DRAFT FOR REVIEW - SUMMER 2019

CAPE COD CANAL
TRANSPORTATION STUDY

Prepared by:

Stantec

ACKNOWLEDGEMENTS

The preparation of this report has been financed in part through MassDOT's Statewide Planning and Research (SPR) Program agreement with the Federal Highway Administration of the United States Department of Transportation. The views and opinions of the authors and agencies expressed herein do not necessarily state or reflect those of the United States Department of Transportation.

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CONTENTS

EXECUTIVE SUMMARY

INTRODUCTION AND STUDY FRAMEWORK

EXISTING ENVIRONMENTAL AND TRAFFIC CONDITIONS

FUTURE NO-BUILD TRANSPORTATION CONDITIONS

ALTERNATIVES DEVELOPMENT AND ANALYSIS

STUDY RECOMMENDATIONS

EXHIBITS

EXECUTIVE SUMMARY

INTRODUCTION AND STUDY FRAMEWORK

EXISTING ENVIRONMENTAL AND TRAFFIC CONDITIONS

FUTURE NO-BUILD TRANSPORTATION CONDITIONS

ALTERNATIVES DEVELOPMENT AND ANALYSIS

STUDY RECOMMENDATIONS

TABLES

EXECUTIVE SUMMARY

INTRODUCTION AND STUDY FRAMEWORK

EXISTING ENVIRONMENTAL AND TRAFFIC CONDITIONS

FUTURE NO-BUILD TRANSPORTATION CONDITIONS

ALTERNATIVES DEVELOPMENT AND ANALYSIS

STUDY RECOMMENDATIONS

massDOT
Massachusetts Department of Transportation

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CONTENTS

EXHIBITS

TABLES

Executive Summary

MassDOT launched the Cape Cod Canal Transportation Study ("the Study") to understand existing and future transportation conditions in the Cape Cod Canal area. The Study provides recommendations for improving multimodal connectivity and reliability across the Canal to protect quality of life for Cape Cod residents, workers, and visitors.

A FAMILIAR STORY: AGING INFRASTRUCTURE AND INCREASED TRAVEL DEMANDS

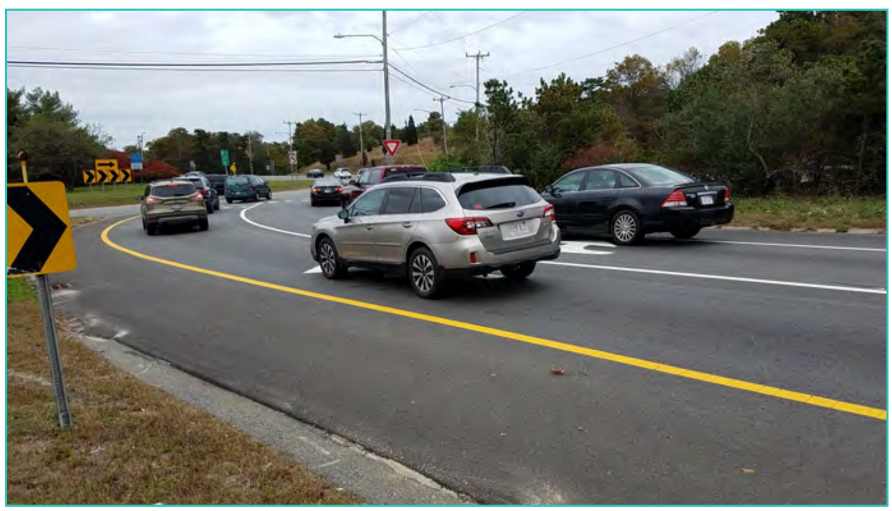
The seven-mile-long Cape Cod Canal was built in 1916 to shorten travel times and improve the safety of ships heading south from Boston and Plymouth. Mass-production of the automobile had only just begun, and roughly 20 years later (in 1935), the newly-constructed Bourne and Sagamore Bridges carried their first cars over the Canal to the delight and relief of Cape Cod's 26,000 residents.

Today, the Bourne and Sagamore Bridges continue to provide the only vehicular connections between the 15 communities and 215,000 residents on Cape Cod with the Massachusetts mainland. The lack of other connections, however, creates challenges. Cape

Cod and the Islands of Martha's Vineyard and Nantucket are major tourist destinations whose recreational activities create travel demands that soar during the summer.

Cape Cod residents and visitors must often contend with substantial traffic congestion during the summer tourist season. During the non-summer season, access over the Canal is frequently complicated by maintenance-related lane closures on the bridges. While these delays result from increased traffic demands created by an influx of visitors, the impacts of these delays impact visitors, year-round residents, and businesses alike by extending travel times, introducing and perpetuating safety concerns, and limiting access to destinations.

This study focuses on transportation issues in the Cape Cod Canal area. These issues include vehicle congestion and delay, incomplete and inaccessible pedestrian and bicycle facilities, and limited transit options. The impact of these issues extends to all of Cape Cod, Martha's Vineyard, and Nantucket. Ultimately, this study identifies a series of multimodal transportation improvements that satisfy study goals and objectives and reflect the study findings and public feedback.



Traffic at the Bourne Rotary.

The Cape Cod Canal, the Sagamore and Bourne Bridges, and the surrounding open space, is owned and operated by the U.S. Army Corps of Engineers (USACE). Identical in design, the Sagamore and Bourne Bridges are now more than 80 years old. They have exceeded their design life and require substantial regular maintenance to function reliably.

Furthermore, under today's engineering guidelines, the bridge design is substandard in several ways: travel-lane widths are too narrow, there are no roadway shoulders, and bicycle and pedestrian accommodations are minimal. At 12-inches, the granite curbing separating the roadway from the sidewalk is higher than is typical.

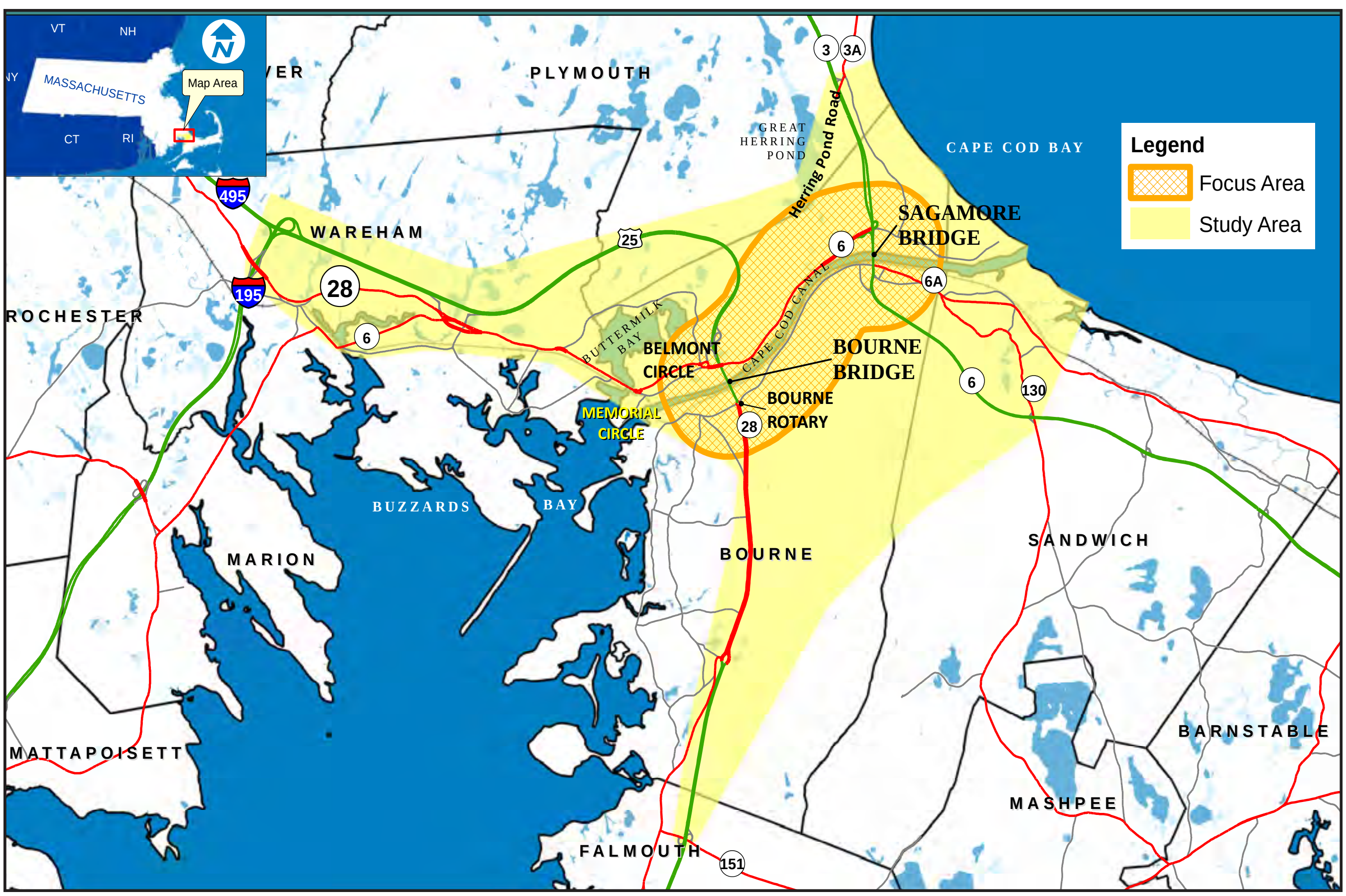
The USACE is currently preparing a ‘Major Rehabilitation Evaluation Report’ that will determine whether the USACE should continue to perform long-term maintenance on the bridges, or to replace them.

In addition to the challenges presented by two aging bridges, many Canal-area roads and intersections experience severe congestion during peak travel periods. Cape Cod also suffers from a lack of transportation options with limited bus, transit, and pedestrian/bicycle facilities. Furthermore, the condition, capacity, and lack of multimodal features of the Sagamore and Bourne Bridges contribute to Cape Cod’s connectivity limitations.

THE STUDY AREA

To gain a thorough understanding of the myriad issues and constraints subsumed in this study, information related to environmental resources, socio-economic data, and traffic was gathered for the “study area”, which includes up to four miles on either side of the Canal (Exhibit ES-1). More detailed traffic data collection and analysis occurred within the study’s “focus area,” an area approximately one mile north and south of the Canal, where most proposed transportation improvements are anticipated to occur.

Exhibit ES-1 Study Area / Focus Area



REPORT AND STUDY PROCESS OVERVIEW

The study, and ultimately this report, has followed a five-step process and framework:

Step 1: Define the Study Goals, Objectives, and Evaluation Criteria

In cooperation with the study Working Group, the study goals and objectives were established. Evaluation criteria were determined for study recommendations. Public engagement and participation, meeting MassDOT's Accessible Meeting Policy Directive, was encouraged. This allowed the community to contribute to the study in a meaningful way throughout the process.

Step 2: Review & Evaluate Existing and Future Conditions

Existing natural and social environmental resource conditions were documented. Multimodal traffic counts were conducted, and existing and future traffic conditions were analyzed. Key problem intersections in the focus area were identified for additional study. Transportation improvement constraints and opportunities were identified.

Step 3: Develop a Range of Design Alternatives

A range of conceptual design alternatives for roadway and other multimodal transportation improvements was developed based on future travel demand at key problem intersections in the focus area. Potential alternatives were developed to improve traffic mobility without overbuilding in a manner inconsistent with the character of Cape Cod.

Step 4: Analyze Design Alternatives Based on Evaluation Criteria

Traffic analysis of improvement alternatives at key problem intersections was developed. Each alternative's effectiveness in meeting the study's goals and objectives was evaluated and documented. The results of the traffic analysis was presented to the Working Group and public for feedback regarding which alternatives to advance to travel demand model analysis.

Regional travel demand model analysis used to evaluate the effectiveness of several transportation improvement groups improvements had been identified in Step 3. The travel demand model also estimated potential shifts or diversions in travel patterns in the study area that could cause unforeseen impacts in other locations.

Step 5: Provide Recommendations

In cooperation with the study Working Group, the multimodal transportation improvement alternatives that best advance the study goals and objectives were identified.

STEP 1: DEFINE THE STUDY GOALS, OBJECTIVES, AND EVALUATION CRITERIA

The study's goals and objectives were developed by MassDOT in cooperation with the study Working Group; all recommended transportation improvements will advance the study's goals and objectives.

The Working Group is made up of representatives from:

- ***Municipal departments and locally elected officials***
- ***State agencies & elected officials***
- ***Federal agencies***
- ***Metropolitan planning organizations***
- ***Chambers of commerce***
- ***Key businesses***
- ***Other interested parties***

Goals

- Improve transportation mobility and accessibility in the Cape Cod Canal area and provide reliable year-round connectivity over the Canal and between the Sagamore and Bourne Bridges.

Objectives

- Improve multimodal connectivity and mobility across the Canal to avoid degrading quality of life on the Cape.
- Ensure that cross-canal connectivity does not become a barrier to reliable intra community travel within Bourne and Sandwich.
- Create reliable multimodal connections across the Canal to ensure public safety in the event of an emergency evacuation of portions of the Cape and accommodate first responders trying to reach the Cape.

As guided by the study's Public Involvement Plan, the community played a key role in shaping the study framework and providing detailed and comprehensive comments to build agreement and support for the study recommendations. Four public meetings and 11 Working Group meetings shaped the framework of the entire study.

The accessible public record is available on the project website: https://www.mass.gov/cape-cod-canal-transportation-study

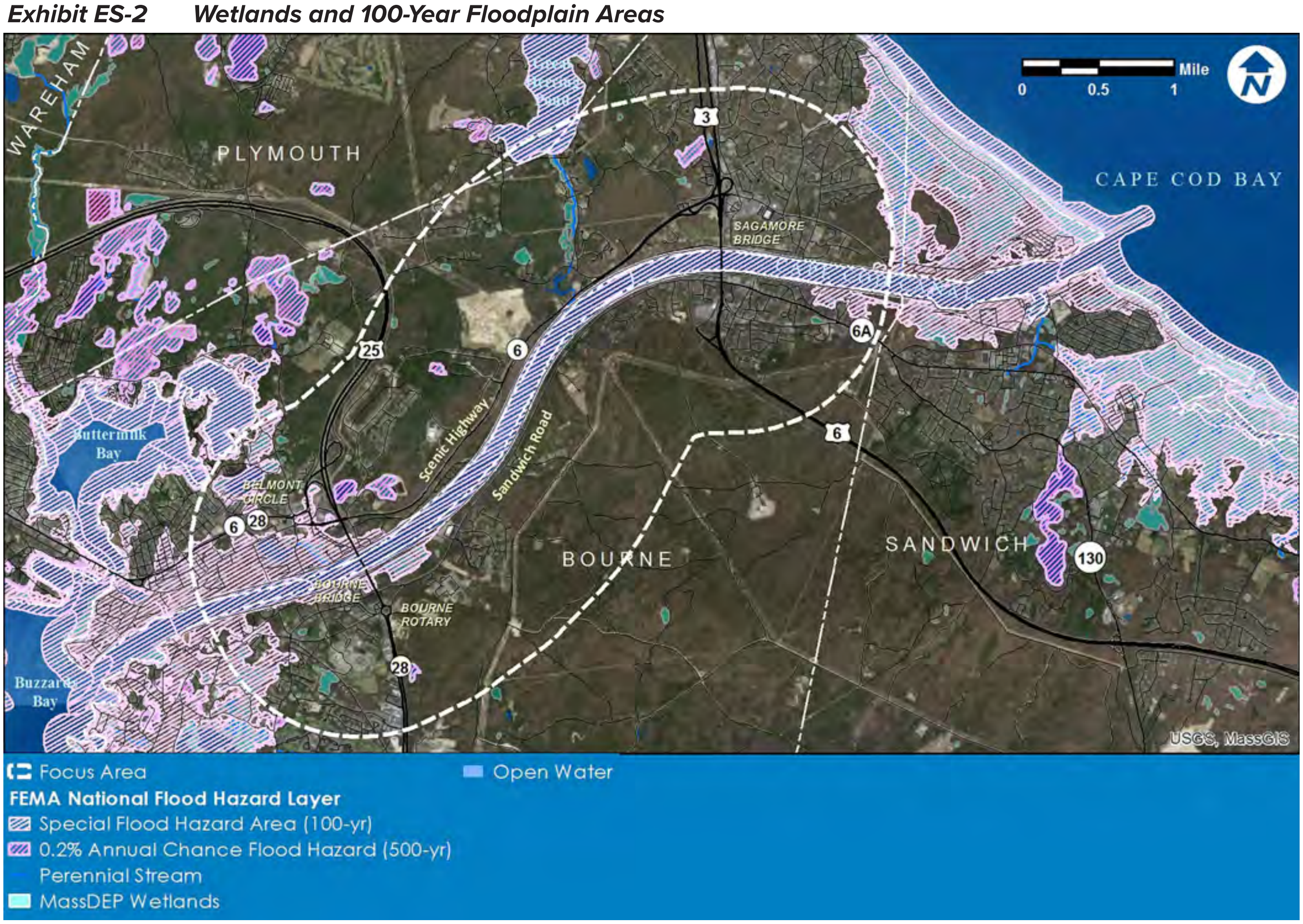
Evaluation Criteria

The Cape Cod Canal study area is home to a variety of environments, land uses, and socio-economic conditions. To advance the study goals and objectives, evaluation criteria were determined to help guide the design and decision-making process. With input from the Working Group, MassDOT identified criteria that could help analyze the study area and inform potential transportation improvements. The following six categories were chosen:

- Transportation
- Environment
- Community
- Land Use / Economic Development
- Safety
- Feasibility

As appropriate, the study team derived individual criteria for each transportation mode directly from either existing data or analytical techniques used in this study. These criteria—both quantifiable and qualitative measures of effectiveness—helped

Exhibit ES-2 Wetlands and 100-Year Floodplain Areas



identify the solutions that best matched the study's goals and objectives.

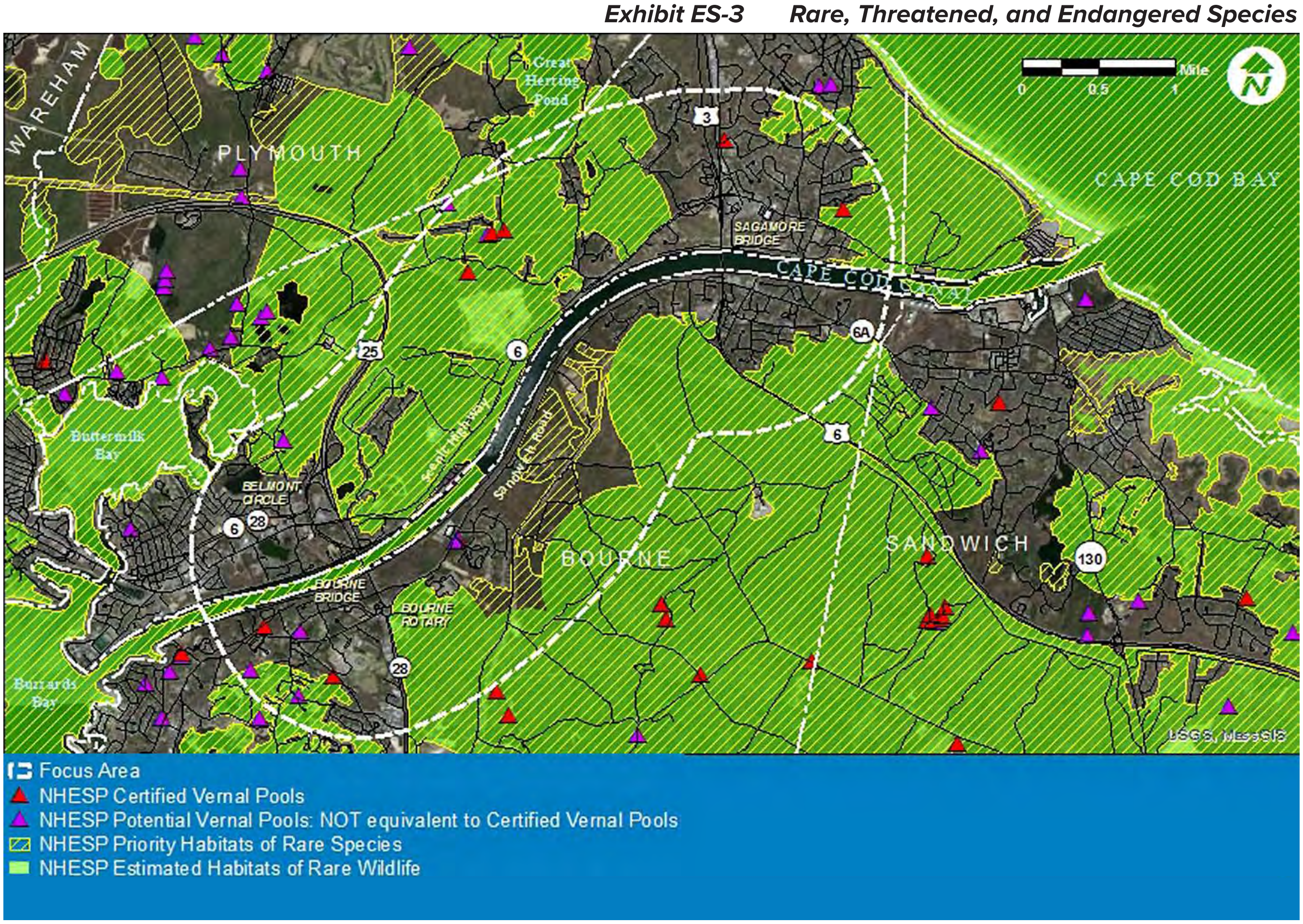
STEP 2: REVIEW & EVALUATE EXISTING AND FUTURE CONDITIONS

Data about existing conditions in the study area – including roadway and multimodal facilities, natural and social environmental resources, and socio-economic conditions – informed the design constraints and provided a basis for the evaluation criteria. Next, existing and future traffic volumes in the study area were modeled to create a future (2040) 'no build' alternative which serves as the baseline for the comparison of future transportation improvements.

Natural Environmental Resources

The study area features an abundance of natural environmental resources, particularly coastal and inland wetlands north and south of the Canal (Exhibit ES-2). Project area wetlands, floodplain, and waterbodies such as the Canal, Herring Pond, and Buttermilk Bay are critical for supporting recreation, fishing, shellfishing, wildlife habitat, and flood control.

Exhibit ES-3 Rare, Threatened, and Endangered Species



Flood hazard areas are identified, in roughly the same areas occupied by wetlands, both north and south of the Canal. Outside of the wetlands, a 100-year floodplain extends north of the Canal beyond Main Street to the Buzzards Bay Bypass.

Rare species habitat is prevalent throughout the study area, particularly within Joint Base Cape Cod (JBCC) and the Shawme-Crowell State Forest (Exhibit ES-3). The rare species include a wide variety of turtles, reptiles, birds, butterflies, moths, mussels, and plants. Numerous certified and potential vernal pools also exist throughout the study area.

The study area features two Areas of Critical Environmental Concern (ACEC), the Bourne Back River and the Herring River ACECs. Aquifers on Cape Cod are a particularly sensitive resource as they are part of a designated drinking water sole source aquifer.

Upper Cape Water Supply Reserve

The Upper Cape Water Supply Reserve includes the northern 15,000 acres of the JBCC. The Massachusetts Legislature created the Reserve through Chapter 47 of the Acts of 2002. Owned by the Commonwealth, the Reserve serves two purposes:

1. New England's largest military training center: provides facilities for soldiers—from the Massachusetts Army National Guard and numerous other military branches—to practice maneuvering exercises and using the small arms ranges.

2. Drinking water and wildlife protection area: the largest piece of undeveloped land on Cape Cod which serves as a drinking water source for Upper Cape Cod and is home to 37 state-listed species living in a variety of habitats throughout the base.

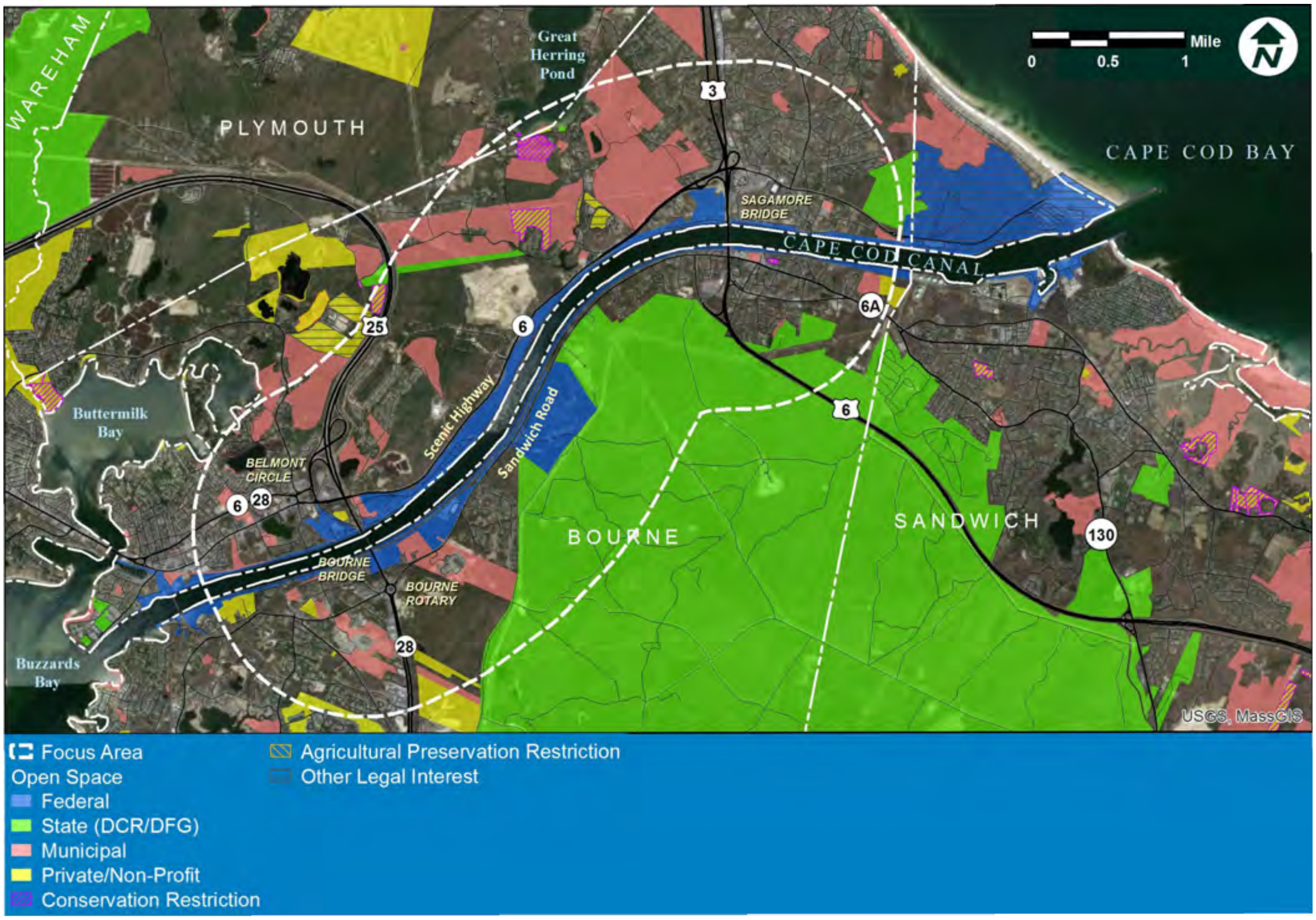
Social Environmental Resources

The study area, including Bourne, Plymouth, Sandwich, and Wareham, features numerous social environmental resources such as historic resources and open space. Historic sites include the Bourne and Sagamore Bridges, the Old Kings Highway Regional Historic District in Sandwich, and the Jarvesville Town Hall Square, and Spring Hill National Historic Districts in Sandwich. Several public buildings in Bourne are individually listed on the National Register of Historic Places including Bourne High School, Jonathon Bourne Public Library, and Bourne Town Hall.

There are many publicly- and privately-owned parcels which are protected as open space (Exhibit ES-4). These properties serve a wide variety of purposes, including watershed protection, wildlife habitat, conservation, recreation, public beaches, marinas, and camping. Open space properties in the study area include the Scusset Beach State Reservation, Shawme-Crowell State Forest, Upper Cape Water Supply Reserve, Cape Cod Canal Recreation Area, Gallo Skating Rink, Carter Beal Conservation Area, Sacrifice Woods Rock, and the Nightingale Pond Recreation Area.

While these natural and social environmental resources contribute to the appeal of Cape Cod, they also represent a constraint when developing alternatives for future transportation improvements.

Exhibit ES-4 Protected Open Space



Utilities

Important utility corridors cross the study area, including an electrical utility corridor which transmits electricity from the Canal Generating Plant in Sandwich across the Canal and on to Cape Cod customers. Natural gas enters Cape Cod through a pipe network attached to the Canal bridges. Natural gas compressor stations are located close to both the Sagamore and Bourne Bridges.

These electrical transmission towers, gas lines, and compressor stations represent a substantial constraint when considering future work on the bridges.

Socio-Economic Conditions and Public Health

Socio-economic conditions in Barnstable County (Cape Cod) are in transition. After several decades of rapid population and employment growth, the county is losing population (Table ES-1). Demographically speaking, Cape Cod is seeing a higher percentage of senior citizens alongside a lower percentage of working adults and school-age children. The unemployment rate in Barnstable County is similar to the state rate but fluctuates widely during the year, with a lower rate during the summer tourist season and a higher rate during the off season.

Any discussion of Barnstable County's population must acknowledge its seasonality. During the summer tourist season, the population of the county nearly doubles, increasing by approximately 200,000 people, due to the influx of seasonal residents, employees, and visitors. This substantial growth in the summertime population (with related increases in vehicle trips) places tremendous pressure on the transportation system in the Cape Cod Canal area.

Commuting is also an important issue in Barnstable County. Nearly 90% of workers use private automobiles to commute, and nearly 34,000 commuters cross one of the Canal bridges each work day, including more than 32% of workers in Bourne and 19% of workers in Sandwich.

Table ES-1 Historical Population Change in Barnstable County

	1960	1970	1980	1990	2000	2010	2017	2018
Population	70,286	96,656	147,925	186,605	222,230	215,888	213,444	213,413
Percent (%) Change from Previous Period		37.52	53.04	26.15	19.09	-2.85	-1.13	-0.01

Source: US Census Bureau

Existing Transportation Network

Study Area Roadways

The following sections describe the main highways corridors and other roadways in the study area (Exhibit ES-5), including:

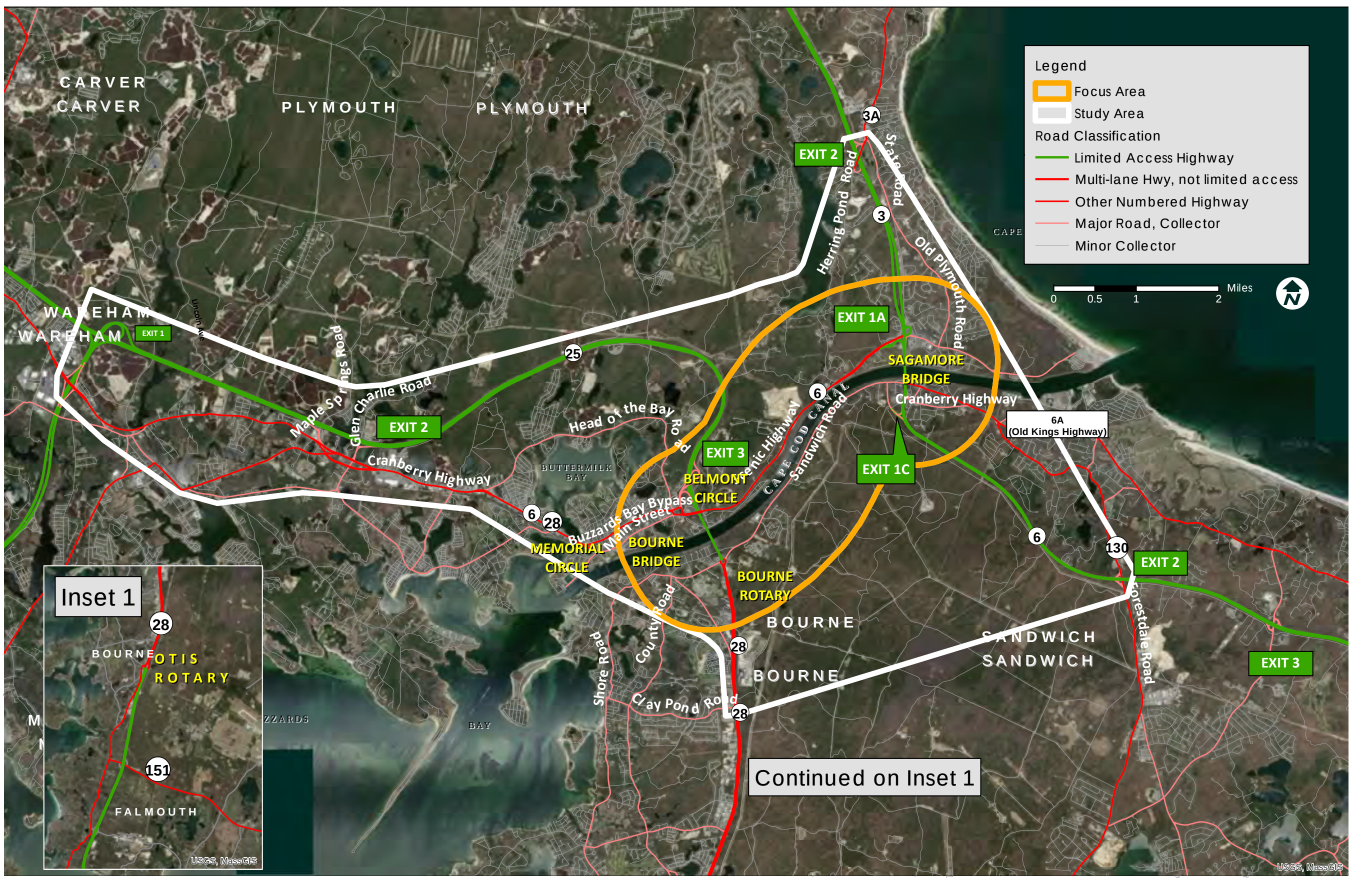
- Route 3/Sagamore Bridge/Route 6 corridor along the eastern side of the study area.
- Route 25/Bourne Bridge/Route 28 corridor along the western side of the study area.

These highways are all under MassDOT jurisdiction while the Canal bridges are owned by the USACE. The Sagamore and

Bourne bridges provide the only roadway access over the Canal to Cape Cod. The cross section of both bridges includes two 10-foot travel lanes in each direction with no roadway shoulder. A single 5-foot wide sidewalk is present on each bridge. The sidewalk is separated from the roadway by a 12-inch high granite curb.

Approaching the Sagamore Bridge on Route 3 southbound, vehicles pass through the "Sagamore Flyover" (Exit 1A – the interchange of Route 3 with Route 6/Scenic Highway). Coming from the north, one of the two Route 3 southbound travel lanes is dropped to allow travelers from Scenic Highway to merge onto Route 3 at Exit 1A, where the second travel lane is reinstated. This lane-drop on Route 3 southbound was a required – but less desirable – design feature of the 2006 reconstruction of the Sagamore Rotary as a highway interchange.

Exhibit ES-5 Major Roadways in the Study Area



Two principal arterial roadways in Bourne provide east-west access between the two Canal bridges:

Route 6 (Scenic Highway)

North of the Canal, Scenic Highway extends approximately 3.5 miles from Route 3 at the Sagamore Flyover in the east to Belmont Circle in the west.

Sandwich Road

South of the Canal, Sandwich Road extends approximately 4.7 miles from the Route 6A/Route 130 intersection in the east to the Sandwich Road/Trowbridge Road/County Road intersection in the west.

Other notable roadways in the study area include:

Route 6A (Old King's Highway)

Owned by the towns of Bourne and Sandwich, Route 6A extends approximately 1.3 miles from the Route 130/Sandwich Road intersection in Bourne to Tupper Road in Sandwich.

Route 130

Owned by the town of Sandwich, Route 130 extends approximately 2.9 miles from the Route 6A/Sandwich Road intersection to Route 6 at Exit 2 in Sandwich.

Route 151

Owned by the towns of Falmouth and Mashpee, Route 151 extends approximately 6.6 miles from the Route 28/Great Neck Road intersection in Mashpee east to the Otis Rotary in Falmouth. A 10 foot wide bike trail runs alongside a portion of the north side of Route 151. The trail extends 0.75 miles from Old Barnstable Road to Job's Fishing Road.

Gateway Intersections

Three major intersections in the focus area ('gateway intersections') provide access to the Sagamore or Bourne Bridges and between the Route 3 – Route 6 corridor and the Route 25 – Route 28 corridor (Exhibit ES-5). These gateway intersections are:

Belmont Circle

This traffic circle is north of the Cape Cod Canal and immediately west of the Route 25 approach to the Bourne Bridge. The roadway approaches to Belmont Circle are Scenic Highway, Main Street, Buzzards Bay Bypass, Head of the Bay Road, and the ramps to Route 25. The entrance ramp to Route 25 eastbound leads directly to the Bourne Bridge.

Bourne Rotary

The Bourne Rotary is located immediately south of the Bourne Bridge. The roadway approaches to the Bourne Rotary include

Top: Belmont Circle, Bourne
Bottom: Bourne Rotary, Bourne

Route 28 (on both the north and south sides of the Rotary), Trowbridge Road, and the Bourne Rotary Connector. A five-foot wide sidewalk exists on the west side of the Bourne Bridge. In 2017, MassDOT extended this sidewalk to the south around the front of the State Police barracks to Veterans Way.

Route 6 Exit 1C Interchange

This interchange includes westbound-only exit- and entrance-ramps to and from Cranberry Highway in Bourne. The highway ramps are immediately south of the Sagamore Bridge. The Christmas Tree Shops retail store is adjacent to the Exit 1C entrance ramp. At approximately 200 feet, these exit- and entrance-ramps are substandard in length. MassDOT Highway Design standards recommend 600-foot exit ramps and 1,000-foot entrance ramps.

Pedestrian Facilities

Pedestrian facilities in the study area include sidewalks and the Cape Cod Canal service roads (bike paths). Sidewalks are generally present in more densely developed residential and commercial areas but absent elsewhere. Many roads in the study area are narrow (20–22 feet) and lack sidewalks, presenting difficulties for pedestrians, particularly the elderly or those with disabilities. Both the Sagamore and Bourne bridges provide a single, narrow sidewalk, but several of the approach roadways to the bridges lack accessible sidewalk connections.

Bicyclists on the Canal bike path road.

Bicycle Facilities

Bicycle facilities in the study area include the Cape Cod Canal service roads (bike paths). The seven mile long paths run along both the north and south sides of the Canal. While there are several accessible connections to the Canal path from the local roadway network or parking lots, there are also notable areas that lack an accessible connection to the Canal path, which is required by the American's with Disabilities Act of 1990 (ADA).

There are gaps in the sidewalk system at the approaches to both bridges which makes it difficult for pedestrians or bicyclists to cross the Canal safely and comfortably. Sidewalks do not exist to connect the south end of the Sagamore Bridge to either Cranberry Highway or Sandwich Road. At the north end of the Bourne Bridge, a lack of sidewalks limit pedestrian access to Belmont Circle.

Bus Service

Bus service on the Cape includes:

- Daily services via the **Cape Cod Regional Transit Authority (CCRTA)**, which includes:
  - Six year-round fixed-route services covering every town on Cape Cod (Sealine, H2O Hyannis-Orleans (H2O Line), FLEX, Barnstable Villager, Sandwich Line, and Bourne Run)
  - Seasonal fixed-route services (WOOSH Trolley, the Hyannis Area Trolley, and the Provincetown/North Truro Shuttle)
  - Demand-response services (Dial-A-Ride Transportation (DART), ADA paratransit services, and Boston Hospital Transportation)
- Privately-owned Peter **Pan Bus Line**, providing weekend service between Cape Cod and Boston, with increased frequency on weekdays and during the summer.
- Privately-owned **Plymouth and Brockton Bus Line**, running four bus routes between Boston and Provincetown 16 times a day from Hyannis to Boston's Logan International Airport via Barnstable, Sagamore, Plymouth, Rockland, and Boston.

Rail Service

The MBTA provides summer weekend service to Cape Cod on the **Cape Flyer**. The Cape Flyer is a service that runs from South Station in Boston to the Hyannis Transportation Center on the Middleborough/Lakeville commuter rail line.

Ferry Service

The **Steamship Authority (SSA)** operates year-round service and licenses private ferry operators to provide year round and seasonal water transport from the mainland to the islands. Ferries run via terminals between:

- Woods Hole and Nantucket/Martha's Vineyard
- Hyannis and Nantucket/Martha's Vineyard
- Boston and Provincetown's MacMillan Pier

Top: Cape Flyer traveling over the Cape Cod Canal
Source: Debee Tlumacki for the Boston Globe

Bottom: The Steamship Authority terminal at Woods Hole

Airline Service

The Barnstable Municipal Airport serves flights by two major airlines:

- **Cape Air** flies from Hyannis to Nantucket and Boston year-round, providing up to 12 round-trip flights a day. From May through October, the airline also flies from Hyannis to Martha's Vineyard
- **JetBlue Airlines** flies one round trip each day between New York City and Hyannis, seasonally.

Barnstable Municipal Airport

Park & Ride Lots

Three Park & Ride lots in (or near) the study area offer commuters and others the ability to carpool or use transit services on Cape Cod. These are:

- The Route 25 eastbound off-ramp at **Exit 2 in Wareham** (120 spaces).
- The **Sagamore Lot**, located north of the Cape Cod Canal at the southeast corner of the Route 3/Route 6 (Scenic Highway) interchange in Bourne (377 spaces). This lot is often at or near capacity year-round.
- A Park & Ride lot in **Barnstable** (just outside of the study area), located at Route 6 Exit 6 in (365 spaces).

Traffic Conditions

To understand the existing traffic conditions throughout the study area, traffic data were collected using methods that include Automatic Traffic Recorders (ATRs), Turning Movement Counts (TMCs), and BlueTOAD™ origin-destination study. Traffic conditions were evaluated using a variety of traffic analysis software including the Highway Capacity Manual Software (HCS), Synchro™ Version 8, VISSIM™, and SIDRA™ 5.1. These traffic analysis techniques are accepted by the Federal Highway Administration (FHWA) and state Departments of Transportation nationwide, including MassDOT.

Based on the existing traffic, future travel demands were projected based on socio-economic factors that lead to changes in traffic volumes, including daily commuting trips to work and school combined with non-commuting trips related to daily shopping, recreation, and other local destinations. As a major tourist destination, visitor travel to Cape Cod can contribute approximately 35% more vehicles on the Canal bridges during the summer compared to the non-summer.

Travel demands were forecast for the future (2040) no-build traffic conditions in the study area. Highway system improvements are typically designed to satisfy traffic demands forecast for 25 years in the future. As the traffic analysis for this study began in 2015, the year 2040 was selected as the design year. This analysis assumes that no substantial transportation improvements will be made in the study area between now and 2040, such as the construction of additional travel lanes, as well as new or reconstructed interchanges, intersections, or multimodal facilities. This 'no-build' alternative serves as the baseline for the comparison of future transportation improvements.

Traffic data collection and analysis methods:

- **Automatic Traffic Recorders (ATRs)** – 57 locations – ATRs use pneumatic tubes placed across a roadway that record the number and type of all vehicles that pass over them.
- **Turning Movement Counts (TMCs)** – 37 locations – TMCs for vehicles were conducted by hand counts. Pedestrian and bicycle traffic were also counted.
- **BlueTOAD™** origin-destination study – 22 locations – A BlueTOAD™ unit performs detailed origin-destination studies by detecting the unique Bluetooth number of phones, navigation, and other GPS-based devices as they enter and exit a study area.
- **Highway Capacity Manual Software (HCS)** – 50 locations – HCS uses the Highway Capacity Manual (HCM) to calculate levels of service (LOS) and other measures of effectiveness of roadway operations for major highways.
- **Traffic analyzation and simulation software** – including Synchro™ v.8, SimTraffic, VISSIM™, and SIDRA™ 5.1 – assessed the efficiency of five signalized and 17 unsignalized intersections in the study area as well as the operations at Belmont Circle and Bourne Rotary.
- **Crash data** – crash data was collected for the years 2012-2014 (the most recent three-year period available at the time data was collected) from all study area intersections analyzed for LOS. These data were used to create diagrams that portray crashes by type and frequency. Analysis of these diagrams contributes to an understanding of why crashes may be occurring at certain locations.

BlueTOAD™ Units.

Data derived from the traffic collection included average daily traffic (ADT), peak-hour volumes, and the turning movements of vehicles in the study area. Traffic operations and crash data were collected and analyzed.

Traffic Volumes

The highest existing and future daily and peak-hour traffic volumes in the study area occur at the following locations:

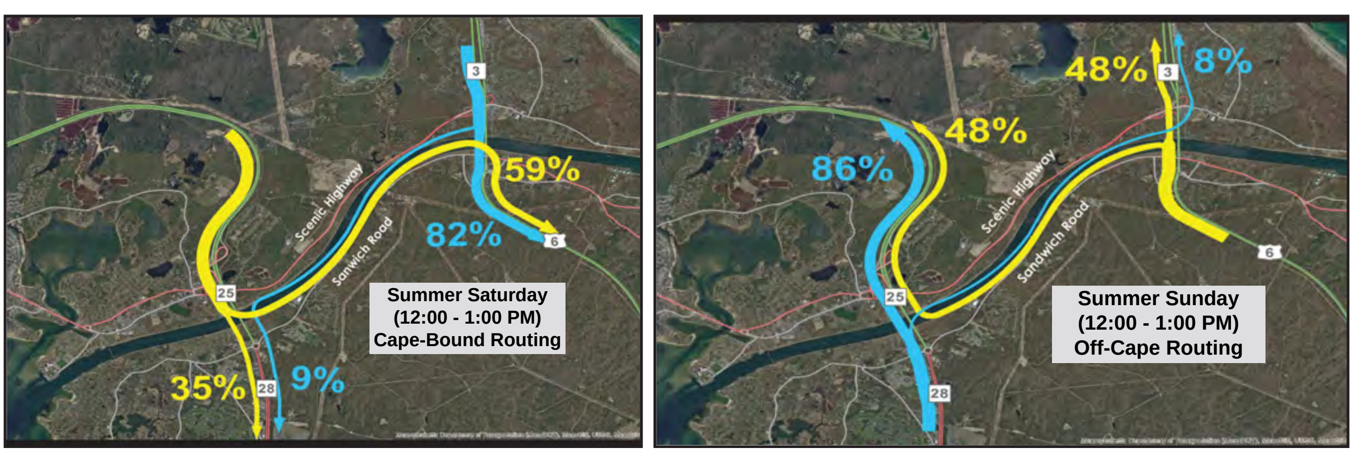
- Major bridges (Sagamore and Bourne Bridges)
- Major highways (Routes 3, 6, 25, 28, and 130)
- Arterial roadways (Scenic Highway, Sandwich Road, and Main Street in Bourne).

There are substantial seasonal differences in traffic volumes in the study area because Cape Cod is a major summer tourist destination. For example, daily traffic volumes on the Bourne and Sagamore Bridge are 49% and 59% higher in the summer compared to non-summer periods. The Sagamore Bridge generally has higher traffic volumes than the Bourne Bridge.

Travel Patterns

A seven-day BlueTOAD™ origin-destination study highlighted a substantial amount of travel moving between the Route 3/Route 6 corridor and the Route 25/Route 28 corridor during all periods of the year. During summer Saturdays when visitors are traveling to Cape Cod, 59% of vehicles on Route 25 exit the highway at Belmont Circle and travel east on Scenic Highway to Route 6 (Exhibit ES-6). Similarly, on summer Sundays when visitors are leaving Cape Cod, 48% of vehicles exit Route 3 at the Sagamore interchange and travel west on Scenic Highway to Route 25, via Belmont Circle. These movements put tremendous pressure on the gateway intersections and lead to high levels of congestion during the peak hours.

Exhibit ES-6 Routing of Traffic Between Highway Corridors



Existing and Future No-Build Traffic Conditions

Traffic conditions along highways and at intersections in the study area, particularly at the gateway intersections in the immediate area of the Canal bridges, often suffer from severe congestion and delay during peak periods. Several intersections, particularly Belmont Circle and Bourne Rotary, have a history of high crash rates.

Traffic volumes in the study area are forecast to increase approximately 30% in the summer period and 26% in the non-summer period between 2014 and 2040. This growth in traffic volumes will not be uniform throughout the study area; some locations will experience greater rates of growth than others.

Under the future (2040) no-build condition, locations forecast to experience the greatest increase in traffic volumes include the Sagamore Bridge and other roadways in the immediate area of the bridge such as Route 3 (between Exits 1A & 2), Route 6 (between Exits 1 & 2), the Mid-Cape Connector, and State Road. Other areas of notable forecast traffic increases include Trowbridge Road, Route 28 (south of the Bourne Rotary),

Table ES-2 Growth in Average Daily Traffic (ADT) at Key Locations 2014 - 2040

ATR COUNTING STATIONS	EXISTING (2014)		FUTURE (2040)		PROJECTED GROWTH	
	SUMMER ADT[1]	NON-SUMMER ADT[1]	SUMMER ADT[1]	NON-SUMMER ADT[1]	SUMMER ADT[1]	NON-SUMMER ADT[1]
Bourne Bridge	56,500	38,000	61,600	45,200	9%	19%
Sagamore Bridge	65,900	41,400	93,300	59,600	42%	44%
Route 3 between Exits 1A and 2	51,600	29,900	72,400	51,800	40%	73%
Route 6 between Exits 1 and 2	72,300	39,600	90,600	51,800	25%	31%
Route 25 West of Exit 2	62,900	42,900	78,900	56,800	25%	32%
Route 25 East of Exit 2	24,500	16,900	26,200	19,700	7%	17%
Route 6 (Scenic Hwy) East of Nightingale Rd	33,600	21,000	36,200	25,400	8%	21%
Sandwich Rd East of Bourne Rotary Connector	30,800	22,600	33,400	28,100	8%	24%
Adams St South of Sandwich Rd	7,600	7,600	11,800	13,900	55%	83%
Buzzards Bay Bypass	7,900	6,000	8,800	6,000	11%	0%
Main St West of Perry Ave	25,600	11,900	28,500	12,120	11%	2%
Trowbridge Rd West of Veterans Way	7,300	6,300	11,500	9,900	58%	57%
Route 28 South of Bourne Rotary	42,500	34,800	49,000	40,100	15%	15%
Route 130 North of Route 6	12,200	9,300	12,500	13,200	2%	42%
Route 6 between Exit 2 and 3	56,400	41,600	67,000	56,000	19%	35%
Mid-Cape Connector South of Sandwich Rd	19,100	15,300	28,500	18,100	49%	18%
Route 6 East of Exit 3	57,000	44,900	70,900	53,400	24%	19%
State Rd North of Ramp to Route 3 NB	5,700	4,700	8,200	6,200	44%	32%
Route 6A East of Cranberry Hwy	12,400	7,500	15,100	8,300	22%	11%
Route 3 between Exits 2 and 3	44,600	37,400	60,000	50,300	35%	35%

[1]*Average Daily Traffic (ADT)*

and Route 6 (between Exits 2 and 3). Table ES-2 shows that traffic volumes are generally forecast to increase more in the non-summer period than in the summer period.

Currently, the level of service (LOS) along the highways in the study area during peak periods are within the LOS A to LOS C range. In the future, traffic operations are forecast to degrade, with substantially more freeway and interchange locations operating at less acceptable levels (LOS D/E) during the summer periods (compared to the existing condition), particularly at the Bourne and Sagamore Bridges and adjacent interchanges.

The roads connecting the bridge approaches – Scenic Highway north of the Canal and Sandwich Road south of the Canal – also experience high traffic volumes and congestion. This is the result of high traffic volumes within the focus area (not just travel through the focus area) and vehicles traveling between the Route 25/Route 28 corridor and the Route 3/Route 6 corridor. This congestion is exacerbated by the inadequate capacity and sub-standard design of the intersections at the bridge approaches, especially gateway intersections at Belmont Circle, Bourne Rotary, and the Route 6 Exit 1C interchange south of the Sagamore Bridge. These intersections and several others along Sandwich Road and Scenic Highway currently experience severe congestion (LOS E/F) during both the summer and non-summer peak periods.

Future No-Build traffic conditions were analyzed for the year 2040. Projecting future travel demand requires an understanding of the socio-economic factors that lead to changes in traffic volumes. The primary contributors to traffic volumes in most locations are the daily commuting trips to work and school combined with non-commuting trips related to daily shopping, recreation, and other local destinations. For this study, forecast visitor trips are also included.

High-Crash Locations

Crash data was collected for the years 2012–2014 (the most recent three-year period available at the time data was collected) from all study area intersections analyzed for LOS. Eight locations within the study area rank as HSIP high-crash locations (Exhibit ES-7). The locations in the study area with the highest crash rates include Belmont Circle, Bourne Rotary, and the intersections of Route 6A at Route 130 and Scenic Highway at Meetinghouse Lane.

Exhibit ES-7 Problem Intersections in the Study Area

Table ES-3 Future (2040) Year-Round Problem Intersections

LOCATION NO. ON EXHIBIT ES-7	LOCATION	TOWN	HIGH CRASH CLUSTER[1]	LOS E OR F (2040)
10	Scenic Highway/Meetinghouse Lane at Canal Street/State Road	Bourne	Yes	Yes
5, 6	Sandwich Road at Bourne Rotary Connector/High School Drive[2]	Bourne	Yes	Yes
8	Route 6A (Sandwich Road) at Cranberry Highway	Bourne	No	Yes
11	Route 130 at Cotuit Road	Sandwich	Yes	Yes
2, 3	Belmont Circle and Scenic Highway at Nightingale Pond Road[2]	Bourne	Yes	Yes
4	Bourne Rotary[3]	Bourne	Yes	Yes
9	Route 6A/Route 130/Tupper Road[4]	Sandwich	Yes	No
N/A	Route 6 Exit 1C Relocation[5]	Bourne	No	No

[1]High crash locations identified by MassDOT for the 2011-2013 or 2012-2014 periods.
[2]Locations combined due to their proximity.
[3]Combined with Sandwich Road at Bourne Rotary Connector intersection.
[4]To be combined with Route 6 Exit 1C Relocation.
[5]Advanced to Alternatives Development due to substandard design.

Issues, Constraints, and Opportunities

Based on the data collected regarding existing natural, cultural, and environmental resources, socio-economic and demographic data, and the traffic study, the following issues, constraints, and opportunities in the study area were identified.

Issues:

- Severe congestion at bridge approaches and gateway intersections.
- High crash rates at multiple intersections in study area.
- Balancing visitor and resident needs.
- Economic expansion hampered by low population growth and aging population.
- Lack of bicycle and pedestrian accommodation.

Constraints:

- Extensive areas of sensitive natural and social environmental resources.
- Existing utility corridors.
- Developed residential and commercial areas.
- Joint Base Cape Cod (including Upper Cape Water Reserve).

Opportunities:

- Collaboration between MassDOT and USACE.
- Reduce peak period congestion and crash rates.
- Enhance multimodal accommodation.
- Improve employment opportunities.

STEP 3: DEVELOP A RANGE OF DESIGN ALTERNATIVES

Based on the review and evaluation of existing and future traffic conditions, a range of design alternatives were developed adhering to MassDOT's standard approach to alternatives development. This approach focuses on:

- Satisfying the study goals and objectives.
- Considering the issues, constraints, and opportunities.
- Minimizing impact to property, community facilities, and environmental resources.

Transportation improvements were developed in accordance with the requirements of MassDOT's Highway Development and Design Guide and reflect a commitment to complete streets and mode shift objectives to the degree appropriate for each individual location, consistent with the principles of MassDOT's Healthy Highway's Transportation Policy Directive. This policy seeks to increase and encourage the use of a greater variety of transportation modes including walking, bicycling, and transit.

Recognizing that Cape Cod is a major summertime tourist destination, trying to design transportation improvements to accommodate the summertime peak period traffic volumes would require the construction of very substantial infrastructure improvements. The study team, in consultation with the study Working Group, concluded that this level of infrastructure would likely be considered an 'over-build' – not in line with the type or scale of development desired on Cape Cod. As a result, the focus of the study was limited to improvements to year-round problem intersections (Exhibit ES-7). The goal of the transportation improvements design was to accommodate traffic volumes related to the future (2040) fall weekday P.M. peak period and include further improvements to accommodate the summer Saturday peak period, as feasible

Year-round problem intersections are forecast to operate as a LOS E or F during at least one summer and non-summer peak travel period in 2040 and include those designated as high-crash locations. Overall, eight locations were advanced to alternatives development. Several of these are a combination of more than one year-round problem intersection, as proximity to one another resulted in them operating as a single traffic point.

Local Intersection Alternatives

Alternatives for local intersections include Transportation System Management (TSM) improvements. Examples of TSM improvements include traffic signal optimization, including

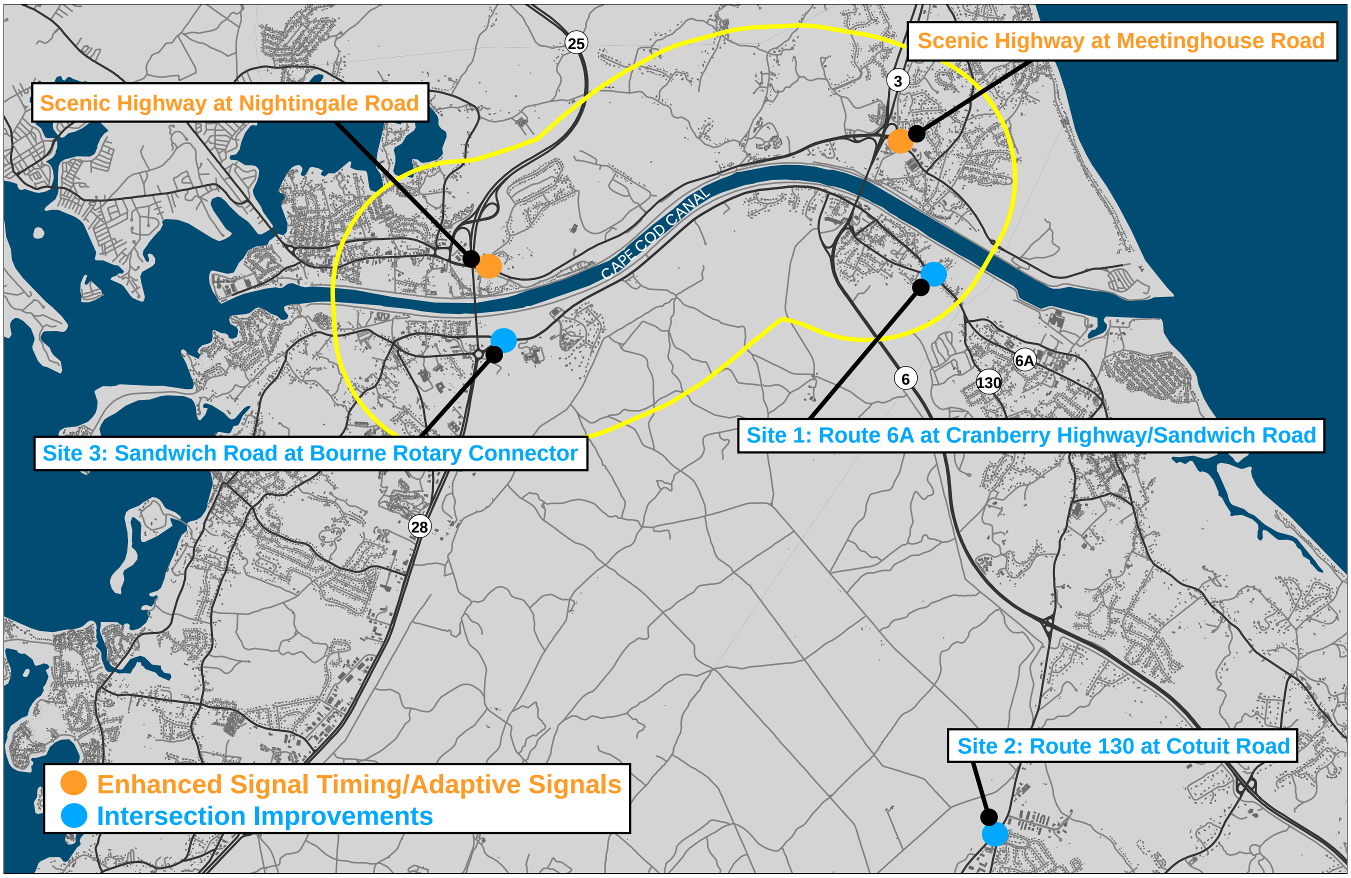
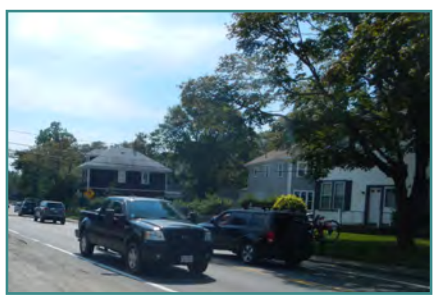
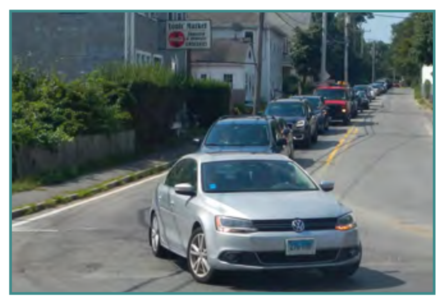


Exhibit ES-8 Local Intersection Improvement Locations

Traffic on local roads. Some local trips must use regional highways (left) and the connecting, local roads are narrow (center). One left turn can create significant traffic on many local roads (right).





adaptive signal controls, installation of new traffic signals and/or signal control equipment, installation of turning lanes, and improved roadway markings and signage. Improvements at the following locations (Exhibits ES-8 and ES-9) were evaluated:

- Scenic Highway at Meetinghouse Lane (TSM improvements)
- Scenic Highway at Nightingale Road (TSM improvements)
- Sandwich Road at Bourne Rotary Connector
- Route 6A (Sandwich Road) at Cranberry Highway
- Route 130 (Forestdale Road) at Cotuit Road

Exhibit ES-9 Local Intersection Improvements

Site 1

Route 6A (Sandwich Road) at Cranberry Highway

Site 2

Route 130 at Cotuit Road

Site 3

Sandwich Road & Bourne Rotary Connector

Gateway Intersection Alternatives

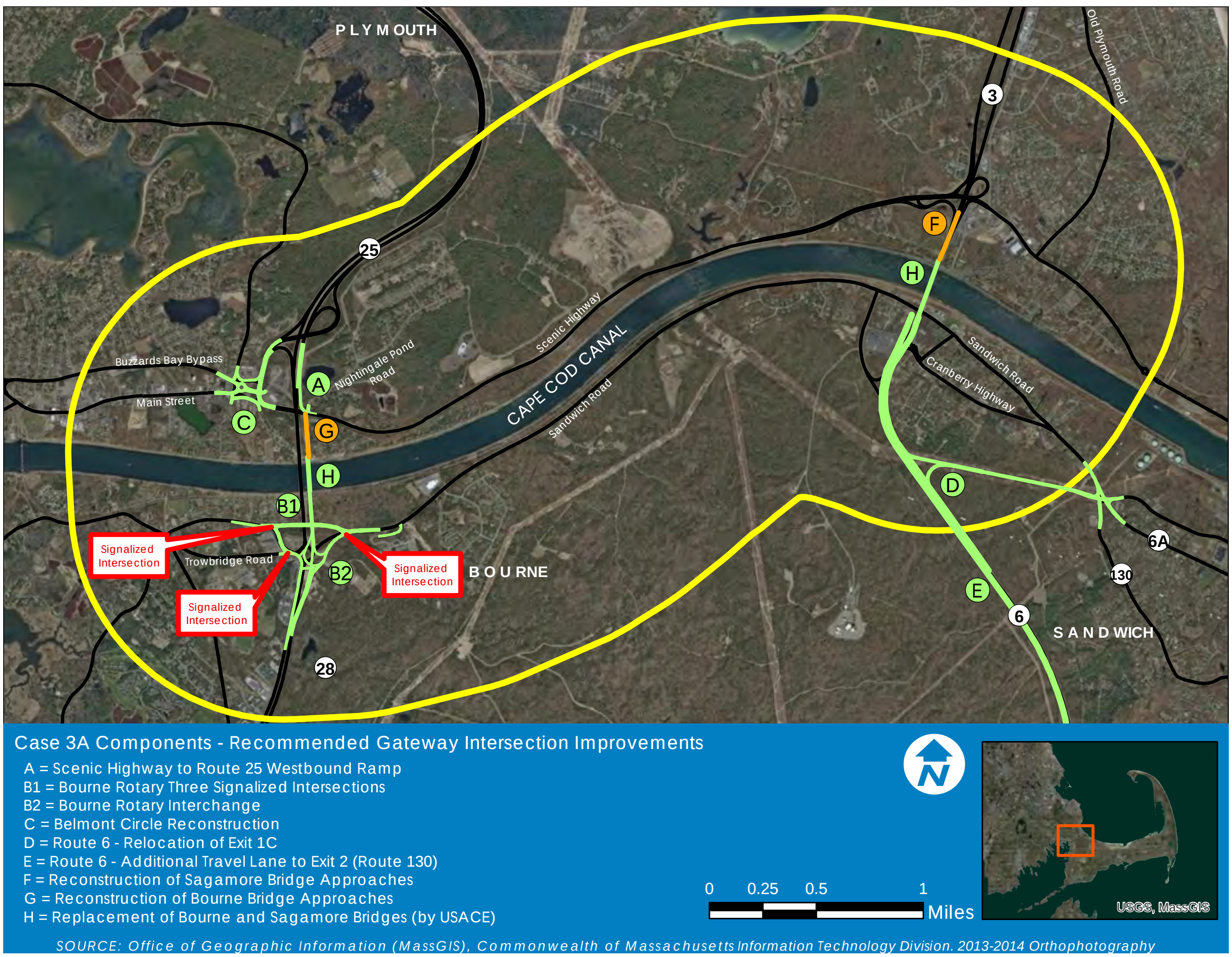
Multiple alternatives were evaluated at the gateway intersections to determine their effectiveness at improving traffic operations and consider their potential impact on environmental resources and property (Exhibit ES-10). The following sections describe the alternatives evaluated at the gateway intersections.

Route 6 Westbound at Exit 1C

Route 6 at Exit 1C (Cranberry Highway) provides an exit and entrance on Route 6 for westbound vehicles only. The geometry of Exit 1C is substandard and not in compliance with current MassDOT highway design standards. The deficiencies of Exit 1C include short acceleration and deceleration lanes and steep grades approaching the Sagamore Bridge.

During summer weekend peak periods, the Route 6 westbound approach to the Sagamore Bridge at the Exit 1C interchange are often characterized by substantial congestion with queues on Route 6 westbound extending 4.4 miles or more, resulting in

Exhibit ES-10 Potential Gateway Intersection Improvements



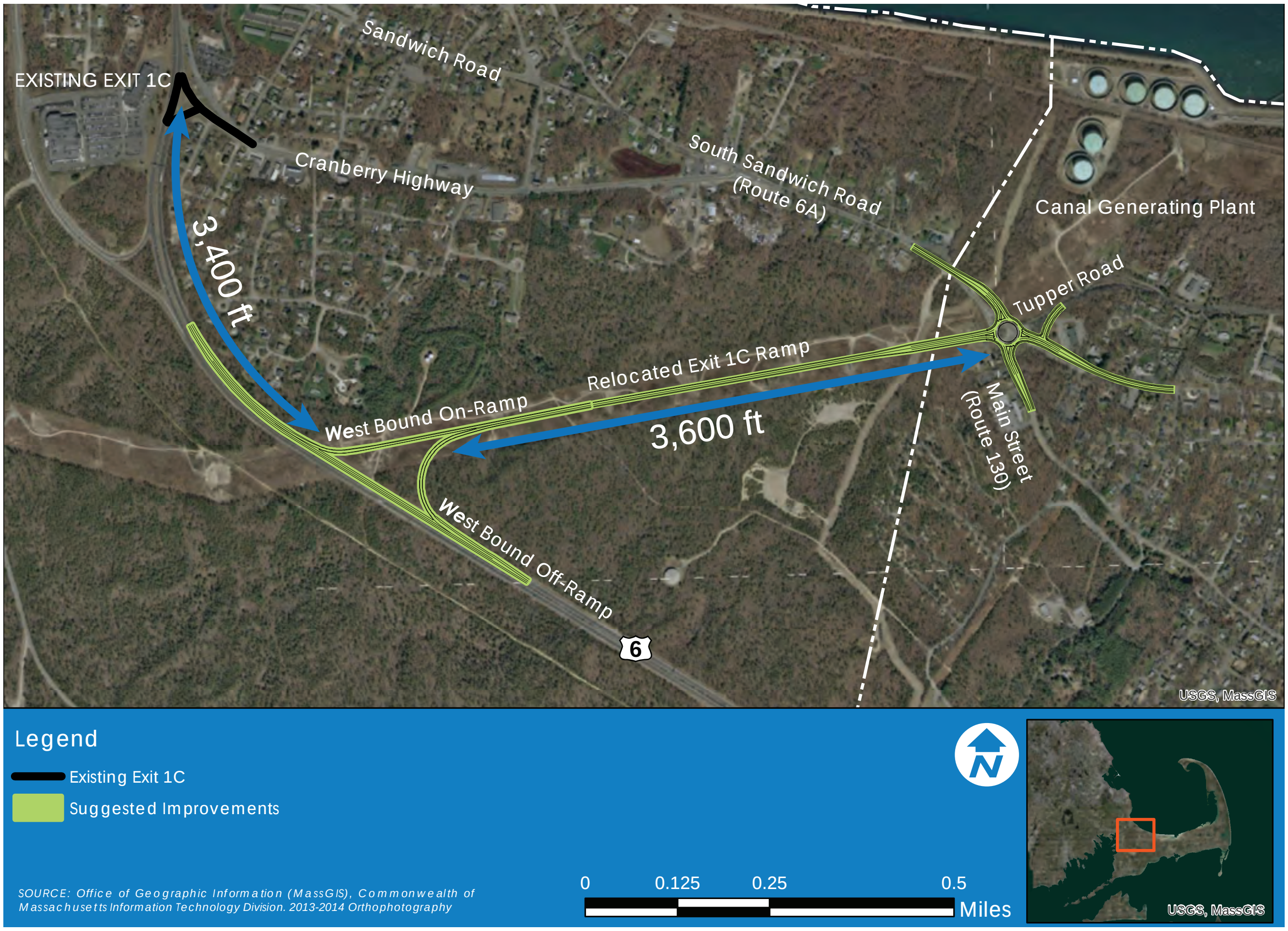


Exhibit ES-11 Relocation of Route 6 Exit 1C

LOS F conditions. This congestion results in substantial delays (average delay of 11.4 minutes) for vehicles heading off-Cape. The summer peak period delay on Route 6 westbound is forecast to increase to 13.5 minutes by 2040.

In addition to improving traffic operations on Route 6 westbound, it is anticipated that the future profile of a potential replacement Sagamore Bridge would be less steep than the six-percent grade on the existing bridge. This would result in a longer bridge, which would tie into Route 6 further east, requiring the relocation of the existing Exit 1C.

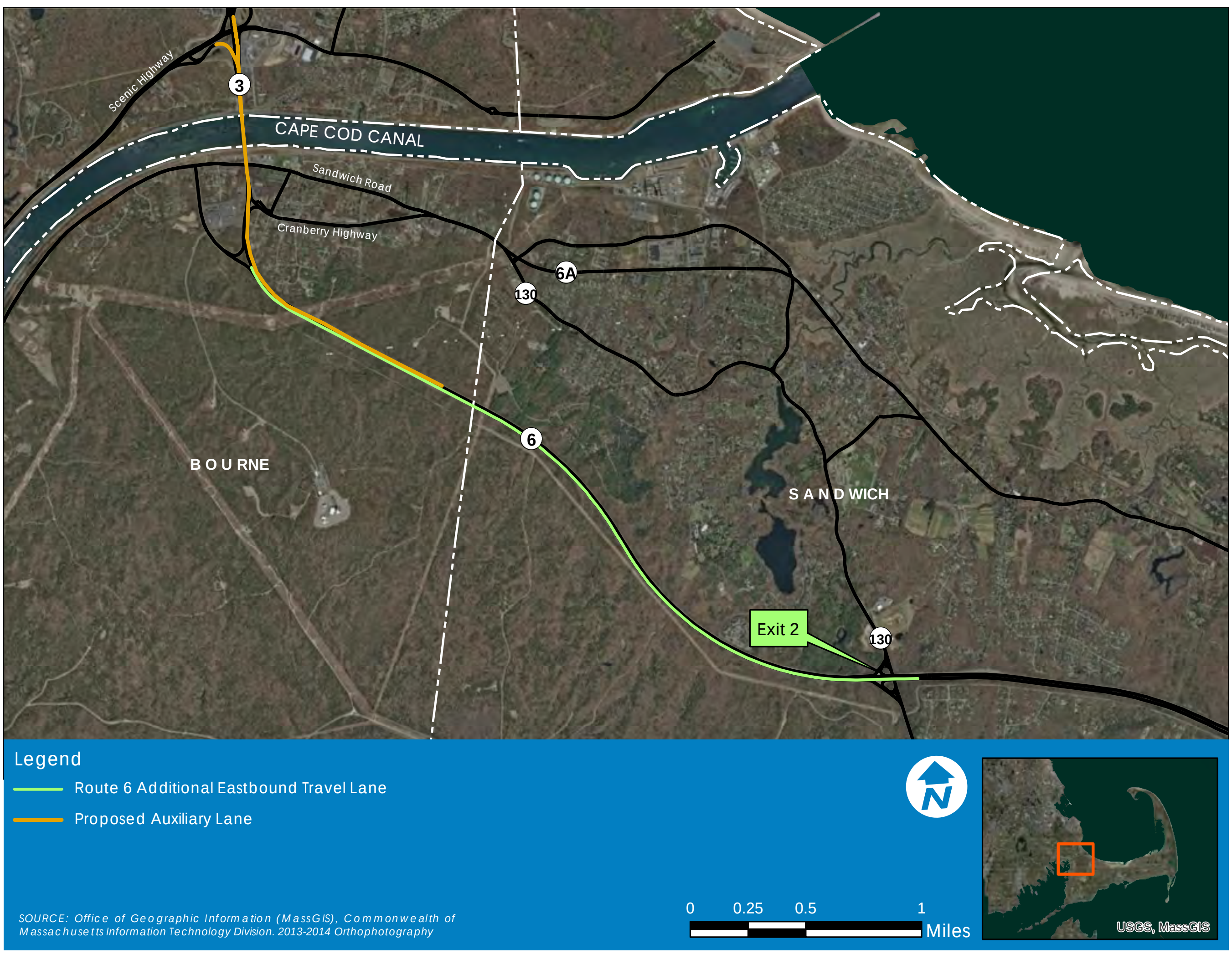
Therefore, the relocation of Route 6 Exit 1C from its existing location at the base of the south end of the Sagamore Bridge was evaluated. The selection of a new location for the Exit 1C interchange would need to be informed by existing land uses adjacent to Route 6 (residential neighborhoods, state forest, and JBCC) and comply with Federal Highway Administration (FHWA) guidelines.

Given these existing constraints, the electrical utility corridor was identified as the most appropriate location for the relocated interchange. This relocated interchange would provide a roadway connection from Route 6 eastbound to the Route 6A/Route 130 intersection which would be reconstructed as a four-leg roundabout (Exhibit ES-11). This location would have only a minor effect on existing commercial and residential properties and state forest land. No wetland, floodplain, or other regulated water resources would be impacted. These improvements would impact approximately 7.2 acres of land designated as a Priority Habitat for Rare Species.

Route 6 Eastbound Travel Lane

The study team evaluated building an additional travel lane on Route 6 eastbound for approximately 3.4 miles from the Mid-Cape Connector to Exit 2 (Route 130, Exhibit ES-12). It is assumed that this additional travel lane would be constructed concurrent with the construction of a replacement Sagamore Bridge. A replacement Sagamore Bridge in envisioned to include auxiliary lanes extending from the Scenic Highway entrance

Exhibit ES-12 Route 6 Eastbound Travel Lane



ramp to Route 3 southbound, over the Sagamore Bridge, to the Mid-Cape Connector entrance ramp to Route 6 eastbound.

An additional eastbound travel lane on Route 6 would act as an extension of this auxiliary lane providing additional capacity and distance for entering vehicles to merge onto the heavily-traveled section of Route 6 eastbound between the Sagamore Bridge and Exit 2 (Route 130). The extension of this additional eastbound travel lane would not be needed beyond Exit 2 because traffic volumes drop substantially after this point. For example, during the future no-build period, traffic volumes west of Exit 2 drop by more than 27%, from 2,765 to 2,000 vehicles, during the non-summer weekday PM peak period.

The construction of an additional eastbound travel lane may impact up to 3.9 acres of rare species habitat. No other regulated environmental resources, such as wetlands or floodplains, would be impacted.

Belmont Circle and Bourne Rotary

Belmont Circle and the Bourne Rotary are located north and south of the Bourne Bridge, respectively. These are two of the most critical intersections in the study area and motorists often must navigate both traffic circles when crossing the Bourne Bridge.

The high traffic volumes and sub-standard design of these unsignalized traffic circles results in severe traffic congestion every day. Each currently operate at LOS F during all peak travel periods during both the summer and non-summer periods resulting in lengthy vehicle queues extending from the approaches to either intersection.

The proximity of these traffic circles means they have a substantial effect on each other. For example, during peak periods, a lengthy queue often forms on the Route 28 southbound approach to the Bourne Bridge, extending several thousand feet north along Route 25. These queues delay other motorists trying to enter Belmont Circle from Route 25 Exit 3 or Scenic Highway. The key to improving traffic operations for both Belmont Circle and Bourne Rotary was recognized as identifying transportation improvements that:

1. **Reduce traffic volumes entering the Belmont Circle and Bourne Rotary.**

2. **Safely accommodate both regional and local traffic.**

3. **Maintain access to local businesses.**

4. **Ensure compatibility with a future replacement Bourne Bridge alignment (likely to the east of the existing bridge).**

Belmont Circle Reconstruction

Several alternatives were developed to improve traffic operations at Belmont Circle. To reduce traffic volumes entering Belmont Circle, the construction of a new highway entrance ramp from Scenic Highway westbound to Route 25 westbound is included in each alternative (Exhibit ES-13). All alternatives also include improvements for bicycle and pedestrian accommodations and maintain access to adjacent properties.

A Route 25 westbound entrance ramp from Scenic Highway would result in approximately 0.2 acres of impact to land within an interim wellhead protection area. No wetland, floodplain, or rare species habitat areas would be impacted. This ramp would be partially within an area containing natural gas lines, requiring close coordination with the utility company to determine if relocation of these gas lines would be necessary.

Ultimately, the alternatives evaluated for this study (Exhibit ES-14) included:

- Three-leg roundabout with signalized intersection (Alternative 1)
- Three-leg roundabout with signalized intersection and fly-over ramp (Alternative 1A)
- Four-leg roundabout (Alternative 2)

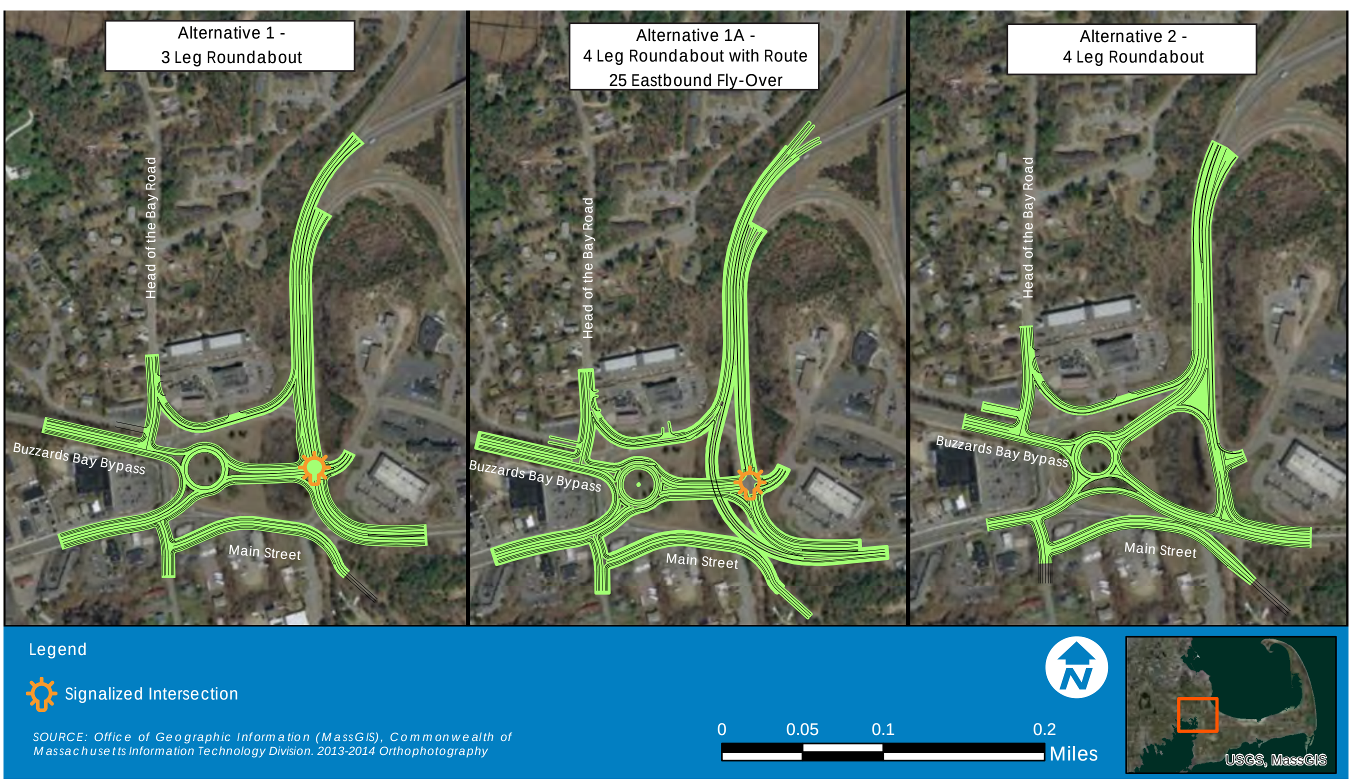
Each of the three alternatives for the reconstruction of Belmont Circle would impact a moderate amount of wetland resources and 100-year floodplain. Open space and residential and commercial property acquisitions may also be required.

Alternative 1 – Three-leg roundabout with signalized intersection – was advanced for further study during the travel model analysis. Under Alternative 1, maximum queue lengths during the non-summer weekday peak period for all approaches except the Buzzards Bay Bypass would be reduced to less than half of the future no-build condition. The reductions in maximum peak period queue length during the summer Saturday peak period is even more favorable with all approaches experiencing substantial reductions.

Overall, this alternative was selected because it would improve traffic operations with a simpler, less costly design (since it does not include the bridge structure that is included in Alternative 1A).

Exhibit ES-13 Scenic Highway Westbound to Route 25 Westbound Ramp

Exhibit ES-14 Alternatives Evaluated – Belmont Circle



Bourne Rotary Reconstruction

Alternatives for the Bourne Rotary were conceived to be compatible with the existing Bourne Bridge and the anticipated vertical and horizontal alignment of a future Bourne Bridge. Each of these alternatives assumes that local intersection improvements for Sandwich Road at the Bourne Rotary Connector (noted above) are completed. A larger-scale alternative to reconstruct Bourne Rotary as a highway interchange was also explored.

As with the Belmont Circle alternatives, all Bourne Rotary alternatives would include improvements to bicycle and pedestrian accommodations and maintain access to adjacent properties. Sidewalks, crosswalks, and bicycle lanes would be constructed on Old Sandwich Road to provide east-west access under the Bourne Bridge. These facilities would enhance access between public facilities such as the Upper Cape Cod Technical High School and the Bourne Middle and High Schools.

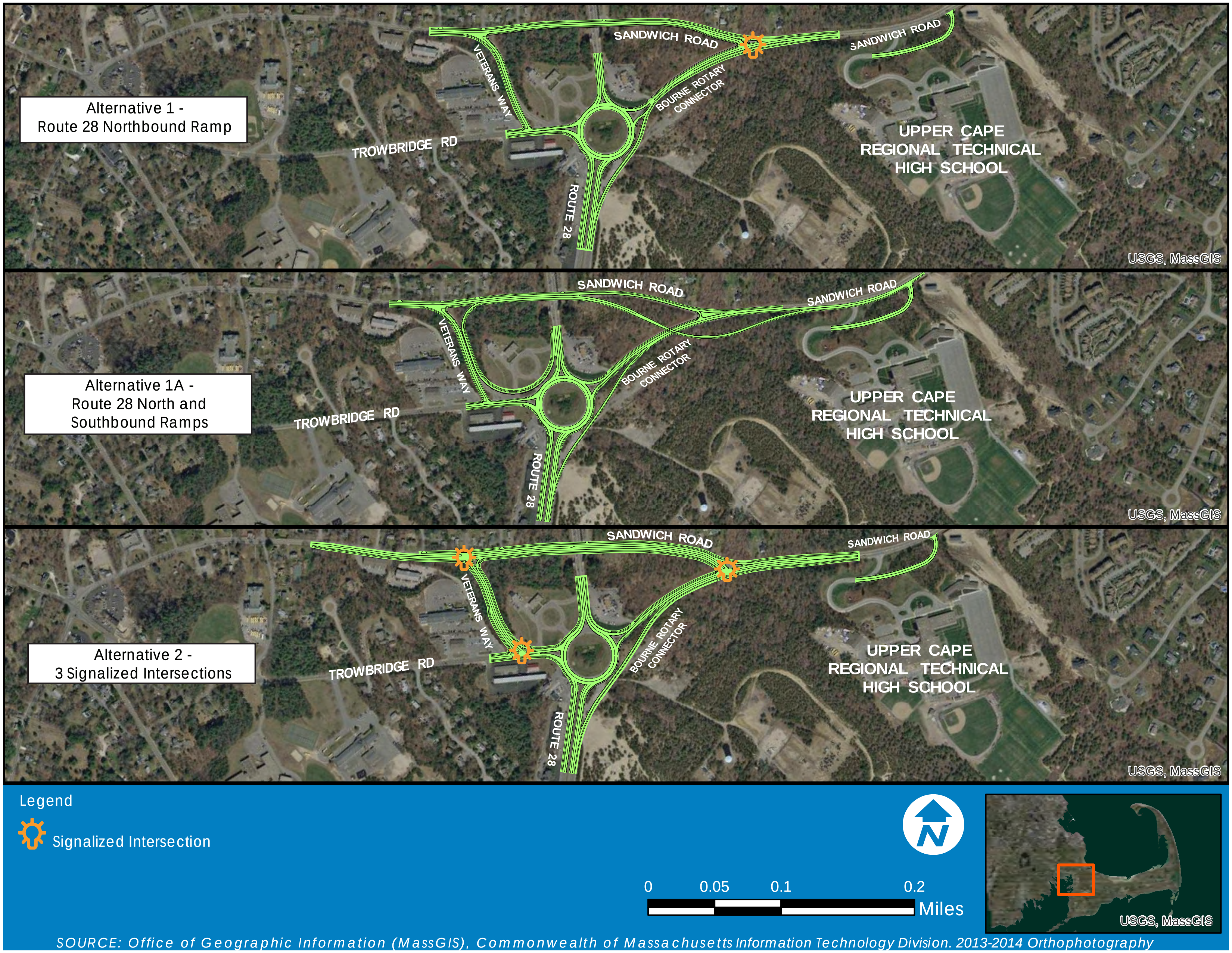
Bourne Rotary alternatives evaluated (Exhibit ES-15) included:

- Route 28 northbound ramp (Alternative 1)
- Route 28 northbound and southbound ramp with Sandwich Road underpass (Alternative 1A)
- Three signalized intersections (Alternative 2)

None of the three alternatives would impact wetland resources, 100-year floodplain, or rare species habitat. All alternatives may require minor property acquisitions from the USACE and adjacent residential and commercial properties.

Alternative 2 – Three Signalized Intersections – was advanced for further study during the travel model analysis. This alternative was selected because it would result in acceptable traffic operations at all three signalized intersections. The Veterans Way at Trowbridge Road intersection would operate at LOS B and C for the non-summer weekday and summer Saturday peak periods, respectively. The Veterans Way at Old Sandwich Road intersection would operate at LOS C and D and the Sandwich Road at Bourne Rotary Connector intersection would operate at LOS C for both time periods. Based on the conceptual design, this alternative could be incorporated into the Bourne Rotary Interchange alternative and, ultimately, a potential replacement Bourne Bridge.

Exhibit ES-15 Alternatives Evaluated – Bourne Rotary



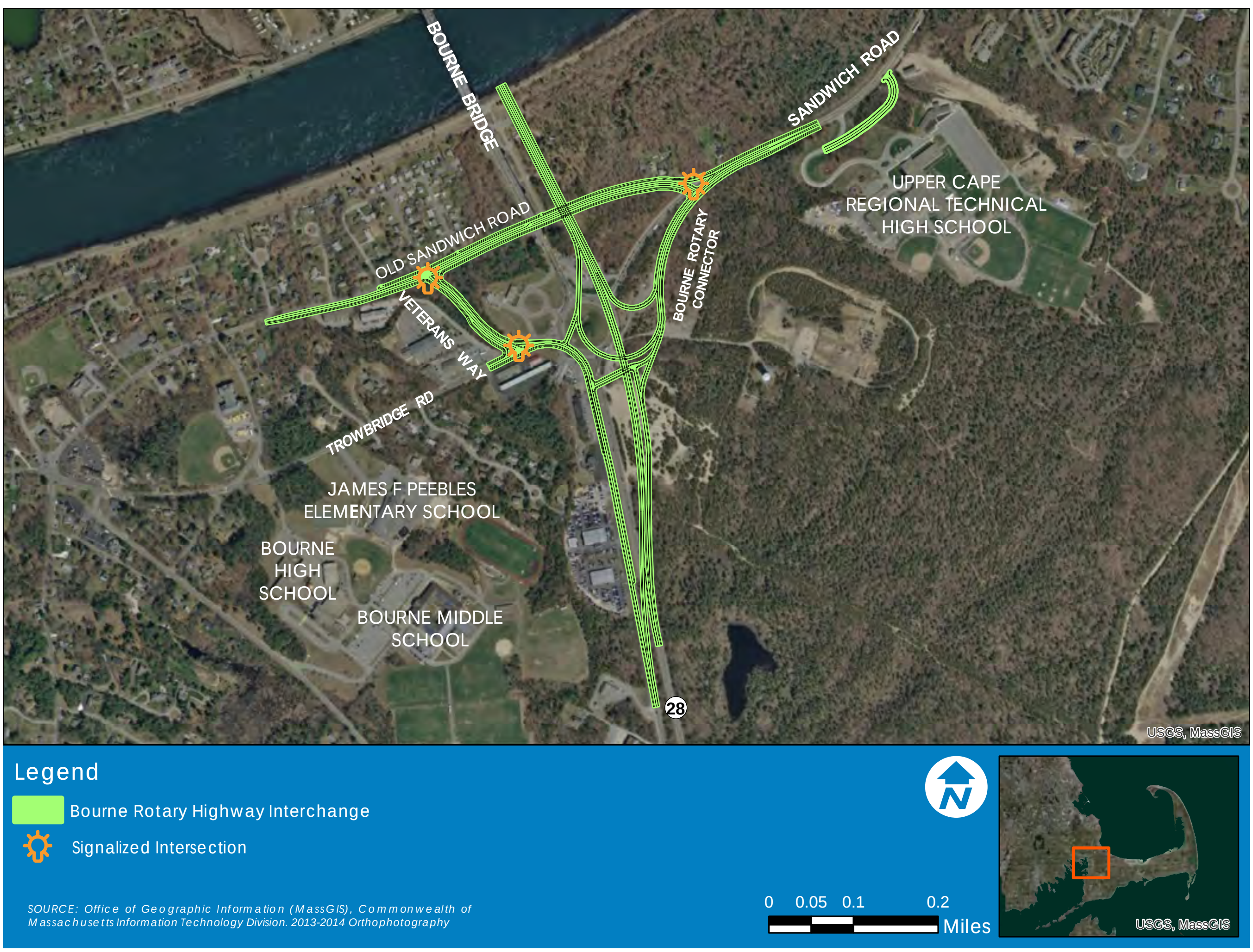
Bourne Rotary Interchange

A larger-scale alternative to improve traffic operations at the Bourne Rotary was evaluated. This alternative involves the reconstruction of the Bourne Rotary as a highway interchange and includes construction of Bourne Rotary Alternative 2 – three signalized intersections. This alternative was conceived to be constructed concurrent with an assumed replacement of the Bourne Bridge, with an alignment immediately east of the existing bridge (Exhibit ES-16).

The reconstruction of the Bourne Rotary as a highway interchange involves the removal of the Rotary and the construction of a grade-separated highway ramp system that would allow vehicles to enter Route 28 (northbound or southbound) directly from Sandwich Road (via the Bourne Rotary Connector) or Trowbridge Road. Local traffic would pass directly over Route 28 on an overpass.

The reconstruction of the Bourne Rotary as a highway interchange would substantially reduce peak period queuing on

Exhibit ES-16 Bourne Rotary Interchange



the Rotary approach roadways including Route 28 (northbound and southbound), Trowbridge Road, and the Bourne Rotary Connector. Currently, the Bourne Rotary suffers from LOS F conditions during all peak periods. Construction of a highway interchange would improve traffic operations, forecast to range from LOS A to LOS C conditions.

A Bourne Rotary Interchange alternative would not impact wetland resources, 100-year floodplains, or land owned by the Town of Bourne. This alternative may impact a minor amount of rare species habitat (0.2 acres). The interchange alternative would require the acquisition of approximately 0.4 acres of land from the USACE and 0.3 acres of residential property. The interchange may also require approximately 2.2 acres of commercial land east of the Rotary.

Bourne and Sagamore Bridges – Potential Replacement Design Features

Historic postcard depicting the Bourne Bridge
Source: Boston Public Library

The Sagamore and Bourne Bridges both opened in 1935 and are nearing the end of their usable service lives. For this planning study, it was assumed that the USACE will determine that both Bridges require complete replacement. Identical in design, each highway bridge is approximately 48 feet in width, providing four 10-foot-wide traffic lanes (two lanes in each direction), with no roadway shoulder or median. A single five-foot wide sidewalk and a two-foot safety walk are provided along opposite sides of the Bridges.

Based on the local topography, existing land uses, and environmental resources, it is assumed that these replacement bridges would be constructed immediately adjacent to and inside of the existing Bridges. A replacement Bourne Bridge would be built to the east of the existing bridge and a replacement Sagamore Bridge would be built to the west of the existing bridge.

It is also assumed that replacement Canal Bridges would be multimodal structures designed to current MassDOT highway design standards and policies. Specifically, a bridge with a much wider cross section is envisioned to accommodate all users. This cross section could be up to 138 feet wide, including two 12-foot lanes in each direction and a single 12-foot auxiliary traffic lane in each direction. These lanes would be separated by a 10-foot wide median. Bicyclists and pedestrians could cross the bridge on a 12-foot wide shared-use path on one side of the bridge with a six-foot wide pedestrian sidewalk on the other side of the bridge (Exhibit ES-17).

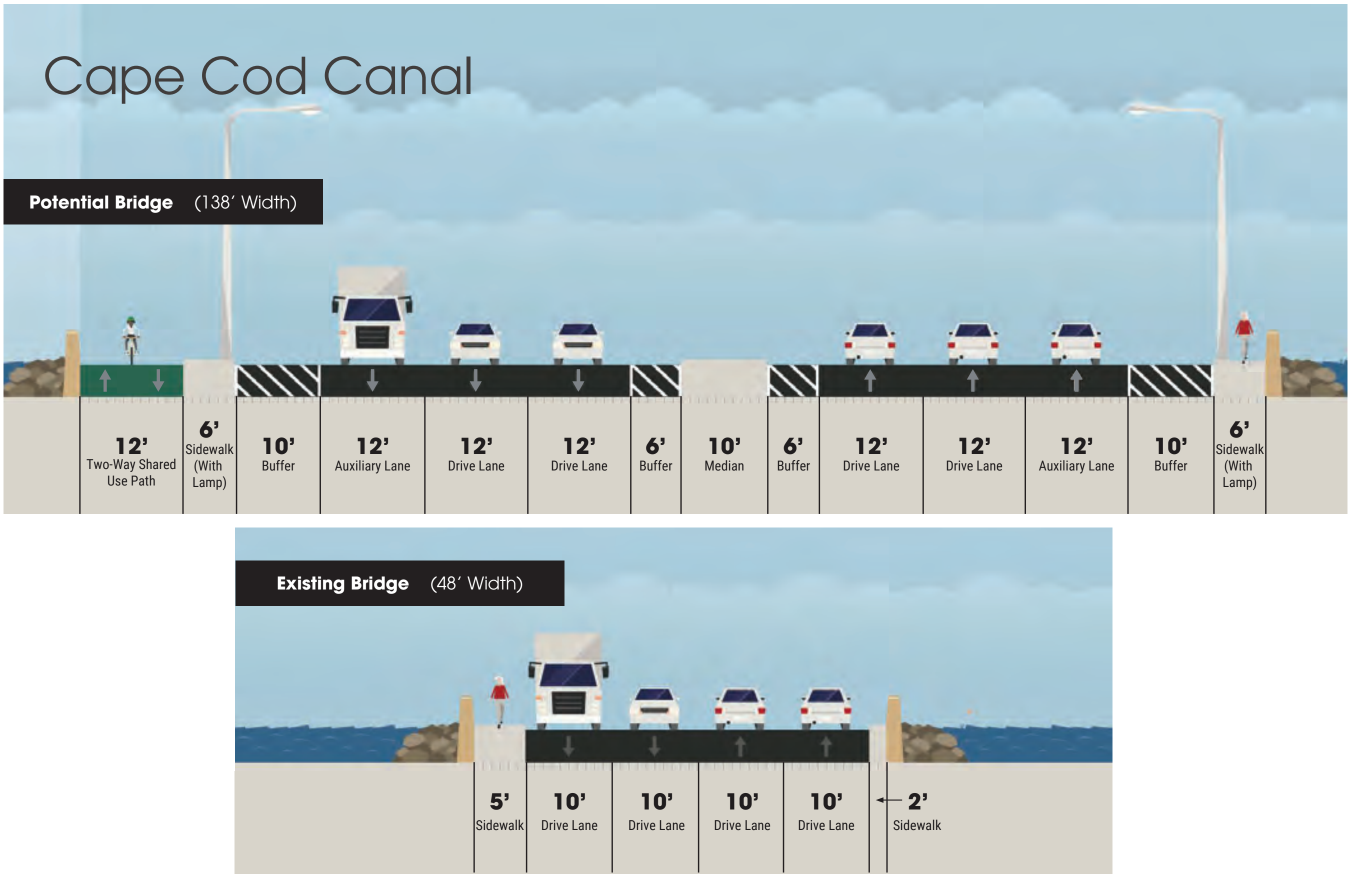


Exhibit ES-17 Potential Cross Section of Replacement Canal Bridges

Multimodal Transportation Alternatives

Improvements to multimodal transportation facilities in the study area were evaluated, including improvements to pedestrian, bicycle, and park-and-ride facilities. This evaluation considered improvements to existing facilities, new connections between existing facilities, and the construction of new facilities.

Bicycle and Pedestrian Alternatives

The following sections describe potential improvements to the bicycle and pedestrian facilities in the study area.

Improved Connections to Canal Service Road (Bike Path)

Access and use of the Canal service road (bike path) by all users could be improved through the construction of new accessible connections to the bike path from the local roadway network. Gaps in the accessible connections to the Canal bike path road were identified both north and south of the Canal. Three potential locations were identified to provide access to the bike path from local roads: including new connections from Pleasant Street and the Bourne Ball Field (south of the Canal in Bourne) and Old Bridge Road on the north side of the Canal in Bourne.

Bicyclists on the Canal bike path road.

Improved Access to/across the Canal

Several potential locations to improve bicycle/pedestrian travel across the Canal were evaluated. Sidewalks that approach the bridges could be widened and reconstructed to meet ADA-compliance. Additionally, gaps in the sidewalk network could be completed to allow uninterrupted sidewalk access across the Canal to the local roadway network and the Canal bike path.

Improved Accommodation along Bus Routes

Multimodal travel in the study area could be enhanced through improvements in bicycle and pedestrian facilities along bus routes. This is an important part of an overall effort to create an integrated multimodal transportation system.

Several key bus routes in the study area, including those along County Road and Route 151 along the Bourne Run bus line and Route 6A, Route 130, Service Road, and Quaker Meeting House Road along the Sandwich Line require pedestrian and bicycle facilities. The roadways along these bus routes lack consistent ADA-compliant sidewalks, roadway shoulders suitable for bicycle travel, bus shelters, and bike racks.

Multimodal Transportation Center

Multimodal centers provide commuters and other travelers with free and secure parking when transferring to carpool or transit services. These centers are beneficial for reducing the cost of daily commutes and reducing traffic volumes by limiting single-occupant vehicle travel.

Constructing an additional Park & Ride lot at Exit 2 (Route 130) was determined feasible because MassDOT owns sufficient land at the southwest quadrant of the interchange, there are no wetland resources present, and the Plymouth & Brockton bus line and CCRTA Sandwich line already pass by this location. Furthermore, the western terminus of the upcoming Service Road shared-use path is Route 130 at this location. The hilly topography of this parcel may initially limit the size of the lot to approximately 100 cars, but a larger lot could eventually be constructed with additional site grading.

STEP 4: ANALYZE DESIGN ALTERNATIVES BASED ON EVALUATION CRITERIA

The following sections describe the analysis conducted using the regional travel demand model to identify the most effective combination of transportation improvements in the study area.

Regional Travel Analysis Modeling

This study's travel analysis model provides a method for combining groups of potential transportation improvements (known as 'cases') to evaluate their effectiveness. The travel analysis model also reveals potential new travel patterns that may cause unforeseen traffic congestion in other locations. This exercise clarified the level of transportation improvements necessary to provide acceptable traffic operations in the study area for the 2040 non summer weekday PM period without overbuilding in a manner inconsistent with the character of Cape Cod.

Seven cases were selected for analysis to provide logical and comprehensive groups of improvements. These seven cases generally build upon one another with the first cases incorporating smaller intersection improvements and subsequent cases including an increasing number of transportation improvements. The nine different components of the travel analysis model cases are listed on Table ES-4 and shown on Exhibit ES-18.

Cases 1, 1A, 1B, 2, and 2B were analyzed with the existing Canal bridges remaining in place as the improvements proposed under these cases could proceed as stand-alone projects without requiring any future action. However, if the USACE proceeds with the replacement of the Canal bridges, these improvements, with modest modifications, would still be compatible with the assumed location and layout of the replacement bridges. Cases 3 and 3A assume that replacement Canal bridges are in place. Case 3A differs from Case 3 with the construction of a highway interchange replacing the Bourne Rotary

The effectiveness of each case was determined by performance during the non-summer weekday PM (4:00 – 6:00 PM) and summer Saturday (10:00 AM – 12:00 PM) peak periods, when compared to the future no-build conditions at Belmont Circle and Bourne Rotary in terms of vehicle queues, delay, and level of service. Traffic conditions were also evaluated for the Route 3 southbound and Route 6 westbound approaches to the Sagamore Bridge.

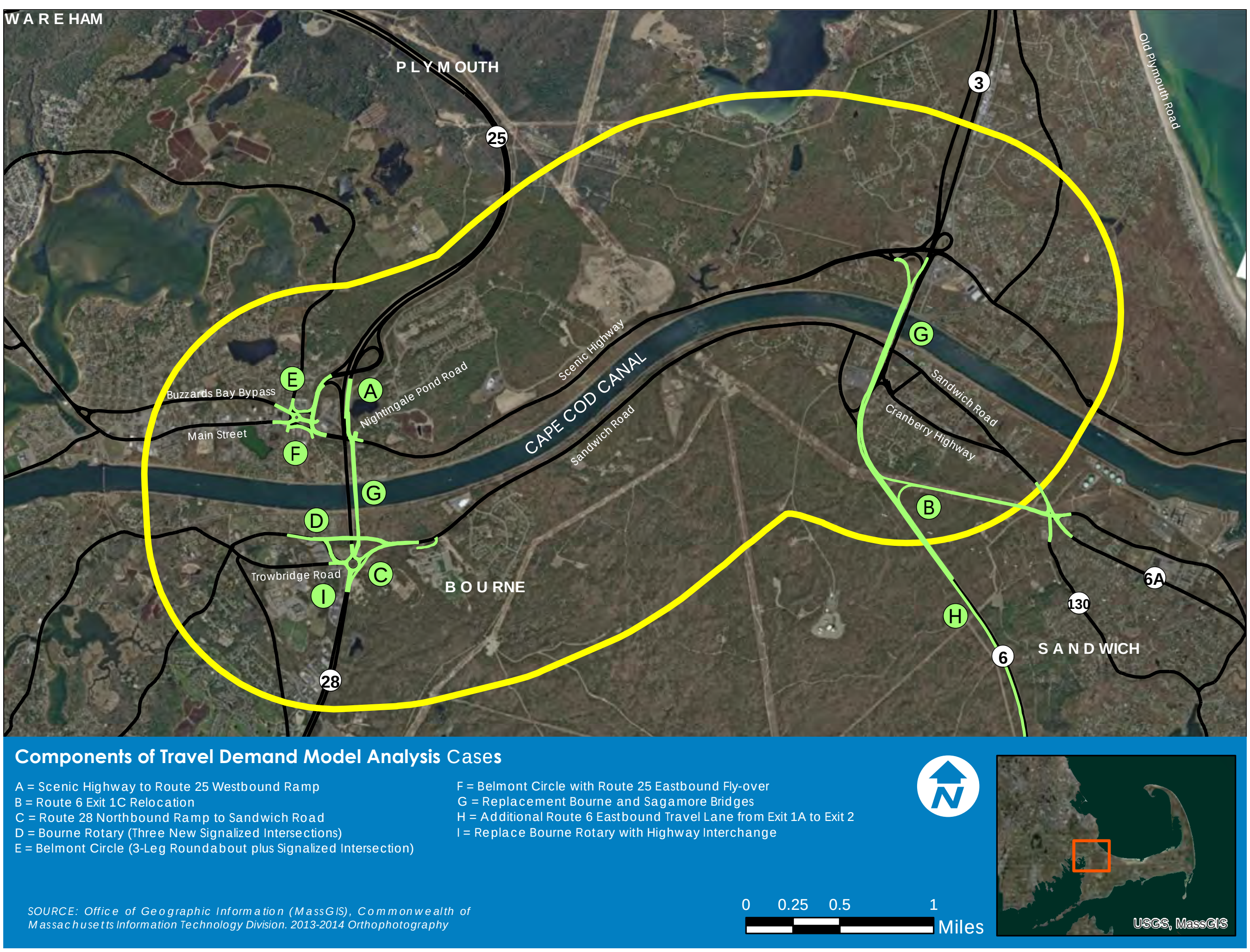
Case Analysis Findings

Because they provide an accurate reflection of traffic conditions throughout the focus area, analysis of the seven-travel demand model cases is predominately based on how these cases would affect traffic operations at Belmont Circle, Bourne Rotary, and the Route 3 and Route 6 approaches to the Sagamore Bridge.

Table ES-4 Components of Seven Travel Demand Analysis Cases

MAP LOCATION (ES-18)	IMPROVEMENTS	CASE 1	CASE 1A	CASE 1B	CASE 2	CASE 2B	CASE 3	CASE 3A
A	Scenic Highway to Route 25 Westbound On-Ramp	X	X	X	X	X	X	X
B	Route 6 Exit 1C Relocation	X			X	X	X	X
C	Route 28 Northbound Ramp to Sandwich Road		X	X	X	X	X	
D	Bourne Rotary (3 New Signalized Intersections)			X	X	X	X	
E	Belmont Circle (3-Leg Roundabout plus Signalized Intersection)				X		X	X
F	Belmont Circle with Route 25 Eastbound Fly over					X		
G	Replacement Bourne and Sagamore Bridges						X	X
H	Route 6 Eastbound Travel Lane from Exit 1A to Exit 2						X	X
I	Bourne Rotary with Highway Interchange							X

Exhibit ES-18 Components of Seven Travel Demand Analysis Cases



In developing the overall findings, the study team remained mindful of the design assumptions that guided the alternatives development process. These design assumptions include a focus on the future year-round problem locations, prioritizing improvements to accommodate the future non-summer weekday peak period and providing further improvements to accommodate the summer Saturday peak period as feasible.

Table ES-5 and Exhibits ES-19 and ES-20 summarize findings for the seven cases analyzed. Table ES-5 provides a summary of the primary measures of effectives for traffic operations at Belmont Circle and Bourne Rotary including average queues, maximum queues, average delays, and LOS.

Exhibit ES-19 and ES-20 provide a comparison of the average delays at Belmont Circle, Bourne Rotary, and the Sagamore Bridge approaches, respectively, during the non-summer period and summer peak periods for the future no-build condition and each of the seven cases analyzed.

The following is a summary of the findings for Case 3A which includes the replacement of both the Sagamore and Bourne Bridges and the other Case 3A transportation improvements listed in Table ES-4.

Economic Analysis

There are several ways in which transportation improvements can affect social and economic conditions within the local area and region in which they occur. From a social and economic standpoint, the most significant effects are changes in accessibility. Accessibility has three components with direct social and economic consequences: travel times, vehicle miles traveled, and mode choices. In this study, travel time differences between the existing and future no-build conditions and the proposed 'cases' represent the primary measurable social and economic effects of alternatives. The following analyses compare the differences in travel times between alternative cases derived in the traffic demand model.

