contains the cost estimates for implementing the facility modifications or other changes identified in the engineering report, and describes and demonstrates, how and when the permittee will finance the needed facility modifications or other changes

11) In the event that effluent limits are not met, or the discharge is determined to impair groundwater quality in accordance with 314 CMR 5.16(1), the permittee may be obligated to modify, supplement or replace the permitted treatment process so as to ensure that the discharge does not impair the ability of the groundwater to act as an actual or potential source of potable water.

12) Pursuant to M.G.L. Chapter 21A, section 18(a), and 310 CMR 4.03, holders of this Permit may be subject to annual compliance assurance fees as assessed each year on July 1st and invoiced by MassDEP. Failure of the Permit holder to pay applicable annual compliance assurance fees shall result in the automatic suspension of the permit by operation of law under the statute. If fee non-payment continues for sixty days or more, MassDEP has the statutory option of revoking the Permit, denying any other pending permit applications filed by the Permit holder or taking other enforcement action. Permit

holders are required to notify MassDEP in writing if they wish to relinquish or transfer a permit. Failure to do so will result in the continued assessment of fees.

E. Appeal Rights

During the thirty (30) day period following issuance of this permit, a Notice of Claim for an Adjudicatory Appeal may be sent by any person aggrieved (the "Petitioner") by the issuance to:

Case Administrator
Office of Appeals and Dispute Resolution
Department of Environmental Protection
One Winter Street/2nd Floor
Boston, MA 02108

310 CMR 1.01(6)(b) requires the Notice of Claim to: include sufficient facts to demonstrate aggrieved person status; state the facts which are grounds for the appeal specifically, clearly and concisely; and, state relief sought. The permit shall become or remain effective at the end of the 30 day appeal period unless the person filing the Notice of Claim requests, and is granted, a stay of its terms and conditions. If a permit is modified under 314 CMR 2.10, only the modified terms and conditions may be subject to an Adjudicatory Appeal. All other aspects of the existing permit shall remain in effect during any such Adjudicatory Appeal.

Per 310 CMR 4.06, the hearing request to the Commonwealth will be dismissed if the filing fee is not paid. Unless the Petitioner is exempt or granted a waiver, a valid check payable to the Commonwealth to Massachusetts in the amount of $100.00 must be mailed to:

Commonwealth of Massachusetts
Department of Environmental Protection
P.O. Box 4062
Boston, MA 02211

The filing fee is not required if the Petitioner is a city, town, county, or district of the Commonwealth, federally recognized Indian tribe housing authority effective January 14, 1994, or any municipal housing authority; or, per MGL 161A s. 24, the Massachusetts Bay Transportation Authority. The Department may waive the adjudicatory hearing filing fee for a Petitioner who shows that paying the fee will create an undue financial hardship. A Petitioner seeking a waiver must file, along with the hearing request, an affidavit setting forth the facts believed to support the claim of undue financial hardship.

II. GENERAL PERMIT CONDITIONS

5.16: General Conditions

The following conditions apply to all individual and general permits:

(1) No discharge authorized in the permit shall cause or contribute to a violation of 314 CMR 4.00: *Massachusetts Surface Water Quality Standards*. Upon promulgation of any amended standard, the permit may be modified to comply with such standard in accordance with the procedures in 314 CMR 2.10: *Modification, Suspension, Revocation and Renewal of Permits and General Permit Coverage* and 314 CMR 5.12. Except as otherwise provided in 314 CMR 5.10(3)(c), 5.10(4)(a)2. and 5.10(9), no discharge authorized in the permit shall impair the ability of the ground water to serve as an actual or potential source of potable water. Evidence that a discharge impairs the ability of the ground water to serve as an actual or potential source of potable water includes, without limitation, analysis of samples taken in a downgradient well that demonstrates one or more exceedances of the applicable water quality based effluent limitations set forth in 314 CMR 5.10. In those cases where it is shown that a measured parameter exceeds the applicable water quality based effluent limitations set forth in 314 CMR 5.10 at the upgradient monitoring well, evidence that a discharge impairs the ability of the ground water to serve as an actual or potential source of potable water is deemed to exist if a measured parameter in any downgradient well exceeds the level of that same measured parameter in the upgradient well for the same sampling period. A statistical procedure approved by the Department shall be used to determine when a measured parameter exceeds the allowable level.