Travel Time Savings

Travel time savings can benefit local and regional economies in several ways:

- It can boost the productivity of labor: travel time savings increase output per hour because workers are less stressed by their commute, more focused and able to spend more time on work tasks.
- Business productivity is boosted by increasing the effective reach of a business to its potential labor force; the same

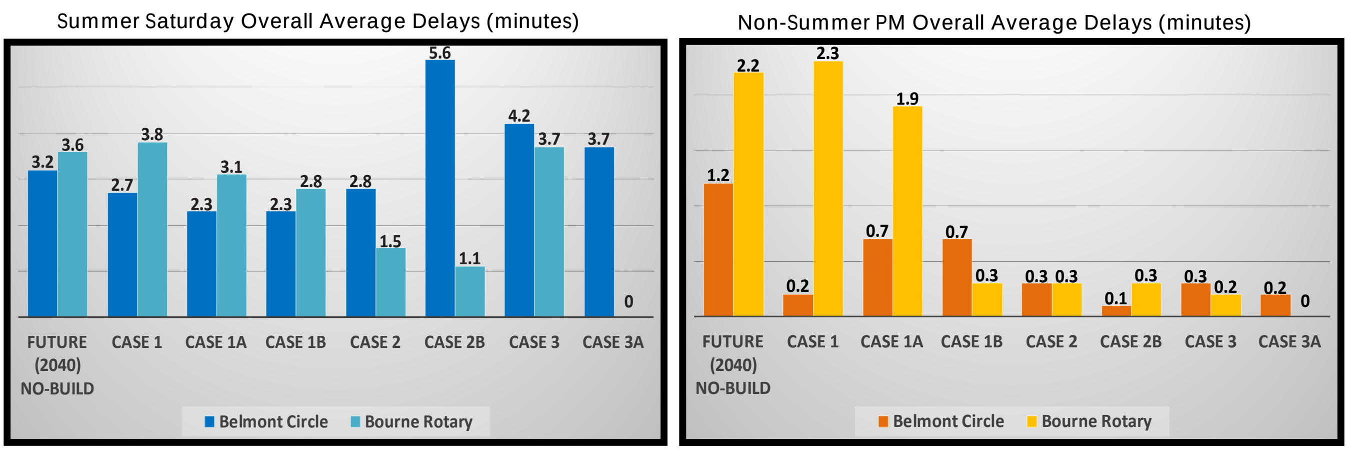
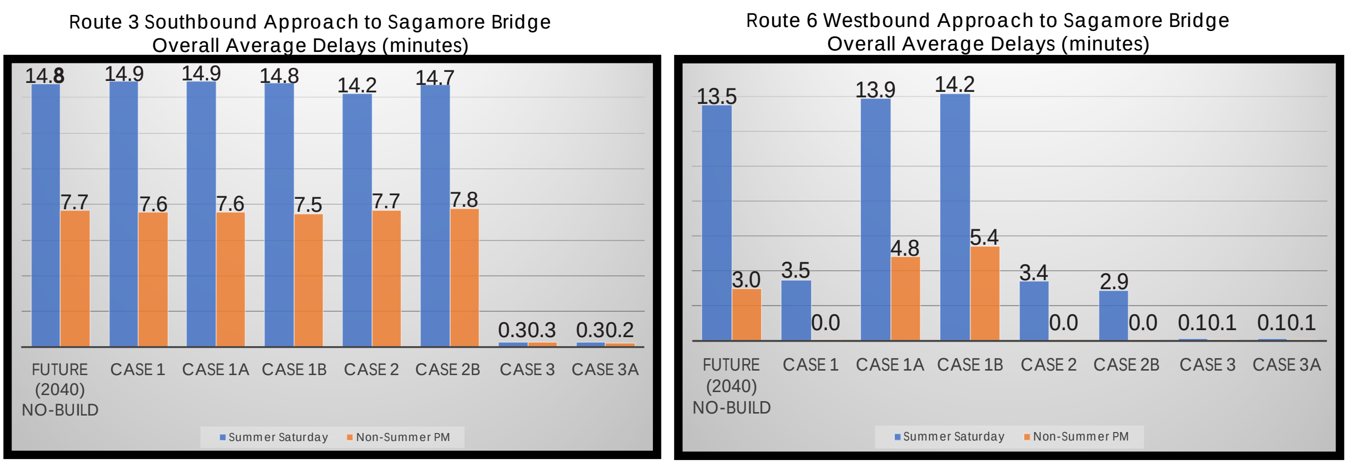


Exhibit ES-19 Average Non-Summer and Summer Delay - Belmont Circle and Bourne Rotary

Exhibit ES-20 Average Non-Summer and Summer Delay – Sagamore Bridge Approaches



commuting times now apply to a larger geographic area and pool of potential workers.

- Reduction in commuting times benefits workers by increasing the amount of time they can spend in more pleasurable and/or more productive activities than commuting.
- Even very minor travel time savings have direct consequences to the costs of freight and shipping; reduced shipping time means businesses can increase the effective geographic reach of their markets.
- For seasonal visitors – an especially important segment of traveler for the Cape Cod economy – reduced travel time allows more opportunities to spend time on shopping and other recreational activities, thereby enhancing the value of their experience on the Cape and possibly increasing visitor spending within the local economy.
- Reduced travel times for non-work trips enhance the quality of life and personal satisfaction of residents,

Table ES-5 Summary of Case Analysis for Queues, Delay, and LOS at Belmont Circle and Bourne Rotary

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS - BUILD CASE 1			FUTURE (2040) BUILD CASE 1A			FUTURE (2040) BUILD CASE 1B			FUTURE (2040) BUILD CASE 2			FUTURE (2040) BUILD CASE 2B			FUTURE (2040) BUILD CASE 3			FUTURE (2040) BUILD CASE 3A		
	AVERAGE DELAY Sec (Min)	LOS	95% QUEUE Feet (Mile)	AVERAGE DELAY Sec (Min)	LOS	95% QUEUE Feet (Mile)	AVERAGE DELAY Sec (Min)	LOS	95% QUEUE Feet (Mile)	AVERAGE DELAY Sec (Min)	LOS	95% QUEUE Feet (Mile)	AVERAGE DELAY Sec (Min)	LOS	95% QUEUE Feet (Mile)	AVERAGE DELAY Sec (Min)	LOS	95% QUEUE Feet (Mile)	AVERAGE DELAY Sec (Min)	LOS	95% QUEUE Feet (Mile)	AVERAGE DELAY Sec (Min)	LOS	95% QUEUE Feet (Mile)	AVERAGE DELAY Sec (Min)	LOS	95% QUEUE Feet (Mile)
BELMONT CIRCLE																											
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)																											
Exit 3 Off Ramps SB	5	A	515	2	A	645	1	A	65	1	A	80	1	A	70	29	D	470	9	A	155	34	D	605	33	D	575
Head of Bay Rd SB	15	C	270	317 (5.28)	F	1,780	35	D	520	30	D	550	142 (2.37)	F	1,055	7	A	350	8	A	330	7	A	325	6	A	280
Buzzards Bay Bypass EB	3	A	100	3	A	110	3	A	85	3	A	95	3	A	125	5	A	170	3	A	205	3	A	180	3	A	215
Main Street EB	13	B	530	29	D	1,245	27	D	1,085	24	C	1,115	61 (1.02)	F	1,745	14	B	560	4	A	85	7	A	175	5	A	100
Scenic Highway WB	7	A	380	14	B	840	1	A	60	1	A	75	7	A	210	36	E	475	16	C	325	29	D	400	22	C	315
Intersection (Overall)	**8.6**	**A**		**73 (1.22)**	**F**		**13.4**	**B**		**11.8**	**B**		**42.8**	**E**		**18.2**	**C**		**8**	**A**		**16**	**C**		**13.8**	**B**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)																											
Exit 3 Off Ramps SB	4	A	510	3	A	1025	2	A	280	2	A	435	2	A	250	43	E	815	18	C	485	33	D	540	32	D	550
Head of Bay Rd SB	83 (1.38)	F	570	656 (10.93)	F	2,700 (0.51)	451 (7.52)	F	2,100	337 (5.62)	F	1,640	622 (10.37)	F	2,810 (0.53)	5	A	320	940 (15.67)	F	8,190 (1.55)	643 (10.7)	F	8,630 (3.4)	552 (9.2)	F	9,570 (3.8)
Buzzards Bay Bypass EB	19	C	335	11	B	305	12	B	305	14	B	370	9	A	285	9	A	290	446 (7.43)	F	2,665 (0.50)	183 (3.1)	F	1505	133 (2.2)	F	1,200
Main Street EB	82 (1.36)	F	5,755 (1.09)	126 (2.1)	F	6,140 (1.16)	185 (3.08)	F	6,140 (1.16)	172 (2.87)	F	6,140 (1.16)	17	C	1,135	243 (4.05)	F	6,020 (1.14)	45	E	4,995 (0.94)	80 (1.3)	F	12,810 (5.1)	87 (1.5)	F	12,900 (5.2)
Scenic Highway WB	125 (2.08)	F	10,605 (2.01)	161 (2.68)	F	11,610 (2.20)	154 (2.57)	F	10,630 (2.01)	154 (2.57)	F	10,525 (1.99)	3	A	235	553 (9.22)	F	11,800 (2.23)	147 (2.45)	F	2,950 (0.56)	315 (5.3)	F	11,605 (4.6)	308 (5.1)	F	11,050 (4.4)
Intersection (Overall)	**62.6 (1.04)**	**F**		**191.4 (3.19)**	**F**		**160.8 (2.68)**	**F**		**135.8 (2.26)**	**F**		**130.6 (2.18)**	**F**		**170.6 (2.84)**	**F**		**319.2 (5.32)**	**F**		**250.8 (4.2)**	**F**		**222.4 (3.7)**	**F**	
BOURNE ROTARY																											
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)																											
Route 25 SB	19	C	650	14	B	620	17	C	65	30	D	1,065	2	A	0	2	A	0	2	A	0	2	A	35			
Trowbridge Rd EB	75 (1.25)	F	840	394 (6.57)	F	3,465 (0.66)	456 (7.6)	F	520	378 (6.3)	F	3,420 (0.65)	33	D	125	20	C	160	17	C	140	19	C	150			
Route 28 NB	14	B	340	102 (1.7)	F	1,275	67 (1.12)	F	85	17	C	325	13	B	265	11	B	300	7	A	185	11	B	240			
Sandwich Rd WB	20	C	1,530	19	C	855	18	C	1,085	29	D	1,265	32	D	435	40	E	640	49	E	975	20	C	0			
Intersection (Overall)	**32**	**D**		**132.25 (2.20)**	**D**		**139.5 (2.33)**	**F**		**113.5 (1.89)**	**F**		**20**	**C**		**18.25**	**B**		**18.75**	**C**		**13**	**B**				
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)																											
Route 25 SB	280 (4.67)	F	8,885 (1.68)	329 (5.48)	F	9,935 (1.88)	333 (5.55)	F	10,000 (1.89)	337 (5.62)	F	10,170 (1.93)	3	A	0	3	A	25	3	A	0	3	A	125			
Trowbridge Rd EB	30	D	335	265 (4.42)	F	2,225	152 (2.53)	F	1525	213 (3.55)	F	1,645	249 (4.15)	F	4,705 (0.89)	62 (1.03)	F	915	136 (2.27)	F	1,370	378 (6.3)	F	3,200 (1.3)			
Route 28 NB	301 (5.02)	F	4,135 (0.78)	189 (3.15)	F	3,605 (0.68)	280 (4.67)	F	5,375 (1.02)	13	B	445	409 (6.82)	F	8,050 (1.52)	268 (4.47)	F	5,820 (1.10)	344 (5.73)	F	6,930 (1.31)	486 (8.1)	F	9,095 (3.6)			
Sandwich Rd WB	27	D	1475	135 (2.25)	F	6,430 (1.22)	139 (2.32)	F	6,095 (1.15)	198 (3.3)	F	9,700 (1.84)	24	C	150	25	D	240	24	C	200	21	C	0			
Intersection (Overall)	**159.5 (2.66)**	**F**		**229.5 (3.83)**	**F**		**226 (3.77)**	**F**		**190.25 (3.17)**	**F**		**171.25 (2.85)**	**F**		**89.5 (1.49)**	**F**		**126.75 (2.11)**	**F**		**222 (3.7)**	**F**				

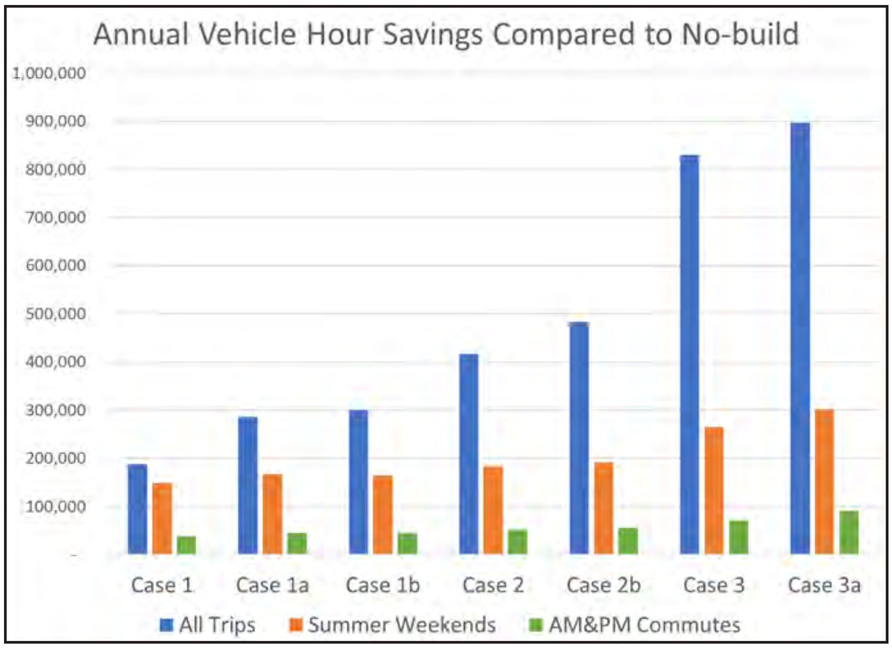
Notes:
LOS E and LOS F movements for the existing and future no-build problem locations are **bold**
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.
Data not available for Case 3A at Bourne Rotary. As a highway interchange, analysis at this location was completed with Synchro software, not VISSIM™ software as was used for other locations.
Results for Case 3A for the intersections adjacent to the Bourne Rotary Interchange are shown in Chapter 4 on Table 4-29.

making Cape Cod a more desirable place to live and work, with consequent effects on property values and business location decisions.

Exhibit ES-21 presents annual vehicle hour savings compared to no-build for all trips, including the non-summer weekday PM and summer Saturday peak hours, plus non-peak trips. While the average delay at Belmont Circle for Case 3A is greater than the Future No-Build condition (Exhibit ES-19). , Exhibit ES-21 demonstrates that overall annual vehicle savings for all trips is greatest for Case 3A.

The greater level of transportation investment in Cases 2B, 3, and 3A compared to the other alternatives leads to a greater reduction in travel times when all peak and non-peak trips are considered. As noted, these reductions in travel times can improve not only

Exhibit ES-21 Annual Vehicle Hours Savings compared to No-Build



Note: The hours saved for the combination of the 'summer Saturday' and 'AM and PM commute' do not equal 'all trips' in Exhibit ES-21 because there are time periods included for 'all trips' calculation that are not included in either the non-summer weekday PM or summer Saturday peak periods.

commuter satisfaction but also business productivity, including accessibility to a larger labor force, making the Cape more attractive for new businesses and investment to expand existing businesses.

Cost Estimates

Conceptual cost estimates were prepared for each of the potential transportation improvements and the combination of these improvements used for the travel model case analysis (Tables

Table ES-6 Summary of Conceptual Cost Estimate by Location ($ million)

MAP LOCATION (ES-18)	IMPROVEMENTS	2017	2030	2040
A	Scenic Highway to Route 25 Westbound Ramp	$7	$11	$16
B	Route 6 Exit 1C Relocation	$30	$51	$75
C	Route 28 Northbound Ramp to Sandwich Road and Intersection Signalization	$6	$11	$16
D	Bourne Rotary Reconstruction (3 Signalized Intersections)	$11	$18	$26
E	Belmont Circle Reconstruction	$14	$23	$33
H	Route 6 Eastbound Travel Lane	$29	$48	$71
I	Bourne Rotary Interchange[1]	$52	$87	$127
	Bourne Bridge Approaches[2]	$51	$84	$125
	Sagamore Bridge Approaches[2]	$39	$64	$95

[1]Includes cost of Bourne Rotary Reconstruction (3 Signalized Intersections).
[2]Not a component of the travel case analysis so not included on Exhibit ES-17.

Table ES-7 Summary of Conceptual Cost Estimate by Travel Model Case ($ million)

CASE	2017	2030	2040
Case 1	$37	$62	$91
Case 1A	$13	$22	$32
Case 1B	$18	$29	$42
Case 2	$62	$103	$150
Case 2B	$72	$121	$177
Case 3[1]	$181	$299	$441
Case 3A[1]	$222	$368	$542

[1]Includes highway approaches to Bourne and Sagamore Bridges. Does not include cost of replacement Bourne and Sagamore Bridges.

ES-6 and ES-7). The cost estimates were based on MassDOT 2017-unit costs per linear foot of new roadway and bridge sections. The cost estimates were escalated by 4.0% per year to develop estimated cost for 2017, 2030, and 2040. This provides an understanding of the increasing cost of these projects at different time periods.

To develop the conceptual estimate, the MassDOT 2017-unit costs were escalated by 4.0% per year to account for inflation. In addition, a 25% to 75% contingency was added to these conceptual costs to account for unknown (but not unexpected) costs related to environmental mitigation, utility relocation, traffic management (police details), and additional structural elements. A lower contingency was used for less complex design alternatives (e.g. local intersection improvements) while a 40% contingency was used for larger, more complex improvement alternatives (e.g. adding a travel lane to Route 6). A 75% contingency was used for larger projects involving substantial utility conflicts/potential relations (e.g. Route 6 Exit 1C relocation and Scenic Highway to Route 25 ramp).

Potential Environmental, Community, and Property Impacts

A summary of potential impacts upon environmental and community resources, and public and private property by location are provided in Tables ES-8 and ES-9. The boundaries of these resources are based on information from the MassGIS database or generated using other publicly-available information. Potential impacts to these resources are based on conceptual designs for transportation improvements and serve to provide an order-of-magnitude understanding of the potential impact and provide a means to compare alternatives to one another.

Table ES-8 Potential Environmental Impact by Location

MAP LOCATION (ES-18)	IMPROVEMENTS	ENVIRONMENTAL (ACRES)			
		WETLAND	100-YEAR FLOODPLAIN[1]	RARE SPECIES	WATER SUPPLY (ZONE I/II IWPA[2])
A	Scenic Highway to Route 25 Ramp	0	0	0	0.2
B	Route 6 Exit 1C Relocation	0	0	7.2	5.7
D	Bourne Rotary (3 Signalized Intersections)	0	0	0	0
E	Belmont Circle (Route 25 Eastbound Flyover)	0.5	5.4	0	0.5
H	Route 6 Eastbound - Additional Travel Lane	0	0	3.9	0
I	Bourne Rotary Interchange	0	0	0.2	0

[1]Conceptual impact to 100-year floodplain calculated in acres
[2]IWPA - Interim Well Protection Area

Table ES-9 Potential Community and Property Impact by Location

MAP LOCATION (ES-18)	IMPROVEMENTS	COMMUNITY (ACRES)		PROPERTY (ACRES)		
		OPEN SPACE	HISTORIC RESOURCES	RESIDENTIAL/ PUBLIC	COMMERCIAL	UTILITY
A	Scenic Highway to Route 25 Ramp	0	0	0	0	0.9
B	Route 6 Exit 1C Relocation	0.6	0.2	0.2	0.9	3.8
D	Bourne Rotary (3 Signalized Intersections)	0.4	0	0.4	0	0
E	Belmont Circle (Route 25 Eastbound Flyover)	0.1	0	< 0.1	< 0.1	0
H	Route 6 Eastbound - Additional Travel Lane	0	0	0	0	0
I	Bourne Rotary Interchange	0.4	0	0.3	2.2	0

Evaluation Matrix

Alternatives were compared to the future no-build transportation conditions on their ability to meet the evaluation criteria established with input from the Working Group at the onset of the study. These evaluation criteria consist of various measures of an alternative's impact on transportation, safety, environmental and community resources, and economic development.

An evaluation matrix compares each of the travel analysis model cases against the future no-build condition. This evaluation matrix characterizes the transportation performance or potential environmental or property impact category based on either quantifiable data (using existing data or data produced for this study) or subjective qualitative measures. Review of an alternative's performance against all the evaluation criteria provides an opportunity to gain a complete understanding of an alternative's potential benefits and impacts prior to making study recommendations.

The matrix uses different symbols to indicate minor, moderate, or substantial benefits or impact. If no impact or benefit is anticipated (or an environmental resource is not present) a neutral symbol is used. The specific definitions used to differentiate minor, moderate, or substantial impact to environmental resources are provided in Exhibit ES-22.

Exhibit ES-22 Evaluation Matrix - Definition of Benefit and Impact Ratings

Alternatives Evaluation Matrix Legend				
Category	**Benefit Levels**			
	◇	○	◒	●
Safety (Emergency Vehicle Response Time)	**Neutral**	**Minor or No Impact**	**Modest Benefit**	**Substantial Benefit**
Bicycle/Pedestrian (facilities or access)				
	Impact Levels			
	◇	○	◒	●
	Neutral (No impact or resource not present)	**Minor or No Impact**	**Modest Impact**	**Substantial Impact**
Wetlands			5,000 SF - 1 acre of wetlands	> 1 acre of wetlands
Rare Species			> 1 acre of work in rare species habitat	Requires a Conservation Management Permit
Area of Critical Environmental Concern (ACEC)			Impacts land within ACEC	Impacts wetlands within ACEC
100-Year Floodplain			Moderate fill within 100-year floodplain	Substantial fill within 100-year floodplain
Water Supply Protection Areas			Impact to land in DEP IWPA or Zone II	Impact to land in DEP Zone I or ORW
Air Quality/Public Health			Modest reductions in idle time/queueing	Substantial reductions in idle time/queueing
Open Space			Acquisition of open space land	Acquisition of open space affecting or active recreational facilities
Historic Resources			Impacts historic parcel or historic district	Adverse Effect on historic property
Land Use/Economic Development			Modest impact to residential, commercial, or utility-owned property	Substantial impact to residential, commercial, or utility-owned property

Exhibit ES-23 Evaluation Matrix - Comparison of Travel Analysis Model Cases

Category			2040 Future No-Build		Case 1		Case 1A		Case 1B		Case 2		Case 2B		Case 3		Case 3A	
			Rating	Data	Rating	Data / % Change from 2040 No-Build (000's)	Rating	Data / % Change from 2040 No-Build (000's)	Rating	Data / % Change from 2040 No-Build (000's)	Rating	Data / % Change from 2040 No-Build (000's)	Rating	Data / % Change from 2040 No-Build (000's)	Rating	Data / % Change from 2040 No-Build (000's)	Rating	Data / % Change from 2040 No-Build (000's)
Traffic	Vehicle Hours Traveled	Annual	◇	16.3 mil	○ (green)	530	○ (green)	659	◒ (green)	860	◒ (green)	1,070	◒ (green)	1,290	● (green)	1,306	● (green)	1,390
Traffic	Average Delay at BC & BR (mins)	Summer Sat	◇	6.8	○ (green)	6.5	◒ (green)	5.4	◒ (green)	5.1	◒ (green)	4.3	○ (green)	6.7	◒ (orange)	7.9	● (green)	3.7
Traffic	Average Delay at BC & BR (mins)	Fall PM	◇	3.4	◒ (green)	2.5	◒ (green)	2.6	● (green)	1.0	● (green)	0.6	● (green)	0.4	● (green)	0.5	● (green)	0.2
Category																		
Safety / Emergency Response Time					○ (green)		○ (green)		◒ (green)		◒ (green)		◒ (green)		◒ (green)		● (green)	
Bike / Ped (Safety and New Facilities)					◇		○ (green)		◒ (green)		◒ (green)		◒ (green)		● (green)		● (green)	
Environmental	Wetlands (acres)				○ (green)	0.0	○ (green)	0.0	○ (green)	0.0	◒ (orange)	0.3	◒ (orange)	0.5	◒ (orange)	0.3	◒ (orange)	0.3
Environmental	Rare Species (acres)				● (orange)	7.2	◇	0.0	◇	0.0	● (orange)	7.2	● (orange)	7.2	● (orange)	11.1	● (orange)	11.3
Environmental	100-yr Floodplain (acres)				◇	0.0	◇	0.0	◇	0.0	◒ (orange)	4.7	◒ (orange)	5.4	◒ (orange)	4.7	◒ (orange)	4.7
Environmental	Water Supply (Zone I/II,IWPA) (acres)				◒ (orange)	5.9	○ (orange)	0.2	◇	0.0	◒ (orange)	6.4	◒ (orange)	6.4	◒ (orange)	6.4	◒ (orange)	6.4
Community	Open Space (acres)				◒ (orange)	0.6	○ (orange)	0.2	○ (orange)	0.2	◒ (orange)	1.1	◒ (orange)	1.1	◒ (orange)	1.1	◒ (orange)	1.1
Community	Historic Resources (acres)				◒ (orange)	0.2	◇	0.0	◇	0.0	◒ (orange)	0.2	◒ (orange)	0.2	◒ (orange)	0.2	◒ (orange)	0.2
Property Impacts	Residential (acres)				○ (orange)	0.2	◇	0.0	◇	0.0	○ (orange)	0.5	○ (orange)	0.6	○ (orange)	0.6	○ (orange)	0.5
Property Impacts	Commercial (acres)				◒ (orange)	0.9	◇	0.0	◇	0.0	◒ (orange)	0.9	◇	0.0	◒ (orange)	0.9	◒ (orange)	0.9
Property Impacts	Utility (acres)				● (orange)	4.7	◒ (orange)	0.9	◒ (orange)	0.9	● (orange)	4.7	● (orange)	4.7	● (orange)	4.7	● (orange)	4.7
Economic Impact					◒ (green)		◒ (green)		◒ (green)		● (green)		◒ (green)		● (green)		● (green)	
2030 Cost ($ millions)						**60**		**20**		**30**		**100**		**120**		**300**		**370**

The complete Evaluation Matrix is provided in Exhibit ES-23. Ultimately, review of the completed evaluation matrix and consultation with the Working Group and the public aided MassDOT's decision-making process to identify which case to recommend for advancement into MassDOT's project development process.

STEP 5: PROVIDE RECOMMENDATIONS TO MEET STUDY GOALS AND OBJECTIVES

Gateway Intersection Improvements

For each of the cases, the results of the traffic analysis were evaluated and the potential benefit and impact on the various evaluation criteria categories were determined, as shown on the evaluation matrix.

The components of Case 3A (Table ES-10 and Exhibit ES-24) were identified as the recommended gateway intersection improvements because they most effectively satisfy the study goals and objectives.

Case 3A would:

- Provide the greatest long-term improvement in accessibility and mobility for Cape Cod residents, employers, and visitors;
- Provide a reliable multimodal transportation system to assure public safety in the event of an emergency evacuation of Cape Cod; and
- Accommodate the rehabilitation or replacement of the Canal bridges, envisioned as having two travel lanes and one auxiliary lane in each direction.

Table ES-10 Components of Case 3A - Recommended Gateway Intersection Improvements

MAP LOCATION (ES-18)	RECOMMENDED GATEWAY INTERSECTION IMPROVEMENT
A	Scenic Highway to Route 25 Westbound Ramp
B	Bourne Rotary Interchange
C	Belmont Circle Reconstruction
D	Route 6 – Relocation of Exit 1C
E	Route 6 – Additional Travel Lane to Exit 2 (Route 130)
F	Reconstruction of Sagamore Bridge Approaches
G	Reconstruction of Bourne Bridge Approaches
H	Replacement of Bourne and Sagamore Bridges (By USACE)

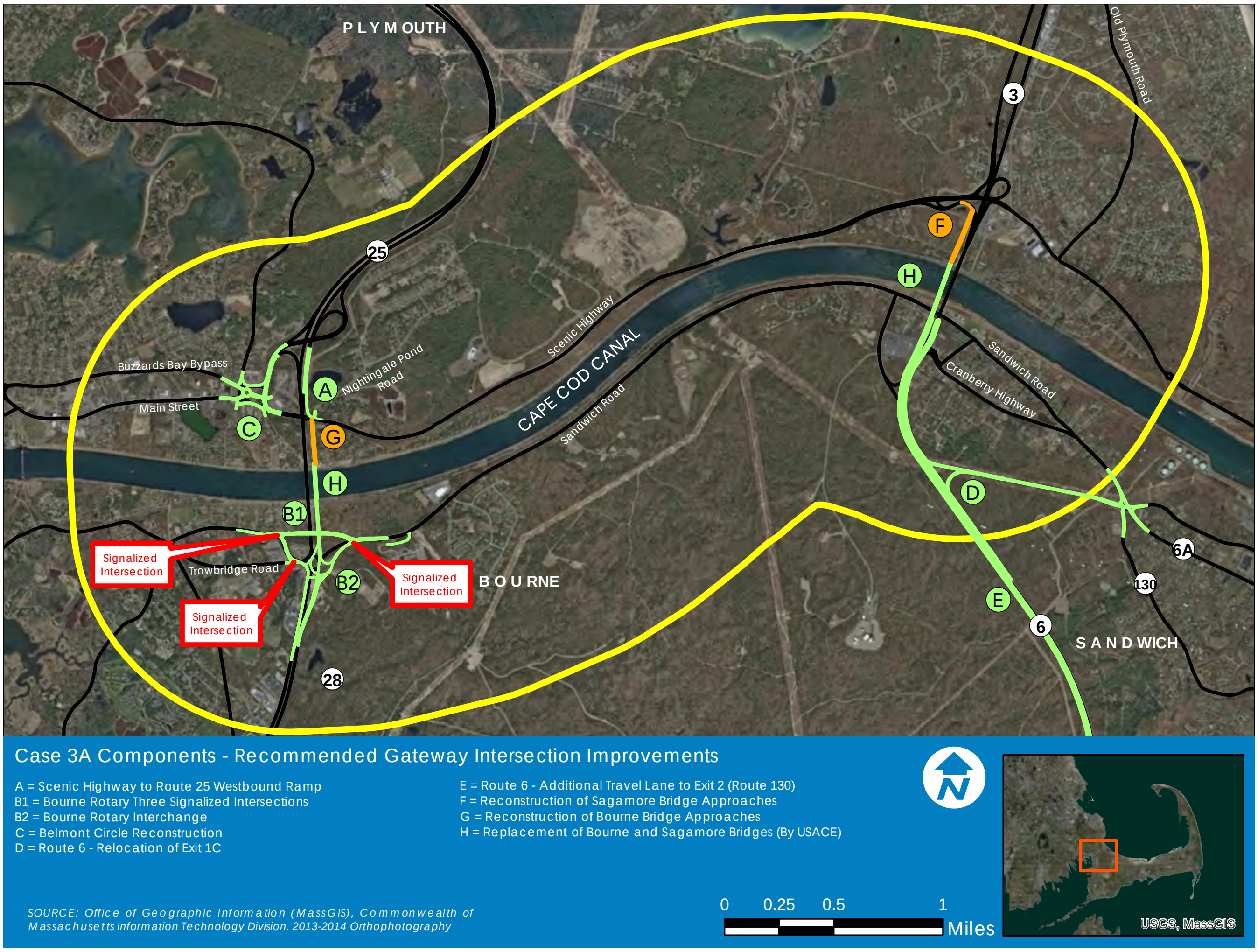


Exhibit ES-24 Recommended Gateway Intersection Improvements – Case 3A

Multimodal Transportation Improvements

This study identifies a series of multimodal transportation improvements that satisfy study goals and objectives and reflect the study findings and public feedback gathered as part of the study. The location and conceptual cost of this study's recommended transportation improvements are provided in Table ES-11.

Roadway Improvements

Recommendations for improvements to the study area roadway system were developed based on the travel model analysis and potential impact to environmental and community resources and public and private property. The roadway recommendations are presented in two groups: local intersection improvements and larger improvements to gateway intersections.

Table ES-11 Recommended Multimodal Transportation Improvements

TRANSPORTATION MODE	RECOMMENDED IMPROVEMENT	LOCATION	MAJOR STAKEHOLDERS	COST ($ MILLION)
MULTIMODAL				**2017 COST**
New bicycle/pedestrian connections to Canal bike trail		Various locations in Bourne	Town of Bourne / MassDOT / USACE	$25K - $50K per location
Bicycle/Pedestrian Facility Improvements		Sagamore Bridge Approaches / Adams Street	MassDOT / USACE	3.9
Bicycle/Pedestrian Facility Improvements		Bourne Bridge Approach (north)	MassDOT / USACE	0.8
Bicycle/Pedestrian accommodation along bus routes: add sidewalks /crosswalks / roadway shoulder /bike racks / bus shelters		Various locations along bus routes in Bourne & Sandwich	Towns of Bourne and Sandwich / MassDOT	Varies by location
Park and Ride Lot		Route 6 Exit 2 (Route 130)	MassDOT	2.8
LOCAL INTERSECTION ROADWAY IMPROVEMENTS				**2017 COST**
Route 6 at Cranberry Highway		Bourne	Town of Bourne / MassDOT	0.6
Route 130 at Cotuit Road		Sandwich	Town of Sandwich / MassDOT	1.0
Sandwich Road at Bourne Rotary Connector		Bourne	Town of Bourne / MassDOT	1.9
GATEWAY INTERSECTION ROADWAY IMPROVEMENTS (CASE 3A IMPROVEMENTS[1])				**2030 COST**
Scenic Highway to Route 25 Westbound Ramp			Town of Bourne / MassDOT	11
Belmont Circle Reconstruction			Town of Bourne / MassDOT	23
Bourne Rotary Interchange[2]			Town of Bourne / MassDOT	87
Route 6 Exit 1C Relocation			Town of Bourne / MassDOT	51
Additional Travel Lane on Route 6 Eastbound to Exit 2			Towns of Bourne and Sandwich / MassDOT	48
Sagamore Bridge Approaches[3]			Town of Bourne / MassDOT / USACE	64
Bourne Bridge Approaches[3]			Town of Bourne / MassDOT / USACE	84

1 Case 3A assumes the prior replacement of the Sagamore and Bourne Bridge by the USACE.
2 Includes cost of Bourne Rotary Reconstruction (Alternative 2, Three Signalized Intersections).
3 Includes approach roadway and bridge relocation and retaining walls.

The project development period for these projects would vary based on project complexity. Larger, more complex projects require a longer period to complete the design, environmental review and permitting, and (if required) the land acquisition process. For example, the Route 6 Exit 1C Relocation and the Scenic Highway to Route 25 westbound entrance ramp would both require extensive coordination with local utility providers to ensure uninterrupted service and safety during the relocation of their equipment (if necessary).

Local Intersection Improvements

Recommendation

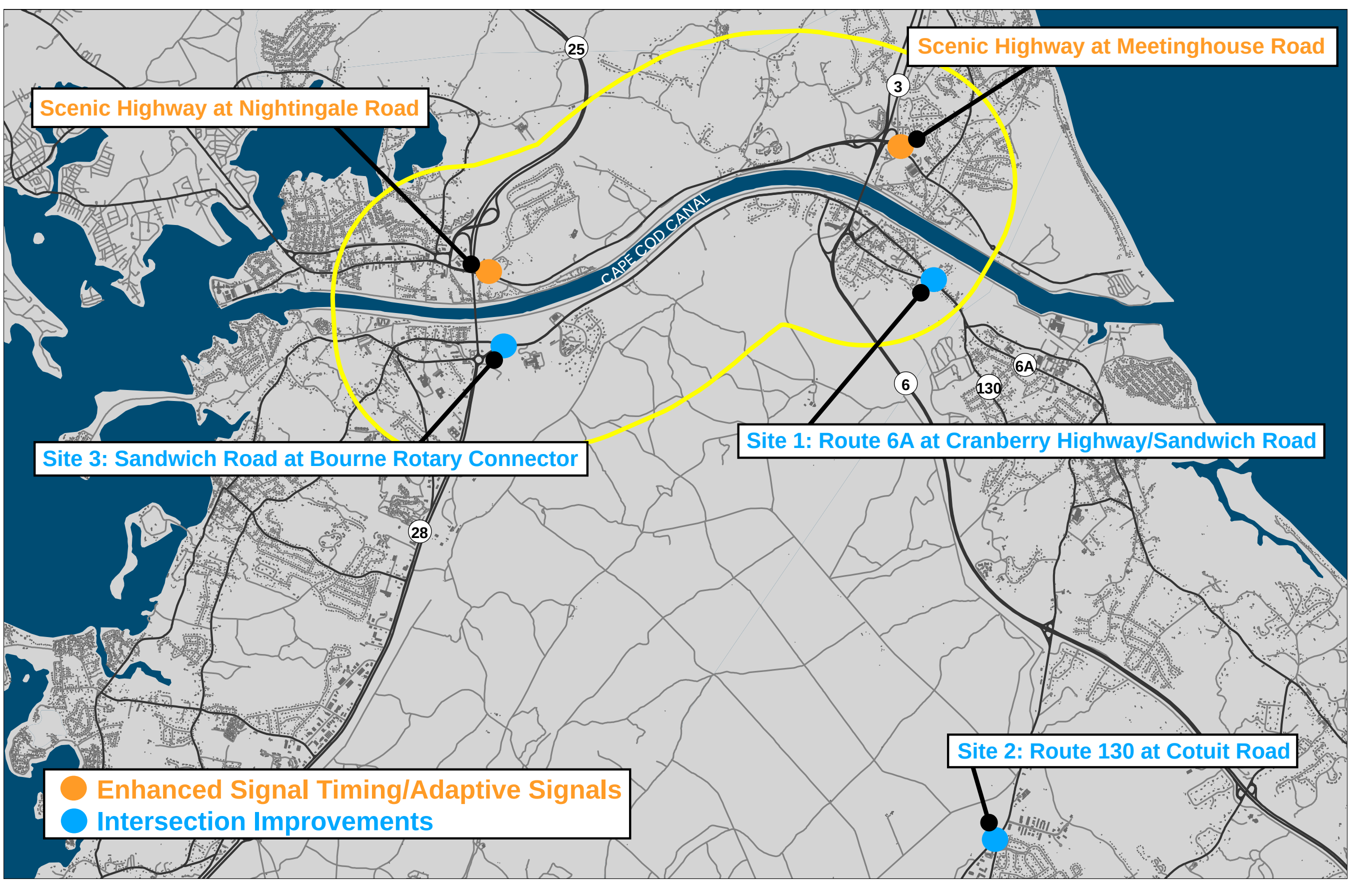
The recommended local intersection improvements include advancing several intersection improvement projects into the project development phase (Exhibits ES 25 and ES-9). These intersection improvements include:

1. **Signal timing improvements at two intersections:**
   - Scenic Highway/Meetinghouse Lane
   - Scenic Highway at Nightingale Road
2. **Intersection improvements at three intersections:**
   - Route 6A (Sandwich Road) at Cranberry Highway
   - Route 130 at Cotuit Road
   - Sandwich Road at Bourne Rotary Connector

Benefit

These short-term roadway improvements represent a lower-cost method to reduce congestion and improve safety at key study area intersections.

Exhibit ES-25 Recommended Local Intersection Improvements



Bicycle and Pedestrian Improvements

Recommendation

Improve and expand bicycle and pedestrian facilities in the study area to encourage greater use of non-motorized transportation by residents and visitors.

1. **New ADA-compliant pedestrian connections to the Canal service road (bike trail) at three locations in Bourne: Bourne Ballfield, Pleasant Street, and Old Bridge Road.**
2. **Improve bicycle-pedestrian connections to/from local roadways over the Canal at Sagamore and Bourne Bridges (Exhibits ES-26 and ES-27).**
3. **Improve bicycle/pedestrian accommodation in the study area, especially along bus routes, by providing:**
    - Accessible sidewalks and crosswalks
    - Pedestrian phases at intersections
    - Shelters at bus stops
    - Bicycle racks
    - Wayfinding signage

Top: Bicyclists on the Canal bike path road.

Bottom: Pedestrians and recreational fishing on the Canal.

Benefit

Improved bicycle and pedestrian connections would provide more multimodal transportation options, encouraging residents and visitors to walk or bike, reducing traffic delays and congestion.

Multimodal Transportation Center

Recommendation

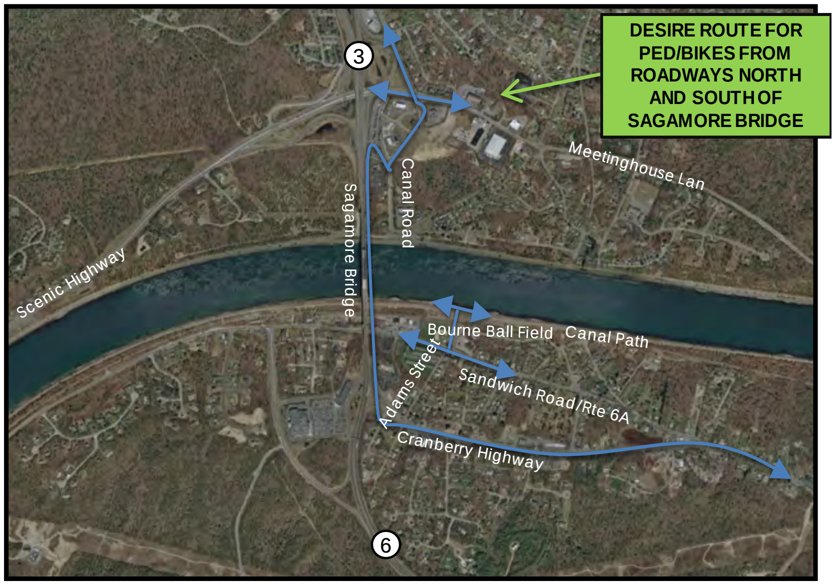
1. **Develop new Multimodal Transportation Center (with 100-space park and ride lot) at the Route 6 Exit 2 (Route 130) interchange.**

Benefit

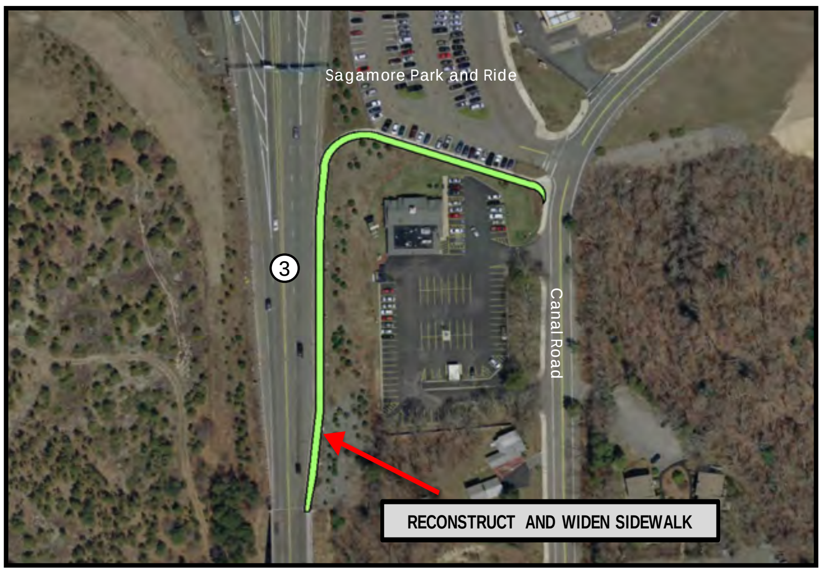
Additional park and ride facilities will encourage more travelers to use bus service and reduce single-occupancy car travel. The location of a park and ride lot at the Route 6 Exit 2 (Route 130) interchange is desirable since it is owned by MassDOT and does not contain any regulated environmental resources. Additionally, the western terminus of the upcoming Service Road shared-use path is Route 130 at this location.

Exhibit ES-26 Enhanced Bicycle/Pedestrian Access at Sagamore Bridge

Desired Bicycle/Pedestrian Access over Sagamore Bridge



Bicycle/Pedestrian Access over Sagamore Bridge (North of Canal)



Bicycle/Pedestrian Access over Sagamore Bridge (South of Canal)

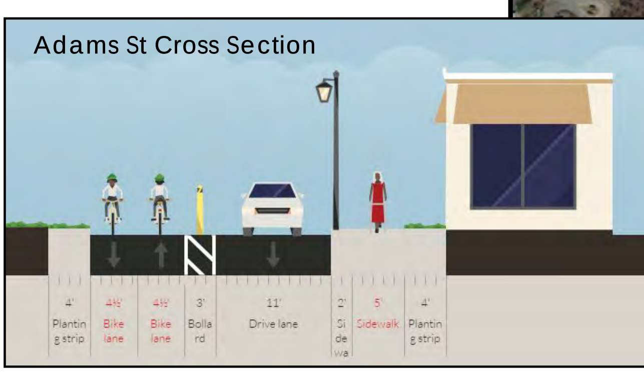
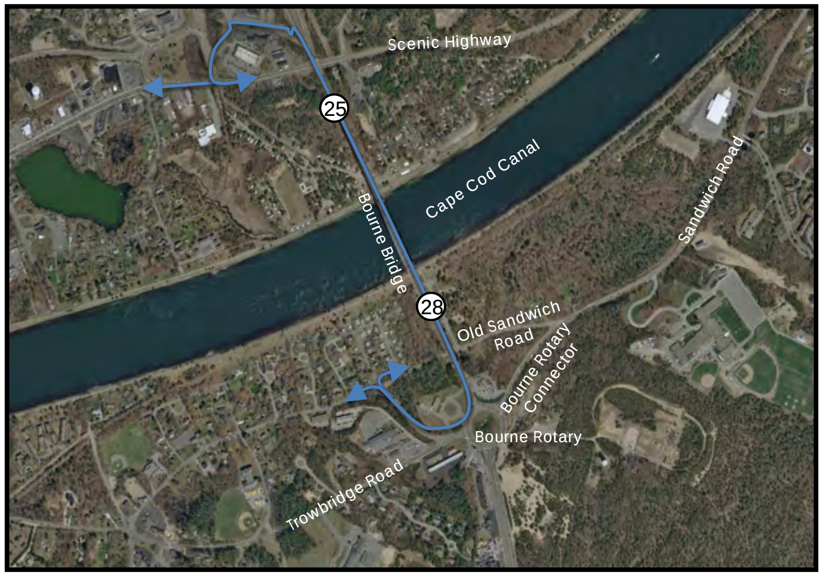


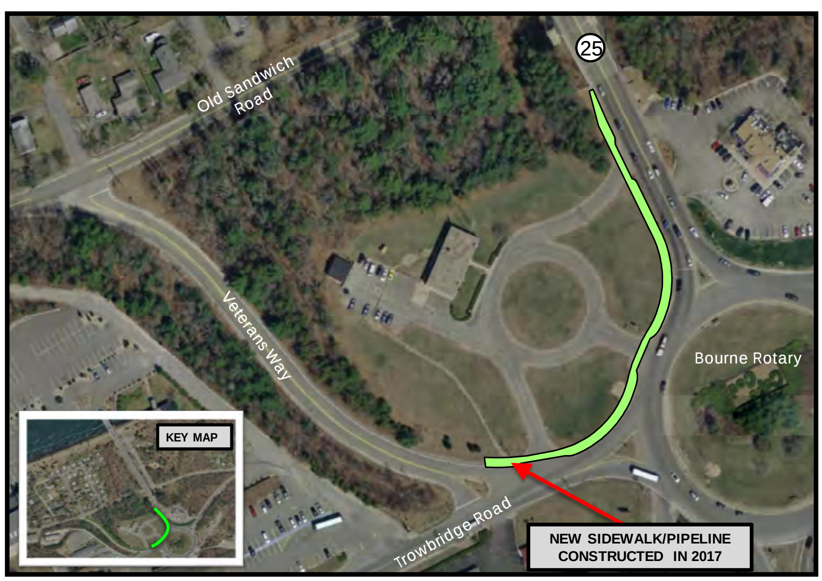
Exhibit ES-27 Enhanced Bicycle-Pedestrian Access at Bourne Bridge

Desired Bicycle/Pedestrian Access over Bourne Bridge



Bicycle/Pedestrian Access over Bourne Bridge (North of Canal)

Bicycle/Pedestrian Access over Bourne Bridge (South of Canal)



NEXT STEPS

The development of transportation improvements is a complex decision-making process that involves many stakeholders, decision makers, and reviewing agencies. All projects developed by or with the involvement of the MassDOT Highway Division are guided by the eight-step process outlined in Chapter 2 of the MassDOT Highway Division's Project Development and Design Guide. This process guides a proposed transportation improvement from concept through design and construction and is designed to ensure that projects meet their stated goals and objectives.

MassDOT Highway Design Process

This project development process is a requirement for all projects involving the MassDOT Highway Division, including projects in which the Highway Division is the project proponent, is responsible for project funding, or controls the infrastructure in question (projects on state highways). In the case of projects involving roadways or other infrastructure and property under the jurisdiction of Cape Cod municipalities, project development and implementation are the municipality's responsibility. Examples of recommendations falling under municipal jurisdiction include local roads and signalization improvements, sidewalk/ADA improvements, and other pedestrian/bicycle infrastructure.

Working Group meetings.

The eight major steps that constitute the MassDOT Project Development and Design Process are:

1. **Need Identification –** Define the problem, establishes project goals and objectives, and define the scope of the planning needed for implementation.

2. **Planning –** Define the existing context, confirm the project need, establish goals and objectives, initiate public outreach, define the project, collect data, develop and analyze alternatives, make recommendations, and provide report documentation.

3. **Project Initiation –** MassDOT Highway Division completes a Project Initiation Form (PIF) which documents the project type and description, summarizes the project planning process, identifies likely funding and project management responsibility, and defines a plan for interagency and public participation.

4. **Public Outreach, Environmental Planning, and Right-of-Way Process –** Four distinct but closely integrated elements: Public Outreach, Environmental Documentation and **Permitting,**

Design, and Right-of-Way Acquisition. The outcome of this step is a fully designed and permitted project ready for construction.

5. **Programming (identification of funding) –** MassDOT requests that the Metropolitan Planning Organization (MPO) include a project from the Regional Transportation Plan in the region's annual Transportation Improvement Plan (TIP) development process. The cost of some of the larger the improvements recommended in this study are well beyond the level of funding the MPO typically has to allocate to projects in this region. Additional funding sources must be identified to advance these projects. The USACE would be responsible for securing federal funding for the assumed replacement of the Bourne and Sagamore Bridges.

6. **Procurement –** MassDOT Highway Division publishes a request for proposals, which is also often referred to as being "advertised" for construction. MassDOT then reviews the bids and awards the contract(s) to the qualified bidder with the lowest bid.

7. **Construction –** MassDOT Highway Division and the contractor develop a public participation plan and a temporary traffic control plan for the construction process and proceed with project construction.

8. **Assessment –** Receive constituents' comments on the project development process and the project's design elements. MassDOT Highway Division can apply what is learned in this process to future projects.

The first two steps, Needs Identification and Planning, are addressed in this study.

Roadway construction.

Project Delivery Methods

The following sections describe three common project delivery methods for highway projects. MassDOT and the USACE would be responsible for selecting the project delivery method that best balances cost, risk, construction schedule, and inconvenience to the residents and visitors to Cape Cod.

Design-Bid-Build

The project development process described previously is based on a conventional project delivery method, commonly referred to as "Design-Bid-Build" (DBB). The essence of the DBB process is that the project is designed to the 100% Plans, Specifications, and Estimates (PS&E) level and then advertised for construction. In this process the design and construction are carried out sequentially with the engineer of record (designer) and the construction contractor as two separate contracting entities.

Design-Build

The design-build (DB) project delivery process is a method to deliver a project in which the design and construction services are contracted by a single team. This process occurs after the completion of the environmental planning and 25% design phase. This type of project delivery process often takes less time than a traditional design-bid-build process because design and construction process happen at the same time.

Public-Private Partnership

An infrastructure public-private partnership (P3) is generally a method of project delivery in which a private entity designs, constructs, finances, and manages a facility in exchange for a portion of the funds generated or through availability payments. In the case of a highway P3 project, the funds generated by the project are generally the tolls charged to users of the facility. A benefit of this type of project delivery process is that the project owner (in this case, MassDOT) does not have to fund the design or construction of the project.

Environmental Considerations

This section provides a summary of the environmental documentation, review, and permitting that would need to be conducted for any alternative to be implemented. Any project will need to follow the project development design process (Step 4), which includes identifying and complying with all applicable federal, state, and local environmental laws and requirements. This includes determining the appropriate project category for both the Massachusetts and National Environmental Policy Acts (MEPA and NEPA). Expected environmental policy acts and permitting application and reviews are discussed below but may vary depending upon actual project design and impacts.

Environmental Policy Acts

Both MEPA and NEPA require an evaluation of a range of alternatives to identify the alternative that meets the project's purpose and need with the least impact to social and natural environmental resources. Mitigation for all environmental impacts must be identified. Based on the scope of the anticipated highway improvements, it is anticipated that a MEPA review will at least consist of an Environmental Notification Form (ENF) and a Draft and Final Environmental Impact Report (EIR). Similar thresholds apply to NEPA where a full Environmental Assessment (EA) or Environmental Impact Statement (EIS) could be warranted for this project.

Environmental Reviews/Permits

Local, state, and federal regulatory agencies will review proposed activities with respect to applicable environmental laws and regulations. The following state and federal regulatory agency reviews and permits would likely be required for the recommended projects:

State Agency Review/Approval

- Massachusetts Environmental Policy Act (MEPA)
- Massachusetts Wetlands Protection Act (WPA) – Wetlands Notice of Intent (NOI)
- Massachusetts Division of Fisheries, Natural Heritage and Endangered Species Program review
- Massachusetts General Law Chapter 21E and the Massachusetts Contingency Plan (MCP) (hazardous materials review)

Federal Agency Review/Approval

- National Environmental Policy Act (NEPA)
- Section 404 Permit – U.S. Army Corps of Engineers (USACE) General Permit
- Section 401 of the Federal Clean Water Act – 401 Water Quality Certification
- Section 106 National Historic Preservation Act (managed by the Massachusetts Historical Commission (MHC))
- Endangered Species Act – Section 7 review
- Environmental Protection Agency (EPA) Construction Stormwater General Permit

Implementation Summary

This study outlines several multimodal transportation improvement projects; all of these improvements should be considered for project development. It is imperative that municipal leadership from Bourne and Sandwich, as well as the Cape Cod Commission, area Chambers of Commerce, members of the broader community, the USACE, and MassDOT continue to coordinate and further define the most appropriate and urgent projects. In addition, continued support from local and regional stakeholders in advancing high-priority projects is critical to successfully implementing this agenda. These local priorities should inform timelines and programming for each improvement to proceed to project development.

massDOT
Massachusetts Department of Transportation

DRAFT FOR REVIEW - SUMMER 2019

CAPE COD CANAL
TRANSPORTATION STUDY

Prepared by:
Stantec

CONTENTS

EXHIBITS

TABLES

Introduction and Study Framework

1.1 INTRODUCTION

The Massachusetts Department of Transportation (MassDOT) commissioned the Cape Cod Canal Transportation Study ("the Study") to gain a comprehensive understanding of multimodal travel within the Cape Cod Canal area — both the conditions that exist today and the forecast conditions for the future. The study identifies a series of multimodal transportation improvements that reflect the study findings and public feedback gathered as part of the study.

Cape Cod and the Islands of Martha's Vineyard and Nantucket are major travel destinations whose recreational activities create travel demands that soar during the summer. The islands and the 15 municipalities that make up Cape Cod (Exhibit 1-1) feature beaches, golf courses, boating and fishing areas, recreation trails, historic sites, national parks, shopping areas, and restaurants. Families from New England and beyond have made Cape Cod and the Islands their preferred vacation destination for decades. For these same reasons, they have always attracted people as a place to live, to work, raise families, and retire.

The condition, capacity, and multimodal features of the Sagamore Bridge and the Bourne Bridge, the cross-Canal bridges that provide the only vehicular access to and from Cape Cod, lie at the heart the Cape's connectivity limitations. However, the configuration of approach roadways and intersections to the Canal bridges contribute to the severe congestion issues, particularly in the summer. Cape Cod also suffers from a lack of transportation options, with limited bus, transit, and pedestrian/bicycle facilities.

Cape Cod residents and visitors must often contend with substantial traffic congestion during the summer tourist season and more frequently during the fall and spring shoulder seasons. While these delays result from increased traffic demands created by an influx of visitors, the impacts of these delays—increased travel time, increased crashes, and decreased mobility—impact visitors, year-round residents, and businesses alike.

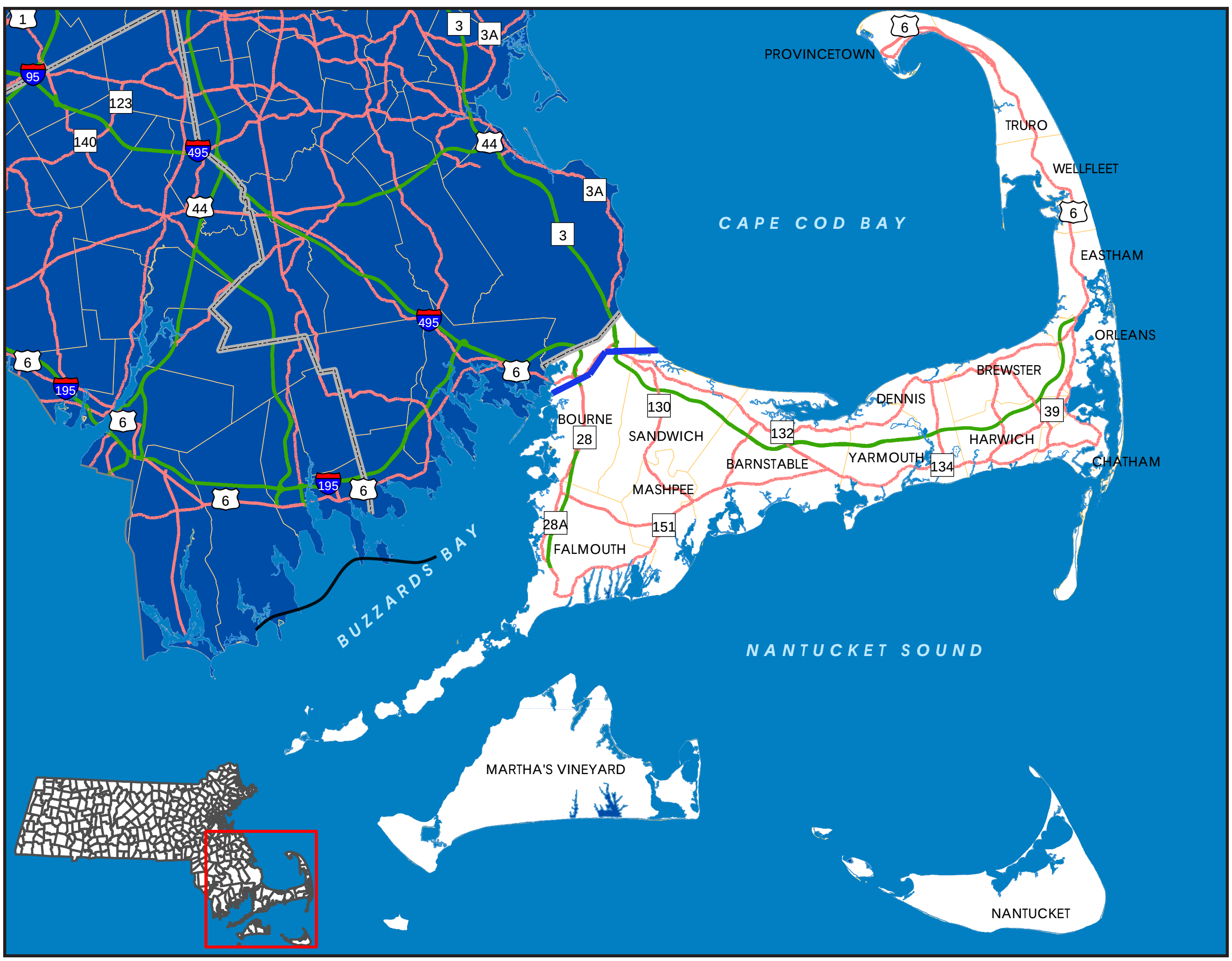
The goal of this study is to provide reliable multimodal connectivity and mobility levels across the Canal to ensure connectivity between Bourne and Sandwich and ensure public safety in the event of an evacuation.

MassDOT launched this study to begin addressing transportation issues surrounding the access points to Cape Cod. The study will provide recommendations for improving all transportation modes in the study area that would expand multimodal connections to protect quality of life for residents and visitors in the future.

This report comprises five main sections, each of which focuses on a study task outlined by MassDOT:

- **Task 1:** Study Area, Goals and Objectives, Evaluation Criteria, and Public Involvement Plan
- **Task 2:** Existing Environmental and Traffic Conditions
- **Task 3:** Future No-Build Conditions
- **Task 4:** Alternatives Development and Analysis
- **Task 5:** Recommendations

Exhibit 1-1 ***Cape Cod, Massachusetts***



1.1.1 Cape Cod Canal Bridges

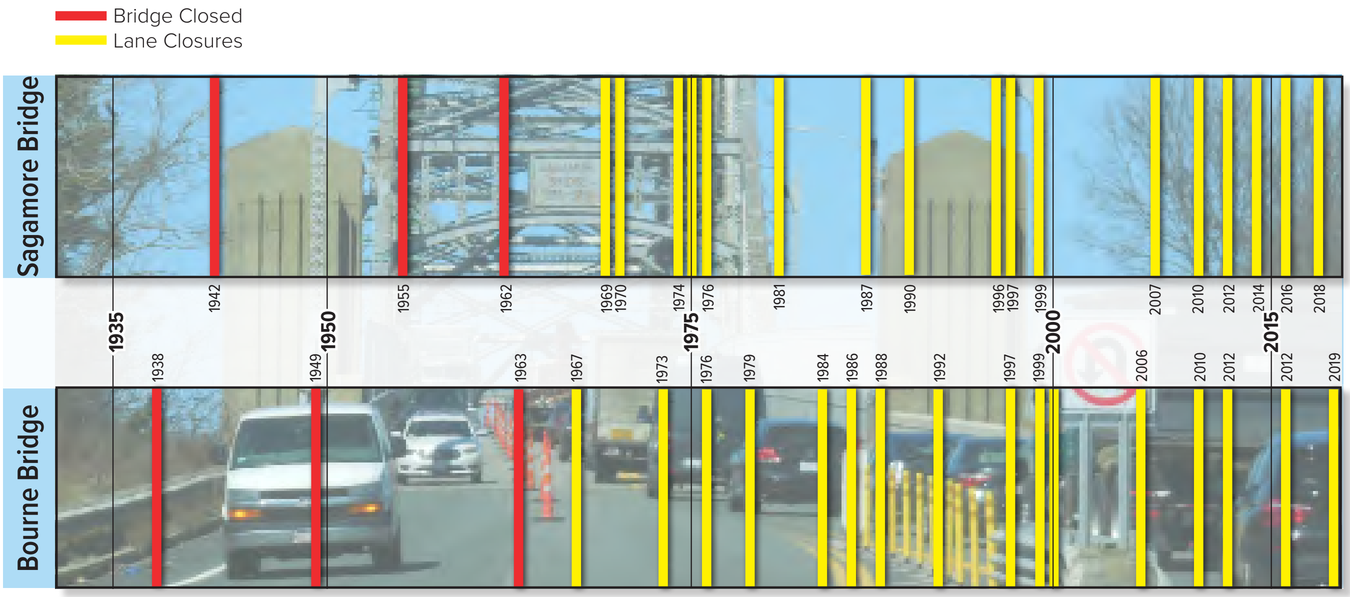
Opened in 1916, the 7-mile-long Cape Cod Canal connects Cape Cod Bay to the east and Buzzards Bay to the west. The Canal bisects the towns of Sandwich and Bourne. The bridges have been designated as eligible for individual listing on the National Register of Historic Places by the Massachusetts Historic Commission.

The U.S. Army Corps of Engineers (USACE) owns and operates the Canal and surrounding lands. Recreational and commercial vessels regularly use the Canal. These recreational and commercial vessels use the Canal extensively, passing beneath three bridges: the Bourne and Sagamore highway bridges and the Buzzards Bay Railroad Bridge.

The USACE began construction on the Sagamore and Bourne bridges in 1933 and both opened on June 22, 1935. Like the Canal, the two highway bridges and the railroad bridge are owned and operated by the USACE. Identical in design, each highway bridge is approximately 48-feet in width providing four 10-foot-wide traffic lanes (two lanes in each direction), with no roadway shoulder and a single five-foot wide sidewalk with 2 foot safety walk on the opposite side. The sidewalks are on the east side of the Sagamore Bridge and the west side of the Bourne Bridge.

The design of the bridges is substandard in several ways: lane widths are too narrow, there are no roadway shoulders, and bicycle and pedestrian accommodations are minimal. At more than 80 years old, the bridges have exceeded their design life and require substantial regular maintenance to function reliably. Since 1990, they have needed more frequent maintenance that

Bourne & Sagamore Bridge Maintenance History



often requires closing a travel lane in the off-season (as shown on the figure below). While necessary, these lane closures cause substantial delay and are disruptive to the local communities.

Due to the condition and age of the bridges, the USACE is currently conducting a 'Major Rehabilitation Study' of both bridges. The outcome of this study will be a determination to either continue long-term maintenance of the bridges or to replace them.

Chapter 2 describes the existing transportation facilities, land uses, socio-economic conditions, and environmental resources in the study area.

1.2 STUDY CONTEXT

This study focuses on transportation issues in the communities in the upper Cape Cod Canal area, including Bourne, Plymouth, Sandwich, and Wareham. However, the impact of these issues extends to all of Cape Cod (Barnstable County), Nantucket County, and Dukes County (Martha's Vineyard and the Elizabeth Islands). Portions of both Bourne and Sandwich are north of the Cape Cod Canal.

This study represents an initial step toward improving the transportation system in the study area. The study aims to:

- build a clear understanding of the existing transportation system, including operational and crash characteristics and projected future conditions at key locations;
- identify roadway locations with substantial operational and/or safety problems; and
- evaluate and provide recommendations, as appropriate, for other forms of transportation, including freight, transit, pedestrian, and bicycle facilities.

While this study makes recommendations for improving multimodal transportation, these recommendations represent only a first step toward solving these problems. Next steps include a thorough evaluation of potential improvements through state and federal environmental analysis, under the processes created by the National Environmental Policy Act (NEPA) and the Massachusetts Environmental Policy Act (MEPA).

These processes ensure that potential improvements undergo public review. They also ensure that a thorough comparison of alternatives is performed to test a project's ability to meet established purposes and needs, measure and minimize social and natural environmental impacts, and evaluate costs. When these processes end, recommended improvements undergo advanced engineering design and are programmed for funding through coordination with local metropolitan planning organizations, the USACE, and MassDOT.

1.3 STUDY AREA

Exhibit 1-2 shows the study area and a focus area. The study area includes land up to four miles on either side of the Canal, extending further at certain points to include major highway interchanges. From the northeast, the study area extends from the Route 3 Exit 2/Herring Pond Road interchange in Plymouth south over the Sagamore Bridge, to the Route 6 Exit 2/Forestdale Road interchange in Sandwich. From the northwest, the study area extends from the Route 25/I-195 interchange in Wareham south, over the Bourne Bridge, to Route 151 in Bourne.

Cape Cod generally refers to all land within the 15 communities east of the Cape Cod Canal. Barnstable County consists of the same 15 communities, but portions of Bourne and Sandwich lie west of the Canal. Therefore, Barnstable County is slightly larger than Cape Cod in both land area and population

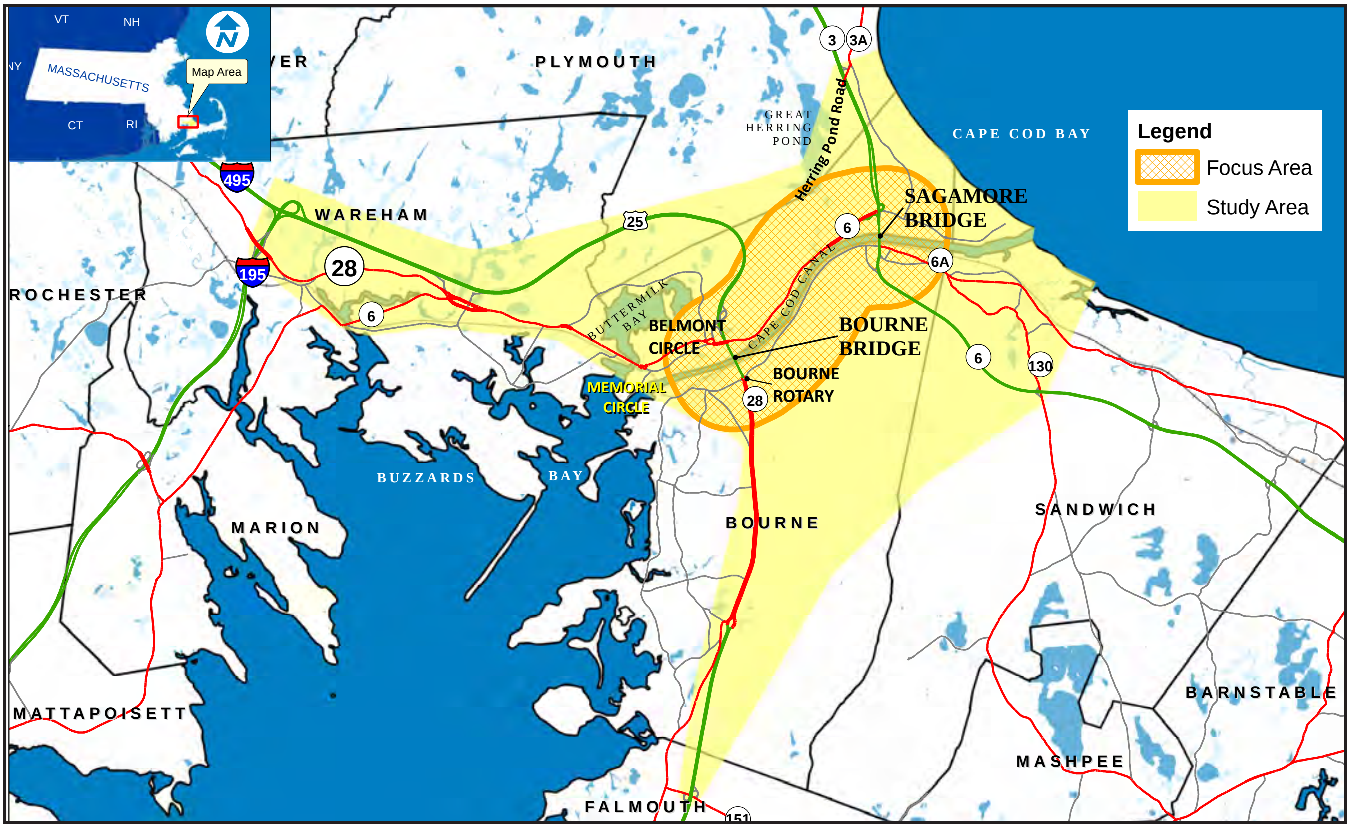


Exhibit 1-2 Study Area/Focus Area

The focus area extends approximately one mile north and south of the Canal. To gain a thorough understanding of the issues and constraints within the study area, information related to environmental resources, socio-economic data, and traffic was gathered for this study area. More detailed data collection and analysis occurred within the focus area where most proposed transportation improvements would likely occur.

1.4 GOALS AND OBJECTIVES

The study's goals and objectives were developed, and revised as necessary, by MassDOT in cooperation with the study Working Group and shape the framework of the entire study. All transportation improvements recommended in this study seek to fulfill the following goals and objectives.

1.4.1 Goals

- Improve transportation mobility and accessibility in the Cape Cod Canal area and provide reliable year-round connectivity over the Canal and between the Sagamore and Bourne Bridges.

1.4.2 Objectives

- Improve multimodal connectivity and mobility across the Canal to avoid degrading quality of life on the Cape.
- Ensure that cross-Canal connectivity does not become a barrier to reliable intra community travel within Bourne and Sandwich.
- Create a reliable multimodal connection across the Canal to assure public safety in the event of an emergency evacuation of portions of the Cape and accommodate first responders trying to reach the Cape.

The study area definition, goals and objectives, and evaluation criteria (Table 1-1) were presented to the project's Working Group in November 2014 and to the public at the study's first public meeting in January 2015.

1.5 EVALUATION CRITERIA

Chapter 4, Alternatives Development and Analysis, documents how potential transportation improvements perform against Transportation Improvement Evaluation Criteria (Table 1-1). These criteria were developed with the aim of advancing the study's goals and objectives (Section 1.4). As appropriate, the study team derived individual criteria directly from either existing data or analytical techniques used in this study. All these criteria—both quantifiable and qualitative measures of effectiveness—helped identify the solutions that best matched the goals and objectives.

1.6 PUBLIC INVOLVEMENT PLAN

Public involvement played a key role in this study, following the steps outlined in a "Public Involvement Plan" (Appendix A). Developed at the initiation of the study, the involvement plan guided the study team's efforts to elicit detailed and

Working Group meeting, Bourne March 10, 2016

Table 1-1 Transportation Improvement Evaluation Criteria

TRANSPORTATION	
Vehicles	Corridor intersections level of service (LOS)
	Corridor volume-to-capacity ratios
	50th- and 95th-percentile queues
Pedestrian and bicycle	Mobility and connectivity
	Bicycle/pedestrian delay
	Expansion/Provision of bicycle facilities
	Expansion/Provision of pedestrian facilities
Travel time	Average roadway travel time along corridor
	Average roadway delay
SAFETY	
Vehicular safety	Conformance with AASHTO and MassDOT standards
	Delay to emergency vehicle access
Pedestrian and bicycle safety	Compliance with ADA requirements
	Compliance with MassDOT requirements
ENVIRONMENT	
Environmental impacts	Impact on coastal resources (sq. ft.)
	Impact on wetland resources (sq. ft.)
	Impact on Areas of Critical Environmental Concern (ACEC)
	Impact on rare species/habitat
	Impact on public water supply
COMMUNITY	
Community impacts	Impact on protected and recreational open space
	Impact on public health
	Impacts on Environmental Justice neighborhoods
	Impact on historical/archaeological resources
Visual	Visual impacts
LAND USE AND ECONOMIC DEVELOPMENT	
Property or business impacts	Impact to residential or commercial property
	Impact to access to commercial property
FEASIBILITY	
Cost	Capital costs
Construction phase impacts	Construction duration
	Impacts on abutting land owners
	Impacts on marine traffic
	Impacts on vehicular traffic
Right-of-way impacts	Permanent and temporary right-of-way impacts

The Public Involvement Plan allows the public to contribute to the study in a meaningful way throughout the study.

comprehensive comments from the public and to build agreement and support for the study recommendations.

Fully aligned with MassDOT's Accessible Meeting Policy Directive, the Public Involvement Plan, guided citizen engagement by emphasizing these principles:

1. **Public Engagement** – The study offered multiple channels for members of the public to learn about or participate. These included public informational meetings, Working Group meetings, a study website, and media outreach. The public and the Working Group received advance notice of meeting times, and MassDOT worked diligently to hold meetings at convenient times and in convenient, comfortable, and accessible places. Meeting notices appeared on the project website, in e-mail notifications, and in local newspapers.

2. **Public Participation** – There were many opportunities for members of the public to participate in the study. The study team recorded all questions from members of the public or the Working Group, whether raised in a meeting or by e-mail or letter and answered them in a timely manner. The study team coordinated and encouraged collaboration among agencies and community organizations with the aim of providing members of the public the most up-to-date and accurate information possible.

3. **Access to Study Information** – The public had, and continues to have, access to information about the study through the study website: (www.mass.gov/cape-cod-canal-transportation-study). Records include all public information and all Working Group presentations, agendas, summaries, and handouts. Community libraries in the study area received printed copies of this report. The study team developed a stakeholder mailing list for distributing e mail. These messages provided notices of website updates, meeting dates and times, media notices, and project documents.

4. **Accessible Documents** – All information posted on the study website appears in an electronic format accessible to people with disabilities in compliance with Section 508 of the U.S. Rehabilitation Act of 1973, the Massachusetts General Law Chapter 272 Section 98/98A, and Web Content Accessibility Guidelines (WCAG 2.0).

5. **Clear Information** – Information provided to the public, including technical terms and regulatory procedures, has been presented in a clear, concise, and understandable manner.

1.6.1 Working Group

A Working Group guided the planning process for identifying transportation improvements in the study area. MassDOT invited members of stakeholder interest groups to join the Working Group. The Working Group, shown in Table 1-2, includes local and state elected officials and representatives from federal and state agencies, area municipalities, metropolitan planning organizations, chambers of commerce, key businesses, and other interested parties. The study team worked closely with the Working Group, sharing relevant study documents as they became available.

Working Group members provided advice and insight on local issues, helped to identify deficiencies in the transportation network, and helped develop and then assess improvement alternatives and their impacts. Feedback from the Working Group allowed continuous refinement of the alternatives under consideration.

Members of the Working Group identified issues important to members' interests and communities, and members served as liaisons to their respective organizations or communities.

Table 1-2 Invited Members of the Study Working Group

- *State and Local Elected Officials*
- *Cape Cod Commission*
- *Army Corps of Engineers*
- *Federal Highway Administration*
- *Joint Base Cape Cod*
- *U.S. Coast Guard*
- *Wampanoag Tribes of Aquinnah and Mashpee*
- *Massachusetts State Police*
- *Massachusetts Bay Transportation Authority (MBTA)*
- *Massachusetts Maritime Academy*
- *Massachusetts Department of Environmental Protection*
- *Massachusetts Office of Coastal Zone Management*
- *Massachusetts Historical Commission*
- *Massachusetts Division of Marine Fisheries*
- *Massachusetts National Heritage and Endangered Species Program*
- *Massachusetts Division of Energy Resources*
- *Southeastern Regional Planning and Economic Development District (SRPEDD)*
- *Old Colony Planning Council*
- *Cape Cod Canal Area Traffic Task Force*
- *Cape Cod Regional Transit Authority*
- *Greater Attleboro Taunton Regional Transit Authority (GATRA)*
- *Local and Regional Chambers of Commerce*
- *Barnstable County Commission*
- *Representatives from Bourne, Sandwich, Plymouth and Wareham*
- *Woods Hole, Martha's Vineyard & Nantucket Steamship Authority*
- *Regional Commercial Bus Lines*
- *Association for Preservation of Cape Cod*
- *Representatives from Canal Area Neighborhoods*

1.6.2 Working Group/Public Meetings

The study team held eleven Working Group and four public meetings between October 2014 and February 2019 (Table 1-3). These meetings were primarily held at the Massachusetts Maritime Academy in Bourne, the Bourne Public Library, and the Sandwich Town Hall.

1.6.3 Outreach to Environmental Resource Agencies

The study team met with representatives of the Massachusetts Division of Fisheries and Wildlife (DFW) to review the parameters

Table 1-3 Public Involvement Meetings

DATE	LOCATION
WORKING GROUP MEETING #1	
October 29, 2014	Upper Cape Cod Regional Technical School, Bourne
CAPE COD COMMISSION	
January 14, 2015	Cape Cod Commission Office, Barnstable
PUBLIC INFORMATION MEETING #1	
January 15, 2015	Massachusetts Maritime Academy, Bourne
WORKING GROUP MEETING #2	
April 2, 2015	Massachusetts Maritime Academy, Bourne
PUBLIC INFORMATION MEETING #2	
April 16, 2015	Massachusetts Maritime Academy, Bourne
WORKING GROUP MEETING #3	
September 10, 2015	Sandwich Town Hall
CAPE COD COMMISSION	
March 3, 2016	Cape Code Commission Office, Barnstable
WORKING GROUP MEETING #4	
March 10, 2016	Bourne Community Building, Bourne
WORKING GROUP MEETING #5	
July 26, 2016	Massachusetts Maritime Academy, Bourne
WORKING GROUP MEETING #6	
September 28, 2016	Massachusetts Maritime Academy, Bourne
PUBLIC INFORMATION MEETING #3	
December 1, 2016	Massachusetts Maritime Academy, Bourne
WORKING GROUP MEETING #7	
January 26, 2017	Bourne Public Library
WORKING GROUP MEETING #8	
June 29, 2017	Sandwich Town Hall
WORKING GROUP MEETING #9	
December 14, 2017	Sandwich Town Hall
WORKING GROUP MEETING #10	
February 1, 2018	Sandwich Town Hall
WORKING GROUP MEETING #11	
August 1, 2018	Massachusetts Maritime Academy, Bourne
PUBLIC INFORMATION MEETING #4	
February 13, 2019	Massachusetts Maritime Academy, Bourne

of the project and discuss rare species in the study area. DFW discussed the potential sensitivity of northern long-eared bat (designated by the US EPA as a threatened species) and the New England cottontail rabbit.

A formal request for information about the presence of rare, threatened, or endangered species was submitted to the Massachusetts Natural Heritage and Endangered Species Program in December 2016.

1.6.4 Outreach to Tribes

The study team held an informational meeting during summer 2015 with representatives of the Mashpee Wampanoag Tribe and the Wampanoag Tribe of Gay Head (Aquinnah). The team presented the overall goals and parameters of the study to tribal representatives. The team also provided a description and mapping of potential transportation improvements to the Mashpee Wampanoag Tribe.

The study team has also held discussions with the Herring Pond Wampanoag Tribal Council about the study goals and potential transportation improvements. The Tribal Council relayed its concerns and identified locations members considered to have cultural significance.

1.6.5 Project Website

MassDOT has created and maintained a study website. The website, found at https://www.mass.gov/cape-cod-canal-transportation-study, provides information about the study including an overview of the purpose of the study, contact information to provide any study-related questions or comments, and public meeting information. For each Working Group or public meeting held, the website provides a copy of the meeting agenda, the PowerPoint presentation, and the meeting notes.

All information posted on the study website is provided in an electronic format accessible to those with disabilities in compliance with Section 508 of the U.S. Rehabilitation Act of 1973, Massachusetts General Law Chapter 272 Section 98/98A and the Web Content Accessibility Guidelines (WCAG 2.0).

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Massachusetts Department of Transportation

DRAFT FOR REVIEW - SUMMER 2019

CAPE COD CANAL TRANSPORTATION STUDY

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Stantec

CONTENTS

EXHIBITS

TABLES

Existing Environmental and Traffic Conditions

This chapter provides a review of existing conditions in the study area including roadway and multimodal facilities, natural and social environmental resources, and socio-economic conditions. These data informed the design constraints and provide a basis for the evaluation criteria. Next, existing and future traffic volumes in the study area were modeled to create a future (2040) 'no build' alternative which serves as the baseline for the comparison of future transportation improvements.

2.1 EXISTING ENVIRONMENTAL CONDITIONS

A survey of existing conditions and trends in the study area shapes a broad understanding of the transportation systems and important environmental resources that any transportation initiative should, if possible, avoid disrupting.

The Cape Cod Canal study area is home to abundant natural, cultural, and recreational resources. This includes unique ecological systems and habitats, including wetlands and waterways, and valuable cultural assets such as park systems, archaeological sites, and historic landmarks and districts.

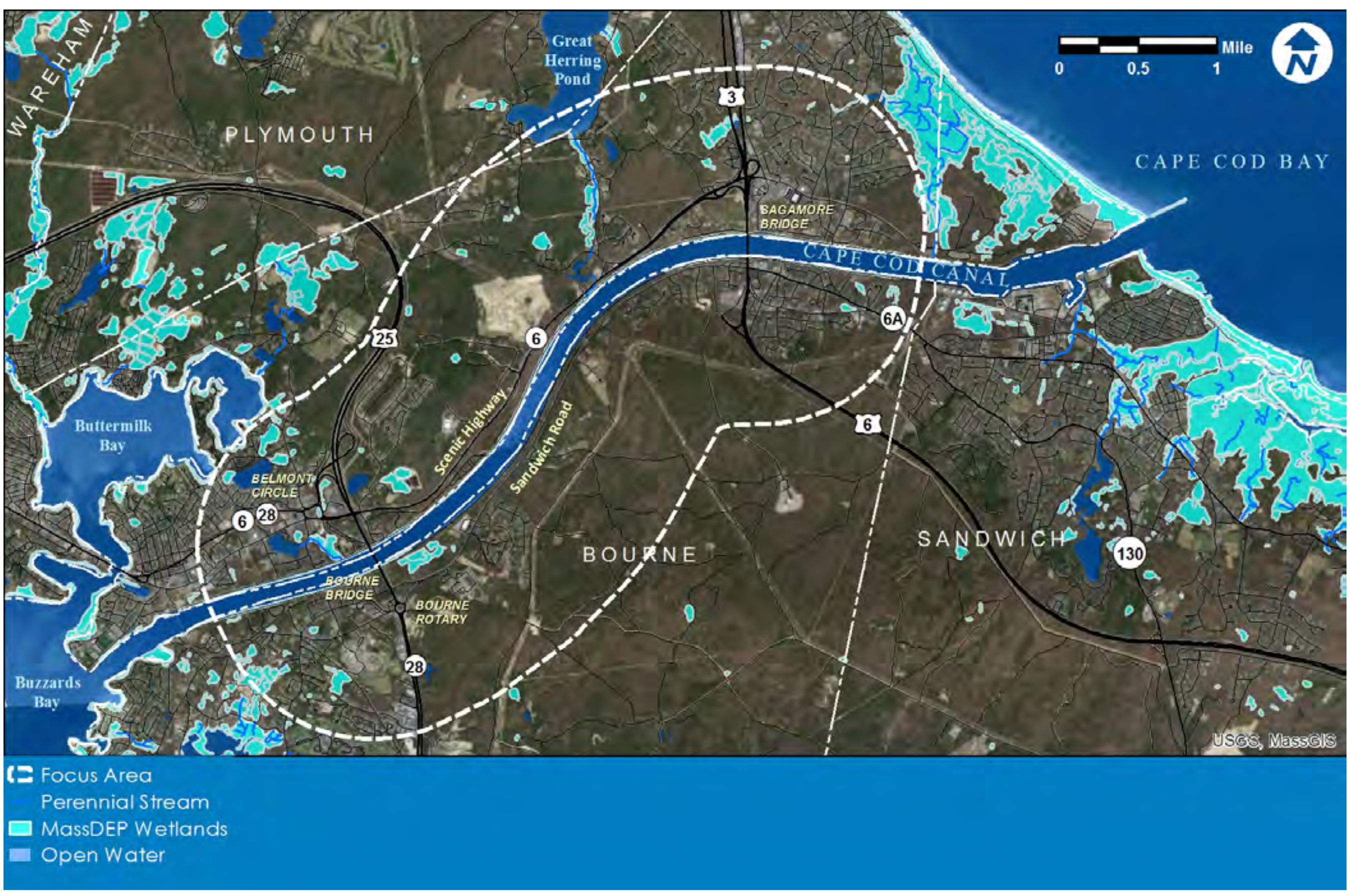
Federal, state, and local laws and regulations—including the federal Clean Water and Endangered Species Acts, the state Wetlands Protection Act (WPA), and municipal wetland ordinances—protect natural wetland, water, and wildlife resources from impact. Similarly, cultural resources such as historic sites and open space receive protection under laws such as the National Historic Preservation Act and Section 4(f) of the DOT Act of 1966.

2.1.1 Wetland, Floodplain, and Surface Waterbodies

Based on information gathered from the MassGIS database, wetland resources in the study area (Exhibit 2-1) include extensive coastal resources both north and south of the Canal, wetlands bordering the Herring River, and scattered wetlands north of Buttermilk Bay. Additional open water wetlands include the Cape Cod Canal, Great Herring Pond, Buttermilk Bay, and smaller waterbodies.

The wetland resources at the east end of the Canal represent the largest extent of wetlands in the study area. Floodplains, as designated by the Federal Emergency Management Agency

Exhibit 2-1 Wetlands and Surface Waterbodies



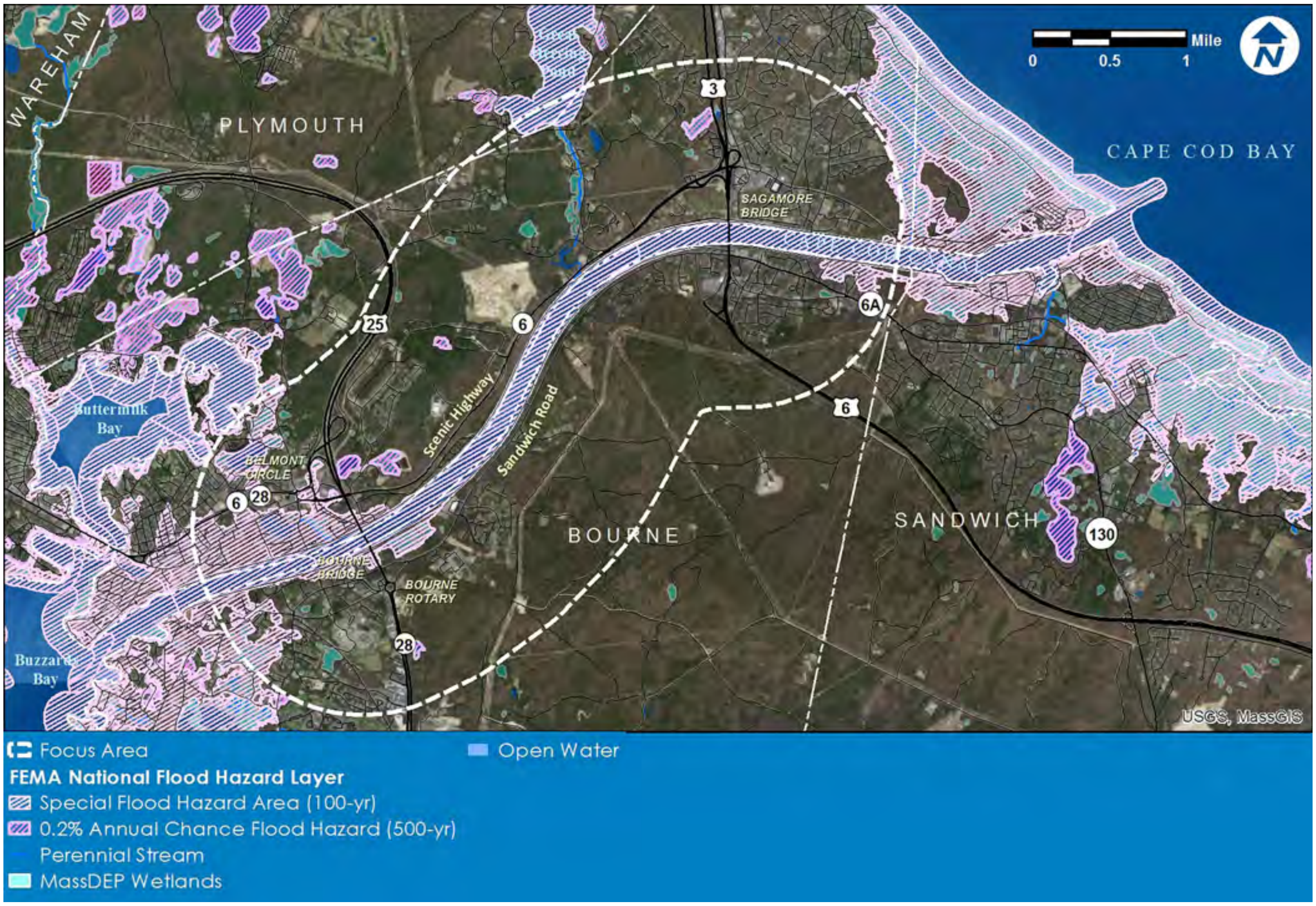


Exhibit 2-2 FEMA Floodplains

(FEMA), exist both north and south of the Canal in nearly the same areas as the wetlands (Exhibit 2-2). The one exception comprises areas in Bourne designated as 100-year floodplains that extend north of the Canal beyond Main Street to the Buzzards Bay Bypass. Areas immediately south of the Canal in Bourne are also designated as 100 year floodplains.

2.1.2 Aquifers and Public Water Supply Wells

An aquifer is an underground layer of rock containing water that can easily move within the layer. Wells provide access to this water for personal uses such as drinking, cooking, and showering, as well as for agricultural use. Exhibit 2-3 (next page) identifies state-designed buffers around drinking-water supply wells (known as Zone II areas and Interim Wellhead Protection Areas (IWPA)).

Protection of aquifers is particularly important because the study area sits atop a designated “sole-source aquifer” that includes all of Barnstable County, the towns of Plymouth and Wareham, and portions of Kingston, Plympton, and Carver.

Under the federal Safe Drinking Water Act, an aquifer qualifies as “sole source” if it provides at least 50% of the drinking water for

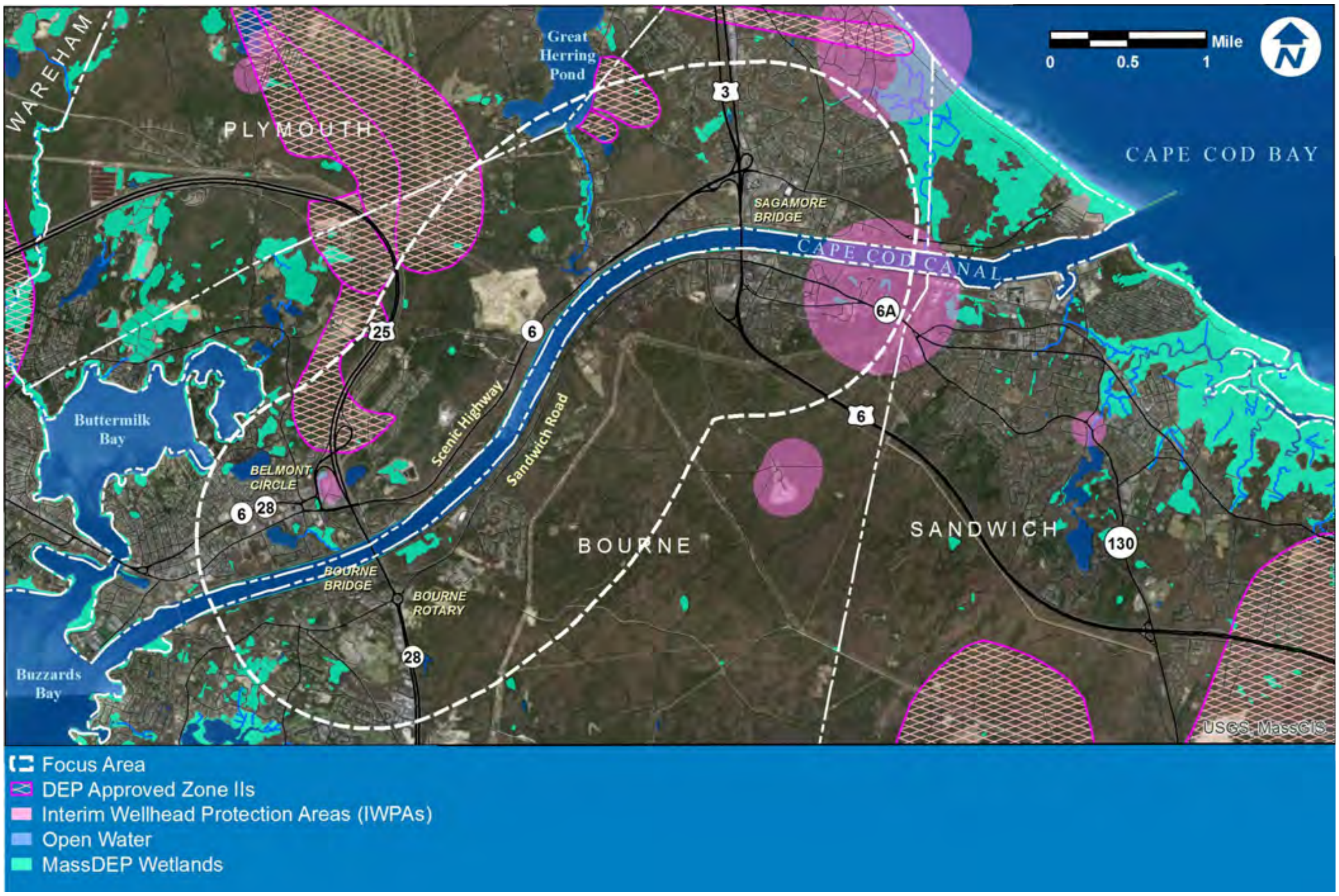


Exhibit 2-3 Aquifers and Public Water Supply Wells

its service area and there are no reasonably available alternative drinking water sources should the aquifer become contaminated.

2.1.3 Fisheries and Shellfish Growing Areas

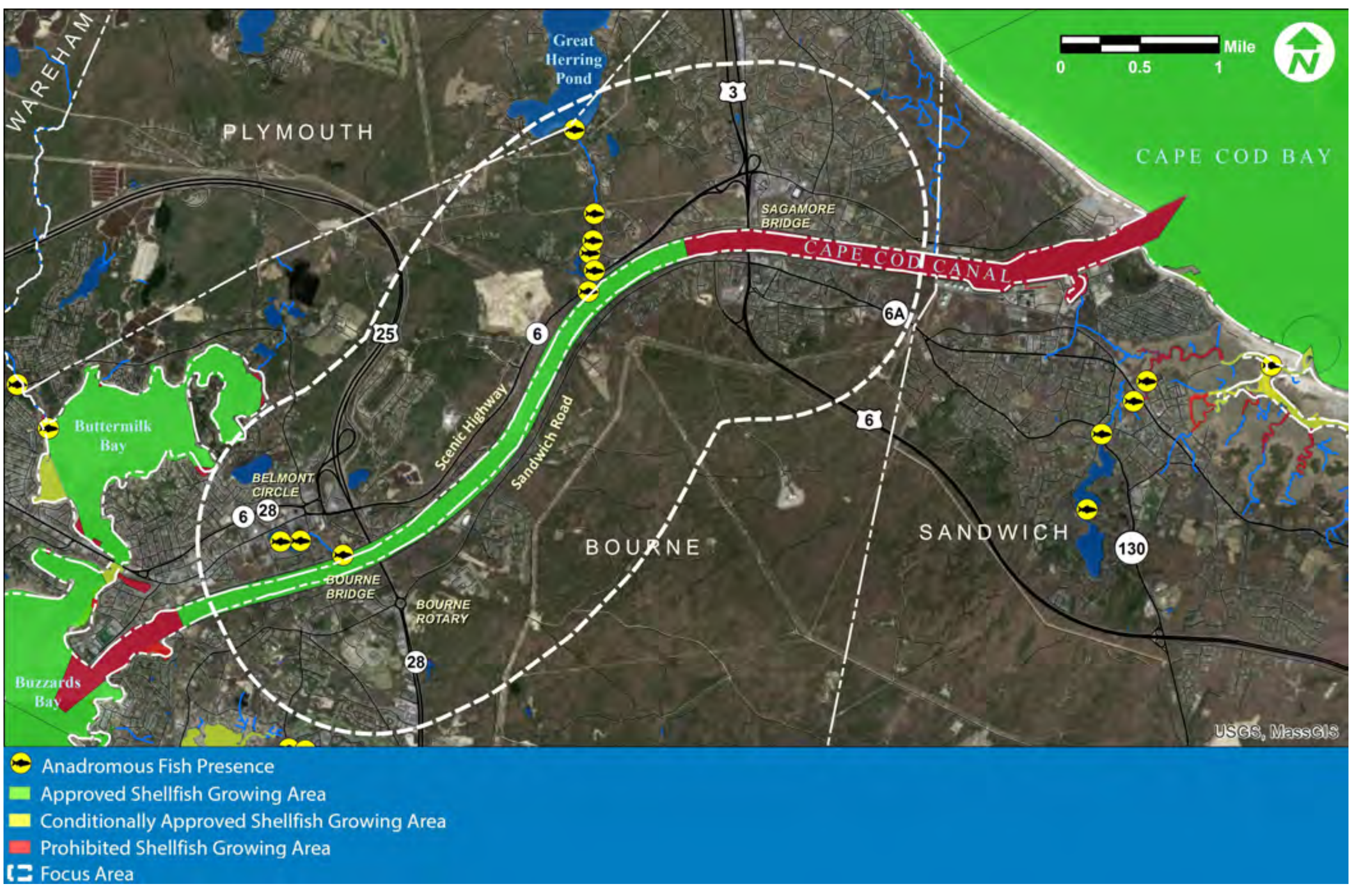
Commercial fishing and shellfishing are key economic activities on Cape Cod and important parts of its history and culture. While there are eight commercial fishing harbors on the Cape only the East Canal Entrance Harbor is within the study area (Exhibit 2-4). Fish species commonly landed by commercial fishermen on Cape Cod include black sea bass, striped bass, bluefin tuna, bluefish, cod, dogfish, flounder, monkfish, and skate. Shellfish (mollusks and crustaceans) species commonly landed include lobster, mussels, sea scallops, bay scallops, and conch.

Shellfishing also occurs in the Cape Cod Canal, Buttermilk Bay, and Buzzards Bay. Shellfishing areas are regularly evaluated through sanitary surveys to confirm whether or not harvested shellfish are safe for human consumption. Based on the sanitary survey shellfish areas are assigned one of five categories.

1. **Approved:** Open to shellfish harvesting for direct human consumption.
2. **Conditionally Approved**: Closed some of the time due to rainfall or seasonally poor water quality or other predictable events.
3. **Restricted:** Contains a limited degree of contamination at all times. When open, shellfish can be relayed to a less contaminated area or harvested for depuration.
4. **Conditionally Restricted:** Contains a limited degree of contamination at all times. Subject to intermittent pollution events and may close due poor water quality from rainfall events or season.
5. **Prohibited:** Closed to the harvest of shellfish under all conditions.

As shown on Exhibit 2-4, shellfishing is approved in most of Buzzards Bay and Buttermilk Bay and the central portion of the Canal. Shellfishing is prohibited at both the eastern and western ends of the Canal.

Exhibit 2-4 Fisheries and Shellfish Growing Areas



(top to bottom)
Fishing on Cape Cod Canal

Roseate Tern – federally listed endangered species

Diamondback Terrapin – state listed threatened species

Recreational fishing and shellfishing are also important parts of the Cape's history and culture. Chartering a fishing boat for the day or fishing from the banks of the Canal for striped bass and sea bass is a popular activity for residents and visitors alike.

The Canal area is also home to several anadromous fish species, including alewife and blueback herring. These fish spend most of their lives in the ocean but migrate up the Herring River or Mill Creek to lay their eggs in Great Herring Pond or Shawme Lake.

2.1.6 Rare, Threatened, and Endangered Species

Extensive areas both north and south of the Canal contain rare-species habitat (Exhibit 2-5). Specifically, the Massachusetts Natural Heritage and Endangered Species Program (MNHESP) has designated these areas as either Estimated Habitats of Rare Wildlife or Priority Habitats of Rare Species.

The MNHESP provided a list of state-designated rare, threatened, or endangered species in the study area (see Appendix B). These species include a wide variety of turtles, reptiles, birds, butterflies, moths, mussels, and plants. Numerous certified and potential vernal pools also exist throughout the study area.

Any proposed work within rare species habitats will require coordination with MNHESP, generally as part of the WPA Notice of Intent process, to ensure there is no significant impact to these rare species (known as a "take"), requiring the development of a Conservation Management Plan.

The federally-listed species known to occur in the study area include the piping plover, roseate tern, and red knot (all bird species), the red bellied cooter turtle, the sandplain gerardia (flower), the northeastern red tiger beetle, and the northern long-eared bat.

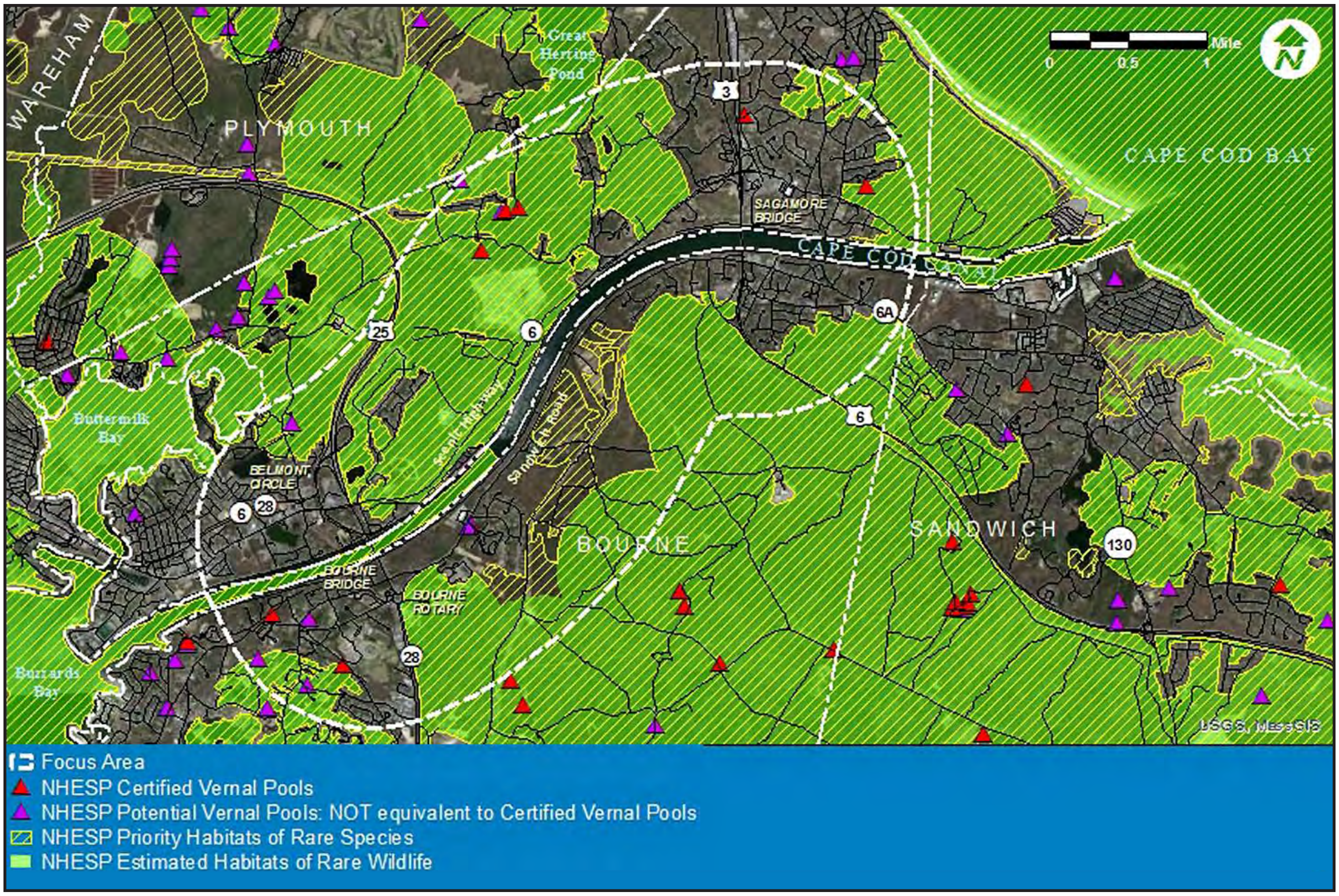


Exhibit 2-5 Rare, Threatened, and Endangered Species

Exhibit 2-6 Areas of Critical Environmental Concern

2.1.7 Areas of Critical Environmental Concern

The study area contains two state-designated Areas of Critical Environmental Concern (ACECs): the Bourne Back River and the Herring River (Exhibit 2-6). ACECs are places in Massachusetts that receive special recognition because of the quality, uniqueness, and significance of their natural and cultural resources. These areas are identified and nominated at the community level, then are reviewed and designated by the state's Secretary of Energy and Environmental Affairs (EEA). The ACEC program is administered by the Department of Environmental Protection on behalf of the EEA Secretary.

The 1,850-acre **Bourne Back River ACEC** in Bourne was designated an ACEC in 1989. It contains outstanding natural resources including marshes, tidal flats, and freshwater wetlands. Because these resources occur within an unaltered and undeveloped area, they function at their maximum capacity as habitats, nurseries, spawning grounds, and in the case of barrier beaches, storm-protection barriers. The estuarine/saltmarsh ecosystem, including headwater wetland areas, supports a wide variety of shellfish, finfish, amphibians, reptiles, birds, and mammals within an extraordinary spectrum of habitat types. The area contains at least three known state-listed rare and endangered species, including osprey, spotted turtle, and diamondback terrapin.

The **Herring River ACEC** in Bourne and Sandwich received ACEC designation in 1990. At 4,450 acres, it contains eleven lakes and ponds (the largest, Great Herring Pond, is 376 acres), numerous freshwater wetlands, productive cranberry bogs, and more than 250 acres of protected open space. The area contains one of the most important anadromous fish runs along the Southeastern Massachusetts coast and Great Herring Pond supports a regionally important freshwater recreational fishery. The area lies within the Plymouth-Carver Sole Source Aquifer and is critical to public water supply. At least three known state-listed rare and endangered species, including the box turtle and spotted turtle, are present.

2.1.8 Oil and Hazardous Materials Sites

Oil and hazardous-material release sites exist in the study area, including active Massachusetts Department of Environmental Protection (MassDEP) Chapter 21E sites, sites with an approved Activity and Use Limitation (AUL, as shown on Exhibit 2-7), and Superfund sites.

MassDEP Chapter 21E sites are sites that have been reported to MassDEP and have been issued a tier classification for the presence of oil and/or hazardous materials. The study area contains sites classified as either Tier ID or Tier II. A site is classified as Tier ID if the responsible party has not met MassDEP reporting requirements. A site is classified as a Tier II site when the hazardous releases do not pose an imminent hazard, involve groundwater contamination, or threaten drinking water supplies.

AULs provide notice that oil and/or hazardous material contamination remains at the location after a cleanup. The AUL is a legal document that identifies activities and uses that may and may not occur on the property, as well as the owner's obligation and maintenance conditions that must be followed to ensure the safe use of the property.

Exhibit 2-7 also identifies the transfer stations in Bourne and Sandwich and the Superfund site at Joint Base Cape Cod, which is described in more detail below.

Superfund sites are locations contaminated with hazardous substances and pollutants that have designated by the U.S. Environmental Protection Agency for cleanup.

The Otis Air National Guard Base (ANGB)/Joint Base Cape Cod (JBCC) is a federal facility that was placed on the National

Exhibit 2-7 Oil and Hazardous Materials Sites

Priorities List as a Superfund site in 1989. The site covers more than 20,000 acres in the towns of Bourne, Falmouth, Mashpee, and Sandwich. The site contains multiple plumes of contaminated groundwater that are undergoing active remediation to protect the Cape's federally-designated sole source aquifer (source of drinking water for 200,000 year-round and 500,000 seasonal residents). Contamination sources include fuel spills, training, disposal, and other past activities at Otis ANGB/JBCC.

Two environmental cleanup programs at the JBCC address groundwater contamination and its sources. One program under the Superfund program is managed by the U.S. Air Force and focuses on contamination found primarily at Otis ANGB on the southern portion of the JBCC. The other, managed by the U.S. Army, addresses contamination from Camp Edwards, the northern portion of the base, under the Safe Drinking Water Act. Both of these programs operate under oversight of the U.S. Environmental Protection Agency and the MassDEP.

2.1.9 Upper Cape Water Supply Reserve

The Upper Cape Water Supply Reserve (Reserve) is the northern 15,000 acres of JBCC (Exhibit 2-8). The Reserve, owned by the Commonwealth, serves two purposes:

1. It is New England's largest military training center serving soldiers from the Massachusetts Army National Guard and numerous other military branches. The Reserve provides facilities for soldiers to practice maneuvering exercises, bivouacking, and using the small arms ranges.