(2) Duty to Comply. The permittee shall comply at all times with the terms and conditions of the permit, 314 CMR 5.00, M.G.L. c. 21, §§ 26 through 53, and all applicable state and federal statutes and regulations.

(3) Standards and Prohibitions for Toxic Pollutants. The permittee shall comply with effluent standards or prohibitions established by § 307(a) of the Federal Act, 33 U.S.C. § 1317(a), for toxic pollutants within the time provided in the regulations that establish these standards or prohibitions, even if the permit has not yet been modified to incorporate the requirement.

(4) Proper Operation and Maintenance. The permittee shall at all times properly operate and maintain all facilities and equipment installed or used to achieve compliance with the terms and conditions of the permit, 314 CMR 12.00: *Operation and Maintenance and Pretreatment Standards for Wastewater Treatment Works and Indirect Discharges*, and 257 CMR 2.00: *Certification of Operators of Wastewater Treatment Facilities*. All equipment shall be maintained in an acceptable condition for its intended use.

(5) Duty to Halt or Reduce Activity. Upon reduction, loss, or failure of the treatment facility, the permittee shall, to the extent necessary to maintain compliance with its permit, control production, discharges, or both, until the facility is restored or an alternative method of treatment is provided. A permittee may not raise as a defense in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of the permit.

(6) Power Failure. In order to maintain compliance with the effluent limitations and prohibitions of the permit, the permittee shall either:

(a) provide an alternative power source sufficient to operate the wastewater control facilities; or

(b) halt, reduce or otherwise control production or all discharges upon the reduction, loss, or failure of the primary source of power to the wastewater control facilities.

(7) Duty to Mitigate. The permittee shall take all reasonable steps to minimize or prevent any adverse impact on human health or the environment resulting from non-compliance with the permit. Additionally, the permittee shall take all necessary steps to prevent an operational upset of the PWTF or POTW.

(8) Duty to Provide Information. The permittee and any operator of the permitted facility shall furnish to the Department within a reasonable time as specified by the Department any information which the Department may request to determine whether cause exists for modifying, suspending, revoking and reissuing, or terminating the permit, or to determine whether the permittee is complying with the terms and conditions of the permit.

(9) Inspection and Entry. The permittee shall allow the Department or its authorized representatives to:

(a) Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records required by the permit are kept;

(b) Have access to and copy, at reasonable times, any records that must be kept under the conditions of the permit;

(c) Inspect at reasonable times any facilities, equipment, practices, or operations regulated or required under the permit; and

(d) Sample or monitor at reasonable times for the purpose of determining compliance with the terms and conditions of the permit.

(9A) The permittee shall physically secure the treatment works and monitoring wells and limit access to the treatment works and monitoring wells only to those personnel required to operate, inspect and maintain the treatment works and to collect samples.

(9B) The permittee shall identify each monitoring well by permanently affixing to the steel protective casing of the well a tag with the identification number listed in the permit.

(10) Monitoring. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity. Monitoring must be conducted according to test procedures approved under 40 CFR Part 136 unless other test procedures are specified in the permit.

(11) Recordkeeping. The permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by the permit, and all records of all data used to complete the application for the permit, for a period of at least five years from the

date of the sample, measurement, report or application. This period may be extended by request of the Department at any time. Records of monitoring information shall include without limitation:

(a) The date, exact place, and time of sampling or measurements;
(b) The individual(s) who performed the sampling or measurement;
(c) The date(s) analyses were performed;
(d) The individual(s) who performed the analyses;
(e) The analytical techniques or methods used; and
(f) The results of such analyses.

(12) Prohibition of Bypassing. Except as provided in 314 CMR 5.16(13), bypassing is prohibited and the Department may take enforcement action against a permittee for bypassing unless:

(a) The bypass was unavoidable to prevent loss of life, personal injury, or severe property damage;
(b) There were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if the permittee could have installed adequate backup equipment to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance; and
(c) The permittee submitted notice of the bypass to the Department:
1. In the event of an anticipated bypass, at least ten days in advance, if possible; or
2. In the event of an unanticipated bypass, as soon as the permittee has knowledge of the bypass and no later than 24 hours after its first occurrence.