2. It serves as a drinking water and wildlife protection area. The Reserve is the largest piece of undeveloped land on Cape Cod which serves as a drinking water source for Upper Cape Cod, and is home to 37 state-listed species living in a variety of habitats throughout the base.

The Reserve was created by the Massachusetts legislature through Chapter 47 of the Acts of 2002. This Act transferred the care, custody, and control of the Reserve (northern 15,000 acres of JBCC) from the Special Military Reservation Commission to the Division of Fisheries and Wildlife of the Massachusetts Department of Fish and Game. The Reserve is designated as public open space, subject to legal protection under both Article 97 of the Massachusetts Constitution and federal Section 4(f) of the DOT Act. Both laws recognize the high value this property provides to the community and requires substantial justification to develop these sites, including converting them to transportation uses.

Exhibit 2-8 Upper Cape Water Reserve

Chapter 47 of the Acts of 2002 also created an Environmental Management Commission (EMC) whose purpose is to ensure the permanent protection of the drinking water supply and wildlife habitat of the Reserve. The Reserve's enacting legislation requires that the Massachusetts National Guard comply with all environmental decisions and orders of the EMC. The EMC includes representatives from the Massachusetts Department of Fish and Game, the Department of Environmental Protection (MassDEP) and the Department of Conservation and Recreation. The Reserve is designated as public conservation land dedicated to three primary purposes:

1. Water supply and wildlife habitat protection,
2. The development and construction of public water supply systems, and,
3. The use and training of the military forces of the commonwealth; provided that such military use and training is compatible with the natural resource purposes of water supply and wildlife habitat protection.

The EMC oversees compliance with, and enforcement of, 19 Environmental Performance Standards. The Environmental

Performance Standards are specifically created through the Massachusetts Environmental Policy Act (MEPA) process to protect the resources in the Reserve. The 19 standards pertain to rare species and habitat management, hazardous materials, solid waste, and pest and fire management. The goal is to ensure the protection of the groundwater and habitat during conduct of compatible military training and civilian use activities, such as hunting.

2.1.4 Cultural, Historical, and Archaeological Resources

There are many important cultural resources in the study area (Exhibit 2-9). Bourne, Plymouth, Sandwich, and Wareham are rich in historic resources and open space properties. The key historic sites and districts in the study area include the Bourne and Sagamore Bridges, the Old Kings Highway Regional Historic District in Sandwich, and the Jarvesville, Town Hall Square, and Spring Hill National Historic Districts in Sandwich. Several public buildings in Bourne are individually listed on the National Register of Historic Places including Bourne High School, Jonathan Bourne Public Library, and Bourne Town Hall.

Exhibit 2-9 Historic Districts and Individual Historic Properties

Overall, cultural resources are categorized as historic, archaeological, and/or cultural/ethnographic:

- Historic resources include above-ground man-made resources such as buildings, structures, objects, districts, landscapes, and sites that meet the criteria for listing in the National Register of Historic Places.
- Archaeological resources are buried pre-colonial Native American and historic-period sites.
- Cultural/ethnographic resources are above and below-ground areas of cultural sensitivity and importance to the Mashpee Wampanoag Tribe and the Wampanoag Tribe of Gay Head (Aquinnah).

The study area, including Bourne, Plymouth, Sandwich, and Wareham, is rich in above-ground historic resources (Table 2-2):

- The Bourne Bridge and the Sagamore Bridge have been identified by the Massachusetts Historical Commission (MHC) as eligible for individual listing in the National Register of Historic Places (NRHP).
- The Cape Cod Canal area may also qualify for listing on the NRHP. The identified area contains 18 structures that add to the district's historical integrity.
- The eastern end of the Canal, and the land just south of it in Sandwich, is in the Old King's Highway Regional Historic District, listed in the State Register of Historic Places.
- All inventoried historic structures and districts in Sandwich are listed in the State Register of Historic Places, with some potentially eligible as NRHP districts.
- North and south of the Cape Cod Canal, in Bourne, are many buildings and districts that are listed, eligible for listing, or potentially eligible for listing in the NRHP (Table 2-1).
- In Plymouth, the Indian Cemetery on the south shore of Great Herring Pond is potentially eligible for the NRHP as a contributing resource to the MHC-inventoried Cedarville District (PLY.G).

The focus area is also rich in archaeological and cultural resources. For thousands of years, the river, marsh, and coastal resources on Cape Cod made the area a prime location for Native American settlements. This is demonstrated through both archaeological finds made during the Canal's construction and oral tradition among the Wampanoag tribes. Archaeological surveys previously undertaken as part of cultural resource management projects in the focus area have identified dozens

Table 2-1 Historic Status of Resources Inventoried by the Massachusetts Historic Commission

SR LISTED	NAME	NR (INDIVIDUAL PROPERTIES)	NR-ELIGIBLE PER MHC	POTENTIALLY NR-ELIGIBLE (DISTRICT)	POTENTIALLY NR-ELIGIBLE PROPERTIES	SR-LISTED
CAPE COD CANAL						
BOU.918	Bourne Bridge		✱			
BOU.919	Sagamore Bridge		✱			
BOU.AF	Cape Cod Canal			✱		
SDW.Z	Cape Cod Canal			✱		✱
NORTH OF CANAL						
BOU.388	Mass. Army NG Armory		✱			
BOU.C	Head of the Bay				1	
BOU.I	Bournedale	1			3	
BOU.J	Main Street Commercial Area				2	
BOU.O	North Sagamore				3	
BOU.P	Savery Avenue					
BOU.U	Sagamore Beach				3	
BOU.AE	Bourne Town Hall	1				✱
PLY.G	Cedarville			✱		
SDW.AA	Sagamore Hill Gun Battery			✱		✱
SOUTH OF CANAL						
BOU.A	Keene St - Sandwich Rd Area	3		✱	6	
BOU.B	Cape Cod Air Station - Otis AFB					
BOU.AG	Aptucxet Trading Post			✱		
BOU.AH	Shore Road North				1	
BOU.AJ	County Road North					
BOU.V	South Sagamore			✱	8	
SDW.906	Route 6 Bridge					✱
SDW.907	Route 6 Bridge					✱
SDW.F	Shawme Road			✱		✱
SDW.G	Route 6A West					✱
SDW.I	Main Street					✱
SDW.R	Old Kings Highway Regional HD					✱

MHC = Massachusetts Historical Commission; NR = National Register of Historic Places; SR = State Register of Historic Places

of archaeological sites. Areas of cultural importance to the Wampanoag tribes are present in numerous locations in the focus area.

Due to sensitivity of the location of archaeological sites and other areas culturally important to Tribal culture, this study does not identify their locations. Both the National Historic Preservation Act and the Archaeological Resources Protection Act mandate that Federal agencies only disclose archaeological site locations if no harm, theft, or destruction of cultural resources will result from disclosure.

In addition to these sites, historic-period Euro-American sites are also likely present in the study area given colonial settlement on the Cape in the early 17th century.

Appendix C, the Cape Cod Transportation Study—Cultural Resource Identification and Evaluation, includes a detailed description of the cultural resources in the study area.

2.1.5 Protected Open Space

Numerous properties in the study area are designated as protected open space (Exhibit 2-10). Examples of these publicly- and privately-owned properties include the Scusset Beach State Reservation, Shawme-Crowell State Forest, Upper Cape Water Supply Reserve, Cape Cod Canal Recreation Area, Gallo Skating Rink, Bourne Scenic Park, Carter Beal Conservation Area, Sacrifice Woods Rock, and the Nightingale Pond Recreation Area.

These open space properties serve a wide variety of purposes, including watershed protection, wildlife habitat, conservation, and recreation. Their owners include the federal government (U.S. Army Corps of Engineers), the Commonwealth of Massachusetts (Division of Fisheries & Wildlife, the Department of Conservation and Recreation), Barnstable County, municipalities, water districts, and private conservation or wildlife trusts.

Exhibit 2-10 Protected Open Space

While varying levels of legal protection safeguard these resources, the publicly-owned properties receive protection under both Article 97 of the Massachusetts Constitution and Section 4(f) of the DOT Act. Both laws recognize the high value these properties provide to the community and require substantial justification to convert them to other uses, including transportation uses.

2.1.6 Utilities

Important utility corridors cross the study area. These include an electrical utility corridor which transmits electricity through transmission towers from the Canal Generating Plant in Sandwich northwest across the Canal and east to Cape Cod customers (Exhibit 2-11). Natural gas enters Cape Cod within a pipe network that crosses the Canal attached to the Canal bridges. Natural gas compressor stations are located close to both the Sagamore and Bourne Bridges.

These electrical transmission towers and gas lines and compressor stations represent a substantial constraint when considering future work on the Canal bridges.

Exhibit 2-11 Utilities

Exhibit 2-12 Environmental Justice Populations

2.1.7 Environmental Justice Populations

Environmental Justice (EJ) refers to an effort to ensure the fair distribution of environmental benefits and burdens created by any action of the federal government. President Clinton issued Executive Order 12898—Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations in 1994. It directs all federal agencies to identify and address the disproportionately high and adverse human health or environmental effects of their actions on minority and low-income populations, to the greatest extent practicable and permitted by law.

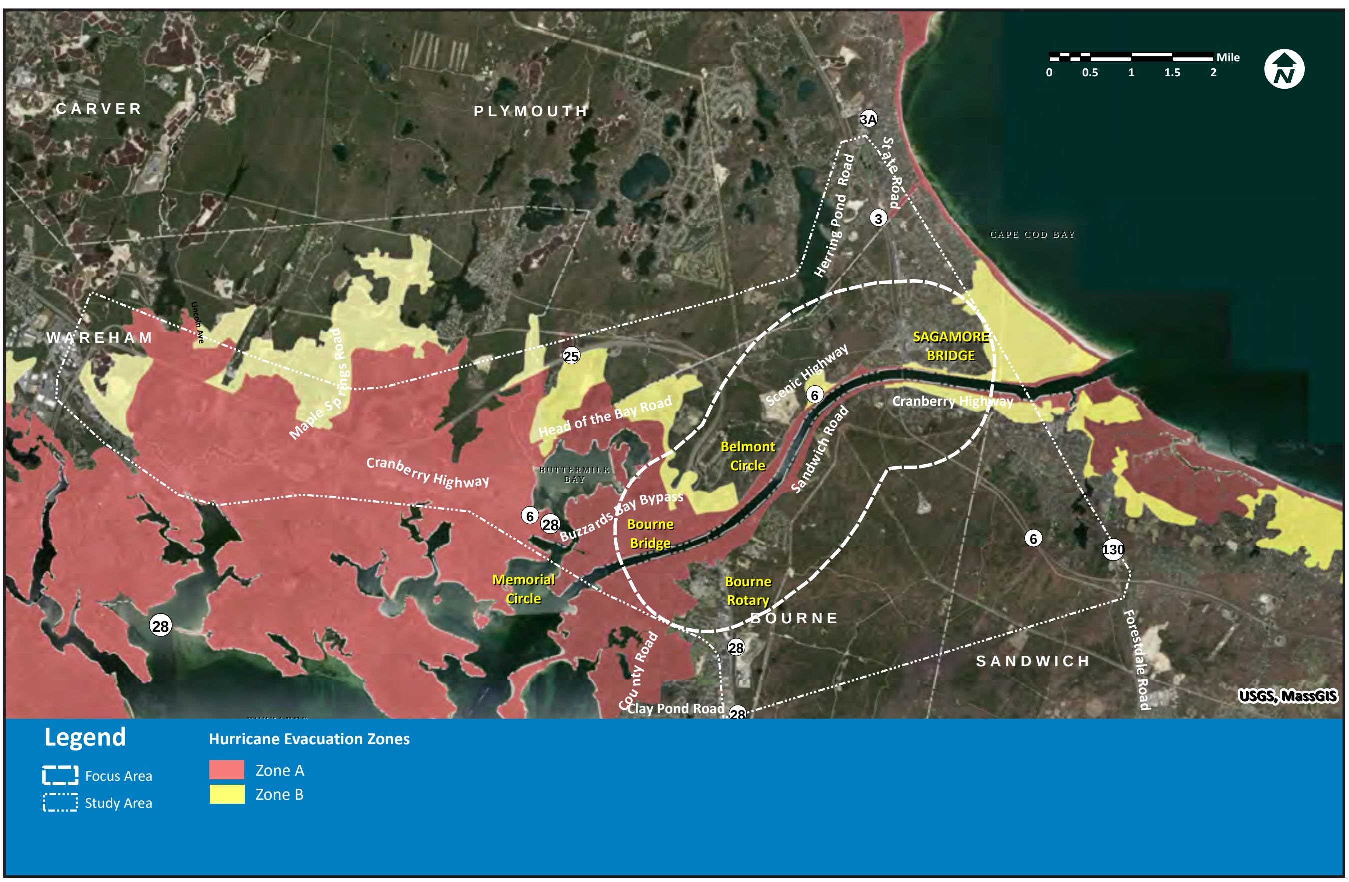
At the state level, the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) ensures that state agencies, divisions, and other entities (including MassDOT) identify and address EJ populations in their projects or other actions. The EEA's Environmental Justice Policy was updated in 2017.

EJ populations are identified according to three criteria: minority (non-white) status, income, and English isolation, which is a metric of English language fluency. Minority status is determined at the block group level with U.S. Census data, and English isolation and income are determined at the state level with American Community Survey (ACS) data. The thresholds that determine EJ status are:

- 25% of households within the census block have a median household income at or below the statewide median income for Massachusetts (2016: $75,297); or
- 25% or more of residents are minority (defined as those who identify themselves as Latino/Hispanic, Black/African American, Asian, Indigenous people, and people who otherwise identify as non-white); or
- 25% or more have English isolation (defined as those that do not have an adult over 14 years old that speaks only English or English very well).

According to the data from the 2010 US Census, the only environmental justice populations in the study area are in Wareham (Exhibit 2-12). The Village of Onset in Wareham and areas west of Onset contain high minority populations (higher than the state average). Other areas in Wareham, including areas surrounding Main Street and west of the I-495/I-195 Interchange, contain areas of low-income populations.

Exhibit 2-13 MEMA Hurricane Evacuation Zones



The study team also reviewed the recommendations within the National Cooperative Highway Research Program Report No. 532 (NCHRP 532), titled Effective Methods for Environmental Justice Assessment. This report emphasized that beyond considering low-income and minority populations, it is appropriate to consider other demographic characteristics such as race, national origin, age, disability, and English-speaking ability.

2.1.8 MEMA Evacuation Zones

The Massachusetts Emergency Management Agency (MEMA) is the state agency responsible for coordinating the planning and response of federal, state, local, voluntary, and private resources during emergencies or disasters, including hurricanes, flooding events, winter storms, nuclear or terrorist events or other natural and man-made disasters.

MEMA has established statewide evacuation zone maps in Massachusetts. On Cape Cod, the evacuation of residents, workers, and visitors may be necessary during a hurricane or tropical storm due to risk of storm surge. A storm surge is an abnormal rise of water generated by a storm, over and above the predicted astronomical tide. The destructive power of a storm surge and large battering waves is often the greatest threat to life and property during a storm, and can result in loss of life, destroyed buildings, beach and dune erosion, and road and bridge damage along the coast.

Evacuation zones A and B exist within the study area (Exhibit 2-13). These zones include areas that, depending on predicted inundation, may flood first from storm surge during a tropical storm or hurricane. Areas in Zone A would flood before areas in Zone B.

The reliability of multimodal travel across the Canal would be critical during an evacuation, this includes ensuring the accessibility of the Canal bridges and all roadway approaches to the bridges.

2.2 LAND USE AND DEVELOPMENT

This section includes a discussion of existing land uses within the study area.

2.2.1 Land Uses within the Study Area

The study area is characterized by a wide variety of land uses (Exhibit 2-14). Along Route 25, land uses include forested areas, interspersed with cranberry bogs, and residential development (particularly on the south side of Route 25). Land use shifts to

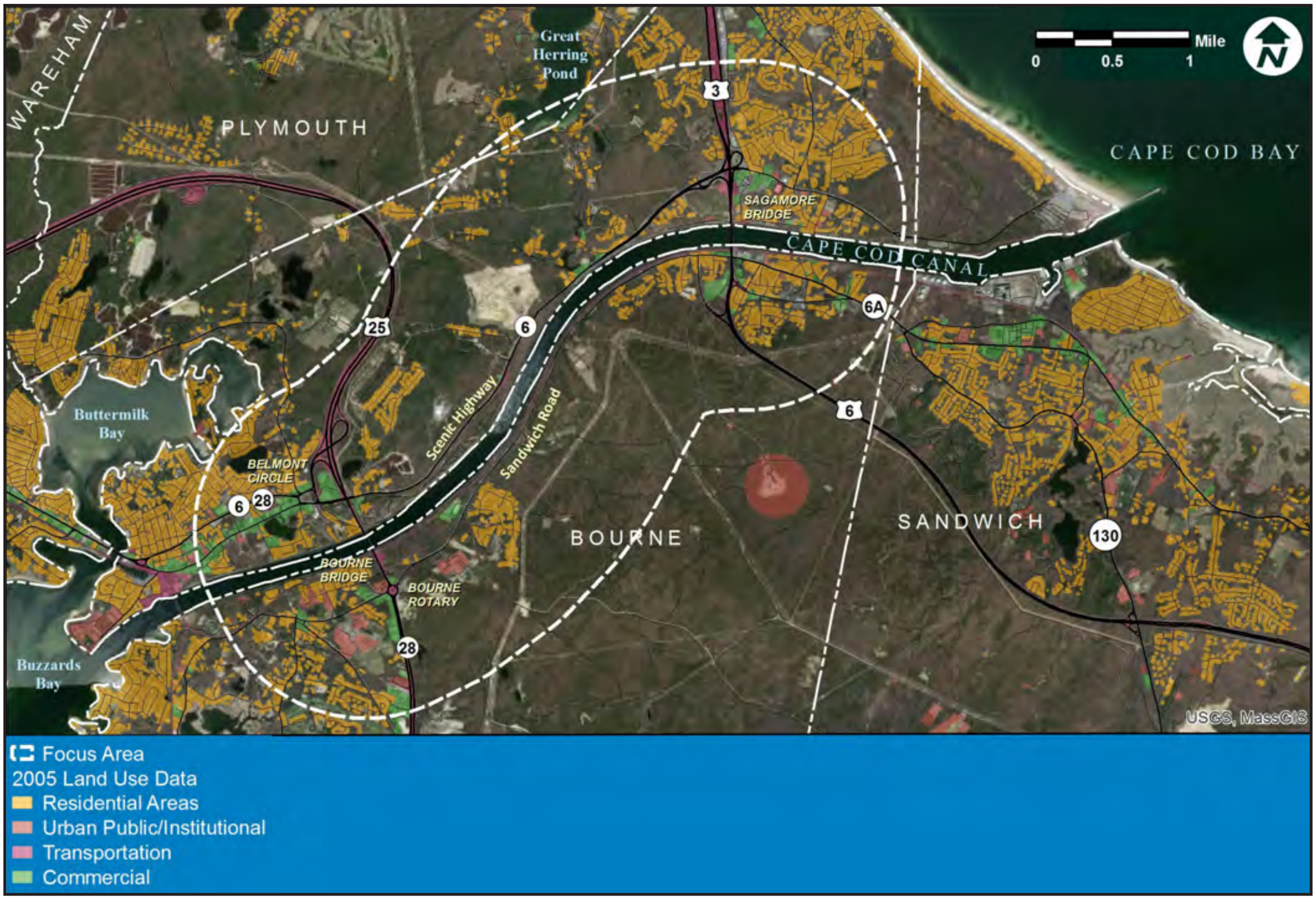


Exhibit 2-14 Land Uses in the Study Area

more high-density residential and commercial development in the Buzzard's Bay section of Bourne.

Located west of Route 28 (south of the Bourne Bridge) are medium- to low-density residential developments and commercial properties. The Bourne Back River ACEC, described in Section 2.1.5, is west of Route 28 and Waterhouse Road. East of Route 28, from Bourne to Route 6 in Sandwich, land use is predominantly protected open space, identified as the Upper Cape Water Supply Reserve (described in Section 2.1.7).

East and west of Route 3, in the northeast portion of the study area, land uses include medium-density residential development with dispersed pockets of municipally-owned open space. Great Herring Pond, a 376-acre pond in Plymouth, is the largest of multiple ponds found west of Route 3. To the east, from Route 3 to the Sagamore Beach in Sandwich, the landscape is characterized by medium-density single- and multi-family residential developments. Further east (and north of the Canal), land use transitions to open space including the Scusset Beach State Reservation (owned by the U.S. Army Corps of Engineers) and a large expanse of wetland marshes.

East of Route 6, south of the Canal, land uses in Bourne and Sandwich include the 624 acre Shawme-Crowell State Forest. The Massachusetts Department of Conservation and Recreation (DCR) owns and manages this state forest, which is protected open space. East of the state forest, development between Route 130 and Route 6A in Sandwich consists of high- to low-density residential uses.

Along Route 6A, land use in Sandwich includes high-density residential development and commercial properties, particularly west of this corridor. Further east of Route 6A in Sandwich, land use is characterized by concentrations of dense residential development with extensive areas of municipally managed wetland resource areas.

2.2.2 Joint Base Cape Cod

Joint Base Cape Cod (JBCC) is a nearly 21,000-acre full scale, joint-use base home to five military commands training for missions at home and overseas, conducting airborne search and rescue missions, and intelligence command and control. Numerous important military training and operating facilities exist at JBCC including:

Tactical Training Base (TTB) Kelley replicates a forward operating base soldiers occupy when deployed overseas.

102nd Intelligence Wing provides world-wide precision intelligence and command and control along with trained and experienced Airmen for expeditionary combat support and homeland security.

U.S. Coast Guard Base Cape Cod serves as the single Deputy Commandant for Mission Support (DCMS) touch point for the support of Coast Guard operations within the 1st Coast Guard District.

Air Station Cape Cod (ASCC), with its three helicopters and four jets, is the only Coast Guard Aviation facility in the northeast. ASCC is responsible for the waters from New Jersey to the Canadian border and maintains the ability to launch a helicopter and/or jet within 30 minutes of a call, 365 days-a-year, 24 hours-a-day, and in nearly any weather condition.

Camp Edwards is the primary military training facility for the National Guard and Army Reserve for soldiers throughout New England. The primary mission of Camp Edwards is to prepare soldiers for combat missions overseas as well as missions to serve and protect the United States.

Upper Cape Water Supply Reserve The 15,000 acres of the northern portion of JBCC is designated as the Upper Cape Water Supply Reserve which, as described in Section 2.1.7 is the largest piece of protected, undeveloped land on Cape Cod providing drinking water and wildlife protection and is used jointly for training by the Massachusetts Army and Air National Guard and the U.S. Coast Guard.

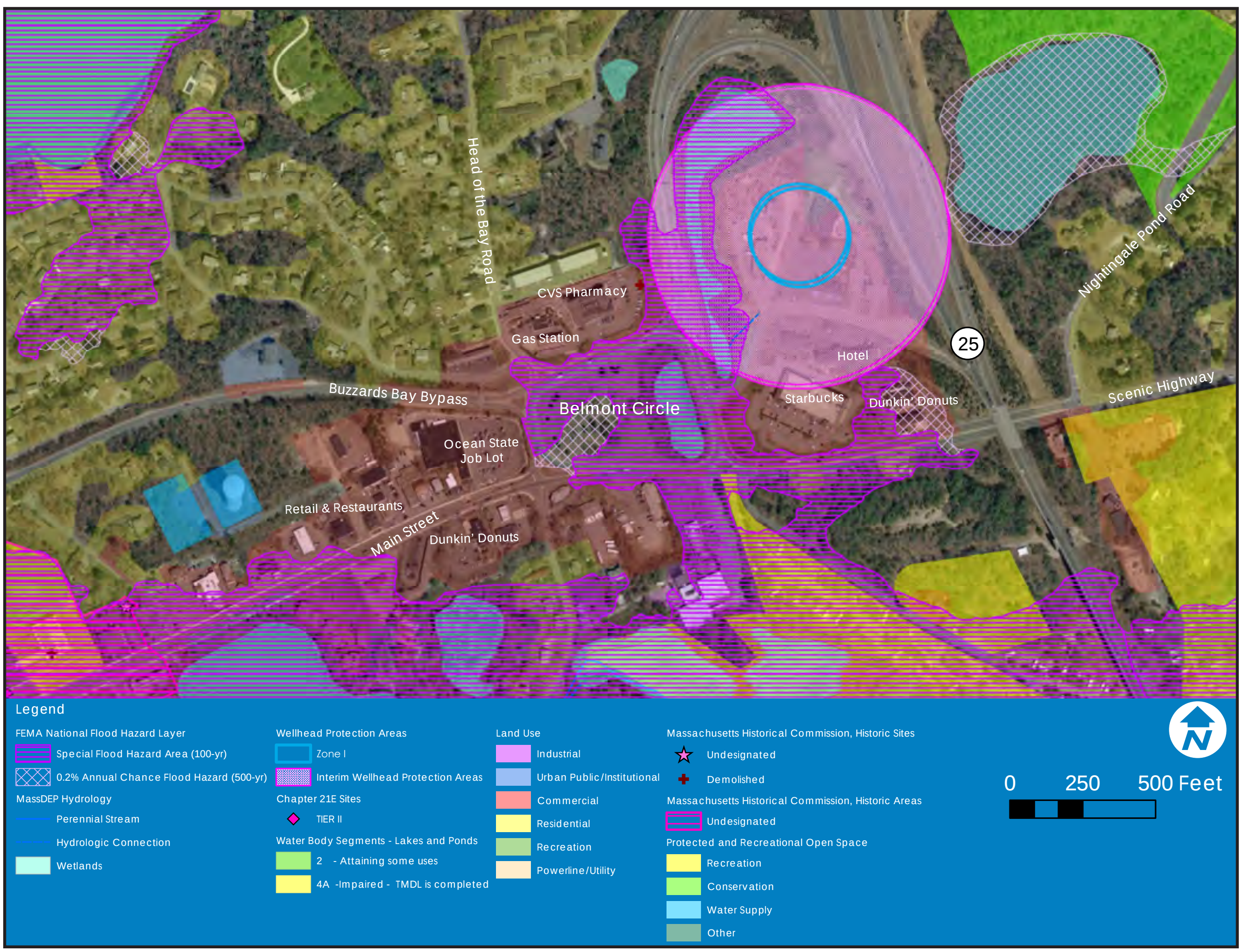
2.2.3 Belmont Circle and Bourne Rotary

As Belmont Circle and the Bourne Rotary are two of the most critical intersections in the study area, this section provides information on the existing land uses and environmental resource found at these locations. The existing traffic conditions at these locations are provided in Section 2.5.10.

Belmont Circle

This section describes the existing land uses and environmental resources at Belmont Circle and the adjacent Scenic Highway at Nightingale Pond Road intersection.

Exhibit 2-15 Existing Land Uses and Environmental Resources - Belmont Circle



Land Uses and Environmental Resources

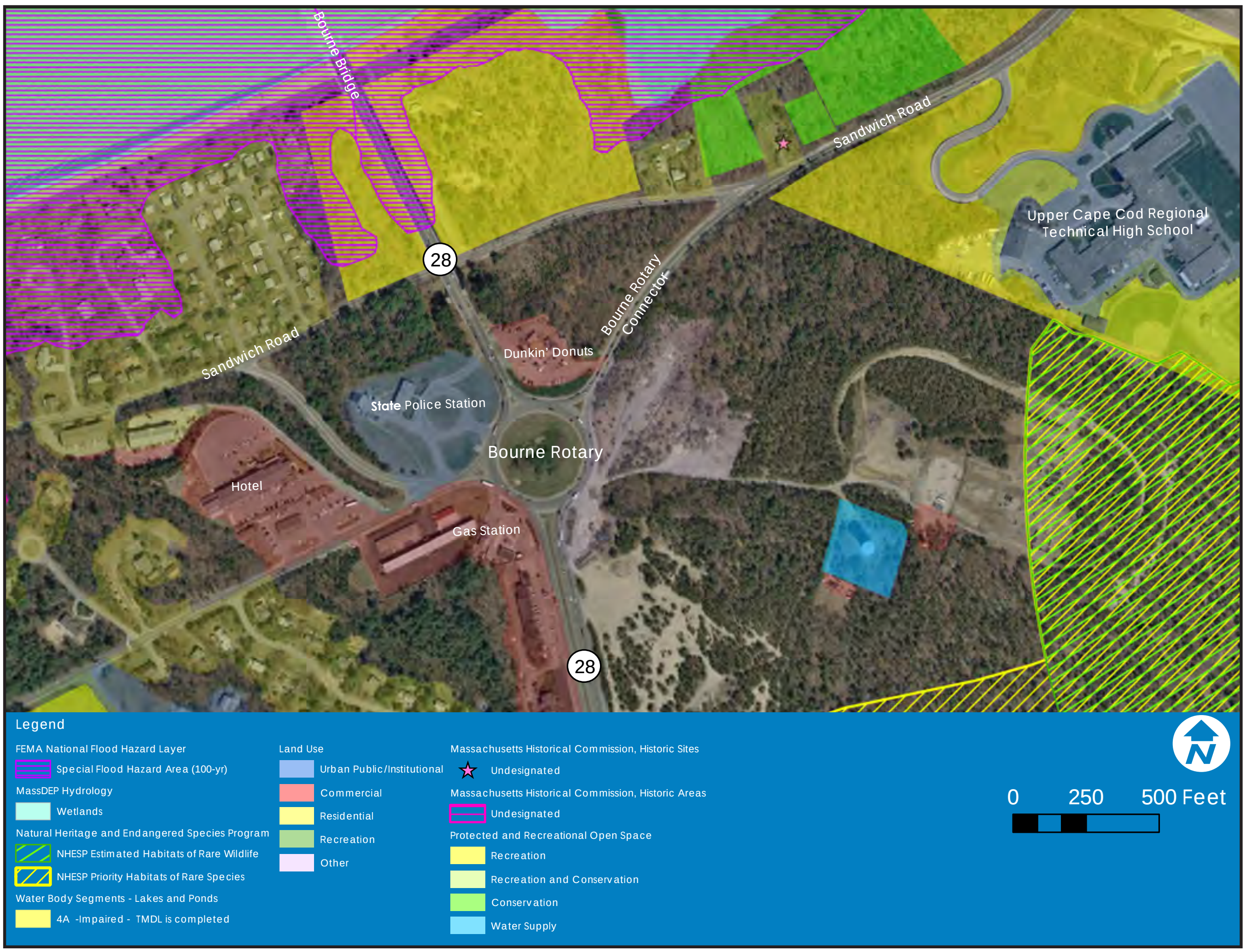
Land uses adjacent to Belmont Circle include numerous retail and restaurant business, such as CVS pharmacy, Starbucks, Mobil Gas, and Ocean State Job Lot, have direct access to Belmont Circle. West of Belmont Circle, Main Street includes numerous retail and restaurant establishments in Bourne's business district and Bourne town hall and police station.

Natural resources in the Belmont Circle area include a one-acre wetland on the east side of the Circle infield. The 100-year floodplain extends from the Canal north to Main Street and the entire Belmont Circle area (see Exhibit 2-15).

Bourne Rotary

This section describes the existing land uses and environmental resources in the Bourne Rotary area.

Exhibit 2-16 ***Existing Land Uses and Environmental Resources - Bourne Rotary***



Land Uses and Environmental Resources

Land uses adjacent to the Bourne Rotary include Dunkin' Donuts and a Cumberland Farms Convenience store and gas station. A Massachusetts State Police barracks is adjacent to the northwest side of the Rotary.

Several schools are in the Bourne Rotary area. The entrance to the Upper Cape Cod Regional Technical High School is 0.4 miles to the east of the Rotary on Sandwich Road. The entrance to the Bourne Middle and High School and the James Pebbles Elementary School are 0.4 miles west of the Rotary on Trowbridge Road.

Traveling east on Sandwich Road from the Rotary for ¼-mile leads to the entrance of the Upper Cape Cod Regional Technical High School. Several restaurants and retail businesses, including Dunkin Donuts and Gulf Oil have direct access to the rotary. Undeveloped land exists east and south of the rotary. No wetland or floodplain areas exist in the Bourne Rotary area (see Exhibit 2-16).

2.3 SOCIO-ECONOMIC CONDITIONS

The socio-economic conditions in Barnstable, Dukes (Martha's Vineyard and nearby islands), and Nantucket counties were evaluated using data from sources including the U.S. Census, the U.S. Department of Labor, the Massachusetts Department of Revenue, and the Nielsen Company. Because the study area includes portions of Wareham and Plymouth, this report also includes certain socioeconomic data for these towns.

This evaluation documents existing conditions and recent trends for population, household makeup, income, employment, and journey to work data.

2.3.1 Population

Socio-economic conditions in Barnstable County (Cape Cod) are in transition. After several decades of rapid population and employment growth, the county has experienced a population decline since 2000. The demographics of this population is also shifting to a higher percentage of senior citizens and a lower percentage of working adults and school-age children.

Table 2-2 Historical Population Change in Barnstable County

	1960	1970	1980	1990	2000	2010	2017	2018
Population	70,286	96,656	147,925	186,605	222,230	215,888	213,444	213,413
% Change from previous period		37.52	53.04	26.15	19.09	-2.85	-1.13	-0.01

Source: US Census Bureau

The population of Barnstable County grew rapidly between 1960 and 2000. Table 2-2 shows growth from approximately 70,000 to more than 220,000 residents during this 40-year period, a 214% increase. However, this growth faltered in the period 2000-2010, with the county experiencing a population decline of 2.85%. The population lost an additional 1.13% from 2010 to 2017. Forecasts for Barnstable County[1] project modest population growth of 2.53% between 2010 and 2019.

By comparison, the population of Plymouth County grew 4.9% between 2000 and 2010 and an additional 3.9% between 2010 and 2017. The population of Plymouth County is forecast to grow an additional 1.7% between 2017 and 2019. The population of Massachusetts as a whole grew 3.1% in the ten years from 2000 to 2010 and an additional 4.5% between 2010 and 2016.

Nantucket and Dukes counties have also experienced significant increases in population since1960. Between 1960 and 2016, Nantucket County's population increased approximately 209% from 3,559 to 11,008 persons. In the same period, Dukes County's population rose approximately 196%, from 5,829 to 17,246 persons. Neither experienced a more recent decline like the one in Barnstable County.

Table 2-3 Change in Age Cohorts 2000–2017, Barnstable County

	2000	2017	% CHANGE
Total population	222,230	213444	-3.95
Under 5 years	10,599	7,764	-26.8
5 to 9 years	12,811	8,670	-32.3
10 to 14 years	14,208	9,579	-32.6
15 to 19 years	11,725	10,375	-11.51
20 to 24 years	7,735	11,002	42.2
25 to 34 years	21,595	18,962	-12.2
35 to 44 years	33,982	18,558	-45.4
45 to 54 years	32,802	27,220	-17.0
55 to 64 years	25,508	37,546	47.2
65 to 74 years	26,357	36,218	37.4
75 to 84 years	11,075	18,794	69.7
85 years and over	6,447	8756	35.8

Source: US Census Bureau, American Community Survey, 2017

Barnstable County has also experienced changes in the age groups (or cohorts) that make up its population (Table 2-3). Between 2000 and 2017, the population of Barnstable County remained relatively stable (decreasing by 3.95%) however, the county experienced considerable change in age cohorts.

1 The Nielsen Company, Site Reports, 2014 data.

Specifically, the population of pre-school and school-age children (residents ages 1 19) dropped significantly, as did the number of working-age adults aged 25 to 54. Conversely, the county experienced a considerable increase in older residents (residents older than 55).

While the drop in the number of prime working-age adults (and their children) is partially due to the natural aging of the large baby boomer generation, the extent of these changes is also likely due, in part, to the increasing cost of Cape Cod residential real estate and limited growth opportunities for local employment. At the same time, 19% of persons who own second homes on Cape Cod have reported their intention to convert these homes to their primary residences over the next 20 years[2]. This would result in the conversion of approximately 11,000 second homes on Cape Cod to primary residences. While this trend may increase the year-round population of Cape Cod, without changes to local zoning or housing stock, it would decrease the stock of rental homes available for visitors.

Any discussion of Barnstable County's population must acknowledge its seasonality. During the summer tourist season, the population of the county nearly doubles, increasing by approximately 200,000 people due to the influx of seasonal residents, employees, and visitors[3]. This substantial increase in the summertime population (with related increases in vehicle trips) places tremendous pressure on the transportation system in the Cape Cod Canal area.

2.3.2 Housing Units

A housing unit is defined as a house, an apartment, a mobile home, a group of rooms, or a single room that is occupied (or if vacant, is intended for occupancy) as separate living quarters.

Table 2-4 Housing Units (2005–2015), Barnstable, Dukes, and Nantucket Counties and the Commonwealth of Massachusetts

COUNTY/COMMONWEALTH	2005	2010	2015	% INCREASE, 2000–2015
Barnstable	153,798	160,281	162,118	4.22
Dukes	15,896	17,188	17,614	8.13
Nantucket	10,296	11,618	11,951	12.84
Massachusetts	2,688,014	2,808,254	2,845,699	4.46

Source: US Census Bureau, American Community Survey

2 UMass Donahue Institute, Cape Cod Second Homeowners, Technical Report of 2017 Survey Findings, Cape Cod Commission, June 2017.

3 Cape Cod Commission, 2015. Calculations based on the UMass Donahue Institute Second Home Owner Survey 2008 and 2010 U.S. Census.

According to U.S. Census Bureau, the number of housing units in Barnstable County increased slightly between 2005 and 2010 and again between 2010 and 2015 (Table 2-4). In the five years ending in 2010, the county experienced a 4.2% increase in housing units; from 2010 to 2015, the increase was only 1%. Dukes and Nantucket counties experienced stronger growth in housing units from 2000 to 2015 (8.13% and 12.84%, respectively). In comparison, the Commonwealth of Massachusetts experienced a more modest 4.5% increase in housing unit growth between 2005 and 2015. Overall, the rate of housing construction in Barnstable County between 2005 and 2015 has kept pace with the construction rate in Massachusetts as a whole, although it slowed considerably from 2010 to 2015.

As a major summer tourist destination, Barnstable County has traditionally had a large percentage of housing units serving as seasonal housing, i.e. second homes. Currently, approximately 38% (62,000 of the 162,000) of the housing units in Barnstable County are seasonal units[4]. The percentage of housing units serving as seasonal units has been increasing since the 2007-2009 recession and is forecast to continue to increase in the future.

2.3.3 Median Household Income

The U.S. Census Bureau defines a household as all the people who occupy a housing unit as their usual place of residence. The occupants may be a single family, one person living alone, two or more families living together, or any other group of related or unrelated persons who share living arrangements. "Median household income" refers to the income earned by a given household where half of the households in an area earn more and half earn less.

According to the American Community Survey (ACS), the median household income for Barnstable County in 2017 was $68,048,

Table 2-5 Median Household Income, 2017

	BARNSTABLE COUNTY	DUKES COUNTY	NANTUCKET COUNTY	MASSACHUSETTS
Median Household Income	$68,048	$67,535	$91,942	$74,167

Source: American Community Survey, 2017

Table 2-6 Per Capita Income, 2017

	BARNSTABLE COUNTY	DUKES COUNTY	NANTUCKET COUNTY	MASSACHUSETTS
Per Capita Income	$40,886	$42,956	$47,924	$39,913

Source: U.S. Census Bureau American Community Survey, 2017 (http://www.census.gov/quickfacts/table/PST045215/25,25007,25001,25019)

4 Regional Housing Market Analysis and 10-year Forecast of Housing Supply and Demand for Barnstable County, Massachusetts, September, 2017, Cape Cod Commission.

roughly 8% less than the statewide median of $74,167 (Table 2-5). The median household income for Barnstable County was also 26% less than the Nantucket County and 0.7% more than Dukes County. Overall, the median household income in Barnstable County is below the state median income but approximately the same as most Massachusetts counties other than Middlesex and Norfolk County.

Table 2-6 compares per capita incomes for Barnstable, Dukes, and Nantucket counties and the Commonwealth of Massachusetts. "Per capita income" is the average income for every person in a particular household group, including those living in group quarters. It is derived by dividing the aggregate income of a particular group by the total population in that group.

According to 2017 American Community Survey data, per capita incomes for Barnstable County were slightly higher (2.4%) than that of Massachusetts as a whole. The per capita income for Nantucket County was approximately 14.6% higher than Barnstable County. Based on a comparison of median household income (Table 2-5) and per capital income (Table 2-6), a greater percentage of households statewide have multiple employed residents, resulting in a higher total household income.

2.3.4 Employment

Historically, Cape Cod and the Islands (Barnstable, Dukes, and Nantucket counties) have experienced considerable seasonal variation in employment, related to their long standing economic dependence on tourism and seasonal service industries.

Table 2-7 Monthly 2017 Labor Force and Unemployment Data, Barnstable County

MONTH	LABOR FORCE	EMPLOYED	UNEMPLOYED	MONTHLY UNEMPLOYMENT RATE[1]	
				BARNSTABLE COUNTY	MASSACHUSETTS[2]
January	105,866	97,764	8,102	7.7%	4.5%
February	105,480	97,515	7,965	7.6%	4.4%
March	106,188	99,071	7,117	6.7%	4.1%
April	107,514	102,239	5,275	4.9%	3.6%
May	110,992	106,293	4,699	4.2%	3.7%
June	120,469	115,937	4,532	3.8%	4.0%
July	126,272	121,981	4,291	3.4%	4.0%
August	125,602	121,616	3,986	3.2%	3.6%
September	114,309	110,471	3,838	3.4%	3.5%
October	111,049	107,483	3,566	3.2%	3.1%
November	108,557	104,167	4,390	4.0%	3.0%
December	107,563	102,507	5,056	4.7%	3.1%
Annual	112,489	107,254	5,235	4.7%	3.7%

[1] U.S. Bureau of Labor Statistics Unemployment rates by county and state, not seasonally adjusted, Massachusetts, 2017

[2] Massachusetts Department of Unemployment Assistance; U.S. Bureau of Labor Statistics, not seasonally adjusted, 2017 (http://lmi2.detma.org/lmi/lmi_lur_b.asp?A=04&GA=000001&T-F=3&Y=2017&Sopt=&Dopt=TEXT)

Tables 2-7 and 2-8 demonstrate this trend in 2017 by charting unemployment rates in January (historically when unemployment on the Cape and Islands peaks) through August (historically when unemployment rates are lowest). Data for September through December and the annualized data for 2017 are also provided.

U.S. Bureau of Labor Statistics data for 2017 shows that, at 7.7%, Barnstable County's January unemployment rate was more than double its 3.2% August rate. The data also demonstrate that Barnstable County experienced higher rates of unemployment compared to the state from January to May, which coincides with Cape Cod's tourist off-season.

Table 2-8 Labor Force and Unemployment Data by Municipality, August 2017 Cape Cod and the Islands

CITY/TOWN	LABOR FORCE	EMPLOYED	UNEMPLOYED	UNEMPLOYMENT RATE
BARNSTABLE COUNTY				
Barnstable	26,726	26,726	909	3.4%
Bourne	11,927	11,466	461	3.9%
Brewster	5,797	5,651	146	2.5%
Chatham	3,292	3,210	82	2.5%
Dennis	7,386	7,148	238	3.2%
Eastham	2,864	2,798	66	2.3%
Falmouth	17,328	16,746	582	3.4%
Harwich	6,791	6,595	196	2.9%
Mashpee	8,824	8,540	284	3.2%
Orleans	3,207	3,137	70	2.2%
Provincetown	2,162	2,106	56	2.6%
Sandwich	12,754	12,375	379	3.0%
Truro	1,333	1,303	30	2.3%
Wellfleet	1,811	1,771	40	2.2%
Yarmouth	13,400	12,953	447	3.3%
DUKES COUNTY				
Aquinnah	275	272	3	1.1%
Chilmark	632	619	13	2.1%
Edgartown	3,076	3,003	73	2.4%
Gosnold	53	52	1	1.9%
Oaks Bluffs	3,335	3,256	79	2.4%
Tisbury	2,917	2,830	87	3.0%
West Tisbury	2,070	2,023	47	2.3%
NANTUCKET COUNTY				
Nantucket	9,532	9,369	163	1.7%
Cape & Islands (total)	**147,492**	**143,040**	**4,452**	**3.0%**
PLYMOUTH COUNTY (SELECT MUNICIPALITIES)				
Plymouth	31,612	30,472	1,140	3.6%
Wareham	14,175	13,608	567	4.0%

Source: MA DUA, US DOL, Local Area Unemployment Statistics (LAUS), not adjusted for seasonality. Tables drawn from http://lmi2.detma.org/lmi/lmi_lur_a.asp.

Conversely, during the peak tourist season, from June to September, Barnstable County experienced lower unemployment rates than Massachusetts as a whole. The 2017 labor force data show that the size of the labor force in the county grows and shrinks in response to seasonal demand, from a July peak of 126,272 persons to a February low of 105,480 persons, a 20% difference. Dukes and Nantucket counties experience even larger percentage increases from peak summer rates to their winter low.

Table 2-8 presents labor force and unemployment data by municipality for the Cape and Islands during August 2017. August is historically the month when unemployment rates in the region are the lowest. As the study area encompasses parts of Wareham and Plymouth, labor force and unemployment data are also provided for these towns.

The highest rates of unemployment in August 2017 were reported in the towns of Wareham (4.0%), Bourne (3.9%), and Plymouth (3.6%), each of which was equal or higher than the statewide rate of 3.6%. Unemployment for all the other towns on Cape Cod and the Islands was lower than the statewide rate. Improving transportation mobility on- and off-Cape Cod may increase year-round employment on Cape Cod, reducing the seasonal variability in the unemployment rates.

2.3.5 Journey to Work

This section describes the different methods that commuters in Barnstable County use for getting to work. According to 2010 and 2017 American Community Survey 5-Year Estimates, the largest share of workers in Barnstable County (81.1%) drove alone to work in 2017, a decrease of 0.6% since 2010. The second most common means of traveling to work was by carpool. Taken together, nearly 90% of commuters use private automobiles to

Table 2-9 Mode of Commuter Transportation to Work in Barnstable County (2010-2017)

MODE OF TRANSPORTATION TO WORK	2010	2017
Drove Alone	81.7%	81.1%
Carpool	7.1%	7.2%
Work at Home	5.6%	6.3%
Walk	2.9%	2.5%
Public Transit (excluding taxi cab)	1.2%	1.3%
Other (includes bicycle travel)	1.4%	1.6%

Source: US Census Bureau, 2006-2010 and 2013-2017 American Community Survey 5-year estimates Dataset: ACS 5-year Estimates, 2006-2010 (https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_17_5YR_S0801&prodType=table) and 2013-2017 (https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_17_5YR_S0801&prodType=table)

travel to work, accounting for the most important component of commuter transportation in Barnstable County (Table 2-9).

Crossing the two roadway bridges over the Canal represents an important part of the daily commute for many residents in Barnstable and nearby counties. U.S. Census data from 2010, shown in Table 2-10, indicate that 13,277 of Barnstable County residents (approximately 12% of working residents) crossed the Canal bridges to off-Cape workplaces. These data also show that residents from all 15 Barnstable County towns commuted off-Cape to work, ranging from 3,133 commuters from Bourne to 20 off-Cape commuters from Truro. Not surprisingly, the closer one lives to mainland Massachusetts the more likely one is to work off-Cape. A little less than one-third (32.4%) of all working Bourne residents commute to jobs off Cape (the highest percentage of any town on the Cape), followed by 19.6% of Sandwich workers, 13% of Falmouth workers and 12.9% of Mashpee workers. Note that portions of both Bourne and Sandwich are north of the Cape Cod Canal. Dennis, Eastham, Barnstable follow with 9.1%, 9.1% and 8.8% of resident workers commuting off-Cape, respectively. Outer-Cape towns such as Provincetown, Truro, and Wellfleet had the lowest percentages of commuters who travel to jobs off-Cape. Table 2-10 illustrates the distribution of off-Cape commuting from Barnstable County by town.

Table 2-10 Barnstable County Labor Force Commuting Off-Cape to Work (2010)

		PLACE OF WORK		
TOWN OF RESIDENCE	**ALL WORKERS**	**ON-CAPE**	**OFF-CAPE**	**PERCENT WORKING OFF-CAPE**
Barnstable	24,034	21,922	2,112	8.8%
Bourne	9,675	6,542	3,133	32.4%
Brewster	5,112	4,833	279	5.5%
Chatham	3,120	2,873	247	7.9%
Dennis	7,328	6,663	665	9.1%
Eastham	2,524	2,294	230	9.1%
Falmouth	16,595	14,443	2,152	13%
Harwich	5,743	5,488	255	4.4%
Mashpee	7,382	6,432	950	12.9%
Orleans	2,772	2,597	175	6.3%
Provincetown	1,745	1,665	80	4.6%
Sandwich	10,594	8,520	2,074	19.6%
Truro	1,312	1,292	20	1.5%
Wellfleet	1,460	1,405	55	3.8%
Yarmouth	10,896	10,046	850	7.8%
Barnstable County (Total)	**110,292**	**97,015**	**13,277**	**12%**

Source: US Census Bureau, 2010

Similarly, a substantial number of workers (9,030) travel from mainland Massachusetts to workplaces on Cape Cod. Overall, 22,307 commuters cross one of the Canal bridges twice a day during their work commute.

2.4 PUBLIC HEALTH CONDITIONS

The prevalence of health problems in Barnstable County was determined using data from the Massachusetts Department of Public Health (DPH).

The leading causes of death in Barnstable County mirror those statewide and include heart disease (25.1%), cancer (24.6%), and stroke (5.9%). Health problems include asthma, heart disease, diabetes, and depression. The data highlight factors that increase the risk of health-related problems, such as obesity and smoking. Finally, suicide and opioid overdose data are provided. The data sets vary; some data track Barnstable County only and some describe Cape Cod and the Islands.

Table 2-11 compares mortality and hospitalization rates in Barnstable County and Massachusetts for asthma, heart disease, and diabetes. It demonstrates that the mortality and hospitalization rates in Barnstable County were lower than statewide rates except for the asthma-specific mortality rate, which was the same.

The Department of Public Health's Behavioral Risk Factor Surveillance System (BRFSS) collects data on general health

Table 2-11 Mortality and Hospitalization Rates in Barnstable County

	MORTALITY[1]		HOSPITALIZATION[1]	
	BARNSTABLE COUNTY	MASSACHUSETTS	BARNSTABLE COUNTY	MASSACHUSETTS
Asthma[2]	0.6	0.6	88.5	155.5
Heart Disease[3]	192.1	201.6	1,244.6	1,536.8
Diabetes[4]	11.4	13.2	352.8	488.5

1 Adjusted by age per 100,000 persons to minimize effects of differences in age and population distributions.
2 Mortality rates based on average of 2008-2010 data, hospitalization based inpatient rate from 2007-2009
3 Mortality rates based on average of 2008-2010, hospitalization rates based on 2007-2009
4 Mortality rates based on 2010, hospitalization based on inpatient rate from 2009

Source: Mass Community Health Information Profile from Massachusetts Executive Office of Health and Human Services website (http://www.mass.gov/eohhs/researcher/community-health/masschip).

Table 2-12 Population with Sad, Blue, or Depressed Feelings

	CAPE COD AND THE ISLANDS	MASSACHUSETTS
15+ days of sad, blue, or depressed in the past 30 days among adults	5.1%	7.2%

Source: MassCHIP from Massachusetts Executive Office of Health and Human Services BRFSS Special Reports: General Health Status for Cape and Islands 2002-2007

Table 2-13 Population with Health Risk Factors in Barnstable County

	BARNSTABLE COUNTY	MASSACHUSETTS
Obesity	15.8%	19.4%
Smoking	12.8%	15.0%

Source: MassCHIP from Massachusetts Executive Office of Health and Human Services BRFSS Special Reports: Risk Factors and Health Behaviors for Cape and Islands 2006-2009

Table 2-14 Suicide Rate in Barnstable County

	BARNSTABLE COUNTY	MASSACHUSETTS
Suicide Rate[1]	12.1	8.7

[1] Age-adjusted rate per 100,000 persons

Source: MDPH Bureau of Communicable Diseases, 2014

status and asks respondents to report the number of days that they had felt sad, blue, or depressed in the previous 30 days. Fewer Cape and Island residents reported these feelings for 15 or more days in the previous month than residents statewide (Table 2-12).

The BRFSS also reports health-risk factors in adult populations in Massachusetts including obesity and smoking. Table 2-13 provides a comparison of these health risk factors for Barnstable County and Massachusetts and demonstrates that the rates of these conditions for Barnstable County were less than the average statewide rates.

Table 2-14 shows the increase in opioid-related deaths in Massachusetts from 2000 to 2015 (up more than 360%, from 355 to 1,658), with a particularly sharp rise since 2013. Opioidrelated deaths rose even more dramatically in Barnstable County, which experienced a 450% increase from 2000 to 2015.

Two other health issues of note are suicide and Lyme disease. Table 2-14 shows a substantially higher age-adjusted suicide rate on Cape Cod and the Islands than for the entire state. Additionally, since 2000, Barnstable County's suicide rate has nearly doubled, from 6.2 to 12.1 suicides per 100,000 persons.

Overall, hospitalizations and mortality rates from common health problems in Barnstable County is lower than statewide rates. The percent of health-risk factors is also lower in Barnstable County than it is for the state.

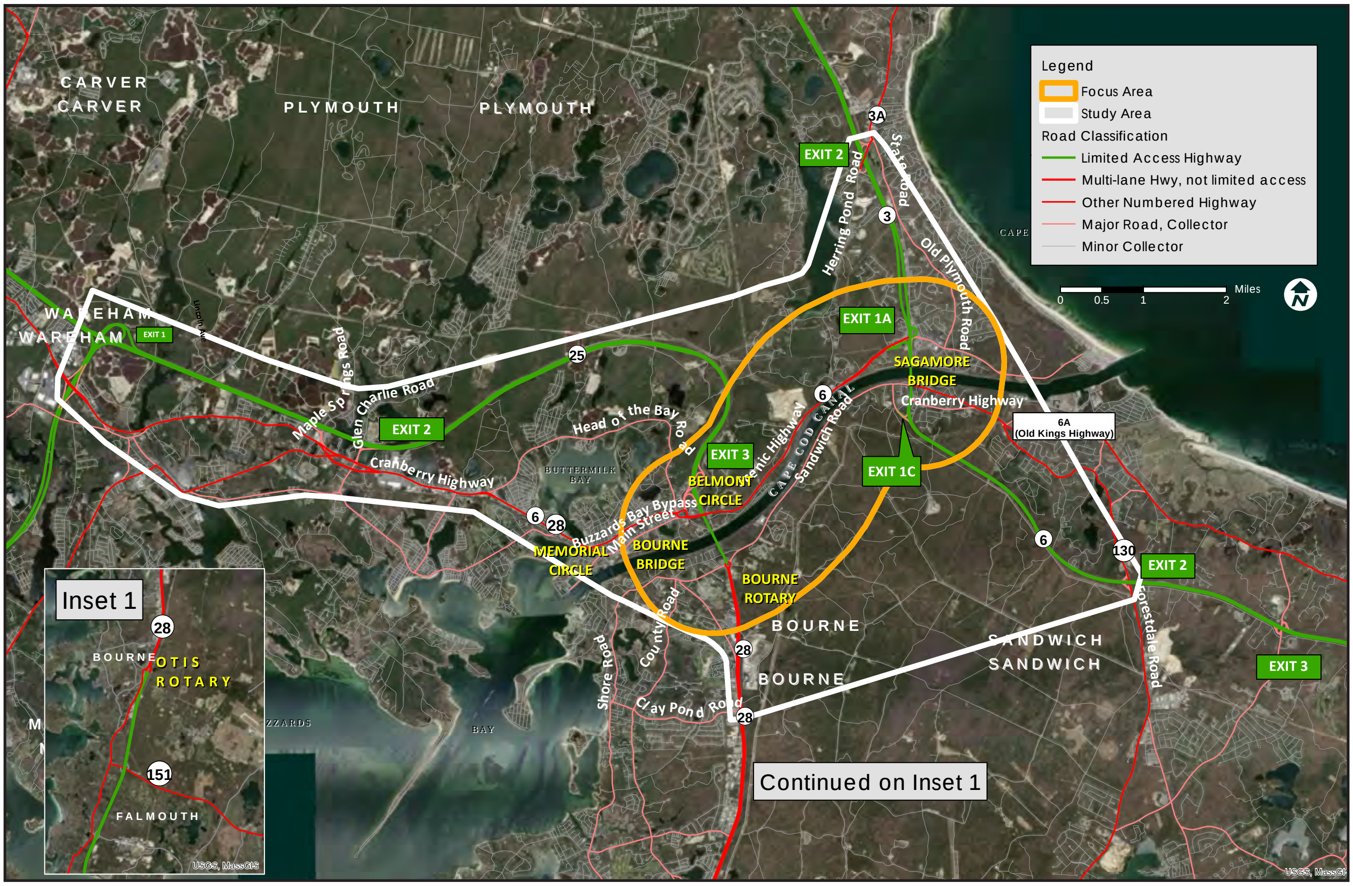


Exhibit 2-17 *Major Roadways in the Study Area*

2.5 TRANSPORTATION CONDITIONS

This section describes existing transportation facilities and traffic conditions in the study area. The major roadways and intersections in the study area are shown on Exhibit 2-17.

(top to bottom)
Sagamore Bridge
Bourne Bridge

2.5.1 Major Highways in the Study Area

Major highway corridors in the study area include the Route 3/ Sagamore Bridge/Route 6 corridor along the eastern side of the study area and the Route 25/Bourne Bridge/Route 28 corridor along the western side. These two bridges provide the only roadway access to Cape Cod (Exhibit 2-17). These highways are all under MassDOT jurisdiction.

Route 6 (Scenic Highway) and Sandwich Road connect these two corridors on the north and south sides of the Canal, respectively.

Route 3/Sagamore Bridge/Route 6 Corridor

Route 3, a principal arterial roadway, provides the main highway connection from Boston and other points north to Cape Cod. From the “Braintree Split” (the I-93/Route 3 Interchange in Braintree) south to the Sagamore Bridge, Route 3 generally has two 12-foot wide travel lanes in each direction with an eight-foot shoulder separated by a grassed median. This configuration continues into the study area from the north at the Route 3/Route 3A Interchange (Exit 2) in Bourne.

Approximately two miles south of the Route 3 Exit 2 at Herring Pond Road interchange, Route 3 passes through the "Sagamore Flyover" (Exit 1A, the interchange of Route 3 with Route 6/Scenic Highway). Approaching this interchange from the north, one of the two travel lanes in Route 3 southbound is dropped to allow travelers from Scenic Highway to merge onto Route 3 at Exit 1A, reinstating the second travel lane. This lane-drop on Route 3 southbound was a required – but less desirable – feature in the design of the 2006 reconstruction of the Sagamore Rotary as a highway interchange because of the need to immediately tie into the two-lane Sagamore Bridge.

South of the Sagamore Rotary the highway designation changes to Route 6 and immediately crosses the Canal on the Sagamore Bridge. The cross section of the Sagamore Bridge includes two 10-foot travel lanes in each direction with no roadway shoulder. A 5-foot wide sidewalk is present on the east side of the bridge. The sidewalk is separated from the roadway by a 12-inch high granite curb.

The roadway geometry in this area, including the dropping of a travel lane on Route 3 southbound and the narrow travel lanes with no roadway shoulder on the Sagamore Bridge, contributes to congestion and delays on Route 3, especially during peak travel periods.

Immediately south of the Sagamore Bridge, Route 6 Exit 1C provides access to Sandwich Road for eastbound travelers via the Mid-Cape Connector and to Cranberry Highway for westbound travelers. The geometry of Route 6 Exit 1C westbound (at Cranberry Highway) is substandard and not in compliance with current MassDOT highway design standards. The deficiencies of Exit 1C include short acceleration and deceleration lanes, and steep grades approaching the Sagamore Bridge. High traffic volumes are common at the Exit 1entrance ramp to Route 6 westbound because travelers often use Route 6A to Cranberry Highway to bypass congestion on Route 6 westbound.

Route 6 eastbound maintains the same roadway cross section as Route 3 (two 12-foot travel lanes in each direction). Route 6 continues southeast for approximately 3.3 miles to the Route 6/Route 130 Interchange in Sandwich, the southeast point of the study area.

Route 25, Wareham

Route 25/Bourne Bridge/Route 28 Corridor

The Route 25/Bourne Bridge/Route 28 corridor provides access to Cape Cod from the south and west. The northwest corner of the study area begins at the I 495/I-195/Route 25 Interchange in Wareham. Route 25, a principal arterial roadway, provides three 12-foot travel lanes with an eight-foot shoulder in each direction separated by a 90 foot grassed median. From the I-495/I-195 Interchange, Route 25 travels southeast 2.4 miles to the partial interchange with Maple Springs Road and another 0.5 miles to the partial interchange at Glen Charlie Road in Wareham. Together, these two interchanges provide access in all directions and are designated as Exit 2.

Route 25 continues south/southeast for six more miles to the Route 25/Route 6 (Scenic Highway) Interchange in Bourne. Belmont Circle, immediately to the west, can be reached through this interchange. At this point the highway designation changes to Route 28, and the highway immediately crosses the Canal on the Bourne Bridge. The cross section of the bridge is substandard, featuring two 10-foot travel lanes in each direction with no roadway shoulder. A five-foot wide sidewalk is present on the west side of the bridge. The sidewalk is separated from the roadway by a 12-inch high granite curb. Continuing south from the bridge is the Bourne Rotary, which handles traffic from several roadways, including Route 28, Sandwich Road, and Trowbridge Road.

Route 28 is a principal arterial roadway. Within the study area, it comprises two 12 foot travel lanes in each direction with a 10-foot shoulder separated by a 70-foot forested median. Route 28 provides at-grade access to roadways to the west and has turn around ramps every 0.5 miles. Route 28 continues south of the Bourne Rotary for approximately 6.75 miles to the southwest corner of the study area at the Route 151 intersection in Bourne.

2.5.2 Local Roadways/Highways and Principal Intersections in the Study Area

The following describes the main local highways/roadways and principal intersections in the study area (Exhibit 2-17).

Scenic Highway (Route 6)

Local Roadways/Highways

Route 6 (Scenic Highway, Buzzards Bay Bypass, Cranberry Highway)

Route 6 (Scenic Highway) is a principal arterial roadway under MassDOT jurisdiction that extends along the north side of the Canal from Route 3 at the Sagamore Interchange and continues to the west approximately 3.5 miles to Belmont Circle in Bourne. Scenic Highway provides a connection between the

Sagamore Bridge and the Bourne Bridge. Traveling west from the Sagamore Bridge for approximately one-mile, the roadway is approximately 84 feet wide consisting of two 12-foot travel lanes in each direction with a 16-foot wide median and 10-foot wide shoulders. No marked bicycles lanes or sidewalks are present. West of Bournedale Road, Scenic Highway narrows to approximately 48 feet wide, consisting of two 11-foot wide travel lanes in each direction with no median. Four-foot-wide shoulders are present on the south side of the roadway. No marked bicycle lanes or sidewalks are present. On the west side of Belmont Circle, Route 6 continues west for approximately one mile as Buzzards Bay Bypass. Traveling west, the bypass has two 11-foot wide westbound travel lanes and a single 11-foot wide eastbound lane. No marked bicycle lanes or sidewalks are present. Prior to the St. Margaret's Street intersection, the roadway shifts to two 11-foot wide travel lanes in each direction to Memorial Circle, where it turns northwest and becomes Cranberry Highway.

Cranberry Highway continues northeast for 2.5 miles, entering Wareham at the Cohasset Narrow Bridge. This portion of Cranberry Highway has a cross section of four 11-foot-wide travel lanes, but it drops to a single lane in each direction for one more mile until it reaches the Route 25 interchange at Glen Charlie Road in Wareham. No marked bicycle lanes or sidewalks are present.

Sandwich Road

Sandwich Road, a principal arterial roadway owned by the Town of Bourne, extends east-west for approximately 4.7 miles, parallel to the south side of the Canal, from the Route 6A/Route 130 intersection to the Sandwich Road/Trowbridge Road/County Road intersection. Sandwich Road is generally 22 to 24 feet wide, consisting of one 11- or 12-foot-wide lane in each direction with little or no shoulder. No marked bicycle lanes or sidewalks are present. Sandwich Road passes underneath Route 6 at the Sagamore Bridge and provides access to Route 6 eastbound via the Mid-Cape Connector in Bourne and Route 3 via Cranberry Highway. At its western end, Sandwich Road provides access to either Routes 25 or 28 via the Bourne Rotary. An unsignalized left-turn lane is provided as one approaches the Upper Cape Cod Regional Technical School from the east, 0.4 miles east of the Bourne Rotary.

Sandwich Road at Technical High School

Route 6A, Sandwich

Route 6A (Old Kings Highway)

Route 6A, a minor arterial, is a municipal roadway owned by the towns of Bourne and Sandwich. Route 6A extends approximately 1.3 miles from the Route 130/Sandwich Road intersection to

Tupper Road in Sandwich at the eastern edge of the study area. Route 6A is generally 22-feet wide, consisting of two 11-foot travel lanes with no shoulder. This section of Route 6A passes through primarily residential areas containing numerous historic structures within the Old Kings Highway Regional Historic District (Exhibit 2-9). While Route 6A is a designated bicycle route, no marked bicycle lanes or roadway shoulders are present. Sidewalks are present along either one or both sides of Route 6A from the Route 130 intersection to Crowell Lane.

Route 130 (Main Street)

Route 130, Sandwich

Route 130 (Main Street), a major collector roadway, is a municipal roadway owned by the town of Sandwich. Route 130 extends approximately 2.9 miles from the Route 6A/Sandwich Road intersection to Route 6 at Exit 2 in Sandwich at the eastern edge of the study area. Route 130 is generally 22-feet wide, consisting of two 11-foot travel lanes with no shoulder. Like Route 6A, this section of Route 130 passes through primarily residential areas containing numerous historic structures within the Old Kings Highway Regional Historic District. Sidewalks are generally present along either one or both sides of Route 130. Other land uses along Route 130 include the Henry Wing School and the Sandwich Landfill.

Route 151

Route 151, Falmouth

Route 151 is a major collector roadway that extends approximately 6.6 miles from the Route 28/Great Neck Road intersection in Mashpee east to the Otis Rotary. Route 151 is owned by the towns of Falmouth and Mashpee. Route 151 is generally 22-feet wide, consisting of two 11-foot travel lanes with a four foot shoulder on both sides of the roadway. Land uses along Route 151 include the Barnstable County Fairgrounds and Mashpee Commons retail center. Sidewalks are not present. A 10 foot wide bike trail runs alongside a portion of the north side of Route 151. The trail extends 0.75 miles from Old Barnstable Road to Job's Fishing Road.

Principal Intersections (Gateway Intersections)

The principal intersections in the study area are Belmont Circle, Bourne Rotary, and Route 6 Exit 1C. Because these intersections lead motorists directly to and from Cape Cod via the Bourne and Sagamore Bridges. For this reason, for this study they are known as the 'Gateway Intersections'. Because each of these gateway intersections suffers from substandard design features and high peak period traffic volumes, they are a main driver of traffic congestion in the study area.

Belmont Circle, Bourne

<u>*Belmont Circle*</u>

Belmont Circle is a rotary north of the Cape Cod Canal immediately west of the Route 25 approach to the Bourne Bridge in Bourne. The roadway approaches to Belmont Circle include Scenic Highway, Main Street, Buzzards Bay Bypass, Head of the Bay Road, and the ramps to Route 25. The entrance ramp to Route 25 eastbound leads directly to the Bourne Bridge. Upon entering the bridge, the roadway designation changes to Route 28 and continues southeast to other Cape Cod destinations in Bourne, Falmouth, Mashpee, and Chatham. Route 28 also provides access to the Massachusetts Steamship Authority's Woods Hole ferry terminal which provides access to the islands of Martha's Vineyard and Nantucket.

East of Belmont Circle, Main Street becomes Scenic Highway at the Nightingale Pond Road intersection. Scenic Highway provides direct access to Route 3 at the Sagamore Interchange, 3.4 miles to the east.

To avoid traffic congestion on Route 25 eastbound while heading toward the Bourne Bridge, travelers often leave Route 25 at Exit 2 (Glen Chen Charlie Road) to access Route 6 eastbound in Wareham towards Main Street and Belmont Circle in Bourne. A strong traveler preference for Main Street eastbound rather than the parallel route of the Buzzards Bay Bypass has been observed. This traffic diversion contributes to additional traffic volumes in Belmont Circle.

The roadway approaches to Belmont Circle generally consist of a single 11 foot lane in each direction. Scenic Highway features two 11-foot lanes in each direction. The rotary itself generally features three 12-foot lanes. The Main Street approach has parking on both sides of the road. No marked bicycle lanes or sidewalks are present.

Several restaurants and retail businesses, including CVS pharmacy, Ocean State Job Lot, the Way-Ho restaurant, and Mobil Gas have driveways directly from the Circle. Traveling west on Main Street from Belmont Circle leads directly to the Bourne business district.

Bourne Rotary, Bourne

<u>*Bourne Rotary*</u>

The Bourne Rotary is immediately south of the Bourne Bridge. The roadway approaches to the Bourne Rotary include Route 28 (on both the north and south sides of the Rotary), Trowbridge Road, and the Bourne Rotary Connector. Sandwich Road provides a roadway connection north of the rotary between Trowbridge Road (via Veterans Way) and the Bourne Rotary Connector.

Sandwich Roads provides a connection to Route 6 (via the Mid Cape Connector) 3.0 miles to the east.

Route 28 north of the Bourne Rotary leads directly to the Bourne Bridge. Upon exiting the bridge, the roadway designation changes to Route 25 and continues northwest to other destination in southeastern Massachusetts and Rhode Island.

The roadway cross section along Route 28 approach from the north includes two 10 foot travel lanes in each direction with no roadway shoulder. A five-foot wide sidewalk exists on the west side of the Bourne Bridge. In 2017, MassDOT extended this sidewalk to the south around the front of the State Police barracks to Veterans Way. Other than this sidewalk at the State Police barracks, no other sidewalks or marked bicycle lanes are present. The cross section of the Route 28 approach from the south consists of two 12 foot travel lanes in each direction with a 10-foot shoulder separated by a 70-foot forested median. The Trowbridge Road approach to the rotary consists of a single 12-foot lane in each direction. Finally, the Bourne Rotary Connector approach to the rotary consists of a single 16-foot lane in each direction.

Route 6 Exit 1C Westbound

Route 6 Exit 1C

Route 6 Exit 1C includes westbound-only exit and entrance ramps to and from Cranberry Highway in Bourne. The highway ramps are immediately south of the Sagamore Bridge. The Christmas Tree Shop retail store is adjacent to the Exit 1C entrance ramp. At approximately 200 feet, these exit- and entrance-ramps are substandard in length. MassDOT Highway Design standards recommend 600-foot exit ramps and 1,000-foot entrance ramps.

The roadway geometry at the Route 6 Exit 1C entrance ramp, including the substandard acceleration lane and steep grades on the Sagamore Bridge approach, contributes to congestion and delays on Route 6 westbound, especially during peak travel periods.

Automatic Traffic Recorders (ATRs) *are pneumatic tubes placed across a roadway that record the number and type of all vehicles that pass over them.*

Turning Movement Counts (TMCs) *are conducted at intersections to determine how many and what types of vehicles approach an intersection and what direction they head to.*

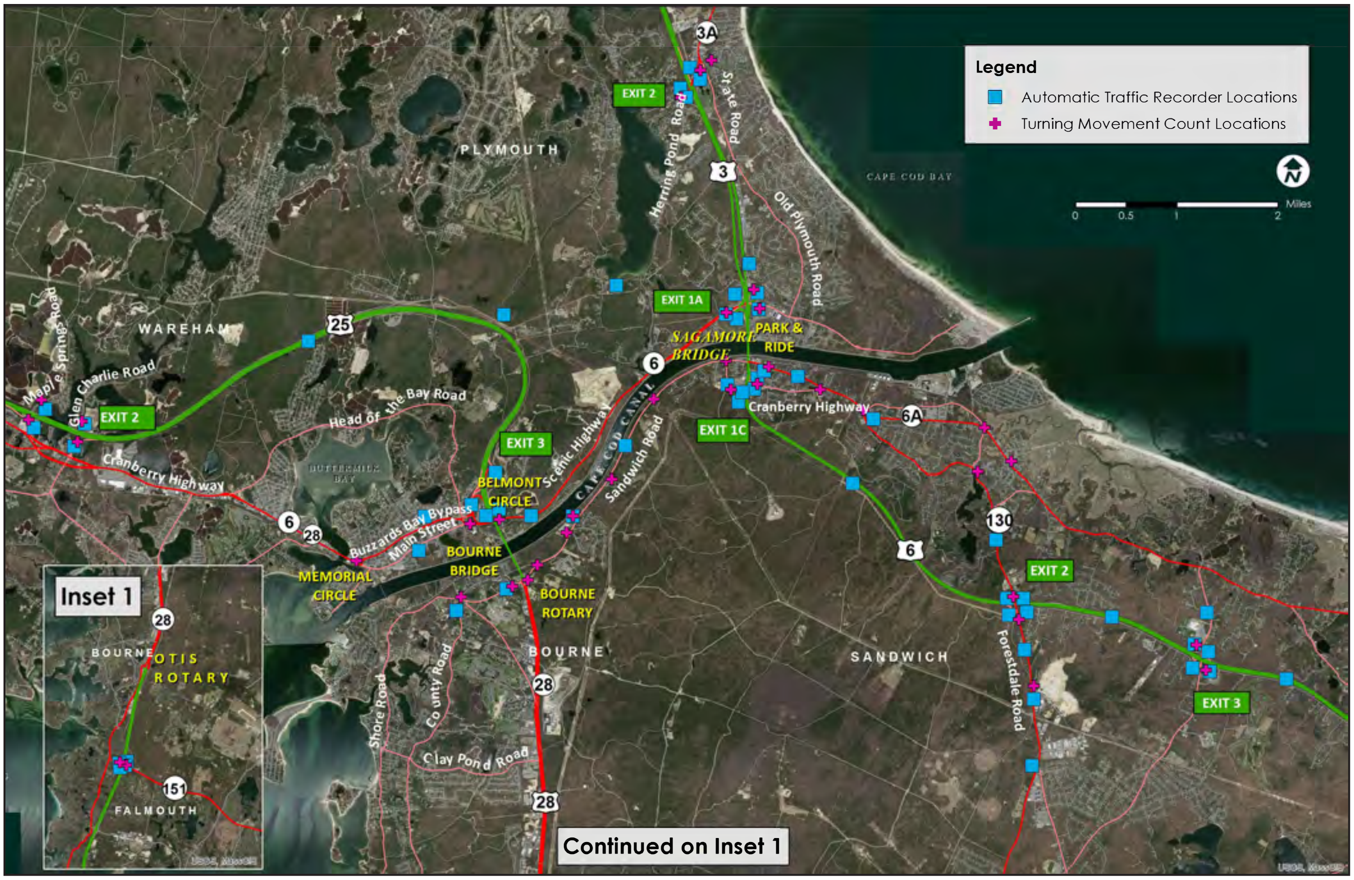


Exhibit 2-18 Location of Automatic Traffic Recorders and Turning Movement Counts

2.5.3 Traffic Counting Methods

The study team collected traffic data in the study area using methods that include Automatic Traffic Recorders (ATRs), Turning Movement Counts (TMCs), and BlueTOAD™ origin-destination study.

Traffic data along highways, local roadways and numerous intersections was collected using a combination of all three methods. Traffic counts were collected using ATRs at 57 locations and conducted TMCs at 37 locations in or close to the study area (Exhibit 2-18). These data identified average daily traffic (ADT), peak-hour volumes, and the turning movements of vehicles in the study area.

Traffic data is presented for two different time periods, the peak period and the peak hour. Traffic data is collected during the peak period, typically a two-hour period. This data is used to identify the one-hour period with the highest traffic volume. The subsequent traffic analysis uses the peak hour traffic volumes to evaluate capacity and Level of Service (LOS).

Automatic Traffic Recorders and Turning Movement Counts

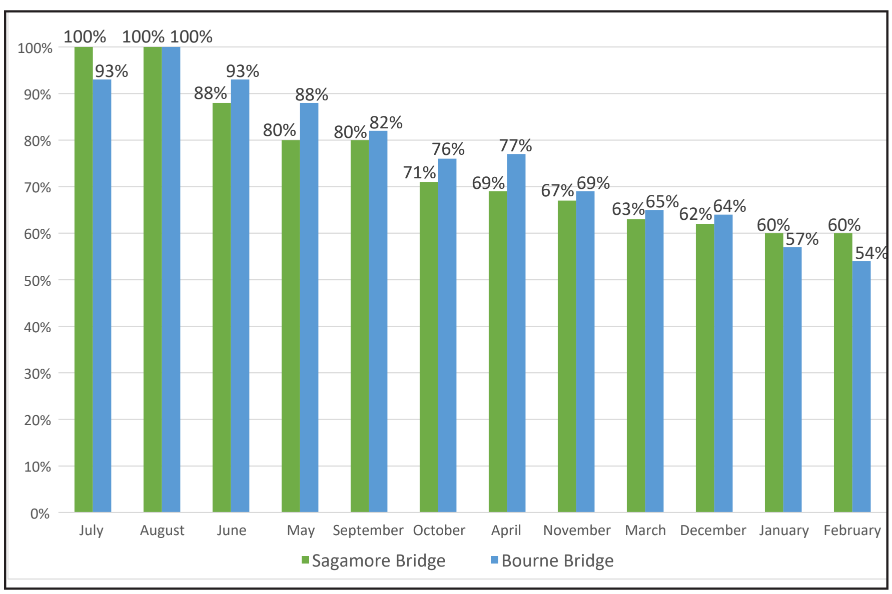
Automatic Traffic Recorders (ATRs) comprise pneumatic tubes laid across a roadway perpendicular to the line of travel. As vehicles pass over the tube, a recording device stores the number of vehicles that pass over during certain time intervals. Turning Movement Counts are important to traffic analysis because they provide the data necessary to analyze delay and queuing at an intersection. These data allow traffic engineers to assign a LOS for that location (as described in Section 2.5.5).

Turning Movement Counts (TMCs) were conducted at roadway intersections, including signalized and stop-controlled intersections, roundabouts, and rotaries. Turning Movement Counts determine how many and what type of vehicles approach an intersection and what direction they head to (left, right, or through). This count is taken for all roadway approaches. The TMCs were conducted by hand counts and they include pedestrian and bicycle traffic.

The study team collected traffic data during a summer period and a non summer period in 2014. The summer period data collection occurred August 10–17 and the non summer collection took place October 19–26, as these months were found to be representative of these periods.

The summer and non-summer collection periods reflect the reality of Cape Cod traffic patterns: as a major summer tourist destination, it has far higher traffic volumes in the summer than in the non-summer periods. For example, as shown on Exhibit 2-19, the average traffic volumes crossing the Canal Bridges during February are only 54% (Bourne Bridge) to 60% (Sagamore Bridge) of the volumes crossing these bridges during August.

Exhibit 2-19 Seasonal Traffic Volumes Differences on Canal Bridges



Traffic data was collected for summer Saturday peak period, a period of high traffic demand because vacation rentals on the Cape generally begin and end on Saturday. Summer Saturdays are a period of high bi-directional volumes with traffic traveling both to and leaving from Cape Cod. Based on the traffic data collected during these two-hour travel periods, the peak one-hour period is identified. The data from this peak hour was used to inform the study's traffic analysis.

The time periods examined were:

- AM summer weekday (7:00 AM – 9:00 AM)
- PM summer weekday (4:00 PM – 6:00 PM)
- Saturday summer (10:00 AM - 12:00 PM)
- AM non-summer weekday (7:00 AM – 9:00 AM)
- PM non-summer weekday (4:00 PM – 6:00 PM)
- Saturday non-summer (10:00 AM - 12:00 PM)

A BlueTOAD™ unit performs detailed origin-destination studies by detecting the unique Bluetooth number of phones, navigation, and other GPS-based devices as they enter and exit a Study Area.

A BlueTOAD™ unit

2.5.4 BlueTOAD™ Origin-Destination Study

The study area presents two sets of unique decision locations not found in most transportation studies. These are the access control represented by the two highway bridge crossings of the Cape Cod Canal and the multiple exit-entrance choices afforded by study area rotaries.

Understanding travel routing in the study area requires an understanding of the travel patterns of vehicles using the roadway network. That emerges from origin-and-destination data collected from vehicles as they enter and exit the roadway. A seven-day origin-destination study was conducted using BlueTOAD™ units and ATRs to gain an understanding of the origins and destinations of traffic in the study area. For example, the BlueTOAD™ study allowed for a better understanding of which roads a vehicle used to travel from Route 25 eastbound in Wareham to Route 6 eastbound in Sandwich.

A BlueTOAD™ unit records the unique Bluetooth number of GPS-enabled devices (cell phones, navigation, and car radios), then records where these devices pass by the BlueTOAD™ units installed throughout the study area. This technology collects information on approximately 10% to 15% of the total traffic

Exhibit 2-20 Location of BlueTOAD™ Units

volume, a level of sampling considered sufficient to estimate origins and destinations for all traffic.

Exhibit 2-20 shows the location of BlueTOAD™ devices throughout the study area for two one-week recording periods: in July 2014 during the peak season and in October 2014 during the non-peak season. Each deployment coincided with ATR data collection. The study team applied the percentages determined by the BlueTOAD™ data to the coinciding traffic counts from ATRs and TMCs, yielding the origins and destinations of all vehicles entering and exiting the study-area roadway network.

2.5.5 Transportation Analysis Methodology

The analyses of study area highway operations primarily used Highway Capacity Manual Software (HCS) and other methodologies based on the Highway Capacity Manual (HCM) to calculate levels of service and other measures of effectiveness of roadway operations for major highways. Synchro™ Version 8 was used to analyze signalized and unsignalized intersection operations and SimTraffic software was used to produce simulations. Belmont Circle, the Bourne Rotary, and other traffic circles in the study area were simulated using VISSIM™ software and analyzed using SIDRA™ 5.1 software. These traffic analysis techniques are accepted by the Federal Highway Administration (FHWA) and state Departments of Transportation nationwide, including MassDOT.

Level of Service (LOS), identified in the Highway Capacity Manual (2016 edition), is a commonly accepted measure of the efficiency for peak-hour traffic operating conditions. Level of Service accounts for such factors as automobile and truck volumes, roadway capacity, speeds, grades, traffic control devices, the progression of vehicular traffic flow along an arterial roadway, roadway types, roadway widths and geometric layouts, as well as anticipated delays. LOS range from A, the optimal free-flow condition, to F, where traffic demands are beyond roadway capacity or create excessive delays (Table 2-15).

Table 2-15 Level of Service (LOS) Criteria[1]

FREEWAY FACILITIES		
LEVEL OF SERVICE	DENSITY (PC/MI/LN)	
A	< 11	
B	> 11 – 18	
C	> 18 – 26	
D	> 26 – 35	
E	> 35 – 45	
F	> 45 or any component v_d/c ratio > 1.00	
SIGNALIZED INTERSECTIONS		
CONTROL DELAY (S/VEH)	LOS BY VOLUME-TO-CAPACITY RATIO[A]	
	<1.0	>1.0
< 10	A	F
> 10 – 20	B	F
> 20 – 35	C	F
> 35 – 55	D	F
> 55 – 80	E	F
> 80	F	F
UNSIGNALIZED INTERSECTIONS		
CONTROL DELAY (S/VEH)	LOS BY VOLUME-TO-CAPACITY RATIO[A]	
	<1.0	>1.0
0-10	A	F
> 10 – 15	B	F
> 15 – 25	C	F
> 25 – 35	D	F
> 35 – 50	E	F
> 50	F	F

Note: For approach-based and intersection-wide assessments, LOS is defined solely by control delay.
Note: The LOS criteria apply to each lane on a given approach and to each approach on the minor street. LOS is not calculated for major-street approaches or for the intersection.

Transportation Research Board, Highway Capacity Manual, Sixth Edition: A Guide for Multimodal Mobility Analysis, 2016

Roadways or intersections operating at LOS F are typically judged 'undesirable'. LOS E has generally become a threshold between acceptable and undesirable traffic operations in urban areas.

Traffic operations are defined by the performance of several components characterized by either uninterrupted flow (highway sections and ramp junctions) or interrupted flow (unsignalized intersections with roadway ramps and arterials or yield-controlled movements at the rotary). In recognition of the distinctly different nature of traffic flow and driver's expectations for these types of traffic facilities, LOS is based on density for highway sections and ramps and average delay at intersections. This concept and the typical characteristics of various components that comprise the roadway network in the study area are explained further in the following paragraphs.

Highway segments or **links** have limited access between interchanges. In these areas, with no ramps, LOS reflects vehicle density per lane, a measure of the spacing between vehicles and the ability of a driver to travel at a desired speed without being delayed by other vehicles on the road. Other measures of effectiveness used to assess operations for links include density in passenger cars per mile per lane (pc/mi/ln) and average passenger car speed in miles per hour.

Ramp junctions are locations where traffic either merges with or diverges from the mainline traffic stream. **Merge movements** occur where vehicles entering the highway from an on-ramp must blend with or merge into the mainline flow. **Diverge movements** occur as a vehicle maneuvers out of the mainline flow and onto an exit ramp. As with links, LOS for merge and diverge sections is a function of the density in the lanes. The main traffic demands are the volumes of merge or diverge traffic and mainline traffic value. A **weave** area occurs as vehicles attempting to enter and where entry and exit points occur close to each other.

VISSIM™ vs. HCM

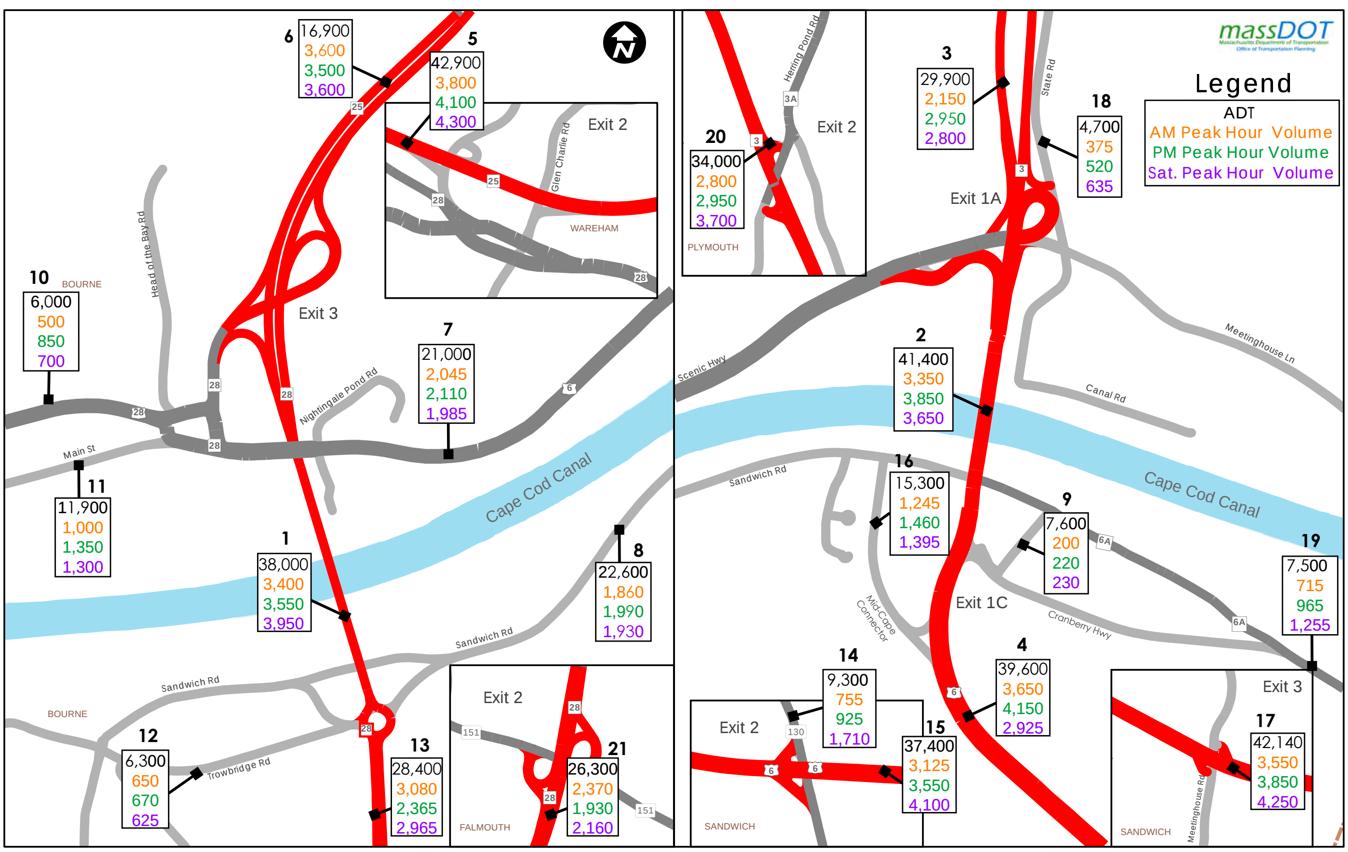
While HCM software determines LOS along highways and at intersections, LOS is not an effective measure of performance at rotaries or other unconventional intersections. To understand how traffic operates in Belmont Circle and the Bourne Rotary (and other rotaries in the study area), VISSIM™ was used to analyze and simulate existing conditions. This highly customizable software can reproduce and predict uncommon roadway conditions more effectively than other industry-standard traffic software.

Therefore, to understand how traffic operates in Belmont Circle and the Bourne Rotary, VISSIM™ software was used to analyze and simulate existing and future conditions. Traffic conditions within these rotaries are described in terms of the VISSIM™ model's output, including queues, vehicle delays, and travel time. The results from the simulation (average delay) are then used to determine LOS based on the criteria in the HCM.

2.5.6 Existing Average Daily Traffic and Peak-Hour Traffic Volumes

Exhibits 2-21 and 2-22 present summer and non-summer Average Daily Traffic (ADT) and the AM, PM, and summer peak-hour traffic volumes at select locations in the study area. Table 2-16 offers a summary of peak-hour traffic volumes for the AM, PM and Saturday periods for both summer and non-summer traffic. The morning peak is 7:00-9:00 AM; the afternoon peak is 4:00-6:00 PM; and the Saturday peak is 10:00 am-12:00 PM.

Exhibit 2-21 Existing Non-Summer Average Daily and Peak Hour Traffic Volumes (AM/PM/Saturday)



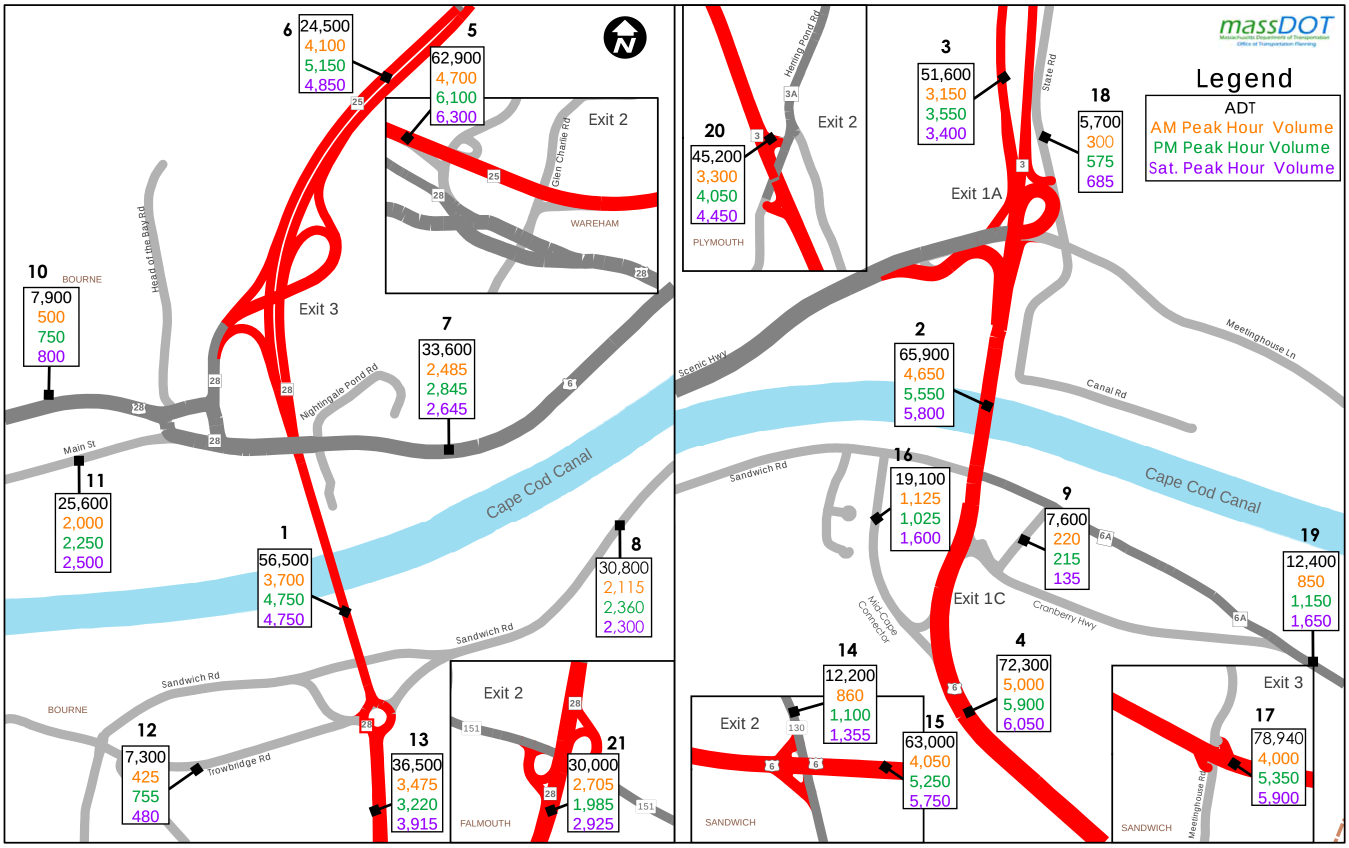


Exhibit 2-22 Existing Summer Average Daily and Peak Hour Traffic Volumes (AM/PM/Saturday)

There are substantial seasonal differences in traffic volumes in the study area because Cape Cod is a major summer tourist destination. For example, daily traffic volumes on the Bourne and Sagamore Bridge are 49% and 59% higher in the summer, respectively, compared to non-summer periods. Daily traffic volumes are 45% higher on Route 25 and 83% higher on Route 6 during the summer (Table 2-17).

Certain count locations were excluded from the table as they were outside of the focus area or did not contribute meaningfully to the study. These locations are:

- Herring Pond Road South of Black Pond Road
- Route 130/Main Street North of Pickerel Cove Road
- Bournedale Road over Route 25
- Route 130 South of Kiahs Way
- Shore Road West of County Road
- Driveway from Cranberry Highway to the Christmas Tree Shop
- Quaker Meeting House Road North of Route 6

Table 2-16 Existing Average Daily Traffic Volumes and Peak Hour Traffic Volumes

		SUMMER 2014				NON-SUMMER 2014			
EXHIBIT LOCATION (2-21 / 2-22)	ATR COUNTING STATIONS	AM	PM	SAT	ADJUSTED ADT[1]	AM	PM	SAT	ADJUSTED ADT[1]
1	Bourne Bridge	3,700	4,750	4,750	56,500	3,400	3,550	3,950	38,000
2	Sagamore Bridge	4,650	5,550	5,800	65,900	3,350	3,850	3,650	41,400
3	Route 3 between Exits 1A and 2	3,150	3,550	3,400	51,600	2,150	2,950	2,800	29,900
4	Route 6 between Exits 1 and 2	5,000	5,900	6,050	72,300	3,650	4,150	2,925	39,600
5	Route 25 West of Exit 2	4,700	6,100	6,300	62,900	3,800	4,100	4,300	42,900
6	Route 25 East of Exit 2	4,100	5,150	4,850	24,500	3,550	3,500	3,600	16,900
7	Route 6 (Scenic Hwy) East of Nightingale Rd	2,485	2,845	2,645	33,600	2,045	2,110	1,985	21,000
8	Sandwich Rd East of Bourne Rotary Connector	2,115	2,360	2,300	30,800	1,860	1,990	1,930	22,600
9	Adams St South of Sandwich Rd	220	215	135	7,600	200	220	230	7,600
10	Buzzards Bay Bypass	500	750	800	7,900	500	850	700	6,000
11	Main St West of Perry Ave	2,000	2,250	2,500	25,600	1,000	1,350	1,300	11,900
12	Trowbridge Rd West of Veterans Way	425	755	480	7,300	650	670	625	6,300
13	Route 28 South of Bourne Rotary	3,475	3,220	3,915	36,500	3,080	2,365	2,965	28,400
14	Route 130 North of Route 6	860	1,100	1,355	12,200	755	925	1,710	9,300
15	Route 6 between Exit 2 and 3	4,050	5,250	5,750	63,000	3,125	3,550	4,100	37,400
16	Mid-Cape Connector South of Sandwich Rd	1,125	1,025	1,600	19,100	1,245	1,460	1,395	15,300
17	Route 6 East of Exit 3	4,000	5,350	5,900	78,940	3,550	3,850	4,250	42,140
18	State Rd North of Ramp to Route 3 NB	300	575	685	5700	375	520	635	4,700
19	Route 6A East of Cranberry Hwy	850	1,150	1,650	12,400	715	965	1,255	7,500
20	Route 3 between Exits 2 and 3	3,300	4,050	4,450	45,200	2,800	2,950	3,700	34,000
21	Route 28 South of Exit 2 (Route 151)	2,705	1,985	2,925	30,000	2,370	1,930	2,160	26,300
22	Route 3 NB Off Ramp to Herring Pond Rd	100	200	100	1,800	100	200	150	1,400
23	Route 3 SB Off Ramp to Herring Pond Rd	250	500	800	4,600	400	450	800	2,100
24	Route 3 SB Off Ramp to Scenic Highway	250	300	300	3,400	350	350	450	3,500
25	Route 6 EB Off Ramp to Mid-Cape Connector	450	600	500	5,900	450	500	250	4,700
26	Route 6 EB Off Ramp to Quaker Meeting House Rd	350	200	200	1,300	100	150	150	1,300
27	Route 6 EB Off Ramp to Route 130	450	250	450	7,000	450	650	400	5,600
28	Route 6 WB Off Ramp to Cranberry Hwy	450	500	450	5,500	450	550	400	2,500
29	Route 6 WB Off Ramp to Meetinghouse Lane EB	300	450	300	4,700	250	350	300	3,300
30	Route 6 WB Off Ramp to Quaker Meeting-house Rd	100	200	200	1,000	200	350	200	2,500

[1] Average Daily Traffic (ADT)

Table 2-16 continues on the next page.

Table 2-16 Existing Average Daily Traffic Volumes and Peak Hour Traffic Volumes

		SUMMER 2014				NON-SUMMER 2014			
EXHIBIT LOCATION (2-21 / 2-22)	ATR COUNTING STATIONS	AM	PM	SAT	ADJUSTED ADT[1]	AM	PM	SAT	ADJUSTED ADT[1]
31	Route 6 WB Off Ramp to Route 130	200	250	300	2,200	250	300	750	2,400
32	Route 6 WB Off Ramp to Scenic Hwy WB	800	1,100	1,000	11,800	700	800	550	7,500
33	Route 25 EB Off Ramp to Belmont Circle	600	750	700	9,000	500	500	400	4,700
34	Route 25 EB Off Ramp to Maple Springs Rd	350	850	1200	7,300	300	650	500	5,100
35	Route 28 NB Off Ramp to Route 151	100	290	185		150	245	200	2,300
36	Route 28 SB Off Ramp to Route 151	355	745	580		400	600	550	5,600
37	Route 130 On Ramp to Route 6 EB	200	200	150	2300	300	200	100	2,000
38	Route 130 On Ramp to Route 6 WB	500	500	300	9,400	550	450	350	4,700
39	Route 130 South of Route 6	1,620	1,900	1,685	24,500	1,655	1,805	1,690	16,900
40	Route 151 On Ramp to Route 28 NB	520	550	565		620	500	600	5,800
41	Route 151 On Ramp to Route 28 SB	245	220	220		280	200	250	2,400
42	Belmont Circle On Ramp to Bourne Bridge	700	700	1,000	8,600	750	700	1,000	7,000
43	Belmont Circle On Ramp to Route 25 WB	1,000	1,050	800	12,100	850	800	850	7,900
44	Bourne Bridge Off Ramp to Belmont Circle	500	700	400	7,200	450	650	600	5,900
45	Scenic Hwy EB On Ramp to Sagamore Bridge	650	750	950	9400	650	550	400	5,400
46	Scenic Hwy WB On Ramp to Sagamore Bridge	285	280	700	3600	275	230	350	2,700
47	Sandwich Rd West of Jillian Drive	1,925	2,295	2,305	31,200	1,845	1,960	1,855	24,300
48	Sandwich Rd East of Adams St	770	1,225	1,430	11,700	1,010	1,220	1,065	8,900
49	Cranberry Hwy On Ramp to Route 6 WB	450	550	800	6,500	400	550	750	5,100
50	Mid Cape Connector On Ramp to Route 6 EB	800	1,000	1,100	12,500	700	800	900	8,400
51	Herring Pond Rd On Ramp to Route 3 NB	350	350	450	4,400	600	300	400	4,000
52	Herring Pond Rd On Ramp to Route 3 SB	350	150	100	2,500	250	150	150	3,800
53	Quaker Meeting House Rd On Ramp to 6 EB	350	200	200	2,700	400	200	200	2,500
54	Quaker Meeting House Rd On Ramp to Route 6 WB	100	100	50	1,000	150	100	100	1,000
55	Glen Charlie Rd On Ramp to Route 25 EB	150	250	250	2,200	350	150	150	1,600
56	Maple Springs Rd On Ramp to Route 25 WB	600	700	700	6,900	600	400	500	4,600

[1] Average Daily Traffic (ADT)

Table 2-17 Comparison of Non-Summer and Summer Daily Traffic Volumes

ATR COUNTING STATIONS	ADJUSTED ADT[1]		PERCENT INCREASE
	NON-SUMMER	SUMMER	
Bourne Bridge	38,000	56,500	49
Sagamore Bridge	41,400	65,900	59
Route 3 between Exits 1A and 2	29,900	46,500	56
Route 6 Between Exits 1 and 2	39,600	72,300	83
Route 25 west of Exit 2	42,900	62,900	47
Route 25 east of Exit 2	16,900	24,500	45
Route 6A East of Tupper Road	7,500	12,400	65
Route 6 (Scenic Hwy) east of Nightingale Rd	21,000	33,600	60
Sandwich Rd East of Bourne Rotary Connector	22,600	30,800	36
Main Street, Bourne West of Perry Avenue	11,900	25,600	115

[1] Average Daily Traffic (ADT)

2.5.7 Existing (2014) Turning Movements

Turning movement counts (TMC) quantify the movement of vehicles traveling through intersections, including signalized, stop-controlled, and rotaries. TMCs are important to traffic analysis because they provide the data necessary to analyze delay and queuing at an intersection. These data allow for the assignment of LOS for that location. Exhibits 2-23 to 2-28 present vehicle turning movements at intersections in the study area for the various summer and non-summer peak periods. Individual results are provided for the AM, PM, and Saturday peak periods. Certain TMC locations were excluded as they were outside of the focus area or did not contribute meaningfully to the study.

Text continues on page 2-55.

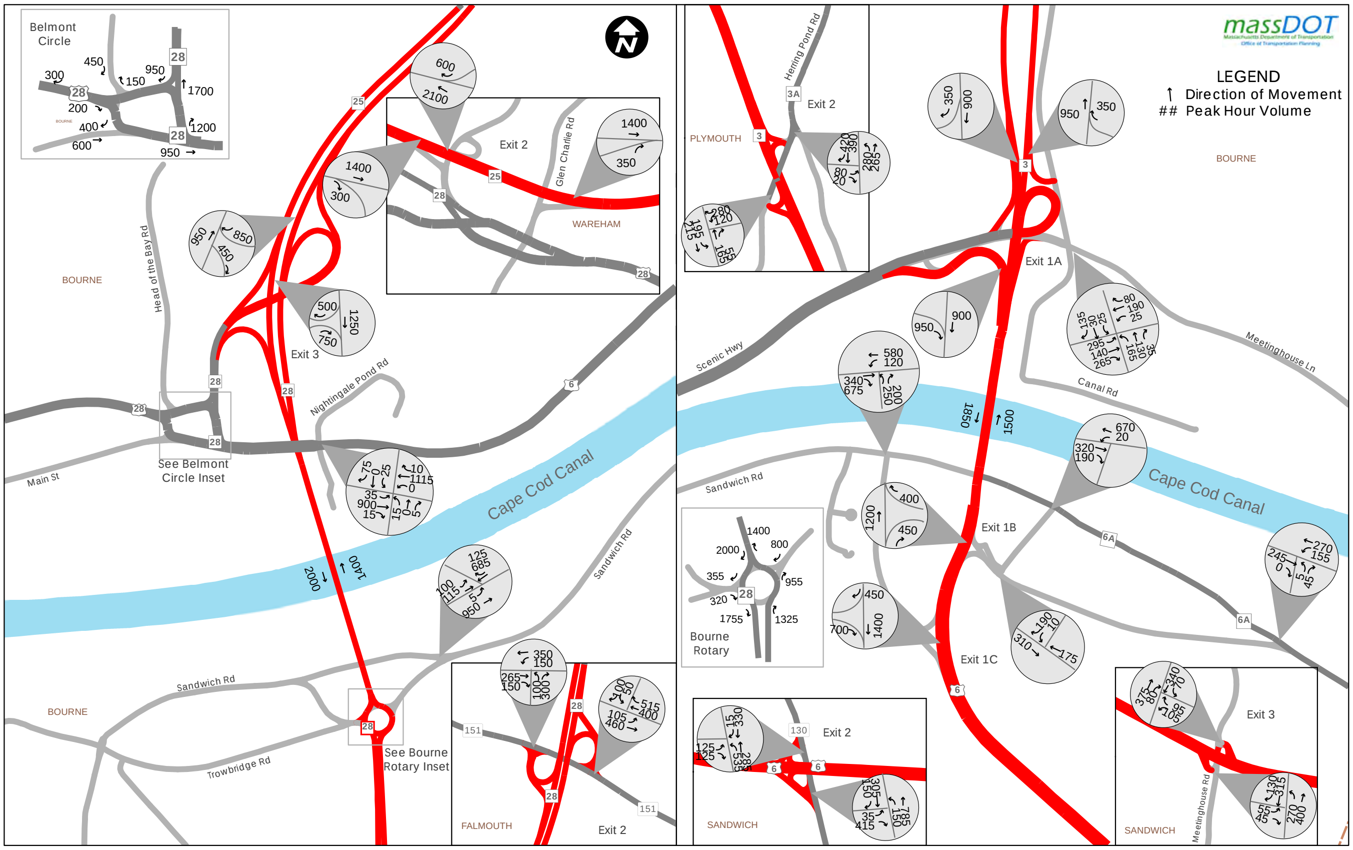
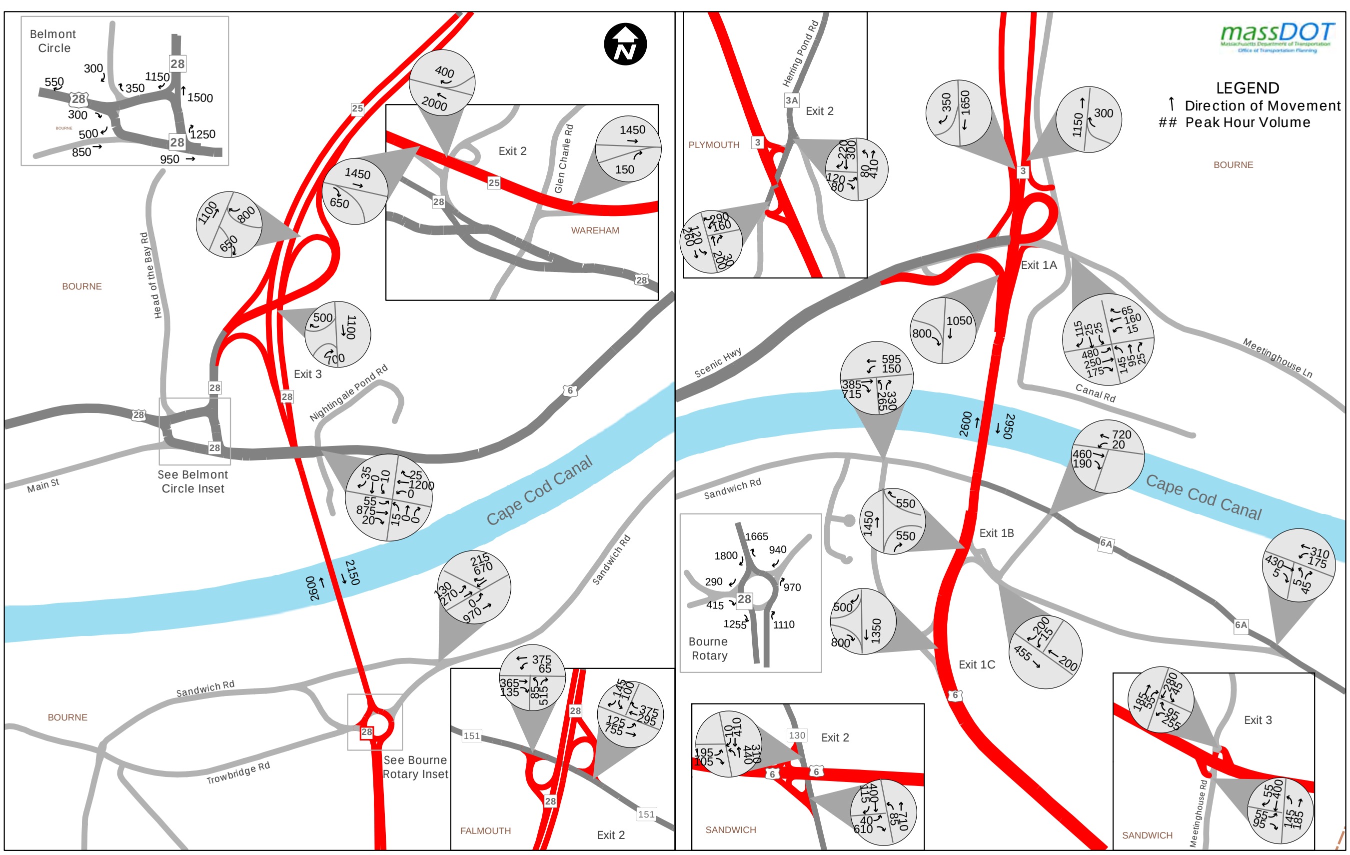


Exhibit 2-23 Existing Non-Summer AM Turning Movements

Exhibit 2-24 Existing Non-Summer Weekday PM Turning Movements



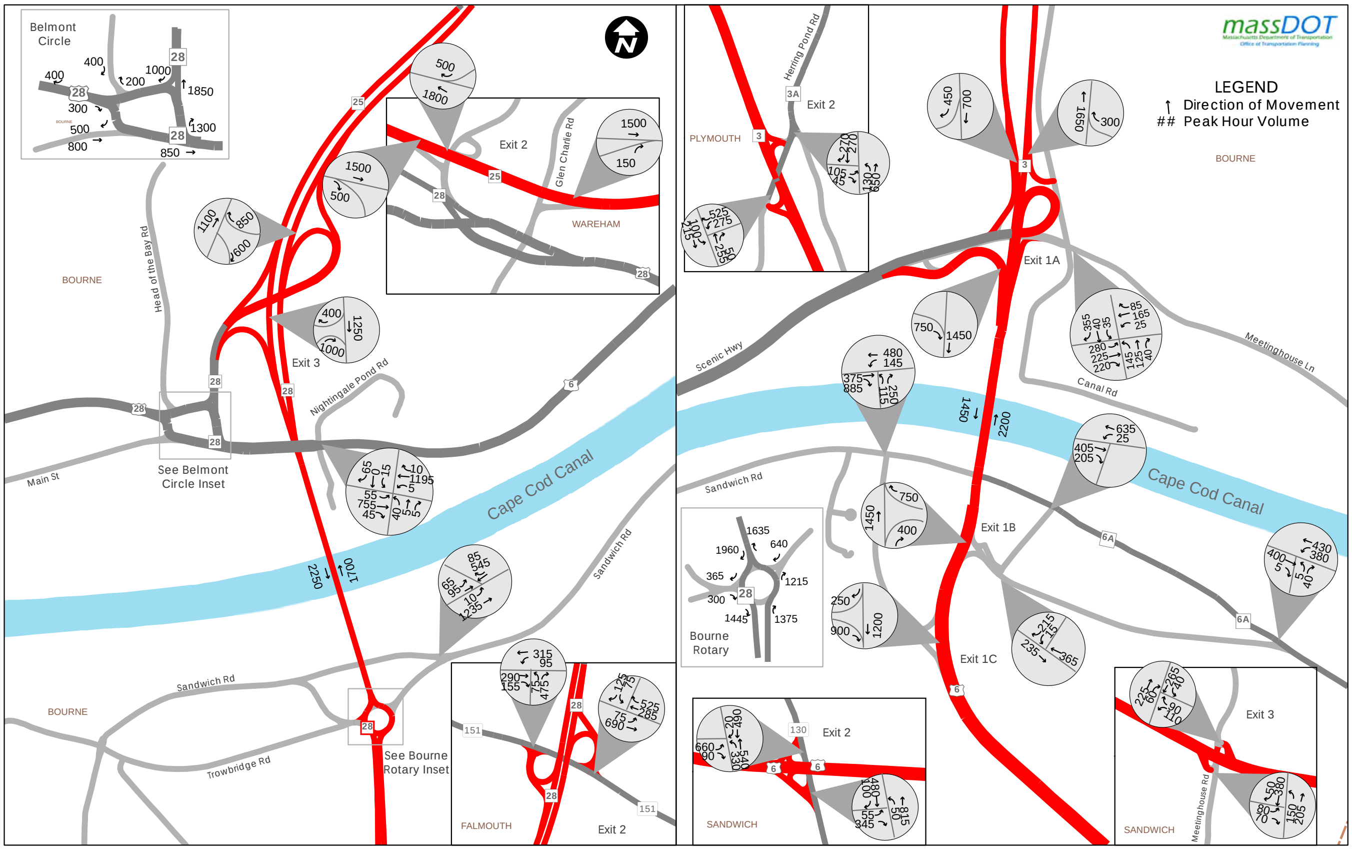
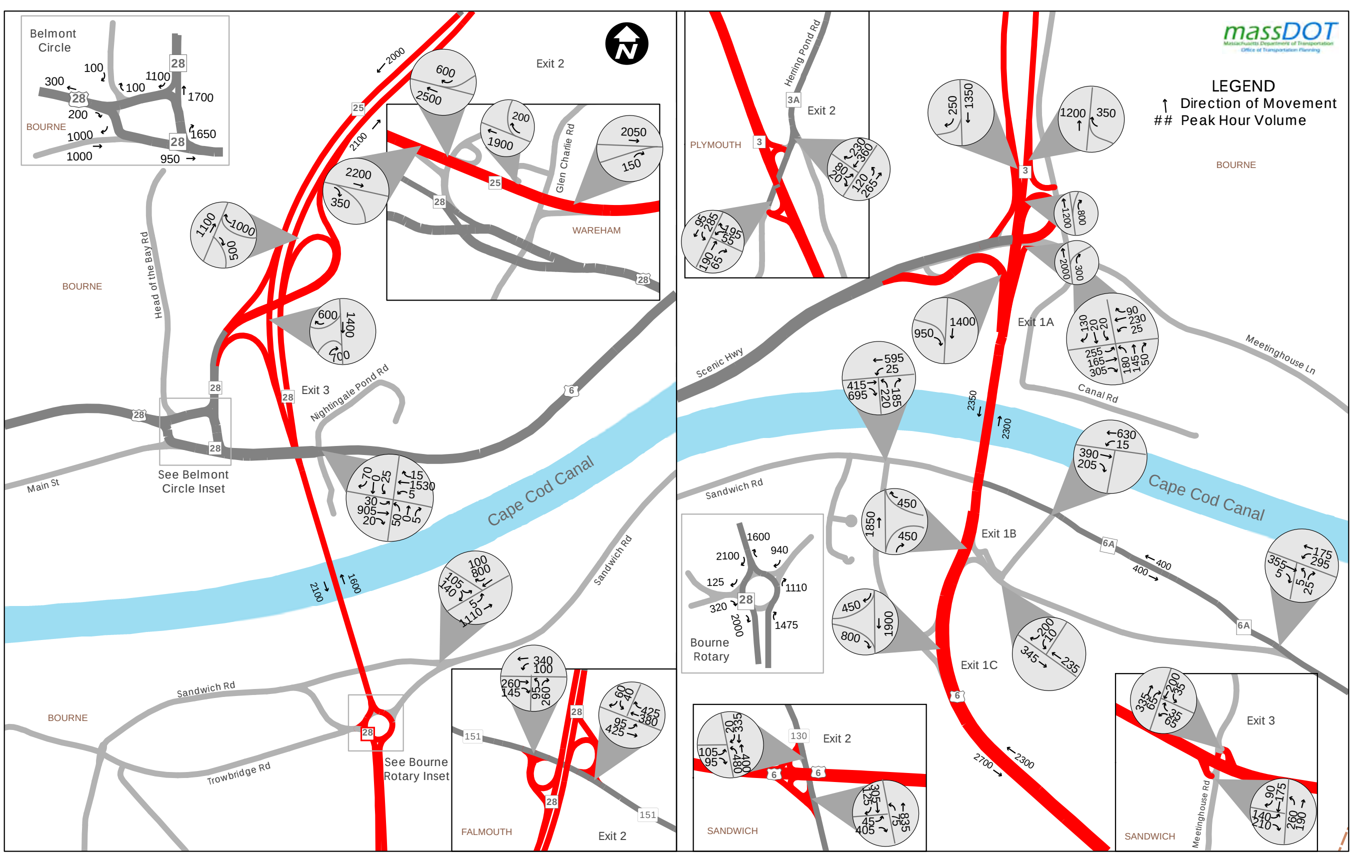


Exhibit 2-26 Existing Non-Summer Saturday Turning Movements

Exhibit 2-25 Existing Summer Weekday AM Turning Movements



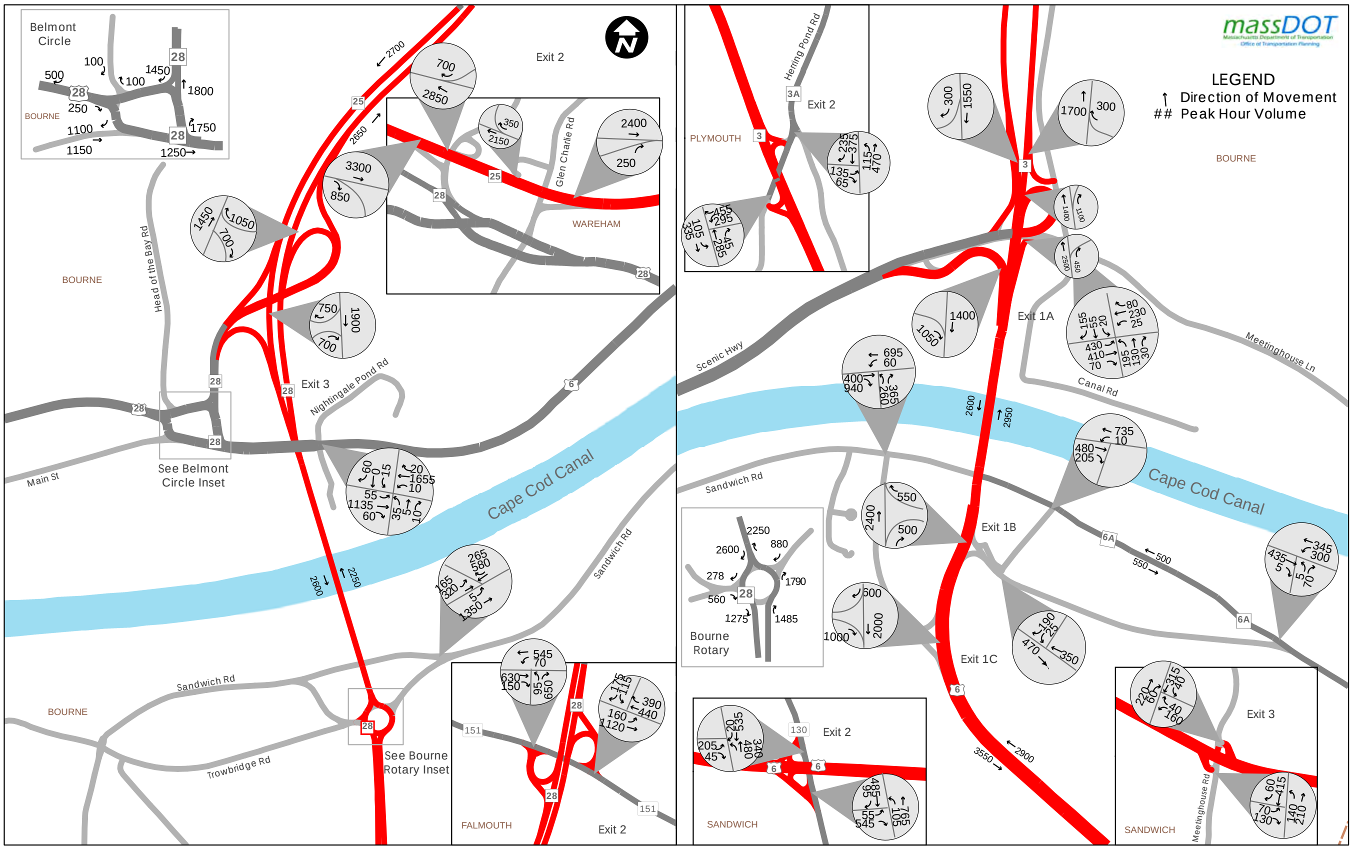
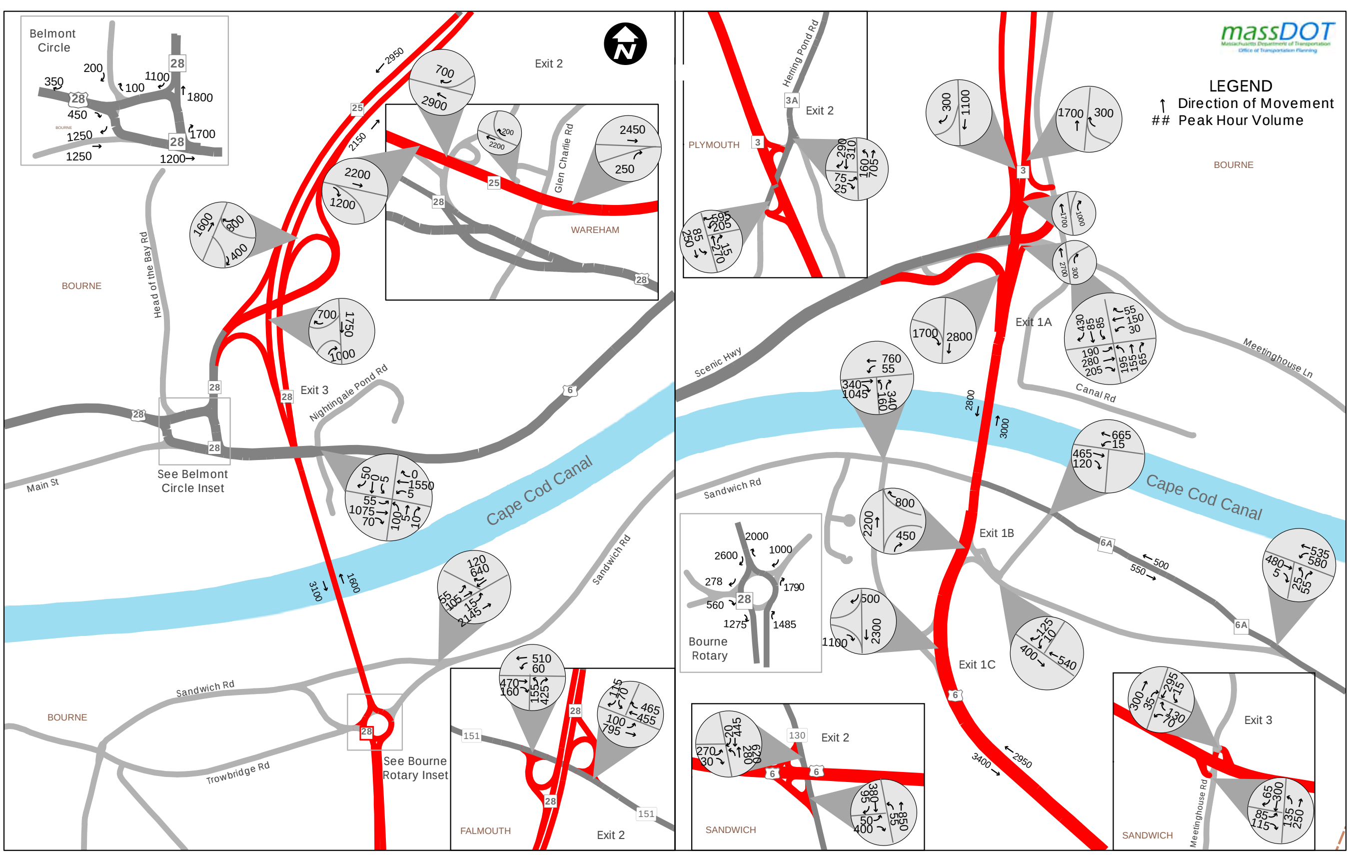


Exhibit 2-27 Existing Summer Weekday PM Turning Movements

Exhibit 2-28 Existing Summer Saturday Turning Movements



2.5.8 Existing (2014) Peak-Hour Levels of Service

Based on the traffic volume counts, peak-hour LOS was analyzed at 50 locations throughout the study area, including six signalized intersections, 15 unsignalized intersections, two rotaries, seven highway links, and 20 highway ramps for the AM and PM weekday peak-periods as well as Saturday mid-day peak hour.

All signalized and stop-controlled intersections were analyzed using Synchro™ Version 8 software and simulated using SimTraffic software. Freeway operations, such as merge, diverge, weave and link analysis were calculated using Highway Capacity Software (HCS) 2010. Finally, Belmont Circle and the Bourne Rotary were simulated using VISSIM™ software and analyzed using SIDRA™ Version 5.1. SIDRA™ provides the overall LOS for the rotaries and traffic circles. The results of this analysis are shown in Tables 2-18 and 2-19. Exhibits 2-29 and 2-30 (freeways) and Exhibits 2-31 through 2-36 (intersections) present the results graphically.

Text continues on page 2-62.

Table 2-18 Existing Levels of Service for Freeway Sections

	SUMMER AM	NON-SUMMER AM	SUMMER PM	NON-SUMMER PM	SUMMER WEEKEND	NON-SUMMER WEEKEND
HIGHWAY LINKS						
Bourne Bridge (NB)	B	B	C	B	C	B
Bourne Bridge (SB)	C	C	C	B	C	C
Route 25 East Of Exit 2 (EB)	A	A	B	A	B	A
Route 25 East Of Exit 2 (WB)	B	A	B	A	B	A
Route 25 West Of Exit 2 (EB)	B	A	B	A	B	A
Route 25 West Of Exit 2 (WB)	B	A	B	A	B	B
Route 3 Between Exits 1A and 2 (NB)	B	A	B	A	B	B
Route 3 Between Exits 1A and 2 (SB)	B	A	B	B	B	A
Route 6 EB Between Exits 1 & 2 (EB)	C	C	D	C	D	C
Route 6 WB Between Exits 1 & 2 (WB)	C	B	D	C	C	B
Sagamore Bridge (NB)	C	B	D	C	D	B
Sagamore Bridge (SB)	C	B	C	B	C	B
HIGHWAY ON-RAMPS						
Belmont Circle to Route 25 WB	B	B	B	B	B	B
Cranberry Highway to Rte. 6 WB (Exit 1C)	C	B	D	B	D	C
Route 130 to Route 6 EB	C	B	C	B	D	B
Glen Charlie to Rte. 25 EB	B	A	B	A	B	A

Notes:
LOS E or LOS F locations are **bold**

Table 2-18 continues on the next page.

Table 2-18 Existing Levels of Service for Freeway Sections

	SUMMER AM	NON-SUMMER AM	SUMMER PM	NON-SUMMER PM	SUMMER WEEKEND	NON-SUMMER WEEKEND
HIGHWAY ON-RAMPS (CONTINUED)						
Route 130 to Rte. 6 WB	C	B	D	B	C	B
Quaker Meeting House Road to Route 6 EB	C	C	C	B	D	B
Herring Pond Road to Route 3 NB	B	B	B	B	C	B
Herring Pond Road to Route 3 SB	B	B	B	B	B	B
Mid Cape Connector to Route 6 EB	C	C	D	C	D	C
Quaker Meeting House Road to Route 6 WB	C	B	C	B	C	C
Scenic Hwy to Route 6 EB/ Bridge	C	B	C	B	C	B
Belmont Circle to Route 25 (Bourne Bridge)	C	C	C	B	C	C
HIGHWAY OFF-RAMPS						
Route 25 EB to Maple Springs Road	B	B	C	B	C	B
Route 6 EB to Route 130	D	C	D	C	**E**	C
Route 6 WB to Route 130	C	B	D	B	D	C
Route 6 EB to Mid-Cape Connector	C	B	C	B	D	B
Route 6 EB to Quaker Meeting House Road	C	C	C	B	D	B
Route 6 WB to Quaker Meetinghouse Road	C	B	D	C	D	C
Route 6 WB (Exit 1) to Cranberry Hwy	C	B	D	C	D	C
Route 25 EB to Belmont Circle	B	B	B	A	B	A
Route 3 NB to Herring Pond Road	B	A	B	B	B	B
Route 3 SB to Herring Pond Road	B	B	C	B	C	B
Bourne Bridge to Belmont Circle	A	A	B	B	B	B
Route 3 SB to Scenic Highway	B	B	B	B	B	B
Route 6 WB (Sagamore Bridge NB) to 6 WB/ Scenic Hwy	C	B	C	B	D	C
Route 6 WB (Sagamore Bridge NB) to Meeting House Road	C	B	D	C	D	C

Notes:
LOS E or LOS F locations are **bold**

Table 2-19 Existing Levels of Service at Selected Intersections

	SUMMER AM	NON-SUMMER AM	SUMMER PM	NON-SUMMER PM	SUMMER WEEKEND	NON-SUMMER WEEKEND
SIGNALIZED INTERSECTIONS						
Route 130 (Main St) at Tupper Rd	B	D	D	C	**E**	**E**
Scenic Hwy at Church Lane	B	C	B	C	C	D
Meetinghouse Lane, State Rd, and Canal Rd	C	C	**F**	D	C	F
Scenic Highway at Nightingale Pond Rd/Andy Olivia Dr	A	A	A	A	B	A
Route 6 EB Off Ramp (Exit 2) at Route 130	B	B	B	A	B	A
UNSIGNALIZED INTERSECTIONS						
Sandwich Rd at Bourne Rotary Connector	**F**	**F**	**F**	**F**	**F**	**F**
Sandwich Rd at High School Drive	**F**	**F**	**F**	**F**	**F**	**F**
Sandwich Rd at Harbor Lights Rd	**F**	**E**	**F**	**F**	**F**	**F**
Sandwich Rd at Jarvis Drive	C	**F**	A	**E**	B	C
County Road, Sandwich Road, and Trowbridge Road	C	C	F	**E**	C	C
Route 28 NB Off-ramp at Route 151	C	D	**F**	**E**	**E**	C
Route 28 SB Off-ramp at Route 151	C	D	**F**	D	**F**	C
Sandwich Rd, Cranberry Hwy, and Regency Drive	E	C	**F**	**E**	**F**	C
Old Kings Hwy at Main Street	B	B	C	C	D	B
Route 6A at Main Street	A	A	A	A	A	A
Maple Springs Rd at Route 25 EB	B	A	D	B	F	B
Route 130 at Cotuit Rd	**F**	**E**	**F**	**F**	**F**	**F**
Herring Pond Rd at State Rd	D	**E**	**F**	**F**	**F**	**F**
Belmont Circle	**F**	**F**	**F**	**F**	**F**	**F**
Bourne Rotary	**F**	**F**	**F**	**F**	**F**	**F**
Route 6 EB Off Ramp (Exit 3) Quaker Meeting House Rd	D	**E**	D	D	D	C
Route 3 SB Off Ramp at Exit 2/Herring Pond Rd	D	D	**F**	D	**E**	D

Notes:
LOS E or LOS F locations are **bold**

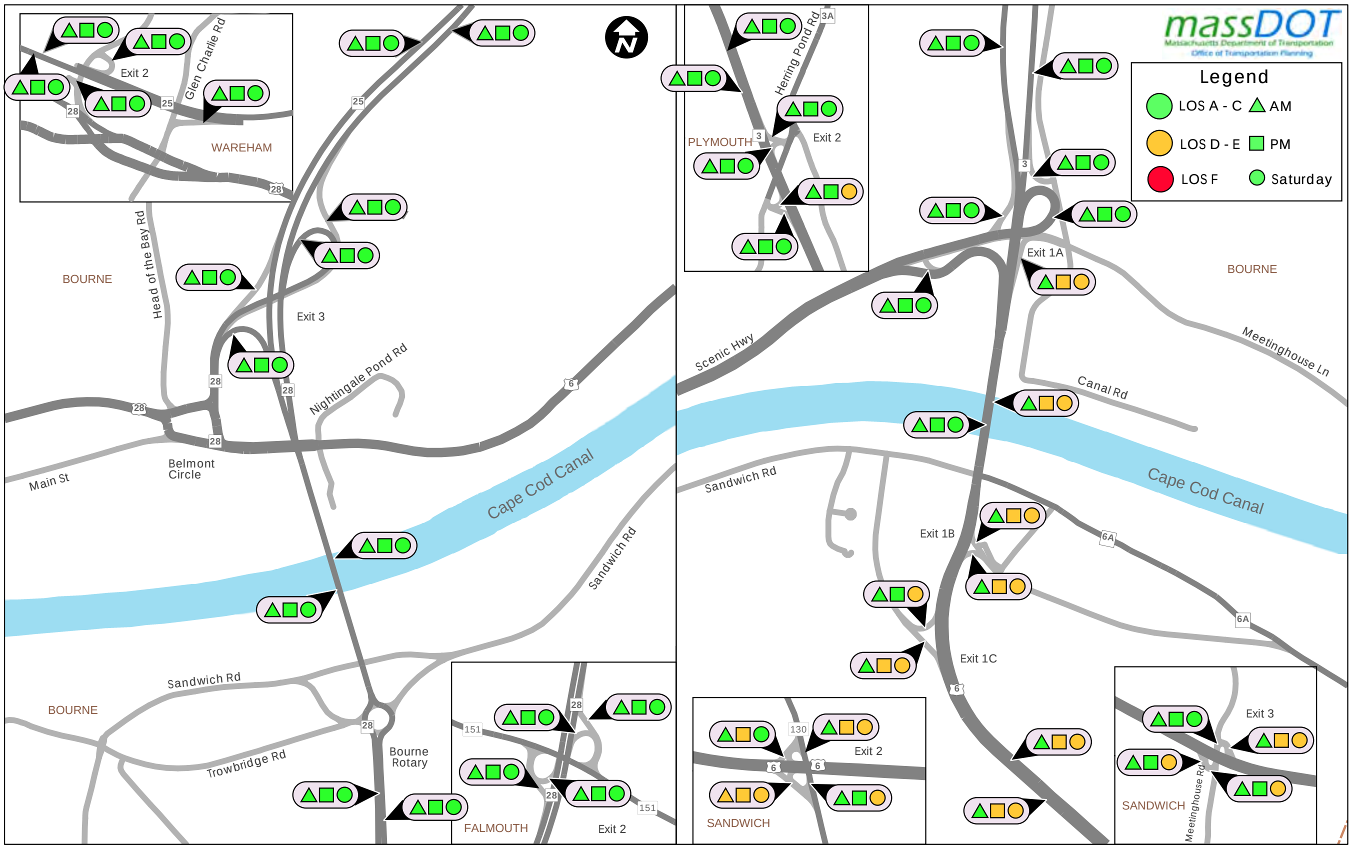
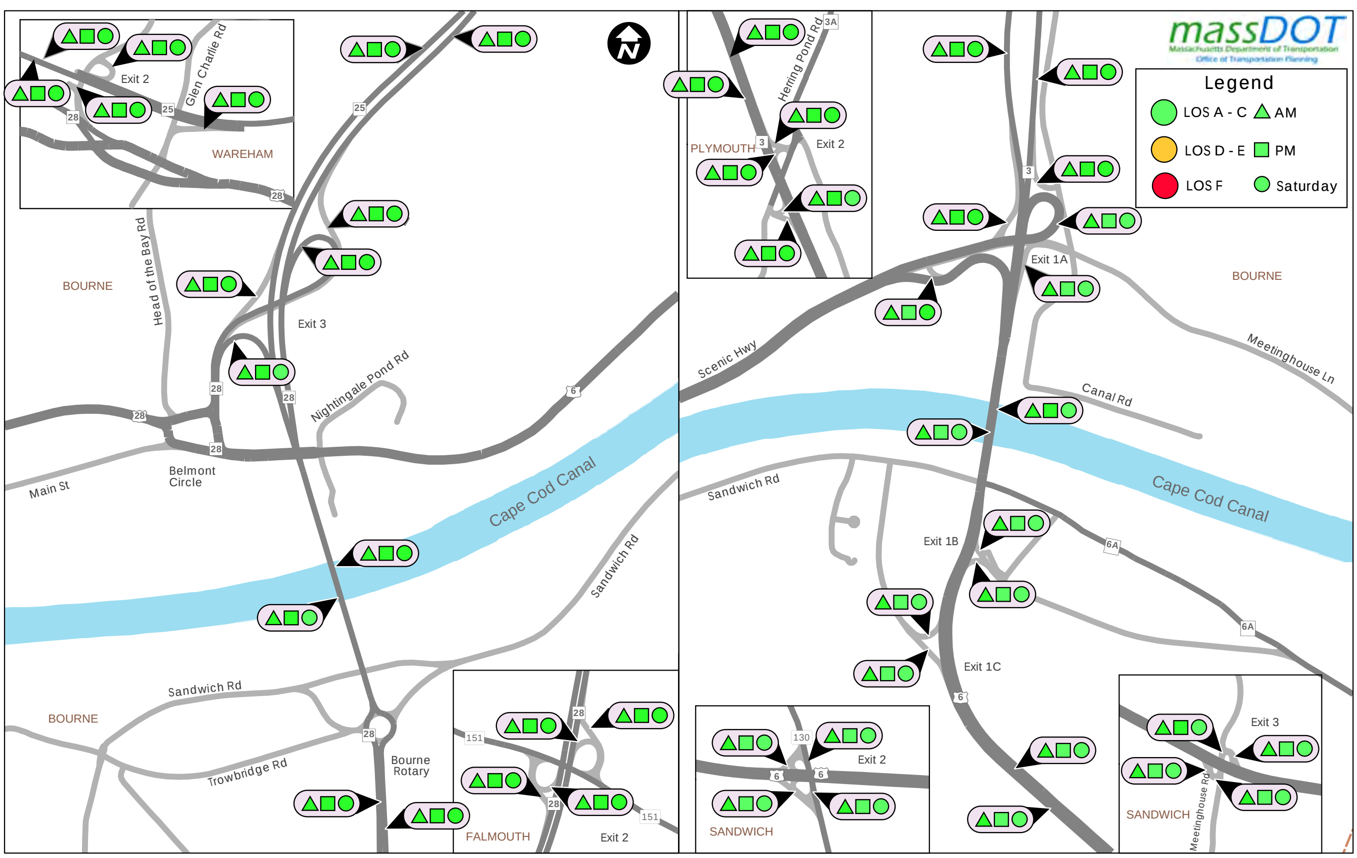


Exhibit 2-29 Existing Non-Summer Levels of Service - AM/PM/Saturday Peak Hour (Freeway)

Exhibit 2-30 Existing Summer Levels of Service - AM/PM/Saturday Peak Hour (Freeway)



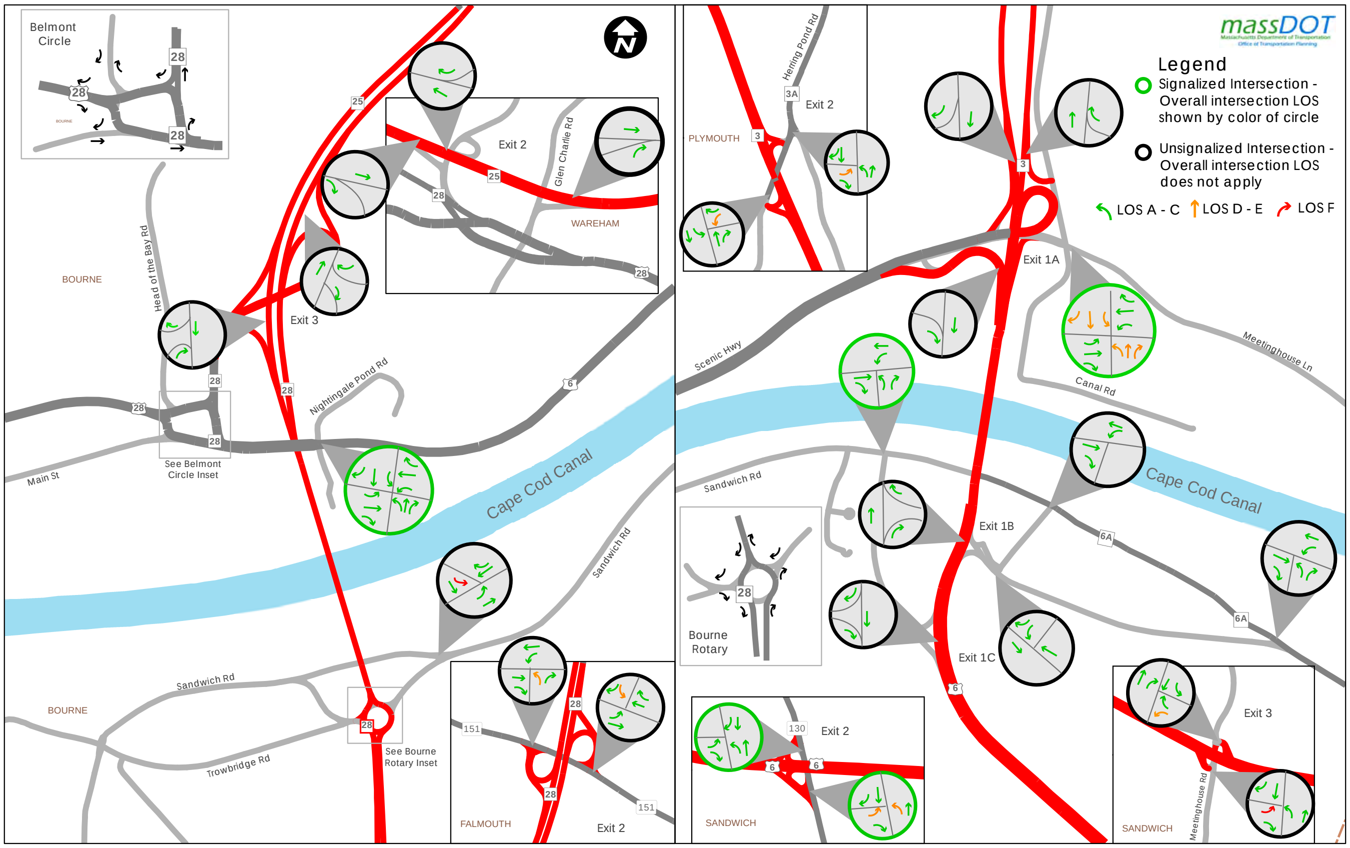
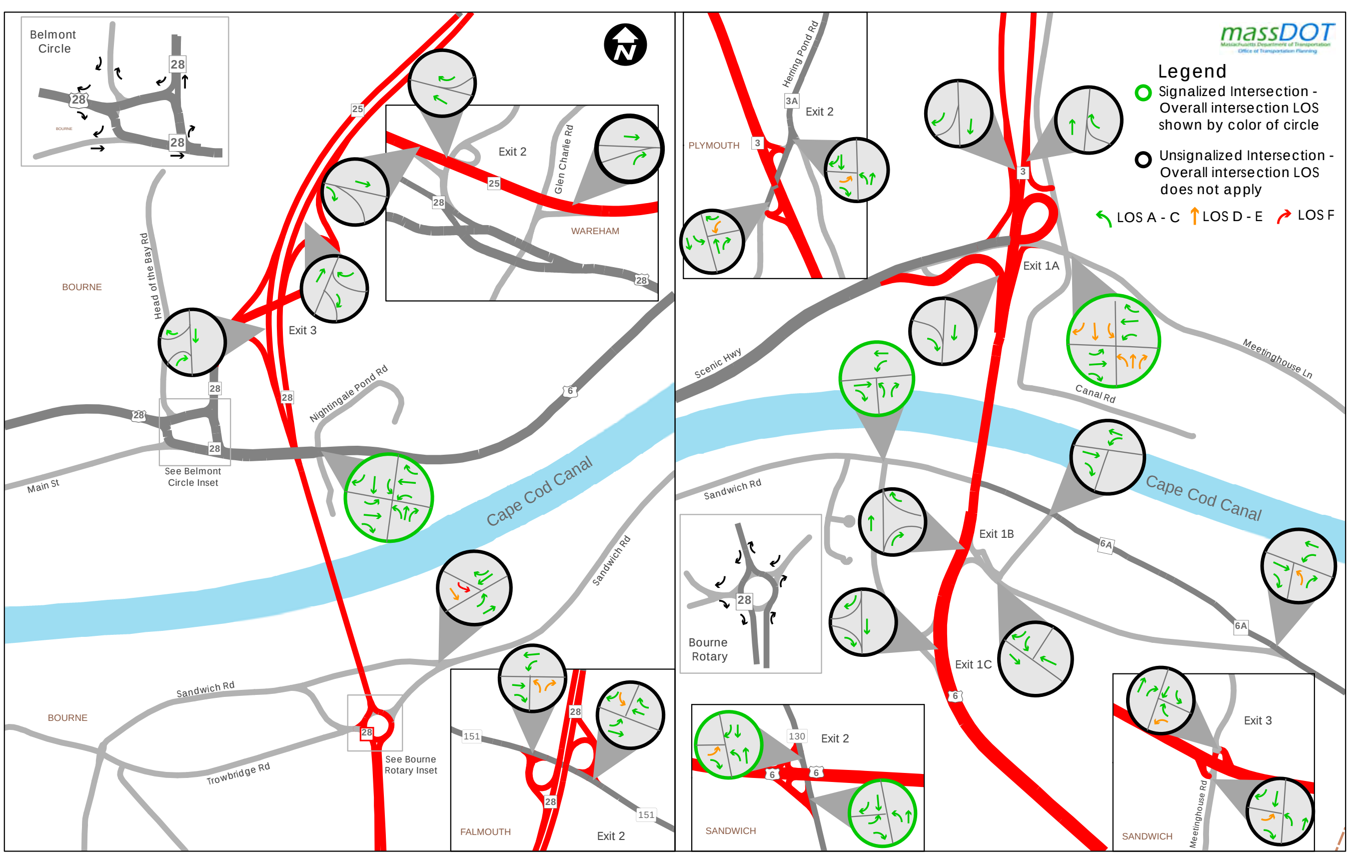


Exhibit 2-31 Existing Non-Summer Weekday AM Levels of Service (Intersections)

Exhibit 2-32 Existing Non-Summer Weekday PM Levels of Service (Intersections)



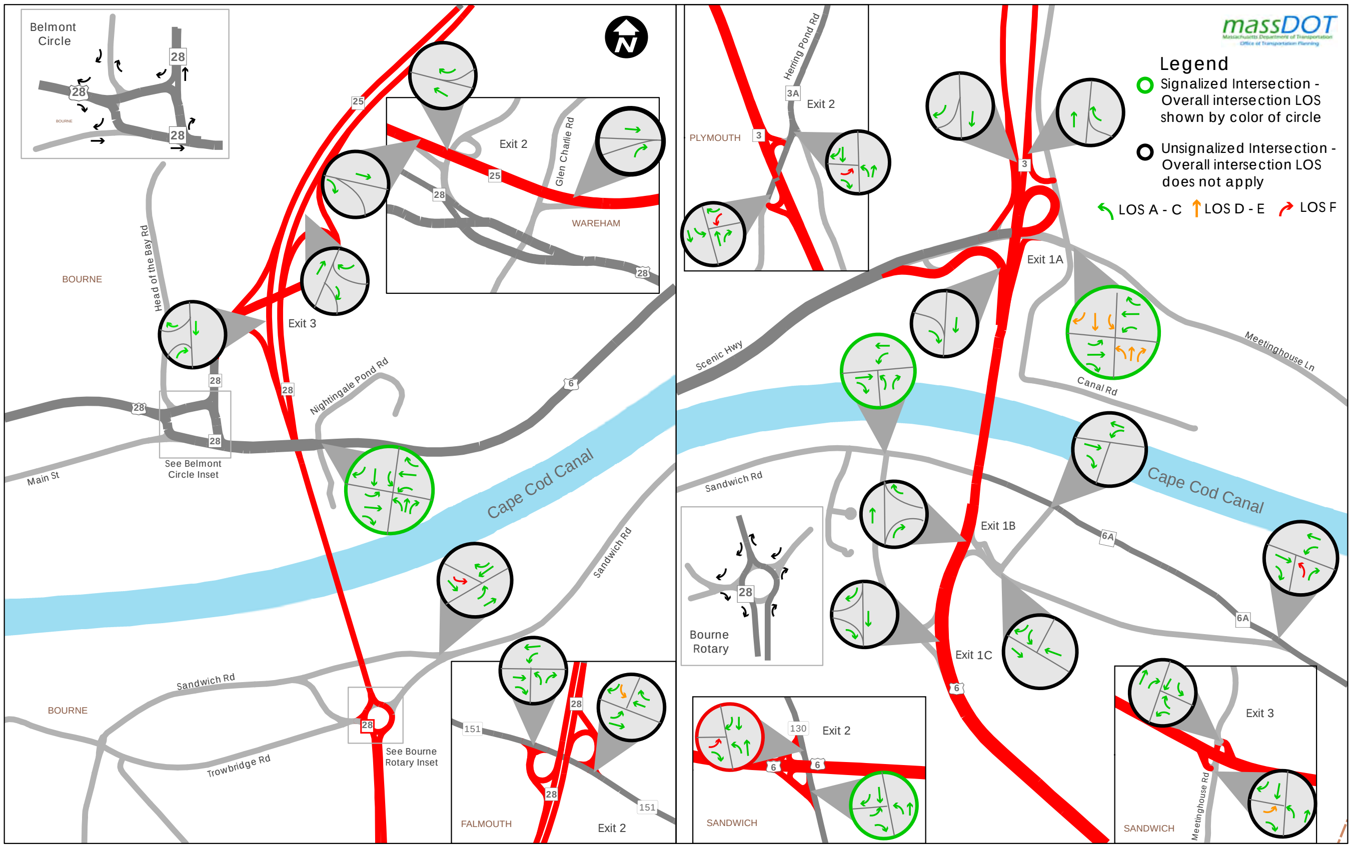
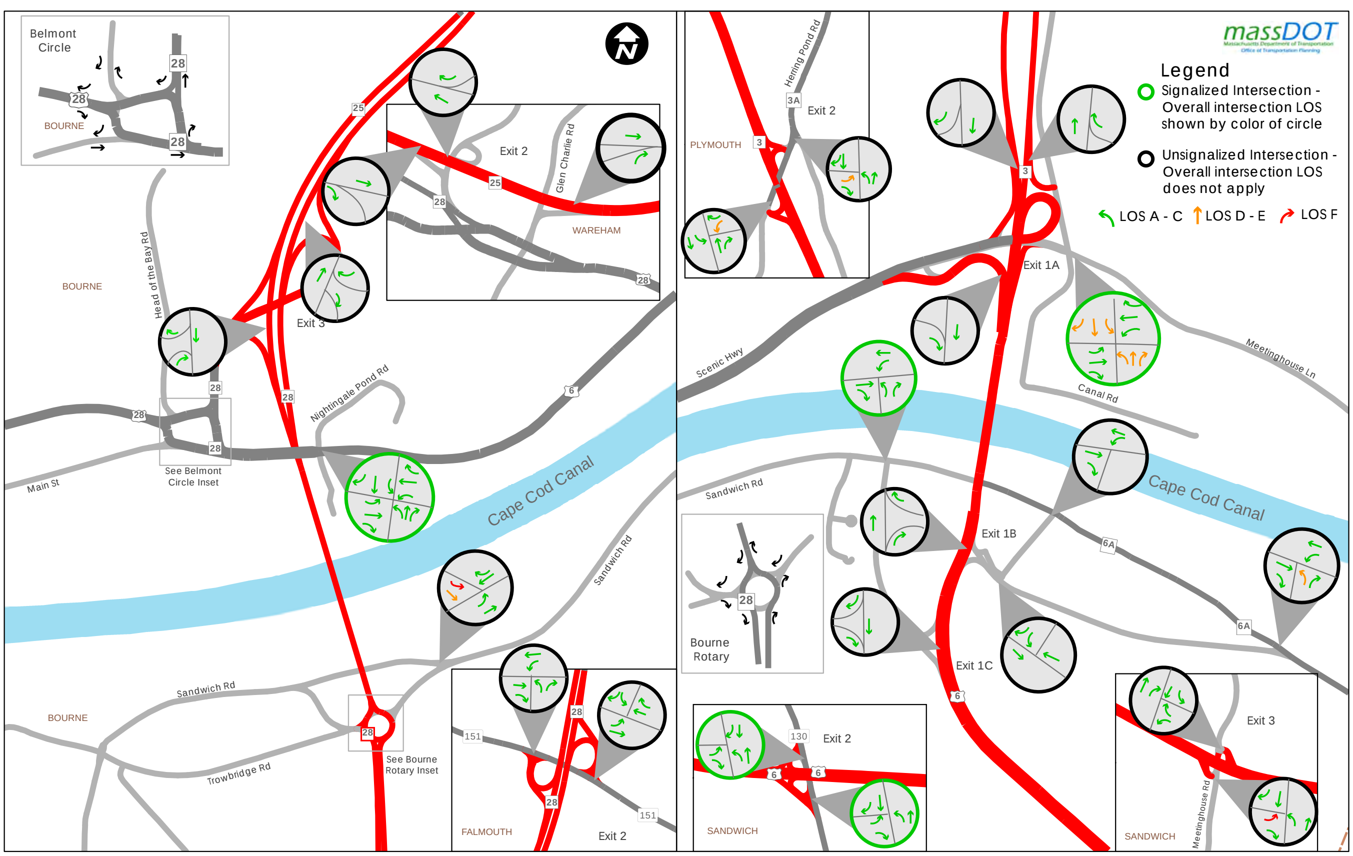


Exhibit 2-34 Existing Non-Summer Saturday Levels of Service (Intersections)

Exhibit 2-33 Existing Summer Weekday AM Levels of Service (Intersections)



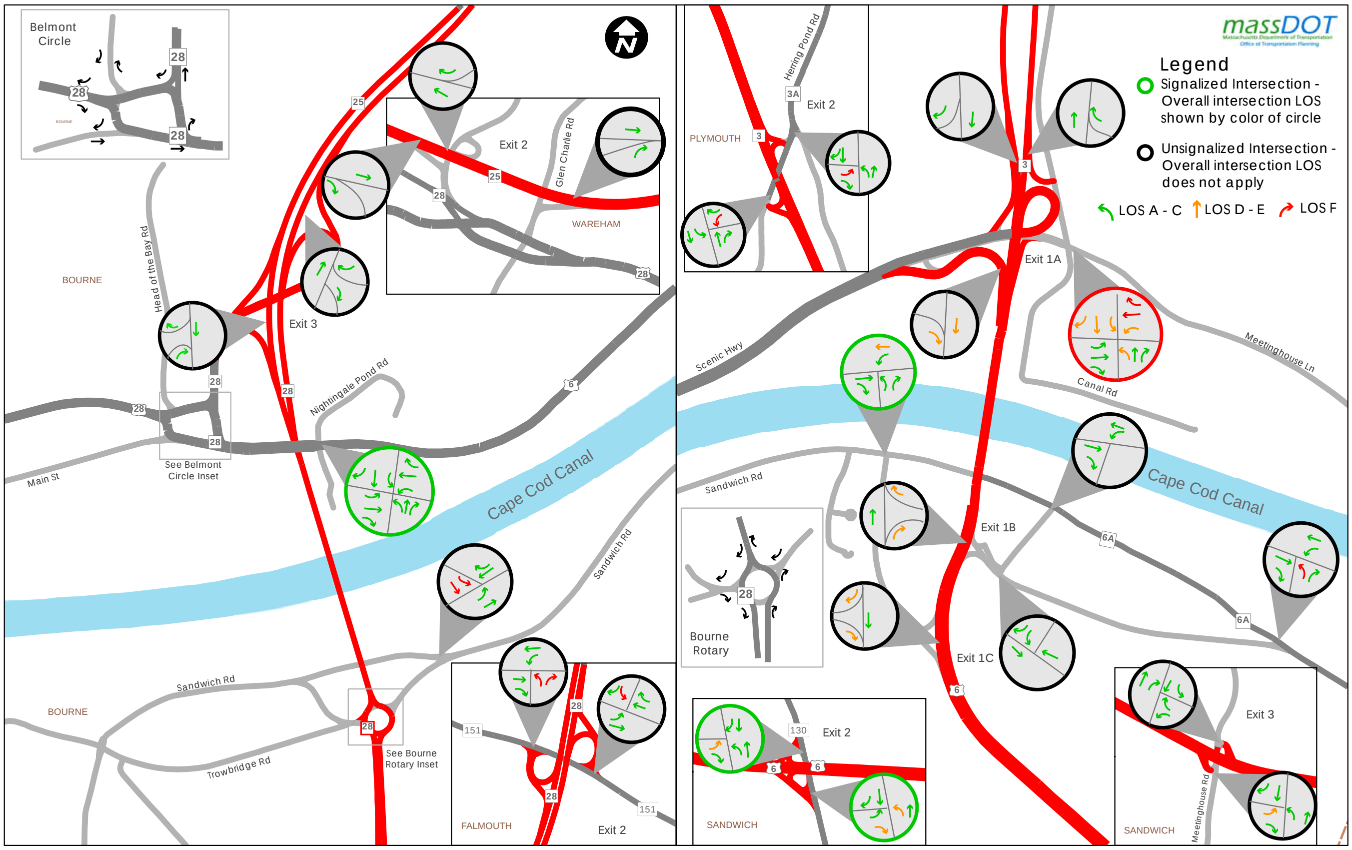
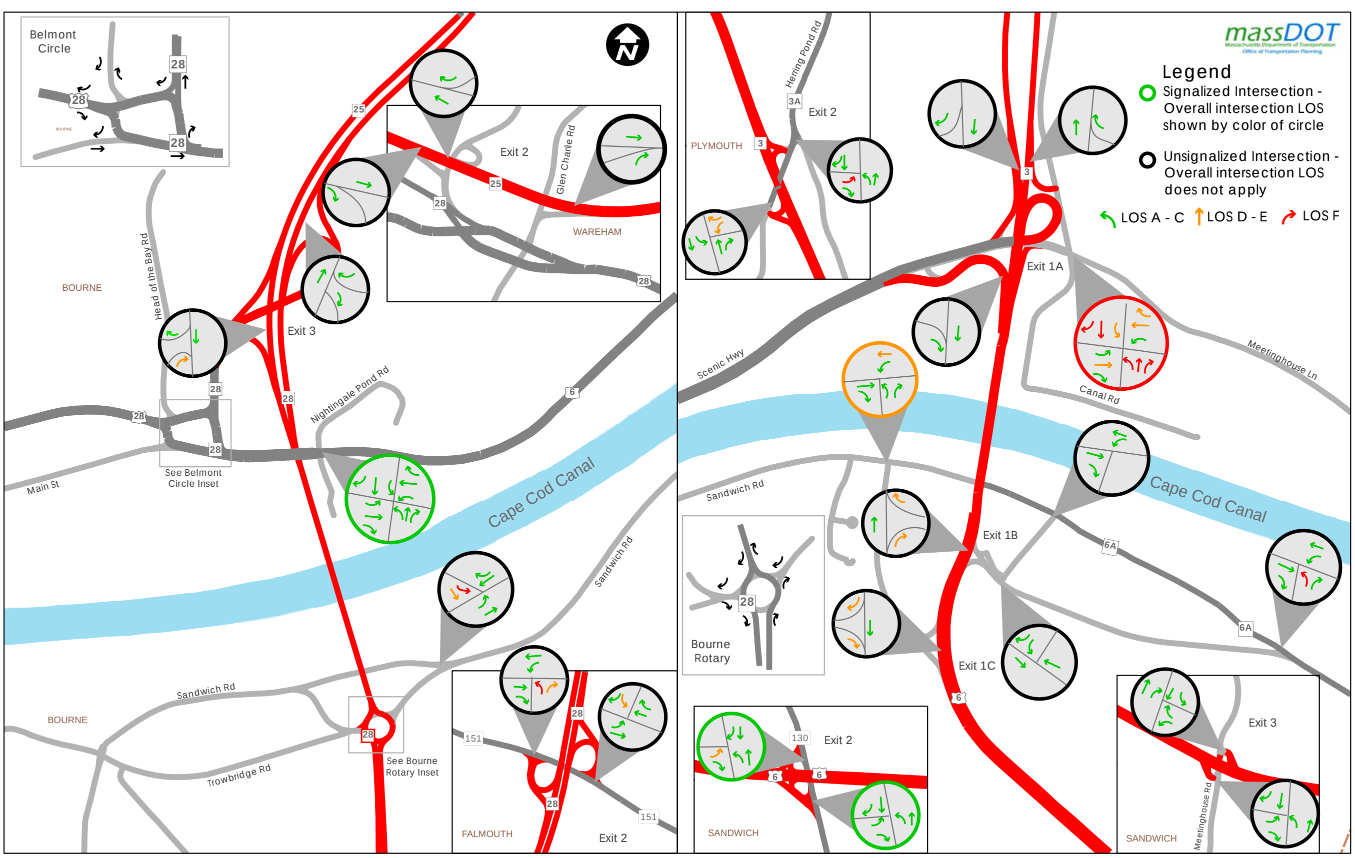


Exhibit 2-35 Existing Summer Weekday PM Levels of Service (Intersections)

Exhibit 2-36 Existing Summer Saturday Levels of Service (Intersections)



The analysis found that most freeway sections operate within a range of LOS A to LOS C during most peak periods. But certain freeway sections experience a lower level of operations (LOS D), especially during summer peak periods, including Route 6 at the Sagamore bridge, Route 6 between Exits 1 and 2, Route 6 at Cranberry Highway, and Route 6 at Route 130. However, as shown on Table 2-18 and Exhibits 2-31 through 2-36 show, far more intersections in the study area operate at an unacceptable LOS E or F during at least one peak hour than operate acceptably.

The most problematic of these locations are intersections that lead directly to the Canal bridges (known as 'gateway intersections') such as Belmont Circle and Bourne Rotary Route 6 Exit 1C is also considered a gateway intersection for this study but is not listed here because, as a highway entrance ramp, it was evaluated for delays and queues, rather than LOS. Other problematic intersections in the study area include Route 130 at Cotuit Road, Herring Pond Road at State Road, and Sandwich Road at its intersections with Adams Street, Bourne Rotary Connector, Technical High School Drive, and Harbor Lights Drive.

2.5.9 Origin-Destination Analysis Findings

The traffic data collected in the study area, including data through Automatic Traffic Recorders (ATRs) and Turning Movement Counts (TMCs), is used in conjunction with data from the BlueTOAD™ study to understand the travel patterns within the study area.

A major finding of the BlueTOAD™ origin-destination analysis was the substantial amount of travel between the Route 3/Route 6 corridor and the Route 25/Route 28 corridor. For example, as shown on Exhibit 2-37, during summer Saturdays when visitors are traveling to Cape Cod, 59% of vehicles on Route 25 exit the highway at Belmont Circle and travel east on Scenic Highway to Route 6. Similarly, on summer Sundays when visitors are leaving Cape Cod, 48% of vehicles exit Route 3 at the Sagamore interchange and travel west on Scenic Highway to Route 25, via Belmont Circle. These movements put tremendous pressure on the 'gateway intersections' adjacent to the Canal such as Route 6 Exit 1C, Belmont Circle, and the Bourne Rotary and lead to high levels of congestion during the peak hours.

2.5.10 Existing Traffic Conditions at Belmont Circle and Bourne Rotary

Traffic conditions at Belmont Circle and Bourne Rotary were simulated using VISSIM™ software and analyzed using SIDRA™ 5.1 software. As noted in Section 2.5.3, while HCM (Highway Capacity Manual) software was used to determines LOS along highways and intersections in the study area, traffic analysis

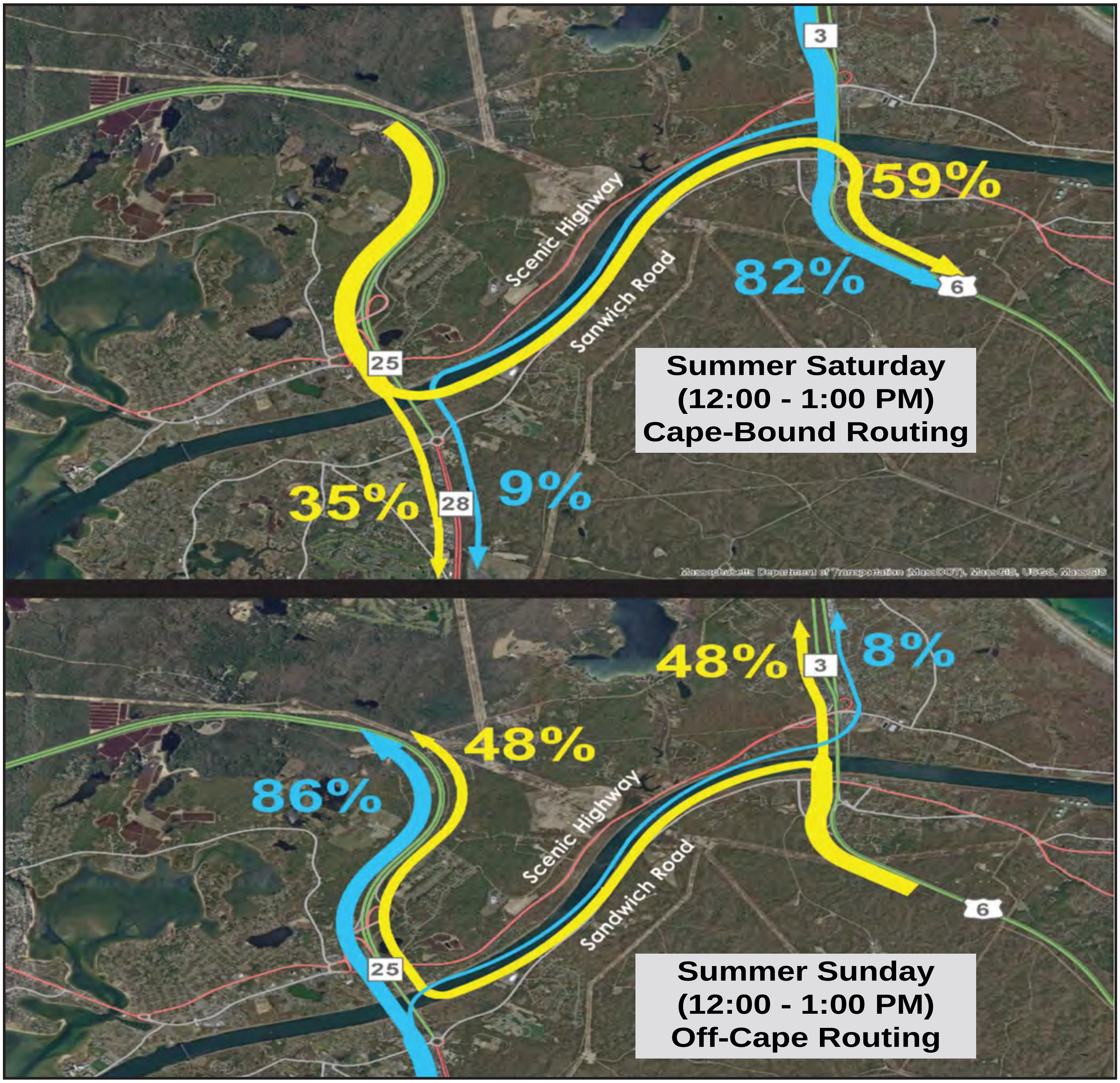


Exhibit 2-37 ***Routing of Traffic Between Highway Corridors***

using VISSIM™ and SIDRA™ 5.1 are preferred by MassDOT for the analysis of rotaries, roundabouts, and other unconventional intersections.

Therefore, to understand how traffic operates in Belmont Circle and Bourne Rotary, VISSIM™ software was used to analyze and simulate existing conditions. Traffic conditions within these rotaries are described in terms of the VISSIM™ model's output, including queues, vehicle delays, and travel time. The results from the simulation (average delay) are then used to determine LOS based on the criteria in the HCM.

Belmont Circle and Bourne Rotary, located immediately north and south of the Bourne Bridge, respectively, play a key role in traffic operations in the study area. The high frequency of cross-corridor travel noted in Section 2.5.9 often results in traffic volumes that exceed the capacity of Belmont Circle and Bourne Rotary. This results in significant queues and delays at their approaches.

Further, the proximity of these rotaries to each other can result in queues at one location negatively affecting traffic operations at the other. For example, congestion at the Bourne Rotary often results in queues on Route 28 southbound that extend over the Bourne Bridge beyond the Route 25 southbound entrance ramp from Belmont Circle. This, in turn, can exacerbate traffic congestion at Belmont Circle as vehicles cannot enter Route 25 because of the lengthy queues from Bourne Rotary.

Tables 2-20 and 2-21 and Exhibit 2-38 provide vehicle delay and queue lengths at Belmont Circle and Bourne Rotary, respectively, for the existing (2014) non-summer weekday PM and summer Saturday peak periods.

Table 2-20 Belmont Circle - Existing (2014) Queue Lengths and Average Delay

	AVERAGE VEHICLE DELAY (SEC./MIN.)		MAX. QUEUE LENGTHS (FEET/MILES)	
STREET NAME/APPROACH	NON-SUMMER PM	SUMMER SATURDAY	NON-SUMMER PM	SUMMER SATURDAY
Route 25 Exit 3 Off-Ramps (westbound)	5	4	515	510
Head of Bay Road (southbound)	15	83 (1.4)	270	570)
Buzzards Bay Bypass (eastbound)	3	19	100	335
Main Street (eastbound)	13	82 (1.4)	530	5,755 (1.1)
Scenic Highway (westbound)	7	125 (2.1)	380	10,605 (2.0)

Notes:
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

Table 2-21 Bourne Rotary - Existing (2014) Queue Lengths and Average Delay

	AVERAGE VEHICLE DELAY (SEC./MIN.)		MAX. QUEUE LENGTHS (FEET/MILES)	
STREET NAME/APPROACH	NON-SUMMER PM	SUMMER SATURDAY	NON-SUMMER PM	SUMMER SATURDAY
Route 25 (southbound)	19	280 (4.7)	650	8,885 (1.7)
Trowbridge Road (eastbound) EB	75	30	840	335
Route 28 (northbound)	14	301 (5.0)	340	4,135 (0.8)
Bourne Rotary Connector (westbound)	20	27	1,530	1,475

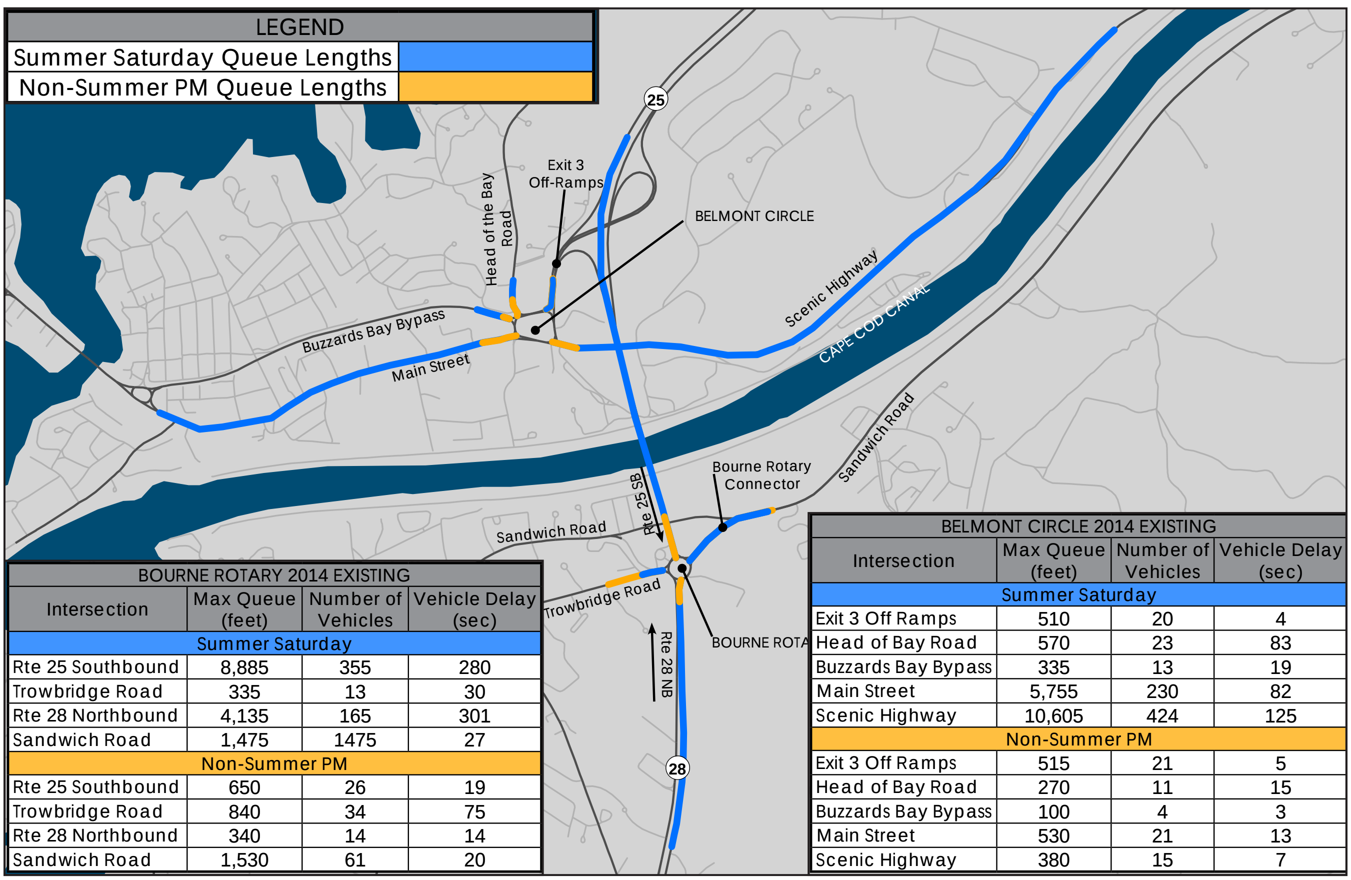
Notes:
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

Belmont Circle

The VISSIM™ analysis quantified average vehicle delays and the maximum queue length for the five approaches to Belmont Circle including Scenic Highway, Main Street, Buzzards Bay Bypass, Head of the Bay Road, and the Route 25 ramps. As shown on Table 2-20 and Exhibit 2-38, the approaches with the greatest average delay and maximum queue lengths include those from Scenic Highway and the Route 25 ramps to Belmont Circle.

While the average delay during the non-summer weekday are relatively minor (3 to 15 seconds), the average delay during summer Saturday peak periods can extend from 4 to 125 seconds (2.1 minutes). The maximum queues of note include the Main Street (eastbound) approach to Belmont Circle which can extend 530 to 5,755 feet (1.1 miles) during the non-summer weekday and summer Saturday peak hours, respectively. The maximum queues on the Scenic Highway (westbound) approach to Belmont Circle can extend 10,605 feet (2.0 miles) during the summer Saturday peak hour.

Exhibit 2-38 Belmont Circle and Bourne Rotary Queue Lengths



BOURNE ROTARY 2014 EXISTING			
Intersection	Max Queue (feet)	Number of Vehicles	Vehicle Delay (sec)
Summer Saturday			
Rte 25 Southbound	8,885	355	280
Trowbridge Road	335	13	30
Rte 28 Northbound	4,135	165	301
Sandwich Road	1,475	1475	27
Non-Summer PM			
Rte 25 Southbound	650	26	19
Trowbridge Road	840	34	75
Rte 28 Northbound	340	14	14
Sandwich Road	1,530	61	20

BELMONT CIRCLE 2014 EXISTING			
Intersection	Max Queue (feet)	Number of Vehicles	Vehicle Delay (sec)
Summer Saturday			
Exit 3 Off Ramps	510	20	4
Head of Bay Road	570	23	83
Buzzards Bay Bypass	335	13	19
Main Street	5,755	230	82
Scenic Highway	10,605	424	125
Non-Summer PM			
Exit 3 Off Ramps	515	21	5
Head of Bay Road	270	11	15
Buzzards Bay Bypass	100	4	3
Main Street	530	21	13
Scenic Highway	380	15	7

Bourne Rotary

The VISSIM™ analysis quantified average vehicle delays and the maximum queue length for the four approaches to the Bourne Rotary, including Route 28 (north and south end), Trowbridge Road, and Sandwich Road. As shown on Table 2-21 and Exhibit 2-38, the approaches with the greatest average delay and maximum queue lengths include those from Route 28 southbound and Route 28 northbound.

While the average delay during the non-summer weekdays are modest (14 to 75 seconds), the average delay during summer Saturdays can extend from 27 to 301 seconds (5.0 minutes). The queues of note include the Route 25 (southbound) approach to the Bourne Rotary which can extend 650 to 8,885 feet (1.7 miles) during the non-summer weekday PM and summer Saturday peak hours, respectively. The queues on the Route 28 (northbound) approach to Bourne Rotary can extend 340 to 4,135 feet (0.8 miles) during the non-summer weekday PM and summer Saturday peak periods, respectively.

2.5.11 Crashes

Crash data was collected for the years 2012-2014 (the most recent three-year period available at the time data was collected)

Exhibit 2-39 Crashes in the Study Area

from all study area intersections analyzed for LOS. These data were used to create diagrams that portray crashes by type and by frequency (provided in Appendix D). Analysis of these diagrams—that is, the types of crashes and where they took place—helped the study team understand why crashes may be occurring at certain locations. Table 2-22 summarizes crash data for the study area. Exhibit 2-39 shows the location crashes in the study area.

Crash rates were calculated for each study area intersection and compared to the average crash rate for MassDOT' s District 5, which includes Cape Cod and Southeastern Massachusetts.

Table 2-22 Crashes in Study Area, 2012–2014

TOWN	NAME OF LOCATION	MAP NUMBER	HSIP LOCATION[1] (Y/N)	2012	2013	2014	TOTAL (2012-2014)	EPDO[2]	CRASH RATE[3]
Plymouth	Herring Pond Road at State Road	1	N	5	3	13	9	13	**0.42**
Plymouth	Route 3 SB Exit 2 Off/On Ramps at Herring Pond Rd	13	N	1	3	4	8	12	**0.52**
Bourne	Belmont Circle	2	Y	26	29	32	87	127	**1.40**
Bourne	Scenic Highway at Nightingale Pond Road/Olivia Drive	3	N	11	9	3	23	27	0.61
Bourne	Scenic Highway at Church Lane	14	N	2	2	1	5	9	0.16
Bourne	Scenic Highway/Meetinghouse Lane at State Road	10	N	4	8	7	19	25	**0.82**
Bourne	Bourne Rotary	4	Y	31	38	45	114	150	**2.12**
Bourne	Sandwich Road at Bourne Rotary Connector	5	N	5	3	1	9	15	0.25
Bourne	Sandwich Road at High School Drive	6	Y	3	1	3	7	9	0.27
Bourne	Sandwich Road at Harbor Lights Road	7	N	0	1	0	1	3	0.04
Bourne	Sandwich Road at Jarvis Drive	15	N	0	0	0	0	0	0.00
Bourne	Sandwich Road at Adams Street[4]	16	Y	8	10	11	29	42	**1.66**
Bourne	Sandwich Road at Cranberry Highway/Regency	8	N	3	7	2	12	26	**0.58**
Sandwich	Route 130 (Main Street)/Route 6A/Tupper Road	9	Y	6	3	3	12	24	0.59
Sandwich	Route 6A at Main Street	17	N	0	0	1	1	3	1.02
Sandwich	Old Kings Highway at Main Street	18	N	1	1	0	2	4	0.16
Sandwich	Route 6 Eastbound (Exit 2) Ramps at Route 130	19	N	0	2	3	5	9	**0.20**
Sandwich	Route 130 at Cotuit Road	11	N	6	1	1	8	18	**0.34**
Falmouth	Route 28 Southbound Off/On Ramps at Route 151	12	N	3	4	2	9	15	**0.34**
Falmouth	Route 28 Northbound Off/On Ramps at Route 151	12	N	5	3	2	10	22	**0.34**

[1] Highway Safety Improvement Program (HSIP) – Crash cluster in which the total number of 'equivalent property damage only' crashes in the cluster are within the top 5% of all clusters in that region.
[2] Equivalent Property Damage Only (EPDO) – crash analysis method that weights factors related to the societal costs of fatal, injury, or property damage-only crashes.
[3] **Bold** text indicates accident rate exceeds District 5 average crash of 0.76 and 0.58 per million entering vehicles for signalized and unsignalized intersections, respectively.
[4] Adams Street converted to one-way (southbound) travel only in 2015.

District 5 had an average crash rate of 0.76 crashes (signalized intersections) and 0.58 crashes (unsignalized intersections) for every million vehicles who traveled through the intersection.[5]

Eight locations within the study area rank as high-crash locations under the Highway Safety Improvement Program (HSIP). This MassDOT designation identifies crash clusters that rank within the top five percent of their respective regional planning agency's crash locations. This criterion reflects a combination of factors, including crash incidence and severity, based on an equivalent property damage only (EPDO) index that assigns points based on the type of accident. Property-damage-only crashes earn 1 point on this scale; injury crashes earn 5 points; and fatal crashes earn 10 points.

The locations in the study area with the highest crash rates include Belmont Circle, Bourne Rotary, and the intersections of Route 6A at Route 130 and Scenic Highway at Meetinghouse Lane.

2.6 MULTIMODAL TRANSPORTATION

This section describes other modes of transportation used by people in the study area, including walking, bicycling, buses, trains, ferries, and airplanes. These other transportation modes provide safe ways to travel and encourage healthy non motorized travel. These facilities function as critical transportation modes for non drivers.

The varied elements of a multimodal transportation system work best when they work together. For example, one may bike to a transit facility to catch a bus to work or drive to a downtown area then walk to various shops.

This section provides details on these transportation modes and gaps identified in connecting these transportation modes.

2.6.1 Pedestrian Facilities

Pedestrian facilities in the focus area include sidewalks and recreational trails. Sidewalks are generally present in more densely developed residential and commercial areas but absent elsewhere (Exhibit 2-40). Many roads in the study area are narrow (20–22 feet) and lack sidewalks, presenting difficulties for pedestrians, particularly the elderly or those with disabilities. Sidewalks are especially important along bus routes to allow people to walk safely to/from bus stops. Sidewalks along major travel corridors in the focus area include those along the southern side of Scenic Highway from Nightingale Road

5 Known as 'crashes per million entering vehicles' (PMEV)

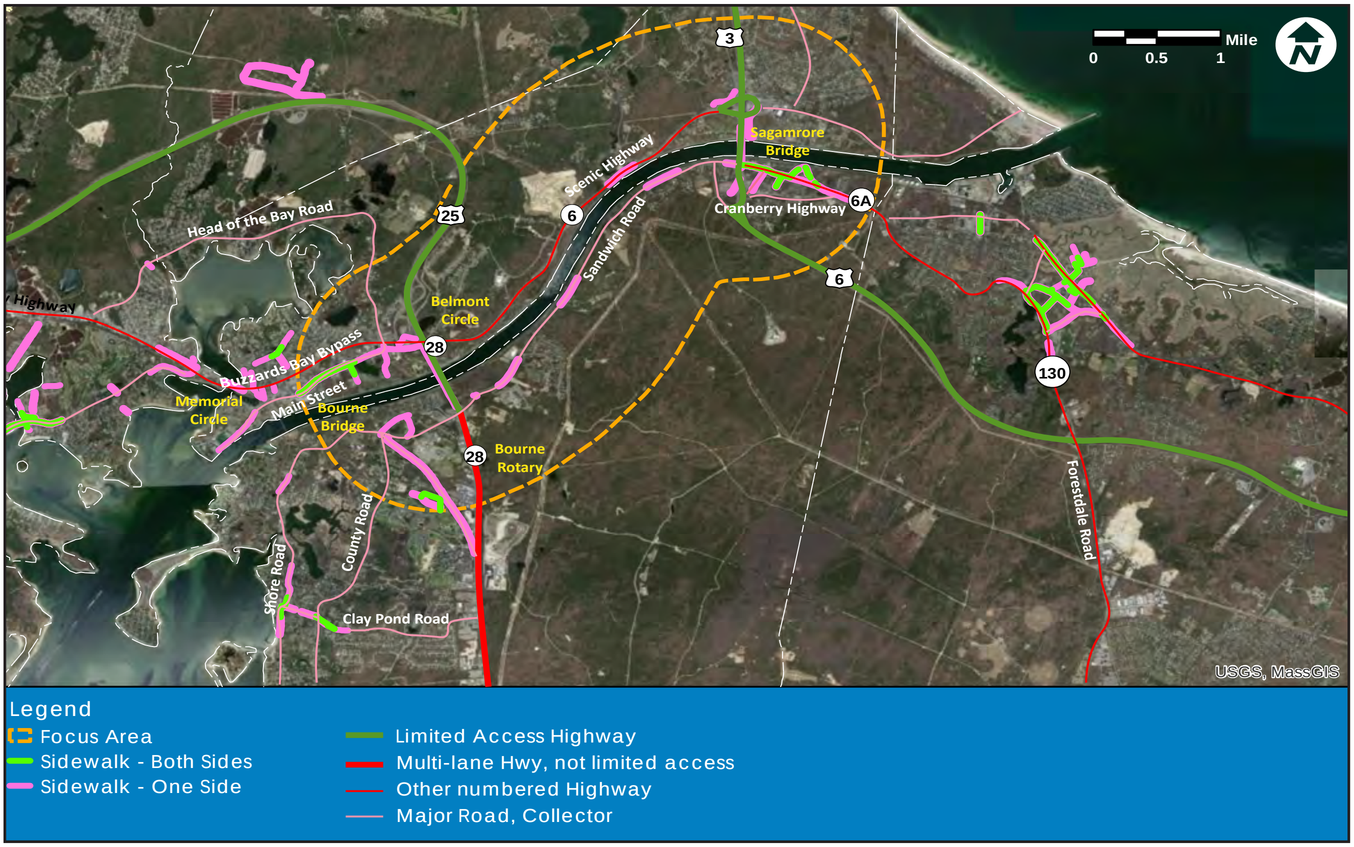


Exhibit 2-40 Pedestrian Facilities in the Focus Area

west along the southern edge of Belmont Circle and continuing through the Main Street business district in Bourne.

Sidewalks also exist on Trowbridge Road and the southern side of Sandwich Road from the Mid-Cape Connector to Route 6A and continuing along either one or both sides of Route 6A to Tory Lane. After a 1.5-mile gap, sidewalks continue Route 6A for 1.25 miles from Tupper Road (east end) to Crowell Lane. Both the Sagamore and Bourne bridges provide a single, narrow sidewalk, but several of the approach roadways to the bridges lack accessible sidewalk connections. For example, pedestrians can only reach the Bourne Bridge sidewalk from the north on an unmarked sidewalk at the end of the Bridge approach via the end of a shopping area entrance drive. To reach the sidewalk at the south end of the Bourne Bridge, a pedestrian would need to enter the Bourne Rotary, a high-volume traffic circle that lacks sidewalks.

For safety reasons, limited-access highways, including those in the study area such as Route 6, Route 3, and Route 25, prohibit pedestrian access and do not have sidewalks. Other roadways in the study area—such as Route 28, Route 151, Buzzards Bay Bypass, Sandwich Road, Tupper Road, Shore Road, County Road, and Scenic Highway (except in the immediate area of the Route 3 interchange)—also generally lack sidewalks.

Counts of pedestrians and bicyclists were conducted at intersections throughout the study area. Table 2-23 presents these counts the results of these counts for the non-summer weekday and summer Saturday peak periods. Higher pedestrian and bicycle activity occur in areas containing a greater concentration of retail or commercial establishments or near residential neighborhoods and schools. These areas include Route 6A in Sandwich and Trowbridge Road and Main Street in Bourne.

Gaps exist in the connections for pedestrian and bicycle access across the Canal and between the Cape Cod Canal service road (bike path) and local roadways in the study area. Exhibit 2-41 displays the desire route for pedestrians and bicyclists over the Canal at both the Bourne and Sagamore Bridges. At the approaches to both bridges gaps exists in the sidewalk system to allow pedestrians or bicyclists to cross the Canal. Sidewalks do not exist that would connect the south end of Sagamore Bridge to either Cranberry Highway or Sandwich Road. At the north end of the Bourne Bridge, lack of sidewalks limit pedestrian access to Belmont Circle.

While scattered pedestrian/bicycle connections exist between the Cape Cod Canal service road (bike path) and local roadways in the

Table 2-23 Pedestrian and Bicycle Counts at Select Intersections

INTERSECTION	BICYCLES						PEDESTRIANS					
	SUMMER			NON-SUMMER			SUMMER			NON-SUMMER		
	AM	PM	SAT	AM	PM	SAT	AM	PM	SAT	AM	PM	SAT
Route 130 at Route 6 EB On-Off Ramps	2	6	17	0	0	2	0	0	0	0	0	0
Route 6A at Route 130 and Tupper Road	0	7	6	0	0	0	0	2	0	2	1	1
Route 6A at Main Street	7	8	24	0	0	1	8	9	5	7	0	3
Cranberry Highway at Sandwich Road and Regency Road	1	3	11	0	0	1	1	7	9	3	4	2
Sandwich Road at Adams Street	0	1	2	0	0	0	0	4	1	0	0	3
Route 130 at Cotuit Road	1	6	11	0	0	1	0	0	2	0	0	0
Route 6 at Quaker Meetinghouse Road	0	3	2	0	0	0	0	0	10	0	0	0
Bourne Rotary	2	1	0	0	0	0	0	0	5	0	1	1
Trowbridge Road at Veterans Way	4	3	7	0	0	0	12	1	4	0	1	2
Trowbridge Road at Sandwich Road and County Road	5	2	25	0	0	5	0	2	0	0	0	6
Route 6 (Scenic Highway) at Nightingale Pond Road	2	2	3	0	1	0	0	22	8	0	0	0
Memorial Circle	2	5	25	0	2	11	1	2	3	0	1	0
Meetinghouse Lane at Canal St.	0	3	6	0	0	0	5	1	1	3	1	8
Tupper Road at Old King's Highway (Route 6A)	5	11	17	0	0	0	6	9	15	0	0	8
State Road at Route 3 NB Ramp and Homestead Road	0	0	7	0	0	0	1	0	2	0	0	0
Route 151 at Route 28 SB On-Off Ramps	5	4	17	0	0	1	0	0	0	0	0	0
Route 151 at Route 28 NB On-Off Ramps	5	3	14	0	0	1	0	0	0	0	0	0
Herring Pond Road at Route 3 NB On-Off Ramps	0	2	0	0	0	0	2	5	13	0	0	0

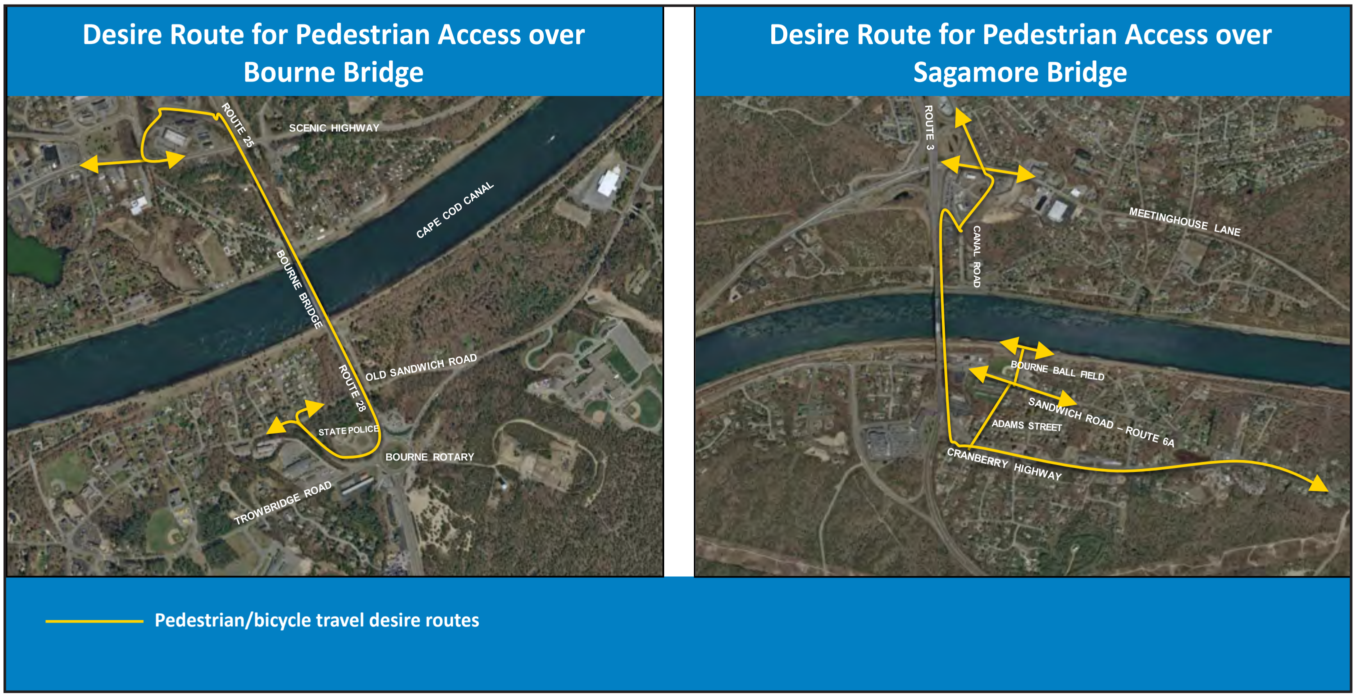


Exhibit 2-41 Pedestrian/Bicycle Travel Desire Routes over the Canal Bridges

focus area, there are notable gaps. Existing connections north of the Canal include Old Bridge Road, Herring River Recreation Center, Sagamore Recreation Area, Old Plymouth Road, and several along Scusset Beach Road. South of the Canal pedestrian connections to the Canal bike path include those at the Sandwich Marina Park, Sandwich Road, Bourne Recreation Area, and the Railroad Bridge Access parking lot. As shown on Exhibit 2-42, gaps in these connections exists west of the Bourne Bridge and east of the Sagamore Bridge.

2.6.2 Bicycle Facilities

Bicycle facilities in the study area include the Cape Cod Canal service roads (bike paths), owned and maintained by the U.S. Army Corps of Engineers. The service roads run on both the north and south sides of the Canal, and each is about 7 miles long. The service roads are very popular local resource for bicycle recreation and commuting. A daily count conducted by the Cape Cod Commission during July 2017 found 827 bicyclists using the Canal service road.

Lighting, benches and seating areas are provided along the path on both sides of the service road. While there are several accessible connections to the service roads from the local roadway network or parking lots, there are also notable areas that lack an accessible, ADA[6]-compliant connection to the service road.

6 Americans with Disabilities Act of 1990.

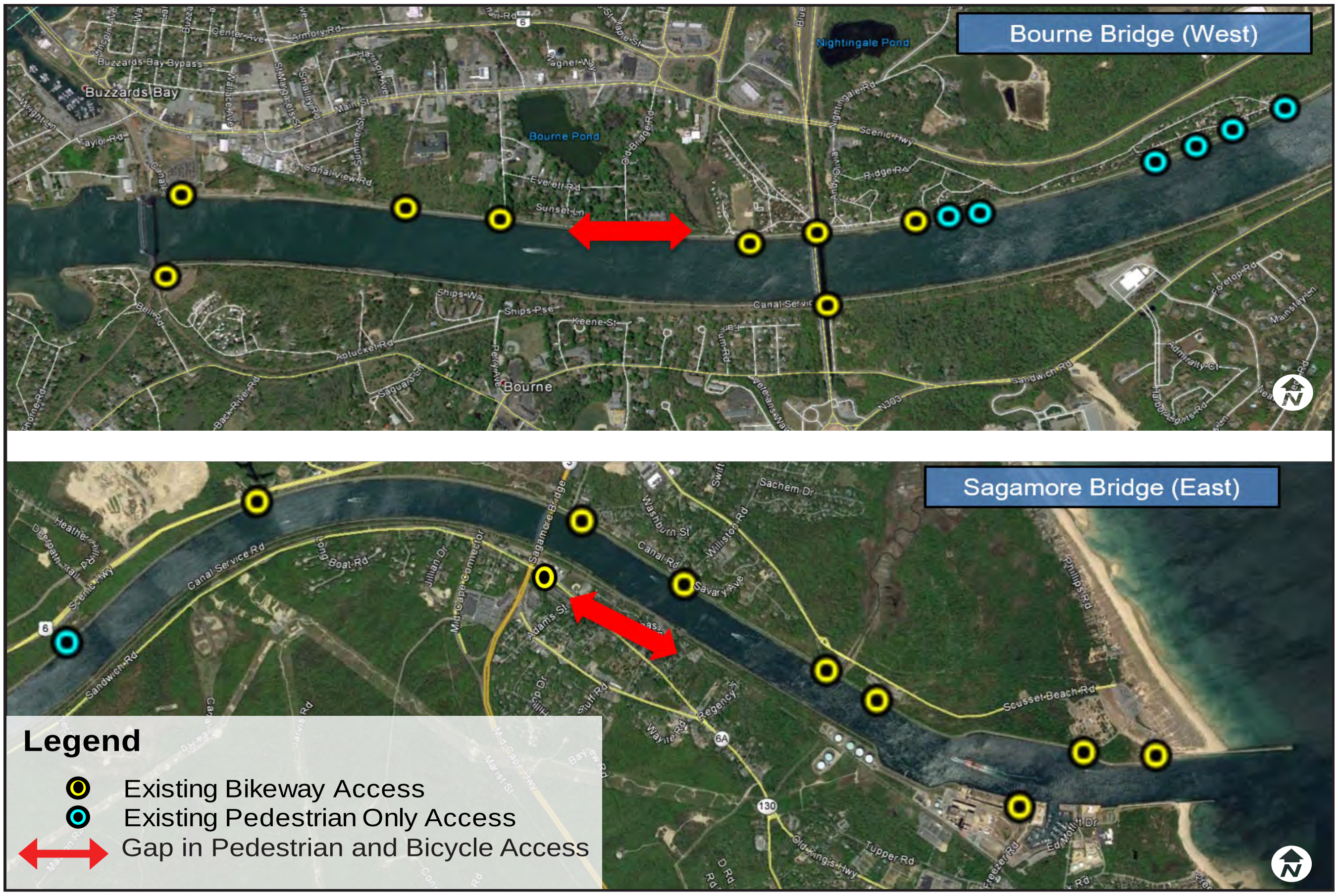


Exhibit 2-42 Gaps in Pedestrian/Bicycle Connections to Canal Bike Path

While somewhat outside of the study area, the Shining Sea Bike Path extends 10.6 miles from the Steamship Authority terminal in Woods Hole to County Road (Route 151) in Falmouth. An on-road bike route is designated on Route 6A in Sandwich.

Exhibit 2-43 shows the proximity of bicycle path and on-road bicycle routes to bus routes. Services provided by area transit organizations enhance bicycle access in the study area. The Cape Cod Regional Transit Authority (CCRTA) buses have racks for two bicycles, and the Steamship Authority (SSA) ferry service allows passengers to pay to take bicycles on the ferries.

Gaps between bicycle facilities and bus routes exist between the Canal service road (bike path) and the bus routes that cross the Canal bridges. Gaps also exist between the northern limit of the off-road Shining Sea bike path in Falmouth and bus routes along County Road and Shore Road in Bourne.

2.6.3 Transit Services

Cape Cod's unique shape allows access from multiple directions through a wide range of modes. For ground transportation, bus

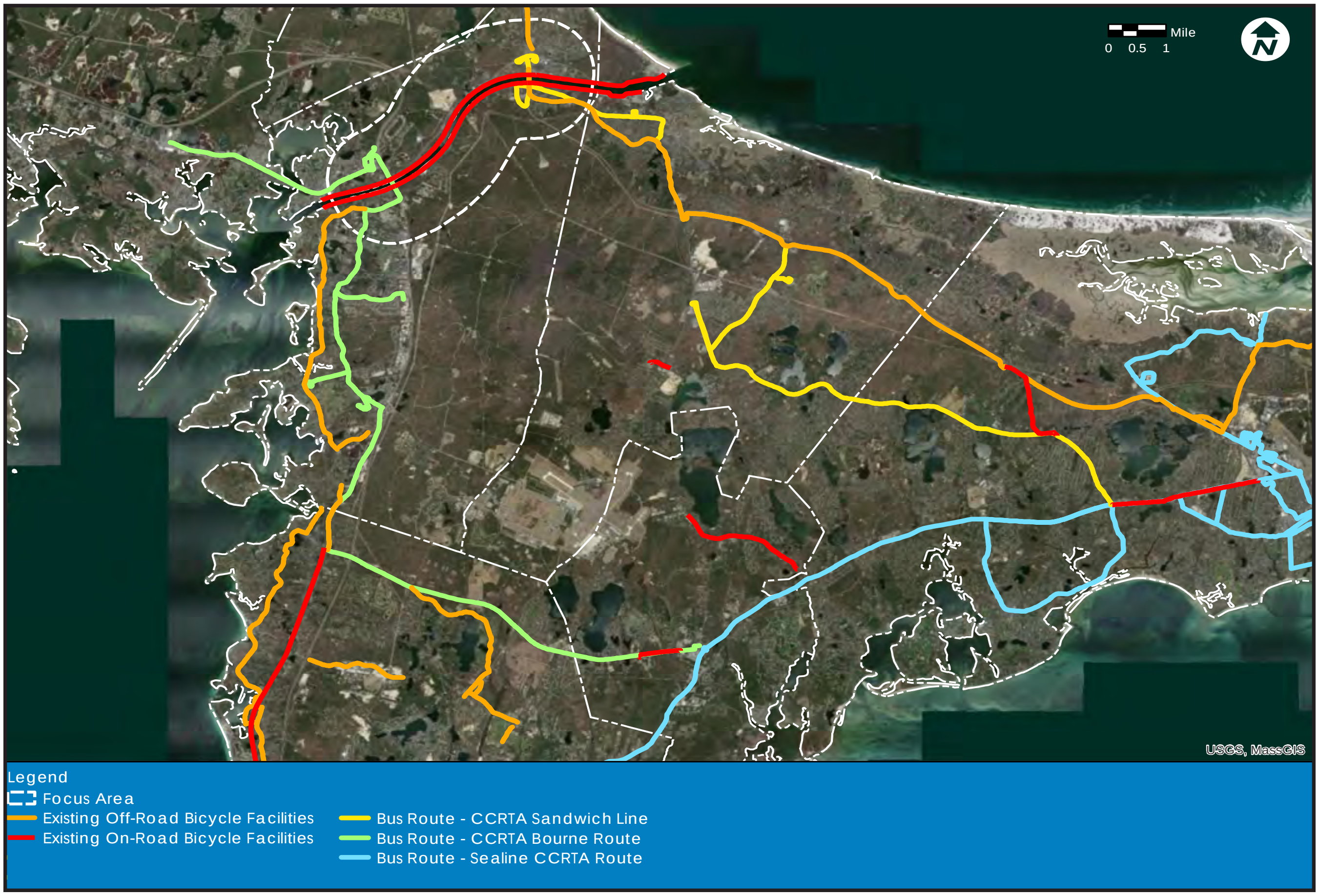


Exhibit 2-43 Bicycle Facilities and Bus Routes in the Study Area

CCRTA Map

and train service connect to places as far as Boston and New York City. Over water, ferry service connects the Cape to Nantucket, Martha's Vineyard, and Boston. Two municipal airports offer direct flights to Martha's Vineyard, Nantucket, Boston, New York City, and Washington D.C.

Multimodal transportation on Cape Cod centers on the Hyannis Transportation Center, built in 2002. The Center serves as a terminal for local and long-distance bus service and as a rail station for the seasonal MBTA Cape Flyer. The Center provides parking for 220 vehicles, and it has entrances from Route 28, Center Street, and Ridgewood Avenue in Hyannis. Proximity to Barnstable Municipal Airport and the Hyannis Ferry Dock (both less than one mile away) allows for quick transfers between transportation modes.

2.6.4 Bus Service

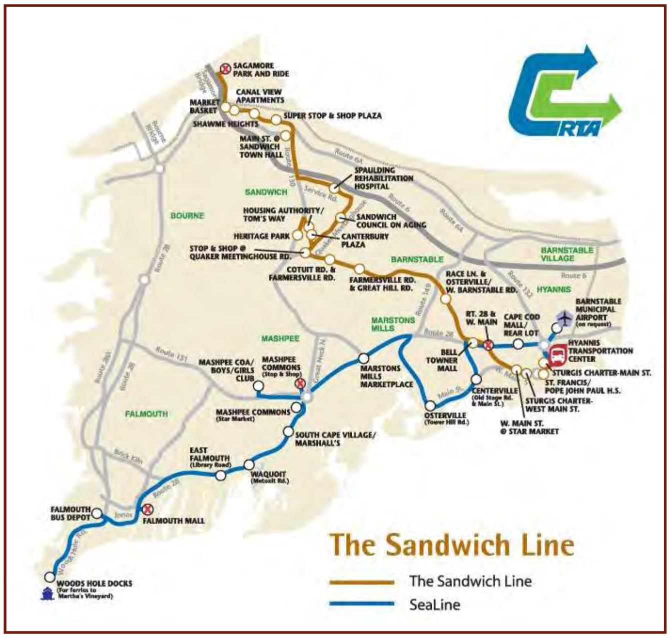
This section summarizes Cape Cod bus services. The Cape Cod Regional Transit Authority (CCRTA) serves as the primary transit provider within the study area. Other bus companies serving the area include the Greater Attleboro Taunton Regional Transit Authority (GATRA), Peter Pan Bus Company, and the Plymouth & Brockton Bus Company.

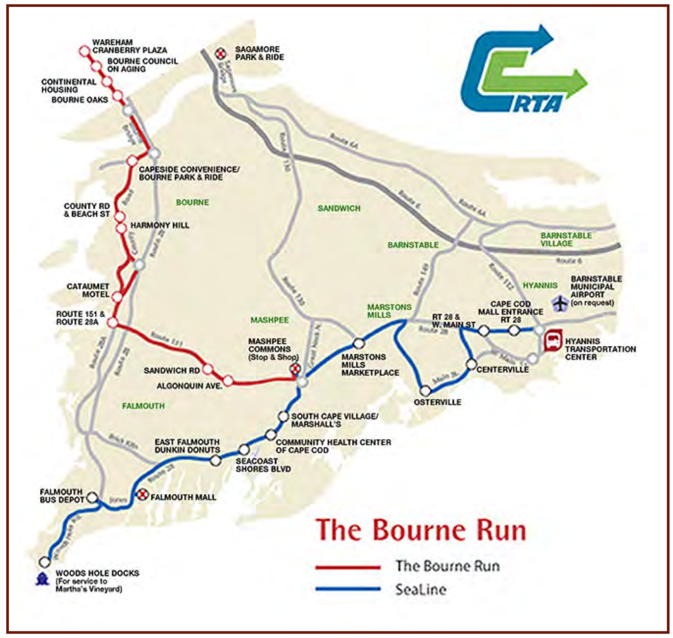
Cape Cod Regional Transit Authority (CCRTA)

A public transit authority, CCRTA provides bus service daily during the summer and weekdays and Saturdays during the off-season. Schedules and some stops also vary seasonally. The routes have designated stops, and passengers can request some stops on board. As described below, CCRTA operates six year-round fixed-route services covering every town on Cape Cod. These include the SeaLine, H2O Hyannis-Orleans (H2O Line), FLEX, Barnstable Villager, Sandwich Line and Bourne Run. Seasonal fixed-route services include the WOOSH Trolley, The Hyannis Area Trolley and the Provincetown/North Truro Shuttle. Access to these transit services is often limited by the lack of accessible sidewalks and bus shelters along CCRTA bus stops in the study area, particularly along Shore Road, County Road, and Route 6A.

CCRTA Fixed Routes

The SeaLine route runs from the Woods Hole docks in Falmouth to the Barnstable Municipal Airport with stops including the Hyannis Transportation Center. The SeaLine travels along Route 28 and deviates to Osterville and Centerville centers. Along Route 28, the SeaLine travels to Mashpee Commons, Falmouth Center, the Falmouth bus depot, and Woods Hole.





CCRTA Route Maps:
The Sandwich Line, left
The Bourne Run, right

The H2O line runs from the Hyannis Transportation Center to the Stop & Shop in Orleans. The bus travels to the Cape Cod Hospital and along Route 28 to the Stop & Shop and Star Market in Yarmouth, the Dennis Shopping Area, the Stop & Shop and Patriot Square in Dennis, the Harwich Chamber of Commerce, through Chatham and to the CVS and Stop & Shop in Orleans. From the H2O line, riders can connect to the FLEX bus that continues to Provincetown. The line also connects at the Hyannis Transportation Center with the SeaLine, the Barnstable Villager, intercity buses and in summer, with the Hyannis Trolley.

The FLEX travels from Route 28 in Harwich, over Queen Anne to Route 137, to Brewster on Route 6A, down Route 6 through the towns of Orleans, Eastham, Wellfleet, and Truro to Provincetown. The FLEX picks up and drops passengers off at designated stops and will deviate off its route for up to 0.75 miles. The FLEX line also offers transfer connections to the H2O line at various points in the towns of Harwich and Orleans.

The Barnstable Villager runs from downtown Hyannis at the Hyannis Transportation Center to the Courthouse Complex in Barnstable Village. The route passes through neighborhoods in the north and south of the Mid-Cape area. During the summer season, the route also serves Barnstable and Hyannis harbors. Passengers make connections to the H2O and SeaLine at the Hyannis Transportation Center.

The Bourne Run travels from the Walmart at Cranberry Plaza in Wareham through Bourne and Falmouth to Mashpee Commons. As shown below, the Bourne Run travels across the Bourne Bridge, through downtown Buzzards Bay, and along Routes 28A and 151 in Bourne, Falmouth and Mashpee. The Bourne

Run offers the only connection to Greater Attleboro Taunton Regional Transit Authority and the Onset/Wareham Link (OWL) fixed-route systems.

The Sandwich Line travels from the Sagamore Park and Ride across the Sagamore Bridge to the Hyannis Transportation Center through Sandwich (see figure on previous page). It passes through historical downtown Sandwich on Route 6A, travels on Race lane in Barnstable and then connects through Route 28 to Hyannis. This route offers transfer connections to the SeaLine, H2O and Barnstable Villager at the Hyannis Transportation Center.

The CCRTA's newest route, the Hyannis Loop, travels from the Hyannis Transportation Center to the Cape Cod Mall, Southwind Plaza, Festival mall, and other downtown locations. It connects the Hyannis Transportation Center with several other CCRTA fixed route services: the SeaLine, Villager, Sandwich Line, and H2O line. It also connects with Plymouth & Brockton and Peter Pan bus services. The Hyannis Loop travels from the Hyannis Transportation Center down Main Street, North Street, and West Main Street to Route 28 then connects to the Festival Mall and Super Stop & Shop via Pitchers Way. It then follows Attucks Lane to Independence Drive before following Route 28 and Barnstable Road back to the Hyannis Transportation Center.

CCRTA Seasonal Fixed Routes

Within Hyannis, Provincetown, and Falmouth, CCRTA runs seasonal trolleys to and from the ferry docks to help meet the demand for increased transit service from May through September. All trolleys run every hour or half-hour for ten or more hours a day.

In Hyannis, the Hyannis Area Trolley (HAT) operates seven days a week, from late June through Labor Day, including holidays. The HAT runs from the Hyannis Transportation Center to the Steamship Authority ferry docks and the Cape Cod Hospital before coming back to the Hyannis Transportation Center. The HAT route includes stops at the JFK Museum, Kennedy Memorial and Veterans Beach.

In Provincetown, CCRTA runs two shuttles. One route travels between MacMillan Pier in Provincetown to the National Park Service's Province Land Visitors Center, Race Point Beach, and the Provincetown Municipal Airport. The other route travels from MacMillan Pier to Beach Point in Provincetown to the North Truro and Horton's Campgrounds.

In Falmouth, the WHOOSH Trolley runs late June through early September daily from the Falmouth Mall to the Steamship

Authority docks. This line connects to the SeaLine fixed route service at the Falmouth bus depot, Falmouth Mall, and the Steamship Authority in Woods Hole.

Demand Response

CCRTA also provides demand-response services: Dial-A-Ride Transportation (DART); Americans with Disabilities Act (ADA) paratransit services, and Boston Hospital Transportation.

DART service, which operates as a door-to-door ride by appointment, is available to the public, with priority given to seniors and individuals with disabilities. DART service is available Monday through Saturday in all 15 Barnstable County towns, with limited service on Sunday. Vehicles used for DART services include 10- to 12-person vans and/or 15- to 18-person mini buses.

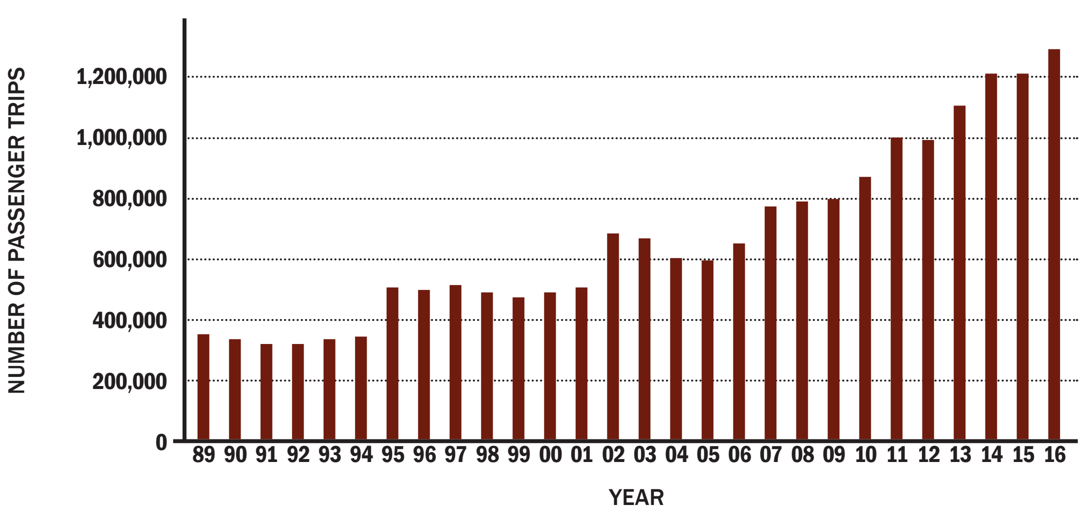
ADA Paratransit is a door-to-door shared-ride service for passengers who meet ADA eligibility requirements established by law in 1990. ADA Paratransit vehicles travel to destinations within 0.75-mile of fixed route bus services for any purpose.

The Boston Hospital Transportation (BHT) is another healthcare transit service. Services are provided from Wellfleet, Eastham, Orleans, Harwich, Barnstable, and Sagamore to 15 Boston-area medical facilities by appointment.

Annual CCRTA Ridership Counts

CCRTA systemwide ridership counts for the last 27 years show a considerable increase in public transit use throughout Cape Cod. Exhibit 2-44 shows that the CCRTA provided just over 357,000 passenger trips in 1989. By 2016, ridership had more than tripled, reaching nearly 1.3 million annual passenger trips.

Exhibit 2-44 Cape Cod Regional Transit Authority (CCRTA) Annual Ridership



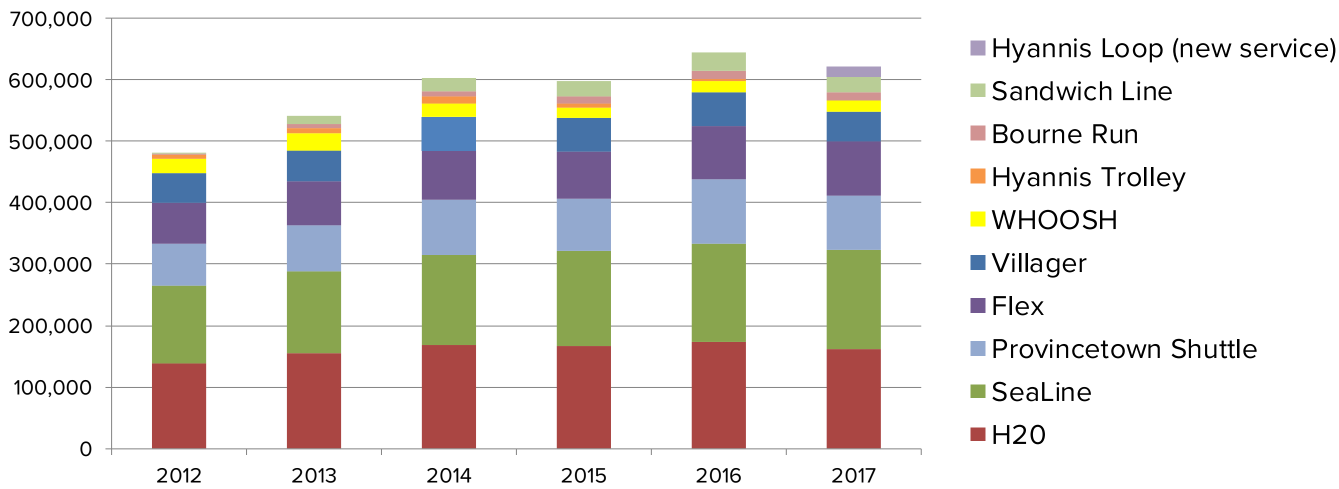


Exhibit 2-45 Cape Cod Regional Transit Authority (CCRTA) Fixed Route Ridership

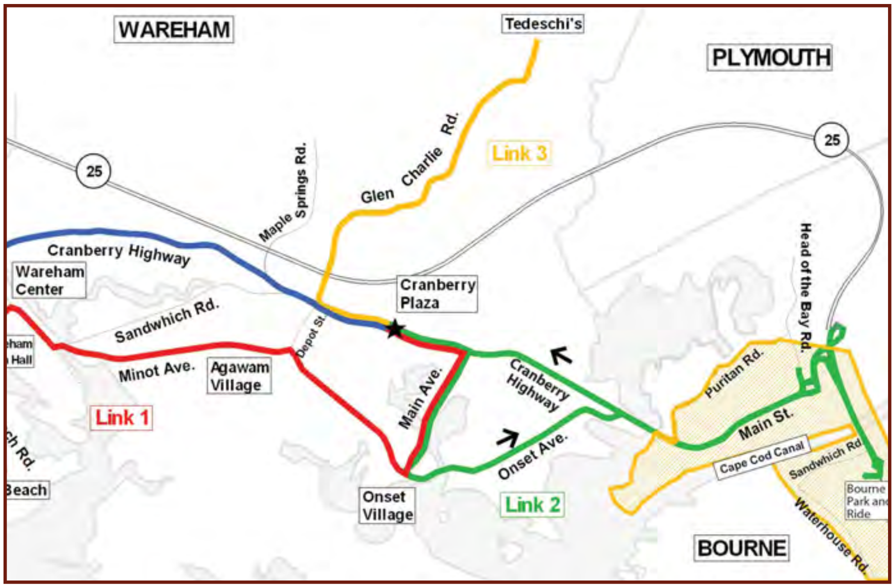
The annual CCRTA counts in Exhibit 2-44 represents trips by all CCRTA services— fixed-route and seasonal services, and demand-response, human service transportation and ADA passenger trips.