(13) Bypass not Exceeding Limitations. The permittee may allow a bypass to occur which does not cause effluent limitations to be exceeded, but only if necessary for the performance of essential maintenance or to assure efficient operation of treatment facilities.

(14) Permit Actions. The permit may be modified, suspended, or revoked for cause. The filing of a request by the permittee for a permit modification, reissuance, or termination, or a notification of planned changes or anticipated non-compliance does not stay any permit condition.

(15) Duty to Reapply. If the permittee wishes to continue an activity regulated by the permit after the expiration date of the permit, the permittee must apply for and obtain a new permit. The permittee shall submit a new application at least 180 days before the expiration date of the existing permit, unless permission for a later date has been granted by the Department in writing.

(16) Property Rights. The permit does not convey any property rights of any sort or any exclusive privilege.

(17) Other Laws. The issuance of a permit does not authorize any injury to persons or property or invasion of other private rights, nor does it relieve the permittee of its obligation to comply with any other applicable Federal, State, or local law, or regulation.

(18) Oil and Hazardous Substance Liability. Nothing in the permit shall be construed to preclude the institution of any legal action or relieve the permittee of any responsibilities, liabilities, or penalties to which the permittee is or may be subject under § 311 of the Federal Act, 33 U.S.C. § 1321, and M.G.L. c. 21E.

(19) Removed Substances. Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters shall be disposed in a manner consistent with applicable Federal and State laws and regulations including, but not limited to, the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26 through 53, and the Federal Act, 33 U.S.C. § 1251 *et seq.*, the Massachusetts Hazardous Waste Management Act, M.G.L. c. 21C, and the Federal Resource Conservation and Recovery Act, 42 U.S.C. § 6901, *et seq.*, 310 CMR 19.000: *Solid Waste Management* and 310 CMR 30.000: *Hazardous Waste.*

(20) Reporting Requirements.

(a) Monitoring Reports. Monitoring results shall be reported on a Discharge Monitoring Report (DMR) at the intervals specified in the permit. If a permittee monitors any pollutant more frequently than required by the permit, the results of this monitoring shall be included in the calculation and reporting of the data submitted in the DMR. Beginning on December 2, 2017, a permittee shall submit all DMRs electronically, using the electronic reporting system designated by the Department. A permittee may seek a waiver of this requirement by submitting a written request for the Department's approval.

(b) Compliance Schedules. Reports of compliance or non-compliance with, or any progress reports on interim and final requirements contained in any compliance schedule in the permit shall be submitted no later than 14 days following each schedule date.

(c) Planned Changes. The permittee shall give notice to the Department as soon as possible of any planned physical alterations or additions to the permitted facility or activity which could significantly change the nature or increase the quantity of pollutants discharged. Unless and until the permit is modified, any new or increased discharge in excess of permit limits or not specifically authorized by the permit constitutes a violation.

(d) Anticipated Non-compliance. The permittee shall give advance notice to the Department of any planned changes in the permitted facility or activity which may result in non-compliance with permit requirements.

(e) 24 Hour Reporting. The permittee shall report any non-compliance which may endanger health or the environment. Any information shall be communicated orally within 24 hours of the time the permittee becomes aware of the circumstances. A written submission shall also be provided within five days of the time the permittee becomes aware of the circumstances. The written submission shall contain: a description of the non-compliance, including exact dates and times, and if the non-compliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent reoccurrence of the non-compliance. The following shall be included as information which must be reported within 24 hours:

1. Any unanticipated bypass which exceeds any effluent limitation in the permit; and
2. Any violation of a maximum daily discharge limitation for any of the pollutants required by the permit to be reported within 24 hours.