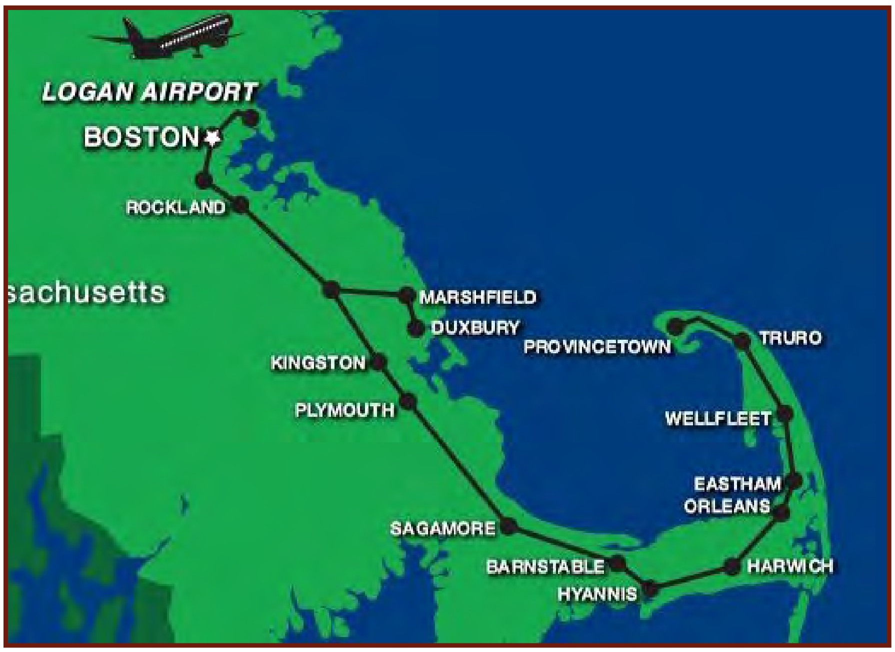
Exhibit 2-45 focuses on ridership for the CCRTA's fixed-routes for the period 2012–2017. This table shows that the routes with the highest ridership are the H2O and SeaLine, which travel the commercial corridor of Route 28. Both the Bourne Run and the Sandwich Line, introduced in 2012, experienced lower ridership than the more established fixed routes. Both lines experienced low ridership in 2012, their first year of operation; since then, however, annual ridership for the Sandwich Line shows a considerable increase. The Bourne Run has experienced slower ridership growth.

Greater Attleboro Taunton Regional Transit Authority (GATRA)

GATRA is a public authority that provides transit service through southern Norfolk County, Plymouth County, and the South Shore. The Wareham/Middleborough/Lakeville Train Connector bus route runs from the Lakeville MBTA commuter rail station/ Cape Flyer station to Onset Town Pier and connects to the CCRTA Bourne Run route at Cranberry Plaza in Wareham. The Plymouth Area Link has four lines that connect the Plymouth and Kingston MBTA commuter rail stations to the Plymouth & Brockton Bus in Plymouth at Route 3 (Exit 5). As shown in the route map, GATRA provides bus service in the study area in Wareham, Plymouth, and Bourne.

One shuttle links Wareham Center with Onset, while another shuttle connects with Marion and Mattapoisett.





(top to bottom)
GATRA Route Map

Plymouth & Brockton Bus Route, Provincetown to Logan Airport, Boston

Plymouth & Brockton Street Railway Co.

The Plymouth and Brockton Street Railway Co. ("Plymouth & Brockton Bus") is another privately-owned transportation company that runs four bus routes between Boston and Provincetown. One route runs from Hyannis to Boston's Logan International Airport via Barnstable, Sagamore, Plymouth, Rockland, and Boston. This route runs 16 times a day on weekdays with additional trips on the same route beginning and ending at South Station. These routes stop at Park and Ride lots on Route 6, providing daily service to Boston for commuters. On weekends the service runs 15 times a day. A second route connects from MacMillan Pier in Provincetown to New York City via New Bedford and Providence. An additional line connects the outer Cape from Provincetown to the Hyannis Transportation Center via North Truro, Truro, Wellfleet, South Wellfleet, North Eastham, Eastham, Orleans, and Harwich. A separate route extends from Logan Airport in Boston to the Hyannis Transportation Center. Both the Provincetown-to-Hyannis line and the Hyannis-to-New York line run twice daily in both directions. Peak period congestion on the Route 6 – Route 3 corridor, particularly along the approaches to the Sagamore Bridge, can contribute to reduced reliability of these bus services.

Peter Pan Bus Line

Peter Pan Bus Line is a privately-owned transportation company that provides weekend service between Cape Cod and Boston a minimum of five times daily, with increased frequency on weekdays and during the summer. One route runs from Woods Hole to Logan Airport via Falmouth, Bourne, Buzzards Bay, Wareham, and Boston. A second route runs from the MacMillan Pier in Provincetown to New York City via Barnstable, Bourne, New Bedford, Fall River, and Providence. Peak period congestion on the Route 6 – Route 3 corridor, particularly along the approaches to the Sagamore Bridge, can contribute to reduced reliability of these bus services.

Other Transit Authorities

In addition to the transit services offered on Cape Cod, Nantucket and Martha's Vineyard each have their own transit system that runs year-round. The Nantucket Regional Transit Authority runs the WAVE with ten routes that originate near the Steamship Authority dock in Nantucket. The Martha's Vineyard Regional Transit Authority runs 13 routes throughout the island's six towns.

2.6.5 Rail

The MBTA provides summer weekend service to Cape Cod (Cape Flyer) through the Middleborough/Lakeville commuter rail line. The service runs from South Station in Boston to the Hyannis Transportation Center with stops in Braintree, Brockton, Middleborough/Lakeville, Wareham Village, and Buzzards Bay. The total trip from Boston to Hyannis takes approximately 2 hours and 20 minutes and costs $22 one way and $40 round trip. During its first season, 2013, the service had 16,586 passenger trips from May through October. For 2014 and 2015, the train serviced 12,625 and 13,278 passenger trips, respectively, from May through September. Passenger trips increased in 2016 to 14,499, an average of 9.2% more passenger trips than 2015.

Cape Flyer traveling over the Cape Cod Canal
Source: Debee Tlumacki for the Boston Globe

2.6.6 Ferry Service

Ferries provide year-round connections from Cape Cod to Nantucket and Martha's Vineyard via terminals at Woods Hole or Hyannis. Seasonally, ferries also run between Boston and Provincetown's MacMillan Pier. The Steamship Authority (SSA) operates year-round service and licenses private ferry operators to provide year round and seasonal ferry services from the mainland to the islands. SeaStreak, LLC, and Hyannis Harbor Tours, Inc. (Hy-Line) each has a license agreement with the SSA to operate ferry service. Both agreements were amended for the 2016 season, as described below.

The Steamship Authority terminal at Woods Hole

The SSA amended the SeaStreak license agreement to allow two daily round trips Monday through Thursday, and three daily round trips Friday through Sunday, during the summer. The trips run directly between New Bedford and Nantucket (in addition to the summer high-speed passenger service that SeaStreak provides between New Bedford and Martha's Vineyard). The crossing from New Bedford through Buzzards Bay, Vineyard Sound, and Nantucket Sound takes just under two hours.

Hy-Line Cruises also operated in 2016 under an amended license agreement with the SSA to provide ferry service from Hyannis Harbor to Nantucket and Oak Bluffs, Martha's Vineyard and between the islands. Under the amended agreement, Hy-Line will retire its 520-passenger ferry, the Brant Point, which provided one daily round trip on a seasonal basis between Hyannis and Oak Bluffs. It will substitute the Brant Point with a new high-speed passenger ferry (with a capacity of 300-350 passengers) running up to five daily round trips between Hyannis and Oak Bluffs on a seasonal basis. Hy-Line will also provide up to three daily round trips with the Lady Martha on a seasonal basis between Oak Bluffs and Nantucket (inter-island service) in addition to providing one morning daily trip from Hyannis to Oak Bluffs and an evening daily trip from Oak Bluffs to Hyannis.

Freedom Cruise Line, Inc. runs ferries between Harwich Port and Nantucket from Memorial Day weekend through September. During June and September, the ferries run one round trip a day; in July and August the ferries run three round trips per day.

Bay State Cruise Company runs a ferry and fast ferry service from Boston to MacMillan Pier in Provincetown from mid-May through mid-October. The fast ferry runs three round trips a day, with an additional early Monday morning service. The traditional ferry runs one round trip during the first three Saturdays in July.

The SSA itself runs ferries year-round from Woods Hole to Martha's Vineyard and from Hyannis to Nantucket. Off-season ferries between Woods Hole and Vineyard Haven run 14 times a day. During the summer, ferries between Woods Hole and Vineyard Haven run nine to ten times a day with an additional four to five trips from Woods Hole to Oak Bluffs. The fare for adults is $8.50 one way and $17 round trip. The round-trip passage fare for vehicles ranges from $87 to $157 depending on the time of year and length of vehicle.

The SSA also runs a high-speed (60 minutes) passenger-only ferry from Hyannis to Nantucket. It runs four-round trips a day, April through mid-May and mid-October through December, and five round trips a day from late May through mid-October. The fare for adults is $36.50 one way and $69 round trip. Traditional ferry service also connects Hyannis to Nantucket. That ferry runs three round trips a day, mid-September through late May, and six round trips a day from late May through mid-September. The fare for adults is $8.50 one way and $17 round trip.

The SSA also runs ferries between Hyannis and Nantucket year-round. During the off season, September through May, the ferries run four round-trips per day. From June through August, they run six round-trips per day. All Steamship Authority ferries except the high-speed ferry carry passenger vehicles.

Steamship Authority Ferry Ridership

The number of passengers and automobiles transported by the SSA has increased significantly during a seven-year period, from 2011 to 2017 (Table 2-24). The only year-to-year decrease came between 2016 and 2017, when there was a slight decrease in the number of passengers and automobiles served. In comparison, the number of trucks carried on these routes decreased between 2011 to 2012, and subsequently increased each year between 2012 and 2017.

Table 2-24 shows that the SSA's vessels transported a total of 3,059,049 passengers, 481,425 automobiles, and 189,388 trucks of all sizes to and from the islands of Martha's Vineyard and Nantucket during 2017.

Table 2-25 presents a monthly summary of passengers transported on SSA vessels during 2016 and 2017. The lowest SSA passenger counts were experienced in the winter months

Table 2-24 Steamship Authority Ferry Ridership

	2011	2012	2013	2014	2015	2016	2017
Passengers	2,712,047	2,802,980	2,846,691	2,893,851	3,023,090	3,127,304	3,059,049
Automobiles	439,721	449,850	452,286	457,682	465,297	482,699	481,425
Trucks	154,380	153,757	162,148	166,577	172,861	182,099	189,388

Source: Massachusetts Steamship Authority

Table 2-25 Steamship Authority Ridership - Monthly Trends 2014 to 2015

	2016	2016	CHANGE
January	103,577	115,333	0.6%
February	104,494	103,861	-0.6%
March	130,505	120,872	-7.4%
April	185,330	199,140	7.5%
May	288,863	283,282	-1.9%
June	346,631	334,141	-3.6%
July	503,565	466,429	-7.4%
August	503,239	498,235	-1.0%
September	343,569	319,418	-7.0%
October	264,043	274,912	4.1%
November	179,606	183,154	2.0%
December	162,776	160,272	-1.5%
Total	**3,127,304**	**3,059,049**	**-2.2%**

Source: Massachusetts Steamship Authority

of January and February. The highest passenger counts, in both 2016 and 2017, were in July and August. There were significant decreases during March (-7.4%), July (-7.4%), and September (-7.0%). Though overall ridership decreased approximately 2% between 2016 and 2017, there was a significant increase during the month of April (+7.5%). There were also slight or moderate increases during several other months: January (+0.6%), October (+4.1%), and November (+2.0%).

Steamship Authority Capital Improvements (2015-2016)

The SSA completed several capital improvement projects in 2015, including the construction of a 1,900-space pervious-pavement parking lot on Landers Road in West Falmouth. This new lot allowed for the closure of two existing lots on Gilford Street in Falmouth, reducing traffic congestion in downtown Falmouth and creating a much more functional and efficient parking and shuttle bus operation for the SSA. The SSA also completed traffic-circulation improvements at its Vineyard Haven terminal.

The SSA christened a new ferry in June 2016. The M/V Woods Hole is a hybrid 235-foot vessel designed to carry up to 10 full-length tractor trailers trucks, 55 passenger vehicles, or some combination of both. The new boat can also carry 384 passengers, including a crew of nine. Finally, design and permitting for a multi-year, multi-phase reconstruction of the Woods Hole Terminal has been completed; construction of an initial phase is scheduled to start in early 2017.

Steamship Authority's New Bedford-to-Martha's Vineyard Freight Ferry Feasibility Study

In April 2016 the SSA completed a draft feasibility study of providing freight ferry service between New Bedford and Martha's Vineyard. As noted above, truckers destined to Martha's Vineyard currently cross one of the Canal highway bridges and make their way south through Falmouth to the SSA terminal at Woods Hole. The primary reason for considering freight ferry service from New Bedford is to divert trucking from the Woods Hole terminal, thereby reducing the number of trucks traversing Falmouth.

A prior 2000-2001 freight ferry pilot program was not financially successful, with collected revenues covering only 15% to 22% of the cost of the service. However, in 2015 the SSA decided to reexamine the issue and initiated a comprehensive study of potential freight service between New Bedford and Martha's Vineyard. The study examined numerous issues related to this potential service including whether it should be year-round or season and whether it should be financially self-supporting.

2.6.7 Airline Service

Barnstable Municipal Airport

The Barnstable Municipal Airport serves flights by two major airlines, Cape Air and JetBlue. Cape Air flies from Hyannis to Nantucket and Boston year-round up to 12 round-trip flights a day. From May through October the airline also flies from Hyannis to Martha's Vineyard. JetBlue Airlines flies one round trip a day between New York City and Hyannis seasonally.

The Martha's Vineyard Airport offers flights from four carriers: Cape Air, Delta, JetBlue, and American. These airlines fly direct to New York City, White Plains, Washington D.C., New Bedford, Boston, Nantucket, and Hyannis, though schedules vary seasonally. Tradewind Aviation also runs shuttle flights May through October to New York City and White Plains.

The same four airlines serve Nantucket Memorial Airport: Cape Air, Delta, JetBlue, and American. Flights from Nantucket to Hyannis, Martha's Vineyard, Boston, and New Bedford are available year-round, while White Plains flights run seasonally. Tradewind Aviation also runs shuttle flights, April through December, to New York City and White Plains.

The Provincetown Municipal Airport has flights through Cape Air year-round to Boston and June through September to White Plains.

2.6.8 Intelligent Transportation Systems

Intelligent Transportation Systems (ITS) refers to information technology applied to mitigate transportation congestion and improve traveler safety. These systems provide the public with the latest information on construction, traffic congestion, accidents, and weather via signs posted along the highway.

Real time traffic information sign along Route 6 in Orleans

In April 2014 a "GO Time" real time traffic information system became operational along Route 6 on Cape Cod. This system anonymously tracks Bluetooth signals from vehicles to measure average vehicle speeds and travel times between points. Approaching Cape Cod and along Route 6 across the Cape, permanent federal highways signs with embedded digital displays show projected travel times to exits. MassDOT intends to continue to improve the ITS infrastructure on Cape Cod in the future.

2.6.9 Park & Ride Lots

Park & Ride lots offer commuters and others the ability to carpool or use transit services on Cape Cod. Exhibit 2-46 shows the three Park & Ride lots within the study area and a fourth lot at Route 6 Exit 6. One is located at the Route 25 eastbound off-ramp at Exit 2 in Wareham. Operated by MassDOT, it has 120 spaces. Peter Pan Bus Lines operate a commuter bus service from Woods Hole to Logan Airport via South Station that stops at the Wareham lot twice on weekdays and once on weekends in each direction.

Exhibit 2-46 Rest Area and Park & Ride Lots in Study Area

A second Park & Ride lot in the study area, known as the Sagamore lot, is located north of the Cape Cod Canal at the southeast corner of the Route 3/Route 6 (Scenic Highway) interchange in Bourne. The lot is owned by MassDOT has a capacity of 377 vehicles. This lot is often at or near capacity year-round. The lot is serviced by the Plymouth & Brockton Bus Company, which runs buses from Hyannis to Boston, with stops including the Bourne Park & Ride lot.

The study team conducted a mid-week occupancy count at the Sagamore lot in October 2016. Their findings confirmed earlier counts, that the lot was 99% occupied. Finally, while outside the study area, a larger (365 spaces) Park & Ride lot is located at Route 6 Exit 6 in Barnstable. Based on this occupancy survey, it appears that the opportunity exists to either increase the number of parking spaces at existing park and ride lots or construct an additional park and ride lot along Route 6. Additional parking spaces, or a new parking lot located on-Cape would be preferable to reduce the need for vehicles to travel over the Sagamore Bridge.

2.6.10 Rest Areas

Rest areas provide locations for drivers to temporarily pull off major roads. They provide restroom facilities and tourist information. Exhibit 2-46 shows the rest areas within the study area. A tourist information center is located at the Park & Ride lot in the southeast corner of the Route 3/Route 6 (Scenic Highway) interchange, in Bourne. Another tourist information center is located between Exits 2 and 3 on Route 25 eastbound. In Sandwich, a small information center with parking sits north of Exit 2 off Route 6.

Along Route 6/Scenic Highway in Bourne there are two rest areas with parking and picnic tables and one at the Herring Run Recreation Center, owned and operated by the U.S. Army Corps of Engineers. This parking area also has paths that connect to the Cape Cod Canal Trail for recreational use.

2.7 SUMMARY OF EXISTING CONDITIONS

Chapter 2 provided a description of the existing natural and cultural conditions in the study area including the existing natural and cultural environmental resources, land uses, socio-economic conditions, public health and transportation.

Natural Environmental Resources

The study area features an abundance of natural environmental resources particularly coastal and inland wetlands north and south of the Canal. Project area wetlands, floodplain, and waterbodies such as the Canal, Herring Pond, Buttermilk Bay are critical for supporting recreation, fishing, shellfishing, wildlife habitat, and flood control.

Rare species habitat is prevalent throughout the study area, particularly within Joint Base Cape Cod and the Shawme-Crowell State Forest. The rare species include a wide variety of turtles, reptiles, birds, butterflies, moths, mussels, and plants. Numerous certified and potential vernal pools also exist throughout the study area.

The study area also features two Areas of Critical Environmental Concern (ACEC); the Bourne Back River and the Herring River ACECs. Aquifers on Cape Cod are a particularly sensitive resource as they are part of a designated drinking water sole source aquifer.

Social Environmental Resources

The study area features numerous social environmental resources such as historic sites and open space.

Concerning historic resources, the study area, including Bourne, Plymouth, Sandwich, and Wareham, is rich in historic resources and open space properties. The historic sites include the Bourne and Sagamore Bridges, the Old Kings Highway Regional Historic District in Sandwich, and the Jarvesville, Town Hall Square, and Spring Hill National Historic Districts in Sandwich. Several public buildings are Bourne are individually listed on the National Register of Historic Places including the Bourne High School, the Jonathon Bourne Public Library, Bourne Town Hall.

There are many publicly- and privately-owned parcels which are protected as open space. These publicly- and privately-owned properties serve a wide variety of purposes, including watershed protection, wildlife habitat, conservation, recreation, public beaches, marinas, and camping. Open space properties in the study area include the Scusset Beach State Reservation, Shawme-Crowell State Forest, Upper Cape Water Supply Reserve, Cape Cod Canal Recreation Area, Gallo Skating Rink, Carter Beal Conservation Area, Sacrifice Woods Rock, and the Nightingale Pond Recreation Area.

The predominately-forested Joint Base Cape Cod dominates the central portion of the study area. The numerous historic and archaeological sites reflect the area’s long and rich history. While these environmental resources contribute to the great appeal of Cape Cod, they also represent a constraint on future transportation improvement alternatives.

Socio-Economic Conditions and Public Health

Socio-economic conditions in Barnstable County (Cape Cod) are in transition. After several decades of rapid population and employment growth, the county has experienced a population decline since 2000. The demographics of this population is also shifting to a higher percentage of senior citizens and a lower percentage of working adults and school-age children. The unemployment rate in Barnstable County is similar to the rate in Massachusetts as a whole, but it fluctuates widely during the year, with a lower rate during the summer tourist season and a higher rate during the off season. The unemployment rate generally held steadier closer to the Canal area (and employment centers in Plymouth County and beyond).

The predominate health problems in Barnstable County include asthma, heart disease, diabetes, and depression. The method workers use to commute to work is an important issue in Barnstable County. Nearly 90% of commuters use private automobiles to travel to work. Crossing the two roadway bridges over the Canal represents an important part of the daily commute for many residents in Barnstable County. Nearly 34,000 commuters cross one of the Canal bridges each work day as part of their daily commute, including over 32% of workers in Bourne and 19% of workers in Sandwich.

Utilities

Important utility corridors cross the study area. These include an electrical utility corridor which transmits electricity through transmission towers from the Canal Generating Plant in Sandwich northwest across the Canal and east to Cape Cod customers. Natural gas enters Cape Cod within a pipe network that crosses the Canal attached to the Canal bridges. Natural gas compressor stations are located close to both the Sagamore and Bourne Bridges.

Joint Base Cape Cod

South of the Canal, Joint Base Cape Cod (JBCC) is a nearly 21,000-acre full scale, joint-use base home to five military commands training for missions at home and overseas, conducting airborne search and rescue missions, and intelligence command and control.

Multimodal Facilities

Cape Cod is well served by multimodal facilities including transit, air, bicycle and pedestrian facilities. Transit services on Cape Cod include public- and private-bus services and seasonal commuter rail. The Hyannis Transportation Center serves as an important regional transportation hub. Barnstable Municipal Airport provides airline service to Nantucket, Boston, New York and beyond. The Massachusetts Steamship Authority provides a robust ferry service with regular ferries between Cape Cod and Nantucket and Martha's Vineyard. Seasonal ferry service is also provided between Provincetown and Boston.

Sidewalks are generally present for pedestrians in more densely developed residential and commercial areas but absent elsewhere. Sidewalks along major travel corridors in the focus area include those along the southern side of Scenic Highway from Nightingale Road west along the southern edge of Belmont Circle and continuing through the Main Street business district in Bourne.

Many other roads in the study area are narrow (20–22 feet) and lack sidewalks. This presents difficulties for pedestrians, particularly the elderly or those with disabilities. Major roadways in the study area, such as Route 28, Route 151, Route 130, Buzzards Bay Bypass, Sandwich Road, Tupper Road, Shore Road, County Road, and Scenic Highway (except in the immediate area of the Route 3 interchange) generally lack sidewalks.

Existing bicycle facilities in the study area include the USACE's Cape Cod Canal bike paths, which runs on both the north and south sides of the Canal. While somewhat outside of the study area, the Shining Sea Bike Path runs through Falmouth along an out-of-service Woods Hole Branch rail right-of-way. The path runs for 10.6 miles from the Steamship Authority terminal in Woods Hole to County Road (Route 151) in Falmouth. An on-road bike route is designated on Route 6A in Sandwich.

Traffic Study Findings

Existing traffic conditions during peak hours along highways in the focus area is often characterized by substantial traffic volumes and congestion (LOS D). There are also numerous roadway intersections that experience severe congestion (LOS E and F) during summer and non-summer peak hours. There are five HSIP high crash locations in focus area.

As described in Section 2.5.6, the highest daily and peak hour traffic volumes in the study area occur along the major highway corridors in the study area, including the Route 3/Sagamore Bridge/Route 6 corridor and the Route 25/Bourne Bridge/Route 28 corridor. Average daily traffic (ADT) on the bridges are generally 30% to 40% higher in the summer compared to the non-summer period. Traffic volumes range from 55,000 to 65,000 vehicles in the summer and 38,000 to 41,000 in the non-summer periods, with the Sagamore Bridge generally having the higher traffic volumes.

The roads connecting the bridge approaches (Scenic Highway north of the Canal and Sandwich Road south of the Canal) also experience high traffic volumes and congestion. This is the result of high traffic volumes within the focus area (not just travel through the focus area) and many travelers crossing from one of the travel corridor to the other.

Exacerbating this congestion is the inadequate capacity and sub-standard design at the intersections at the bridge approaches. These gateway intersections include Belmont Circle and Bourne Rotary (north and south of the Bourne Bridge) and Route 6 Exit 1C south of the Sagamore Bridge. These intersections and several others in the focus area experience extended queueing and poor LOS during the summer and non summer periods (see Sections 2.5.8 and 2.5.10). The roadway geometry on Route 3, including the dropping of a travel lane on Route 3 southbound and the narrow travel lanes with no roadway shoulder on the Sagamore Bridge, contributes to congestion and delays, especially during peak travel periods.

More frequent maintenance on the Canal bridges, with the resultant lane closures, also contributes to off-season traffic congestion. Congestion on the Canal bridges negatively effects the daily commute of the over 34,000 commuters who cross the Canal every work day.

2.8 ISSUES, CONSTRAINTS, AND OPPORTUNITIES

Based on the information gathered in Chapter 2, including existing natural and cultural environmental resources, socio-economic and demographic data, and the traffic study, a series of issues, constraints, and opportunities in the study area were identified (as listed below) which provide a framework for the alternatives development process described in Chapter 4.

Issues:

1. **Severe congestion at Gateway Intersections at Canal bridge approaches**

   Transportation conditions in the focus area are characterized by substantial congestion and delay, particularly during periods of high traffic volumes in the summer tourist season. Traffic conditions at the gateway intersections, including Belmont Circle, Bourne Rotary, the highway approaches to Route 6, and the Route 6 Exit 1C entrance ramp, are exacerbated by substandard roadway geometry. Peak period congestion also reduces the reliability of transit services.

This congestion may also negatively affect seasonal tourism as some people choose other, less congested vacation destinations.

Additionally, the roadway geometry on Route 3, including the dropping of a travel lane on Route 3 southbound and the narrow travel lanes with no roadway shoulder on the Sagamore Bridge, contributes to congestion and delays, especially during peak travel periods.

Peak period congestion in the Canal area affects the nearly 34,000 commuters who cross one of the Canal bridges each work day as part of their daily commute, including over 32% of workers in Bourne and 19% of workers in Sandwich.

2. **High Crash Rates in Study Area**

   Eight locations within the study area rank as high-crash locations under the Highway Safety Improvement Program (HSIP). This MassDOT designation identifies crash clusters that rank within the top five percent of their respective regional planning agency's crash locations. The locations in the study area with the highest crash rates include Belmont Circle, Bourne Rotary, and the intersections of Route 6A at Route 130 and Scenic Highway at Meetinghouse Lane.

3. **Balancing visitor and resident needs**

   It will be important to develop alternatives that improve regional travel while retaining the character of Cape Cod. Designing transportation improvements to accommodate the summertime peak period traffic levels would require very substantial infrastructure improvements, likely considered an 'over-build' not be in keeping with the type or scale of development desired on Cape Cod.

4. **Lack of population growth and aging population**

   Peak period congestion, particularly at the Canal bridges, decreases the reliability of the transportation system. This inhibits the growth of Cape Cod businesses and may contribute to the stagnation of population growth. The population of Barnstable County has not grown since 2000 and has actually experienced a minor population decrease. Age cohorts in the county have also shifted since 2000 with a substantial decrease in the population of working-age adults and school-age children with a corresponding increase in senior citizens.

5. **Lack of bicycles and pedestrian accommodation and connections**

   The study area suffers from a lack of bicycle and pedestrian facilities and connections between the existing facilities. Other than the Canal bike path, there are few bicycle facilities in the study area. Accessible connections to the Canal path are often lacking. Sidewalks for pedestrians are also often absent outside of more densely developed residential and commercial areas in Bourne and Sandwich. This lack of sidewalks is especially problematic along bus routes in the study area.

Constraints:

1. **Extensive areas of sensitive environmental resources**

   The abundance of natural and social environmental resources in the study area. Natural environmental resources include coastal and inland wetlands north and south of the Canal; Herring Pond, Buttermilk Bay and other waterbodies; floodplains, and rare species.

   Areas of Critical Environmental Concern (ACEC), recreational, commercial fishing and shellfishing, and the numerous historic sites in the study area also represent a constraint on future transportation improvements. Aquifers on Cape Cod are a particularly sensitive resource as they are part of a designated sole source aquifer.

   Social environmental constraints include publicly- and privately-owned open space parcels, including the Scusset Beach State Reservation, Shawme-Crowell State Forest, Upper Cape Water Supply Reserve, Cape Cod Canal Recreation Area, Gallo Skating Rink, Carter Beal Conservation Area, Sacrifice Woods Rock, and the Nightingale Pond Recreation Area.

   Historic resources in the study area also represent a constrain to transportation improvements. The historic sites include the Bourne and Sagamore Bridges, the Old Kings Highway Regional Historic District in Sandwich, and the Jarvesville, Town Hall Square, and Spring Hill National Historic Districts in Sandwich.

2. **Developed residential and commercial area**

   Outside of areas of natural environmental resources, much of the study area contains dense residential and commercial development. This development along the region's major roadways represents a constraint of the expansion of these transportation facilities.

3. **Joint Base Cape Cod (JBCC, including the Upper Cape Water Reserve)**

   The 22,000 acres of JBCC, particularly the 15,000 acres of JBCC designated as the Upper Cape Water Reserve, represent a constraint on transportation improvements as use of this land for transportation purposes would require approval of the Massachusetts National Guard and the Massachusetts Legislature.

Opportunities:

1. **Collaboration between MassDOT and U.S. Army Corps of Engineers (USACE)**

   An opportunity for collaboration exists between MassDOT and the USACE to work together to exchange information to allow a more cost-effective and timely advancement of their agency and community transportation goals.

2. **Reduced Peak Period Congestion and Crash Rates**

   The opportunity exists to reduce peak period congestion and crash rates in the study area, reducing costs related to lost time commuting to work, school, shopping, etc. Reduced peak period congestion also increases the attractiveness of study area transit services by reducing travel times and improving reliability. Reducing crash rates would reduce the risk of property or injury for residents, workers, and visitors in the study area.

3. **Enhance multimodal accommodation**

   The opportunity exists to enhance multimodal transportation accommodation in the study area. While there is a robust transit network in the study area, including bus and ferry service, providing more accessible sidewalks and bicycle lanes, especially along bus routes, would encourage people to use other transportation modes. An additional multimodal facility (park and ride lot) on Route 6 in the study area could address demand for commuter car-pooling and bus travel.

4. **Improve employment opportunities**

   Improving transportation mobility on- and off-Cape Cod provides the opportunity to increase year-round employment on Cape Cod, reducing the seasonal variability in the unemployment rates.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DRAFT FOR REVIEW - SUMMER 2019

CAPE COD CANAL
TRANSPORTATION STUDY

Prepared by:
Stantec

CONTENTS

EXHIBITS

TABLES

Future No-Build Transportation Conditions

3.1 INTRODUCTION

This chapter analyzes future (2040) no-build traffic conditions in the study area. Highway system improvements are typically designed to satisfy traffic demands forecast for 25 years in the future. As the traffic analysis for this study began in 2015, the year 2040 was selected as the design year. This analysis assumes that no substantial transportation improvements will be made in the study area between now and 2040, such as the construction of additional travel lanes, as well as new or reconstructed interchanges, intersections, or multimodal facilities. This 'no-build' alternative serves as the baseline for the comparison of future transportation improvements.

This transportation analysis includes:

- Average daily and peak-period traffic volumes to provide a better understanding of the locations that experience the most vehicular activity. Traffic volumes are provided for different times of day, on both weekends and weekdays, and during the summer and non-summer periods.

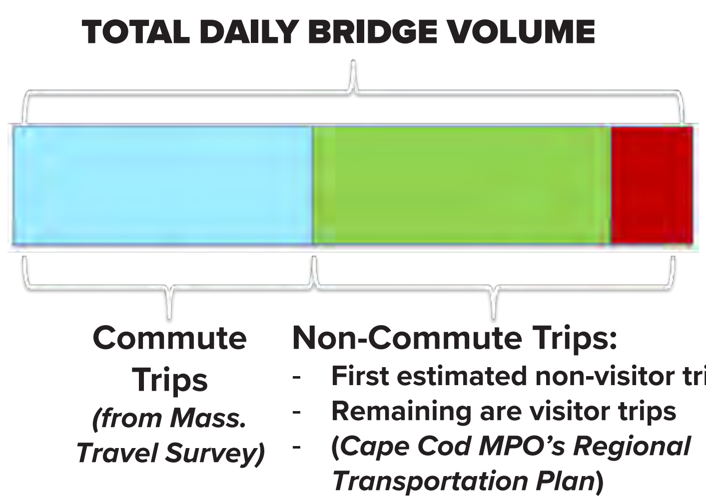
- Turning movement counts to quantify the movement of vehicles traveling through intersections.
- Measurements of efficiency (levels of service), including an analysis of traffic operations for a range factors, as described in Section 2.5.5.
- Detailed analysis of traffic operations of the Bourne Rotary and Belmont Circle.

3.2 FACTORS AFFECTING FUTURE TRANSPORTATION CONDITIONS

Projecting future travel demand requires an understanding of the socio-economic factors that lead to changes in traffic volumes. The primary contributors to traffic volumes in most locations are the daily commuting trips to work and school combined with non-commuting trips related to daily shopping, recreation, and other local destinations. As a major tourist destination, visitor travel to Cape Cod can contribute approximately 35% more vehicles on the Canal bridges during the summer compared to the non-summer. Therefore, as demonstrated in Exhibit 3-1, overall traffic volumes have two main components, daily local (commuting/non-commuting) trips and visitor trips.

The forecast 2040 commuter/non-commuter trips used for this study are based on socio-economic data provided by the Central Transportation Planning Staff (CTPS)[1] of the Boston Metropolitan Planning Organization (MPO). This socio-economic data is based

Exhibit 3-1 Visitors as a Percent of Traffic on Cape Cod Canal Bridges CTPS Method



1 Destination 2040, Long-Range Transportation Plan, Boston MPO, Central Transportation Planning Staff

on forecast changes in population, employment, and housing. Known future developments, which would increase population and employment, are also included in this forecast. Increases (or decreases) in population and employment lead directly to similar changes in traffic volumes as more (or less) people are commuting to work or school or other daily trips.

The socio-economic data indicated only modest changes in the forecast population and employment levels in Barnstable County. The population of Barnstable County decreased by 2.8% between 2000 and 2010 but is forecast to increase very modestly (less than 1.0%) in this decade. Total employment in Barnstable County is also not projected to substantially increase in the coming decade.

Unlike commuter and non-commuter trips, there is no direct method to count visitor trips to Cape Cod. To estimate the changes in the volume in visitor trips, a non-direct method was used based on an economic analysis of trends in the hotel and restaurant industry as well as other factors. Based on this economic analysis, annual visitor trips to Cape Cod were forecast to increase within a range of 0.26% to 0.69% annually. To provide a conservative estimate, the higher 0.69% annual growth in visitors was used to forecast the growth in traffic volumes attributable to visitors. Based on multiple coordination sessions with the Cape Cod Commission, it was agreed that this was a reasonable forecast of visitor growth.

Overall, the combined forecast increase for all trips results in a 0.11% annual increase in vehicle trips during the non-summer weekday period and a 0.50% annual increase during the summer weekend (Friday - Sunday) period. This would result in an overall growth in traffic volumes of 30% in the summer period and 26% in the non-summer period between 2014 and 2040. These growth factors were applied to the existing (2014) traffic volumes to calculate future (2040) traffic volumes. A travel demand model (described below) was used to evaluate future no-build and build conditions.

By 2040, traffic volumes in the study area are forecast to increase 30% in the summer period and 26% in the non-summer period.

3.3 TRANSPORTATION

3.3.1 Regional Travel Demand Modeling

Future (2040) no-build traffic conditions in the study area were forecast using a regional travel demand model. To develop a transportation model of the study area, the Cape Cod Commission's (CCC) regional traffic model and portions of the CTPS regional traffic model were obtained. The network links for highways and transit, as well the existing traffic analysis zone

(TAZ) geographies, were reviewed and the model was updated as necessary within the study area. As described in Chapter 4, the travel demand model was also used to test the effectiveness of proposed transportation improvements.

A crucial step in the process of creating a regional travel-demand model is calibrating the model to replicate travel times on key routes crossing the Canal and existing traffic volumes on study area highways. The model-calibration not only replicates existing traffic counts but also attempts to match travel time data collected during the peak season by the BlueTOAD™ units (as described in Section 2.5.4.)

The model-calibration process gives the model the ability to assign traffic to specific routes through the study area during a wide variety of time ranges during summer and non summer periods. The model was calibrated to within 5% of the existing total two-way volumes on the two bridge crossings, in accordance with Federal Highway Administration (FHWA) and MassDOT guidelines.

3.3.2 Planned Transportation Improvements

To further refine the analysis of study area's transportation system, known planned transportation improvements were identified. The following projects within the study area are anticipated to be constructed as they are listed on the Cape Cod Commission's 2017 – 2021 Transportation Improvement Program (TIP).

- Sandwich (MassDOT Project No. 608422) Service Road Shared-Use Bike Path from Route 130 to Chase Road
- Bourne (MassDOT Project No. 606900) Belmont Circle Multimodal Improvements
- Wareham (MassDOT Project No. 608554) Resurfacing on Route 6 & 28 Bypass Road

3.3.3 Cape Cod Commission Regional Transportation Plan

The Cape Cod Commission serves as the Metropolitan Planning Organization (MPO) for Barnstable County. The MPO's Regional Transportation Plan (2016 – 2040) was reviewed to gain an understanding of the regional future priorities for all modes of transportation on Cape Cod. The following projects within the study area are listed in the MPO's long range plan.

Highway/Roadway Improvements:

- Belmont Circle to Route 25 Westbound Ramp
- Route 6 Exit 1C Reconfiguration
- Buzzards Bay Commuter Rail Infrastructure

Multimodal Improvements:

- Cape Cod Rail Trail Extension: Barnstable to Cape Cod Canal
- Shining Sea Bike Path Extension to Cape Cod Canal

The AM weekday peak period is 7:00 - 9:00AM; the PM weekday peak period is 4:00 - 6:00PM; and the Saturday peak period is 10:00AM - 12:00PM.

3.3.4 Future (2040) No-Build Average Daily Traffic Volumes and Peak-Period Traffic Volumes

This section presents the future (2040) no-build average daily traffic (ADT) volumes and the peak hour traffic volumes in the study area. Table 3-1 provides future ADT and peak-hour traffic volumes for the AM, PM, and Saturday periods for both summer and non-summer traffic. Exhibits 3-2 and 3-3 present future

Table 3-1 Future (2040) No-Build Average Daily Traffic and Peak Hour Traffic Volumes

ATR COUNTING STATIONS	FUTURE (2040) NO-BUILD SUMMER				FUTURE (2040) NO-BUILD NON-SUMMER			
	AM	PM	SAT	ADJUSTED ADT[1]	AM	PM	SAT	ADJUSTED ADT[1]
Bourne Bridge	4,215	5,945	4,930	61,600	3,780	4,045	4,480	45,200
Sagamore Bridge	6,305	7,635	8,175	93,300	4,870	5,660	5,470	59,600
Route 3 between Exits 1A and 2	4,895	6,430	5,530	72,400	3,910	4,890	4,840	51,800
Route 6 between Exits 1 and 2	6,115	7,705	7,565	90,600	4,665	5,370	5,535	51,800
Route 25 West of Exit 2	5,735	8,455	7,845	78,900	4,580	5,340	5,900	56,800
Route 25 East of Exit 2	4,595	6,940	5,240	26,200	3,940	3,960	4,235	19,700
Route 6 (Scenic Hwy) East of Nightingale Rd	2,895	3,695	2,810	36,200	2,435	2,735	2,590	25,400
Sandwich Rd East of Bourne Rotary Connector	2,435	2,935	2,400	33,400	2,105	2,185	2,680	28,100
Adams St South of Sandwich Rd	400	350	275	11,800	345	380	420	13,900
Buzzards Bay Bypass	570	760	810	8,800	505	845	830	6,000
Main St West of Perry Ave	2,065	2,395	2,680	28,500	1,080	1,375	1,155	11,600
Trowbridge Rd West of Veterans Way	885	1,465	895	12,000	890	1,035	1,175	9,900
Route 28 South of Bourne Rotary	3,820	3,715	4,685	49,000	3,330	2,580	3,685	40,100
Route 130 North of Route 6	845	980	1,170	12,500	610	770	1,875	13,200
Route 6 between Exit 2 and 3	5,005	6,150	6,645	67,000	4,520	4,115	5,205	56,000
Mid-Cape Connector South of Sandwich Rd	1,380	1,855	1,800	28,500	1,380	1,600	1,825	18,100
Route 6 East of Exit 3	4,995	6,395	7,330	70,900	3,905	4,405	5,375	53,400
State Rd North of Ramp to Route 3 NB	450	710	785	8,200	445	610	745	6,200
Route 6A East of Cranberry Hwy	765	1,500	1,760	15,100	655	790	1,240	8,300
Route 3 between Exits 2 and 3	4,895	6,435	5,525	60,000	3,905	4,885	4,835	50,300
Route 28 South of Exit 2 (Route 151)	1,100	2,070	1,115	12,800	1,440	1,650	1,465	16,800

[1] *Average Daily Traffic (ADT)*

Table 3-1 continues on the next page.

Table 3-1 Future (2040) No-Build Average Daily Traffic and Peak Hour Traffic Volumes

ATR COUNTING STATIONS	FUTURE (2040) NO-BUILD SUMMER				FUTURE (2040) NO-BUILD NON-SUMMER			
	AM	PM	SAT	ADJUSTED ADT[1]	AM	PM	SAT	ADJUSTED ADT[1]
Route 3 NB Off Ramp to Herring Pond Rd	230	425	225	3,100	190	335	310	2,500
Route 3 SB Off Ramp to Herring Pond Rd	385	645	945	7,900	465	605	925	3,400
Route 3 SB Off Ramp to Scenic Highway	375	730	430	5,000	535	685	700	6,200
Route 6 EB Off Ramp to Mid-Cape Connector	710	815	800	8,600	655	730	515	5,900
Route 6 EB Off Ramp to Quaker Meeting House Rd	415	295	275	1,700	170	230	225	2,100
Route 6 EB Off Ramp to Route 130	695	995	735	15,700	685	935	670	7,200
Route 6 WB Off Ramp to Cranberry Hwy	410	660	220	3,800	405	510	535	2,400
Route 6 WB Off Ramp to Meetinghouse Lane EB	340	510	340	4,500	275	375	340	3,500
Route 6 WB Off Ramp to Quaker Meetinghouse Rd	125	345	655	2,300	240	400	265	2,500
Route 6 WB Off Ramp to Route 130	175	215	225	2,000	195	245	810	4,200
Route 6 WB Off Ramp to Scenic Hwy WB	830	990	1,350	13,400	720	765	615	6,800
Route 25 EB Off Ramp to Belmont Circle	665	1,280	1,025	11,200	590	835	565	5,500
Route 25 EB Off Ramp to Maple Springs Rd	695	1,055	1,745	14,800	510	770	920	8,000
Route 28 NB Off Ramp to Route 151	25	285	80	600	105	230	130	1,500
Route 28 SB Off Ramp to Route 151	385	900	550	5,500	455	685	475	5,500
Route 130 On Ramp to Route 6 EB	165	135	145	1,800	185	160	155	1,400
Route 130 On Ramp to Route 6 WB	755	910	550	12,300	815	725	625	6,800
Route 130 South of Route 6	2,045	2,555	2,025	28,600	1,970	2,235	2,345	21,100
Route 151 On Ramp to Route 28 NB	535	660	385	5,500	620	540	620	6,500
Route 151 On Ramp to Route 28 SB	155	225	100	1,600	260	230	240	2,600
Belmont Circle On Ramp to Bourne Bridge	800	785	1,115	11,800	825	785	1,175	9,800
Belmont Circle On Ramp to Route 25 WB	1,110	1,335	940	12,200	925	1000	1,070	9,600
Bourne Bridge Off Ramp to Belmont Circle	595	835	540	7,100	530	730	705	6,700
Scenic Hwy EB On Ramp to Sagamore Bridge	705	815	955	11,100	670	590	485	5,200
Scenic Hwy WB On Ramp to Sagamore Bridge	305	310	740	6,700	295	255	345	3,500
Sandwich Rd West of Jillian Drive	2,255	2,840	2,395	34,600	2,055	2,225	2,610	29,800
Sandwich Rd East of Adams St	1,095	1,505	1,365	14,900	1,030	1,255	1,275	9,200
Cranberry Hwy On Ramp to Route 6 WB	685	790	1030	11,100	585	780	1,020	8,500
Mid Cape Connector On Ramp to Route 6 EB	795	1,015	1,000	12,500	630	710	1,065	9,400
Herring Pond Rd On Ramp to Route 3 NB	425	455	445	5,500	735	460	575	6,300
Herring Pond Rd On Ramp to Route 3 SB	495	615	720	7,800	385	605	330	7,200
Quaker Meeting House Rd On Ramp to 6 EB	410	345	410	4,400	490	260	305	3,500
Quaker Meeting House Rd On Ramp to Route 6 WB	130	150	85	1,100	200	145	175	1,600
Glen Charlie Rd On Ramp to Route 25 EB	155	255	195	2,000	360	150	95	1,400
Maple Springs Rd On Ramp to Route 25 WB	820	1,050	1,275	11,000	780	610	990	8,700

[1] Average Daily Traffic (ADT)

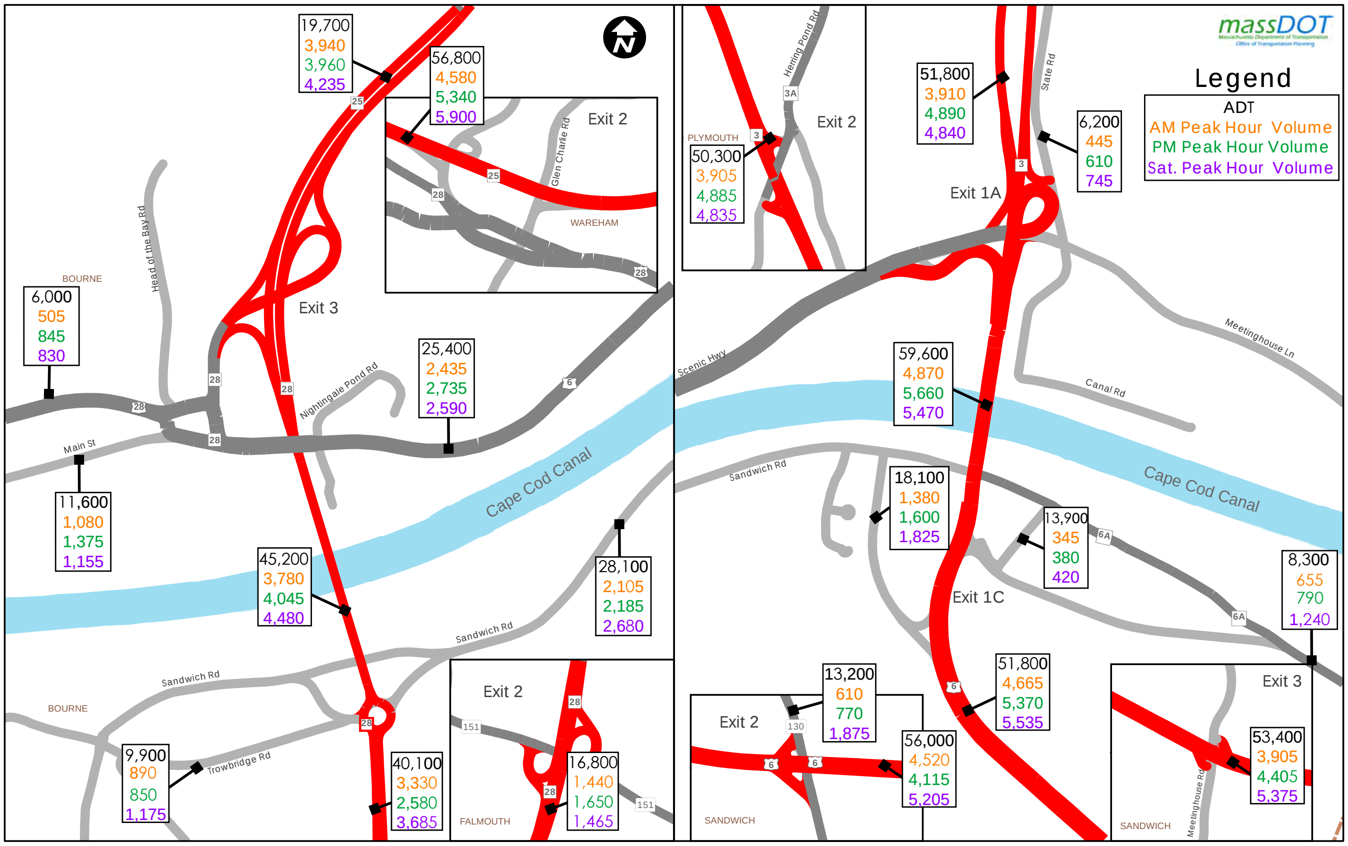
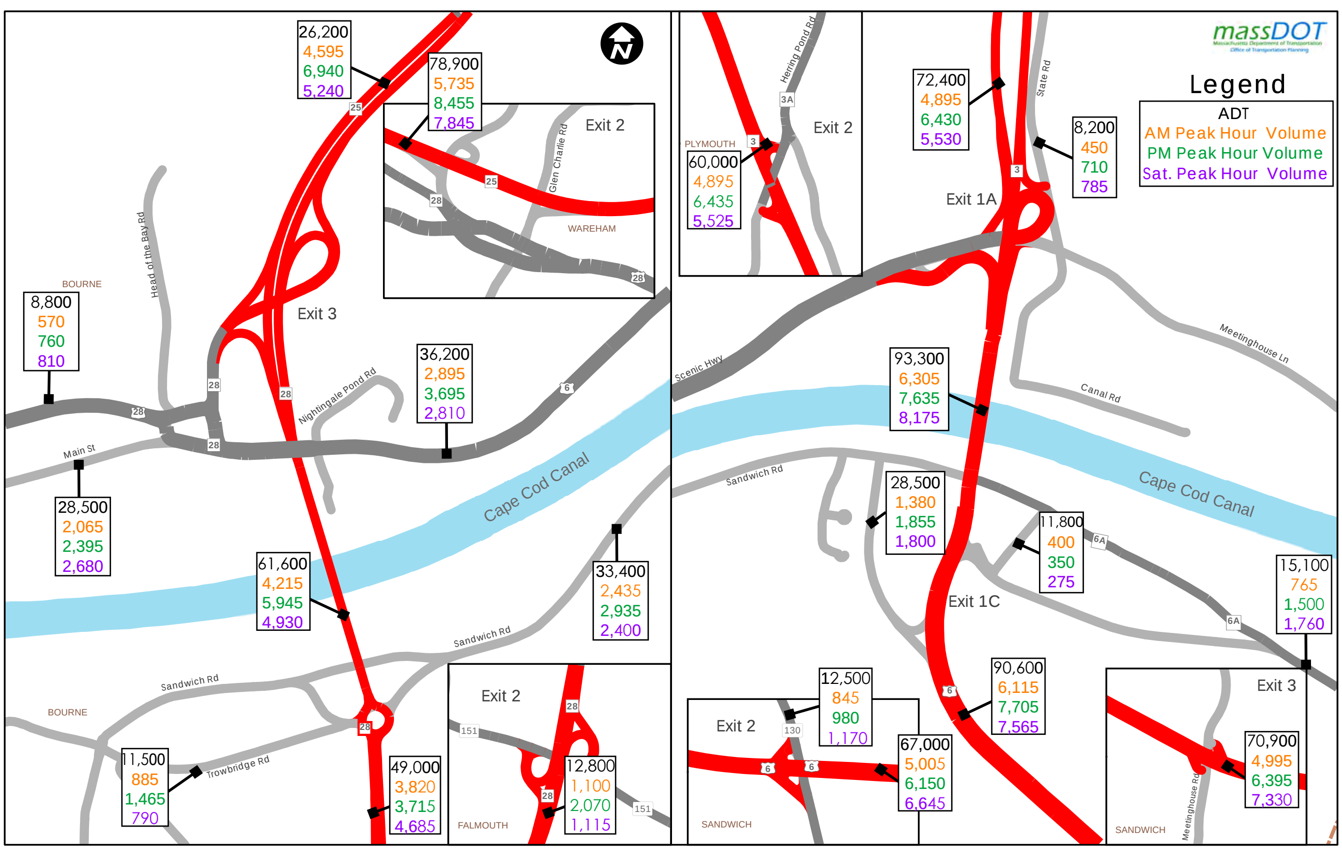


Exhibit 3-2 Future (2040) Non-Summer Average Daily and Peak Period Traffic Volumes (AM/PM/Saturday)

Exhibit 3-3 Future (2040) Summer Average Daily and Peak Period Traffic Volumes (AM/PM/Saturday)



summer and non-summer ADT and the AM, PM, and summer peak-hour traffic volumes at select locations in the study area. The ADT and peak-period traffic volumes for the existing condition are discussed in Chapter 2.5.6.

These exhibits show that, similar to the existing condition, the highest daily and peak-hour traffic volumes in the study area occur at the following locations:

- Major bridges (Sagamore and Bourne Bridges)
- Major highways (Routes 3, 6, 25, 28, and 130)
- Arterial roadways (Scenic Highway, Sandwich Road, and Main Street in Bourne).

Summary of Future ADT

As noted in Section 3.2, traffic volumes in the study area are forecast to increase approximately 30% in the summer period and 26% in the non-summer period between 2014 and 2040. This growth in traffic volumes will not be uniform throughout the study area; some locations will experience greater rates of growth than others.

Locations forecast to experience the greatest increase in traffic volumes include the Sagamore Bridge and other roadways in the immediate area of the bridge such as Route 3 (between Exits 1A & 2), Route 6 (between Exits 1 & 2), the Mid-Cape Connector, and State Road. Other areas of notable forecast traffic increases include Trowbridge Road, Route 28 (south of the Bourne Rotary), and Route 6 (between Exits 2 and 3). Table 3-2 also shows that traffic volumes are generally forecast to increase more in the non-summer period than in the summer period.

3.3.5 Turning Movement Counts

Turning movement counts (TMC) quantify the movement of vehicles traveling through intersections, including signalized intersections, stop-controlled intersections, and rotaries. The methodology for determining TMCs is provided in Section 2.5.3 and Exhibit 2-19 shows the location of the intersections for which TMCs are provided. Exhibits 3-4 through 3-9 display future (2040) TMCs for the AM, PM, and Saturday peak hours during the summer and non summer periods.

Turning Movement Counts are important to traffic analysis because they provide the data necessary to analyze delay and queuing at an intersection. These data allow a LOS to be assigned for that location. The future (2040) TMCs are used to assign a LOS at signalized and unsignalized intersections in the study area (as presented in Section 3.3.6).

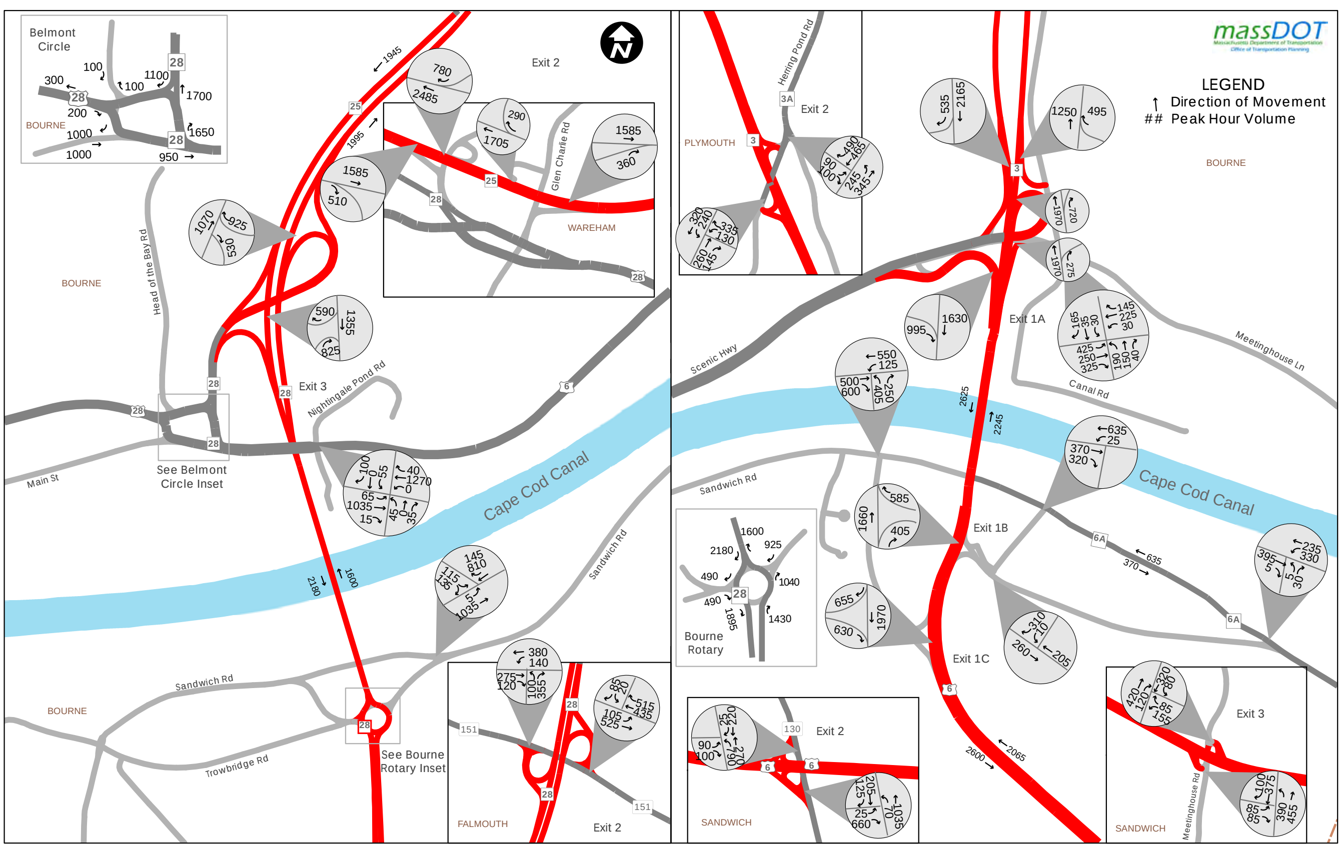
Text continues on page 3-12.

Table 3-2 *Growth in Average Daily Traffic (ADT) at Key Locations 2014 - 2040*

ATR COUNTING STATIONS	EXISTING (2014)		FUTURE (2040)		PROJECTED GROWTH	
	SUMMER ADT[1]	NON-SUMMER ADT[1]	SUMMER ADT[1]	NON-SUMMER ADT[1]	SUMMER ADT[1]	NON-SUMMER ADT[1]
Bourne Bridge	56,500	38,000	61,600	45,200	9%	19%
Sagamore Bridge	65,900	41,400	93,300	59,600	42%	44%
Route 3 between Exits 1A and 2	51,600	29,900	72,400	51,800	40%	73%
Route 6 between Exits 1 and 2	72,300	39,600	90,600	51,800	25%	31%
Route 25 West of Exit 2	62,900	42,900	78,900	56,800	25%	32%
Route 25 East of Exit 2	24,500	16,900	26,200	19,700	7%	17%
Route 6 (Scenic Hwy) East of Nightingale Rd	33,600	21,000	36,200	25,400	8%	21%
Sandwich Rd East of Bourne Rotary Connector	30,800	22,600	33,400	28,100	8%	24%
Adams St South of Sandwich Rd	7,600	7,600	11,800	13,900	55%	83%
Buzzards Bay Bypass	7,900	6,000	8,800	6,000	11%	0%
Main St West of Perry Ave	25,600	11,900	28,500	12,120	11%	2%
Trowbridge Rd West of Veterans Way	7300	6,300	11,500	9,900	58%	57%
Route 28 South of Bourne Rotary	42,500	34,800	49,000	40,100	15%	15%
Route 130 North of Route 6	12,200	9,300	12,500	13,200	2%	42%
Route 6 between Exit 2 and 3	56,400	41,600	67,000	56,000	19%	35%
Mid-Cape Connector South of Sandwich Rd	19,100	15,300	28,500	18,100	49%	18%
Route 6 East of Exit 3	57,000	44,900	70,900	53,400	24%	19%
State Rd North of Ramp to Route 3 NB	5,700	4,700	8,200	6,200	44%	32%
Route 6A East of Cranberry Hwy	12,400	7,500	15,100	8,300	22%	11%
Route 3 between Exits 2 and 3	44,600	37,400	60,000	50,300	35%	35%

[1]*Average Daily Traffic (ADT)*

Exhibit 3-4 Future (2040) Non-Summer Weekday AM Turning Movements



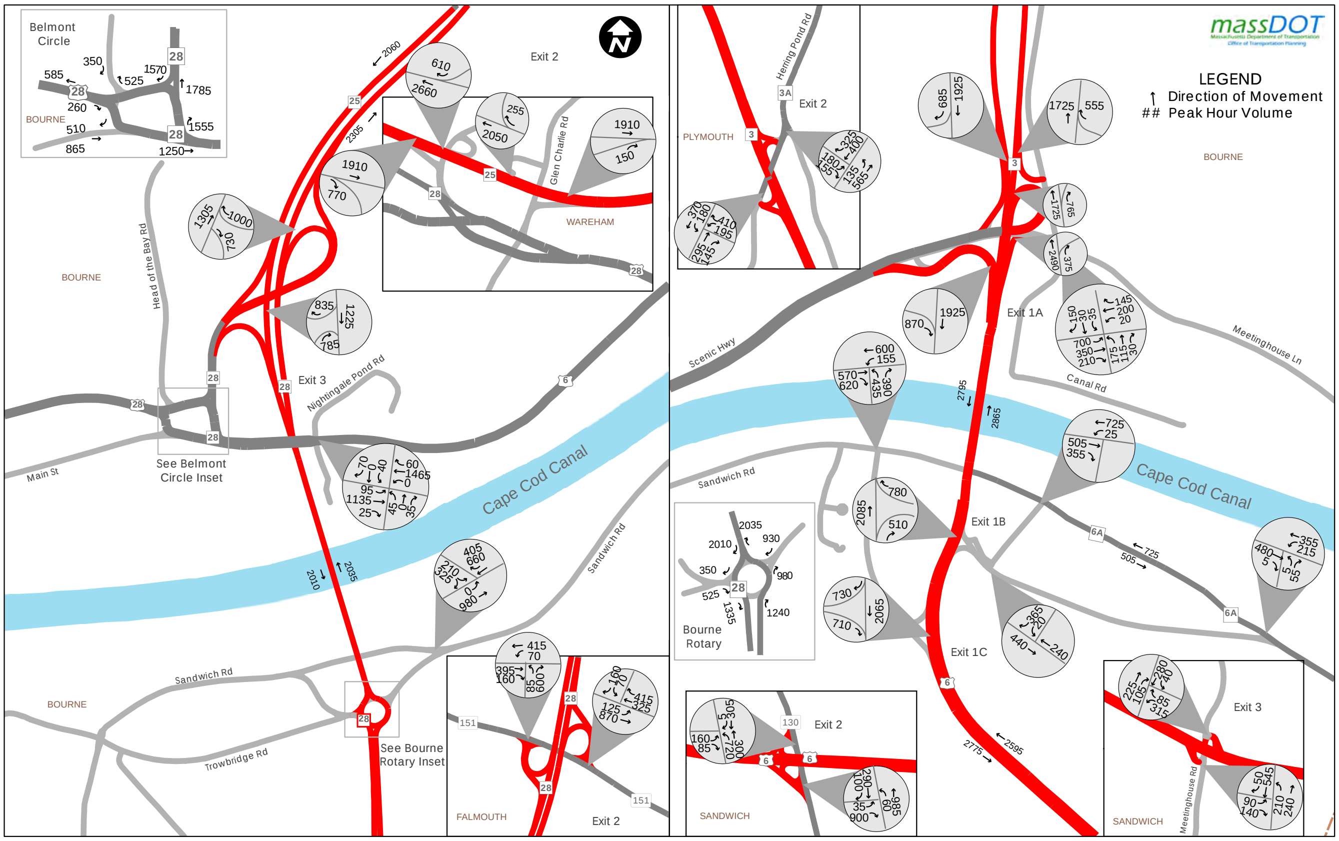
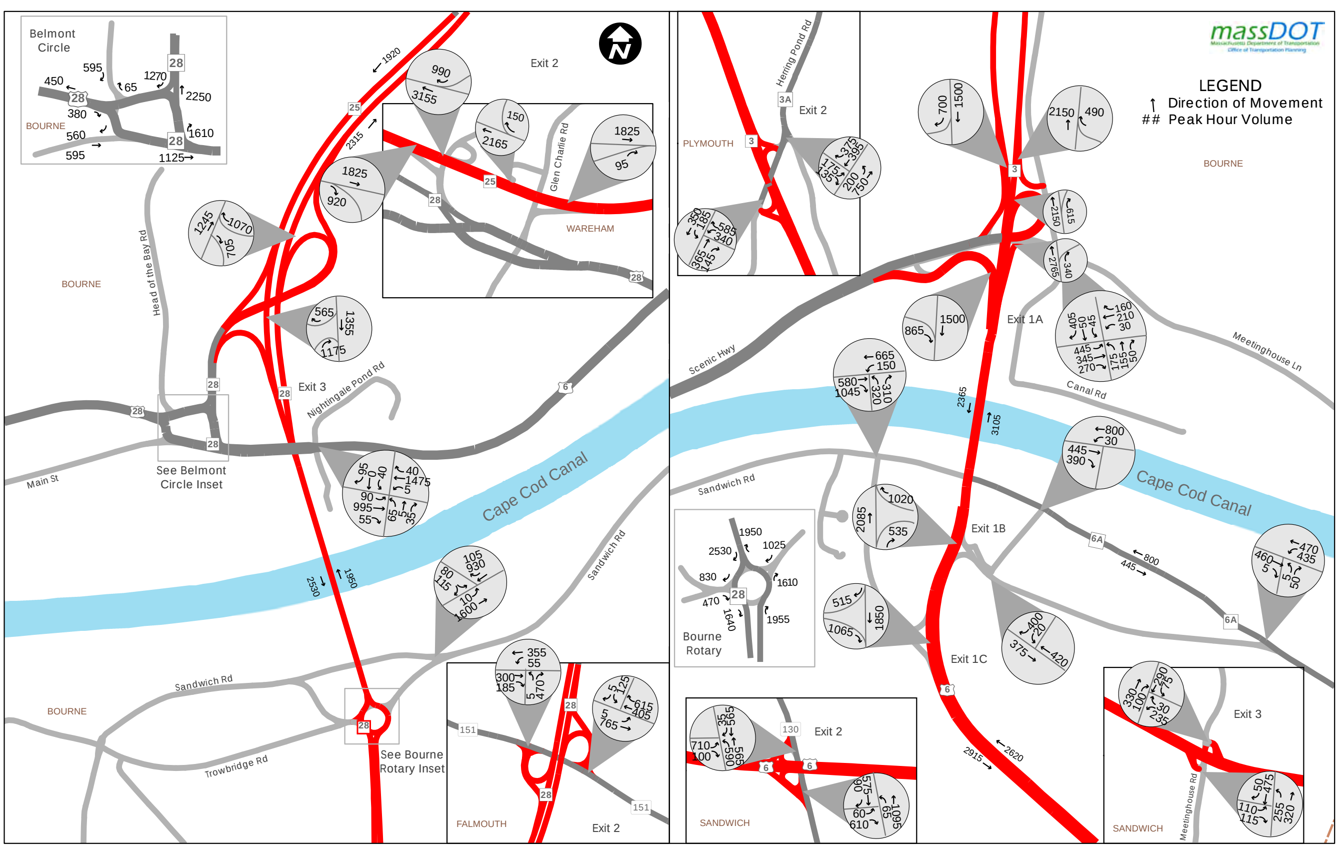


Exhibit 3-5 Future (2040) Non-Summer Weekday PM Turning Movements

Exhibit 3-6 Future (2040) Non-Summer Saturday Turning Movements



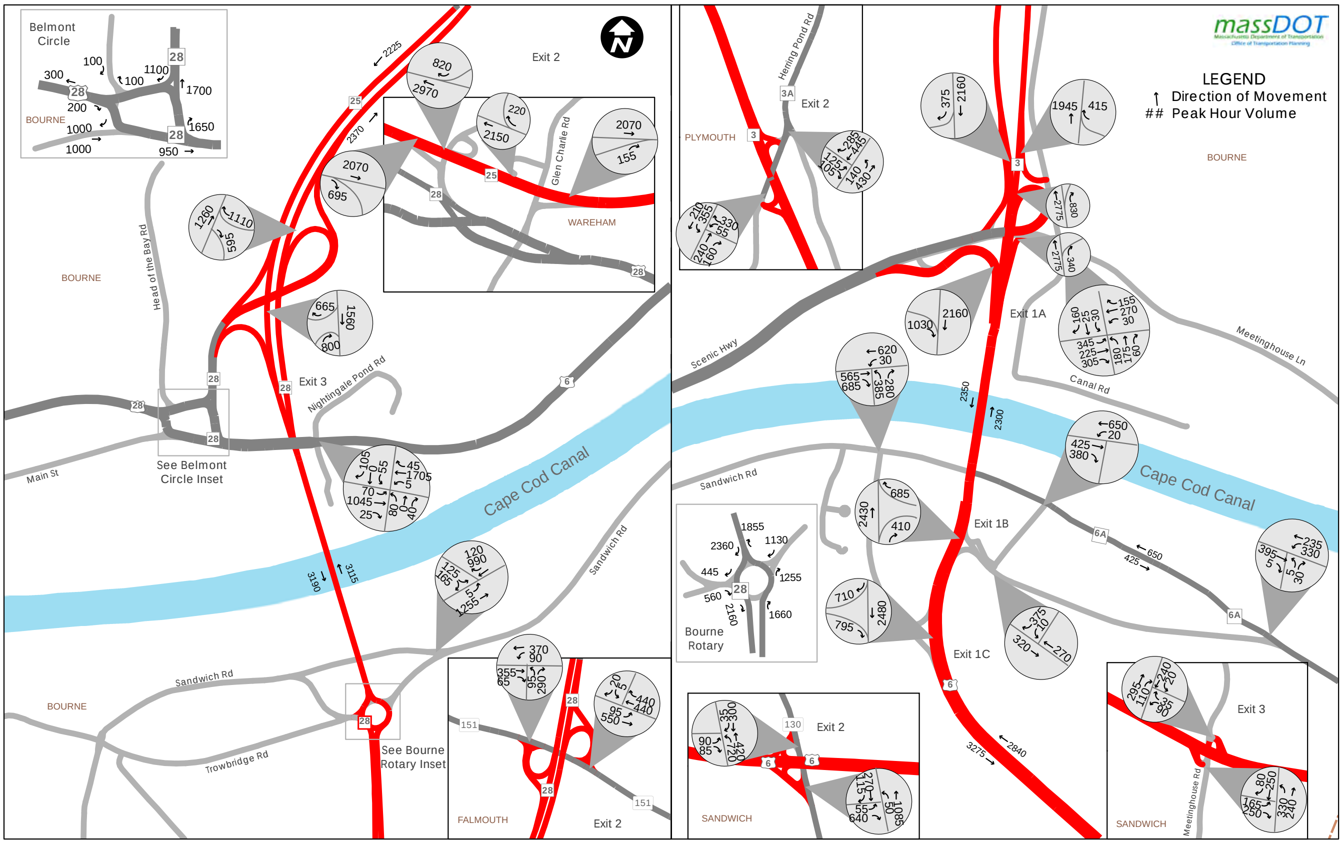
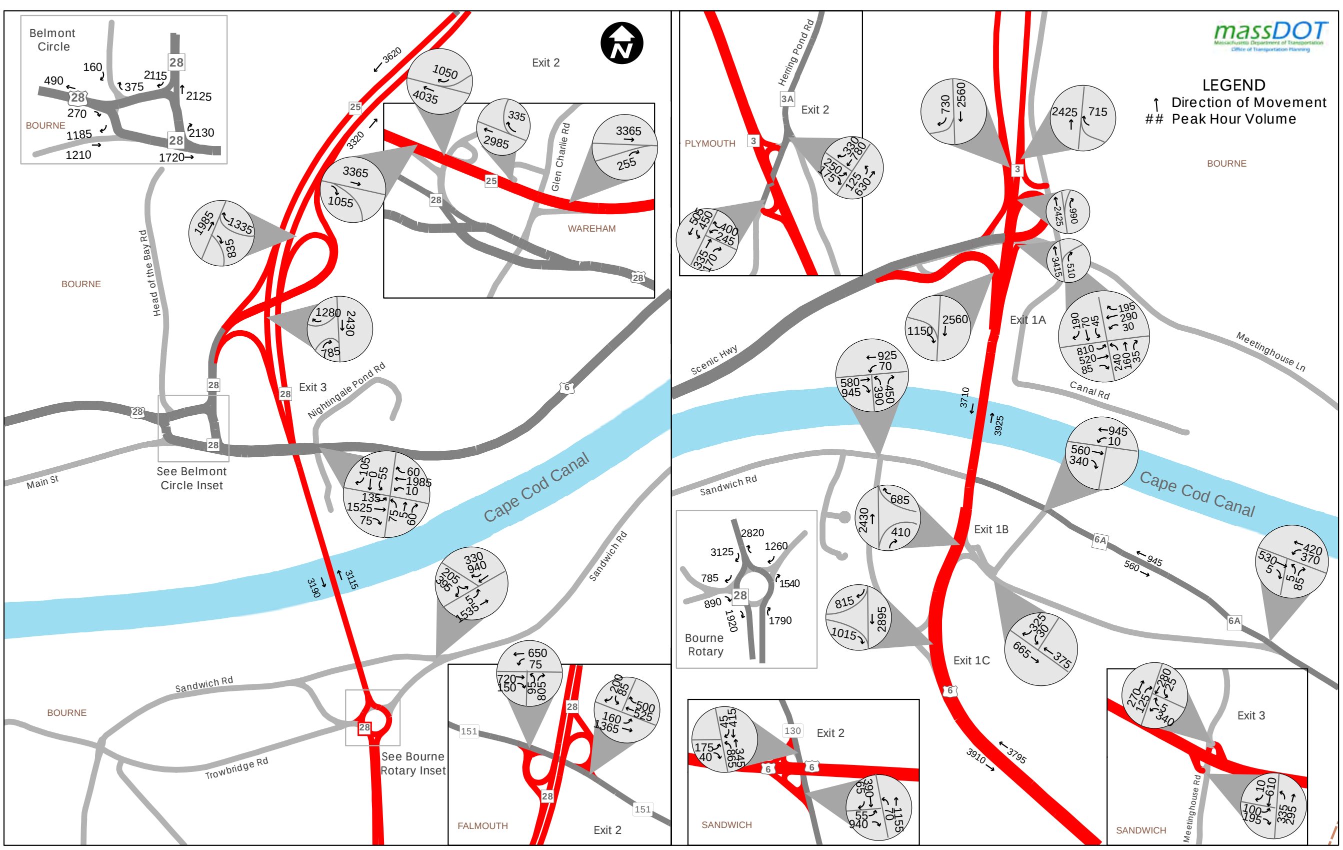


Exhibit 3-7 Future (2040) Summer Weekday AM Turning Movements

Exhibit 3-8 Future (2040) Summer Weekday PM Turning Movements



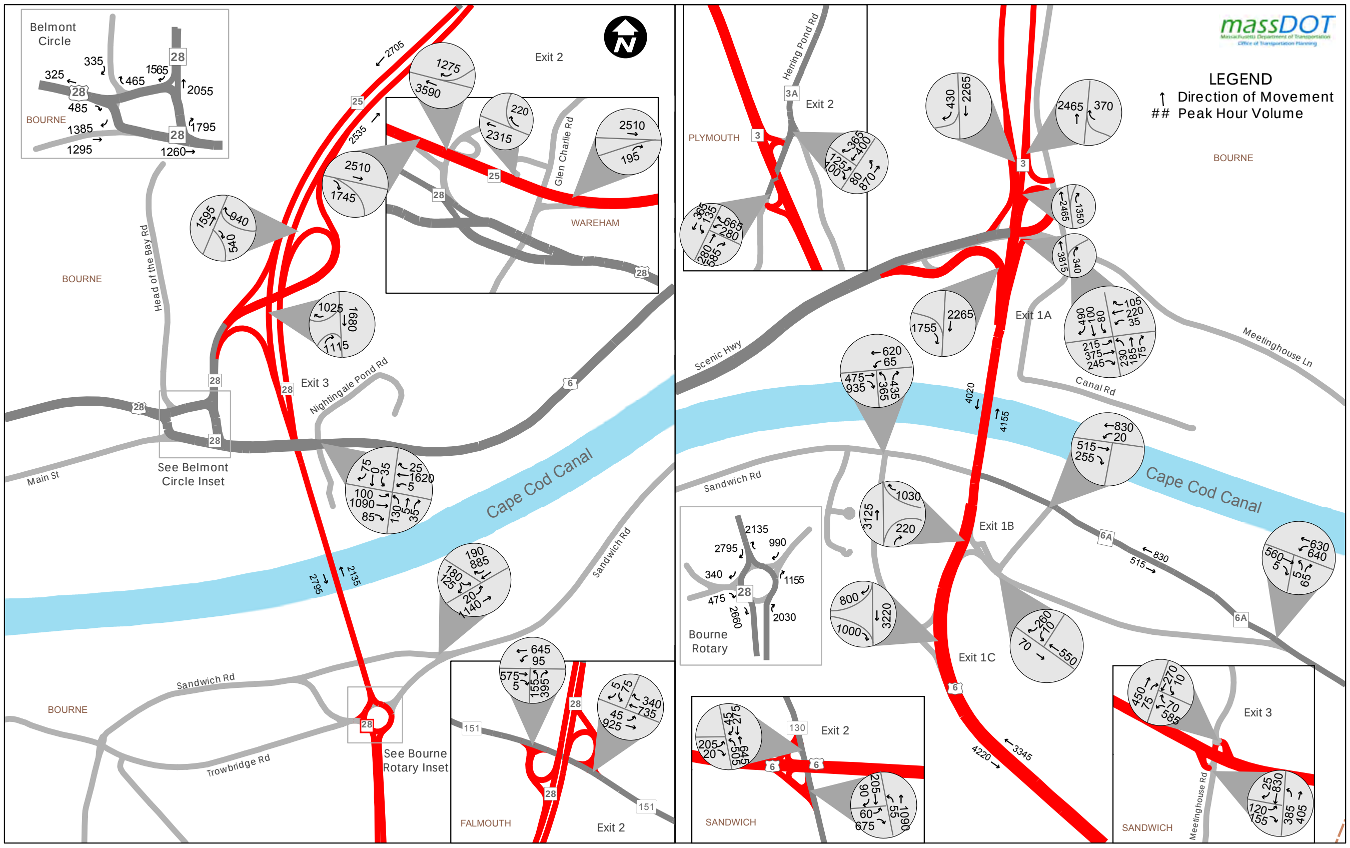


Exhibit 3-9 *Future (2040) Summer Saturday Turning Movements*

3.3.6 Future (2040) No-Build Levels of Service

Based on the future (2040) forecast traffic volumes, LOS were analyzed at 60 locations throughout the study area, including signalized and unsignalized intersections, highway links, and highway ramps. As with other data, LOS was calculated for the AM and PM weekday peak-periods and Saturday mid-day peak periods. The time periods examined were:

- AM summer weekday (7:00 AM – 9:00 AM)
- PM summer weekday (4:00 PM – 6:00 PM)
- Saturday summer (10:00 AM -12:00 PM)
- AM non-summer weekday (7:00 AM – 9:00 AM)
- PM non-summer weekday (4:00 PM – 6:00 PM)
- Saturday non-summer (10:00 AM -12:00 PM)

The methodology for determining LOS is provided in Section 2.5.8. This same methodology is used to forecast future LOS. The LOS for the existing conditions is also provided in Section 2.5.8. The results of the future no-build analysis for LOS appear in Tables 3-3 and 3-4. Exhibits 3-10 and 3-11 (freeways) and Exhibits 3-12 through 3-17 (intersections) present the results graphically.

Text continues on page 3-19.

Table 3-3 *Future (2040) No-Build Levels of Service for Freeway Sections*

	SUMMER AM	NON-SUMMER AM	SUMMER PM	NON-SUMMER PM	SUMMER SATURDAY	NON-SUMMER SATURDAY
HIGHWAY LINKS						
Bourne Bridge (NB)	C	B	D	C	C	C
Bourne Bridge (SB)	C	C	D	C	D	C
Route 25 East of Exit 2 (EB)	B	A	C	A	B	A
Route 25 East of Exit 2 (WB)	B	A	B	B	B	B
Route 25 West of Exit 2 (EB)	B	A	C	B	C	B
Route 25 West of Exit 2 (WB)	B	B	C	B	C	B
Route 3 Between Exits 1A and 2 (NB)	C	B	D	C	C	C
Route 3 Between Exits 1A and 2 (SB)	C	C	D	C	C	C
Route 6 EB Between Exits 1 and 2 (EB)	D	C	**E**	C	**E**	D
Route 6 WB Between Exits 1 and 2 (WB)	D	C	**E**	C	D	C
Sagamore Bridge (NB)	D	C	**E**	D	**E**	D
Sagamore Bridge (SB)	D	C	D	D	**E**	C
HIGHWAY ON-RAMPS						
Belmont Circle to Route 25 WB	B	B	B	B	B	B
Cranberry Highway to Route 6 WB (Exit 1C)	D	C	**E**	D	**E**	D
Route 130 to Route 6 EB	C	C	D	B	**E**	C
Glen Charlie to Route 25 EB	B	B	C	B	B	B
Route 130 to Route 6 WB	D	C	**E**	C	D	C
Quaker Meeting House Rd to Route 6 EB	C	C	D	C	**E**	C
Herring Pond Road to Route 3 NB	C	C	D	C	D	C
Herring Pond Road to Route 3 SB	C	C	D	B	C	C
Mid Cape Connector to Route 6 EB	D	C	**E**	C	**E**	D
Quaker Meeting House Road to Route 6 WB	C	B	D	C	D	C
Scenic Hwy to Route 6 EB/Bridge	D	C	**E**	D	**E**	C
Belmont Circle to Route 25 EB (Bourne Bridge)	C	C	D	B	D	C
HIGHWAY OFF-RAMPS						
Route 25 EB to Maple Springs Rd	B	B	C	B	C	B
Route 6 EB to Route 130	**E**	C	**E**	D	**E**	D
Route 6 WB to Route 130	C	B	D	C	D	D
Route 6 EB to Mid-Cape Connector	D	D	**E**	D	**E**	C
Route 6 EB to Quaker Meeting House Rd	D	C	D	C	**E**	C
Route 6 WB to Quaker Meetinghouse Rd	C	B	D	C	**E**	D
Route 6 WB (Exit 1) to Cranberry Hwy	D	C	**E**	D	**E**	D
Route 25 EB to Belmont Circle	B	B	C	B	B	B
Route 3 NB to Herring Pond Rd	C	B	D	C	D	C
Route 3 SB to Herring Pond Rd	C	C	D	D	D	D

LOS E or LOS F locations are **bold**

Table 3-3 continues on the next page.

Table 3-3 Future (2040) No-Build Levels of Service for Freeway Sections

	SUMMER AM	NON-SUMMER AM	SUMMER PM	NON-SUMMER PM	SUMMER SATURDAY	NON-SUMMER SATURDAY
Bourne Bridge to Belmont Circle	B	A	B	B	B	B
Route 3 SB to Scenic Hwy	C	C	**E**	D	D	C
Route 6 WB (Sagamore Bridge NB) to 6 WB/Scenic Hwy	D	C	**E**	C	**E**	D
Route 6 WB (Sagamore Bridge NB) to Meeting House Rd	D	C	**E**	D	**E**	D

LOS E or LOS F locations are **bold**

Table 3-4 Future (2040) No-Build Levels of Service at Select Intersections

	SUMMER AM	NON-SUMMER AM	SUMMER PM	NON-SUMMER PM	SUMMER SATURDAY	NON-SUMMER SATURDAY
SIGNALIZED INTERSECTIONS						
Route 130 (Main St) at Tupper Rd	B	B	D	B	D	C
Scenic Hwy at Church Lane	C	C	C	B	D	C
Meetinghouse Lane, State Rd and Canal Rd	D	D	**F**	**F**	C	D
Scenic Highway at Nightingale Pond Rd/Andy Olivia Drive	B	A	**F**	B	D	B
Route 6 EB Off Ramp (Exit 2) at Route 130	C	C	**F**	**F**	C	**F**
UNSIGNALIZED INTERSECTIONS (FOR MINOR ROAD APPROACH)						
Sandwich Rd at Bourne Rotary Connector	**F**	**F**	**F**	**F**	**F**	**F**
Sandwich Rd at High School Drive	**F**	**F**	**F**	**F**	**F**	**F**
Sandwich Rd at Harbor Lights Rd	**F**	**F**	**F**	**F**	**F**	**F**
Sandwich Rd at Jarvis Drive	D	**F**	A	**F**	A	**E**
County Road, Sandwich Road, & Trowbridge Road	**E**	D	**F**	**F**	C	**E**
Route 28 NB Off-ramp at Route 151	C	D	**F**	**F**	**F**	D
Route 28 SB Off-ramp at Route 151	D	D	**F**	**F**	**F**	C
Sandwich Rd, Cranberry Hwy, and Regency Drive	**F**	D	**E**	**E**	**F**	C
Old Kings Hwy at Main Street	B	B	C	C	**F**	D
Route 6A at Route 130 (Main Street) / Tupper Road	**F**	D	C	F	**F**	**F**
Maple Springs Rd at Route 25 EB	C	B	**F**	D	**F**	**F**
Route 130 at Cotuit Rd	**F**	**F**	**F**	**F**	**F**	**F**
Herring Pond Rd at State Road	**E**	**F**	**F**	**F**	**F**	**F**
Belmont Circle	**F**	**F**	**F**	**F**	**F**	**F**
Bourne Rotary	**F**	**F**	**F**	**F**	**F**	**F**
Route 6 EB Off Ramp (Exit 3) Quaker Meeting House Rd	**F**	**F**	**F**	**F**	**F**	**F**
Route 3 SB Off Ramp at Exit 2/Herring Pond Rd	**E**	**F**	**F**	**F**	**F**	**F**

LOS E or LOS F locations are **bold**

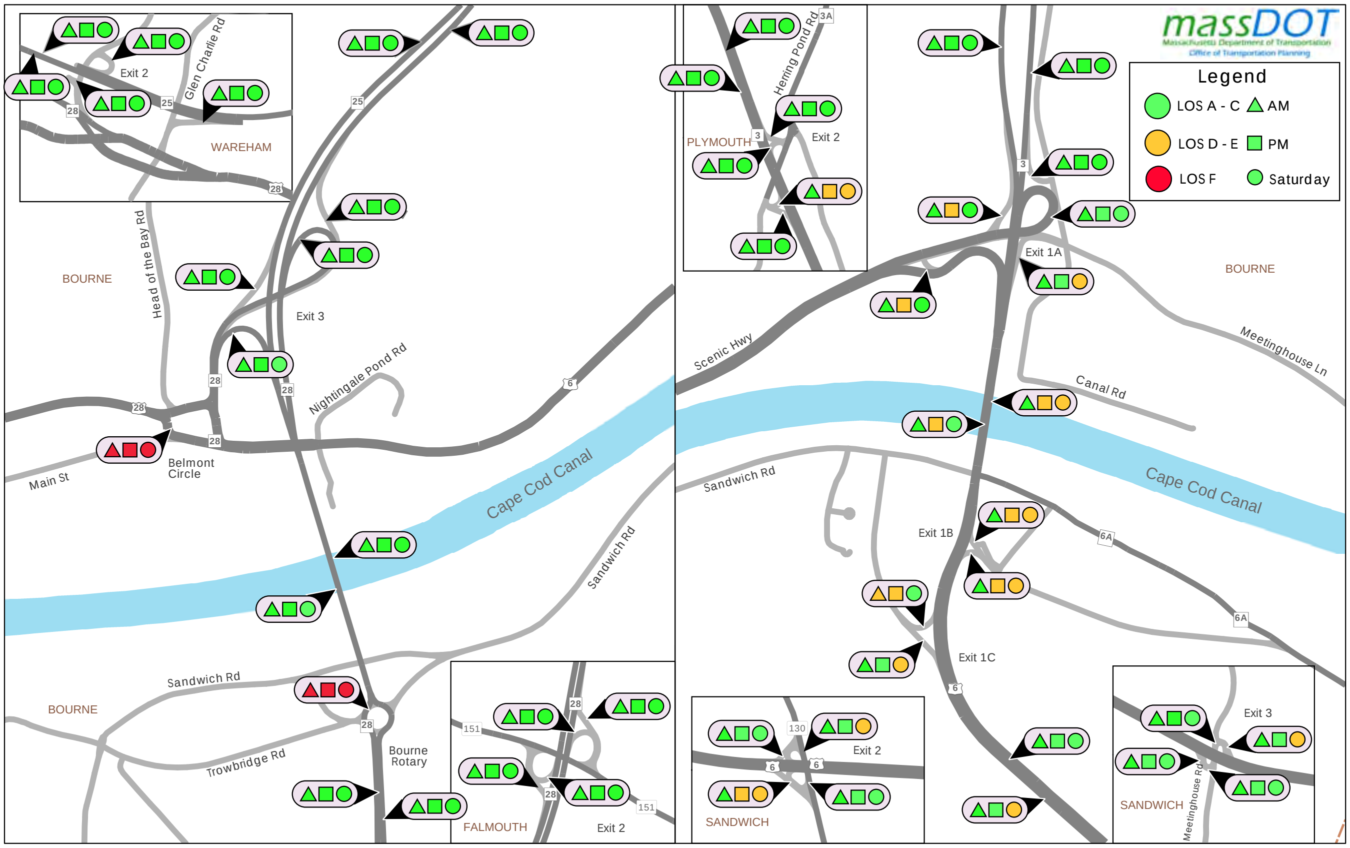
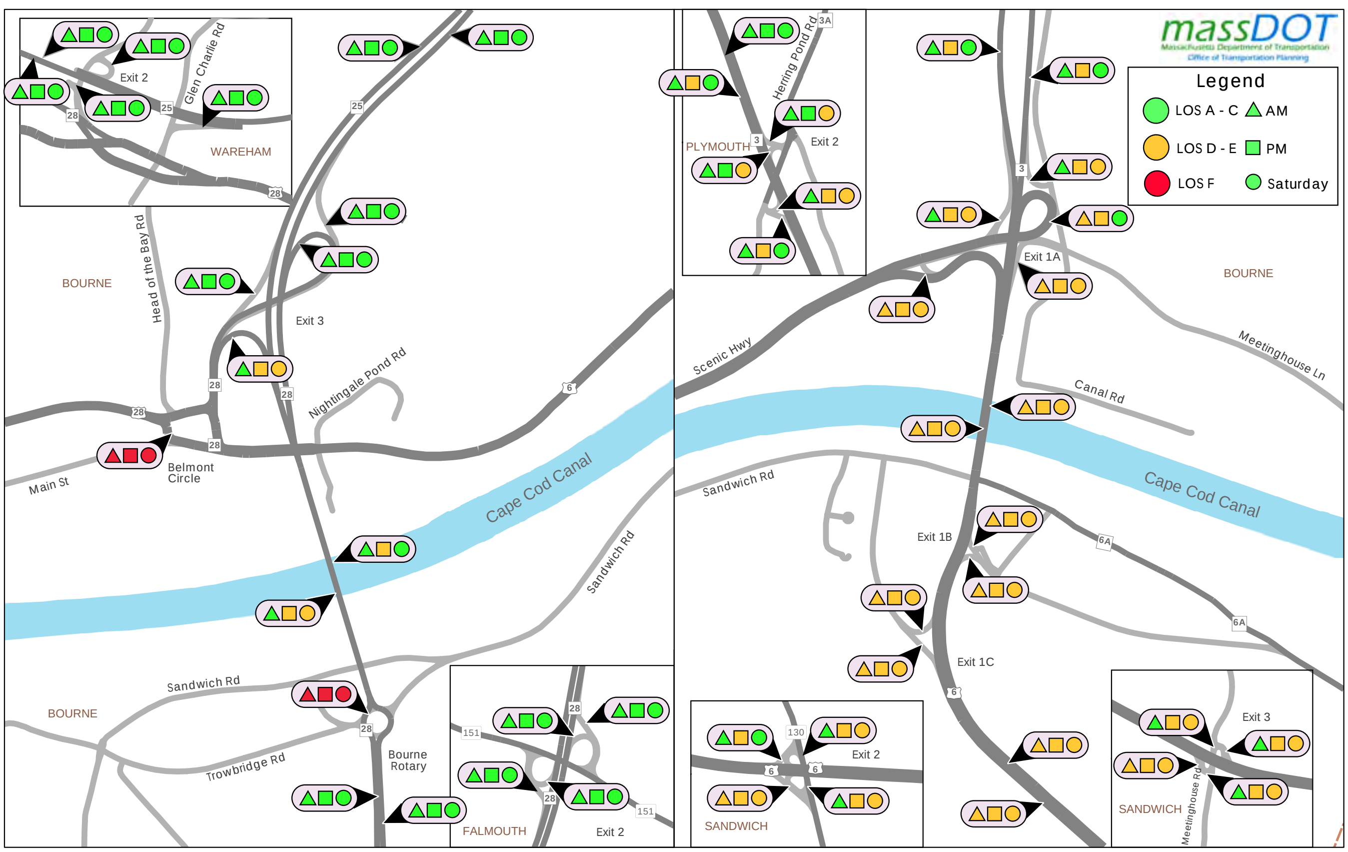


Exhibit 3-10 Future (2040) No-Build Non-Summer Levels of Service - AM/PM/Saturday (Freeway)

Exhibit 3-11 Future (2040) No-Build Summer Levels of Service - AM/PM/Saturday (Freeway)



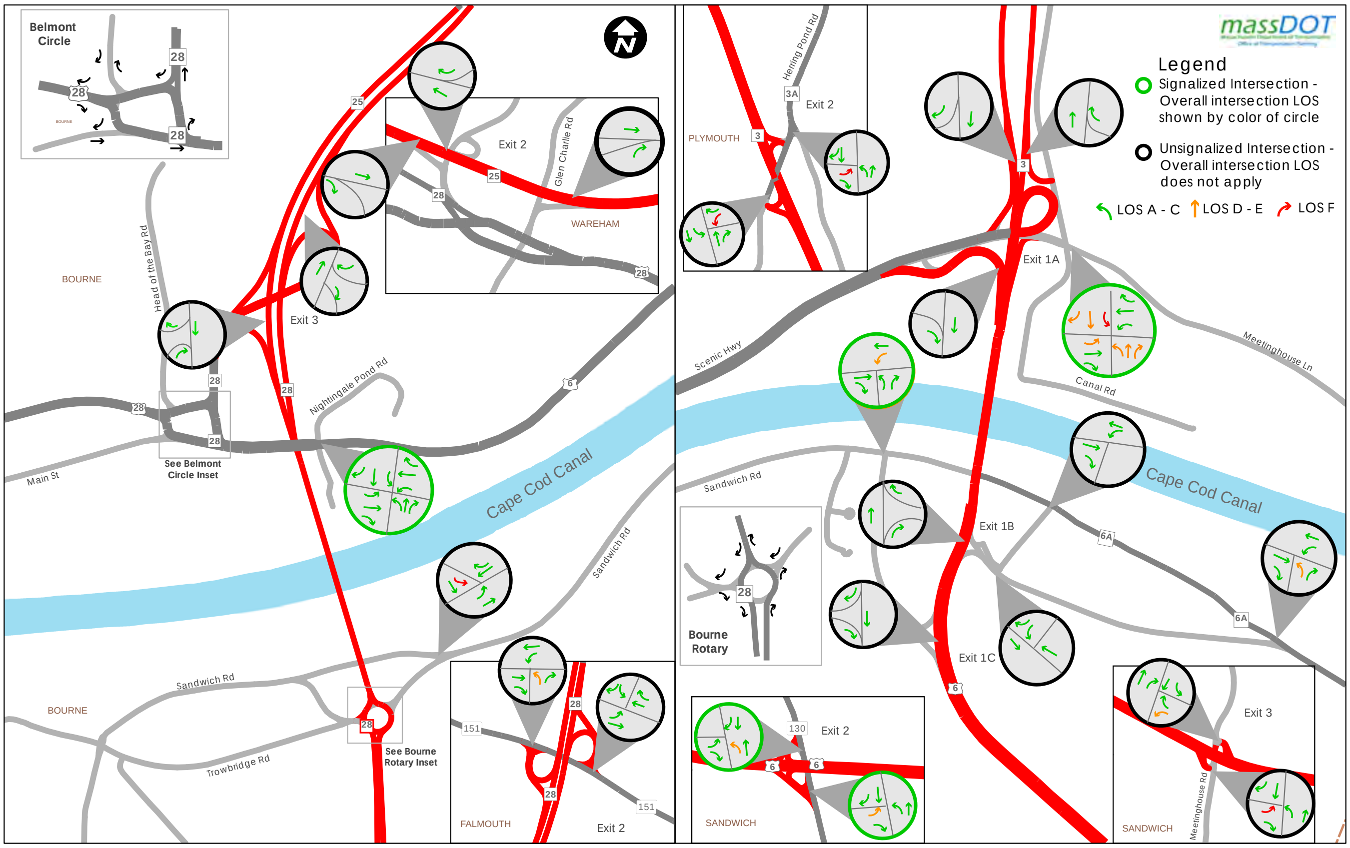
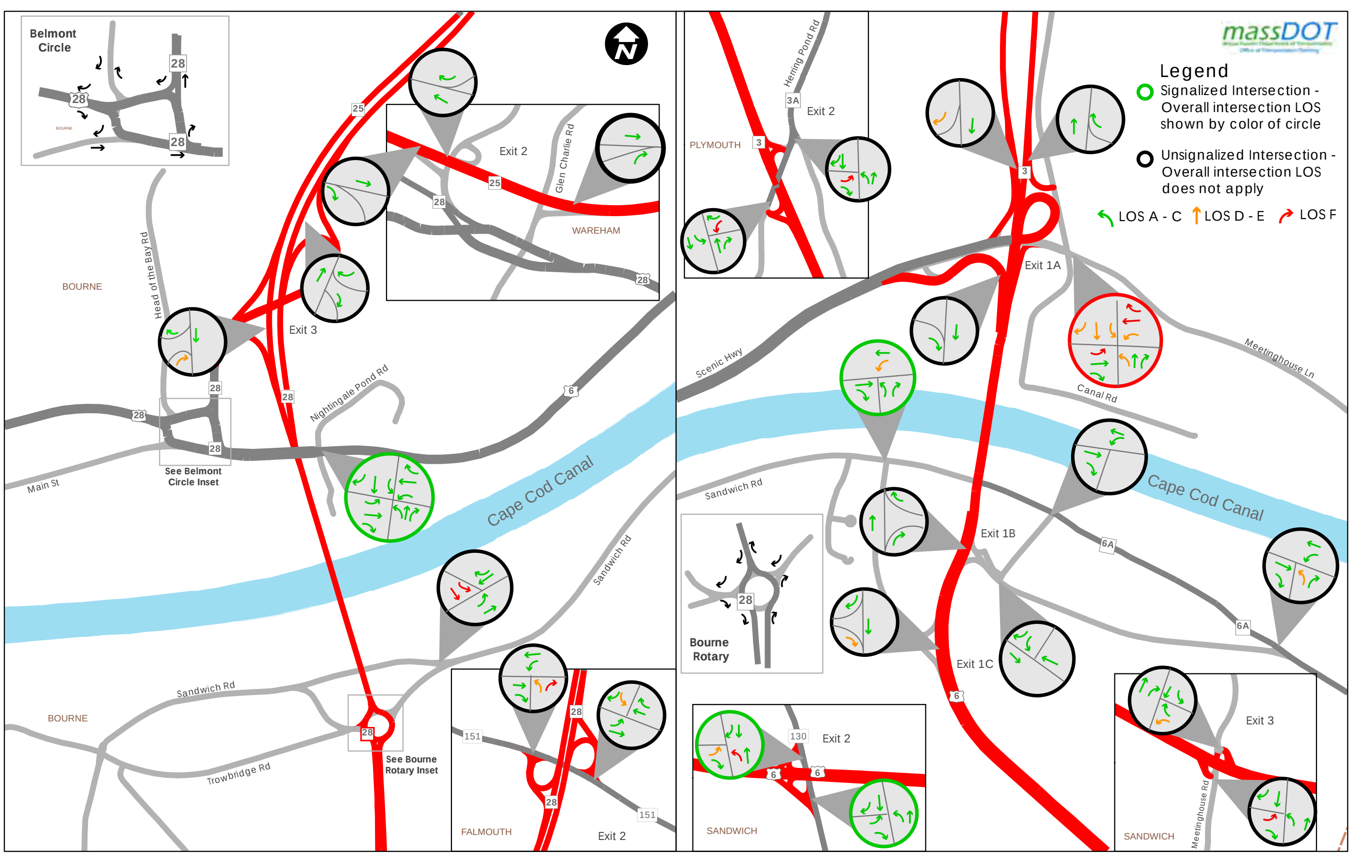


Exhibit 3-12 Future (2040) No-Build Non-Summer Weekday AM Levels of Service (Intersections)

Exhibit 3-13 Future (2040) Non-Build Non-Summer Weekday PM Levels of Service (Intersections)



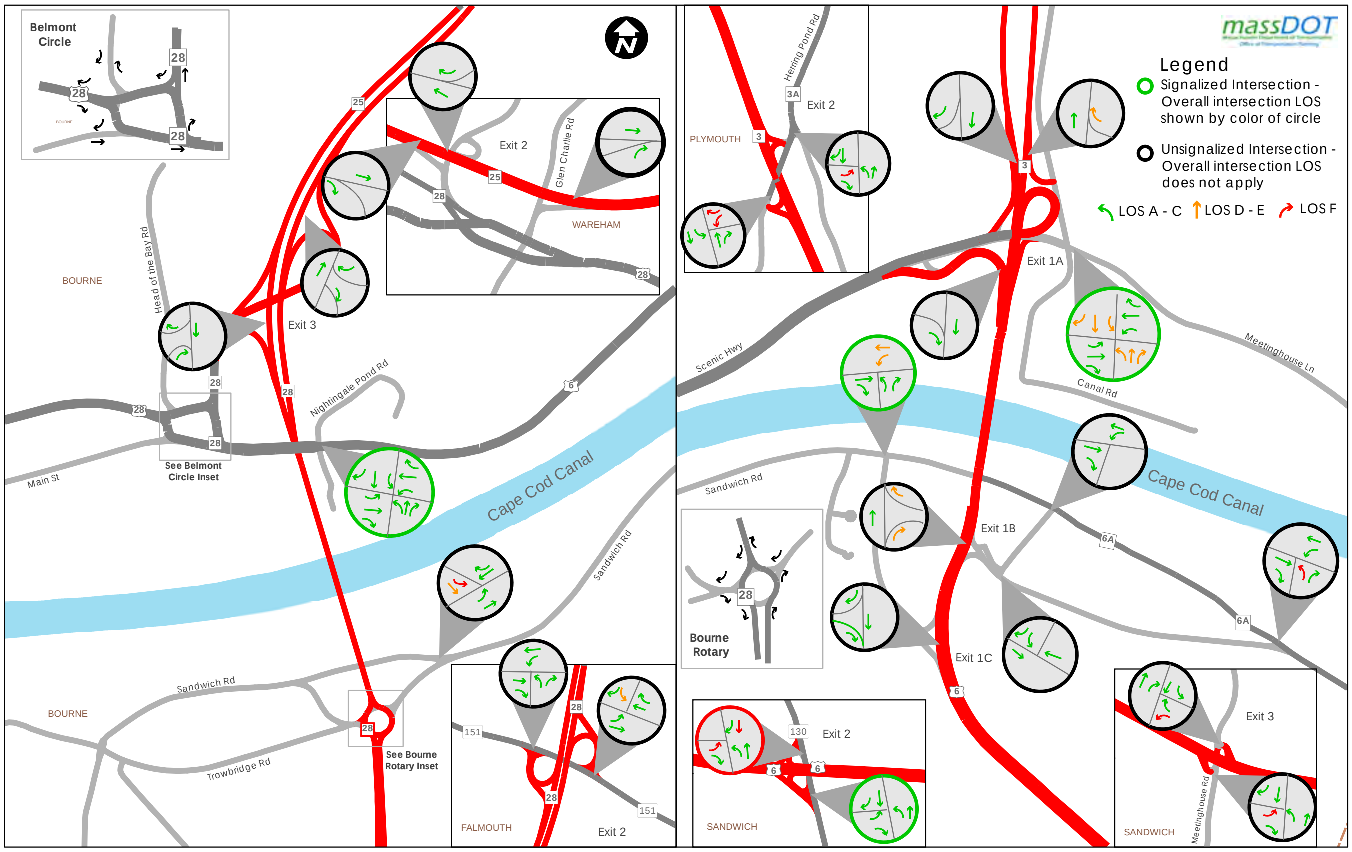
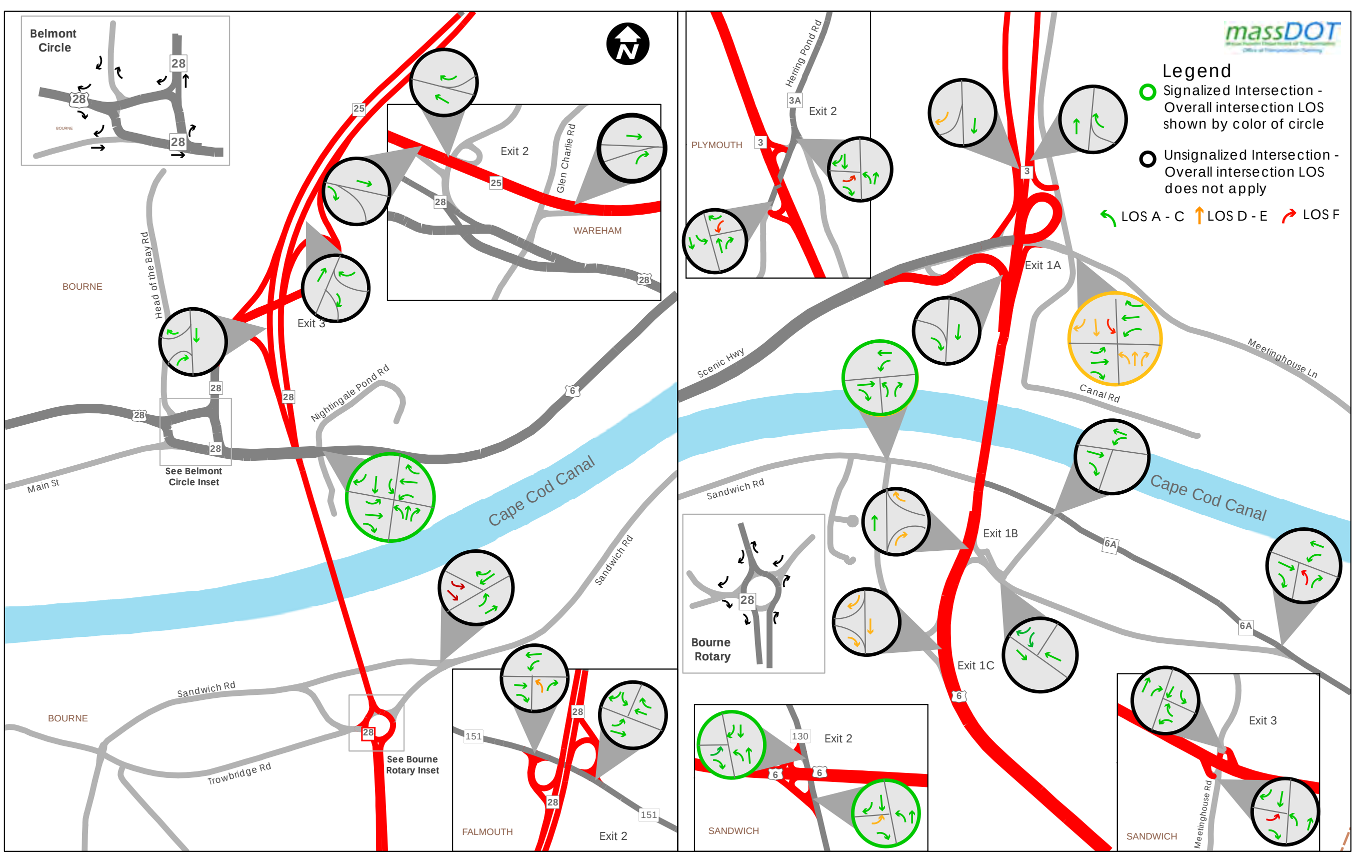


Exhibit 3-15 Future (2040) No-Build Non-Summer Saturday Levels of Service (Intersections)

Exhibit 3-14 Future (2040) No-Build Summer Weekday AM Levels of Service (Intersections)



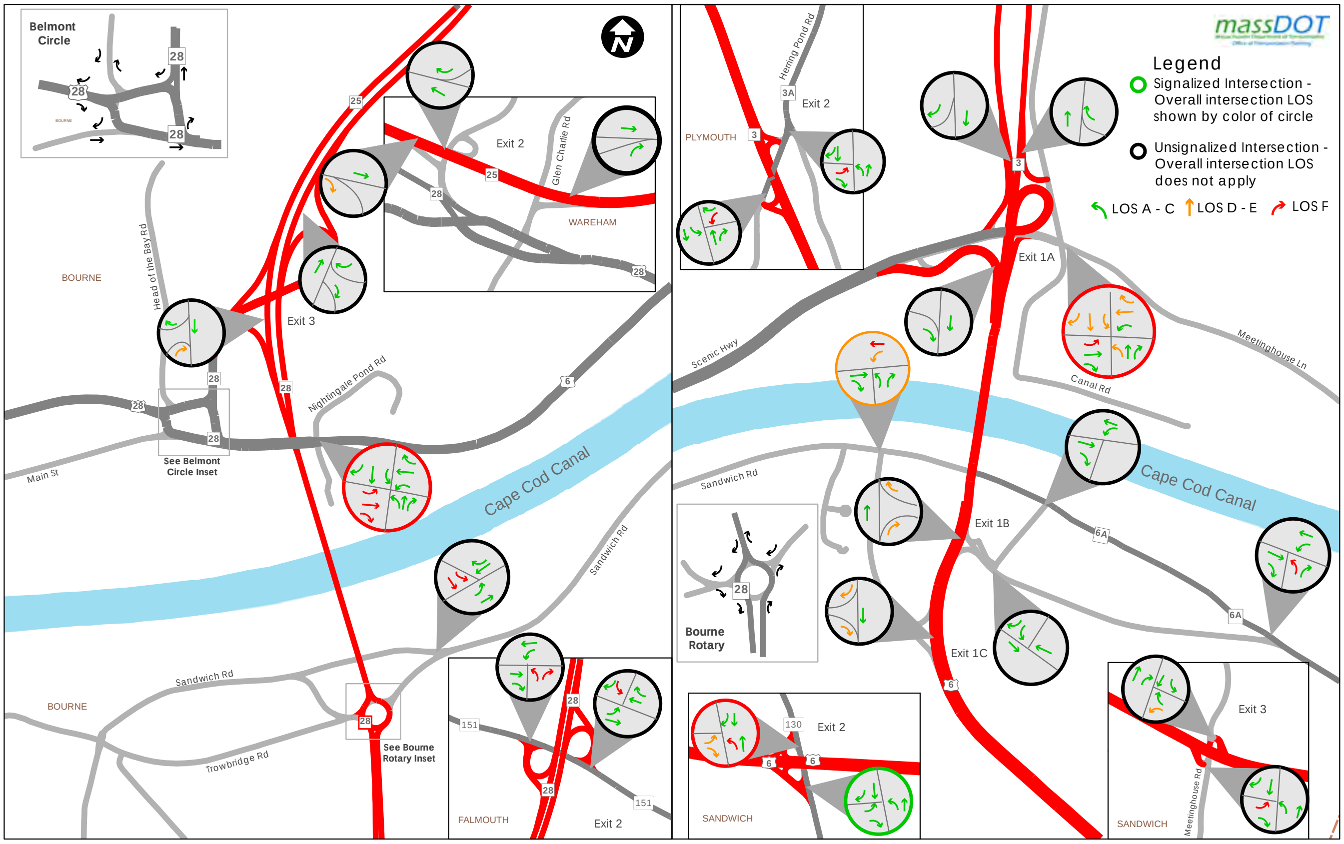
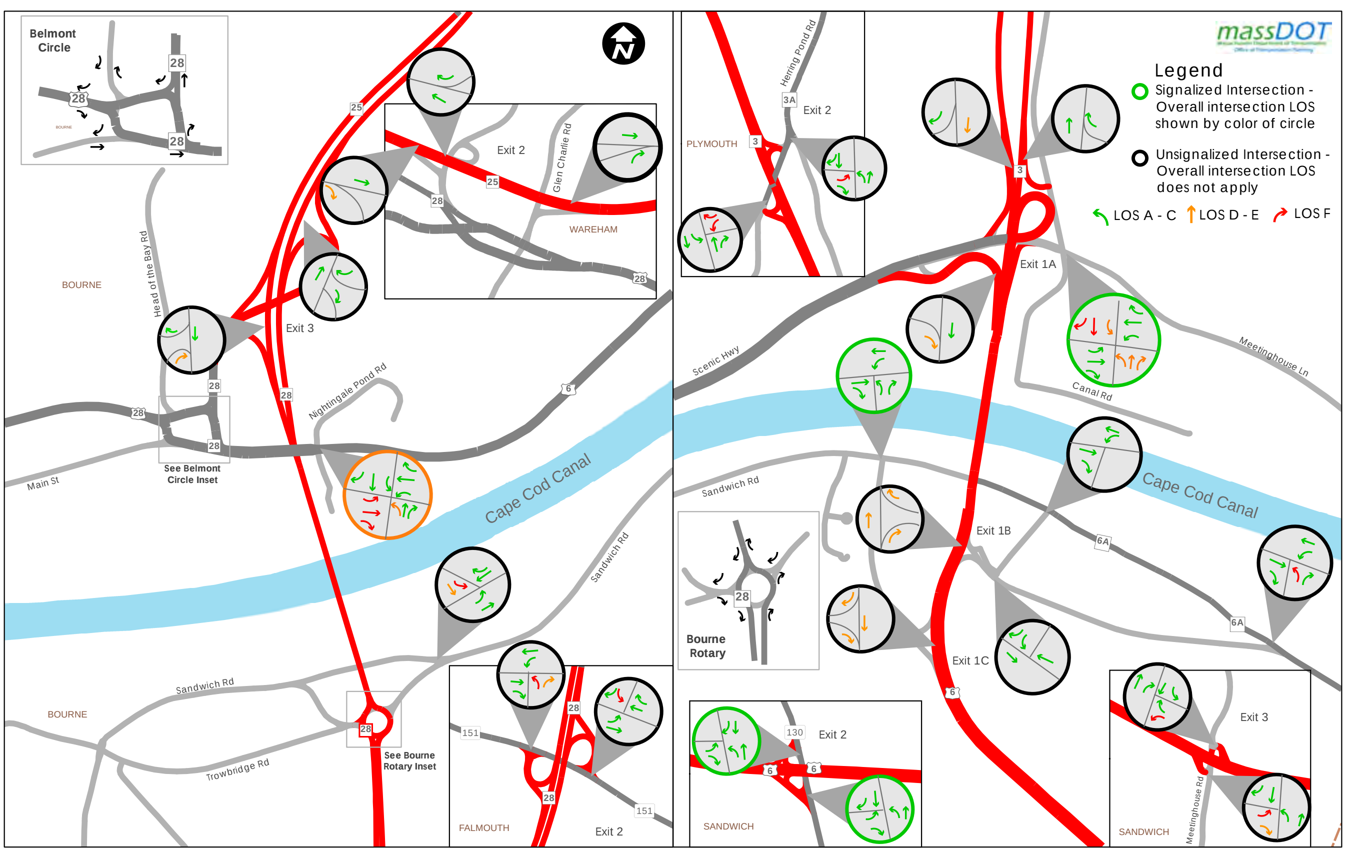


Exhibit 3-16 Future (2040) No-Build Summer Weekday PM Levels of Service (Intersections)

Exhibit 3-17 Future (2040) No-Build Summer Saturday Levels of Service (Intersections)



The following presents a summary of traffic operations (in terms of LOS) for both the existing and future no-build conditions.

Summary of Freeway Traffic Operations

Existing (2014) Conditions

- Generally acceptable traffic operations (LOS A – C) during most non-summer and summer periods along the mainline and interchanges of Route 3, Route 6, and Route 25.
- Less acceptable traffic operations (LOS D) on the Sagamore Bridge and the Route 6 approach to the Sagamore Bridge during summer periods.
- Less acceptable traffic operations (LOS D) during the summer periods at several Route 6 interchanges, including Exit 1C (Cranberry Highway), Exit 2 (Route 130), and Exit 3 (Quaker Meetinghouse Road).

Future (2040) No-Build Conditions

- Generally acceptable traffic operations (LOS A – C) during all non-summer periods along the mainline and interchanges of Route 3, Route 6, and Route 25.
- Substantially more freeway and interchange locations operating at less acceptable levels (LOS D/E) during the summer periods (compared to the existing condition), particularly at the Bourne and Sagamore Bridges, and adjacent interchanges.

Summary of Intersection Traffic Operations

Existing (2014) Conditions

- Numerous intersections with poor traffic operations (LOS E/F), especially during summer periods.
- Worst performing intersections (LOS E/F during all time periods) include:
- Belmont Circle
- Bourne Rotary
- Sandwich Road at Bourne Rotary Connector
- Sandwich Road at High School Drive
- Sandwich Road at Harbor Lights Drive
- Route 130 at Cotuit Road

Future (2040) No-Build Conditions

- Numerous intersections with poor traffic operations (LOS E/F), especially during summer periods. Compared to the existing conditions, degraded traffic conditions occur at intersections throughout the study area.

- The most congested intersections (LOS E/F during all time periods) include those identified for the existing conditions plus three additional locations:
- Belmont Circle
- Bourne Rotary
- Sandwich Road at Bourne Rotary Connector
- Sandwich Road at High School Drive
- Sandwich Road at Harbor Lights Drive
- Route 130 at Cotuit Road
- Herring Pond Road at State Road
- Route 3 SB Off-Ramp at Exit 2/Herring Pond Road
- Route 6 EB Off-Ramp (Exit 3) at Quaker Meeting House Lane

3.3.7 Traffic Operations at Belmont Circle and Bourne Rotary

As noted in Section 2.5.10, Belmont Circle and the Bourne Rotary have a considerable impact on regional travel patterns and traffic operations. The high frequency of cross-corridor travel often results in traffic volumes that exceed the capacity of Belmont Circle and Bourne Rotary. This results in significant queues and delays at their approaches. Further, the proximity of these rotaries to each other can result in queues at one location negatively affecting traffic operations at the other. Both locations currently experience LOS F conditions during all peak periods in the summer and non summer.

Tables 3-5 and 3-6 and Exhibit 3-18 provide a comparison of vehicle delay and queue lengths for approaches to Belmont Circle and Bourne Rotary, respectively, for the existing (2014) and future (2040) non-summer weekday PM and summer Saturday peak periods.

Belmont Circle

The VISSIM™ analysis quantified vehicle delays and the queue length for the five approaches to Belmont Circle including Scenic Highway, Main Street, Buzzards Bay Bypass, Head of the Bay Road, and the Route 25 ramps. As shown in Table 3-6 and Exhibit 3-18, the approaches with the greatest delay and queue lengths include those from Scenic Highway and Main Street to Belmont Circle.

The queues of note for the future no-build condition include the Scenic Highway (westbound) and the Main Street (eastbound)

Table 3-5 Belmont Circle – Comparison of Existing (2014) and Future (2040) No-Build Queue Lengths and Average Delay

Street Name/ Approach	2014 EXISTING				2040 FUTURE NO BUILD			
	Ave. Vehicle Delay (sec./min.)		95% Max. Queue Lengths (feet/miles)		Ave. Vehicle Delay (sec./min.)		95% Max. Queue Lengths (feet/miles	
	Non-Summer PM	Summer Saturday	Non-Summer PM	Summer Saturday	Non-Summer PM	Summer Saturday	Non-Summer PM	Summer Saturday
Route 25 Exit 3 Off-Ramps (WB)	5	**4**	515	510	2	3	645	**1,025**
Head of Bay Road (SB)	15	**83 (1.4)**	270	570	317 (5.3)	656 (10.9)	1,780	2,700 (0.5)
Buzzards Bay Bypass (EB)	3	19	100	335	3	11	110	305
Main Street (EB)	13	**82 (1.4)**	530	**5,755 (1.1)**	29	**126 (2.1)**	**1,245**	**6,140 (1.2)**
Scenic Highway (WB)	7	**125 (2.1)**	380	**10,605 (2.0)**	14	**161 (2.7)**	**840**	**11,610 (2.2)**

Notes:
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles
Locations of excessive delay are **bold**

Table 3-6 Bourne Rotary – Comparison of Existing (2014) and Future (2040) No-Build Queue Lengths and Average Delay

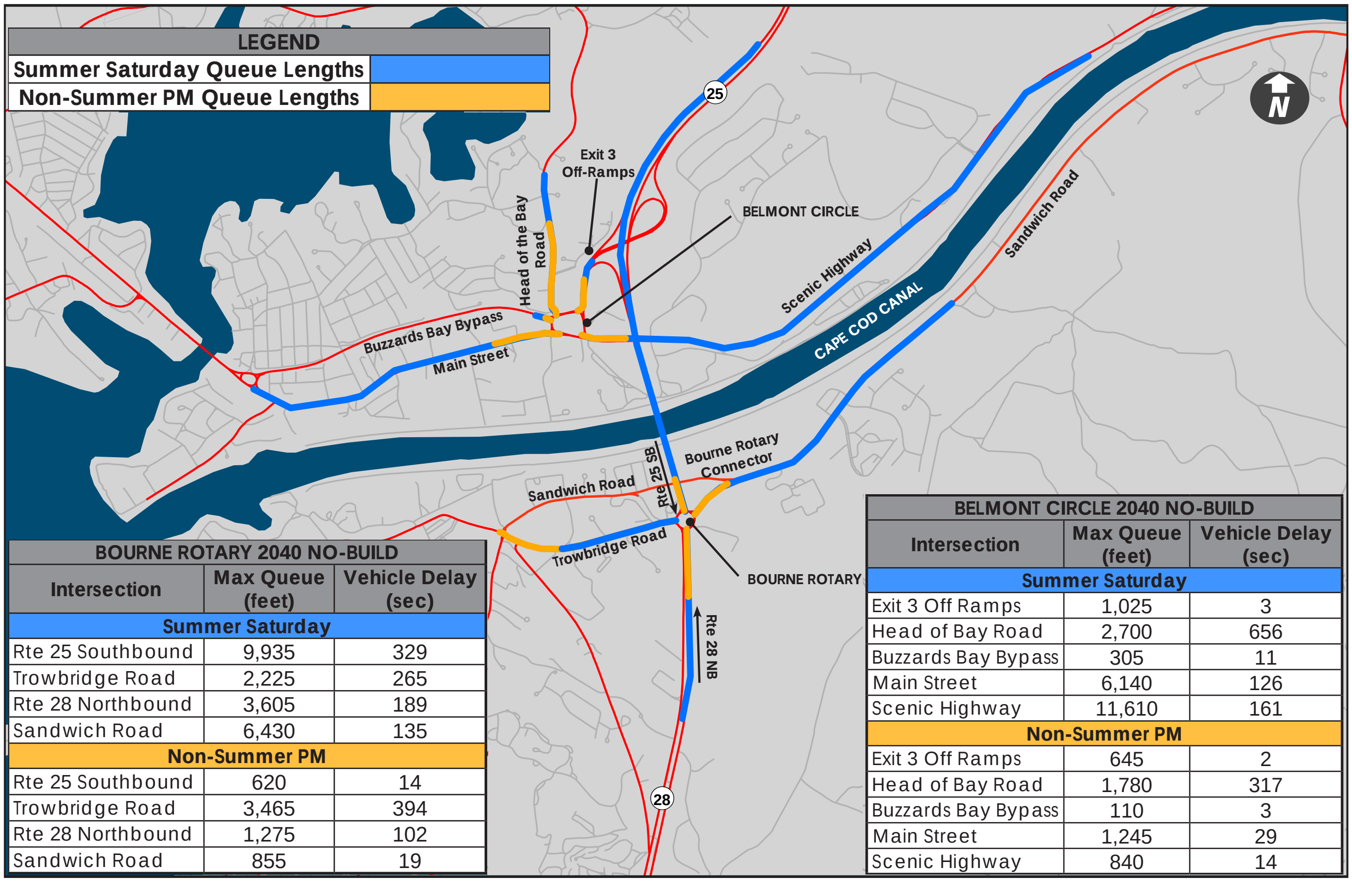
STREET NAME/ APPROACH	2014 EXISTING				2040 FUTURE NO BUILD			
	Ave. Vehicle Delay (sec./min.)		95% Max. Queue Lengths (feet/miles)		Ave. Vehicle Delay (sec./min.)		95% Max. Queue Lengths (feet/miles	
	Non-Summer PM	Summer Saturday	Non-Summer PM	Summer Saturday	Non-Summer PM	Summer Saturday	Non-Summer PM	Summer Saturday
Route 25 (SB)	19	**280 (4.7)**	650	**8,885 (1.7)**	14	329 (5.5)	620	**9,935 (1.9)**
Trowbridge Road (EB)	75 (1.3)	30	840	335	**394 (6.6)**	**265 (4.4)**	**3,465 (0.7)**	**2,225**
Route 28 (NB)	14	**301 (5.0)**	340	**4,135 (0.8)**	**102 (1.7)**	**189 (3.2)**	**1,275**	**3,605 (0.7)**
Bourne Rotary Connector (WB)	20	27	1,530	1,475	19	135 (2.3)	855	**6,430 (1.2)**

Notes:
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles
Locations of excessive delay are **bold**

approach to Belmont Circle which can extend 6,140 to 11,610 feet (1.2 to 2.2 miles) during the summer Saturday peak periods, respectively. The queues on the Main Street (eastbound) approach to Belmont Circle can extend 1,245 feet during the non-summer weekday peak period.

Bourne Rotary

The VISSIM™ analysis quantified vehicle delays and the queue length for the four approaches to Belmont Circle, including Route 28 (north and south approaches), Trowbridge Road, and Sandwich Road. As shown on Table 3-6 and Exhibit 3-18, the approaches with the greatest delay and queue lengths include those from Route 25 southbound and the Bourne Rotary Connector.



BOURNE ROTARY 2040 NO-BUILD

Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Rte 25 Southbound	9,935	329
Trowbridge Road	2,225	265
Rte 28 Northbound	3,605	189
Sandwich Road	6,430	135
Non-Summer PM		
Rte 25 Southbound	620	14
Trowbridge Road	3,465	394
Rte 28 Northbound	1,275	102
Sandwich Road	855	19

BELMONT CIRCLE 2040 NO-BUILD

Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Exit 3 Off Ramps	1,025	3
Head of Bay Road	2,700	656
Buzzards Bay Bypass	305	11
Main Street	6,140	126
Scenic Highway	11,610	161
Non-Summer PM		
Exit 3 Off Ramps	645	2
Head of Bay Road	1,780	317
Buzzards Bay Bypass	110	3
Main Street	1,245	29
Scenic Highway	840	14

Exhibit 3-18 Belmont Circle and Bourne Rotary - Future (2040) No-Build Queue Lengths

The queues of note for the future no-build condition include the Route 25 (southbound) and the Bourne Rotary Connector approach to the Bourne Rotary which can extend 9,935 and 6,430 feet (1.9 and 1.2 miles), respectively during the summer Saturday peak period. The queues on the Route 28 (northbound) approach to Bourne Rotary can extend 1,275 to 3,605 feet during the non-summer PM and summer Saturday peak periods, respectively.

3.4 PROBLEM INTERSECTIONS

The following section provides information on the 12 year-round problem intersections in the study area (Table 3-7). Problem intersections are defined as those that operated (or are forecast to operate) as an LOS E or F during at least one summer and non-summer peak period in 2014 or 2040. Problem intersections also include those intersections designated as high-crash locations under the Highway Safety Improvement Program (HSIP -described in greater detail in Section 2.5.11).

Roadway improvement alternatives will focus on these intersections. Particular attention was paid to problem intersections in the study area that experience the highest

Table 3-7 Growth in Average Daily Traffic (ADT) at Key Locations 2014 - 2040

LOCATION NUMBER (EXHIBITS 3-21)	NAME OF LOCATION	TOWN	HSIP LOCATION (Y/N)	NON-SUMMER PM LOS 2040 FUTURE NO-BUILD	SUMMER SATURDAY LOS 2040 FUTURE NO-BUILD
1	Herring Pond Road at State Road	Plymouth	N	F	F
2	Belmont Circle	Bourne	Y	F	F
3	Scenic Highway at Nightingale Pond Road	Bourne	N	B	D
4	Bourne Rotary	Bourne	Y	F	F
5	Sandwich Road at Bourne Rotary Connector	Bourne	N	F	F
6	Sandwich Road at High School Drive	Bourne	Y	F	F
7	Sandwich Road at Harbor Lights Road	Bourne	N	F	F
8	Sandwich Road at Cranberry Highway/Regency Drive	Bourne	N	E	F
9	Route 6A at Route 130 (Main Street)/Tupper Road	Sandwich	Y	F	F
10	Scenic Highway/Meetinghouse Lane at State Road	Bourne	N	F	C
11	Route 130 at Cotuit Road	Sandwich	N	F	F
12	Route 28 Northbound Off/On Ramps at Route 151 (outside of study area)	Falmouth	N	E/F	F

Exhibit 3-19 Problem Intersections in the Study Area

Exhibit 3-20 Photos of Problem Intersections

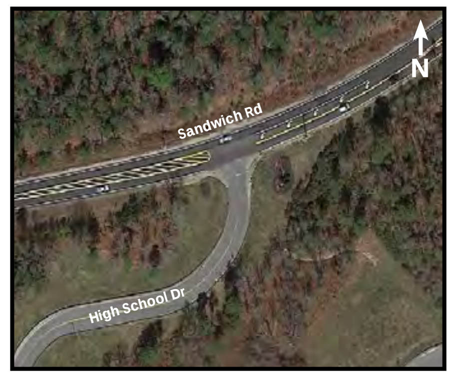
Intersection #	1
Roadways	Herring Pond Rd at State Rd
Town	Plymouth
Traffic Control	Yield
HSIP	No

Intersection #	2
Roadways	Belmont Circle
Town	Bourne
Traffic Control	Yield/Rotary
HSIP	Yes

Intersection #	3
Roadways	Scenic Hwy at Nightingale Pond Rd
Town	Bourne
Traffic Control	Signalized
HSIP	No

Intersection #	4
Roadways	Bourne Rotary
Town	Bourne
Traffic Control	Yield/Rotary
HSIP	Yes

Intersection #	5
Roadways	Sandwich Rd at Bourne Rotary Conn.
Town	Plymouth
Traffic Control	Yield
HSIP	No



Intersection #	6
Roadways	Sandwich Rd at High School Dr
Town	Bourne
Traffic Control	Flashing Yellow
HSIP	Yes

Intersection #	7
Roadways	Sandwich Rd at Harbor Lights Rd
Town	Bourne
Traffic Control	Unsignalized
HSIP	No

Intersection #	8
Roadways	Sandwich Rd at Cranberry Hwy
Town	Bourne
Traffic Control	Stop-Controlled
HSIP	No

Intersection #	9
Roadways	Route 6A at Route 130
Town	Sandwich
Traffic Control	Stop-Controlled
HSIP	Yes

Figure 3-20 (continued) Photos of Problem Intersections

Intersection #	10
Roadways	Scenic Hwy at Meetinghouse Ln
Town	Bourne
Traffic Control	Signalized
HSIP	No

Intersection #	11
Roadways	Route 130 at Cotuit Road
Town	Sandwich
Traffic Control	Stop-Controlled
HSIP	No

Intersection #	12
Roadways	Route 28 at Route 151 On/Off Ramps
Town	Falmouth
Traffic Control	Yield-Control
HSIP	No

travel volumes and associated congestion and delays. While not meeting the definition of a 'problem intersection', the Scenic Highway at Nightingale Pond Road intersection will be evaluated because of its proximity to, and effect on, Belmont Circle. The Route 6 Exit 1C interchange has also been evaluated because its location and substandard design contribute to congestion on Route 6 westbound, particularly during summer Sundays. The existing problem intersections are shown in Exhibits 3-19 and 3-20.

3.5 SUMMARY OF FUTURE NO-BUILD TRAFFIC CONDITIONS

As described in Chapters 2 and 3, traffic conditions along highways and at intersections in the study area, particularly in the immediate area of the Canal bridges, often suffer from severe congestion and delay. Several intersections have a history of high crash rates. While historically known to occur during the summer tourist season, this roadway congestion now often occurs during the spring and fall shoulder seasons.

The highest daily- and peak-period traffic volumes in the study area occur along the major highway corridors in the study area, including the Route 3/Sagamore Bridge/Route 6 corridor and the Route 25/Bourne Bridge/Route 28 corridor. Under existing conditions, average daily traffic (ADT) on the bridges is 30% to 40% higher in the summer compared to the non-summer peak period. Daily traffic volumes range from 56,000 to 65,000 vehicles in the summer and 38,000 to 41,000 in the non-summer periods, with the Sagamore Bridge generally having the higher traffic volumes. In the future, daily traffic crossing the Canal bridges is forecast to increase by 30% in the summer and 22% in the non-summer period.

Currently, the levels of service (LOS) along the highways in the study area were generally found to be within the acceptable LOS A – C range. In the future, traffic operations are forecast to degrade, with substantially more freeway and interchange locations operating at less acceptable levels (LOS D/E) during the summer periods (compared to the existing condition), particularly at the Bourne and Sagamore Bridges, and adjacent interchanges.

The roads connecting the bridge approaches – Scenic Highway north of the Canal and Sandwich Road south of the Canal – also experience high traffic volumes and congestion. This is the result of high traffic volumes within the focus area (not just travel through the focus area) and vehicles traveling between the Route 25/Route 28 corridor and the Route 3/Route 6 corridor. This congestion is exacerbated by the inadequate capacity and substandard design at the intersections at the bridge approaches, especially Belmont Circle and Bourne Rotary (north and south of the Bourne Bridge) and Route 6 Exit 1C south of the Sagamore Bridge. The former Sagamore Rotary, north of the Bourne Bridge, was reconstructed as a highway interchange in 2006. These intersections and several others along Sandwich Road and Scenic Highway experience severe congestion (LOS E / F) during both the summer and non-summer periods.

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DRAFT FOR REVIEW - SUMMER 2019

CAPE COD CANAL
TRANSPORTATION STUDY

Prepared by:
Stantec

CONTENTS

EXHIBITS

TABLES

Alternatives Development and Analysis

This chapter describes the alternatives development and analysis process conducted to identify multimodal transportation improvements that advance the study's goals and objectives (listed in Section 1.4). The development of alternatives was guided by MassDOT' s Project Development and Design Guide (with consideration of the study's issues, constraints, and opportunities described in Section 2.8) and the study's design assumptions. Through regular and meaningful coordination, the study Working Group provided substantial input into the alternative's development process.

This process was also influenced by the U.S. Army Corps of Engineers (USACE) on-going planning study of the Bourne and Sagamore Bridges. The result of their study will be a decision by the USACE to either continue to maintain the Bourne and Sagamore Bridges or prepare for their replacement. This decision may not be the same for both bridges.

While MassDOT and the USACE are coordinating their respective study efforts, it is acknowledged that the potential transportation improvements described in this chapter represent conceptual scenarios that could occur in the future given the uncertainties in permitting, funding, and actions by the USACE affecting the study area's transportation system. Ultimately, continued coordination would be required between the USACE and MassDOT to ensure that future infrastructure investments by these agencies are compatible with each other in terms of alignment, design elements and standards, and future travel demand.

4.1 DESIGN APPROACH AND ASSUMPTIONS

MassDOT' s standard approach to alternatives development was used, which focuses on:

- Satisfying the study goals and objectives (Section 1.4);
- Consideration of issues, constraints, and opportunities (Section 2.8); and
- Minimizing impact to property, community facilities, and environmental resources.

Also, recognizing that Cape Cod is a major summertime tourist destination and trying to design transportation improvements to accommodate the summertime peak period traffic volumes would require the construction of very substantial infrastructure improvements. In consultation with the Working Group, it was concluded that this level of infrastructure would likely be considered an 'over-build' not in line with the type or scale of development desired on Cape Cod. As a result, the following **assumptions** guided the alternatives analysis process:

- Focus on future (2040) year-round safety and mobility problem locations;
- Focus on improvements to existing infrastructure;
- Focus on improvements that reduce cut-through traffic on local roadways;
- Design to accommodate the future (2040) non-summer weekday PM peak period traffic volumes;
- Provide further feasible improvements to accommodate summer Saturday peak period travel volumes, in line with community character;
- Design in accordance with design standards and processes found within the MassDOT Project Development and Design Guide, LRFD Bridge Manual, Separated Bike Lane Planning and Design Guide, and other MassDOT design standards, as appropriate.
- Design will incorporate Intelligent Transportation System (ITS) improvements to provide real-time traveler

information, weather conditions, work-zone management, and emergency management information.

- Recommended alternatives to be compatible with future Canal bridges with minimal modification; and
- Replacement Canal bridges to be built adjacent to existing bridges. The replacement Bourne Bridge would be located immediately to the east of the existing bridge and the replacement Sagamore Bridge immediately to the west (this assumption is made with the knowledge that the Canal bridges are owned by the USACE who will decide if the Canal bridges will be replaced or rehabilitated).

4.2 ALTERNATIVES DEVELOPMENT AND ANALYSIS

Transportation improvement alternatives were developed – in coordination with the Working Group and based on the existing and future traffic conditions and environmental constraints in the study area. The 'design assumptions' described above provided a framework for the development of these alternatives.

As noted in Section 4.1, evaluation of potential improvements focused on 'year-round problem intersections'. These are intersections (listed on Table 3 7) that operate (or are forecast to operate) as a LOS E or F during at least one summer Saturday and non-summer weekday peak travel period in 2014 or 2040. Problem intersections also include those identified as high-crash locations under the Highway Safety Improvement Program (HSIP). While not meeting the definition of a 'year-round problem intersection', the Scenic Highway at Nightingale Pond Road intersection and the Route 6 Exit 1C interchange were also evaluated due to their effect on traffic operations in the study area.

Overall, eight locations were advanced to alternatives development (Table 4-1). Several of these are a combination of more than one year-round problem intersection, as proximity to one another resulted in them operating as a single traffic point.

Transportation improvements were developed in accordance with the requirements of MassDOT' s Project Development and Design Guide and reflect a commitment to complete streets and mode shift objectives to the degree appropriate for each individual location, consistent with the principles of MassDOT' s Healthy Transportation Policy Directive. This policy seeks to increase and encourage the use of a greater variety of transportation modes including walking, bicycling, and transit.

Table 4-1 Future (2040) Year-Round Problem Intersections

LOCATION NO. ON EXHIBIT 3-19/3-20	LOCATION	TOWN	HIGH CRASH CLUSTER[1]	LOS E OR F (2040)
8	Scenic Highway/Meetinghouse Lane at Canal Street/State Road	Bourne	Yes	Yes
10/11[2]	Sandwich Road at Bourne Rotary Connector/High School Drive	Bourne	Yes	Yes
15	Route 6A (Sandwich Road) at Cranberry Highway	Bourne	No	Yes
21	Route 130 at Cotuit Road	Sandwich	Yes	Yes
4/52	Belmont Circle and Scenic Highway at Nightingale Pond Road	Bourne	Yes	Yes
9	Bourne Rotary	Bourne	Yes	Yes
16/17	Route 6A/Route 130/ Tupper Road[3]	Sandwich	Yes	No
N/A	Route 6 Exit 1C Relocation[4]	Bourne	No	No

1 High crash locations identified by MassDOT for the 2011-2013 or 2012-2014 periods.
2 Locations combined due to their proximity.
3 To be combined with Route 6 Exit 1C Relocation.
4 Advanced to Alternatives Development due to substandard design.

Ultimately, the recommended alternatives were developed to address the evaluation criteria (described in Section 1.5). These alternatives were compared to each other to identify a suite of recommended build alternatives. An evaluation matrix is provided for each of the travel demand model cases described in Section 5.2. The evaluation matrix provides a summary of the analysis of the recommended alternatives against the evaluation criteria.

4.2.1 Traffic Analysis – Measures of Effectiveness

As described in Section 2.5.5, the measures of effectiveness for the traffic analysis are based on level of service (LOS) and queue lengths (which is a measure of intersection delay). Delay is defined as the difference between travel time during free-flow travel periods and the travel time during congested conditions.

LOS is a qualitative measure used to relate the quality of peak-hour traffic operating conditions. LOS is based on density for highway sections and ramps and average delay traffic at intersections. LOS ranges from A, the optimal free-flow condition, to F, where traffic demands are beyond roadway capacity or create excessive delays (Table 2-17). LOS E or LOS F is generally considered to be unacceptable travel delay.

While LOS is a useful measure of effectiveness along highways and signalized and unsignalized intersections, it is not a helpful measure at complex, non-traditional traffic circles such as Belmont Circle and the Bourne Rotary which are described in terms of queuing, vehicle delays, and travel time.

Queues are the length of a line of vehicles waiting to pass through an intersection, generally calculated during the peak period. These vehicles may be stopped or advancing slowing. The

50% queue is the median length of this line of vehicles (during the peak hour) and the 95% queue is the maximum length of this line of vehicles.

Generally, each vehicle (including the space between vehicles) occupies approximately 25 feet; so a queue of 250 feet includes approximately 10 vehicles.

4.2.2 Conceptual Cost Estimate Methodology

Conceptual cost estimates were prepared for each of the potential transportation improvements. The cost estimates were based on MassDOT 2017 unit costs per linear foot of new roadway and bridge sections (see the methodology section of Appendix E).

The cost estimates were escalated by 4% per year to develop cost for 2017, 2030, and 2040, to provide an understanding of the increasing cost of these projects at different time periods. The conceptual cost estimates, including the unit costs for various roadway and bridge sections, are provided in Appendix E.

The unit-costs for the various alternatives were increased by an additional 25% to 40% to account for contingencies such as environmental mitigation, traffic management, utility relocation, traffic management and/or structural elements (such as retaining walls). A lower contingency was used for less complex design alternatives (e.g., local intersection improvements) while a 40% contingency was used for larger, more complex mid- and long-term design alternatives. A 75% contingency was used for larger projects involving substantial utility conflicts/potential relocations. The conceptual cost estimates do not include the costs of design, permanent or temporary right-of-way costs, or construction engineering.

4.3 ROADWAY IMPROVEMENT ALTERNATIVES ANALYSIS

The following sections describe the transportation improvements alternatives developed for the year round problem intersections listed in Table 4-1. Based on anticipated project complexity and cost, these potential improvements are divided into ‘local intersection improvements’ and ‘gateway intersection improvements’. The gateway intersections are those immediately adjacent to the Bourne and Sagamore Bridges, including Belmont Circle, Bourne Rotary, and Route 6 Exit 1C. A brief description of each location is provided, including roadway layout, adjacent land uses and environmental resources. A summary of the existing and future traffic conditions is also provided.

For clarity, traffic operations are provided for the two key travel periods; the non-summer weekday PM period (4:00 – 6:00

PM) and the summer Saturday (10:00 AM to 12:00 PM) period. The non-summer weekday PM period represents the weekday commuter period and the summer Saturday represents the peak travel period for visitors.

More detailed information related to existing and future traffic operations at these locations is provided in Chapters 2 (Section 2.5) and Chapter 3 (Section 3.3), respectively, and Appendix H.

4.3.1 Working Group Transportation Improvement Submissions

Numerous thoughtful suggestions for transportation system improvements were received from individual members of the Working Group or members of the public. Each of these concepts was considered to ascertain whether they warranted inclusion in the alternatives analysis. Several of these concepts were similar to alternatives already being pursued by the study. These transportation improvement concepts and the results of the evaluation of them are provided in Table 4-2.

Table 4-2 Working Group Submissions

TRANSPORTATION SYSTEM CONCEPT	RESULT OF STUDY EVALUATION
Funding transportation improvements through bridge tolling	Bridge tolling not allowed by USACE bridge legislation (PL 516, Chapter 188, Section 109 33 USC 534)
Expanded rail service	Expanding rail service would improve multimodal mobility on Cape Cod, however it would have capacity to meaningfully alleviate traffic congestion in study area. No stations exist in Bourne or Sandwich south of the Canal.
Additional Canal bridges and approach highways connecting Route 25 to Route 6	Not advanced due to substantial environmental impact; including wetlands, ACECs, open space, and tribal resources. Contrary to the goal of focusing on existing infrastructure.
Cross-Canal tunnel	Based on conceptual analysis, tunneling options not advanced due to high cost of construction and maintenance compared to bridge options and substantial property acquisition requirements.
Route 6 Exit 2 (Route 130) improvements	Additional capacity at Exit 2 not needed.
Scenic Highway to Route 25 entrance ramp	Concept advanced into conceptual design (see Section 4.6.4).
Sandwich Road capacity improvements	Capacity improvements not needed on Sandwich Road. Widening Sandwich Road would also result in substantial impact to public open space.
Bourne Rotary Improvements	Similar concept advanced into conceptual design (see Section 4.6.5).

4.4 LOCAL INTERSECTION IMPROVEMENTS

Improvements to local intersections include incorporation of Transportation System Management (TSM) measures at key intersections in the study area. Examples of TSM improvements include: traffic signal optimization, installation of new traffic signals and/or signal control equipment, installation of turning lanes, and improved roadway markings and signage. Local intersection improvements generally take less than three years to implement.

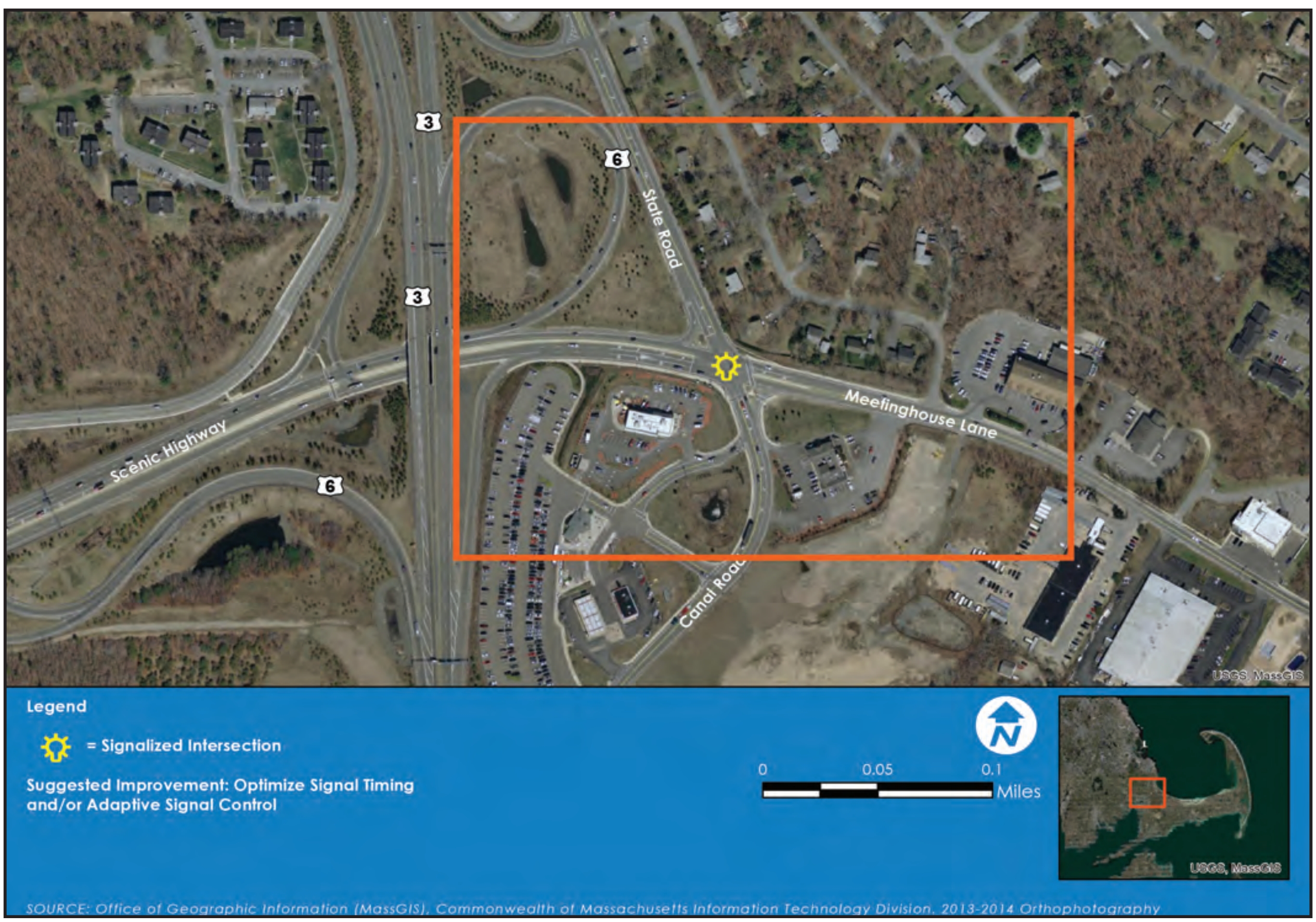
Conceptual cost estimates were prepared for each of the potential transportation improvements. The methodology used for preparing the cost estimates can be found in Section 4.2.2. More detailed conceptual cost estimates are provided in Appendix E.

4.4.1 Scenic Highway/Meetinghouse Lane at Canal Road/State Road

Existing Conditions

The Scenic Highway/Meetinghouse Lane intersection with Canal Road/State Road in Bourne (Exhibit 4-1) is a signalized

Exhibit 4-1 Scenic Highway/Meetinghouse Lane at Canal Road/State Road



intersection north of the Cape Cod Canal. The intersection is immediately east of Route 6 Exit 1A (Sagamore interchange). Each approach to the intersection features multiple lanes providing separate through or left-turn lanes. The Scenic Highway eastbound approach has three lanes; a right-, through-, and left-turn lane.

At this intersection, sidewalks exist on the south side of the Scenic Highway, the north side of Meetinghouse Lane and both sides of Canal Road. Crosswalks on both sides of Canal Road lead pedestrians to a roadway island and then to the north side of Meetinghouse Lane.

Land Uses and Environmental Resources

MassDOT' s Sagamore Park & Ride lot, a McDonald's restaurant, a Dunkin' Donuts restaurant, and a Shell gas station are accessed from Canal Road south of the intersection. Residential properties are present along Homestead Road at the northeast quadrant of the intersection. The northwest quadrant of the intersection features highway ramps and grassed areas related to the Route 6 at Scenic Highway interchange. No regulated environmental resources exist at this intersection.

Traffic Conditions

This intersection experiences high traffic volumes during both the non-summer weekday PM and the summer Saturday periods because of its proximity to the Route 6 at Scenic Highway interchange (Table 4-3). These high traffic volumes result in predominately LOS C and D during non-summer weekday and summer Saturdays for the existing and future periods. LOS F conditions are forecast in 2040 during the non summer weekday PM peak period for several intersection approaches, including Scenic Highway eastbound and Meetinghouse Lane westbound.

Suggested Improvements

The optimization of the timing of the traffic signals would provide more efficient processing of vehicles traveling through the intersection. Traffic signal optimization generally reduces overall intersection delay by approximately 10%, which can improve LOS. With traffic signal optimization, the non-summer weekday PM peak period is forecast to improve from LOS F to LOS E. During the non-summer weekday PM peak period, average delay at the intersection would be reduced from140 seconds to 66 seconds. Delay during the summer Saturday peak period would improve from 34 seconds to 23 seconds (Table 4-3).

The installation of 'adaptive signal control' should also be evaluated. Adaptive signal control uses real-time traffic

Table 4-3 *Traffic Operations – Scenic Hwy/Meetinghouse Lane at Canal Road/State Road*

	EXISTING (2014) CONDITIONS					FUTURE (2040) NO-BUILD CONDITIONS					FUTURE (2040) BUILD CONDITIONS				
	AVERAGE DELAY Sec (Min)	LOS	V/C	50% QUEUE Feet (Miles)	95% QUEUE Feet (Miles)	AVERAGE DELAY Sec (Min)	LOS	V/C	50% QUEUE Feet (Miles)	95% QUEUE Feet (Miles)	AVERAGE DELAY Sec (Min)	LOS	V/C	50% QUEUE Feet (Miles)	95% QUEUE Feet (Miles)
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)															
Scenic Highway EB Lt	26	C	0.78	225	450	173 (2.9)	**F**	1.3	621	930	84 (1.4)	**F**	1.06	779	1,035
Scenic Highway EB Th	21	C	0.35	87	202	25	C	0.5	134	298	10	B	0.3	130	181
Scenic Highway EB Rt	18	B	0.12	0	8	19	B	0.14	0	29	9	A	0.14	0	27
Meetinghouse Ln WB Lt	38	D	0.09	4	16	38	D	0.14	6	21	46	D	0.11	16	42
Meetinghouse Ln WB Th/Rt	156 (2.6)	**F**	1.16	146	295	418 (7.0)	**F**	1.79	305	488	99 (1.7)	**F**	0.99	325	538
Canal Road NB Lt	45	D	0.62	96	153	45	D	0.67	115	175	129 (2.2)	**F**	1.01	176	340
Canal Road NB Th/Rt	33	C	0.29	65	116	32	C	0.33	81	134	46	D	0.37	115	186
State Road SB Lt	49	D	0.34	17	44	50	D	0.46	23	56	66	**E**	0.44	34	74
State Road SB Th	39	D	0.11	16	42	39	D	0.14	20	49	62	**E**	0.25	29	66
State Road SB Rt	39	D	0.08	0	0	39	D	0.1	0	0	61 (1.0)	**E**	0.1	0	72
Intersection (Overall)	**46.8**	**D**	**0.74**			**140 (2.3)**	**F**	**1.09**			**66.5 (1.1)**	**E**	**1.03**		
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)															
Scenic Highway EB LT	14	B	0.34	73	149	16	B	0.42	81	154	13	B	0.49	57	100
Scenic Highway EB Th	22	C	0.35	147	274	25	C	0.49	226	386	14	B	0.45	123	196
Scenic Highway EB Rt	19	B	0.14	0	52	20	C	0.17	0	59	11	B	0.17	0	37
Meetinghouse Ln WB Lt	20	C	0.07	11	33	21	C	0.09	13	37	22	C	0.15	14	38
Meetinghouse Ln WB Th/Rt	27	C	0.31	106	220	31	C	0.49	185	368	32	C	0.67	130	250
Canal Road NB Lt	32	C	0.51	129	165	33	C	0.58	148	192	30	C	0.74	87	165
Canal Road NB Th/Rt	44	D	0.58	161	214	49	D	0.7	191	257	21	C	0.46	88	155
State Road SB Lt	42	D	0.21	27	47	43	D	0.35	47	74	36	D	0.59	37	82
State Road SB Th	49	D	0.38	68	110	51	D	0.48	80	131	31	C	0.43	46	91
State Road SB Rt	48	D	0.3	0	99	49	D	0.26	0	95	30	C	0.26	0	78
Intersection (Overall)	**32.6**	**C**	**0.47**			**34.1**	**C**	**0.60**			**23.0**	**C**	**0.76**		

Notes:
- *LOS E and LOS F movements are shaded **bold***
- *Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound*
- *LOS = Level of Service.*
- *V/C = Volume to Capacity Ratio*
- *Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.*

information to actively adjust signal timing at each approach. This technology can further reduce traffic congestion and delay. Although ADA-compliant sidewalks and crosswalks already exist at this intersection, they should be evaluated to ensure a state of good repair.

Property or Environmental Resource Impact

Signal optimization would not impact any regulated environmental resources. No property taking would be required.

Conceptual Cost Estimate

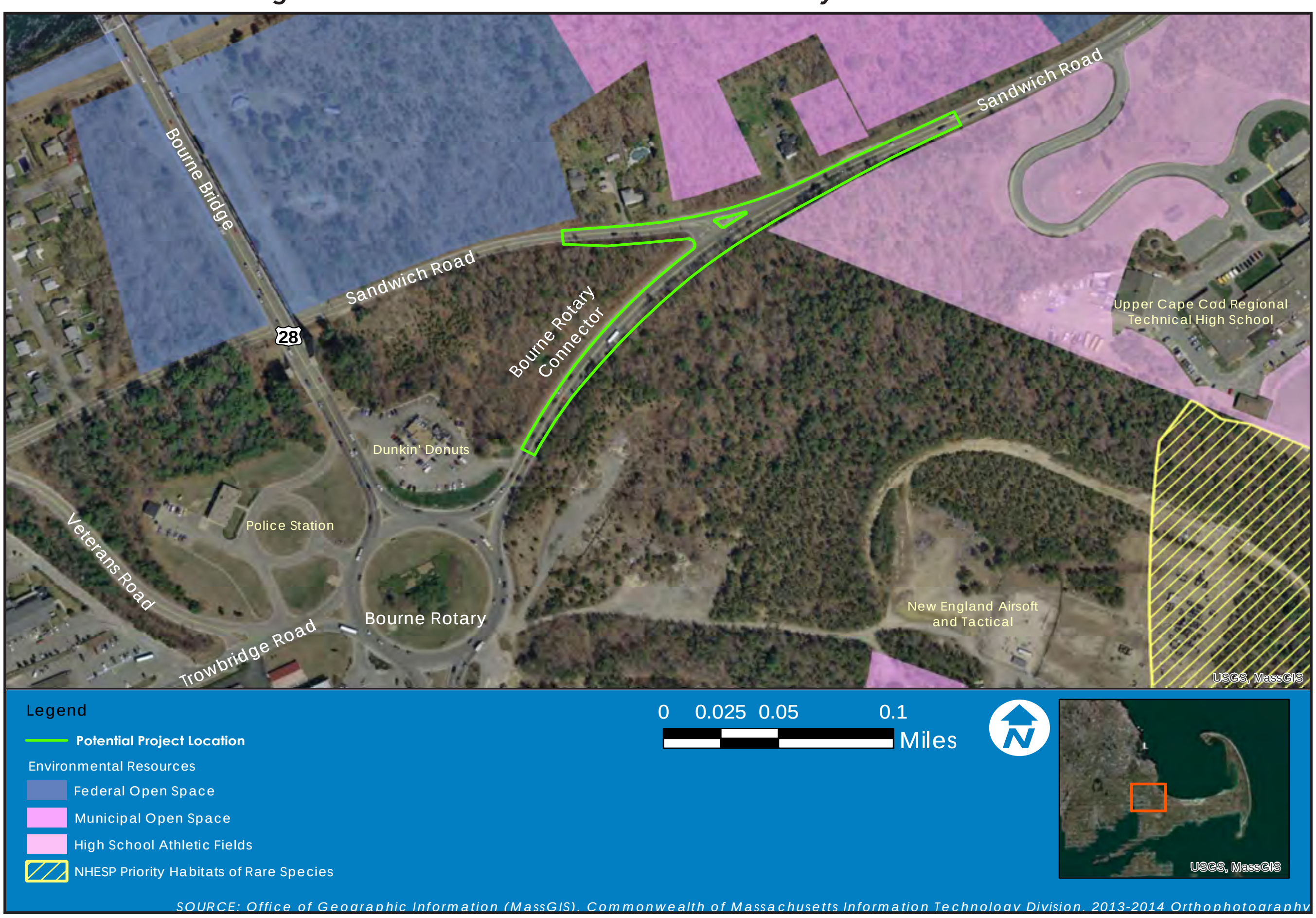
The cost of these improvements would range from approximately $25,000 to $50,000 (2017 costs).

4.4.2 Sandwich Road at Bourne Rotary Connector

Existing Conditions

Sandwich Road at Bourne Rotary Connector in Bourne (Exhibit 4-2) is an unsignalized Y intersection immediately east of the Bourne Rotary, which is south of the Cape Cod Canal. Each approach to the intersection features a single lane. The Bourne

Exhibit 4-2 Existing Conditions - Sandwich Road at Bourne Rotary Connector



Rotary Connector provides direct access from Sandwich Road to the Bourne Rotary (and the Bourne Bridge and other points north). The combination of the Bourne Rotary Connector and Sandwich Road (east of the intersection) acts as the through movement at this intersection with the Sandwich Road approach from the west acting as the minor roadway approach. There are no sidewalks or crosswalks on any of the approaches to this intersection.

Land Uses and Environmental Resources

Except for three residential properties, land uses north of the intersection consist of public open space owned by either the Town of Bourne or the U.S. Army Corps of Engineers. The Cape Cod Regional Technical High School property is southeast of the intersection (with its entrance drive approximately 1,000 feet east on Sandwich Road).

There are no wetlands, floodplains, or other regulated water resources within 100 feet of the intersection. Land south of the intersection is designated by the Massachusetts Natural Heritage and Endangered Species Program as a 'Priority Habitat for Rare Species'.

Traffic Conditions

This intersection experiences high traffic volumes during both the non-summer weekday PM and the summer Saturday peak periods. Combined with the lack of signalization at this intersection, these factors result in LOS F conditions during existing and future at the Old Sandwich Road eastbound approach for left-turning vehicles entering Sandwich Road.

Suggested Improvements

The effectiveness of installing traffic signals at this intersection (Exhibit 4-3) was evaluated. Both the Sandwich Road eastbound and the Bourne Rotary Connector eastbound approach would have designated left-turn lanes. Additionally, a through-lane would provide a direct connection from the Bourne Rotary Connector to Sandwich Road eastbound. This movement would be free-flow, instead of being subject to traffic signals. This through lane would be separated from the other lanes with a raised median barrier.

Due to these improvements, traffic operations along the Old Sandwich Road eastbound approach would be improved considerably from LOS F to LOS C for the non-summer weekday PM period (Table 4-4). Overall, this intersection would operate at LOS A and LOS B for the non-summer weekday and summer Saturday peak periods, respectively. The timing of the new traffic

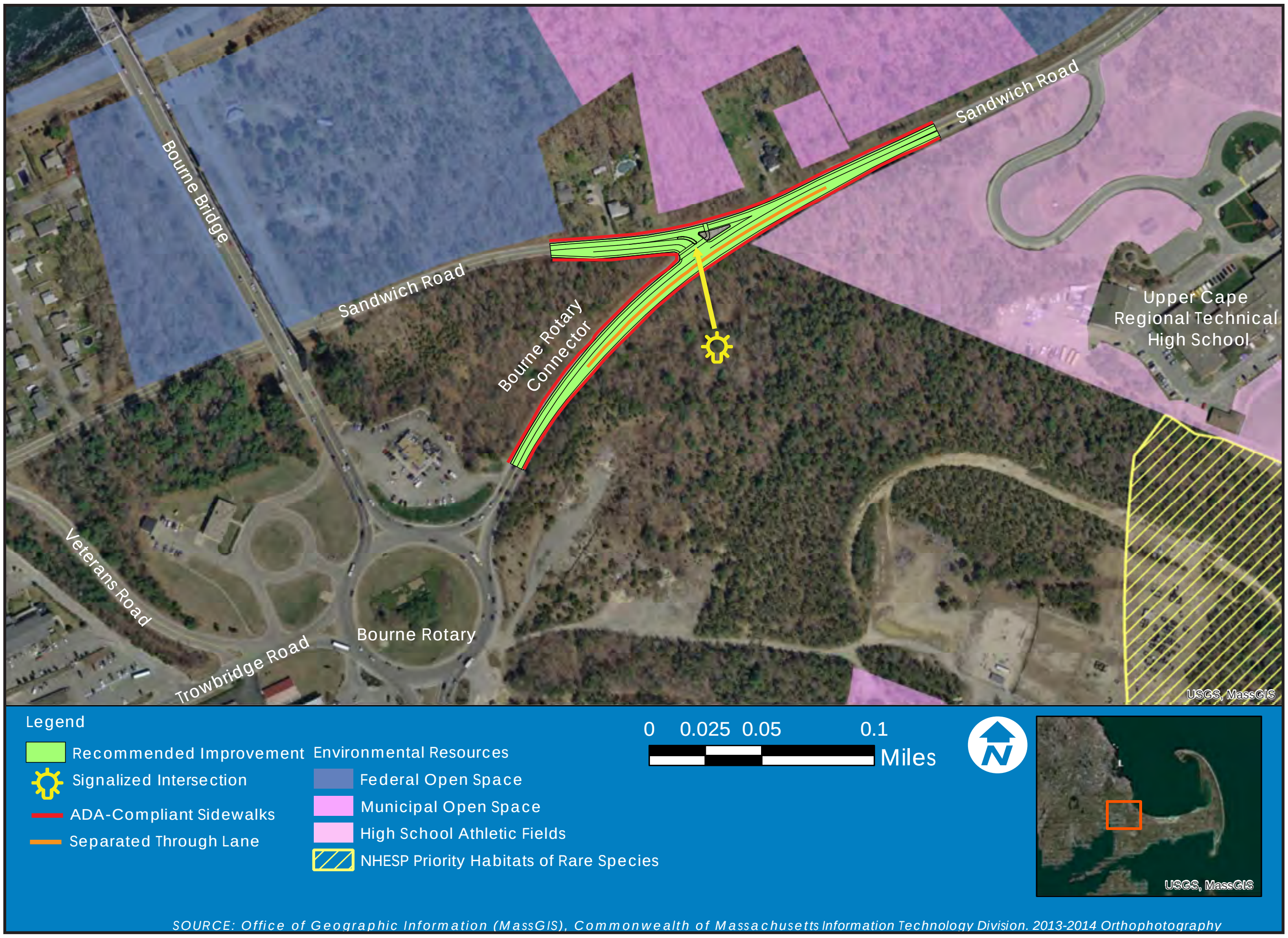


Exhibit 4-3 Sandwich Road at Bourne Rotary Connector

signals would be optimized to provide more efficient processing of vehicles traveling through the intersection. The installation of 'adaptive signal control' would also be evaluated.

Improvements to bicycle/pedestrian facilities including ADA-compliant sidewalks and crosswalks along Sandwich Road, in addition to a sidewalk connection to the Technical High School driveway are also proposed. In addition to the roadway travel lanes, shoulders would provide safe accommodation for bicyclists.

Property or Environmental Resource Impact

The improvements may require the acquisition of less than 1,000 square feet of Town of Bourne open space and undeveloped commercial property. No regulated wetland/water resources would be impacted.

Table 4-4 Traffic Operations - Sandwich Road at Bourne Rotary Connector

	EXISTING (2014) CONDITIONS					FUTURE (2040) NO-BUILD CONDITIONS					FUTURE (2040) BUILD CONDITIONS				
	AVERAGE DELAY Sec (Min)	LOS	V/C	50% QUEUE Feet (Miles)	95% QUEUE Feet (Miles)	AVERAGE DELAY Sec (Min)	LOS	V/C	50% QUEUE Feet (Miles)	95% QUEUE Feet (Miles)	AVERAGE DELAY Sec (Min)	LOS	V/C	50% QUEUE Feet (Miles)	95% QUEUE Feet (Miles)
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)															
Bourne Rotary Connector NEB Lt/Th	0	A	0	--	0	0	A	0	--	0					
Sandwich Rd WB Th/Rt	0	A	0.57	--	0	0	A	0.69	--	0					
Old Sandwich Road EB Lt	537 (8.9)	**F**	1.89	--	313	n/a	**F**	3.35	--	n/a	22	C	0.54	69	127
Old Sandwich Road EB Rt	47	**E**	0.82	--	179	131 (2.2)	**F**	1.14	--	363	14	B	0.47	63	131
Bourne Rotary Connector NEB Lt											0	A	0	0	0
Bourne Rotary Connector NEB Th											1	A	0.59	0	0
Sandwich Road WB Th											17	B	0.79	205	436
Sandwich Road WB Rt											9	A	0.29	0	41
Intersection (Overall)											**9.7**	**A**	**0.78**		
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)															
Bourne Rotary Connector NEB Lt/Th	1	A	0.02	--	2	1	A	0.03	--	2					
Sandwich Rd WB Th/Rt	0	A	0.65	--	0	0	A	0.67	--	0					
Old Sandwich Road EB Lt	606 (10.1)	**F**	1.74	--	165	n/a	**F**	6.25	--	n/a	36	D	0.7	108	192
Old Sandwich Road EB Rt	27	D	0.41	--	48	31	D	0.5	--	66	19	B	0.15	14	52
Bourne Rotary Connector NEB Lt											33.1	C	0.13	10	32
Bourne Rotary Connector NEB Th											2.2	A	0.69	0	0
Sandwich Road WB Th											23.9	C	0.9	396	715
Sandwich Road WB Rt											7	A	0.12	0	25
Intersection (Overall)											**13.9**	**B**	**0.89**		

Notes:
- *LOS E and LOF movements are **bold***
- *Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound*
- *LOS = Level of Service; V/C = Volume to Capacity Ratio*
- *Overall LOS, V/C and queues not calculated for unsignalized intersections.*
- *Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.*
- *n/a = Volume exceeds capacity to the point where the respective value cannot be determined.*
- *Shaded areas do not exist in listed configuration during this period.*

Conceptual Cost Estimate

Reconstruction and signalization at the Sandwich Road at Bourne Rotary Connector intersection would cost approximately $1.9 million (2017 costs). More detailed conceptual cost estimates are provided in Appendix E.

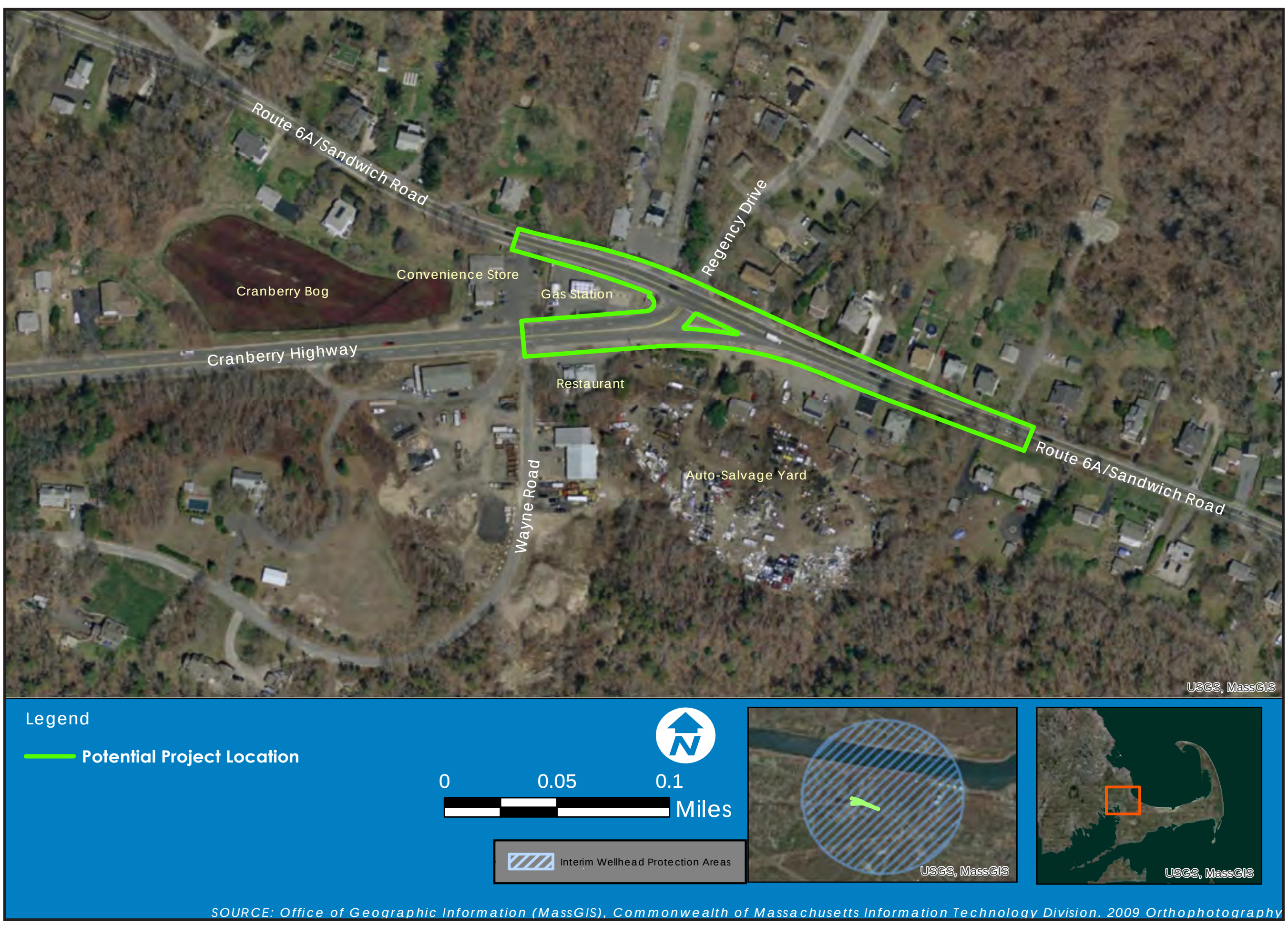
4.4.3 Route 6A (Sandwich Road) at Cranberry Highway

Existing Conditions

The Sandwich Road at Cranberry Highway intersection in Bourne (Exhibit 4-4) is an unsignalized Y-intersection approximately 0.75-miles east of the Route 6/Cranberry Highway Interchange (Exit 1C). Each approach to the intersection features a single lane. The Cranberry Highway eastbound approach has a channelized right-turn lane separated from the left-turn lane by a large traffic island.

Regency Drive, a dead-end residential street, has access from Sandwich Road directly opposite the Cranberry Highway approach. The north side of Sandwich Road has sidewalks that

Exhibit 4-4 Existing Conditions - Route 6A (Sandwich Road) at Cranberry Highway



are frequently interrupted by driveways. These sidewalks are generally not ADA-compliant. There are no sidewalks along Cranberry Highway, or any crosswalks on any of the approaches to this intersection.

Land Uses and Environmental Resources

Land uses in the area include residential properties along Sandwich Road, and a gas station and a convenience store on the parcel between Sandwich Road and Cranberry Highway. The Cranberry Highway approach features a mix of residential properties, a cranberry bog, restaurant, and an auto salvage yard.

There are no wetlands, floodplains, or other regulated water resources within 100 feet of the intersection. The entire intersection is within an interim wellhead protection area of a public water supply.

Traffic Conditions

This intersection experiences generally acceptable traffic conditions (LOS A and B) except for the Cranberry Highway east-bound approach. Left-turning vehicles on this approach experience LOS E and F conditions during the future non-summer weekday PM and the summer Saturday periods, respectively. Vehicles entering this intersection from Regency Drive are expected to experience LOS F conditions during the future non summer weekday peak period.

Suggested Improvements

The suggested improvements include the construction of a left-turn lane on the Sandwich Road westbound approach (Exhibit 4 5). This left-turn lane would reduce queuing on this approach that currently form behind vehicles on Sandwich Road westbound turning left onto Cranberry Highway. Reducing these queues would create more gaps in traffic, allowing vehicles from Cranberry Highway to more easily enter Sandwich Road (Table 4-5). During the non-summer weekday PM peak period, traffic operations for vehicles entering from Regency Drive would improve from LOS F to LOS B.

Improvements to bicycle/pedestrian facilities including ADA-compliant sidewalks and crosswalks along Sandwich Road and Cranberry Highway are also proposed. Roadway shoulders would be widened to provide safer accommodation for bicyclists.

Property or Environmental Resource Impact

The improvements may require the acquisition of less than 1,000 square feet of residential property. No regulated environmental resources would be impacted.

Exhibit 4-5 Route 6A (Sandwich Road) at Cranberry Highway

Conceptual Cost Estimate

These improvements would cost approximately $584,000 (2017 costs). More detailed conceptual cost estimates are provided in Appendix E.

4.4.4 Route 130 (Forestdale Road) at Cotuit Road

Existing Conditions

The Route 130 (Forestdale Road) at Cotuit Road intersection in Sandwich (Exhibit 4-6) is an unsignalized T intersection approximately 1.6 miles south of the Route 6/Route 130 (Exit 2) interchange. The Route 130 southbound approach to the intersection has two lanes; a through- and a left-turn lane. The Route 130 northbound approach is a single-lane approach. The Cotuit Road northbound approach is stop-controlled and has two lanes; a left- and right-turn lane.

There are no sidewalks or crosswalks on Route 130 or Cotuit Road near the intersection. Route 130 has roadway shoulders, approximately eight feet in width, on both sides of the road. Cotuit Road has three-foot shoulders.

Table 4-5 *Traffic Operations - Route 6A (Sandwich Road) at Cranberry Highway*

	EXISTING (2014) CONDITIONS				FUTURE (2040) NO-BUILD CONDITIONS				FUTURE (2040) BUILD CONDITIONS			
	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)												
Sandwich Road EB Lt/Th/Rt	0	A	0	0	0	A	0	0	0	A	0	0
Sandwich Road WB Lt									22	A	0.22	22
Sandwich Road WB Lt/ Th/Rt	4	A	0.18	16	22	A	0.22	22	0	A	0.23	0
Cranberry Hwy EB Lt/Th	32	D	0.07	5	8	**E**	0.1	8	8	E	0.1	8
Cranberry Hwy EB Rt	12	B	0.08	7	9	B	0.11	9	9	B	0.11	9
Regency Drive SB Lt/Th/Rt	35	D	0.04	3	5	**A**	0.06	5	1	B	0.01	1
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)												
Sandwich Road EB Lt/Th/Rt	0	A	0.01	0	0	A	0.01	0	0	A	0.01	0
Sandwich Road WB Lt									184 (3.1)	C	0.75	184
Sandwich Road WB Lt/ Th/Rt	14	B	0.61	110	184 (3.1)	C	0.75	184	0	A	0.36	0
Cranberry Hwy EB Lt/Th	1,416 (23.6)	**F**	2.71	124	n/a	**F**	7.13	n/a	n/a	**F**	7.11	n/a
Cranberry Hwy EB Rt	12	B	0.11	9	13	B	0.15	13	13	B	0.15	13
Regency Drive SB Lt/Th/Rt	12	B	0.01	1	1	B	0.01	1	1	B	0.01	1

Notes:
- *LOS E and LOS F movements are **bold***
- *Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound*
- *LOS = Level of Service; V/C = Volume to Capacity Ratio*
- *Overall LOS, V/C and queues not calculated for unsignalized intersections.*
- *Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.*
- *Shaded areas do not exist in listed configuration during this period.*

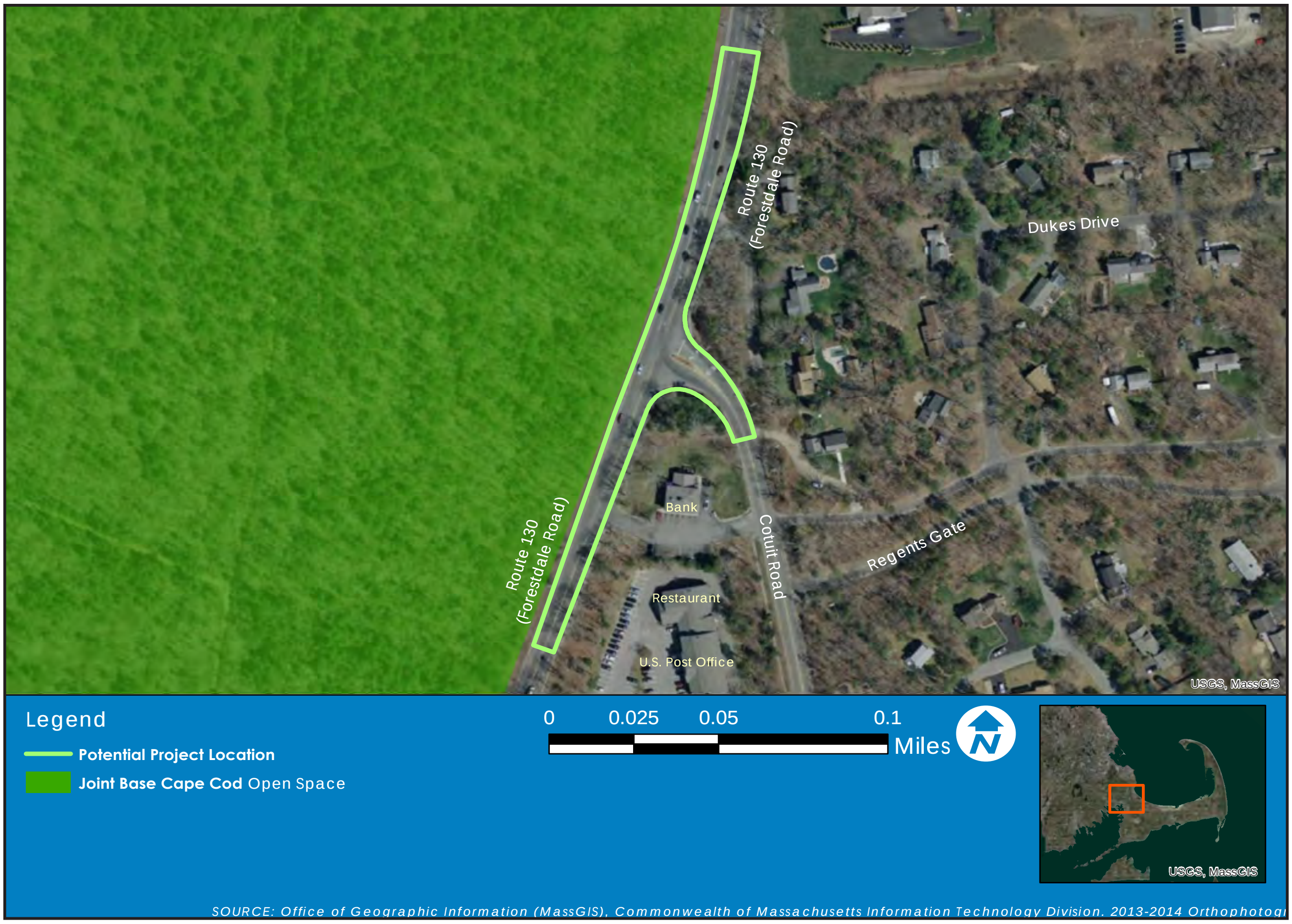


Exhibit 4-6 **Existing Conditions - Route 130 at Cotuit Road**

Land Uses and Environmental Resources

Land uses in the area include residential properties along the east side of Cotuit Road and Route 130. Land to the west of Route 130 is undeveloped forest belonging to Joint Base Cape Cod (JBCC). Numerous commercial developments exist in the land between Route 130 and Cotuit Road.

There are no wetlands, floodplains, or other regulated wetland resources within 100 feet of the intersection. Land west of Route 130 within JBCC is designated by the Massachusetts Natural Heritage and Endangered Species Program as a 'Priority Habitat for Rare Species'.

Traffic Conditions

This intersection experiences generally acceptable traffic conditions (LOS A and B) except for the Cotuit Road northbound approach. Left-turning vehicles on this approach experience LOS F conditions during both the existing and future non-summer weekday PM and the summer Saturday periods (Table 4-6).

Table 4-6 Traffic Operations – Route 130 at Cotuit Road

	EXISTING (2014) CONDITIONS				FUTURE (2040) NO-BUILD CONDITIONS				FUTURE (2040) BUILD CONDITIONS				
	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	V/C	50% QUEUE *Feet (Miles)*	95% QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)													
Route 130 NB Th/Rt	0	A	0.25	0	0	A	0.3	0	19	B	0.71	141	403
Route 130 SB Lt	11	B	0.5	72	14	B	0.64	121	14	B	0.77	72	285
Route 130 SB Th	0	A	0.27	0	0	A	0.32	0	1	A	0.34	0	70
Cotuit Road NB Lt	137 (2.3)	**F**	0.16	12	387 (6.5)	**F**	0.37	24	33	C	0.18	2	12
Cotuit Road NB Rt	16	C	0.5	71	27	D	0.74	157	14	B	0.49	74	136
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)													
Route 130 NB Th/Rt	0	A	0.24	0	0	A	0.33	0	16	B	0.74	106	281
Route 130 SB Lt	10	A	0.34	37	12	B	0.47	65	8	A	0.63	15	165
Route 130 SB Th	0	A	0.24	0	0	A	0.25	0	1	A	0.28	0	56
Cotuit Road NB Lt	57	**F**	0.14	11	133 (2.2)	**F**	0.29	24	28	C	0.31	3	16
Cotuit Road NB Rt	25	D	0.75	167	88 (1.5)	**F**	1.07	432	17	B	0.71	93	228
Intersection (Overall)									**11.4**	**B**	**0.8**		

Notes:
•LOS E and LOS F movements are ***bold***
•Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
•LOS = Level of Service; V/C = Volume to Capacity Ratio
•Overall LOS, V/C and queues not calculated for unsignalized intersections.
•Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

Suggested Improvements

The installation of a traffic signal at this intersection would provide opportunities for vehicles from Cotuit Road to safely enter Route 130, reducing delays on this approach (Exhibit 4-7).

This would result in an improvement in traffic operations for left-turning vehicles on the Cotuit Road northbound approach from LOS F to LOS C for the non-summer weekday and summer Saturday peak periods. During the non-summer period, this would reduce average delay by 91% (387 seconds reduced to 33 seconds).

Additionally, improvements to pedestrian facilities including ADA-compliant sidewalks along the east side of Route 130 extending to the entrance of the Trade Winds Plaza are also proposed. The roadway shoulders on Route 130, which currently meet MassDOT' s bicycle accommodation standards, would be maintained.

Exhibit 4-7 Route 130 at Cotuit Road

Property or Environmental Resource Impact

These improvements may require the acquisition of less than 1,000 square feet of residential property along the roadway frontage. No regulated environmental resources would be impacted.

Conceptual Cost Estimate

The improvements would cost approximately $956,000 (2017 costs). Conceptual cost estimates are provided in Appendix E.

4.5 SCREENING-LEVEL ANALYSIS

A screening-level analysis was completed for the potential larger transportation improvements. The initial purpose of the screening-level analysis is to identify potential significant impact to natural and social environmental resources or property. For this screening analysis stage, it is assumed that the existing Canal bridges remain.

This step is completed in anticipation of the requirement of any potential improvements to complete federal and state environmental review in compliance with the National Environmental Policy Act and Massachusetts Environmental Policy Act (NEPA, 40 CFR 1500-1508 and MEPA, 301 CMR 11:00). These environmental laws require federal and state agencies – prior to receiving funding or other approvals – to evaluate the potential environmental effects of their actions and, through a detailed alternative analysis, select an alternative that meets the project purpose and need with the least environmental impact.

Project alternatives that would result in significant environmental or property impact – projects which would be unlikely to receive approval under MEPA and NEPA – were dismissed from further consideration.

Project alternatives that were not anticipated to result in significant environmental impact were advanced to the next stage of the screening analysis, preliminary traffic analysis. Based on a conceptual design, the effectiveness of potential projects as stand-alone improvements were evaluated using future (2040) traffic volumes.

As described in the following sections, a new Canal bridge on new highway alignment (Public-Private Partnership alternatives) were determined to result in significant environmental impact and were dismissed from further consideration. Potential transportation improvements at gateway intersections were advanced to the traffic analysis stage, and through coordination with the Working Group, suggested alternatives were advanced for further study. Section 4.8 describes the evaluation of combinations of these potential improvements using the regional travel demand model.

4.5.1 Public-Private Partnership Alternatives

Concurrent with the beginning of this study, MassDOT began consideration of several projects as potential Public-Private Partnerships (P3). An infrastructure P3 is generally a method of project delivery in which a private entity designs, constructs, finances, and manages a facility in exchange for a portion of the funds generated or through availability payments. In the case of a highway P3 project, the funds generated by the project are generally the tolls charged to users of the facility.

Based on the long-standing highway congestion in the Canal area, the age and condition of the Canal bridges, and the uncertainty of the USACE's plans related to the rehabilitation or replacement of the bridges, MassDOT identified the Canal area as a potential P3 project envisioned to provide major transportation infrastructure improvements including a new highway bridge over the Canal.

The highway alternatives developed as part of this P3 development process were informed by the cross-Canal travel patterns. As described in Section 2.5.9, the origin-destination analysis identified a high percentage of vehicles traveling between the Route 3/Route 6 corridor to the Route 25/Route 28 corridor, particularly during the summer Saturday peak period. The transition from one corridor to the other occurs in the Canal area using either Sandwich Road or Scenic Highway. These movements place tremendous pressure on the interchanges adjacent to the Canal such as the Sagamore Rotary, Belmont Circle, and the Bourne Rotary, which lead to high levels of congestion at these locations during peak travel periods.

P3 Alternatives – Project Description

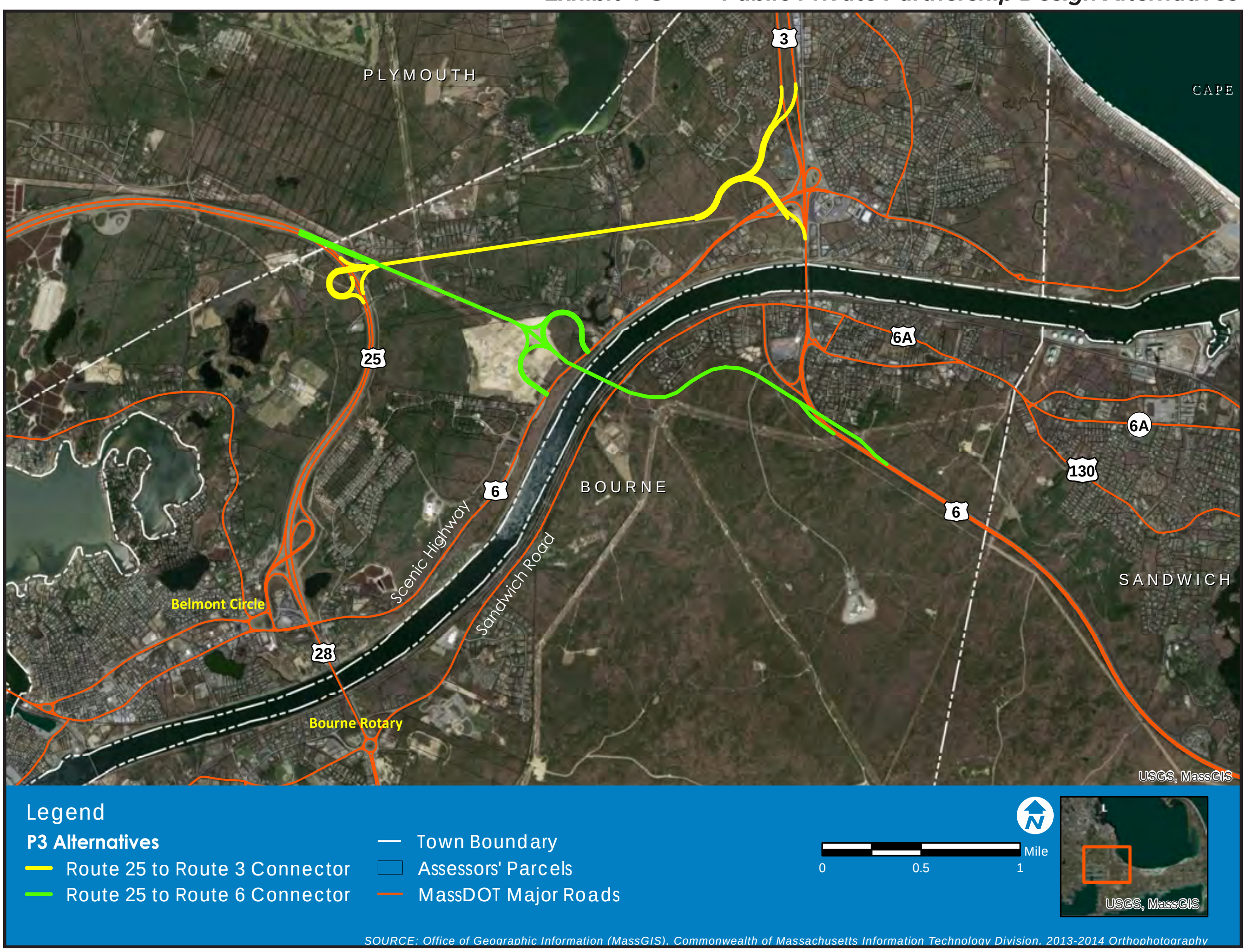
To address this desire for cross-Canal travel, two primary alternatives were developed (Exhibit 4-8). The first alternative would provide a direct roadway connection from Route 25 to Route 3 (north of the Canal). The second alternative would provide a roadway connection from Route 25 to Route 6, including an interchange at Scenic Highway and a new bridge over the Canal. Both alternatives were envisioned to address the high percentage of vehicles traveling between the Route 3/Route 6 highway corridor to the Route 25/Route 28 corridor. These alternatives would be multi-lane highways with interchanges connecting them to the existing highways (Route 3, Route 6, and Route 25).

Public-Private Partnership Alternatives – Environmental Impact

A GIS-based review was conducted to evaluate the potential environmental and social impacts of the two P3 alternatives (Exhibits 4-9 and 4-10). Using a conceptual-level design, the impact analysis was based on two potential roadway widths; a 160-foot width corridor for highway segments having two lanes in each direction and an 80-foot width corridor for those roadway segments and highway ramps having one lane in each direction. As shown on Tables 4-7 and 4-8, each of the P3 alternatives would result in substantial impact to wetlands, open space, Areas of Critical Environmental Concern (ACEC), and rare species habitat. The Route 25 to Route 6 Connector would also impact land within Joint Base Cape Cod (JBCC), the Upper Cape Water Reserve and numerous residential properties.

As noted in Section 2.1.7, the Massachusetts Legislature created the Upper Cape Water Reserve in 2002 to serve as a military training center and as a drinking water and wildlife protection

Exhibit 4-8 Public-Private Partnership Design Alternatives



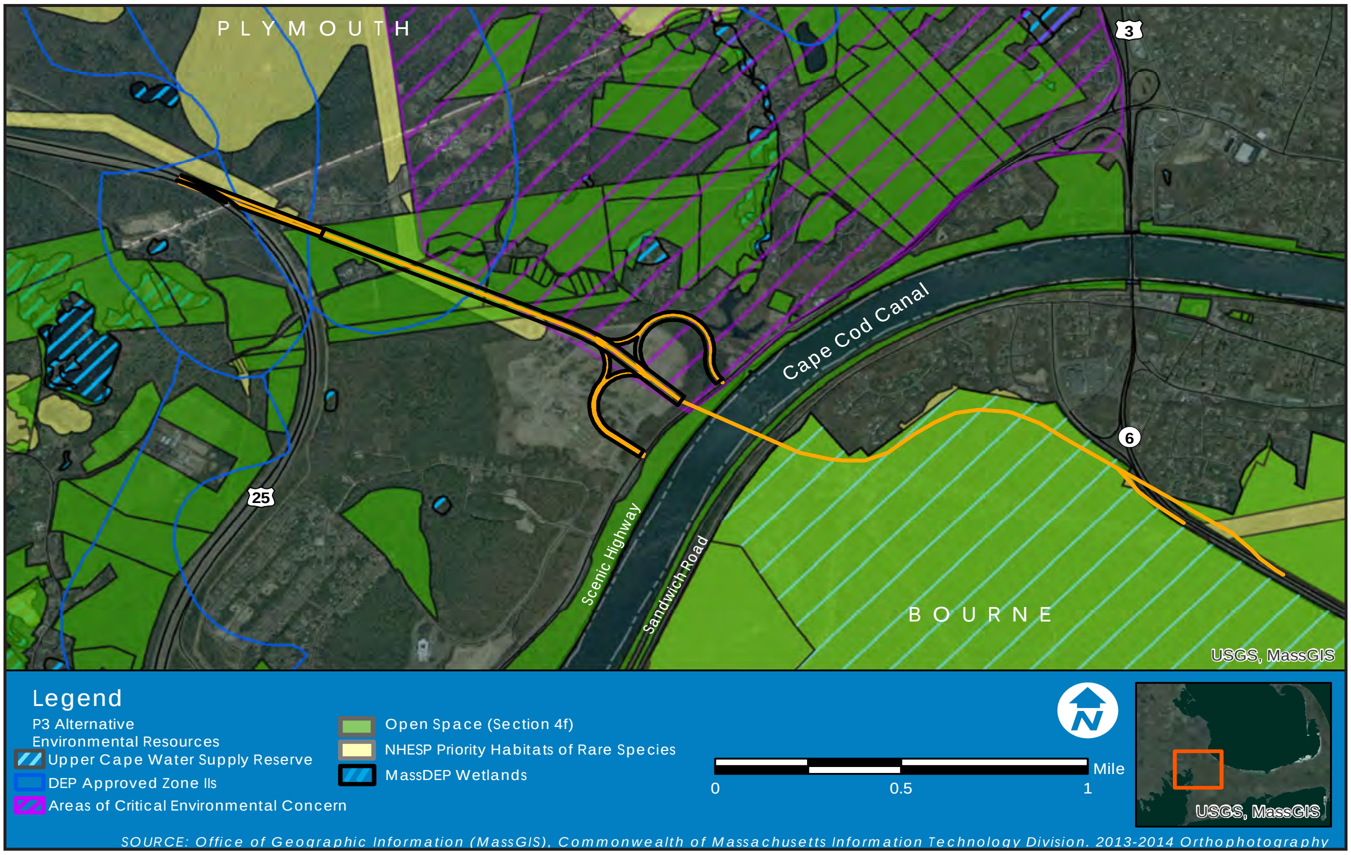


Exhibit 4-9 *Route 25 to Route 6 Connector (Mid-Canal Bridge) – Environmental Impact*

Exhibit 4-10 *Route 25 to Route 3 Connector – Environmental Impact*

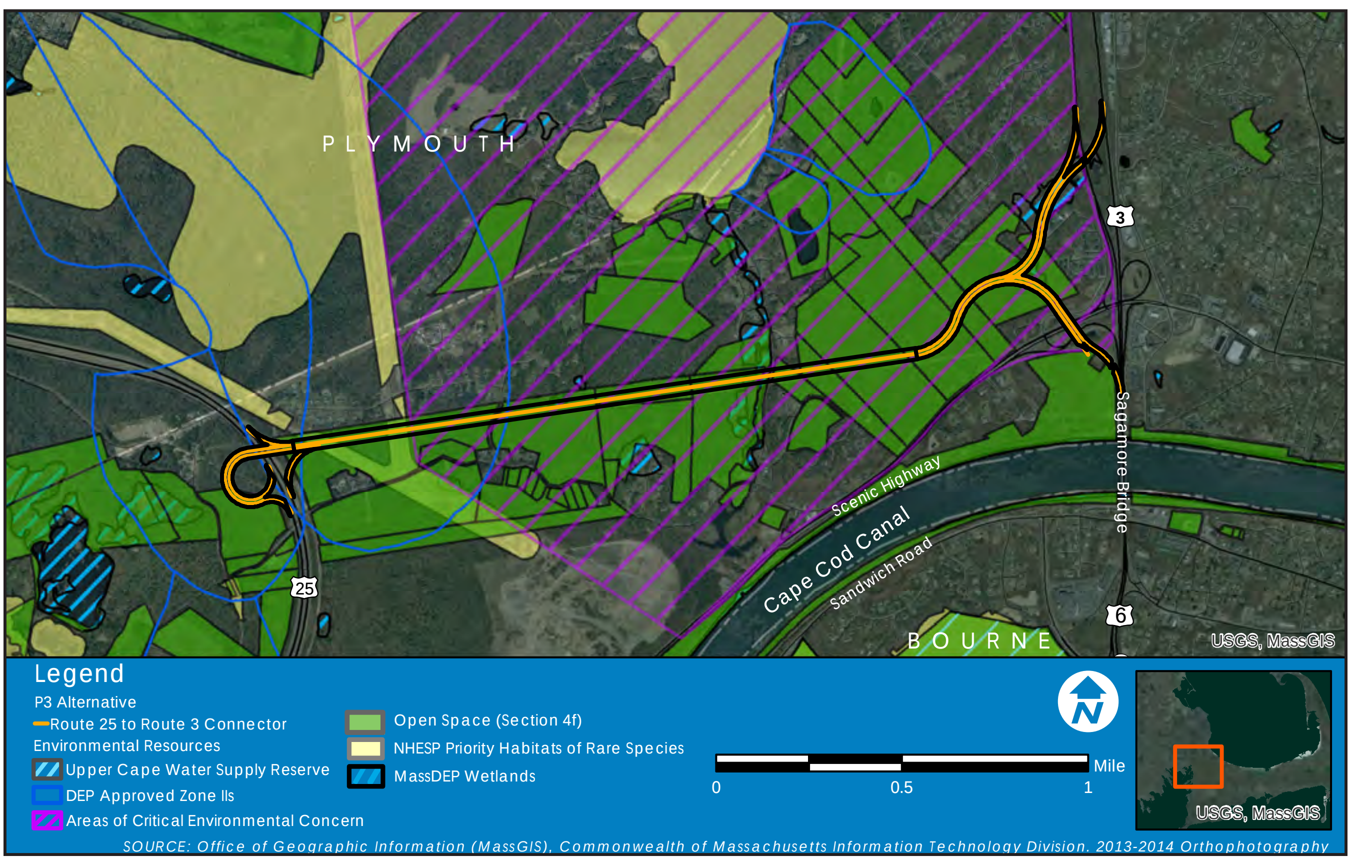


Table 4-7 Route 25 to Route 6 Connector (Mid-Canal Bridge) - Environmental Impact

P3 ALTERNATIVE	WETLANDS	OPEN SPACE (ARTICLE 97)	ACEC	RARE SPECIES	JBCC	RESIDENTIAL PARCELS
	ACRES OF IMPACT (ACRES)					# OF PARCELS
Route 3 to Route 25 Connector	7.2	53.6	54.7	51.3	0	1

Table 4-8 Route 25 to Route 6 Connector - Environmental Impact

P3 ALTERNATIVE	WETLANDS	OPEN SPACE (ARTICLE 97)	ACEC	RARE SPECIES	JBCC	RESIDENTIAL PARCELS
	ACRES OF IMPACT (ACRES)					# OF PARCELS
Route 25 to Route 6 Connector	1.2	37.8	19.2	63.1	19.9	17

area. As designated public open space protected under Article 97 of the Massachusetts Constitution, any change in the ownership or use of the Reserve would require the authorization of the Massachusetts Legislature.

Public-Private Partnership (P3) Alternatives Analysis Determination

The two P3 alternatives evaluated during this study were presented at several Working Group and Public Informational meetings. The P3 alternatives included a new highway connection from Route 25 to Route 6, including a new bridge crossing of the Cape Cod Canal and a new highway connection from Route 25 to Route 3.

The reaction to these alternatives were mixed, with some people expressing strong support for these alternatives as a potentially effective means of alleviating traffic congestion. Others expressed substantial concern regarding the potential impact of these alternatives on residential neighborhoods, wetland and drinking water resources, and sensitive tribal areas. Several Working Group members noted that any construction within Joint Base Cape Cod (JBCC), particularly the portion of JBCC designated as the Upper Cape Water Reserve, would very likely be met with considerable opposition.

Based on the determination of the significant environmental impact which would not likely receive approval during the NEPA and MEPA environmental review process, and the determination that that the project's goals and objectives could be met through improvements to existing infrastructure, these two P3 alternatives were dismissed from further consideration for this study.

4.6 GATEWAY INTERSECTION IMPROVEMENTS

The following section describes roadway improvement alternatives at the major intersections in the focus area which provide access between the Route 3 – Route 6 corridor and the Route 25 – Route 28. These so-called 'gateway intersections' include Belmont Circle, Bourne Rotary, and Route 6 Exit 1C. The fourth gateway intersection is the Route 6 Sagamore Interchange which was reconstructed by MassDOT in 2006.

Multiple alternatives were evaluated at each of the gateway intersections to determine their effectiveness at improving traffic operations and their potential impact on environmental resources and property.

4.6.1 Route 6 Exit 1C Relocation

The following presents the evaluation of the relocation of Route 6 Exit 1C from its existing location at the base of the south end of the Sagamore Bridge to a point further east on Route 6.

Existing Roadway Conditions

Route 6 at Exit 1C (at Cranberry Highway) provides an exit and entrance on Route 6 for westbound vehicles only (Exhibit 4-11). Exit 1C is the last westbound interchange on Route 6 prior to crossing the Cape Cod Canal on the Sagamore Bridge. The geometry of Exit 1C is substandard and not in compliance with current MassDOT highway design standards. The deficiencies of Exit 1C include short acceleration and deceleration lanes, and steep grades approaching the Sagamore Bridge.

Deceleration lanes allow vehicles to safely separate from the through-travel lanes, slow down, and exit a highway at an interchange. Acceleration lanes allow vehicles to enter the highway on a separate lane, while accelerating up to highway speed before merging safely into the through-traffic lane. According to MassDOT' s Project Development and Design Guide, the desired length of a deceleration lane is 600 feet, while the desired length of an acceleration lane is 1,000 feet. At Exit 1C, these lanes are well below these desired lengths, with the existing deceleration lane approximately 300 feet long and the acceleration lane approximately 200 feet long.

Additionally, vehicles traveling west on Route 6 toward Exit 1C are on a long downgradient section (greater than one mile) of the highway. They must then quickly contend with a right-hand bend on Route 6 together with traffic entering the travel lane from Exit 1C and the steep grades (greater than six percent) on Route 6 as it approaches the Sagamore Bridge. These changes

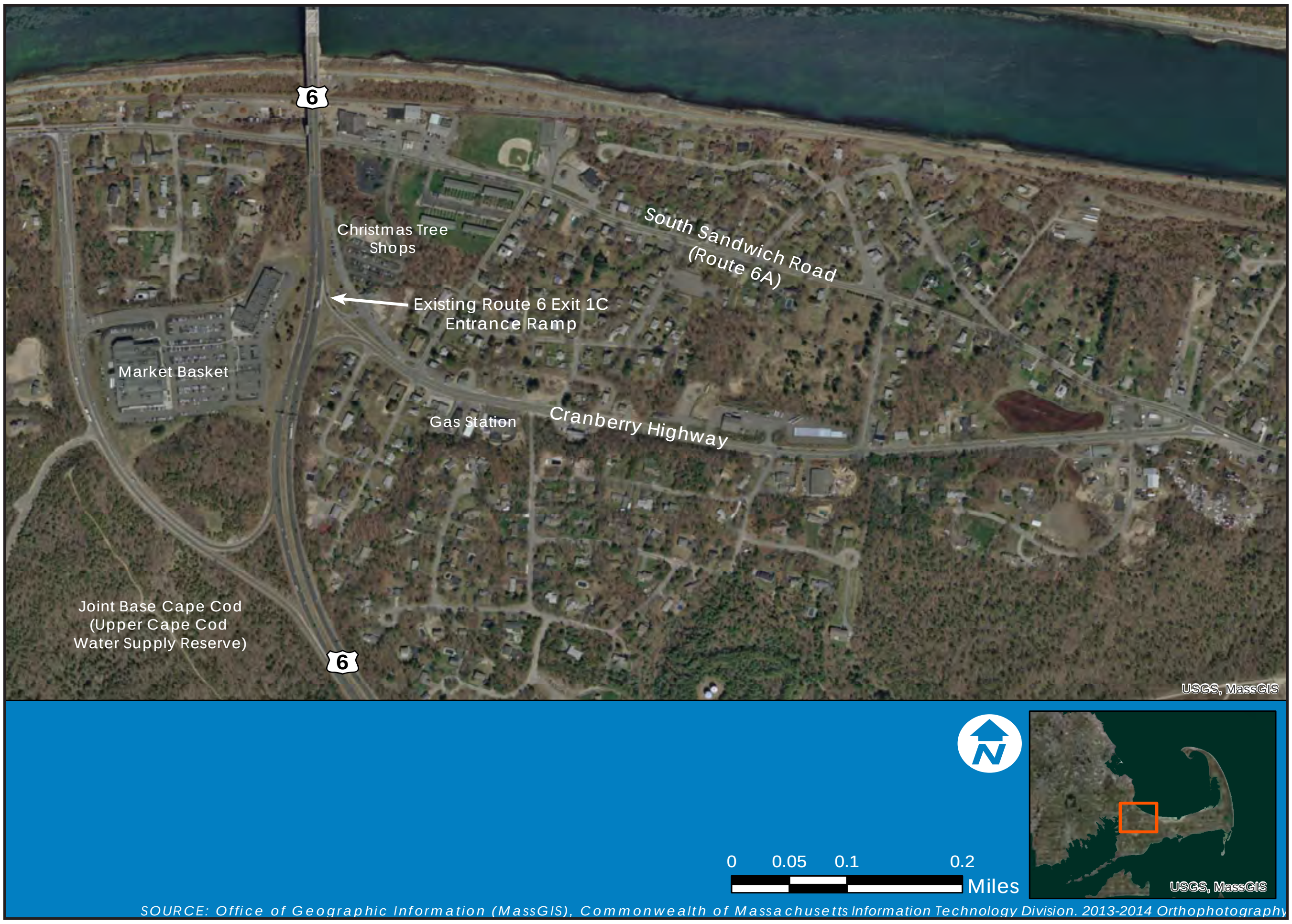


Exhibit 4-11 Existing Conditions - Route 6 Exit 1C

in the highway profile and the high volume of vehicles entering from Exit 1C cause substantial congestion on Route 6.

In the near-term, the relocation of Exit 1C would reduce delay by providing acceleration lanes for vehicles entering Route 6 westbound from Cranberry Highway. Additionally, it is anticipated that the future profile of a replacement Sagamore Bridge would be less steep than the six-percent grade on the existing bridge. This would result in a longer bridge, which would tie into Route 6 further east, requiring the relocation of the existing Exit 1C.

Land Uses and Environmental Resources

Land uses around Exit 1C include residential properties east of Route 6 and a retail shopping plaza (including a Market Basket grocery store) on the west side of Route 6 (Exhibit 4-12). Land uses along Cranberry Highway include the Christmas Tree Shops retail store, and mix of residential, retail, restaurant, and auto-related shops. Further east, Joint Base Cape Cod abuts the west side of Route 6 from the Mid-Cape Connector interchange to Exit 2. Land use east of Route 6 includes residential

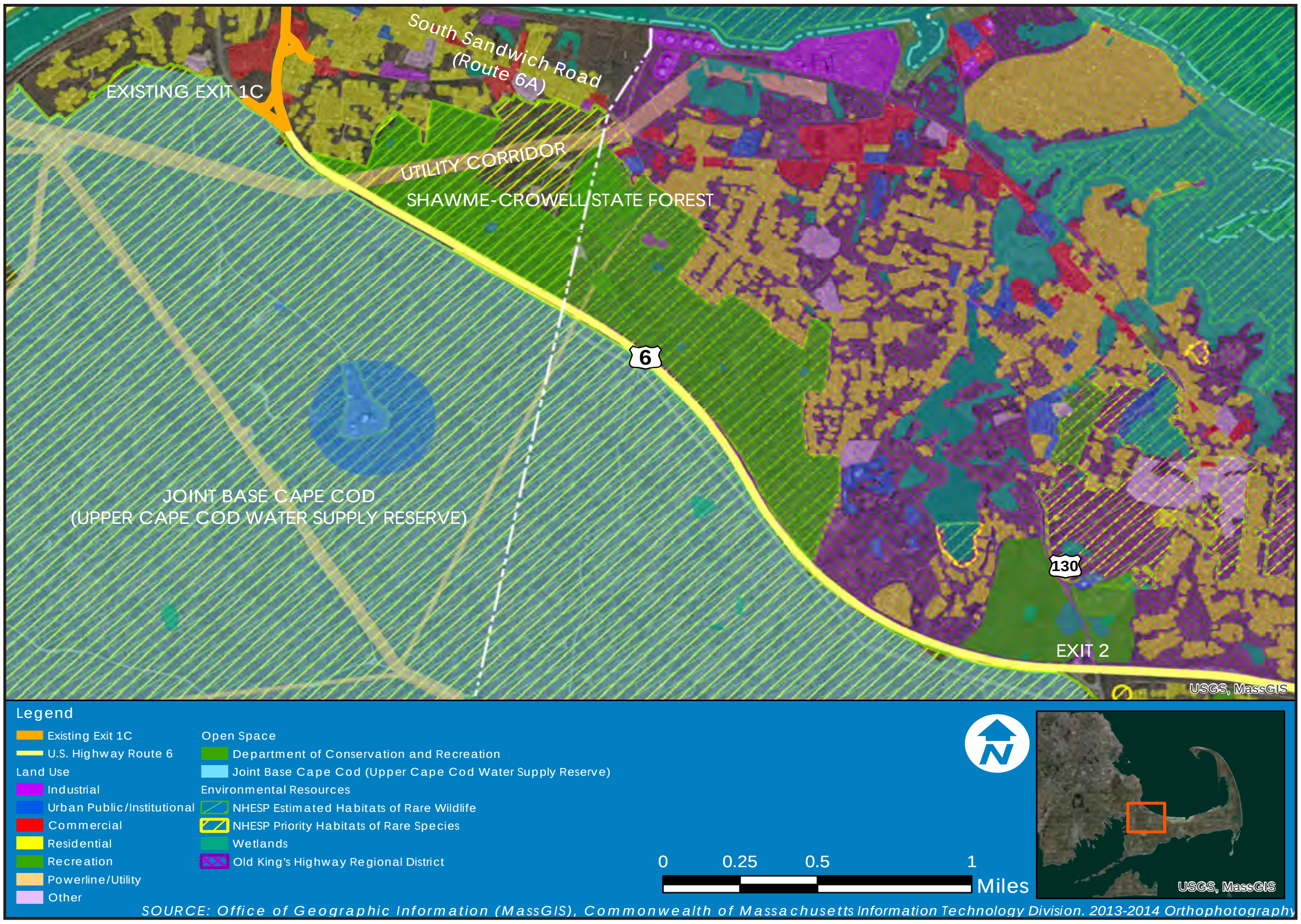


Exhibit 4-12 Adjacent Land Uses - Route 6 Between Exit 1C and Exit 2 (Route 130)

neighborhoods and the Shawme-Crowell State Forest (which extends nearly to Exit 2). An electrical utility corridor divides the state forest and extends 3,600 feet from Route 6 to the Route 6A at Route 130 intersection, continuing northeast approximately 3,300 feet to the Canal Electrical Generating Plant.

There are no wetlands, floodplains, or other regulated wetland resources within 100 feet of the Exit 1C interchange. The land within JBCC, the Shawme Crowell State Forest, and the utility corridor is designated by the Massachusetts Natural Heritage and Endangered Species Program as a 'Priority Habitat for Rare Species'.

Traffic Conditions on Route 3 / Route 6 Approaches to Sagamore Bridge

Currently, the Route 6 westbound approach to the Sagamore Bridge at the Exit 1C interchange experiences acceptable traffic conditions (LOS A, with an average delay of five seconds) during the non-summer weekday peak period. However, conditions during summer Saturday peak periods are often characterized by substantial congestion with average queuing on Route 6 westbound extending 4.4 miles, resulting in LOS F conditions. This congestion results in substantial delays (average delay of 11.4 minutes) for vehicles heading off-Cape. The peak period delays on Route 6 westbound are forecast to increase by 2040 to 3.0- to 13.5-minutes during the non-summer and summer Saturday peak period, respectively (Table 4-9).

Existing summer Saturday peak period traffic conditions on the Route 3 southbound approach to the Sagamore Bridge are also poor with existing average delays of 6.9 minutes. These are forecast to increase to 14.8 minutes by 2040.

The location and sub-standard geometry of Exit 1C contributes to this traffic congestion. Exit 1C's short acceleration- and deceleration-lanes require vehicles to rapidly decelerate or accelerate when exiting or entering through-traffic lanes. These sudden movements cause other drivers to react by slowing down, increasing traffic congestion.

Additionally, the steep grades (greater than six percent) as Route 6 approaches the Sagamore Bridge beyond Exit 1C make it more difficult for entering vehicles to increase speed and merge into traffic.

Identification of Interchange Location

Potential locations for the relocation of Exit 1C further to the east were evaluated. Relocating Exit 1C to the east would allow it to be designed in accordance with current MassDOT design standards, thereby providing a safer and smoother transition to and from Route 6. Relocating Exit 1C to the east would also be necessary to accommodate the anticipated lower profile of an assumed replacement of the Sagamore Bridge.

The selection for a new location for the Route 6 Exit 1C interchange was informed by existing land uses and compliance with Federal Highway Administration (FHWA) guidelines. As described above, the land uses adjacent to the east side of Route 6 consists of developed residential neighborhoods and state forest land (Exhibit 4-12). Additionally, in accordance with FHWA guidance, a new highway interchange should be one-mile or more from an adjacent interchange (in this case, Exit 2 at Route 130) and must provide a connection to and from an existing public street.

Given these existing constraints, the electrical utility corridor was identified as the most appropriate location for the relocated interchange. This relocated interchange would provide a roadway connection from Route 6 eastbound to the Route 6A/Route 130 intersection (Exhibits 4-13 and 4-14). This location would have

Text continues on page 4-32.

Table 4-9 *Traffic Operations – Route 3 / Route 6 Approaches to Sagamore Bridge*

	EXISTING (2014) CONDITIONS				FUTURE (2040) NO-BUILD CONDITIONS				FUTURE (2040) BUILD CONDITIONS			
	AVERAGE DELAY *Sec (Min)*	**LOS**	**AVERAGE QUEUE** *Feet (Miles)*	**MAXIMUM QUEUE** *Feet (Miles)*	**AVERAGE DELAY** *Sec (Min)*	**LOS**	**AVERAGE QUEUE** *Feet (Miles)*	**MAXIMUM QUEUE** *Feet (Miles)*	**AVERAGE DELAY** *Sec (Min)*	**LOS**	**AVERAGE QUEUE** *Feet (Miles)*	**MAXIMUM QUEUE** *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)												
Route 3 Southbound	11	B	77	478	460 (7.7)	**F**	7,481 (1.4)	8,476 (1.6)	453 (7.5)	**F**	3,534 (0.7)	4,090 (0.8)
Route 6 Westbound	5	A	53	232	178 (3.0)	**F**	6,801 (1.3)	7,967 (1.5)	2	A	0	0
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)												
Route 3 Southbound	416 (6.9)	**F**	4,823 (0.91)	5,393 (1.02)	887 (14.8)	**F**	22,814 (4.3)	24,484 (4.6)	895 (14.9)	**F**	23,308 (4.4)	24,826 (4.7)
Route 6 Westbound	683 (11.4)	**F**	23,318 (4.4)	25,014 (4.7)	812 (13.5)	**F**	24,825 (4.7)	25,029 (4.7)	210 (3.5)	**F**	7,253 (1.4)	10,037 (1.9)

Notes:
LOS E and LOS locations are ***bold***
LOS = Level of Service.
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

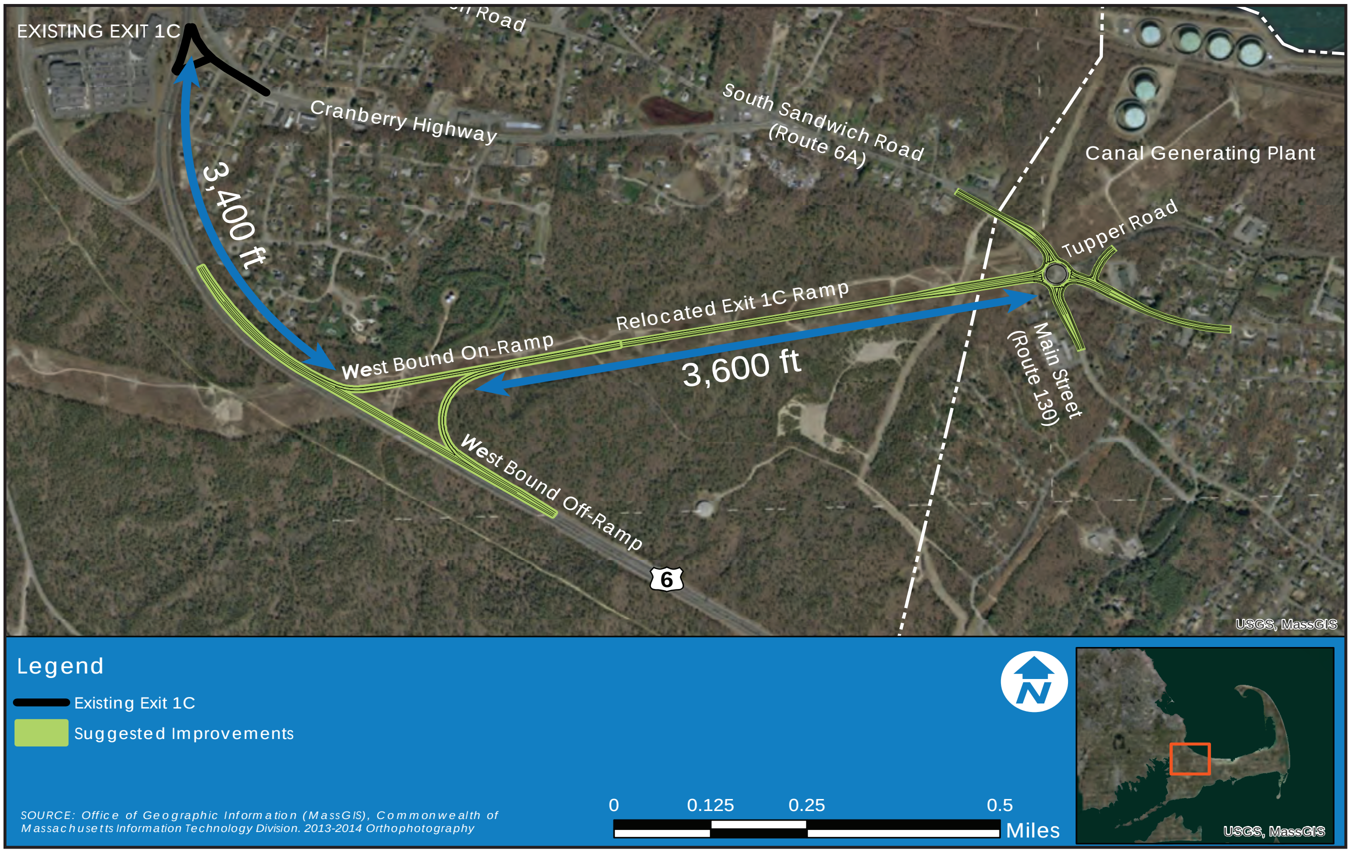


Exhibit 4-13 Route 6 Exit 1C Relocation

Exhibit 4-14 Route 6 Exit 1C Ramp

only a minor effect on existing commercial and residential properties and state forest land, is more than one mile from Exit 2, and would connect to a public street.