(f) Other Non-compliance. The permittee shall report all instances of non-compliance not reported under 314 CMR 5.16(20)(a), (b), or (e) at the time monitoring reports are submitted. The reports shall contain the information listed in 314 CMR 5.16(20)(e).
(g) Toxics. All manufacturing, commercial, mining, or silvicultural dischargers must notify the Department as soon as they know or have reason to believe:

1. That any activity has occurred, or will occur, that would result in the discharge of any toxic pollutant listed in 314 CMR 3.17: *Appendix B - Toxic Pollutants* not limited by the permit, if that discharge will exceed the highest of the following notification levels:
    a. 100 micrograms per liter (100 ug/l);
    b. 200 micrograms per liter (200 ug/l) for acrolein and acrylonitrile, 500 micrograms per liter (500 ug/l) for 2,4-dinitrophenol, and for 2-methyl-4,6-dinitrophenol, and one milligram per liter (1 mg/l) for antimony;
    c. Five times the maximum concentration value reported for that pollutant in the permit application; or
2. That they have begun or expect to begin to use or manufacture as an intermediate or final product or byproduct any toxic pollutant which was not reported in the permit application.

(h) Indirect Dischargers. All Publicly Owned Treatment Works shall provide adequate notice to the Department of the following:

1. Any new introduction of pollutants into the POTW from an indirect discharger which would be subject to § 301 or § 306 of the Federal Act, 33 U.S.C. § 1311 or 1316, if it were directly discharging those pollutants; and
2. Any substantial change in the volume or character of pollutants being introduced into the POTW by a source introducing pollutants into the POTW at the time of issuance of the permit.

(i) Information. Where a permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to the Department, it shall promptly submit the relevant facts or correct information.
(j) The permittee shall notify the Department in writing within seven days of any change in contract operators.

(21) Signatory Requirement. All applications, reports, or information submitted to the Department shall be signed and certified in accordance with 314 CMR 5.14 and 5.15.

(22) Severability. The provisions of the permit are severable. If any provision of the permit, or the application of any provision of the permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of the permit, shall not be affected thereby.

(23) Reopener Clause. The Department reserves the right to make appropriate revisions to the permit to establish any appropriate effluent limitations, schedules of compliance, or other provisions, as authorized by the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26 through 53, or the Federal Act, 33 U.S.C. § 1251 *et seq.*, to bring all discharges into compliance with these statutes.

(24) Approval of Treatment Works. All discharges and associated treatment works authorized in 314 CMR 5.00 shall remain in compliance with the terms and conditions of the permit. Any modification of the approved treatment works shall require written approval of the Department prior to the construction of the modification.

(25) Transfer of Permits.

(a) RCRA Facilities. Any permit which authorizes the operation of a RCRA facility subject to the requirements of 314 CMR 8.07: *Standards for all other RCRA Facilities* shall be valid only for the person to whom it is issued and may not be transferred.

(b) Transfers by Modification. Except as provided in 314 CMR 5.16(25)(a) and (c), a permit may be transferred by the permittee to a new permittee if the permit has been modified or revoked and reissued in accordance with 314 CMR 5.12(2), or a minor modification is made to identify the new permittee in accordance with 314 CMR 5.12(3) and (4).

(c) Automatic Transfers. For facilities other than Privately Owned Wastewater Treatment Facilities (PWTFs) that treat at least some sewage from residential uses, hospitals, nursing or personal care facilities, residential care facilities, or assisted living facilities, PWTFs that have been required to establish, fund and maintain financial assurance mechanism(s) pursuant to 314 CMR 5.15(6), and RCRA facilities subject to the requirements of 314 CMR 8.07: *Standards for all other RCRA Facilities*, a permit may be automatically transferred in accordance with 314 CMR 5.12(5).

(26) Permit Compliance Fees and Inspection Information. Except as otherwise provided, any permittee required to obtain a ground water discharge permit pursuant to M.G.L. c. 21, § 43, and 314 CMR 5.00 shall submit the annual compliance assurance fee established in accordance with M.G.L. c. 21A, § 18 and 310 CMR 4.00: *Timely Action Schedule and Fee Provisions*, as provided in 314 CMR 2.12: *Applications, Fees and Inspection Information.* The requirement to submit the annual compliance fee does not apply to any local government unit other than an authority. Any permittee required to obtain a ground water discharge permit pursuant to M.G.L. c. 21, § 43 and 314 CMR 5.00, may be required to submit inspection information annually, as provided in 314 CMR 2.12.

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