Identification of Intersection Type

Several alternatives for incorporating the new highway ramp into the Route 6A at Route 130 intersection (Exhibit 4-15) were evaluated. These alternatives included:

- Alternative 1 – Two Signalized Intersections
- Alternative 2 – Four-Leg Roundabout
- Alternative 3 – Five-Leg Roundabout

Traffic Operations at Route 6A/Route 130 Intersection

During existing and future no-build peak periods, traffic operates acceptably at the existing unsignalized intersection of Route 6A at Route 130 intersection (LOS A and B) except for the Route 6A eastbound approach, which operates at LOS F during the summer for both the existing and future peak periods. During the summer Saturday peak period, the Route

Exhibit 4-15 Route 6 Exit 1C - Route 6A Intersection Alternatives

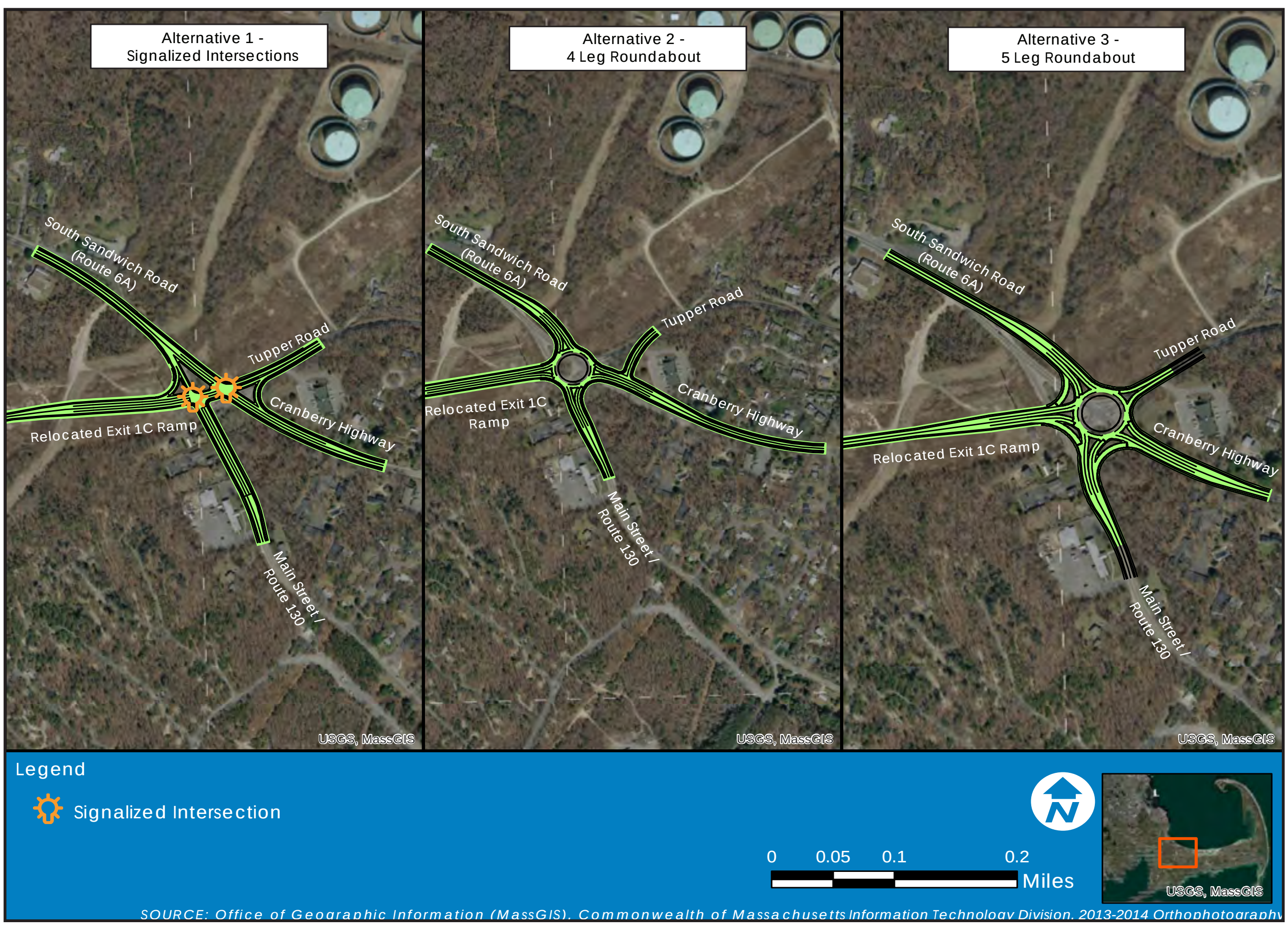


Table 4-10 Traffic Operations – Existing and Future No-Build Conditions, Route 6A at Route 130

	EXISTING (2014) CONDITIONS				FUTURE (2040) NO-BUILD CONDITIONS			
	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)								
Route 6A EB Lt/Th/Rt	32	D	0.52	70	74	**F**	0.83	151
Route 6A WB Lt/Th/Rt	11	B	0.17	16	12	B	0.21	19
Route 130 NB Lt/Th/Rt	2	A	0.06	5	2	A	0.08	6
Tupper Road WB Lt/Th/Rt	0.2	A	0	0	0.1	A	0	0
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)								
Route 6A EB Lt/Th/Rt	n/a	**F**	5.62	n/a	n/a	**F**	24.15	n/a
Route 6A WB Lt/Th/Rt	30	D	0.69	128	703 (11.7)	**F**	0.94	251
Route 130 NB Lt/Th/Rt	3	A	0.11	9	4	A	0.16	14
Tupper Road WB Lt/Th/Rt	0.1	A	0	0	0.1	A	0	0

Notes:
•LOS E and LOS F movements are ***bold***
•Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
•LOS = Level of Service; V/C = Volume to Capacity Ratio
•Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.
•n/a = Volume exceeds capacity to the point where the respective value cannot be determined.

6A westbound approach operates at LOS F/D under existing and future no-build conditions, respectively (Table 4-10).

Future Traffic Operations at new intersection of the Route 6 Exit 1C Ramp at Route 6A and Route 130

Traffic operations at the new intersection consisting of the Exit 1C ramp, Route 6A and Route 130 under the three different intersection alternatives was evaluated. The results of this analysis for these three different intersection alternatives are summarized below on Table 4-11(Alternative 1 - Two Signalized Intersections) and Table 4-12 (Alternatives 2 and 3, Four-Leg and Five-Leg Roundabouts).

Overall, Alternative 1 would operate at LOS B during the non-summer weekday peak period and LOS F during the summer Saturday peak period. However, at 152 and 206 seconds, the average delay during the summer Saturday peak period is longer than the summer Saturday peak period delay for either roundabout alternative.

Under the future build conditions, Alternative 2, the Four-Leg Roundabout, and Alternative 3, the Five-Leg Roundabout, would operate similarly. During the non-summer weekday peak period, the LOS for each approach to the roundabout would range from LOS A to LOS D, with delays ranging from eight to 27 seconds. During the summer Saturday peak period, the delays at the approaches to both roundabout alternatives would range from nine- to 213 seconds.

Table 4-11 Traffic Operations – Exit 1C Ramp at Route 6A/Route. 130, Two Signalized Intersection Alternative

ALTERNATIVE 1 - INTERSECTION 1 ROUTE 6 EXIT 1C RAMP AT ROUTE 6A AND TUPPER RD	FUTURE (2040) BUILD CONDITIONS - INITIAL SCREENING				
	AVERAGE DELAY *Sec (Min)*	LOS	V/C	50% QUEUE *Feet (Miles)*	95% QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)					
Route 6A (Sandwich Rd) SB Lt	18	B	0.14	14	36
Route 6A (Sandwich Rd) SB Th/Rt	19	B	0.35	54	99
Route 6A NB Lt	27	C	0.71	80	149
Route 6A SB Th/Rt	18	B	0.27	41	79
Exit1C Off Ramp Connector Rd EB Lt	9	A	0.8	22	323
Exit1C Off Ramp Connector Rd EB Lt/Th/Rt	7	A	0.74	10	65
Tupper Road WB Lt/Th/Rt	43	D	0.71	41	140
Intersection (Overall)	**15.5**	**B**	**0.75**		
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)					
Route 6A (Sandwich Rd) SB Lt	28	C	0.39	51	102
Route 6A (Sandwich Rd) SB Th/Rt	30	C	0.56	229	330
Route 6A NB Lt	505 (8.4)	**F**	2.01	605	816
Route 6A SB Th/Rt	31	C	0.58	247	352
Exit1C Off Ramp Connector Rd EB Lt	17	B	0.82	64	567
Exit1C Off Ramp Connector Rd EB Lt/Th/Rt	14	B	0.8	51	88
Tupper Road WB Lt/Th/Rt	356 (5.9)	**F**	1.62	359	550
Intersection (Overall)	**151.9**	**F**	**1.45**		

ALTERNATIVE 1 - INTERSECTION 2 ROUTE 130 AT EXIT 1C CONNECTOR RAMP	FUTURE (2040) BUILD CONDITIONS - INITIAL SCREENING				
	AVERAGE DELAY *Sec (Min)*	LOS	V/C	50% QUEUE *Feet (Miles)*	95% QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)					
Route 130 (Main Street) (NB) Lt	18	B	0.27	27	60
Route 130 (Main Street) (NB) Rt	17	B	0.04	0	8
Route 6A SB Th	18	B	0.24	37	72
Route 6A SB Rt	18	B	0.28	0	56
Exit1C Off Ramp EB Th/Rt	20	C	0.77	177	323
Exit1C Off Ramp Connector Rd WB Lt/Th	14	B	0.32	108	221
Intersection (Overall)	**18.5**	**B**	**0.56**		
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)					
Route 130 (Main Street) (NB) Lt	30	C	0.51	141	223
Route 130 (Main Street) (NB) Rt	24	C	0.12	0	47
Route 6A SB Th	25	C	0.18	67	113
Route 6A SB Rt	26	C	0.3	51	125
Exit1C Off Ramp EB Th/Rt	33	C	0.69	303	377
Exit1C Off Ramp Connector Rd WB Lt/Th	605 (10)	**F**	2.23	1008	504
Intersection (Overall)	**206.1 (3.4)**	**F**	**1.59**		

Notes:
*LOS E and LOS F movements are **bold***
Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB- Southbound
LOS = Level of Service; V/C = Volume to Capacity Ratio
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

Table 4-12 Exit 1C Ramp at Route 6A and Route 130, Roundabout Alternatives

ROUTE 6 EXIT 1C RAMP AT ROUTE 6A AND ROUTE 130	ALTERNATIVE 2 – 4 LEG ROUNDABOUT				ALTERNATIVE 3 – 5 LEG ROUNDABOUT			
	FUTURE (2040) BUILD CONDITIONS - SCREENING ANALYSIS							
	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)								
Exit 1C Ramp (EB) Lt	27	D	0.85	10	27	D	0.85	10
Exit 1C Ramp (EB) Th/Rt	9	A	0.37	2	8	A	0.37	2
Route 6A (WB) Lt/Th	17	C	0.56	3	14	B	0.44	2
Route 6A (WB) Rt	10	B	0.32	1	10	A	0.25	1
Route 130 (NB) Lt/Th	13	B	0.32	1	13	B	0.32	1
Route 130 (NB) Rt	8	A	0.03	0	8	A	0.03	0
Route 6A (Sandwich Rd) SB Lt/Th	10	B	0.44	2	8	A	0.28	1
Route 6A (Sandwich Rd) SB Rt	12	B	0.54	3	6	A	0.15	1
Tupper Road WB Lt/Th/Rt					13	B	0.31	1
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)								
Exit 1C Ramp (EB) Lt	54	F	0.98	15	55	F	0.98	15
Exit 1C Ramp (EB) Th/Rt	9	A	0.32	1	9	A	0.32	1
Route 6A (WB) Lt/Th	213 (3.6)	F	1.39	32	112 (1.9)	F	1.13	18
Route 6A (WB) Rt	73 (1.2)	F	1.02	15	44	E	0.86	9
Route 130 (NB) Lt/Th	48	E	0.87	9	48	E	0.87	9
Route 130 (NB) Rt	9	A	0.11	0	9	A	0.11	0
Route 6A (Sandwich Rd) SB Lt/Th	105 (1.8)	F	1.13	20	26	D	0.73	6
Route 6A (Sandwich Rd) SB Rt	16	C	0.53	3	12	B	0.38	2
Tupper Road WB Lt/Th/Rt					171 (2.9)	F	1.23	16

Notes:
Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service; V/C = Volume to Capacity Ratio
Overall LOS, V/C and delay not calculated for unsignalized intersections
Shaded areas do not exist in listed configuration during this period

Future Traffic Operations along Route 3 and Route 6 Approaches to Sagamore Bridge

With a relocated Route 6 Exit 1C in place, queuing and delays in the future (2040) would be substantially reduced for vehicles heading off-Cape on Route 6 westbound during both the non-summer weekday PM and summer Saturday peak periods (Table 4-9). For example, the future summer Saturday peak period delay would be reduced from 13.5 minutes to 3.5 minutes. During the non-summer weekday peak period, delay would be reduced from 3.0 minutes to 0.0 minutes. Delay on Route 3 southbound would not be reduced with the relocation of Exit 1C.

For this screening analysis stage, it is assumed that the existing Canal bridges remain. More detailed information on results of the future traffic operations on Route 6 westbound with the relocated Exit 1C in place is discussed under Travel Demand Model Case 1 and Case 3A (Section 4.8).

Property or Environmental Resource Impact

The relocation of Exit 1C would require the use of approximately 3.8 acres of land owned by the utility provider, Eversource, either as a land acquisition or a permanent easement. The improvements may also require the acquisition of approximately 0.15 acres of residential property and approximately 0.9-acres of commercial property at the Route 6A (Sandwich Road) at Route 130 intersection (Table 4-13).

No wetland, floodplain, or other regulated water resources would be impacted. These improvements would impact approximately 7.2 acres of land designated as a 'Priority Habitat for Rare Species'.

Table 4-13 Potential Environmental Impact - Exit 1C Ramp at Route 6 and Route 130

	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
RESOURCE AREAS (ACRES):			
Rare Species Habitat	7.4	7.2	7.0
OPEN SPACE (ACRES):			
DCR - Shawme-Crowell State Forest	0.5	0.6	0.5
Interim Wellhead Protection Area (IWPA)	4.6	5.7	5.5
RIGHT OF WAY (ACRES):			
Residential	0.02	0.15	0.03
Commercial	0.02	0.9	0.26
Utility	3.5	3.8	3.8

Notes:
Environmental and right-of-way impact based on conceptual design and GIS-based data.

Suggested Alternative

The suggested alternative involves the relocation of Route 6 Exit 1C interchange approximately 3,400 feet to the east (Exhibit 4-13). A relocated highway interchange would be constructed on Route 6 providing westbound-only access (the Mid-Cape Connector provides eastbound access to Route 6). The new interchange ramp would extend approximately 3,600 feet within the electrical utility corridor to the Route 6A (Sandwich Road) and Route 130 intersection (Exhibit 4-16).

Alternative 2 – Relocated Interchange with Four-Leg Roundabout – was advanced for further study during the travel demand model analysis. This alternative was selected because it would provide better traffic operations at the Route 6A/Route 130 intersection (when compared to Alternative 1). Furthermore, when compared to the larger Five-Leg Roundabout featured in Alternative 3, the

Four-Leg Roundabout was considered a simpler design and more in line with the community context. Environmental impacts were approximately the same for all alternatives.

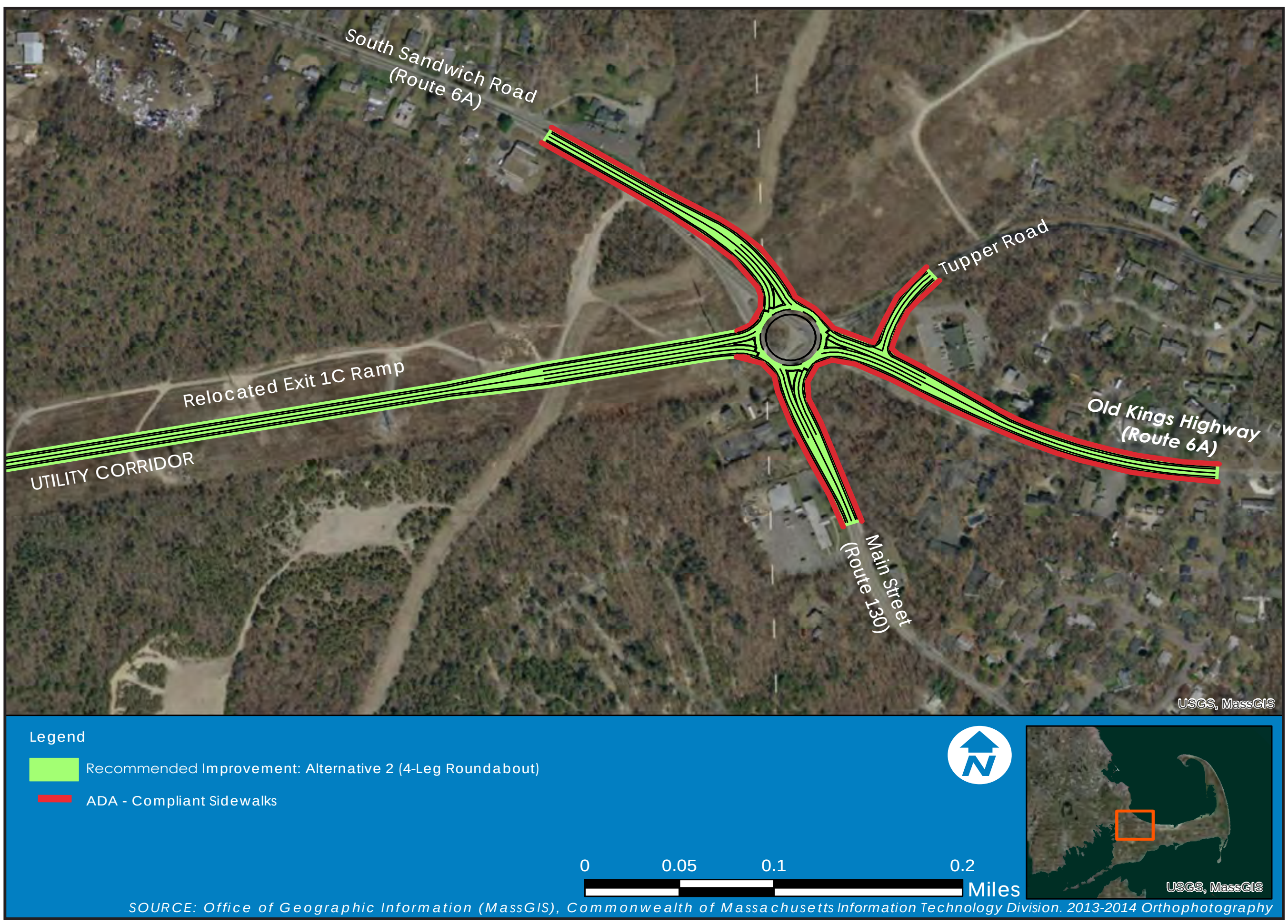
Conceptual Cost Estimate

The conceptual cost estimates for the three alternatives to relocate the Route 6 Exit 1C interchange are provided by construction year in Table 4-14. More detailed conceptual cost estimates are provided in Appendix E.

Table 4-14 Relocation of Route 6 Exit 1C, Conceptual Cost Estimate

	2017 ($ MILLION)	2030 ($ MILLION)	2040 ($ MILLION)
Alternative 1	27	45	67
Alternative 2 (suggested alternative)	30	51	75
Alternative 3	28	47	69

Exhibit 4-16 Route 6 Exit 1C at Route 6A/Route 130 Intersection – Suggested Alternative



4.6.2 Route 6 Additional Eastbound Travel Lane

The construction of an additional travel lane on Route 6 eastbound for approximately 3.4 miles from the Mid-Cape Connector to Exit 2 (Route 130) was evaluated. It is assumed that this additional travel lane would be constructed concurrent with the construction of a replacement Sagamore Bridge. A replacement Sagamore Bridge in envisioned to include auxiliary lanes extending from the Scenic Highway entrance ramp to Route 3 southbound, over the Sagamore Bridge, to the Mid-Cape Connector entrance ramp to Route 6 eastbound.

An additional eastbound travel lane on Route 6 would act an extension of this auxiliary lane providing additional capacity and distance for entering vehicles to merge onto the heavily-traveled section of Route 6 eastbound between the Sagamore Bridge and Exit 2 (Route 130). The extension of this additional westbound travel lanes is not required beyond Exit 2 because traffic volumes drop substantially after this point. For example, during the future no-build period, traffic volumes west of Exit 2 drop by more than 27%, from 2,765 to 2,000 vehicles, during the non-summer weekday PM peak period.

Existing Conditions

Currently, Route 6 between the Mid-Cape Connector and Exit 2 (Route 130) consists of two 12-foot wide travel lanes in each direction separated by a 30-foot wide grassed median. An eight-foot wide gravel shoulder abuts the right travel lane in each direction.

Route 6 eastbound currently operates at LOS C during the non-summer weekday peak period and LOS D during the summer Saturday peak period. This degrades to LOS D and LOS E in 2040.

Land Uses and Environmental Resources

Land uses in the area include approximately 100 residential properties east of Route 6, with access to Cranberry Highway at Exit 1C. Other than a utility corridor and a small residential development south of Shawme Lake, land uses adjacent to Route 6 for the remainder of the corridor consist of undeveloped forest within Joint Base Cape Cod west of Route 6 and the Shawme-Crowell State Forest east of Route 6 (Exhibit 4-17).

There are no wetlands, floodplains, or other regulated wetland resources within 100 feet of the Route 6 corridor. The forested land within Joint Base Cape Cod and the Shawme-Crowell State Forest is designated by the Massachusetts Natural Heritage and Endangered Species Program as a ‘Priority Habitat for Rare Species’.

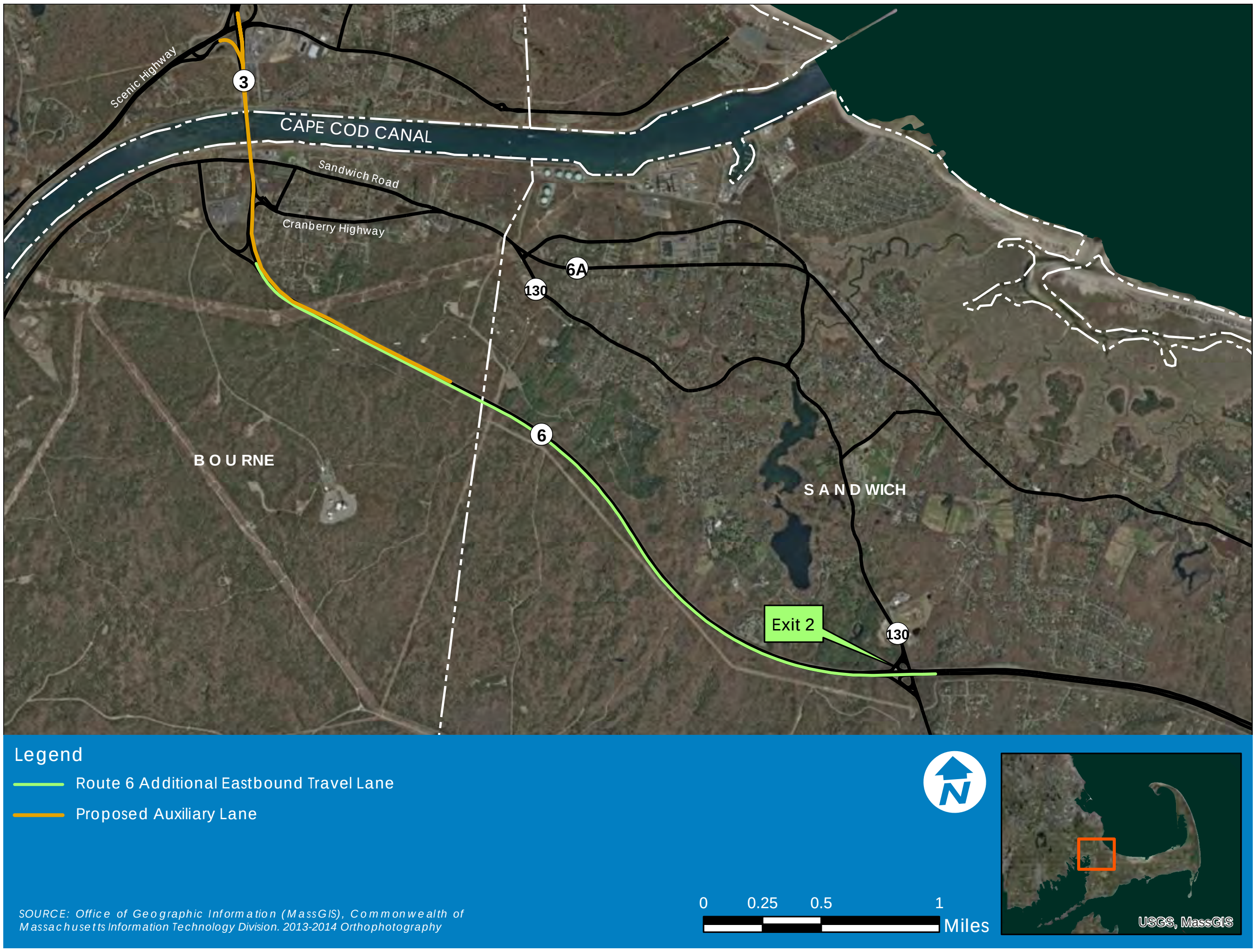


Exhibit 4-17 Route 6 - Additional Eastbound Travel Lane and Westbound Auxiliary Lane

Suggested Improvements

Suggested improvements on Route 6 involve the construction of an additional travel lane on Route 6 eastbound for approximately 3.4 miles from the Mid-Cape Connector to Exit 2 at Route 130 (Exhibit 4-17).

The effect of the relocation of Exit 1C on queuing on Route 6 is provided in Section 4.8; under Case 1 for the existing Canal bridge condition and under Case 3A for the replacement Canal bridge condition.

Property or Environmental Resource Impact

These improvements could be constructed entirely within the MassDOT right-of-way, with no property acquisitions required. The work may impact up to 3.9 acres of rare species habitat. No other regulated environmental resources, such as wetlands or floodplains, would be impacted.

Conceptual Cost Estimate

The conceptual cost of the additional Route 6 eastbound travel lane is provided by construction year in Table 4-15. More detailed conceptual cost estimates are provided in Appendix E.

Table 4-15 Route 6 Eastbound Travel Lane - Conceptual Cost Estimate by Build Year

	2017 ($ MILLION)	2030 ($ MILLION)	2040 ($ MILLION)
Route 6 Eastbound Travel Lane	29	48	71

4.6.3 Belmont Circle and Bourne Rotary – Introduction

Belmont Circle and the Bourne Rotary, located north and south of the Bourne Bridge, respectively, are two of the most critical intersections in the study area. Motorists often must navigate both traffic circles when traveling through Bourne and when crossing the Bourne Bridge. Belmont Circle is the intersection of Route 25, Main Street, Scenic Highway, and the Buzzards Bay Bypass. Bourne Rotary processes vehicles from Route 28, Sandwich Road, and Trowbridge Road.

From the west, access to the Bourne Bridge is provided on Route 25. To avoid traffic congestion on Route 25 eastbound while heading toward the Bourne Bridge, travelers often leave Route 25 at Exit 2 (Glen Chen Charlie Road) to access Route 6 eastbound in Wareham towards Main Street and Belmont Circle in Bourne. A strong traveler preference for Main Street eastbound rather than the parallel route of the Buzzards Bay Bypass has been observed.

The existing land uses and environmental resources at Belmont Circle and Bourne Rotary, presented in Chapter 2 (Section 2.2.3), informed the constraints on the potential transportation improvements in these areas. In developing improvement alternatives, avoiding impact to property and environmental resources was prioritized.

The high traffic volumes and sub-standard design of these unsignalized traffic circles result in severe traffic congestion during peak periods. Each operate at LOS F during all peak travel period during the non-summer weekday and summer Saturday peak periods resulting in lengthy queues of vehicles extending from the approaches to both Belmont Circle and the Bourne Rotary. The existing and future traffic operations at Belmont Circle and Bourne Rotary are described in Chapters 2 and 3 (Sections 2.5.10 and 3.3.7).

Further, the proximity of these traffic circles to one another results in their having a substantial effect on each another. For example, during peak periods the traffic queuing on Route 28 southbound extends over the Bourne Bridge, and several thousand feet north along Route 25. These queues in turn delay other motorists trying to enter Belmont Circle from Route 25 Exit 3 or Scenic Highway.

The key to improving traffic operations at both Belmont Circle and Bourne Rotary was identifying transportation improvements that:

1. Reduce traffic volumes entering the Belmont Circle and Bourne Rotary;
2. Safely accommodate both regional and local traffic;
3. Maintain access to local businesses; and
4. Ensure compatibility with a future replacement Bourne Bridge alignment (assumed to the east of the existing bridge).

Transportation improvements at Belmont Circle and Bourne Rotary (and the other problem intersections in the study area) is the most important factor in minimizing diversions of regional traffic diversions to local roadways.

The following sections describe the transportation improvements alternatives at Belmont Circle and Bourne Rotary that were evaluated by the study team, in conjunction with the study Working Group.

4.6.4 Belmont Circle

As described below, several alternatives were evaluated to improve traffic operations at Belmont Circle. To provide the context of Belmont Circle, Exhibit 4-18 presents the existing roadways at Belmont Circle. These alternatives were conceived to be compatible with the existing Bourne Bridge as well as with the vertical and horizontal alignment of an assumed replacement of the Bourne Bridge. The traffic analysis is based on location and geometry of the existing Bourne Bridge.

Suggested Improvement – New Entrance Ramp, Scenic Highway Westbound to Route 25 Westbound

Currently, vehicles traveling from the east on Scenic Highway heading for Route 25 enter the east side of Belmont Circle and then immediately exit onto the Route 25 entrance ramps. This roadway configuration contributes to congestion in Belmont Circle because it requires vehicles to enter Belmont Circle when their destination is Route 25.

Exhibit 4-18 Belmont Circle - Existing Conditions

As noted previously, one key to improving traffic operations at Belmont Circle is to reduce traffic volumes entering the Circle. To achieve this goal, roadway improvements were evaluated involving the construction of a new highway entrance ramp from Scenic Highway westbound to Route 25 westbound (Exhibit 4-19). The Scenic Highway at Nightingale Pond Road intersection would be reconstructed to accommodate this new ramp. This new ramp would divert vehicles from entering Belmont Circle from Route 25 eastbound before they entered Belmont Circle.

Traffic Analysis

A new Scenic Highway to Route 25 westbound entrance ramp would achieve the goal of reducing traffic volumes entering Belmont Circle by diverting approximately 40% of vehicles on Scenic Highway westbound to this new Route 25 westbound ramp. Specifically, during peak periods this ramp would result in the diversion from Belmont Circle 680 of 1,605 vehicles (non-summer weekday PM) and 875 of 2,095 vehicles (summer Saturday).

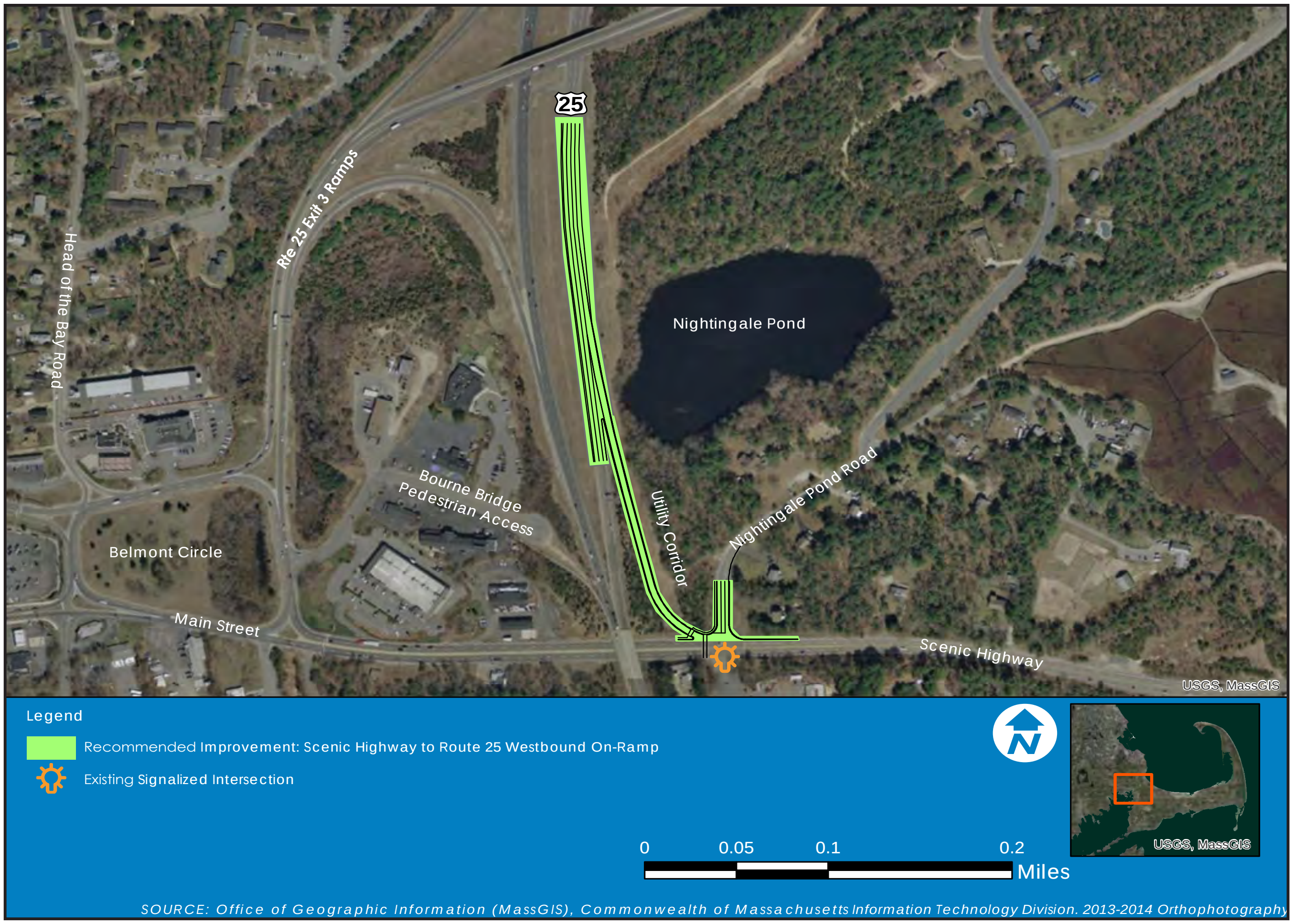


Exhibit 4-19 Suggested Improvements - Scenic Highway Westbound to Route 25 Westbound Ramp

These improvements would result in a reduction in the length of queues on the Scenic Highway westbound approach to Belmont Circle during both the non-summer weekday and summer Saturday peak periods. During the summer Saturday peak period, other approaches to Belmont Circle would not experience a notable reduction in queuing or delays (Table 4-16).

Environmental Resource/Utility Impact

A Route 25 westbound entrance ramp from Scenic Highway would result in approximately 0.2 acres of impact to land within an interim wellhead protection area. No wetland, floodplain, or rare species habitat areas would be impacted (Table 4-20).

This ramp would be partially within an area containing natural gas lines, requiring close coordination with the utility company to determine if relocation of these gas lines would be necessary.

Table 4-16 Scenic Highway to Route 25 WB Ramp - Traffic Operations at Belmont Circle

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS		
	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Exit 3 Off Ramps SB	5	A	515	2	A	645	1	A	65
Head of Bay Rd SB	15	C	270	317 (5.3)	**F**	1,780	35	D	520
Buzzards Bay Bypass EB	3	A	100	3	A	110	3	A	85
Main Street EB	13	B	530	29	D	1,245	27	D	1,085
Scenic Highway WB	7	A	380	14	B	840	1	A	60
Intersection (Overall)	**8.6**	**A**		**73**	**F**		**13.4**	**B**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Exit 3 Off Ramps SB	4	A	510	3	A	1,025	2	A	280
Head of Bay Rd SB	83 (1.4)	**F**	570	656 (11.0)	**F**	2,700 (0.51)	451 (7.5)	**F**	2,100
Buzzards Bay Bypass EB	19	C	335	11	B	305	12	B	305
Main Street EB	82 (1.4)	**F**	5,755 (1.1)	126 (2.1)	**F**	6,140 (1.2)	185 (3.1)	**F**	6,140 (1.2)
Scenic Highway WB	125 (2.1)	**F**	10,605 (2.0)	161 (2.7)	**F**	11,610 (2.2)	154 (2.6)	**F**	10,630 (2.2)
Intersection (Overall)	**62.6 (1.0)**	**F**		**191.4 (3.2)**	**F**		**160.8 (2.7)**	**F**	

Notes:
*LOS E and Los F movements are shaded **bold***
Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service; V/C = Volume to Capacity Ratio
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

Table 4-17 Scenic Highway to Route 25 WB Ramp – Conceptual Cost Estimate

	2017 ($ MILLION)	2030 ($ MILLION)	2040 ($ MILLION)
Scenic Highway to Route 25 WB Ramp	7	11	16

Conceptual Cost Estimate

The conceptual cost estimate for the Route 25 entrance ramp from Scenic Highway is provided by construction year in Table 4-17. More detailed conceptual cost estimates are provided in Appendix E.

Belmont Circle Reconstruction – Alternatives Evaluated

Several alternatives to improve traffic operations at Belmont Circle were evaluated. These alternatives each incorporate the construction of the Route 25 westbound entrance ramp from Scenic Highway.

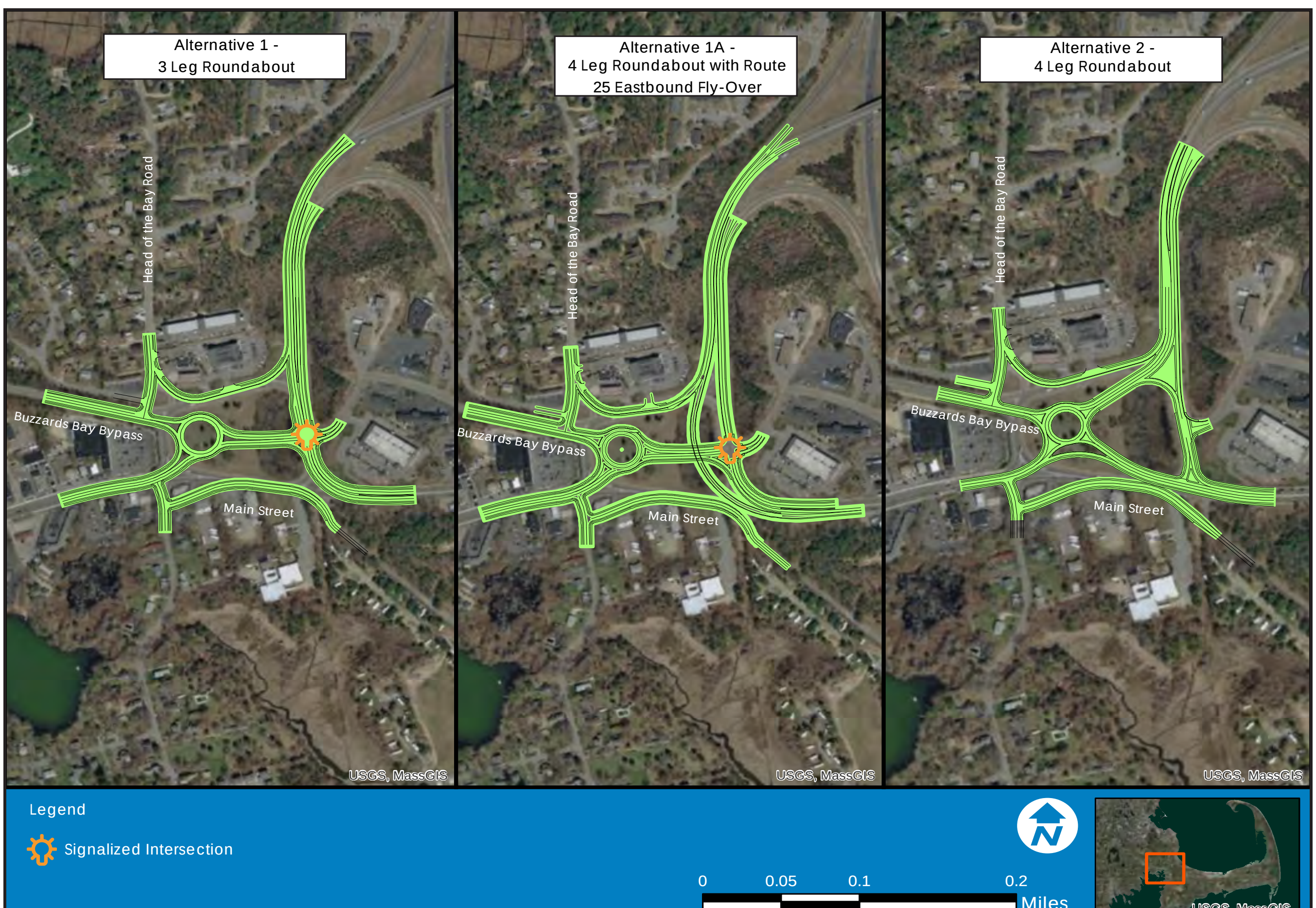
All alternatives would include improvements for bicycle and pedestrian accommodations and maintain access to adjacent properties. Sidewalks, crosswalks, and bicycle lanes would be constructed to provide access between businesses and residential areas west of Belmont Circle in Bourne and Scenic Highway, the Canal bike trail and the Bourne Scenic Park Campground.

As shown on Exhibit 4-20, three alternatives were advanced for analysis. These alternatives included:

Alternative 1 – Three-Leg Roundabout with Signalized Intersection

Alternative 1 involves the construction of a three-leg roundabout (approximately 200 feet in diameter) within the existing Belmont Circle infield with legs of the roundabout for Main Street, Buzzards Bay Bypass, and a new connector roadway from a new signalized intersection on the eastern side of the Circle. This new intersection would accommodate vehicles from Scenic Highway and the Route 25 Exit 3 ramps.

Exhibit 4-20 Alternatives Evaluated - Belmont Circle



SOURCE: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division. 2013-2014 Orthophotography

Alternative 1A – Three-Leg Roundabout with Signalized Intersection and Flyover Ramp

Alternative 1A is similar to Alternative 1 in that it involves the construction of a three-leg roundabout within the existing Belmont Circle infield with legs of the roundabout for Main Street, Buzzards Bay Bypass, and an approach roadway from a new signalized intersection on the eastern side of the Circle. Alternative 1A differs with the addition of a ramp directly from the Route 25 Exit 3 off-ramp to Scenic Highway eastbound. This ramp would pass directly over the roundabout eastern approach road (on a new bridge). Vehicles with destinations other than eastbound on Scenic Highway would use the separate ramp to access Head of the Bay Road or use the new signalized intersection to access the roundabout.

Alternative 2 – Four-Leg Roundabout

Alternative 2 involves the construction of a four-leg roundabout (approximately 200 feet in diameter) within the existing Belmont Circle infield. The legs of the roundabout would include Main Street, Buzzards Bay Bypass, Scenic Highway, and the Route 25 Exit 3 ramps. Vehicles destined for Head of the Bay Road from this Route 25 off-ramp would use a separate ramp.

Traffic Analysis

A traffic analysis was completed of the three alternatives developed for Belmont Circle. The results of this analysis are summarized below and shown on Table 4-18. A comparison of the maximum peak period queue lengths for the approaches to Belmont Circle for the existing, future no-build and the three alternatives are provided in Table 4-19. The existing and future no-build traffic conditions at Belmont Circle are provided in Section 3.3.7.

Alternative 1 (Three-Leg Roundabout with Signalized Intersection)

The approaches to the Belmont Circle roundabout would operate within the range of LOS A to E, with average delay ranging from nine to 42 seconds. In comparison, Belmont Circle would operate at LOS F during both the non-summer weekday and summer Saturday peak period under the future no-build condition.

At 42- and 272-seconds during the non-summer weekday and summer Saturday peak periods, respectfully, the Main Street approach to the Circle would have the longest delays. Other than the Roundabout Connector (1.7 minutes) during the summer Saturday peak period, all other average delays are less than one minute.

Table 4-18 Belmont Circle Reconstruction, Traffic Operations - Comparison of Alternatives

	ALTERNATIVE 1 (RECOMMENDED)				ALTERNATIVE 1A				ALTERNATIVE 2			
	FUTURE (2040) BUILD CONDITIONS - SCREENING ANALYSIS											
	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)												
Buzzards Bay (EB) Lt/Th	16	C	0.64	5	16	C	0.64	5	89 (1.5)	**F**	1.06	15
Buzzards Bay (EB) Rt	6	A	0.16	1	6	A	0.16	1	7	A	0.17	1
Roundabout Conn. (WB) Lt	11	B	0.52	3	11	B	0.52	3				
Roundabout Conn. (WB) Th/Rt	11	B	0.51	3	11	B	0.51	3				
Main Street (NB) Lt	9	A	0.35	2	9	A	0.35	2				
Main Street (NB) Th/Rt	42	**E**	0.93	13	42	**E**	0.93	13				
Main Street (NB) Lt/Th/Rt									188 (3.1)	**F**	1.33	26
Scenic Highway (WB) Lt/ Th									15	C	0.45	2
Exit 3 Off Ramps SB LT									18	C	0.64	5
Exit 3 Off Ramps SB Th/Rt									15	B	0.55	3
Exit 3 Off Ramps SB Rt									10	B	0.4	2
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)												
Buzzards Bay (EB) Lt/Th	25	D	0.66	5	25	D	0.66	5	288 (4.8)	**F**	1.49	18
Buzzards Bay (EB) Rt	46	**E**	0.88	10	46	**E**	0.88	10	131 (2.2)	**F**	1.16	17
Roundabout Conn. (WB) Lt	101 (1.7)	**F**	1.16	31	101 (1.7)	**F**	1.16	31				
Roundabout Conn. (WB) Th/Rt	8	A	0.36	2	8	A	0.36	2				
Main Street (NB) Lt	6	A	0.21	1	6	A	0.21	1				
Main Street (NB) Th/Rt	272 (4.5)	**F**	1.56	68	272 (4.5)	**F**	1.56	68				
Main Street (NB) Lt/Th/Rt									348 (5.8)	**F**	1.70	45
Scenic Highway (WB) Lt/ Th									110 (1.8)	**F**	1.12	17
Exit 3 Off Ramps SB LT									88 (1.5)	**F**	1.1	18
Exit 3 Off Ramps SB Th/Rt									204 (3.4)	**F**	1.38	35
Exit 3 Off Ramps SB Rt									7	A	0.19	1

Notes:
LOS E and LOS F movements are ***bold***
Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service; V/C = Volume to Capacity Ratio
Overall LOS, V/C and queues not calculated for unsignalized intersections.
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.
Shaded areas: Lane configuration does not exist during listed period.

Table 4-19 Belmont Circle - Comparison of Alternatives, Maximum Queue Length

APPROACHES	EXISTING (2014)		FUTURE (2040) NO-BUILD		ALTERNATIVE 1 (RECOMMENDED)		ALTERNATIVE 1A		ALTERNATIVE 2	
	NON-SUMMER	SUMMER	NON-SUMMER	SUMMER	NON-SUMMER	SUMMER	NON-SUMMER	SUMMER	NON-SUMMER	SUMMER
	(FEET/MILES)		(FEET/MILES)		(FEET/MILES)		(FEET/MILES)		(FEET/MILES)	
Route 25 Exit 3 Exit Ramp	515	510	645	**1,025**	135	24	35	60	75	525
Buzzards Bay Bypass WB	100	335	110	305	261	36	261	636	225	270
Main Street EB	530	**5,755 (1.1)**	1,245	**6,140 (1.2)**	474	1,749	474	1,749	390	675
Scenic Highway WB	380	**10,605 (2.0)**	840	**11,610 (2.2)**	290	870	290	870	30	255

Notes:
Queues over 2,500 feet also provided in miles.
*Locations of excessive delay are **bold***

Under Alternative 1, maximum queue lengths during the non-summer weekday peak period for all approaches except the Buzzards Bay Bypass would be reduced to less than half of the future no-build condition. For example, the queuing at the Route 25 Exit 3 ramps approaching Belmont Circle would be reduced from 645 feet to 135 feet. However, the peak period maximum queue for the Buzzards Bay Bypass would increase from 110 feet to 261 feet. The reductions in maximum peak period queue length during the summer Saturday peak period is even more favorable with all approaches experiencing substantial reductions including the queuing on the Scenic Highway approach being reduced from 11,610 feet to 870 feet.

Alternative 1A (Three-Leg Roundabout with Signalized Intersection and Flyover Ramp)

The approaches to the roundabout would operate the same as Alternative 1 having the same result for LOS and delay for each roundabout approach. As in Alternative 1, the longest queues for Alternative 1B would be found on Main Street.

The new signalized intersection of Scenic Highway at the Route 25 exit ramp and the new roundabout connector road would operate at LOS B and LOS D during the non-summer weekday and summer Saturday peak periods, respectively. The signalized intersection is forecast to reduce the number and severity of crashes at this high crash location.

The results for the peak period maximum queue lengths under Alternative 1A would be very similar to Alternative 1 with the queues for all approaches except the Buzzards Bay Bypass being reduced to less than half of the future no-build condition. The reductions in the maximum length of peak period queues during the summer Saturday peak period would also be favorable with all approaches experiencing substantial reductions including a reduction in the Main Street queue from 6,140 feet to 1,749 feet.

Alternative 2 (Four-Leg Roundabout)

The approaches to Belmont Circle would operate within a range of LOS A to LOS F during the non-summer weekday peak period, with delays ranging from seven seconds at the Buzzards Bay Bypass to 3.1 minutes at Main Street approaches. However, during the summer Saturday peak period, all approaches would at LOS F with average delays ranging from 1.5 minutes (Exit 3 off ramps) to 5.8 minutes (Main Street).

Under Alternative 2, maximum queue lengths during the non-summer weekday peak period for all approaches except the Buzzards Bay Bypass would be reduced to less than half of the future no-build condition. For example, the queue at the Route 25 Exit 3 ramps approaching Belmont Circle would be reduced from 645 feet to 75 feet. However, the peak period maximum queue for the Buzzards Bay Bypass would increase from 110 feet to 225 feet. The reductions in maximum peak period queue length during summer Saturdays are even more favorable with all approaches experiencing substantial reductions including the queue on the Main Street approach being reduced from 11,610 feet to 255 feet.

Environmental Resource Impact

As shown on Table 4-20, each of the three alternatives for the reconstruction of Belmont Circle would impact wetland resources and 100-year floodplain. Open space and residential and commercial property acquisitions may also be required.

Table 4-20 Belmont Circle Reconstruction - Environmental Impact by Alternative

	SCENIC HWY TO ROUTE 25 WB RAMP	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
RESOURCE AREAS (ACRES):				
Rare Species Habitat	0	0	0	0
DEP Wetlands	0	0.3	0.5	0.03
100-year Floodplain	0	4.7	5.4	4.6
Rare Species Habitat	0	0	0	0
IWPA (Interim Wellhead Protection Area)	0.2	0.5	0.5	0.4
RIGHT OF WAY (ACRES):				
USACE	0	0.1	0.1	0.1
Residential	0	0.02	0.02	0.02
Commercial	0	0.02	0.02	0.02
Utility	0.88	0	0	0

Notes:
Environmental and right-of-way impact based on conceptual design and GIS-based data.

Conceptual Cost Estimate

The conceptual cost estimate for alternatives to reconstruct Belmont Circle are provided by construction year in Table 4-21. More detailed conceptual cost estimates are provided in Appendix E.

Suggested Alternative

Alternative 1 – Three-Leg Roundabout with Signalized Intersection was advanced for further study during the travel model analysis (Exhibit 4-21). This alternative was selected because it would improve traffic operations with a simpler,

Table 4-21 Belmont Circle Reconstruction – Conceptual Cost Estimate

	2017 ($ MILLION)	2030 ($ MILLION)	2040 ($ MILLION)
Alternative 1 (recommended)	14	23	33
Alternative 1A	24	41	60
Alternative 2	13	21	26

Note:
Cost estimates do not include construction cost for the Scenic Highway to Route 25 WB Ramp

Exhibit 4-21 Belmont Circle - Suggested Alternative

less costly design (not having the bridge structure included in Alternative 1A).

Alternative 1 would substantially reduce queuing and vehicle delays compared to the future no-build condition. Environmental impacts were approximately the same for all alternatives.

4.6.5 Bourne Rotary

Several alternatives were evaluated to improve traffic operations at the Bourne Rotary. These alternatives were conceived to be compatible with the existing Bourne Bridge as well as with the vertical and horizontal alignment of an assumed replacement of the Bourne Bridge. The traffic analysis is based on location and geometry of the existing Bourne Bridge.

Each of these alternatives assumes that the local intersection improvements at the Sandwich Road at the Bourne Rotary Connector (described in Section 4.4.2) are completed. A larger-scale alternative to reconstruct Bourne Rotary as a highway interchange, likely in conjunction with the replacement of the Bourne Bridge, is described in Section 4.6.6.

All alternatives would include improvements to bicycle and pedestrian accommodations and maintain access to adjacent properties. Sidewalks, crosswalks, and bicycle lanes would be constructed on Old Sandwich Road to provide east-west access under the Bourne Bridge. These facilities would enhance access between public facilities such as the Upper Cape Cod Technical High School and the Bourne Middle School and High School. Pedestrian and bicycle access would also be improved between residential neighborhoods west of Route 28 and the Canal bike trail at the Bourne Recreational Area.

The development of alternatives is constrained by the existing environmental resources (Exhibit 2-16) and land uses at the Bourne Rotary (Exhibit 4-22) including the State Police Station and other commercial developments immediately adjacent to the Rotary. The existing and future traffic operations at Belmont Circle and Bourne Rotary are provided in Section 3.3.7.

As shown on Exhibit 4-23, three alternatives were advanced for analysis. A larger-scale improvement alternative for Bourne Rotary was also evaluated, as described in Section 4.6.6. The alternatives evaluated include:

Alternative 1 – Route 28 Northbound Ramp

Alternative 1 involves the construction of a ramp immediately east of the Rotary leading vehicles directly from Route 28 northbound to Sandwich Road, via the Bourne Rotary Connector.

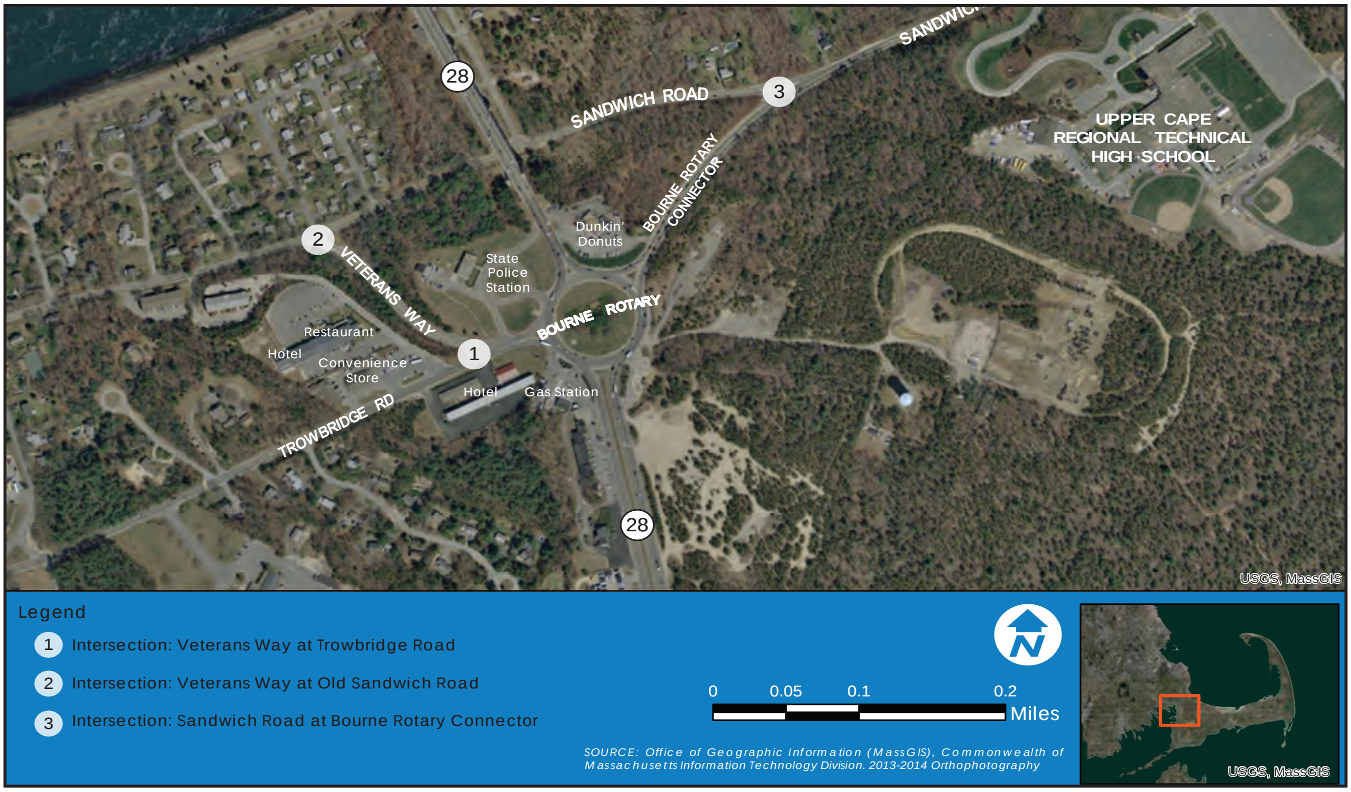
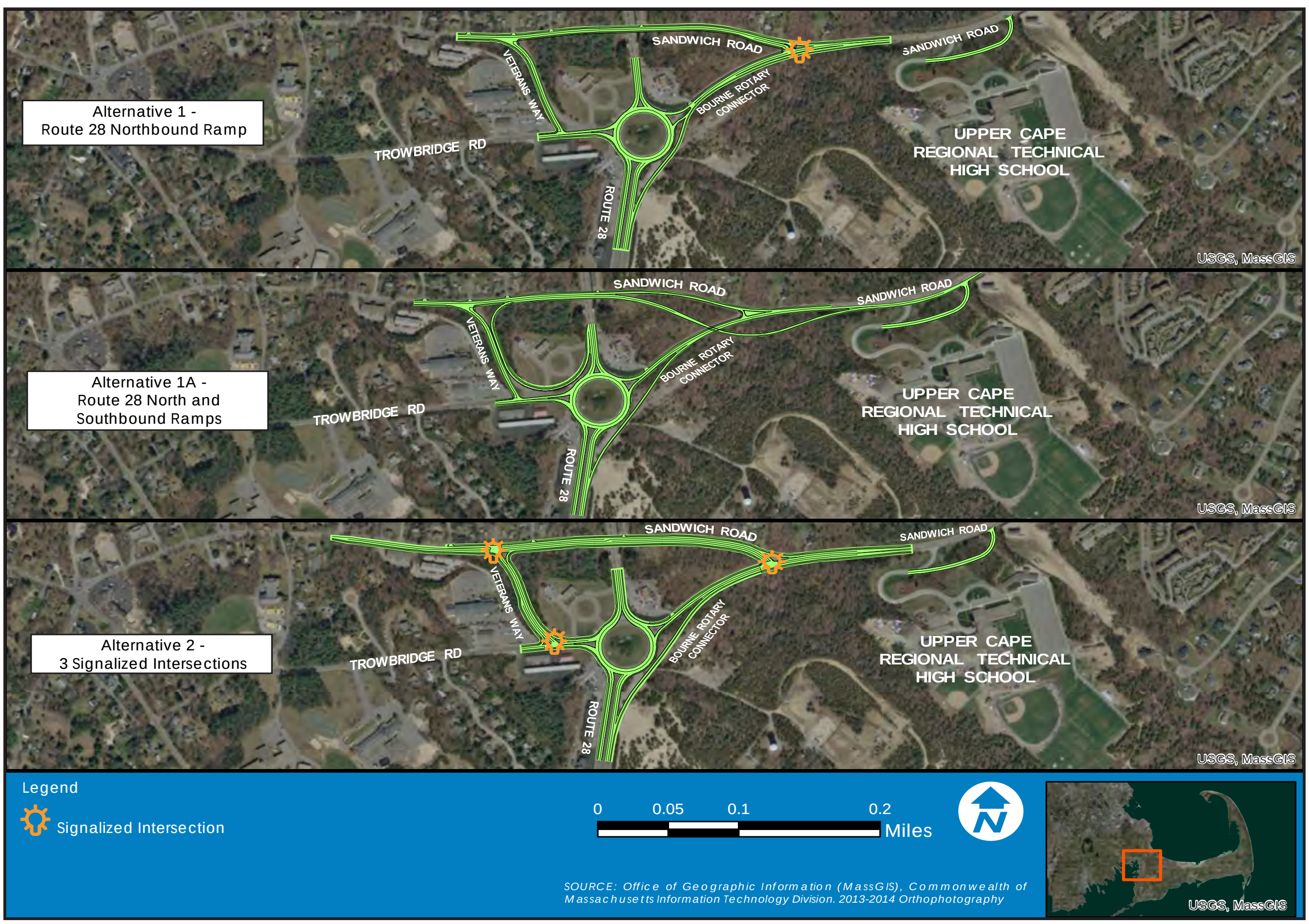


Exhibit 4-22 Bourne Rotary - Existing Conditions

Exhibit 4-23 Alternatives Evaluated – Bourne Rotary



This ramp would allow northbound vehicles on Route 28 direct access to Sandwich Road without having to enter the Rotary.

In addition to the reconstruction of the Sandwich Road at Bourne Rotary Connector intersection, this alternative includes the relocation of the Upper Cape Technical High School driveway approximately 300 feet to the east to provide some separation of the traffic entering and exiting the high school from the traffic entering Sandwich Road from the new Route 28 northbound ramp[1].

Alternative 1A – Route 28 Northbound and Southbound Ramp with Sandwich Road Underpass

Alternative 1A builds upon the Route 28 northbound ramp to Sandwich Road (proposed under Alternative 1) in proposing a second ramp leading from Route 28 southbound looping around State Police property at Veterans Way and continuing north to Sandwich Road. These ramps would allow northbound and southbound vehicles on Route 28 direct access to Sandwich Road without having to enter the Rotary.

This alternative also includes the relocation and conversion of an approximately 0.3 mile section of the Sandwich Road eastbound lanes into an underpass at the Bourne Rotary Connector intersection. The relocated section of Sandwich Road eastbound would begin immediately east of the Bourne Bridge underpass and re-connect with the existing Sandwich Road alignment approximately 300 feet east of the Bourne Rotary Connector. This new eastbound alignment of Sandwich Road, with the Bourne Rotary Connector underpass, would allow eastbound vehicles a direct path to Sandwich Road without having to enter the Bourne Rotary.

This alternative also includes the relocation of the Technical High School driveway approximately 300 feet to the east to provide some separation of the traffic entering and exiting the high school from the traffic entering Sandwich Road from the new Route 28 northbound ramp.

1 The relocation of the high school driveway is a conceptual element of the reconstruction of Bourne Rotary. When the project advances into the implementation phase, MassDOT will hold coordination meetings with the Upper Cape Cod Technical High School

Alternative 2 – Three Signalized Intersections

Alternative 2 involves the reconstruction and signalization of three intersections in the immediate Bourne Rotary area at the following locations:

- Intersection 1: Veterans Way at Trowbridge Road
- Intersection 2: Veterans Way at Old Sandwich Road
- Intersection 3: Sandwich Road at Bourne Rotary Connector

In addition to construction of these three signalized intersections, Alternative 2 includes the construction of a ramp providing a direct connection from Route 28 northbound to Sandwich Road, via the Bourne Rotary Connector, as in Alternatives 1and 1A. A second ramp leading from Route 28 southbound, looping around the State Police property at Veterans Way and continuing north to Sandwich Road is also incorporated, as well as the relocation of the Technical High School driveway approximately 300 feet to the east.

Unique to Alternative 2 is the reconstruction of the Rotary such that travel across the north side of the Rotary would not be allowed. Vehicles entering the Rotary from Trowbridge Road or Route 28 northbound would only be allowed to exit at the Bourne Rotary Connector (to Sandwich Road) or continue to Route 28 northbound across the Bourne Bridge. This disconnection would reduce traffic volumes in the Rotary and allow for freer movement from Route 28 southbound into the Rotary. East-west travel in this area would be accomplished using Sandwich Road.

Traffic Analysis

A traffic analysis was completed of the three alternatives developed for the Bourne Rotary. Traffic operations at the three intersections adjacent to the Rotary (listed above for Alternative 2) were compared to identify a preferred alternative. The results of this analysis are summarized below and shown on Table 4-22 through Table 4-24. A comparison of the maximum peak period queue lengths for the approaches to Belmont Circle for the existing condition, future no-build condition, and the three alternatives are provided in Table 4-25.

Alternative 1 - Route 28 Northbound Ramp

1. Veterans Way at Trowbridge Road: This intersection would remain unsignalized with the approaches operating within the range of LOS A – C. At 22 and 20 seconds, the Veterans Way approach would have the longest delay during the non-summer weekday and summer Saturday peak periods, respectively.

Text continues on page 4-58.

Table 4-22 Bourne Rotary, Traffic Operations - Comparison of Alternatives, Veterans Way at Trowbridge Road

	ALTERNATIVE 1				ALTERNATIVE 1A				ALTERNATIVE 2 (RECOMMENDED)				
	FUTURE (2040) BUILD CONDITIONS - SCREENING ANALYSIS												
	AVERAGE DELAY *Sec (Min)*	**LOS**	**V/C**	**95% QUEUE** *Feet (Miles)*	**AVERAGE DELAY** *Sec (Min)*	**LOS**	**V/C**	**95% QUEUE** *Feet (Miles)*	**AVERAGE DELAY** *Sec (Min)*	**LOS**	**V/C**	**50% QUEUE** *Feet (Miles)*	**95% QUEUE** *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)													
Trowbridge Road EB Th	0.5	A	0.02	2	0.5	A	0.02	2					
Trowbridge Road WB Th/Rt	0	A	0.26	0	0	A	0.26	0					
Veterans Way NB Lt/Rt	22	C	0.29	29	22	C	0.29	29					
Trowbridge Rd EB Lt/Th									19	B	0.81	136	241
Trowbridge Rd WB Th									10	B	0.34	44	80
Trowbridge Rd WB Rt									12	B	0.56	0	49
Veteran's Way SB Lt									16	B	0.62	102	221
Veteran's Way SB Rt									10	A	0.1	0	29
Intersection (Overall)									**14.3**	**B**	**0.72**		
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)													
Trowbridge Road EB Th	0.3	A	0.01	1	0.3	A	0.01	1					
Trowbridge Road WB Th/Rt	0	A	0.24	0	0	A	0.24	0					
Veterans Way NB Lt/Rt	20	C	0.18	17	20	C	0.18	17					
Trowbridge Rd EB Lt/Th									42	D	0.93	262	458
Trowbridge Rd WB Th									17	B	0.27	56	100
Trowbridge Rd WB Rt									21	C	0.62	0	96
Veteran's Way SB Lt									29	C	0.88	311	549
Veteran's Way SB Rt									10	A	0.14	0	31
Intersection (Overall)									**26.9**	**C**	**0.9**		

Notes:
Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service; V/C = Volume to Capacity Ratio
Overall LOS, V/C and queues not calculated for unsignalized intersections.
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.
Shaded areas: Lane configuration does not exist during listed period.

Table 4-23 Bourne Rotary, Traffic Operations - Comparison of Alternatives, Veterans Way at Old Sandwich Road

	ALTERNATIVE				ALTERNATIVE 1A				ALTERNATIVE 2 (RECOMMENDED)				
	FUTURE (2040) BUILD CONDITIONS - SCREENING ANALYSIS												
	AVERAGE DELAY Sec (Min)	LOS	V/C	95% QUEUE Feet (Miles)	AVERAGE DELAY Sec (Min)	LOS	V/C	95% QUEUE Feet (Miles)	AVERAGE DELAY Sec (Min)	LOS	V/C	95% QUEUE Feet (Miles)	95% QUEUE Feet (Miles)
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)													
Old Sandwich Road EB Th/Rt	0	A	0.24	0	0	A	0.25	0	25	C	0.6	75	111
Old Sandwich Road WB Th/Lt	3	A	0.05	4	2	A	0.02	2					
Veterans Way NB Lt/Rt	13	B	0.1	8	13	B	0.09	8					
Old Sandwich Road WB Th									28	C	0.9	138	317
Old Sandwich Road WB Rt									8	A	0.13	24	46
Veterans Way NB Lt									16	B	0.19	30	65
Veterans Way NB Rt									28	C	0.72	46	281
Intersection (Overall)									**25.4**	**C**	**0.88**		
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)													
Old Sandwich Road EB Th/Rt	0	A	0.13	0	0	A	0.14	0	49	D	0.6	80	120
Old Sandwich Road WB Th/Lt	1	A	0.02	2	0.5	A	0.01	1					
Veterans Way NB Lt/Rt	10	B	0.05	4	11	B	0.06	5					
Old Sandwich Road WB Th									25	C	0.89	424	897
Old Sandwich Road WB Rt									5	A	0.13	29	71
Veterans Way NB Lt									37	D	0.14	29	57
Veterans Way NB Rt									53	D	0.69	23	274
Intersection (Overall)									**37.1**	**D**	**0.88**		

Notes:
Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service; V/C = Volume to Capacity Ratio
Overall LOS, V/C and queues not calculated for unsignalized intersections.
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.
Shaded areas: Lane configuration does not exist during listed period.

Table 4-24 *Bourne Rotary, Traffic Operations - Comparison of Alternatives, Sandwich Road at Bourne Rotary Connector*

	ALTERNATIVE					ALTERNATIVE 1A				ALTERNATIVE 2 (RECOMMENDED)				
	FUTURE (2040) BUILD CONDITIONS - SCREENING ANALYSIS													
	AVERAGE DELAY *Sec (Min)*	LOS	V/C	50% QUEUE *Feet (Miles)*	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*	95% QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)														
Bourne Rotary Connector EB Lt	0	A	0	0	0					13	B	0.37	17	37
Bourne Rotary Connector EB Th	1	A	0.59	0	0					11	B	0.49	118	190
Sandwich Road WB Th	17	B	0.79	205	436					31	C	0.88	236	422
Sandwich Road WB Rt	98 (1.6)	A	0.29	0	41					15	B	0.38	0	58
Old Sandwich Road EB Lt	22	C	0.54	69	127					28	C	0.86	194	297
Old Sandwich Road EB Rt	14	B	0.47	63	131	51	F	0.73	126					
Old Sandwich Road EB Lt/Rt										16	B	0.12	0	38
Bourne Rotary Conn. EB Lt/Th						0.5	A	0.02	1					
Sandwich Rd WB Th/Rt						0	A	0.71	0					
Intersection (Overall)	**9.7**	**A**	**0.78**							**21.9**	**C**	**0.85**		
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)														
Bourne Rotary Connector EB Lt	33	C	0.13	10	32					38	D	0.87	50	172
Bourne Rotary Connector EB Th	2	A	0.69	0	0					15	B	0.76	237	384
Sandwich Road WB Th	24	C	0.9	396	715					37	D	0.92	262	467
Sandwich Road WB Rt	7	A	0.12	0	25					18	B	0.58	2	82
Old Sandwich Road EB Lt	36	D	0.7	108	192					34	C	0.9	195	303
Old Sandwich Road EB Rt	19	B	0.15	14	52	110 (1.8)	F	0.91	158					
Old Sandwich Road SB Lt/Rt										17	B	0.09	0	35
Bourne Rotary Conn EB Lt/ Th						1	A	0.03	3					
Sandwich Rd WB Th/Rt						0	A	0.92	0					
Intersection (Overall)	**13.9**	**B**	**0.89**							**26**	**C**	**0.93**		

Notes:
Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service; V/C = Volume to Capacity Ratio
Overall LOS, V/C and queues not calculated for unsignalized intersections.
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles
Shaded areas: Lane configuration does not exist during listed period.

2. Veterans Way at Old Sandwich Road: This intersection would remain unsignalized with the approaches operating within the range of LOS A – B. At 13 and 10 seconds, the Veterans Way approach would have the longest delay during the non-summer weekday and summer Saturday peak periods, respectively.

3. Sandwich Road at Bourne Rotary Connector: Under Alternative 1, this intersection would be signalized with dedicated turning lanes provided at the Old Sandwich Road eastbound and Bourne Rotary Connector eastbound approaches. This intersection would operate at an overall LOS A during the non-summer weekday and LOS B during the summer Saturday peak periods.

Under Alternative 1, maximum queue lengths would vary for the four approaches to the Bourne Rotary when compared to the future no-build condition during the non-summer weekday peak period (Table 4-25). While the queues for Route 28 northbound and Bourne Rotary Connector approaches would experience modest or no improvement, the peak period queues on the Route 28 southbound and Trowbridge Road approaches would increase. The queue at the Route 28 southbound approach would increase from 620 feet to 9,320 feet and the Trowbridge Road queue would increase from 3,465 feet to 4,895 feet. The results for the summer Saturday peak period are similar except for Trowbridge Road would experience a modest increase in queuing and the Route 28 southbound approach queue would increase from 1.9 miles to 5.2 miles.

Table 4-25 Bourne Rotary - Comparison of Alternatives, Maximum Queues Length

APPROACHES	EXISTING (2014)		FUTURE (2040) NO-BUILD		ALTERNATIVE 1		ALTERNATIVE 1A		ALTERNATIVE 2 (RECOMMENDED)	
	NON-SUMMER	SUMMER	NON-SUMMER	SUMMER	NON-SUMMER	SUMMER	NON-SUMMER	SUMMER	NON-SUMMER	SUMMER
	Feet (Miles)		*Feet (Miles)*		*Feet (Miles)*		*Feet (Miles)*		*Feet (Miles)*	
Route 28 SB	650	**8,885 (1.7)**	620	**9,935 (1.9)**	**9,340 (1.8)**	**27,564 (5.2)**	**2,955 (1.8)**	**17,029 (3.2)**	**5,620 (1.1)**	**13,685 (2.6)**
Trowbridge Road EB	840	335	**3,465 (0.7)**	**2,225**	**4,895 (0.9)**	**3,052 (0.6)**	**1,760**	**1,684**	**7,445 (1.4)**	**7,443 (1.4)**
Route 28 NB	340	4,130 (0.8)	1,275	**3,605 (0.7)**	635	309	175	214	210	371
Bourne Rotary	1,530	1,475	855	**6,430 (1.2)**	875	877	875	874	50	50

Notes:
Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service; V/C = Volume to Capacity Ratio
Overall LOS, V/C and queues not calculated for unsignalized intersections.
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.
*Excessive delays **bold***

Alternative 1A – Route 28 Northbound and Southbound Ramp

1. Veterans Way at Trowbridge Road: This intersection would remain unsignalized with the approaches operating within the range of LOS A – C. At 22 and 20 seconds, the Veterans Way approach would have the longest delay during the non-summer weekday and summer Saturday peak periods, respectively.

2. Veterans Way at Old Sandwich Road: This intersection would remain unsignalized with the approaches operating within the range of LOS A – B. At 13 and 11 seconds, the Veterans Way approach would have the longest delay during the non-summer weekday and summer Saturday peak periods, respectively.

3. Sandwich Road at Bourne Rotary Connector: This intersection would remain unsignalized under Alternative 1A. Similar to the existing condition, vehicles would have difficulty entering Sandwich Road from Old Sandwich Road, with that minor approach operating at LOS F during both the non-summer weekday and summer Saturday peak periods.

Under Alternative 1A, maximum queue lengths would vary for the four approaches to the Bourne Rotary when compared to the future no-build condition during the non-summer weekday peak period. Similar to Alternative 1, the queues for Route 28 northbound and Bourne Rotary Connector approaches would experience modest or no improvement. However, the peak period queues on the Route 28 southbound and Trowbridge Road approaches would increase. The queue at the Route 28 southbound approach would increase from 620 feet to 2,955 feet and the Trowbridge Road queue would increase from 3,465 feet to 4,895 feet. The results for the summer Saturday peak period are similar except for Trowbridge Road would experience a modest reduction in queue length. During the summer Saturday peak period the Route 28 southbound queue would increase from 1.9 miles to 3.2 miles.

Alternative 2 – Three Signalized Intersections

1. Veterans Way at Trowbridge Road: Under Alternative 2, this intersection would be signalized with dedicated turn lanes at the Trowbridge Road westbound and Veterans Way southbound approaches. The intersection would have an overall LOS of B in the non-summer weekday and LOS C during the summer Saturday peak periods. Average delay for the intersection would be approximately 14 seconds (non summer weekday) and 27 seconds (summer Saturday).

2. Veterans Way at Old Sandwich Road: Under Alternative 2, this intersection would be signalized with dedicated turn lanes at the Old Sandwich Road westbound and Veterans Way northbound approaches. The intersection would have an overall LOS of C during the non-summer weekday and LOS D during the summer Saturday peak periods. Average delay for the intersection during peak periods would be approximately 25 seconds (non summer weekday) and 37 (summer Saturday).

3. Sandwich Road at Bourne Rotary Connector: Under Alternative 2, this intersection would be signalized with dedicated turn lanes at the Bourne Rotary Connector eastbound and Old Sandwich Road southbound approaches. The intersection would have an overall LOS of C during the non-summer weekday and summer Saturday peak periods. Average delay for the intersection during peak periods would be approximately 25 seconds (non-summer weekday) and 37 seconds (summer Saturday).

Under Alternative 2, maximum queue lengths would vary for the four approaches to the Bourne Rotary when compared to the future no-build condition during the non-summer weekday peak period. The queue for Route 28 northbound approach would be substantially reduced from 1,275 feet to 210 feet and the queue at the Bourne Rotary Connector reduced from 855 feet to 50 feet. However, the peak period queues would persist on the Route 28 southbound and Trowbridge Road approaches with non-summer weekday queues at 5,620 feet and 7,445 feet, respectively.

The results for the summer Saturday peak period are similar to the non-summer weekday period with only minor queues at the Route 28 northbound and Bourne Rotary Connector approaches but persistent, longer queues at the Route 28 southbound and Trowbridge Road approaches. However, the queue on Route 28 southbound is substantially shorter when compared to Alternatives 1 and 1A.

Environmental Resource and Property Impacts

As shown on Table 4-26, none of the three alternatives evaluated for the reconstruction of the Bourne Rotary would impact wetland resources, 100-year floodplain, or rare species habitat. Alternative 1A would require the acquisition of approximately one acre of land from the Town of Bourne. All alternatives may require minor property acquisitions from the USACE and adjacent residential and commercial properties.

This Route 28 ramp may require a minor property acquisition from the Massachusetts State Police barracks.

Table 4-26 Bourne Rotary - Environmental Impact by Alternative

	ALTERNATIVE 1	ALTERNATIVE 1A	ALTERNATIVE 2
RESOURCE AREAS (ACRES):			
DEP Wetlands	0	0	0
100-year Floodplain	0	0	0
Rare Species Habitat	0	0	0
RIGHT OF WAY (ACRES):			
Town of Bourne	0	1.0	0
USACE	0.1	0.2	0.4
Residential	0.02	0.02	0.3
Commercial	0	0.2	0.01

Notes:
Environmental and right-of-way impact based on conceptual design and GIS-based data.

Table 4-27 Bourne Rotary Reconstruction – Conceptual Cost Estimates

	2017 ($ MILLION)	2030 ($ MILLION)	2040 ($ MILLION)
Alternative 1	8	13	19
Alternative 1A	16	27	39
Alternative 2 (recommended)	11	18	26

Conceptual Cost Estimate

The conceptual costs for alternatives to reconstruct Bourne Rotary are provided by construction year in Table 4-27. More detailed conceptual cost estimates are provided in Appendix E.

Suggested Alternative

Alternative 2 – Three Signalized Intersection – was advanced for further study during the travel model analysis (Exhibit 4-24). This alternative was selected because it would result in acceptable traffic operations at all three adjacent intersections. The Veterans Way at Trowbridge Road intersection would operate LOS B and C for the non-summer weekday and summer Saturday peak periods, respectively. The Veterans Way at Old Sandwich Road intersection would operate at LOS C and D and the Sandwich Road at Bourne Rotary Connector intersection would operate at LOS C for both time periods.

Based on the conceptual design, this alternative could be incorporated into the Bourne Rotary Interchange alternative and, ultimately, a replacement Bourne Bridge. This alternative would have less property impact to the Massachusetts State Police barracks.

Exhibit 4-24 Bourne Rotary - Suggested Alternative

4.6.4 Bourne Rotary Interchange

A larger-scale alternative to improve traffic operations at the Bourne Rotary was evaluated. This alternative involves the reconstruction of the Bourne Rotary as a highway interchange. This alternative assumes the prior intersection improvements at Bourne Rotary (Alternative 2 – Three Signalized Intersections) are already in place.

This alternative was conceived to be constructed concurrent with an assumed replacement of the Bourne Bridge, with an alignment immediately east of the existing bridge. The existing and future traffic operations at the Bourne Rotary are described in Sections 2.5.10 and 3.3.7, respectively. The existing land uses and environmental resources in the Bourne Rotary area are described in Section 2.2.2.

Suggested Improvements

The reconstruction of the Bourne Rotary as a highway interchange intersection involves the removal of the Rotary and the construction of a grade-separated highway ramp system allowing vehicles to enter Route 28 (northbound or southbound)

Exhibit 4-25 Bourne Rotary Interchange

directly from Sandwich Road (via the Bourne Rotary Connector) or Trowbridge Road (Exhibit 4-25). Local traffic would pass directly over Route 28 on an overpass. The grade-separated interchange would remove the numerous conflict points that currently exist at the Rotary, substantially reducing queuing and crash rates.

Traffic Conditions

The reconstruction of the Bourne Rotary as a highway interchange would substantially reduce peak period queuing on the Rotary approach roadways including Route 28 (northbound and southbound), Trowbridge Road, and the Bourne Rotary Connector (Table 4-28). Currently, the Bourne Rotary suffers from LOS F conditions during all peak periods. Construction of a highway interchange would improve traffic operations, forecast to range from LOS A to LOS C conditions.

Property or Environmental Resource Impact

As shown on Table 4-29, the Bourne Rotary Interchange alternative would not impact wetland resources, 100-year

Table 4-28 Traffic Operations - Bourne Rotary Interchange

	FUTURE (2040) BUILD CONDITIONS - BUILD CASE 3A		
	DELAY *Sec*	LOS	95% QUEUE *Feet/Direction*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)			
Trowbridge Rd & Veteran's Way	9	A	73/SB
Bourne Rotary Connector & Old Sandwich Road	11	B	200/EB
Veteran's Way & Old Sandwich Road	21	C	348/EB
Exit 4 SB On Ramp/Trowbridge Road & Sandwich Rd Connector	1	--	4/WB
Exit 4 NB Off Ramp & Sandwich Rd Connector	9	--	42/NB
Trowbridge Road & Exit 4 SB Off Ramp	1	--	12/SB
Intersection (Overall)	**8.9**	**A**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)			
Trowbridge Rd & Veteran's Way	10	A	107/SB
Bourne Rotary Connector & Old Sandwich Road	13	B	257/EB
Veteran's Way & Old Sandwich Road	28	C	452/WB
Exit 4 SB On Ramp/Trowbridge Road & Sandwich Rd Connector	0.4	--	2/WB
Exit 4 NB Off Ramp & Sandwich Rd Connector	13	--	99/NB
Trowbridge Road & Exit 4 SB Off Ramp	2	--	28/SB
Intersection (Overall)	**11.0**	**B**	

Notes:
EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service

Table 4-29 Bourne Rotary Interchange - Potential Property or Environmental Impact

	ALTERNATIVE 1
ENVIRONMENTAL RESOURCES	
DEP Wetlands	0
100-year Floodplain	0
Rare Species Habitat	0.2
PROPERTY IMPACT	
Town of Bourne	0
USACE	0.4
Residential	0.3
Commercial	2.2

floodplains or land owned by the Town of Bourne. This alternative may impact a minor amount of rare species habitat (0.2 acres). The interchange alternative would require the acquisition of approximately 0.4 acres of land from the USACE and 0.3 acres of residential property. The interchange would also require approximately 2.2 acres of commercial land east of the Rotary.

Conceptual Cost Estimate

The conceptual cost for the Bourne Rotary Interchange is provided by construction year in Table 4-30. More detailed conceptual cost estimates are provided in Appendix E.

Table 4-30 Bourne Rotary Interchange – Conceptual Cost Estimate by Build Year

	2030 ($ MILLION)	2040 ($ MILLION)
Bourne Rotary Interchange[1]	69	101

Note:
[1] Includes cost of Bourne Rotary - Three Signalized Intersections Improvements.

4.7 BOURNE AND SAGAMORE BRIDGE REPLACEMENT OR REHABILITATION

The Bourne and Sagamore Bridges play an integral part of the transportation network in the study area. However, they are both owned by the USACE, not the Commonwealth of Massachusetts, and decisions regarding their future rehabilitation or replacement will be made by the USACE. The following section provides information regarding the existing bridge features and the potential features of replacement bridge structures based on current highway design standards, characteristics of the adjacent highway network, and future traffic volumes. Multimodal transportation facilities have also been considered for the potential future bridge design.

4.7.1 Bourne and Sagamore Bridges – Potential Replacement Design Features

The Sagamore and Bourne Bridges both opened in 1935 and are nearing the end of their usable service lives. The bridges have been designated as eligible for individual listing on the National Register of Historic Places by the Massachusetts Historic Commission.

As noted in chapter 1, the U.S. Army Corps of Engineers (USACE) owns and maintains these bridges. The USACE is currently conducting a study of both bridges called a Major Rehabilitation Evaluation Report. The outcome of this study will be a determination of whether to continue long-term maintenance of the bridges or to replace them. This determination may be different for each bridge.

For this planning study, it is assumed that the USACE will determine that both Bridges require complete replacement. However, most study alternatives were developed to be compatible with the existing or replacement bridges.

Identical in design, each highway bridge is approximately 48-feet in width, providing four 10-foot-wide traffic lanes (two lanes in each direction), with no roadway shoulder or median. A single six-foot-wide sidewalk and a two-foot safety walk are provided along opposite sides of the Bridges.

The sidewalks are on the east side of the Sagamore Bridge and the west side of the Bourne Bridge. The design of the bridges is substandard for lane widths, lack of roadway shoulders and medians, and having no ADA compliant bicycle and pedestrian accommodation. At a six-percent grade, the vertical profile of the bridges is steeper than the four- to five-percent maximum grade typical for a limited-access highway.

Additional substandard design features at the highway approaches to the bridges contribute to peak period congestion. Approaching the Sagamore Bridge from the north, one of the two travel lanes in Route 3 southbound is dropped to allow travelers from Scenic Highway to merge onto Route 3 at Exit 1A, reinstating the second travel lane. This substandard roadway geometry contributes to congestion and delays on Route 3 southbound, especially during peak periods.

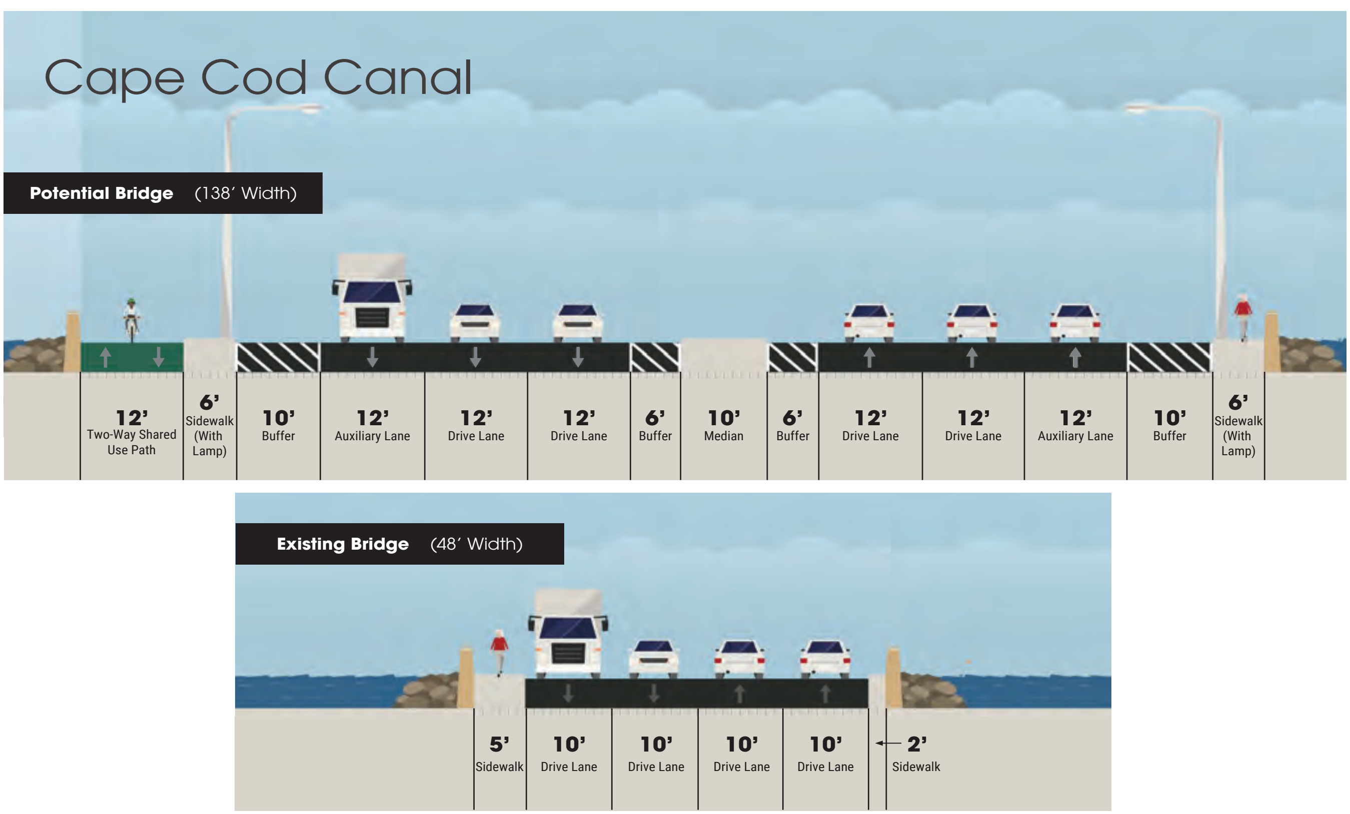
Immediately south of the Bourne Bridge, the unsignalized Bourne Rotary constrains Route 25 eastbound traffic flows over the bridge. During peak periods, queues extend from all rotary approaches, particularly on Route 28 northbound and Route 25 eastbound. The queue on Route 25 often extends several thousand feet over the Bourne Bridge, to the point where vehicles are constrained from entering Route 25 from Belmont Circle.

Based on the local topography, existing land uses, and environmental resources, it is assumed that these replacement bridges would be constructed immediately adjacent to and inside of the existing Bridges. A replacement Bourne Bridge would be built to the east of the existing bridge and a replacement Sagamore Bridge would be built to the west of the existing bridge (Exhibit 4-26).

It is also assumed that replacement Canal Bridges would be multimodal structures designed to current MassDOT highway design standards and policies. Specifically, a bridge with a much

Exhibit 4-26 Potential Alignment - Bourne and Sagamore Bridge Replacement

Exhibit 4-27 Potential Cross Section - Bourne and Sagamore Bridge Replacements



wider cross section is envisioned to accommodate all users. This cross section could be up to 138 feet wide, including two 12-foot lanes in each direction and a single12-foot auxiliary traffic lane in each direction. These lanes would be separated by a 10-foot wide median. Bicyclists and pedestrians could cross the bridge on a 12-foot wide shared-use path on one side of the bridge with a 6.0-foot wide pedestrian sidewalk on the other side of the bridge (Exhibit 4-27).

The addition of auxiliary lanes on the replacement bridges would provide appropriate acceleration and deceleration lanes for vehicles entering or exiting at the gateway intersections in the Canal area and eliminate the need for the lane drop present at the Route 3 southbound approach to the Sagamore Bridge. By separating the vehicles entering and exiting the highway from through traffic, the auxiliary lanes would reduce turbulence in the roadway system, alleviating the traffic bottleneck common at the Canal bridges.

These auxiliary lanes are intended to reduce congestion and improve safety in the immediate area of the bridges but not result in a significant increase in the capacity of the overall Canal-area roadway system.

4.8 REGIONAL TRANSPORTATION ANALYSIS MODELING

The following sections describe the analysis conducted using the regional travel demand model to identify the most effective combination of transportation improvements in the study area.

As noted in Section 3.3.1, future no-build traffic conditions in the study area were forecast using a regional travel demand model (based on existing travel volumes and forecast socio-economic conditions in the study area). The maximum queuing and average delays for the future no-build, non-summer weekday and summer Saturday at Belmont Circle and Bourne Rotary are presented on Exhibit 3-18. Building on that data, the travel demand model was also used to test the effectiveness of transportation improvements in the study area.

The travel demand model provides a method for combining groups of transportation improvements (known as ‘cases’) to evaluate their effectiveness. Based on the 2040 traffic volumes presented in Chapter 3, the travel demand model also estimates potential shifts or diversions in travel patterns in the study area that may cause unforeseen traffic congestion in other locations. For example, improved roadway and bridge infrastructure may result in travelers diverting trips across the Canal from one bridge rather than the other.

This exercise enabled the understanding of the level of transportation improvements necessary to provide acceptable traffic operations in the study area for the 2040 non summer weekday PM period without overbuilding in a manner inconsistent with the character of Cape Cod.

The initial alternative screening analysis (described in Sections 4.5) was based on future no-build traffic volumes at specific locations. The travel demand model simulates traffic movements throughout the study area, assuming existing traffic patterns continue in the future. The model produces future traffic volumes at numerous locations throughout the study area for various daily time periods and time of year. Using these traffic volumes, further analysis is conducted using traffic analysis software including VISSIM™ and Synchro™ (as described in Section 2.5.5). As the travel demand model re assigns travel routes based on travel times, the volume of vehicles traveling through intersections in the study area often changes compared to the volumes used during the screening analysis, resulting in somewhat different results.

Seven cases were selected for analysis to provide logical and comprehensive groups of improvements. These seven cases, presented in the following sections, generally build upon one another with the first cases incorporating smaller intersection improvements and subsequent cases including an increasing number of transportation improvements. The nine different potential components of the travel demand model cases are listed on Table 4-31 and shown on Exhibit 4-28.

Table 4-31 Components of the Seven Travel Analysis Cases

MAP LOCATION	IMPROVEMENTS	CASE 1	CASE 1A	CASE 1B	CASE 2	CASE 2B	CASE 3	CASE 3A
A	Scenic Highway to Route 25 Westbound On-Ramp	*	*	*	*	*	*	*
B	Route 6 Exit 1C Relocation	*			*	*	*	*
C	Route 28 Northbound Ramp to Sandwich Road		*	*	*	*	*	
D	Bourne Rotary (3 New Signalized Intersections)			*	*	*	*	
E	Belmont Circle (3-Leg Roundabout plus Signalized Intersection)				*		*	*
F	Belmont Circle with Route 25 Eastbound Flyover					*		
G	Replacement Canal Bridges (Bourne and Sagamore)						*	*
H	Route 6 Eastbound Travel Lane from Exit 1A to Exit 2						*	*
I	Bourne Rotary with Highway Interchange							*

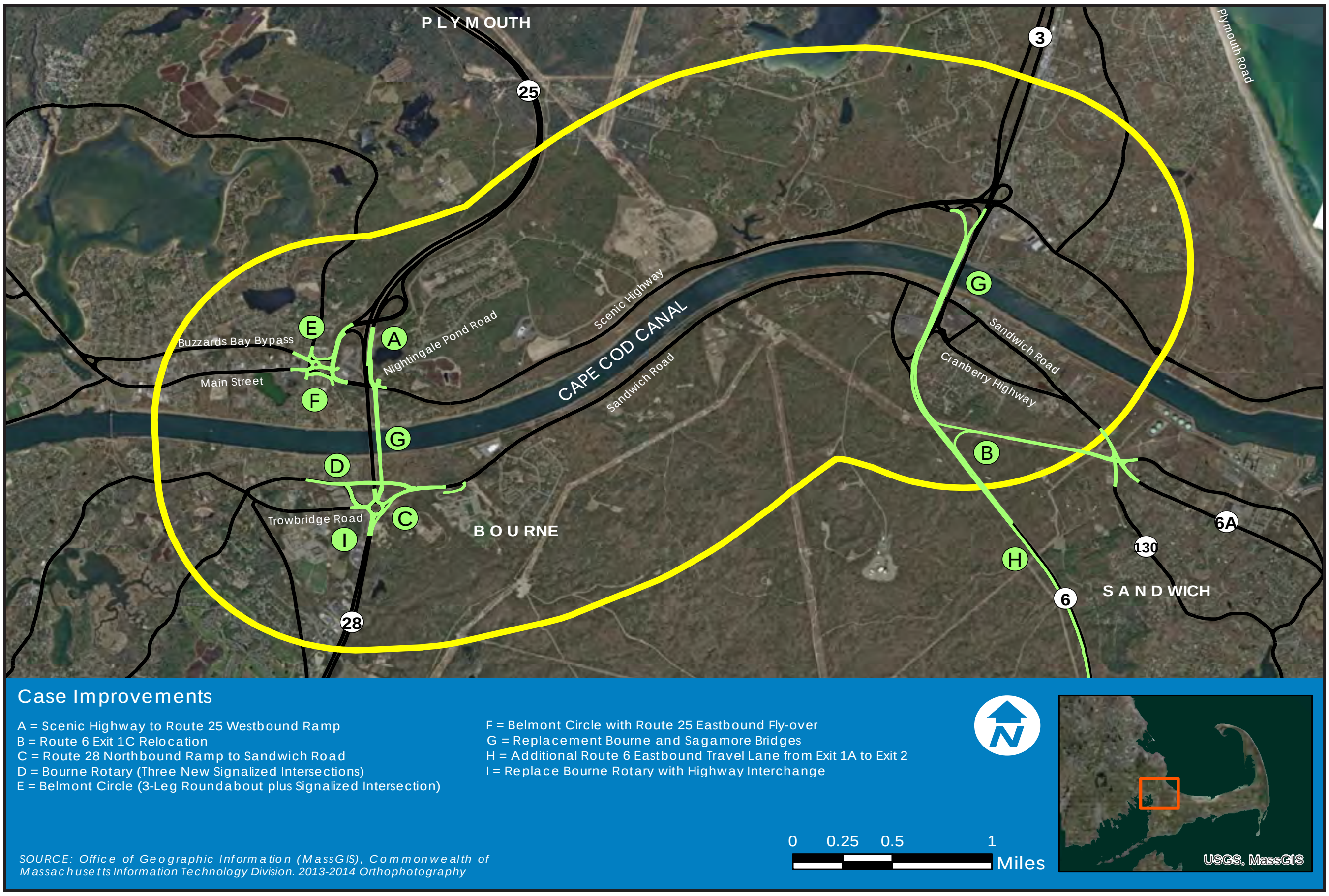
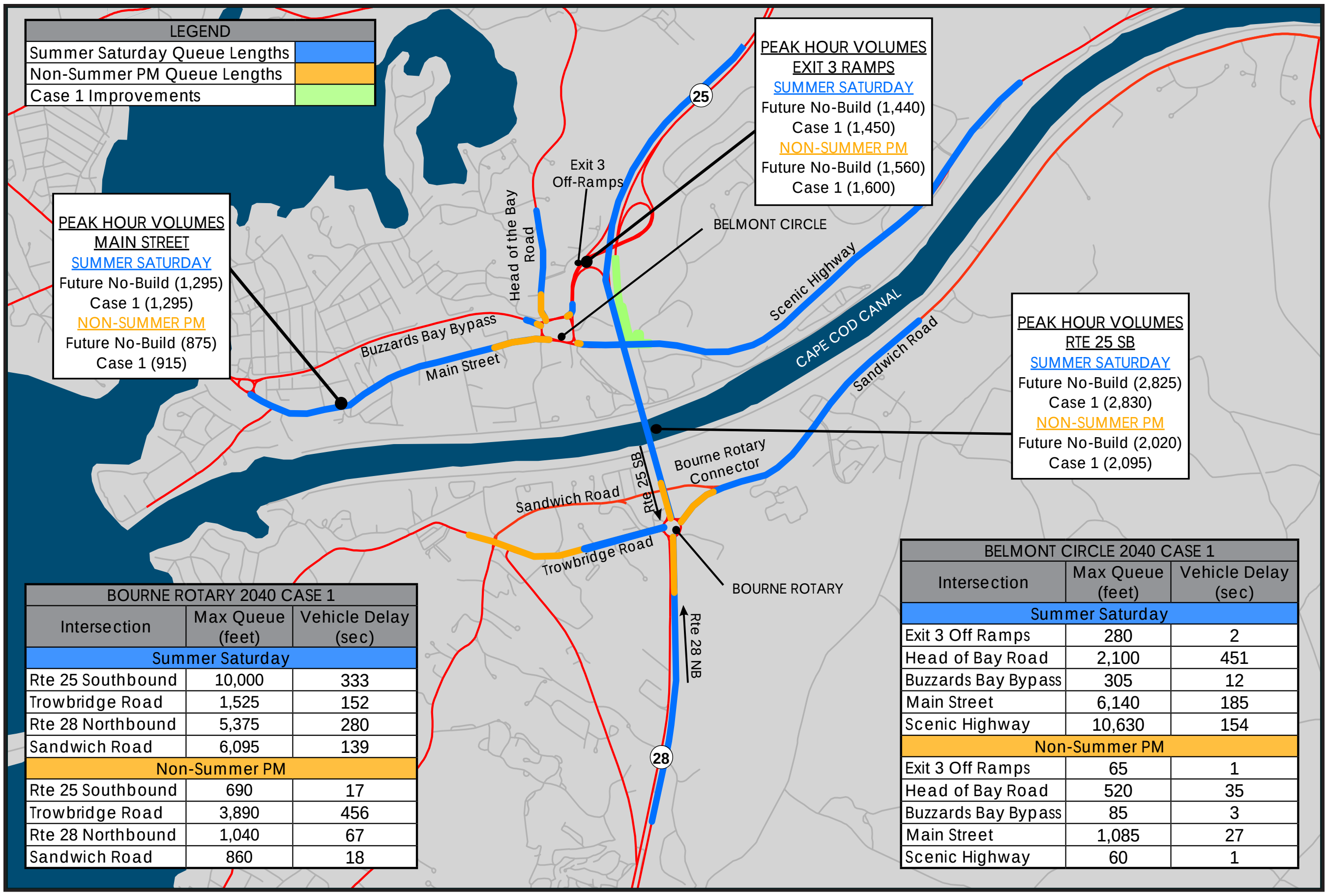


Exhibit 4-28 Location of Components of Travel Demand Model Cases

Cases 1, 1A, 1B, 2, and 2B were analyzed with the existing Canal bridges remaining in place as the improvements proposed under these cases could proceed as stand-alone projects without requiring any future action by the USACE. However, if the USACE proceeds with the replacement of the Canal bridges, these improvements, with modest modifications, would be compatible with the assumed location and layout of these replacement bridges. Cases 3 and 3A assume that replacement Canal bridges are in place.

The effectiveness of the following cases was determined by how they perform during the non-summer weekday PM (4:00 – 6:00 PM) and summer Saturday (10:00 AM – 12:00 PM) peak periods, when compared to the future no-build conditions at Belmont Circle and Bourne Rotary in terms of vehicle queuing, delays, and level of service.

Traffic conditions were also analyzed for the Route 3 southbound and Route 6 westbound approaches to the Sagamore Bridge (Exhibit 4-29). The results of this analysis are described in the following sections for Cases 1, 3, and 3A. A description of the results for Cases 1A and 1B are not provided as they effectively



BOURNE ROTARY 2040 CASE 1		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Rte 25 Southbound	10,000	333
Trowbridge Road	1,525	152
Rte 28 Northbound	5,375	280
Sandwich Road	6,095	139
Non-Summer PM		
Rte 25 Southbound	690	17
Trowbridge Road	3,890	456
Rte 28 Northbound	1,040	67
Sandwich Road	860	18

BELMONT CIRCLE 2040 CASE 1		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Exit 3 Off Ramps	280	2
Head of Bay Road	2,100	451
Buzzards Bay Bypass	305	12
Main Street	6,140	185
Scenic Highway	10,630	154
Non-Summer PM		
Exit 3 Off Ramps	65	1
Head of Bay Road	520	35
Buzzards Bay Bypass	85	3
Main Street	1,085	27
Scenic Highway	60	1

Exhibit 4-29 Case 1- Maximum Queue and Average Delay, Belmont Circle and Bourne Rotary

unchanged from the future no-build condition because these cases do not include improvements in the Sagamore Bridge area (such as the relocation of Route 6 Exit 1C or the addition of a travel lane of Route 6 eastbound). The results for Cases 2 and 2B are effectively the same as Case 1.

4.9 TRAVEL DEMAND MODEL – CASE ANALYSIS

The following sections describe the seven travel demand model cases evaluated and the findings of this analysis.

4.9.1 Case 1

Case 1 includes the evaluation of the following transportation improvements:

- Scenic Highway to Route 25 Westbound Entrance Ramp
- Route 6 – Relocation of Exit 1C

These two improvements were selected to be evaluated together as Case 1 because they are modestly-priced improvements that would improve peak period traffic operations in two of the most congested intersections in the study area, Belmont Circle and Bourne Rotary. They could both be built entirely within MassDOT right-of-way.

More detailed information is provided below on the forecast traffic operations under Case 1 at Belmont Circle and Bourne Rotary (also see Table 4-32 and Exhibit 4-29), and the Route 3 and Route 6 approaches to the Sagamore Bridge (Table 4-33 and Exhibit 4-30).

Belmont Circle

Result: Overall, Implementation of Case 1 would result in a modest improvement to traffic operations in Belmont Circle with more substantial improvement forecast during the non-summer weekday than the summer Saturday peak period.

Cause: The construction of a new Route 25 westbound entrance ramp (described in Section 4.6.4) would divert 1,340 of 1,705 vehicles during the non-summer weekday peak period that currently travel west on Scenic Highway and enter Belmont Circle to the new ramp. With fewer vehicles entering the Circle from Scenic Highway westbound, there would be a notable reduction in queuing at certain approaches to Belmont Circle, including the Route 25 Exit 3 ramp and Head of the Bay Road during both the non-summer weekday PM and summer Saturday peak periods. However, other approaches to Belmont Circle, including Scenic Highway, Buzzards Bay Bypass, and Main Street would not see a reduction in queuing and delays.

Bourne Rotary

Result: Traffic operations at the Bourne Rotary would not improve under Case 1 either in the non-summer weekday or summer Saturday peak periods. As shown in Table 4-32, some approaches would experience a reduction in queuing and related delays, while others may experience an increase in queuing and delays. Bourne Rotary would experience little improvement in traffic operations.

Cause: Roadway design at Bourne Rotary remains unchanged and there is no change in traffic volumes entering the Rotary.

Sagamore Bridge Approaches - Route 3 Southbound and Route 6 Westbound

Result: With the relocation of Route 6 Exit 1C, implementation of Case 1 would also affect traffic operations on the Route 3/Route 6 corridor. Queuing and delays are forecast to be substantially reduced for vehicles heading off-Cape on Route 6 westbound. Compared to the future no-build condition, during the summer

Table 4-32 *Case 1 - Future (2040) Traffic Operations, Belmont Circle and Bourne Rotary*

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS - BUILD CASE 1		
	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*
BELMONT CIRCLE									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Exit 3 Off Ramps SB	5	A	515	2	A	645	1	A	65
Head of Bay Rd SB	15	C	270	317 (5.28)	**F**	1,780	35	D	520
Buzzards Bay Bypass EB	3	A	100	3	A	110	3	A	85
Main Street EB	13	B	530	29	D	1,245	27	D	1,085
Scenic Highway WB	7	A	380	14	B	840	1	A	60
Intersection (Overall)	**8.6**	**A**		**73 (1.22)**	**F**		**13.4**	**B**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Exit 3 Off Ramps SB	4	A	510	3	A	1,025	2	A	280
Head of Bay Rd SB	83 (1.38)	**F**	570	656 (10.93)	**F**	2,700 (0.51)	451 (7.52)	**F**	2,100
Buzzards Bay Bypass EB	19	C	335	11	B	305	12	B	305
Main Street EB	82 (1.36)	**F**	5,755 (1.09)	126 (2.1)	**F**	6,140 (1.16)	185 (3.08)	**F**	6,140 (1.16)
Scenic Highway WB	125 (2.08)	**F**	10,605 (2.01)	161 (2.68)	**F**	11,610 (2.20)	154 (2.57)	**F**	10,630 (2.01)
Intersection (Overall)	**62.6 (1.04)**	**F**		**191.4 (3.19)**	**F**		**160.8 (2.68)**	**F**	
BOURNE ROTARY									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Route 25 SB	19	C	650	14	B	620	17	C	65
Trowbridge Rd EB	75 (1.25)	**F**	840	394 (6.57)	**F**	3,465 (0.66)	456 (7.6)	**F**	520
Route 28 NB	14	B	340	102 (1.7)	**F**	1,275	67 (1.12)	**F**	85
Sandwich Rd WB	20	C	1,530	19	C	855	18	C	1,085
Intersection (Overall)	**32**	**D**		**132.25 (2.20)**	**D**		**139.5 (2.33)**	**F**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Route 25 SB	280 (4.67)	**F**	8,885 (1.68)	329 (5.48)	**F**	9,935 (1.88)	333 (5.55)	**F**	10,000 (1.89)
Trowbridge Rd EB	30	D	335	265 (4.42)	**F**	2,225	152 (2.53)	**F**	1,525
Route 28 NB	301 (5.02)	**F**	4,135 (0.78)	189 (3.15)	**F**	3,605 (0.68)	280 (4.67)	**F**	5,375 (1.02)
Sandwich Rd WB	27	D	1475	135 (2.25)	**F**	6,430 (1.22)	139 (2.32)	**F**	6,095 (1.15)
Intersection (Overall)	**159.5 (2.66)**	**F**		**229.5 (3.83)**	**F**		**226 (3.77)**	**F**	

Notes:
*LOS E and LOS F movements are **bold***
EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

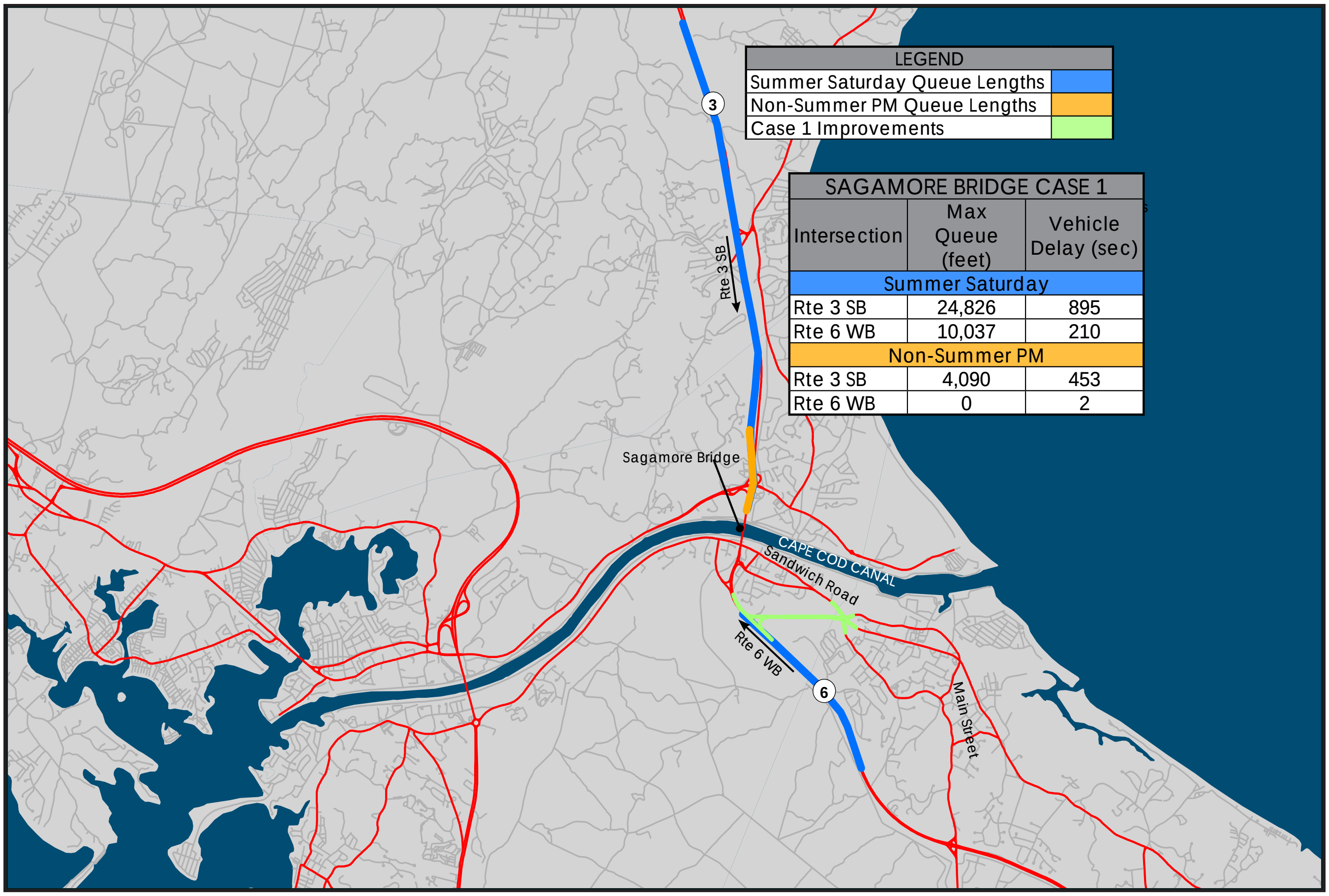


Exhibit 4-30 Case 1 - Maximum Queues and Average Delay, Sagamore Bridge Approaches

Table 4-33 Case 1 Traffic Operations, Sagamore Bridge Approaches

	EXISTING (2014) CONDITIONS				FUTURE (2040) NO-BUILD CONDITIONS				FUTURE (2040) BUILD CONDITIONS - BUILD CASE 1			
	AVERAGE DELAY *Sec (Min)*	LOS	AVERAGE QUEUE *Feet (Miles)*	MAXIMUM QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	AVERAGE QUEUE *Feet (Miles)*	MAXIMUM QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	AVERAGE QUEUE *Feet (Miles)*	MAXIMUM QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)												
Route 3 Southbound	11	B	77	478	460 (7.7)	F	7,481 (1.4)	8,476 (1.6)	453 (7.5)	F	3,534 (0.7)	4,090 (0.8)
Route 6 Westbound	5	A	53	232	178 (3.0)	F	6,801 (1.3)	7,967 (1.5)	2	A	0	0
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)												
Route 3 Southbound	416 (6.9)	F	4,823 (0.91)	5,393 (1.02)	887 (14.8)	F	22,814 (4.3)	24,484 (4.6)	895 (14.9)	F	23,308 (4.4)	24,826 (4.7)
Route 6 Westbound	683 (11.4)	F	23,318 (4.4)	25,014 (4.7)	812 (13.5)	F	24,825 (4.7)	25,029 (4.7)	210 (3.5)	F	7,253 (1.4)	10,037 (1.9)

Notes:
LOS = Level of Service
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

Saturday peak period, the maximum queue length is forecast to decline from approximately 4.7 miles to 1.9 miles (Table 4-33). Average delay during this same peak period would decrease from 13.5 minutes to 3.5 minutes. During the non-summer weekday period, in 2040 queuing and delays on Route 6 westbound would be eliminated, improving traffic conditions from LOS F to LOS A.

However, traffic queuing and delays on Route 3 southbound is not forecast to change compared to the future no-build condition because no roadway improvements are proposed that would change traffic conditions on Route 3 southbound. The result of the traffic analysis at the proposed roundabout at the Route 6 Exit 1C ramp at Route 6A and Route 130 is provided in Table 4-12 in Section 4.6.1.

Cause: The longer acceleration and deceleration lanes associated with the relocated Exit 1C and the greater distance from the Sagamore Bridge approach both contribute to reduced turbulence along Route 6 westbound.

4.9.2 Case 1A

Case 1A includes the following transportation improvements:

- Scenic Highway to Route 25 Westbound Entrance Ramp
- Route 28 Northbound Ramp to Sandwich Road (at Bourne Rotary)

Case 1A represents two transportation improvements with modest cost and limited environmental permitting requirements based on conceptual design completed for this study. This case assumes that the improvement at the intersection of Sandwich Road at Bourne Rotary Connector (including the relocation of the Technical High School driveway) has been implemented. More detailed information on the forecast traffic operations under Case 1A at Belmont Circle and Bourne Rotary is provided below (also see Table 4-34 and Exhibit 4-31).

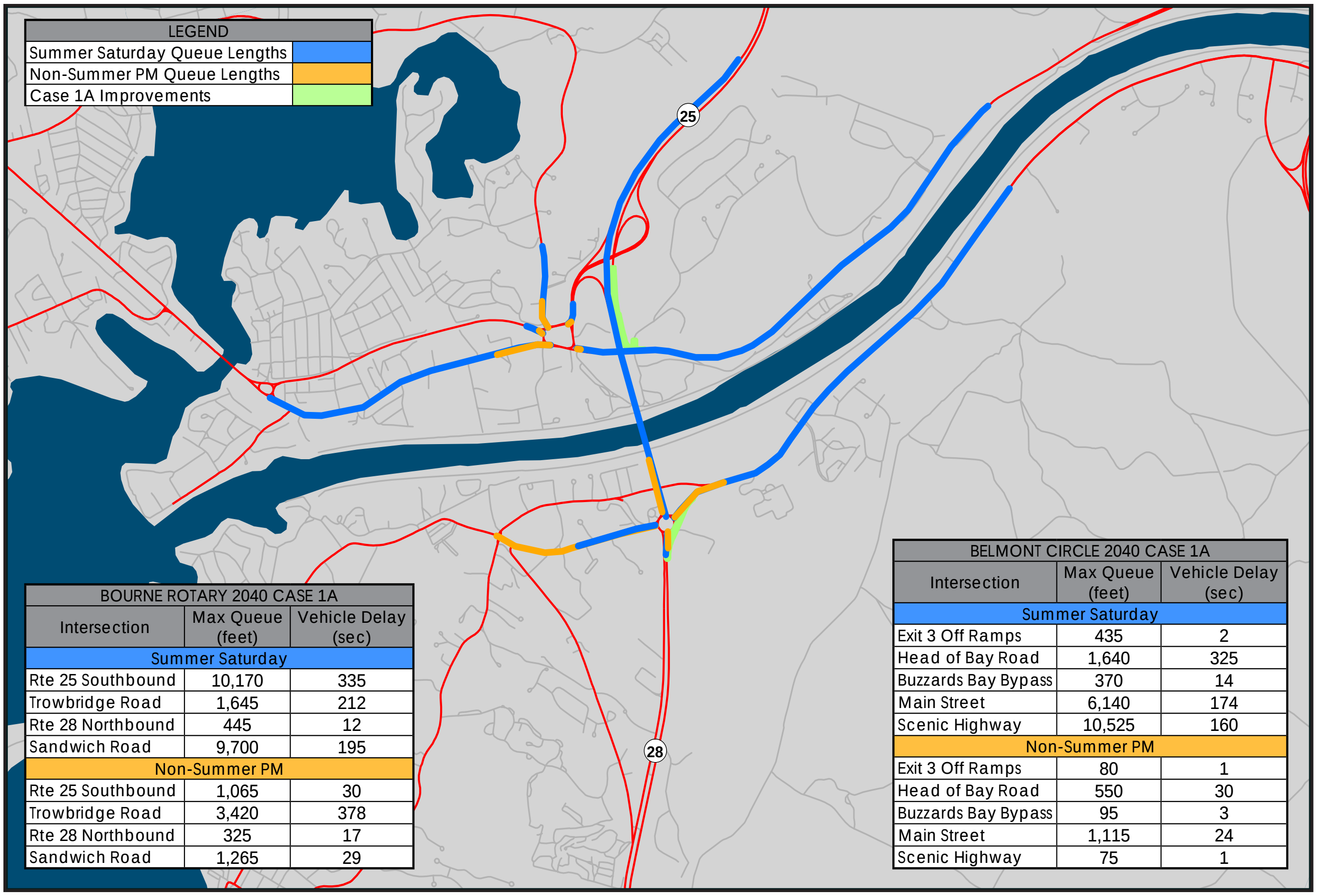
Belmont Circle

Result: Overall, the implementation of the Case 1A improvements would result in a moderate improvement in traffic operations at Belmont Circle with more substantial improvement forecast during the non-summer weekday than the summer Saturday peak period when comparing the future no-build condition to the build condition. Greater reductions in queues are forecast at the Route 25 off-ramps and Head of the Bay Road approach to the Circle but little improvement at the other approaches to the Circle, including Scenic Highway, Buzzards Bay Bypass, and Main Street.

Table 4-34 Case 1A - Future (2040) Traffic Operations, Belmont Circle and Bourne Rotary

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS - BUILD CASE 1A		
	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*
BELMONT CIRCLE									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Exit 3 Off Ramps SB	5	A	515	2	A	645	1	A	80
Head of Bay Rd SB	15	C	270	317 (5.28)	**F**	1,780	30	D	550
Buzzards Bay Bypass EB	3	A	100	3	A	110	3	A	95
Main Street EB	13	B	530	29	D	1,245	24	C	1,115
Scenic Highway WB	7	A	380	14	B	840	1	A	75
Intersection (Overall)	**8.6**	**A**		**73 (1.22)**	**F**		**11.8**	**B**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Exit 3 Off Ramps SB	4	A	510	3	A	1,025	2	A	435
Head of Bay Rd SB	83 (1.38)	**F**	570	656 (10.93)	**F**	2,700 (0.51)	337 (5.62)	F	1,640
Buzzards Bay Bypass EB	19	C	335	11	B	305	14	B	370
Main Street EB	82 (1.36)	**F**	5,755 (1.09)	126 (2.1)	**F**	6,140 (1.16)	172 (2.87)	F	6,140 (1.16)
Scenic Highway WB	125 (2.08)	**F**	10,605 (2.01)	161 (2.68)	**F**	11,610 (2.20)	154 (2.57)	F	10,525 (1.99)
Intersection (Overall)	**62.6 (1.04)**	**F**		**191.4 (3.19)**	**F**		**135.8 (2.26)**	**F**	
BOURNE ROTARY									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Route 25 SB	19	C	650	14	B	620	30	D	1,065
Trowbridge Rd EB	75 (1.25)	**F**	840	394 (6.57)	**F**	3,465 (0.66)	378 (6.3)	F	3,420 (0.65)
Route 28 NB	14	B	340	102 (1.7)	**F**	1,275	17	C	325
Sandwich Rd WB	20	C	1,530	19	C	855	29	D	1,265
Intersection (Overall)	**32**	**D**		**132.25 (2.20)**	**D**		**113.5 (1.89)**	**F**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Route 25 SB	280 (4.67)	**F**	8,885 (1.68)	329 (5.48)	**F**	9,935 (1.88)	337 (5.62)	F	10,170 (1.93)
Trowbridge Rd EB	30	D	335	265 (4.42)	**F**	2,225	213 (3.55)	F	1,645
Route 28 NB	301 (5.02)	**F**	4,135 (0.78)	189 (3.15)	**F**	3,605 (0.68)	13	B	445
Sandwich Rd WB	27	D	1,475	135 (2.25)	**F**	6,430 (1.22)	198 (3.3)	F	9,700 (1.84)
Intersection (Overall)	**159.5 (2.66)**	**F**		**229.5 (3.83)**	**F**		**190.25 (3.17)**	**F**	

Notes:
*LOS E and LOS F locations are **bold***
EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.



BOURNE ROTARY 2040 CASE 1A		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Rte 25 Southbound	10,170	335
Trowbridge Road	1,645	212
Rte 28 Northbound	445	12
Sandwich Road	9,700	195
Non-Summer PM		
Rte 25 Southbound	1,065	30
Trowbridge Road	3,420	378
Rte 28 Northbound	325	17
Sandwich Road	1,265	29

BELMONT CIRCLE 2040 CASE 1A		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Exit 3 Off Ramps	435	2
Head of Bay Road	1,640	325
Buzzards Bay Bypass	370	14
Main Street	6,140	174
Scenic Highway	10,525	160
Non-Summer PM		
Exit 3 Off Ramps	80	1
Head of Bay Road	550	30
Buzzards Bay Bypass	95	3
Main Street	1,115	24
Scenic Highway	75	1

Exhibit 4-31 Case 1A - Maximum Queue and Average Delay, Belmont Circle and Bourne Rotary

Cause: The construction of a new Route 25 westbound entrance ramp would divert 1,310 of 1,735 vehicles during the non-summer weekday peak period to the ramp that currently travel west on Scenic Highway and enter Belmont Circle. With fewer vehicles entering the Circle from Scenic Highway westbound, there would be a notable reduction in queuing at certain approaches to Belmont Circle, including the Route 25 Exit 3 off-ramp and Head of the Bay Road during both the non-summer weekday and summer Saturday peak periods. However, other approaches to Belmont Circle, including Scenic Highway, Buzzards Bay Bypass, and Main Street would not see a reduction in queues and delay substantial traffic volumes would continue to enter the Circle from those approaches.

Bourne Rotary

Result: Overall, traffic operations at the Bourne Rotary would improve moderately under Case 1A compared to the future no-build condition. Route 28 northbound is the only approach that is forecast to experience a substantial reduction in delay, especially during the summer Saturday peak period. Delay at all other approaches would remain approximately the same as the future no-build condition during both the non-summer weekday and summer Saturday peak periods.

Cause: The new Route 28 northbound ramp to Sandwich Road reduces delay on the Route 28 northbound approach to the Bourne Rotary. During the summer Saturday peak period, maximum queues are forecast to drop from over 3,600 feet to 445 feet, with a corresponding reduction in average delay from 3.1 minutes to 13 seconds. The results for the other approaches during the summer Saturday peak period would be mixed, with some delays increasing and others decreasing. Compared to the future no-build condition, the maximum queue on the Sandwich Road westbound approach to the Bourne Rotary would increase from 6,430 feet to 9,700 feet while the Trowbridge Road approach would decrease from 2,225 feet to 1,645 feet.

Sagamore Bridge Approaches - Route 3 Southbound and Route 6 Westbound

As shown on Exhibit 4-39, under Case 1A travel conditions on the approaches to the Sagamore Bridge would be effectively unchanged for the future no-build condition during both the non-summer weekday PM and summer Saturday peak periods. Because these cases do not include improvements in the Sagamore Bridge area (including the relocation of Route 6 Exit 1C or the addition of a travel lane of Route 6 eastbound).

4.9.3 Case 1B

Case 1B includes the following transportation improvements:

- Scenic Highway to Route 25 Westbound Ramp
- Route 28 Northbound Ramp to Sandwich Road (at Bourne Rotary)
- Bourne Rotary Reconstruction (Alternative 2 - Three Signalized Intersections)

Case 1B includes a highway entrance ramp from Scenic Highway westbound to Route 25 westbound, a ramp from Route 28 northbound to Sandwich Road, and the full reconstruction of the Bourne Rotary, including three new signalized intersections in the immediate are of the Rotary. This case represents a potential interim condition if the Bourne Rotary reconstruction were to be completed prior to the Belmont Circle reconstruction.

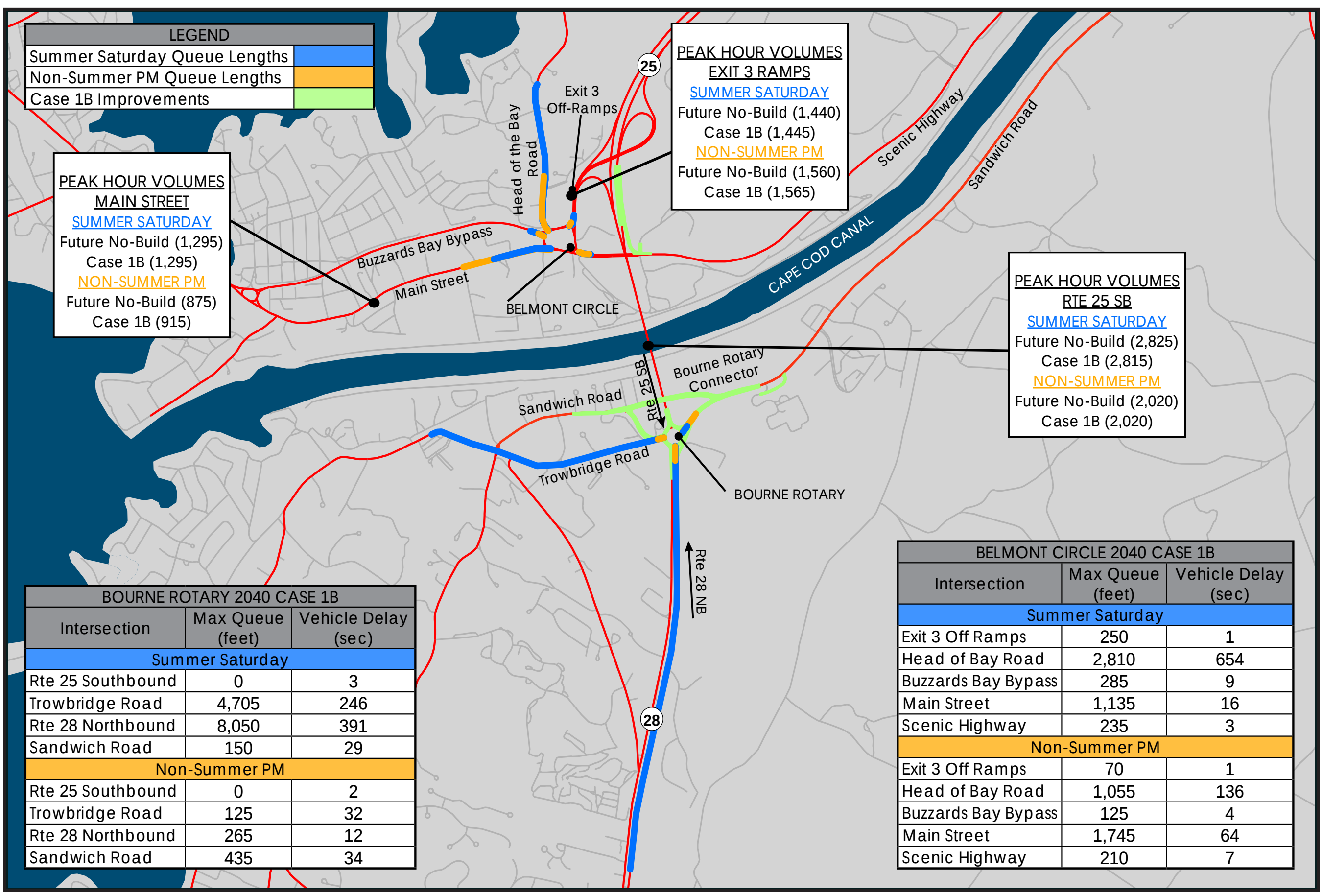
The reconstruction of Bourne Rotary prior to Belmont Circle would be desirable because of the proximity of Belmont Circle and Bourne Rotary to one another. Improvements to Bourne Rotary - particularly at the Route 25 southbound approach - are required for improvements at Belmont Circle to be effective because of queuing on the Route 25 southbound approach to the Bourne Rotary. During the summer Saturday peak period, these queues extend nearly 9,000 feet, delaying vehicles trying to exit Route 25 to Belmont Circle. More detailed information is provided below on the forecast traffic operation at Belmont Circle and Bourne Rotary (also see Table 4-35 and Exhibit 4-32).

Belmont Circle

Result: Overall, Case 1B would result in a moderate improvement in traffic operations at Belmont Circle. The results for the non-summer weekday and summer Saturday peak periods are inconsistent, with the most pronounced delay reductions forecast on the Main Street and Scenic Highway approaches during the summer Saturday peak period. During the non-summer weekday peak period, Head of the Bay Road is forecast to experience the greatest delay reductions.

Cause: With the Scenic Highway westbound to Route 25 westbound ramp as the only roadway improvements to be implemented at Belmont Circle under Case 1B, traffic operations in Belmont Circle would only moderately improve compared to the future no-build condition.

Exhibit 4-32 Case 1B - Maximum Queue and Average Delay, Belmont Circle and Bourne Rotary



BOURNE ROTARY 2040 CASE 1B		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Rte 25 Southbound	0	3
Trowbridge Road	4,705	246
Rte 28 Northbound	8,050	391
Sandwich Road	150	29
Non-Summer PM		
Rte 25 Southbound	0	2
Trowbridge Road	125	32
Rte 28 Northbound	265	12
Sandwich Road	435	34

BELMONT CIRCLE 2040 CASE 1B		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Exit 3 Off Ramps	250	1
Head of Bay Road	2,810	654
Buzzards Bay Bypass	285	9
Main Street	1,135	16
Scenic Highway	235	3
Non-Summer PM		
Exit 3 Off Ramps	70	1
Head of Bay Road	1,055	136
Buzzards Bay Bypass	125	4
Main Street	1,745	64
Scenic Highway	210	7

Table 4-35 Case 1B - Future (2040) Traffic Operations, Belmont Circle and Bourne Rotary

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS - BUILD CASE 1B		
	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*
BELMONT CIRCLE									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Exit 3 Off Ramps SB	5	A	515	2	A	645	1	A	70
Head of Bay Rd SB	15	C	270	317 (5.28)	**F**	1,780	142 (2.37)	**F**	1,055
Buzzards Bay Bypass EB	3	A	100	3	A	110	3	A	125
Main Street EB	13	B	530	29	D	1,245	61 (1.02)	**F**	1,745
Scenic Highway WB	7	A	380	14	B	840	7	A	210
Intersection (Overall)	**8.6**	**A**		**73 (1.22)**	**F**		**42.8**	**E**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Exit 3 Off Ramps SB	4	A	510	3	A	1,025	2	A	250
Head of Bay Rd SB	83 (1.38)	**F**	570	656 (10.93)	**F**	2,700 (0.51)	622 (10.37)	**F**	2,810 (0.53)
Buzzards Bay Bypass EB	19	C	335	11	B	305	9	A	285
Main Street EB	82 (1.36)	**F**	5,755 (1.09)	126 (2.1)	**F**	6,140 (1.16)	17	C	1,135
Scenic Highway WB	125 (2.08)	**F**	10,605 (2.01)	161 (2.68)	**F**	11,610 (2.20)	3	A	235
Intersection (Overall)	**62.6 (1.04)**	**F**		**191.4 (3.19)**	**F**		**130.6 (2.18)**	**F**	
BOURNE ROTARY									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Route 25 SB	19	C	650	14	B	620	2	A	0
Trowbridge Rd EB	75 (1.25)	**F**	840	394 (6.57)	**F**	3,465 (0.66)	33	D	125
Route 28 NB	14	B	340	102 (1.7)	**F**	1,275	13	B	265
Sandwich Rd WB	20	C	1,530	19	C	855	32	D	435
Intersection (Overall)	**32**	**D**		**132.25 (2.20)**	**D**		**20**	**C**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Route 25 SB	280 (4.67)	**F**	8,885 (1.68)	329 (5.48)	**F**	9,935 (1.88)	3	A	0
Trowbridge Rd EB	30	D	335	265 (4.42)	**F**	2,225	249 (4.15)	F	4,705 (0.89)
Route 28 NB	301 (5.02)	F	4,135 (0.78)	189 (3.15)	F	3,605 (0.68)	409 (6.82)	F	8,050 (1.52)
Sandwich Rd WB	27	D	1475	135 (2.25)	**F**	6,430 (1.22)	24	C	150
Intersection (Overall)	**159.5 (2.66)**	**F**		**229.5 (3.83)**	**F**		**171.25 (2.85)**	**F**	

Notes:
*LOS E and LOS F movements are **bold***
EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

During the summer Saturday peak period, queuing and delays would decrease substantially on the Scenic Highway and Main Street approaches, while remaining about the same on the other approaches to Belmont Circle. With a forecast delay of over 11 minutes during the summer Saturday peak period (similar to the future no-build condition), the Head of the Bay Road approach would continue to be the most problematic approach. This is likely travelers bypassing Route 25 or Route 6 in Wareham and approaching Belmont Circle from Head of the Bay Road.

Bourne Rotary

Result: Overall, traffic operations at the Bourne Rotary would improve substantially under Case 1B compared to the future no-build condition. More substantial improvement is forecast during the non-summer weekday peak period than the summer Saturday period. During the summer Saturday peak period, approaches to the Bourne Rotary that would continue to experience considerable delay include Trowbridge Road and Route 28 northbound.

Cause: Improvements at Bourne Rotary include modifications that would not allow traffic to cross over the north side of the Rotary. This action would allow traffic from the Route 25 southbound approach to enter freely without having to contend with traffic coming from the east side of the Rotary. This would eliminate both the non-summer weekday and non-summer Saturday peak period delays from the Route 25 southbound approach.

However, the current configuration, having vehicles circulate counter-clockwise around the Rotary results in regular gaps in the rotary traffic for vehicles entering from all approaches. Not allowing traffic to cross the top of the Rotary would result in fewer gaps for traffic entering from Trowbridge Road and Route 28 northbound, resulting in continued extended queues from those approaches during the summer Saturday peak period.

Sagamore Bridge Approaches – Route 3 Southbound and Route 6 Westbound

As shown on Exhibit 4-39, under Case 1B travel conditions on the approaches to the Sagamore Bridge would be effectively unchanged for the future no-build condition during both the non-summer weekday PM and summer Saturday peak periods. Because these cases do not include improvements in the Sagamore Bridge area (including the relocation of Route 6 Exit 1C or the addition of a travel lane of Route 6 eastbound).

4.9.4 Case 2

Case 2 includes the following transportation improvements:

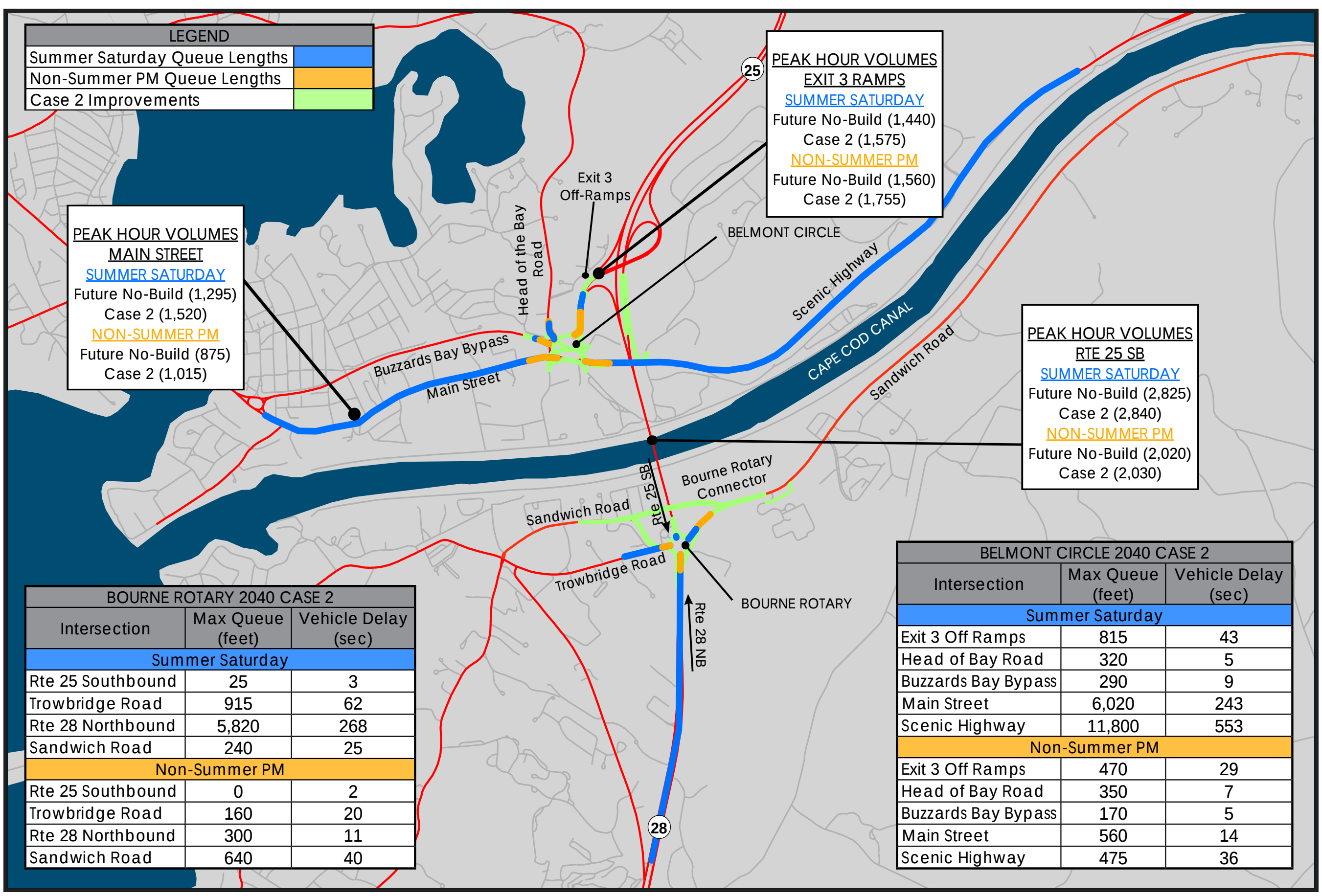
- Scenic Highway to Route 25 Westbound Ramp
- Route 6 – Relocation of Exit 1C
- Belmont Circle Reconstruction (Alternative 1 – Four-Leg Roundabout and Signalized Intersection)
- Bourne Rotary Reconstruction (Alternative 2 – Three Signalized Intersections)

This case represents the implementation of all suggested transportation improvements, prior to the assumed replacement of the Bourne and Sagamore Bridges (although these improvements would also be compatible with replacement Canal bridges). More detailed information is provided below on the forecast traffic operation at Belmont Circle and Bourne Rotary (also see Table 4-36 and Exhibit 4-33).

Belmont Circle

Result: Overall, implementing the Case 2 improvements would modestly improve traffic operations at Belmont Circle compared to the future no-build condition. More substantial reduction

Exhibit 4-33 Case 2 - Maximum Queue and Average Delay, Belmont Circle and Bourne Rotary



BOURNE ROTARY 2040 CASE 2		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Rte 25 Southbound	25	3
Trowbridge Road	915	62
Rte 28 Northbound	5,820	268
Sandwich Road	240	25
Non-Summer PM		
Rte 25 Southbound	0	2
Trowbridge Road	160	20
Rte 28 Northbound	300	11
Sandwich Road	640	40

BELMONT CIRCLE 2040 CASE 2		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Exit 3 Off Ramps	815	43
Head of Bay Road	320	5
Buzzards Bay Bypass	290	9
Main Street	6,020	243
Scenic Highway	11,800	553
Non-Summer PM		
Exit 3 Off Ramps	470	29
Head of Bay Road	350	7
Buzzards Bay Bypass	170	5
Main Street	560	14
Scenic Highway	475	36

Table 4-36 Case 2 - Future (2040) Traffic Operations, Belmont Circle and Bourne Rotary

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS - BUILD CASE 2		
	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*
BELMONT CIRCLE									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Exit 3 Off Ramps SB	5	A	515	2	A	645	29	D	470
Head of Bay Rd SB	15	C	270	317 (5.28)	**F**	1,780	7	A	350
Buzzards Bay Bypass EB	3	A	100	3	A	110	5	A	170
Main Street EB	13	B	530	29	D	1,245	14	B	560
Scenic Highway WB	7	A	380	14	B	840	36	**E**	475
Intersection (Overall)	**8.6**	**A**		**73 (1.22)**	**F**		**18.2**	**C**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Exit 3 Off Ramps SB	4	A	510	3	A	1,025	43	E	815
Head of Bay Rd SB	83 (1.38)	**F**	570	656 (10.93)	**F**	2,700 (0.51)	5	A	320
Buzzards Bay Bypass EB	19	C	335	11	B	305	9	A	290
Main Street EB	82 (1.36)	**F**	5,755 (1.09)	126 (2.1)	**F**	6,140 (1.16)	243 (4.05)	**F**	6,020 (1.14)
Scenic Highway WB	125 (2.08)	**F**	10,605 (2.01)	161 (2.68)	**F**	11,610 (2.20)	553 (9.22)	**F**	11,800 (2.23)
Intersection (Overall)	**62.6 (1.04)**	**F**		**191.4 (3.19)**	**F**		**170.6 (2.84)**	**F**	
BOURNE ROTARY									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Route 25 SB	19	C	650	14	B	620	2	A	0
Trowbridge Rd EB	75 (1.25)	**F**	840	394 (6.57)	**F**	3,465 (0.66)	20	C	160
Route 28 NB	14	B	340	102 (1.7)	**F**	1,275	11	B	300
Sandwich Rd WB	20	C	1,530	19	C	855	40	E	640
Intersection (Overall)	**32**	**D**		**132.25 (2.20)**	**D**		**18.25**	**B**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Route 25 SB	280 (4.67)	**F**	8,885 (1.68)	329 (5.48)	**F**	9,935 (1.88)	3	A	25
Trowbridge Rd EB	30	D	335	265 (4.42)	**F**	2,225	62 (1.03)	**F**	915
Route 28 NB	301 (5.02)	**F**	4,135 (0.78)	189 (3.15)	**F**	3,605 (0.68)	268 (4.47)	**F**	5,820 (1.10)
Sandwich Rd WB	27	D	1,475	135 (2.25)	**F**	6,430 (1.22)	25	D	240
Intersection (Overall)	**159.5 (2.66)**	**F**		**229.5 (3.83)**	**F**		**89.5 (1.49)**	**F**	

Notes:
*LOS E and LOS F movements are **bold***
EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

in queuing and delays would occur during the non-summer weekday than the summer Saturday peak period at both locations.

Cause: Traffic operations substantially improve under Case 2 compared to the future no-build condition during the non-summer weekday peak period. Compared to the future no-build condition, the average delay on the Head of the Bay Road approach would decrease from 317 seconds to seven seconds during the non-summer weekday peak period and from 656 seconds to five seconds during the summer Saturday peak period. All other approaches to Belmont Circle during the non-summer weekday peak period are modest (less than 30 seconds) for the future no-build condition and would remain so under Case 2.

During the summer Saturday peak period, extended queuing would persist at the Main Street and Scenic Highway approaches. The persistent queuing and delays on Main Street can be partly attributed to the increased traffic volumes of regional travelers and local residents accessing the numerous business on Main Street. During the summer Saturday peak period, traffic volumes increase 16%, from 1,295 to 1,520 vehicles per hour. As additional improvements are implemented, travelers who may have avoided Belmont Circle because of the delay, are forecast to more frequently use Main Street to access Belmont Circle.

Bourne Rotary

Result: Traffic operations at Bourne Rotary under Case 2 would substantially improve during the non-summer weekday peak period compared to the future no-build condition. Average delay would be less than one minute at all approaches during both the non-summer weekday and summer Saturday peak periods except for Trowbridge Road (62 seconds) and Route 28 northbound (4.5 minutes). These two approaches would continue to experience LOS F conditions during the summer Saturday peak period.

Cause: The new configuration of the Bourne Rotary – which doesn’t allow traffic to cross over the north side of the Rotary – is forecast to improve overall traffic operations, especially during the non-summer weekday period. However, this configuration results in fewer gaps for vehicles trying to enter the Rotary from Route 28 northbound, preventing delay reductions at that approach.

Sagamore Bridge Approaches – Route 3 Southbound and Route 6 Westbound

As shown on Exhibit 4-39, under Case 2 travel conditions on the approaches to the Sagamore Bridge would be effectively the same as Case 1 for the future no-build condition during both the non-summer weekday PM and summer Saturday peak periods. Because these cases do not include improvements in the Sagamore Bridge area (including the relocation of Route 6 Exit 1C or the addition of a travel lane of Route 6 eastbound).

4.9.5 Case 2B

Case 2B includes the following transportation improvements:

- Scenic Highway to Route 25 Westbound Ramp
- Route 6 – Relocation of Exit 1C
- Belmont Circle Reconstruction (Alternative 1A – Four-Leg Roundabout with Route 25 Flyover to Scenic Highway Eastbound)
- Bourne Rotary Reconstruction (Alternative 2 – Three Signalized Intersections)

Under Case 2A, a flyover ramp would allow traffic from Route 25 Exit 3 to bypass the signalized intersection on the east side of Belmont Circle and merge directly onto Scenic Highway. All improvements included in Case 2B would be implemented prior to the assumed replacement of the Bourne and Sagamore Bridges.

More detailed information is provided below on the forecast traffic operation at Belmont Circle and Bourne Rotary (also see Table 4-37 and Exhibit 4-34).

Belmont Circle

Result: Overall, Case 2B would result in substantially reduced queuing and delays in Belmont Circle during the non-summer weekday period with delay at all approaches less than 10 seconds, except Scenic Highway, which would only be 16 seconds. However, during the summer Saturday peak period extended queues are forecast at several approaches, including Head of the Bay Road and Buzzards Bay Bypass.

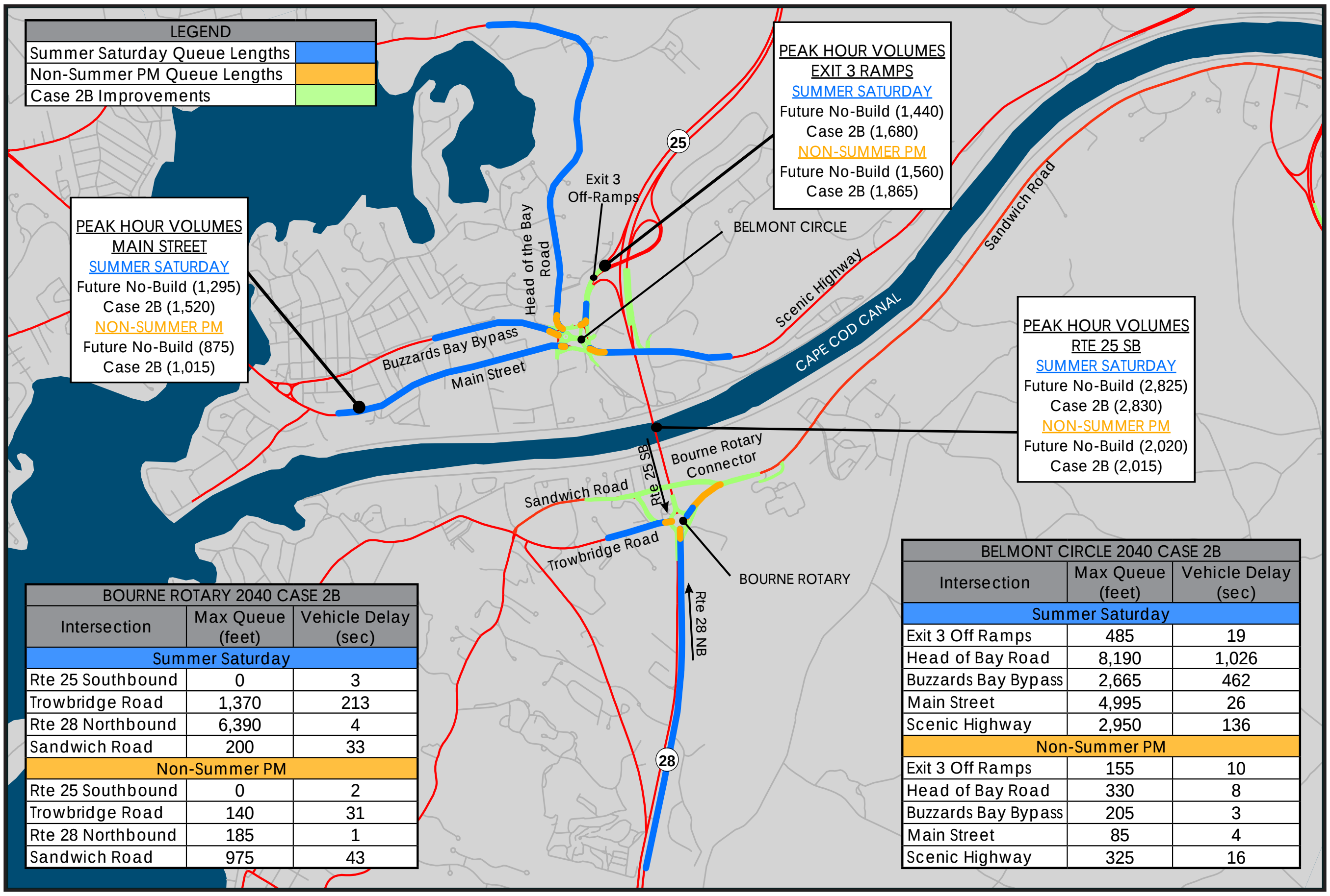
The new flyover ramp from Route 25 to Scenic Highway westbound would reduce queuing and delays at Belmont Circle, resulting in only minor delay (3-16 seconds) during the non-summer weekday peak period. However, traffic conditions during the summer Saturday peak period would be worse than the forecast future no-build conditions with extended queuing and delays at the Head of the Bay Road (15.5-minute delay) and the Buzzards Bay Bypass (7.5-minute delay).

Cause: The more freely flowing traffic entering the new roundabout from the Route 25 Exit 3 exit ramp results in fewer gaps between vehicles in the roundabout. This increases the difficulty for vehicles trying to enter from other approaches,

Table 4-37 Case 2B - Future (2040) Traffic Operations, Belmont Circle and Bourne Rotary

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS - BUILD CASE 2B		
	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*
BELMONT CIRCLE									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Exit 3 Off Ramps SB	5	A	515	2	A	645	9	A	155
Head of Bay Rd SB	15	C	270	317 (5.28)	**F**	1,780	8	A	330
Buzzards Bay Bypass EB	3	A	100	3	A	110	3	A	205
Main Street EB	13	B	530	29	D	1,245	4	A	85
Scenic Highway WB	7	A	380	14	B	840	16	C	325
Intersection (Overall)	**8.6**	**A**		**73 (1.22)**	**F**		**8**	**A**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Exit 3 Off Ramps SB	4	A	510	3	A	1,025	18	C	485
Head of Bay Rd SB	83 (1.38)	**F**	570	656 (10.93)	**F**	2,700 (0.51)	940 (15.67)	**F**	8,190 (1.55)
Buzzards Bay Bypass EB	19	C	335	11	B	305	446 (7.43)	**F**	2,665 (0.50)
Main Street EB	82 (1.36)	**F**	5,755 (1.09)	126 (2.1)	**F**	6,140 (1.16)	45	**E**	4,995 (0.94)
Scenic Highway WB	125 (2.08)	**F**	10,605 (2.01)	161 (2.68)	**F**	11,610 (2.20)	147 (2.45)	**F**	2,950 (0.56)
Intersection (Overall)	**62.6 (1.04)**	**F**		**191.4 (3.19)**	**F**		**319.2 (5.32)**	**F**	
BOURNE ROTARY									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Route 25 SB	19	C	650	14	B	620	2	A	0
Trowbridge Rd EB	75 (1.25)	**F**	840	394 (6.57)	**F**	3,465 (0.66)	17	C	140
Route 28 NB	14	B	340	102 (1.7)	**F**	1,275	7	A	185
Sandwich Rd WB	20	C	1,530	19	C	855	49	**E**	975
Intersection (Overall)	**32**	**D**		**132.25 (2.20)**	**D**		**18.75**	**C**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Route 25 SB	280 (4.67)	**F**	8,885 (1.68)	329 (5.48)	**F**	9,935 (1.88)	3	A	0
Trowbridge Rd EB	30	D	335	265 (4.42)	**F**	2,225	136 (2.27)	**F**	1370
Route 28 NB	301 (5.02)	**F**	4,135 (0.78)	189 (3.15)	**F**	3,605 (0.68)	344 (5.73)	**F**	6,930 (1.31)
Sandwich Rd WB	27	D	1,475	135 (2.25)	**F**	6,430 (1.22)	24	C	200
Intersection (Overall)	**159.5 (2.66)**	**F**		**229.5 (3.83)**	**F**		**126.75 (2.11)**	**F**	

Notes:
LOS E and LOS F movements are ***bold***
EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.



BOURNE ROTARY 2040 CASE 2B		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Rte 25 Southbound	0	3
Trowbridge Road	1,370	213
Rte 28 Northbound	6,390	4
Sandwich Road	200	33
Non-Summer PM		
Rte 25 Southbound	0	2
Trowbridge Road	140	31
Rte 28 Northbound	185	1
Sandwich Road	975	43

BELMONT CIRCLE 2040 CASE 2B		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Exit 3 Off Ramps	485	19
Head of Bay Road	8,190	1,026
Buzzards Bay Bypass	2,665	462
Main Street	4,995	26
Scenic Highway	2,950	136
Non-Summer PM		
Exit 3 Off Ramps	155	10
Head of Bay Road	330	8
Buzzards Bay Bypass	205	3
Main Street	85	4
Scenic Highway	325	16

Exhibit 4-34 Case 2B - Maximum Queue and Average Delay, Belmont Circle and Bourne Rotary

particularly the Head of the Bay Road and Main Street approaches.

As noted under Case 2, a contributing factor in the poor traffic conditions at Belmont Circle during the summer Saturday peak period includes the diversion of additional traffic to the Bourne Bridge area as overall traffic conditions in this area improve. The persistent queuing and delays on Main Street can be partly attributed to the increased traffic volumes. During the summer Saturday peak period, traffic volumes increase from 1,295 to 1,520 vehicles per hour.

Bourne Rotary

Result: Traffic operations at Bourne Rotary under Case 2B would substantially improve during the non-summer weekday peak period compared to the future no-build condition. Average delay would be less than one minute at all approaches during both the non-summer weekday and non-summer Saturday peak periods except for Trowbridge Road (2.2 minutes) and Route 28 northbound (5.7 minutes). These two approaches would continue to experience LOS F conditions during the summer Saturday peak period.

Cause: The new configuration of the Bourne Rotary which would not allow traffic to cross over the north side of the Rotary would allow increased traffic flow from Route 28 southbound. This improves overall traffic operations, especially during the non-summer weekday peak period. However, during the summer Saturday peak period, this configuration results in fewer gaps for vehicles trying to enter the Rotary from Trowbridge Road and Route 28 northbound, preventing delay reductions at those approaches.

Sagamore Bridge Approaches – Route 3 Southbound and Route 6 Westbound

As shown on Exhibit 4-39, under Case 2B travel conditions on the approaches to the Sagamore Bridge would be effectively the same as Case 1 for the future no-build condition during both the non-summer weekday PM and summer Saturday peak periods. Because these cases do not include improvements in the Sagamore Bridge area (including the relocation of Route 6 Exit 1C or the addition of a travel lane of Route 6 eastbound).

4.9.6 Case 3

Case 3 includes the following transportation improvements:

- Scenic Highway to Route 25 Westbound Ramp
- Belmont Circle Reconstruction (Alternative 1 – Four-Leg Roundabout and Signalized Intersection)
- Bourne Rotary Reconstruction (Alternative 2 – Three Signalized Intersections)
- Sagamore Bridge Replacement
- Bourne Bridge Replacement
- Route 6 – Relocation of Exit 1C
- Route 6 – Additional Eastbound Travel Lane to Exit 2 (Route 130)

Case 3 includes all transportation improvements described under Case 2, plus several additional major transportation improvements including the assumed replacement of the Bourne and Sagamore Bridges (by the USACE) and the construction of an additional eastbound travel lane on Route 6 to Exit 2 (Route 130). Case 3 represents the implementation of nearly all suggested transportation improvements. More detailed information is provided below on the forecast traffic operation at Belmont Circle and Bourne Rotary (also see Table 4-38 and Exhibit 4-35).

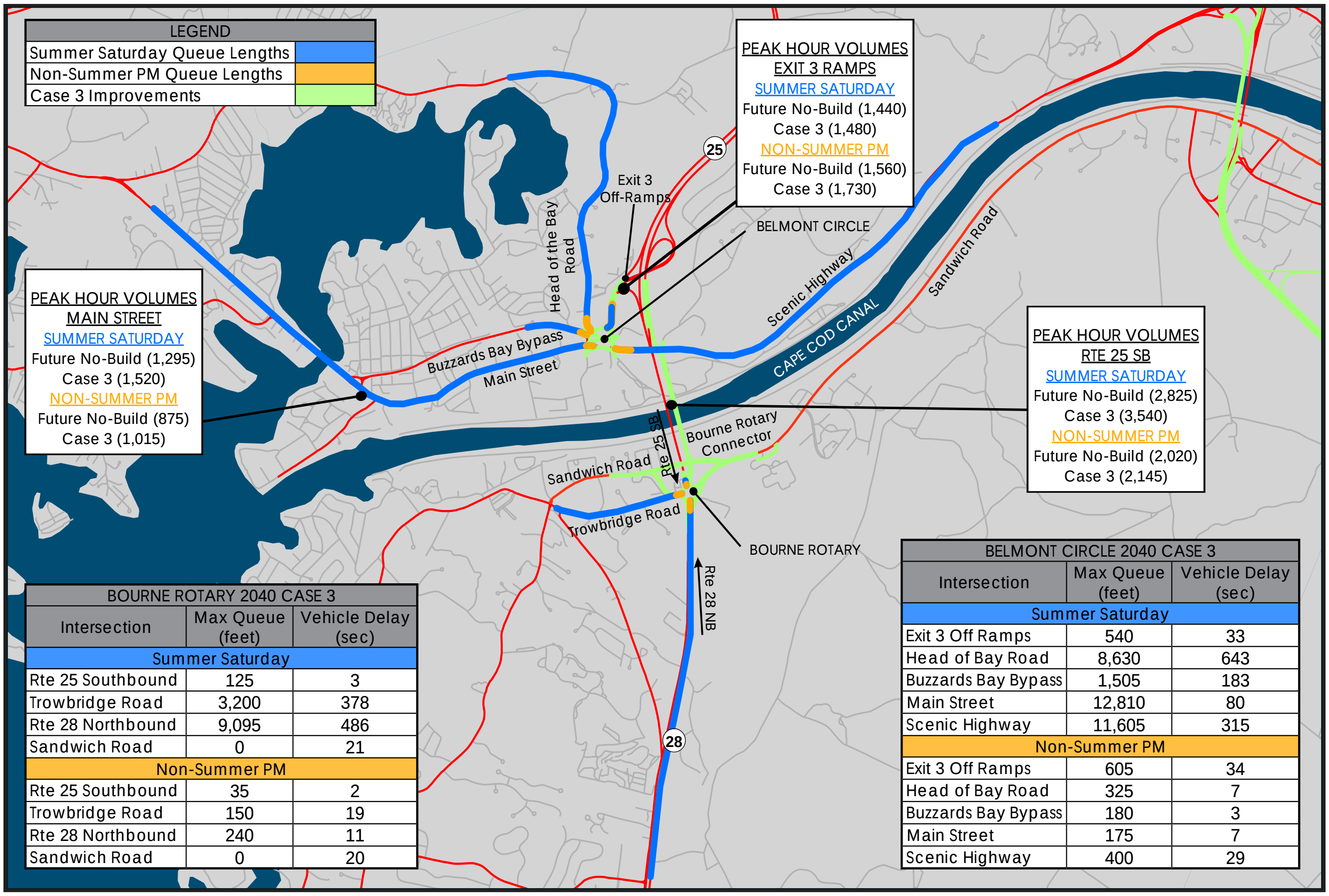
Belmont Circle

Result: The replacement bridges (with auxiliary lanes for entering and exiting traffic) together with the highway

Table 4-38 *Case 3 - Future (2040) Traffic Operations, Belmont Circle and Bourne Rotary*

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS - BUILD CASE 3		
	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*
BELMONT CIRCLE									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Exit 3 Off Ramps SB	5	A	515	2	A	645	34	D	605
Head of Bay Rd SB	15	C	270	317 (5.28)	**F**	1,780	7	A	325
Buzzards Bay Bypass EB	3	A	100	3	A	110	3	A	180
Main Street EB	13	B	530	29	D	1,245	7	A	175
Scenic Highway WB	7	A	380	14	B	840	29	D	400
Intersection (Overall)	**8.6**	**A**		**73 (1.22)**	**F**		**16**	**C**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Exit 3 Off Ramps SB	4	A	510	3	A	1,025	33	D	540
Head of Bay Rd SB	83 (1.38)	**F**	570	656 (10.93)	**F**	2,700 (0.51)	643 (10.72)	**F**	8,630 (1.63)
Buzzards Bay Bypass EB	19	C	335	11	B	305	183 (3.05)	**F**	1,505
Main Street EB	82 (1.36)	**F**	5,755 (1.09)	126 (2.1)	**F**	6,140 (1.16)	80 (1.33)	**F**	12,810 (2.43)
Scenic Highway WB	125 (2.08)	**F**	10,605 (2.01)	161 (2.68)	**F**	11,610 (2.20)	315 (5.25)	**F**	11,605 (2.20)
Intersection (Overall)	**62.6 (1.04)**	**F**		**191.4 (3.19)**	**F**		**250.8 (4.18)**	**F**	
BOURNE ROTARY									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Route 25 SB	19	C	650	14	B	620	2	A	35
Trowbridge Rd EB	75 (1.25)	**F**	840	394 (6.57)	**F**	3,465 (0.66)	19	C	150
Route 28 NB	14	B	340	102 (1.7)	**F**	1,275	11	B	240
Sandwich Rd WB	20	C	1,530	19	C	855	20	C	0
Intersection (Overall)	**32**	**D**		**132.25 (2.20)**	**D**		**13**	**B**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Route 25 SB	280 (4.67)	**F**	8,885 (1.68)	329 (5.48)	**F**	9,935 (1.88)	3	A	125
Trowbridge Rd EB	30	D	335	265 (4.42)	**F**	2,225	378 (6.3)	**F**	3,200 (0.61)
Route 28 NB	301 (5.02)	**F**	4,135 (0.78)	189 (3.15)	**F**	3,605 (0.68)	486 (8.1)	**F**	9,095 (1.72)
Sandwich Rd WB	27	D	1,475	135 (2.25)	**F**	6,430 (1.22)	21	C	0
Intersection (Overall)	**159.5 (2.66)**	**F**		**229.5 (3.83)**	**F**		**222 (3.7)**	**F**	

Notes:
*LOS E and LOS F movements are **bold***
EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.



BOURNE ROTARY 2040 CASE 3		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Rte 25 Southbound	125	3
Trowbridge Road	3,200	378
Rte 28 Northbound	9,095	486
Sandwich Road	0	21
Non-Summer PM		
Rte 25 Southbound	35	2
Trowbridge Road	150	19
Rte 28 Northbound	240	11
Sandwich Road	0	20

BELMONT CIRCLE 2040 CASE 3		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Exit 3 Off Ramps	540	33
Head of Bay Road	8,630	643
Buzzards Bay Bypass	1,505	183
Main Street	12,810	80
Scenic Highway	11,605	315
Non-Summer PM		
Exit 3 Off Ramps	605	34
Head of Bay Road	325	7
Buzzards Bay Bypass	180	3
Main Street	175	7
Scenic Highway	400	29

Exhibit 4-35 Case 3- Maximum Queue and Average Delay, Belmont Circle and Bourne Rotary

interchange at the existing Bourne Rotary and improvements to Belmont Circle would reduce existing vehicle conflict points and separate regional from local traffic. With these transportation improvements in place, traffic would operate substantially better during the non-summer weekday peak period at Belmont Circle compared to the future no build condition.

However, during the summer Saturday peak period, traffic operations degrade substantially, becoming worse than the future no build conditions. Average delay during the summer Saturday peak period would exceed 10.7 and 5.2 minutes at the Head of the Bay Road and Scenic Highway approaches, respectively.

Cause: A contributing reason for the poor traffic operations at Belmont Circle under Case 3 is that the improved roadway system in the Bourne Bridge area results in a diversion of a substantial number of additional vehicles from other locations to this area. For example, during the summer Saturday peak period, Main Street is forecast to process 225 additional vehicles (increasing from 1,295 to 1,520 vehicles).

Bourne Rotary

Result: Traffic operations under Case 3 at the Bourne Rotary would improve substantially during the non-summer weekday peak period. Average delay for all approaches would range from two- to 20-seconds. However, during the summer Saturday peak period, delay would vary depending on the approach. The Route 25 southbound and Sandwich Road approaches would have relatively minor delay at three- and 21-seconds, respectively. Conversely, average delay during the summer Saturday peak period at the Trowbridge Road and Route 28 northbound approaches would each be worse than future no-build conditions, at 6.3 and 8.1 minutes, respectively.

Cause: The replacement Bourne Bridge together with the new configuration of the Bourne Rotary, which would not allow traffic to cross over the north side of the Rotary, would result in diversions of traffic to the Bourne Bridge. Under existing and future no-build conditions, traffic congestion at Belmont Circle and the Bourne Rotary discourages use of the Bourne Bridge. As traffic operations improve, traffic that currently diverts to the Sagamore Bridge is forecast to shift to the more direct route over the Bourne Bridge. Specifically, during the summer Saturday peak period, the Bourne Bridge is forecast to have an additional 715 vehicles (increasing from 2,825 to 3,540 vehicles).

These increased summer period traffic volumes, without corresponding improvements in the roadway infrastructure at the Bourne Rotary, result in fewer gaps for vehicles trying to enter the Rotary from Trowbridge Road and Route 28 northbound, preventing delay reductions at those approaches (Exhibit 4-35).

4.9.7 Case 3A

Case 3A includes the following transportation improvements:

- Scenic Highway to Route 25 Westbound Ramp
- Route 6 – Relocation of Exit 1C
- Belmont Circle Reconstruction (Alternative 1 – Four-Leg Roundabout and Signalized Intersection)
- Sagamore Bridge Replacement
- Bourne Bridge Replacement
- Route 6 – Additional Travel Lane to Exit 2 (Route 130)
- Bourne Rotary Reconstruction as Highway Interchange

Case 3A includes all the transportation improvements described under Case 3 plus the reconstruction of Bourne Rotary as a highway interchange.

Case 3A represents the implementation of all suggested transportation improvements. More detailed information is provided below on the forecast traffic operation at Belmont Circle and Bourne Rotary (also see Table 4-39 and Exhibit 4-36), and the Route 3 and Route 6 approaches to the Sagamore Bridge (also see Table 4-41 and Exhibit 4-37).

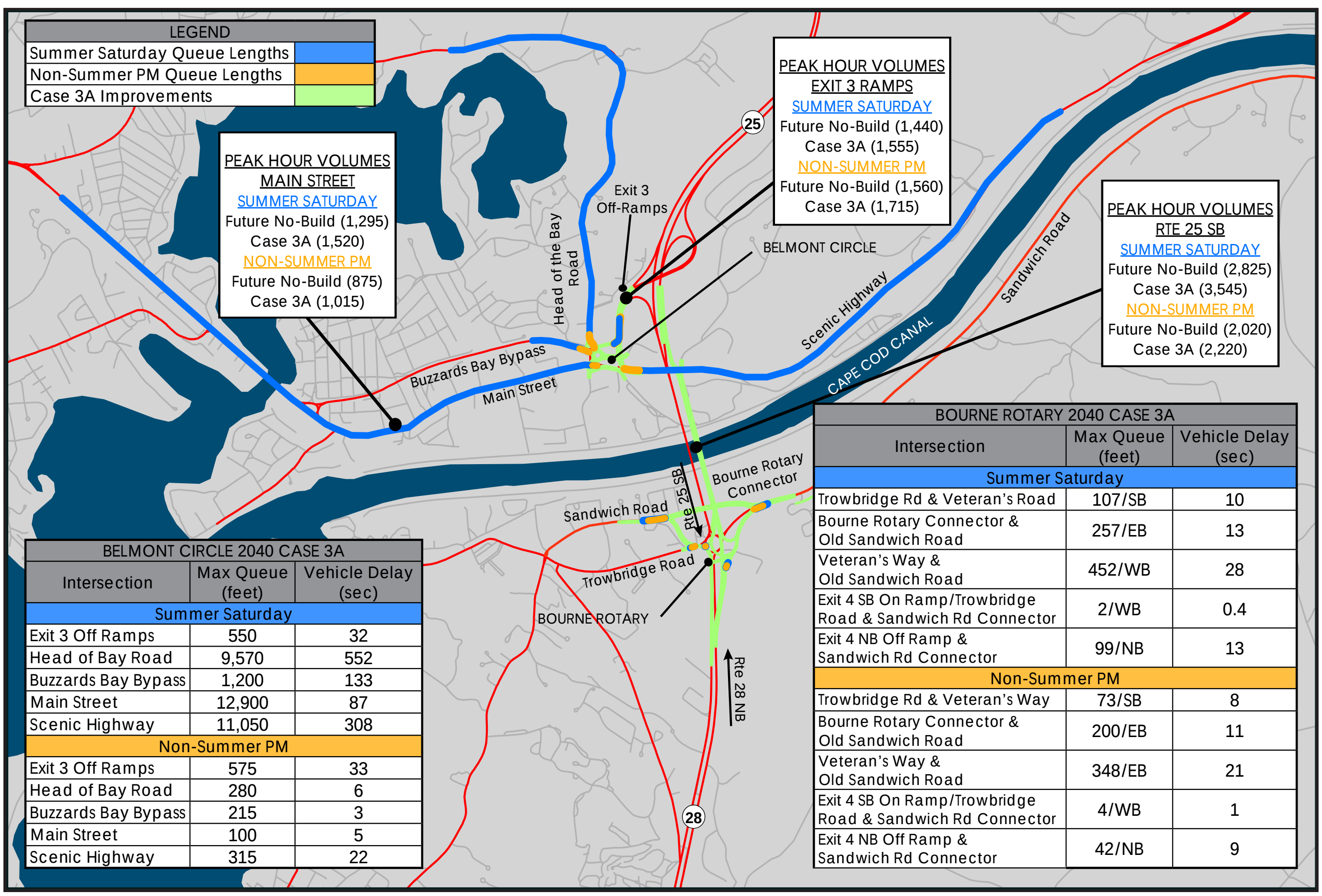
Belmont Circle

Result: Traffic operations under Case 3A would operate substantially better at Belmont Circle during the non summer weekday peak period compared to the future no build condition. Average delay for all approaches would range from three- to 33-seconds. Traffic operations at Belmont Circle degrade during the summer Saturday peak period as the improved roadway system results in diversions of additional vehicles to the Bourne Bridge area. Average delay would be worse than the future no-build condition, with delays ranging from 0.5 minutes at the Route 25 Exit 3 Exit ramps, to 9.2 minutes at the Head of the Bay Road approach.

Cause: The reason for the poor performance at Belmont Circle during the summer Saturday peak period is that as overall traffic

Text continues on page 4-95.

Exhibit 4-36 ***Case 3A - Maximum Queue and Average Delay, Belmont Circle and Bourne Rotary***



BELMONT CIRCLE 2040 CASE 3A		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Exit 3 Off Ramps	550	32
Head of Bay Road	9,570	552
Buzzards Bay Bypass	1,200	133
Main Street	12,900	87
Scenic Highway	11,050	308
Non-Summer PM		
Exit 3 Off Ramps	575	33
Head of Bay Road	280	6
Buzzards Bay Bypass	215	3
Main Street	100	5
Scenic Highway	315	22

BOURNE ROTARY 2040 CASE 3A		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Trowbridge Rd & Veteran's Road	107/SB	10
Bourne Rotary Connector & Old Sandwich Road	257/EB	13
Veteran's Way & Old Sandwich Road	452/WB	28
Exit 4 SB On Ramp/Trowbridge Road & Sandwich Rd Connector	2/WB	0.4
Exit 4 NB Off Ramp & Sandwich Rd Connector	99/NB	13
Non-Summer PM		
Trowbridge Rd & Veteran's Way	73/SB	8
Bourne Rotary Connector & Old Sandwich Road	200/EB	11
Veteran's Way & Old Sandwich Road	348/EB	21
Exit 4 SB On Ramp/Trowbridge Road & Sandwich Rd Connector	4/WB	1
Exit 4 NB Off Ramp & Sandwich Rd Connector	42/NB	9

Table 4-39 Case 3A - Future (2040) Traffic Operations, Belmont Circle and Bourne Rotary

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS - BUILD CASE 3A		
	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*
BELMONT CIRCLE									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Exit 3 Off Ramps SB	5	A	515	2	A	645	33	D	575
Head of Bay Rd SB	15	C	270	317 (5.28)	**F**	1,780	6	A	280
Buzzards Bay Bypass EB	3	A	100	3	A	110	3	A	215
Main Street EB	13	B	530	29	D	1,245	5	A	100
Scenic Highway WB	7	A	380	14	B	840	22	C	315
Intersection (Overall)	**8.6**	**A**		**73 (1.22)**	**F**		**13.8**	**B**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Exit 3 Off Ramps SB	4	A	510	3	A	1,025	32	D	550
Head of Bay Rd SB	83 (1.38)	**F**	570	656 (10.93)	**F**	2,700 (0.51)	552 (9.2)	**F**	9,570 (1.81)
Buzzards Bay Bypass EB	19	C	335	11	B	305	133 (2.22)	**F**	1,200
Main Street EB	82 (1.36)	**F**	5,755 (1.09)	126 (2.1)	**F**	6,140 (1.16)	87 (1.45)	**F**	12,900 (2.44)
Scenic Highway WB	125 (2.08)	**F**	10,605 (2.01)	161 (2.68)	**F**	11,610 (2.20)	308 (5.13)	**F**	11,050 (2.09)
Intersection (Overall)	**62.6 (1.04)**	**F**		**191.4 (3.19)**	**F**		**222.4 (3.71)**	**F**	
BOURNE ROTARY									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Route 25 SB	19	C	650	14	B	620			
Trowbridge Rd EB	75 (1.25)	**F**	840	394 (6.57)	**F**	3,465 (0.66)			
Route 28 NB	14	B	340	102 (1.7)	**F**	1,275			
Sandwich Rd WB	20	C	1,530	19	C	855			
Intersection (Overall)	**32**	**D**		**132.25 (2.20)**	**D**		**8.9**	**A**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Route 25 SB	280 (4.67)	**F**	8,885 (1.68)	329 (5.48)	**F**	9,935 (1.88)			
Trowbridge Rd EB	30	D	335	265 (4.42)	**F**	2,225			
Route 28 NB	301 (5.02)	**F**	4,135 (0.78)	189 (3.15)	**F**	3,605 (0.68)			
Sandwich Rd WB	27	D	1475	135 (2.25)	**F**	6,430 (1.22)			
Intersection (Overall)	**159.5 (2.66)**	**F**		**229.5 (3.83)**	**F**		**11**	**B**	

Notes:
*LOS E and LOS F movements are **bold***
EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.
Data not available in shaded areas. Highway interchanges not evaluated with VISSIM software

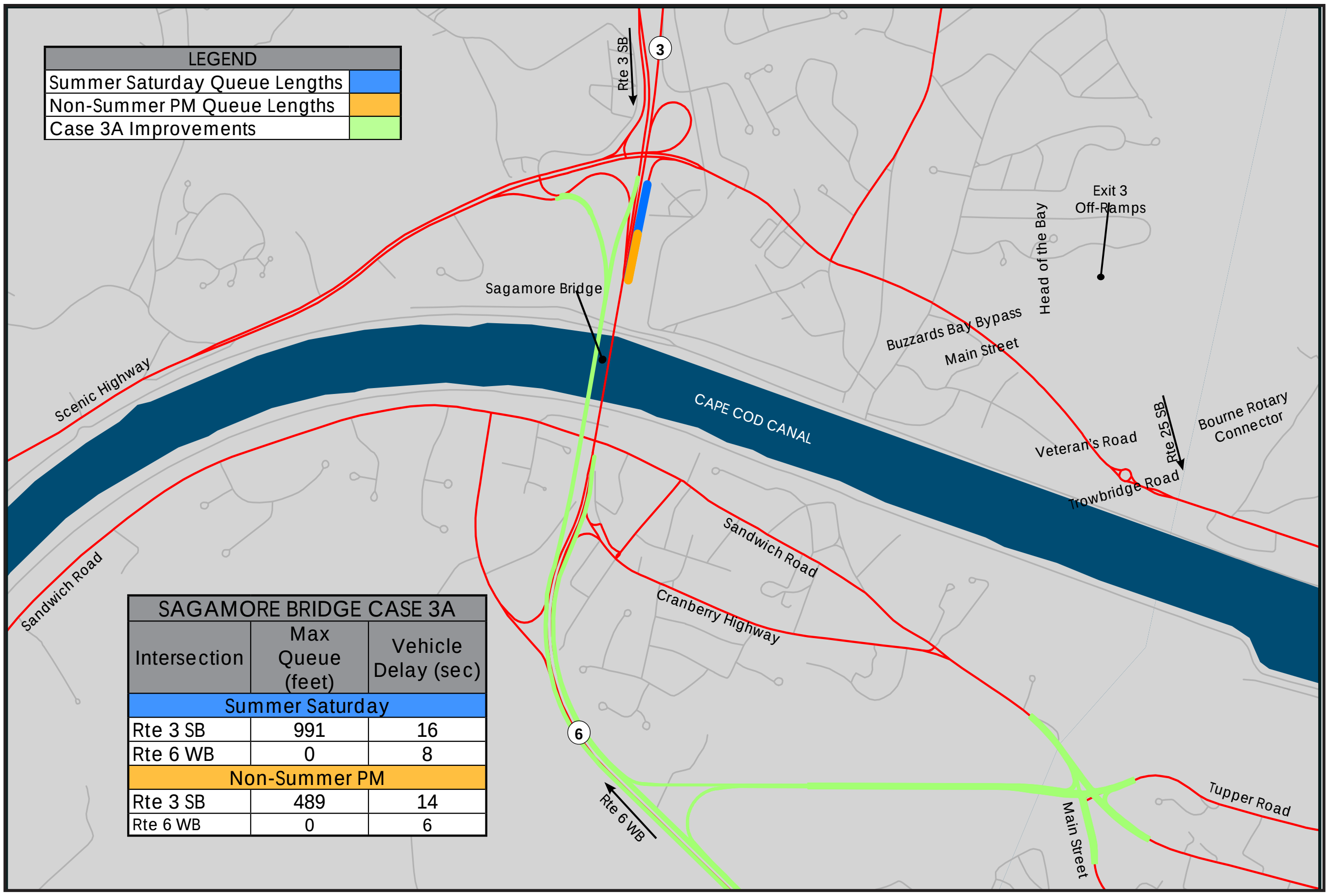


Exhibit 4-37 Case 3A - Maximum Queue and Average Delay, Sagamore Bridge Approaches

Table 4-40 Case 3A - Future (2040) Traffic Operations, Sagamore Bridge Approaches

	EXISTING (2014) CONDITIONS				FUTURE (2040) NO-BUILD CONDITIONS				FUTURE (2040) BUILD CONDITIONS - BUILD CASE 1			
	AVERAGE DELAY *Sec (Min)*	LOS	AVERAGE QUEUE *Feet (Miles)*	MAXIMUM QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	AVERAGE QUEUE *Feet (Miles)*	MAXIMUM QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	AVERAGE QUEUE *Feet (Miles)*	MAXIMUM QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)												
Route 3 Southbound	11	B	77	478	460 (7.7)	F	7,481 (1.4)	8,476 (1.6)	14	B	45	296
Route 6 Westbound	5	A	53	232	178 (3.0)	F	6,801 (1.3)	7,967 (1.5)	5	A	0	0
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)												
Route 3 Southbound	416 (6.9)	F	4,823 (0.91)	5,393 (1.02)	887 (14.8)	F	22,814 (4.3)	24,484 (4.6)	16	C	581	990
Route 6 Westbound	683 (11.4)	F	23,318 (4.4)	25,014 (4.7)	812 (13.5)	F	24,825 (4.7)	25,029 (4.7)	8	A	0	0

Notes:
LOS = Level of Service
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

conditions improve, additional vehicles would be diverted to the Bourne Bridge area. For example, during the summer Saturday peak period, Main Street is forecast to have 225 additional vehicles (increasing from 1,295 to 1,520 vehicles).

Further, the major improvement at the Bourne Rotary results in the elimination of queuing on the Route 25/Route 28 southbound approach to the Bourne Rotary. These southbound queues act to limit the volume of vehicles entering Belmont Circle from Route 25. With the elimination of queues on Route 25, more vehicles can freely enter Belmont Circle. This increases the difficulty for vehicles to enter the Circle from other approaches such as Head of the Bay Road and Main Street.

Bourne Rotary Interchange

Result: Traffic operations under Case 3A would improve substantially during the non-summer weekday and summer Saturday peak periods at the Bourne Rotary Interchange. Average delay for all approaches during the non-summer Saturday peak period would range from one- to 21-seconds. During the summer Saturday peak period, delay would also be modest with average delay ranging from one- to 28-seconds (Table 4-40).

Cause: The interchange design allows the free-flow of vehicles on Route 28 with local traffic on Sandwich Road and Trowbridge Road directed under and over Route 28 to signalized intersections.

Sagamore Bridge Approaches – Route 3 Southbound and Route 6 Westbound

Result: On the highway approaches to the Sagamore Bridge on Routes 3 and Route 6, the construction of an additional eastbound travel lane, combined with the relocation of Route 6 Exit 1C and assumed replacement Canal Bridges would result in substantial improvements compared to the no-build condition.

Compared to the future no-build condition, the average delay on Route 6 westbound would be reduced from 3.0 minutes to five seconds during the non-summer weekday peak period. During the summer Saturday peak period, the delay on Route 6 westbound would be reduced from 13.5 minutes to eight seconds. Delay on Route 3 southbound would experience similar delay reductions compared to the future no-build condition. Delay would drop from 7.7 minutes to 14 seconds and 14.8 minutes to 16 seconds for the non-summer weekday and summer Saturday peak periods, respectively.

Cause: The highway and bridge improvements proposed under Case 3A would provide the capacity and design features necessary to safely accommodate non-summer weekday PM and summer Saturday peak period traffic volumes in 2040 and beyond. The additional westbound travel lane on Route 6 eastbound would provide additional highway capacity. The northbound and southbound auxiliary lanes envisioned on the replacement Sagamore Bridge would allow vehicles to safely enter and exit the highway without causing additional congestion.

4.9.8 Overall Findings of Transportation Demand Modeling Analysis

After review of the results of the seven travel demand modeling cases, overall conclusions of their effectiveness in improving traffic operations within the study area were reached. Because the modeling cases provide a reflection of traffic conditions throughout the focus area, this analysis is predominately based on how the cases would affect traffic operations at Belmont Circle, Bourne Rotary, and the Route 3 and Route 6 approaches to the Sagamore Bridge.

In developing the overall findings, the study team remained mindful of the design assumptions that guided the alternatives development process (see Section 4.1). These design assumptions include maintaining a focus on the future year-round problem locations, prioritizing improvements to accommodate the future non-summer weekday peak period and providing further improvements to accommodate the summer Saturday peak period, as feasible.

The following tables and exhibits summarize findings for the seven cases analyzed. Table 4-41 provides a summary of the primary measures of effectiveness for traffic operations at Belmont Circle and Bourne Rotary, including average queues, maximum queues, average delays, and LOS.

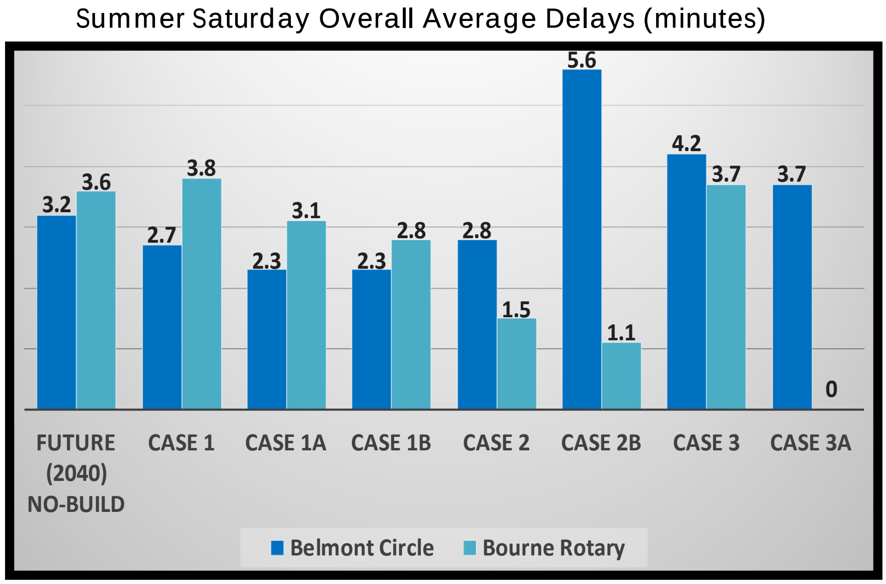
Exhibits 4-38 and 4-39 provide a comparison of the average delays at Belmont Circle, Bourne Rotary and the Sagamore Bridge approaches during the non-summer weekday period and summer Saturday peak periods for the future no-build condition and each of the seven cases analyzed.

The following is a summary of the overall findings the for regional transportation modeling case analyses for the roadways within the vicinity of the Bourne and Sagamore Bridges. This analysis is divided into cases that include replacement Canal bridges and those that do not.

Table 4-41 Summary of Case Analysis for Queues, Delay, and LOS at Belmont Circle and Bourne Rotary

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS - BUILD CASE 1			FUTURE (2040) BUILD CASE 1A			FUTURE (2040) BUILD CASE 1B			FUTURE (2040) BUILD CASE 2			FUTURE (2040) BUILD CASE 2B			FUTURE (2040) BUILD CASE 3			FUTURE (2040) BUILD CASE 3A		
	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Mile)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Mile)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Mile)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Mile)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Mile)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Mile)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Mile)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Mile)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Mile)*
BELMONT CIRCLE																											
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)																											
Exit 3 Off Ramps SB	5	A	515	2	A	645	1	A	65	1	A	80	1	A	70	29	D	470	9	A	155	34	D	605	33	D	575
Head of Bay Rd SB	15	C	270	317 (5.28)	**F**	1,780	35	D	520	30	D	550	142 (2.37)	**F**	1,055	7	A	350	8	A	330	7	A	325	6	A	280
Buzzards Bay Bypass EB	3	A	100	3	A	110	3	A	85	3	A	95	3	A	125	5	A	170	3	A	205	3	A	180	3	A	215
Main Street EB	13	B	530	29	D	1,245	27	D	1,085	24	C	1,115	61 (1.02)	**F**	1,745	14	B	560	4	A	85	7	A	175	5	A	100
Scenic Highway WB	7	A	380	14	B	840	1	A	60	1	A	75	7	A	210	36	**E**	475	16	C	325	29	D	400	22	C	315
Intersection (Overall)	**8.6**	**A**		**73 (1.22)**	**F**		**13.4**	**B**		**11.8**	**B**		**42.8**	**E**		**18.2**	**C**		**8**	**A**		**16**	**C**		**13.8**	**B**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)																											
Exit 3 Off Ramps SB	4	A	510	3	A	1,025	2	A	280	2	A	435	2	A	250	43	**E**	815	18	C	485	33	D	540	32	D	550
Head of Bay Rd SB	83 (1.38)	**F**	570	656 (10.93)	**F**	2,700 (0.51)	451 (7.52)	**F**	2,100	337 (5.62)	**F**	1,640	622 (10.37)	**F**	2,810 (0.53)	5	A	320	940 (15.67)	**F**	8,190 (1.55)	643 (10.7)	**F**	8,630 (3.4)	552 (9.2)	**F**	9,570 (3.8)
Buzzards Bay Bypass EB	19	C	335	11	B	305	12	B	305	14	B	370	9	A	285	9	A	290	446 (7.43)	**F**	2,665 (0.50)	183 (3.1)	**F**	1,505	133 (2.2)	**F**	1200
Main Street EB	82 (1.36)	**F**	5,755 (1.09)	126 (2.1)	**F**	6,140 (1.16)	185 (3.08)	**F**	6,140 (1.16)	172 (2.87)	**F**	6,140 (1.16)	17	C	1,135	243 (4.05)	**F**	6,020 (1.14)	45	**E**	4,995 (0.94)	80 (1.3)	**F**	12,810 (5.1)	87 (1.5)	**F**	12,900 (5.2)
Scenic Highway WB	125 (2.08)	**F**	10,605 (2.01)	161 (2.68)	**F**	11,610 (2.20)	154 (2.57)	**F**	10,630 (2.01)	154 (2.57)	**F**	10,525 (1.99)	3	A	235	553 (9.22)	**F**	11,800 (2.23)	147 (2.45)	**F**	2,950 (0.56)	315 (5.3)	**F**	11,605 (4.6)	308 (5.1)	**F**	11,050 (4.4)
Intersection (Overall)	**62.6 (1.04)**	**F**		**191.4 (3.19)**	**F**		**160.8 (2.68)**	**F**		**135.8 (2.26)**	**F**		**130.6 (2.18)**	**F**		**170.6 (2.84)**	**F**		**319.2 (5.32)**	**F**		**250.8 (4.2)**	**F**		**222.4 (3.7)**	**F**	
BOURNE ROTARY																											
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)																											
Route 25 SB	19	C	650	14	B	620	17	C	65	30	D	1,065	2	A	0	2	A	0	2	A	0	2	A	35			
Trowbridge Rd EB	75 (1.25)	**F**	840	394 (6.57)	**F**	3,465 (0.66)	456 (7.6)	**F**	520	378 (6.3)	**F**	3,420 (0.65)	33	D	125	20	C	160	17	C	140	19	C	150			
Route 28 NB	14	B	340	102 (1.7)	**F**	1,275	67 (1.12)	**F**	85	17	C	325	13	B	265	11	B	300	7	A	185	11	B	240			
Sandwich Rd WB	20	C	1,530	19	C	855	18	C	1,085	29	D	1,265	32	D	435	40	E	640	49	E	975	20	C	0			
Intersection (Overall)	**32**	**D**		**132.25 (2.20)**	**D**		**139.5 (2.33)**	**F**		**113.5 (1.89)**	**F**		**20**	**C**		**18.25**	**B**		**18.75**	**C**		**13**	**B**				
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)																											
Route 25 SB	280 (4.67)	**F**	8,885 (1.68)	329 (5.48)	**F**	9,935 (1.88)	333 (5.55)	**F**	10,000 (1.89)	337 (5.62)	**F**	10,170 (1.93)	3	A	0	3	A	25	3	A	0	3	A	125			
Trowbridge Rd EB	30	D	335	265 (4.42)	**F**	2,225	152 (2.53)	**F**	1,525	213 (3.55)	**F**	1,645	249 (4.15)	**F**	4,705 (0.89)	62 (1.03)	**F**	915	136 (2.27)	**F**	1,370	378 (6.3)	**F**	3,200 (1.3)			
Route 28 NB	301 (5.02)	**F**	4,135 (0.78)	189 (3.15)	**F**	3,605 (0.68)	280 (4.67)	**F**	5,375 (1.02)	13	B	445	409 (6.82)	**F**	8,050 (1.52)	268 (4.47)	**F**	5,820 (1.10)	344 (5.73)	**F**	6,930 (1.31)	486 (8.1)	**F**	9,095 (3.6)			
Sandwich Rd WB	27	D	1,475	135 (2.25)	**F**	6,430 (1.22)	139 (2.32)	**F**	6,095 (1.15)	198 (3.3)	**F**	9,700 (1.84)	24	C	150	25	D	240	24	C	200	21	C	0			
Intersection (Overall)	**159.5 (2.66)**	**F**		**229.5 (3.83)**	**F**		**226 (3.77)**	**F**		**190.25 (3.17)**	**F**		**171.25 (2.85)**	**F**		**89.5 (1.49)**	**F**		**126.75 (2.11)**	**F**		**222 (3.7)**	**F**				

Notes:
LOS E and LOS F movements for the existing and future no-build problem locations are **bold**
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.
Data not available for Case 3A at Bourne Rotary. As a highway interchange, analysis at this location was completed with Synchro software, not VISSIM™ software as was used for other locations.
Results for Case 3A for the intersections adjacent to the Bourne Rotary Interchange are shown on Table 4-29



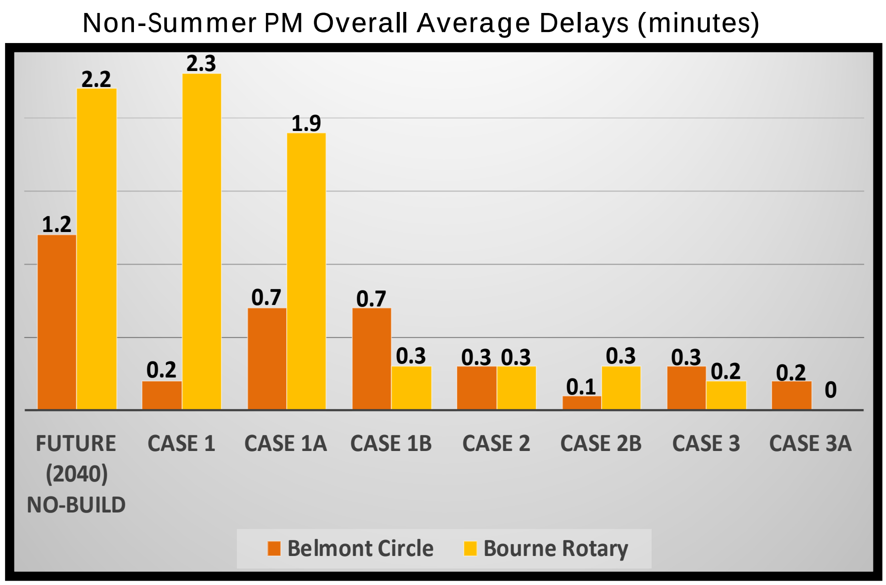


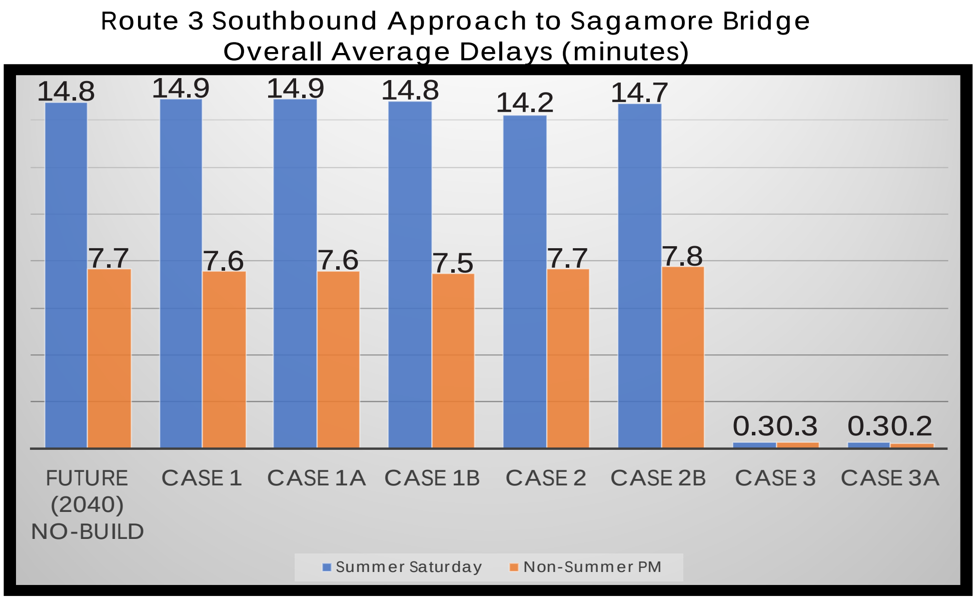
Exhibit 4-38 Average Non-Summer Weekday and Summer Saturday Peak Period Delay, Belmont Circle and Bourne Rotary

Cases 1, 1A, 1B, 2, and 2B (Cases without replacement Canal bridges) – Bourne Bridge Area

Non-Summer Weekday Peak Period: Modest reductions in average delay during the non-summer weekday peak period can be achieved at Belmont Circle and Bourne Rotary with Case 1 and Case 1A when compared to the future no-build condition. Belmont Circle under Case 1 experiencing greater delay reduction.

More substantial reduction in delays can be achieved at Belmont Circle and Bourne Rotary with Case 1B and Case 2 improvements. Case 2B is also very effective during non-summer weekdays.

Summer Saturday Peak Period: More modest delay reductions can be achieved at Belmont Circle and Bourne Rotary under Case



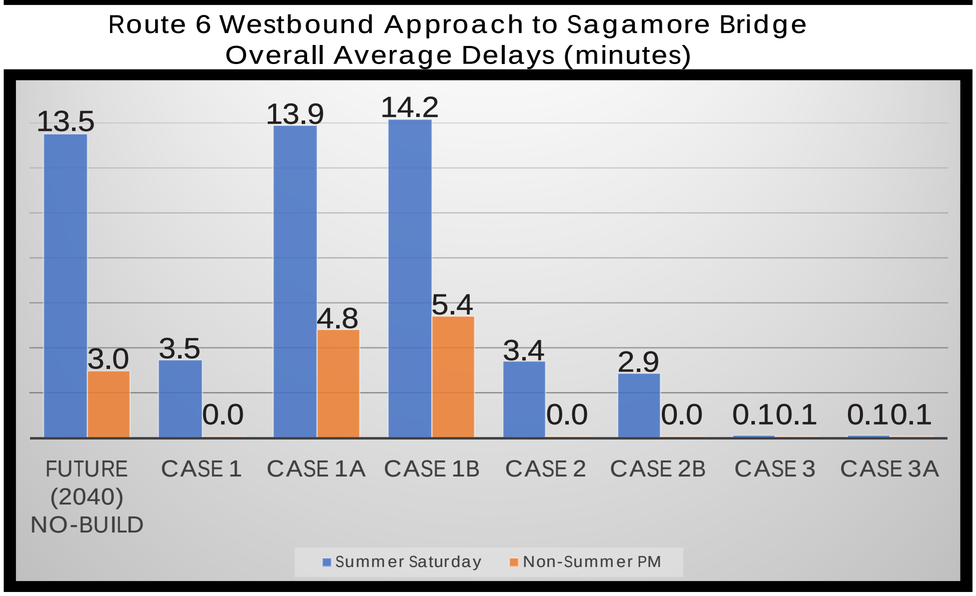


Exhibit 4-39 Average Non-Summer Weekday and Summer Saturday Peak Period Delay, Sagamore Bridge Approaches

1A, Case 1B, and Case 2. Case 2 would provide the greatest delay reduction at Bourne Rotary.

Roadway approaches to Belmont Circle that would continue to experience some delays during summer Saturday peak periods under these cases include Head of the Bay Road, Main Street, and Scenic Highway. Other than the Head of the Bay Road approach, Case 1B operates the best during the summer Saturday peak period among all the cases at Belmont Circle.

Roadway approaches to Bourne Rotary that would continue to experience some delays under these cases include Route 28 northbound and Trowbridge Road. Case 2 operates the best at Bourne Rotary among all the cases.

Overall, delay reduction in the Bourne Bridge area is dampened because, as roadway improvements are implemented, diversions of traffic to this area would occur. For example, under Case 2, compared to the 2040 no-build condition, peak hour volumes on Main Street would increase by 17% (1,295 to 1,520 vehicles) during the non-summer PM and by 16% during summer Saturdays.

Cases 1, 1A, 1B, 2, and 2B (Cases without replacement Canal bridges) – Sagamore Bridge Area

Non-Summer Weekday Peak Period: With the relocation of Route 6 Exit 1C under Case 1 and Case 2, a substantial reduction in delay can be achieved on the Route 6 westbound approach to the Sagamore Bridge during non-summer weekday peak period. Average delay would be reduced from three minutes to two seconds when compared to the future no-build condition. The delay during the summer Saturday peak period on Route 3 southbound for these cases would be reduced from 13.5 minutes to 3.5 minutes. These delay reductions do not occur under Cases 1A and 1B because they do not include the relocation of Exit 1C.

The Route 3 southbound approaches to the Sagamore Bridge would not see any reductions during delay for the non-summer weekday peak period under Cases 1, 1A, 1B, 2, and 2B with average delay remaining at approximately 7.5 minutes. Under these cases no transportation improvements would be implemented that would divert traffic from Route 3 southbound during the non-summer weekday peak period.

Summer Saturday Peak Period: A substantial reduction in delay under Case 1 and Case 2 can also be achieved on the Route 6 westbound approach to the Sagamore Bridge during the summer Saturday peak period, with average delay being reduced from 13.5 minutes to 3.4 minutes. These delay reductions do not occur under Cases 1A and 1B because they do not include the relocation of Exit 1C.

The Route 3 southbound approaches to the Sagamore Bridge would not see any reductions in delay during summer Saturday peak period under Cases 1, 1A, 1B, 2, and 2B with average delay remaining at approximately 15 minutes. Under these cases no transportation improvements would be implemented that would divert traffic from Route 3 southbound during the summer Saturday peak period.

Cases 3 and 3A (Cases with replacement Canal bridges) – Bourne Bridge Area

Non-Summer Weekday Peak Period: Cases 3 and 3A include the assumed replacement Canal bridges, the relocation of Route 6

Exit 1C, and an additional Route 6 eastbound travel lane. Both Belmont Circle and Bourne Rotary would operate well with average delays ranging from two to 34 seconds on the various roadway approaches. Few delays would be experienced during the non-summer weekday peak period.

Summer Saturday Peak Period: Traffic would operate worse than the future no-build conditions at both Belmont Circle and Bourne Rotary under Case 3. Extended queuing and delays would be experienced at the Scenic Highway, Main Street, and Head of the Bay Road approaches to Belmont Circle.

Under Case 3A (which differs from Case 3 with the construction of a highway interchange replacing the Bourne Rotary), the Bourne Rotary area would operate with very few delays. Belmont Circle however, would continue to suffer from extended queuing at several approaches.

Cases 3 and 3A (Cases with replacement Canal bridges) – Sagamore Bridge Area

Non-Summer Weekday Peak Period: Implementation of the improvements proposed under Cases 3 and 3A would result in a substantial reduction in delay on the Route 6 westbound approach to the Sagamore Bridge during the non-summer weekday peak period. Average delay would be reduced from three minutes to six seconds, when compared to the future no-build condition.

The Route 3 southbound approaches to the Sagamore Bridge are also forecast to experience a substantial reduction in delay during the non-summer weekday peak period under both Cases 3 and 3A, with average delay being reduced from 7.6 minutes to 14 seconds.

Summer Saturday Peak Period: Under Cases 3 and 3A, a substantial reduction in delay can also be achieved on the Route 6 westbound approach to the Sagamore Bridge during the summer Saturday peak period, with average delay being reduced from 13.5 minutes to only eight seconds.

The Route 3 southbound approaches to the Sagamore Bridge are forecast to experience a substantial reduction in delay during the summer Saturday peak period under both Cases 3 and 3A, with average delay being reduced from 14.7 minutes to 16 seconds.

4.10 ADDITIONAL STUDY ANALYSIS

The following sections describe the results of the additional analysis conducted for the travel demand model cases to determine the degree of impact and/or benefit to air quality, highway noise, and economic conditions.

The preliminary air quality and noise evaluations were conducted based on the potential location of roadway and traffic forecasts for Case 2 and Case 3A. These two cases were chosen because they represent the most complete cases involving in which the existing Canal bridges remain and those in which replacement bridges replacement Canal bridges and those that replacement Canal bridges are in place. These cases represent the maximum potential air quality and highway noise impact.

4.10.1 Air Quality Evaluation

A preliminary air quality evaluation was conducted based on the conceptual design of potential transportation improvements and future traffic forecasts. As such, the study did not include roadway prediction modeling of air quality levels with the U.S. Environmental Protection Agency (EPA) and FHWA approved air quality models. Instead, a more qualitative evaluation was conducted to assess the potential for increased or decreased air quality impacts within the study area utilizing EPA and FHWA guideline criteria. The complete preliminary air quality analysis can be reviewed in Appendix F.

A detailed air quality study would be conducted during the preparation of an environmental document for future projects. These future detailed air quality analyses would evaluate existing and future air quality impacts associated with project roadways. Impact would be assessed with respect to the methodologies and assumptions for each pollutant consistent with FHWA and EPA guidance as well as that of the MassDOT and Massachusetts Department of Environmental Protection (MassDEP).

A qualitative carbon monoxide (CO), Mobile Source Air Toxics (MSATs), VOCs/NOX, and greenhouse gas (GHG) analysis was conducted. Below is a summary of the preliminary air quality evaluation. The complete preliminary air quality analysis can be reviewed in Appendix F.

Preliminary Air Quality Evaluation Findings

Carbon Monoxide (CO): Typically, CO is used in microscale studies to indicate roadway pollutant levels since it is the most abundant pollutant emitted by motor vehicles and can result in so-called "hot spot" (high concentration) locations around congested intersections.

A total of twelve intersections were included in the analysis, which were comprised of both existing and future intersections. In general, the LOS for the Peak AM and PM conditions are approximately the same for Case 2 and Case 3A, when compared to the future No Build conditions. Similarly, the intersection Peak AM and PM delay, volumes and VHT also generally increased for the two cases compared to the future no-build conditions. There were only a few intersections where the LOS, peak period volumes and delay were expected to improve under Case 2A or Case 3A, compared to the future no-build.

Overall, it can therefore reasonably be concluded that implementation of Case 2 or Case 3A could increase traffic volumes and delay at most of the 12 intersections evaluated, which could result in an increase of CO emissions compared to the future no-build conditions.

Mobile Source Air Toxics (MSAT): MSATs include a large suite of pollutants emitted from motor vehicles, airplanes, locomotives, and other engine-powered transportation modes. The forecast in increase in average daily traffic (ADT), which would result in an increase in vehicle miles traveled (VMT), would lead to overall higher MSAT emissions in the study area for the Build Alternatives.

However, regardless of the option chosen, vehicle emissions would likely be lower than present levels because of the U.S. EPA's national air quality control programs mandated under the federal Clean Air Act. These programs are projected to reduce annual MSAT emissions by over 90% between 2010 and 2050. Note that local conditions may differ from these national projections in terms of fleet mix and turnover, VMT growth rates, and local control measures. However, the magnitude of the EPA-projected reductions is so great (even after accounting for VMT growth) that MSAT emissions in the study area are likely to be lower in the future in nearly all cases.

VOCs/NOX: A mesoscale analysis was performed to calculate the potential regional air quality impact of future projects using a measure of the total daily emissions of volatile organic compounds (VOCs) and oxides of nitrogen (NOx) within the study area. Calculations were performed to compare area-wide emissions for future build scenarios with the existing and future no-build conditions. Typically, emission factors for each pollutant are generated for each roadway link using the EPA emission models based on vehicle miles traveled, vehicle speeds and other roadway data relative to the proposed cases.

As summer ADT is expected to slightly increase with Case 2 and Case 3A compared to the future no-build condition, overall emissions of VOCs and NOx could also slightly increase with the implementation of the projects that make up these cases. Given the relatively small expected ADT increase associated with the cases of approximately two percent and 1.5 percent relative to the total VMT's in the region, it is unlikely that this would result in a substantial change in emissions or any subsequent direct or indirect impacts to the mesoscale analysis.

Greenhouse Gases: The transportation system is a critical component of Massachusetts' infrastructure and contributes over one third of the Commonwealth's greenhouse gas (GHG) emissions. The Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA), in consultation with other state agencies and the public, released the Massachusetts Clean Energy and Climate Plan for 2020. This implementation plan establishes targets for overall, statewide GHG emissions:

- By 2020, 20% reduction below statewide 1990 GHG emission levels;
- By 2050, 80% reduction below statewide 1990 GHG emission levels

MassDOT's Healthy Transportation Policy Directive, released in September 2013, includes the primary goals of reducing GHG emissions; promoting the healthy transportation modes of walking, bicycling, and public transit; and supporting smart growth development. The Cape Cod Regional Transportation Plan (RTP) reflects the vision of the Healthy Transportation Policy Directive Policy with the Multimodal Options/Healthy Transportation Goal, including a performance measure reflecting the state Mode Shift Goal. The Cape Cod Commission conducted a GHG analysis as part of the 2016 Regional Transportation Plan[2]. Anticipated GHG impacts from nine specific regional target projects were conducted. Two of those projects, Belmont Circle/Route 25 Ramp Improvements and Route 6 Exit 1C reconfiguration were included in the GHG analysis. The results of the anticipated GHG impacts from these two projects were documented as "quantified decrease in emissions from traffic operation improvement–to be verified by statewide modeling".

Overall, even with the larger improvements proposed under Case 3A, potential impact to air quality would be minor and Barnstable County is forecast to remain in attainment, based on the current National Ambient Air Quality Standards (NAAQS).

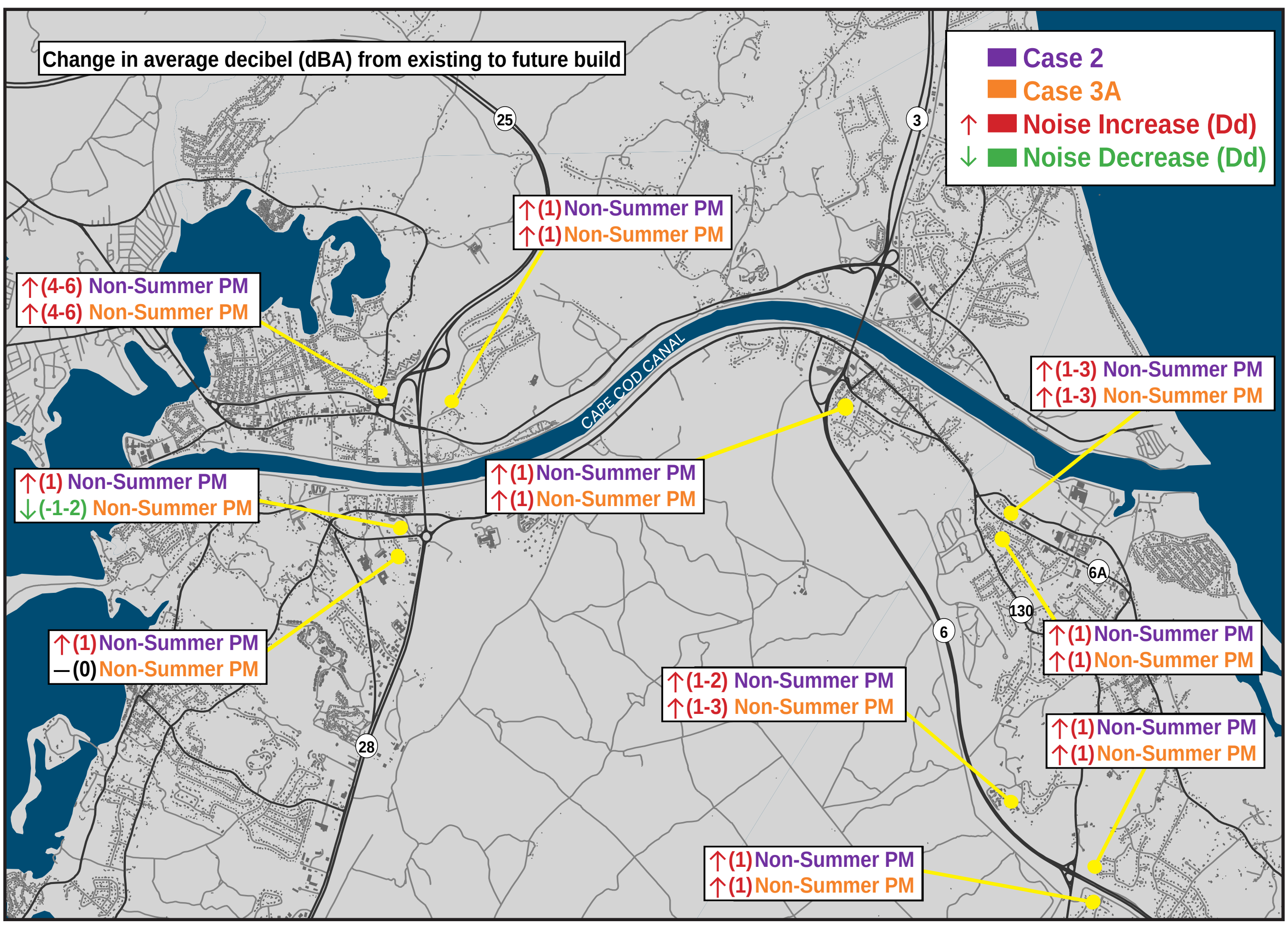
2 http://www.capecodcommission.org/resources/transportation/rtp/2016/FinalReport/Appendices/RTP%20Appendix%20N%20-%20Greenhouse%20Gas%20Analysis%20(Endorsed%207-20-15).pdf

4.10.2 Preliminary Noise Evaluation

FHWA and MassDOT regulations and policies require noise assessments to evaluate future equivalent noise levels in decibels (dB) during the loudest hour of the day (known as Leq dBA). The worst-case existing and future traffic conditions (i.e. highest traffic volumes found during the summer Saturday peak period) were used to correlate to higher (i.e. worst case) noise impacts at noise sensitive locations (mostly residential neighborhoods).

The increases in the hourly sound level from the 2014 Existing to 2040 Build conditions were computed for all three peak hours for Cases 2 and 3A. The range of increases and the peak hour with the highest increase are reported for the areas near residential land use. For reference, a sound level increase of three dB or less is generally not noticeable under most circumstances. An increase of five dB is generally noticeable in a community setting. An increase of 10 dB is perceived by most people as about twice as loud. Also, MassDOT' s Noise Policy considers an increase of 10 dB or more above existing noise levels to be a "substantial increase." This is a more impactful noise increase that would require consideration of abatement in a final environmental document.

Exhibit 4-40 Preliminary Noise Analysis



The predicted sound level increases are small for most roadways, generally less than three decibels, which is expected to be generally not noticeable (Exhibit 4-40). However, due to expected changes in traffic patterns, the Head of the Bay Road adjacent to Belmont Circle is predicted to experience up to four-fold increases in traffic volumes in both Cases 2 and 3A, which would result in increases up to six decibels. These are expected to be readily noticeable, but not approach a 'substantial increase' per MassDOT policy.

The complete preliminary noise evaluation is provided in Appendix G.

4.10.3 Economic Analysis

Transportation improvements can affect social and economic conditions within the local area and region in which they occur in several ways. They can improve or constrain physical access to existing commercial and residential uses. They can also open land for potential development where access did not exist or was limited prior to the implementation of the transportation improvements. In the case of the alternatives under consideration (discussed in terms of groups of alternatives, known as 'cases'), physical access is essentially maintained for existing uses and currently vacant land. This type of social and economic effect, which may include impacts on property values, is therefore limited and not measured in this analysis.

There are also social and economic benefits to reducing crashes because of the roadway geometry, shoulder widths, and other design characteristics of the transportation improvements. Benefits may also accrue because of operational improvements in signalization and other traffic control measures. While such benefits are important and discussed in Sections 4.4 through 4.6, they will not be sufficiently quantified in this planning study to allow for economic measures of their magnitude.

An additional class of social and economic effects of transportation improvements, and often the most significant from a social and economic impact standpoint, are changes in accessibility. Accessibility has three components with direct social and economic consequences: travel times, vehicle miles travelled, and mode choices. In this study, travel time differences between the existing and future no-build conditions, and the proposed 'cases' represent the primary measurable social and economic effects of alternatives.

The analyses which follow compare the differences in travel times between alternative cases derived in the traffic demand model. The analyses then estimate the dollar value of those changes using commonly accepted measures of the value of time found in transportation literature. Finally, the economic analysis compares the annualized value of travel time savings to the annualized cost of the alternative transportation investments.

Travel Time Savings

Travel time savings can benefit local and regional economies in several ways:

- Reduction in commuting times benefits workers by increasing the amount of time they can spend in more pleasurable and/or more productive activities than commuting.
- It can boost the productivity of labor – travel time savings increase output per hour because workers are less stressed by their commute, more focused and able to spend more time on work tasks.
- Business productivity is boosted by increasing the effective reach of a business to its potential labor force; the same commuting times now apply to a larger geographic area and pool of potential workers.
- For goods movements, where even very minor travel time savings have direct consequences to the costs of shipping, businesses can increase the effective geographic reach of their markets.
- For seasonal visitors – an especially important segment of traveler for the Cape Cod economy – reduced travel allows more opportunities to spend time on shopping and other recreational activities, thereby enhancing the value of their experience on the Cape and possibly increasing visitor spending within the local economy.
- Finally, reduced travel times for non-work trips enhance the quality of life and personal satisfaction of residents, making Cape Cod a more desirable place to live and work, with consequent effects on property values and business location decisions.

Exhibit 4-41 presents the annual vehicle hour savings during weekday AM and PM peak periods (commuter travel periods) attributable to each demand model case compared to future (2040) no-build condition. The annual vehicle hour savings increases as additional transportation improvements are implemented, from 38,000 annual hours of savings for Case 1 to nearly 91,000 hours savings in Case 3A.

For the average daily commuter, the time saved annually could range from as much as 2 hours in Case 1 to over 4 hours in Case

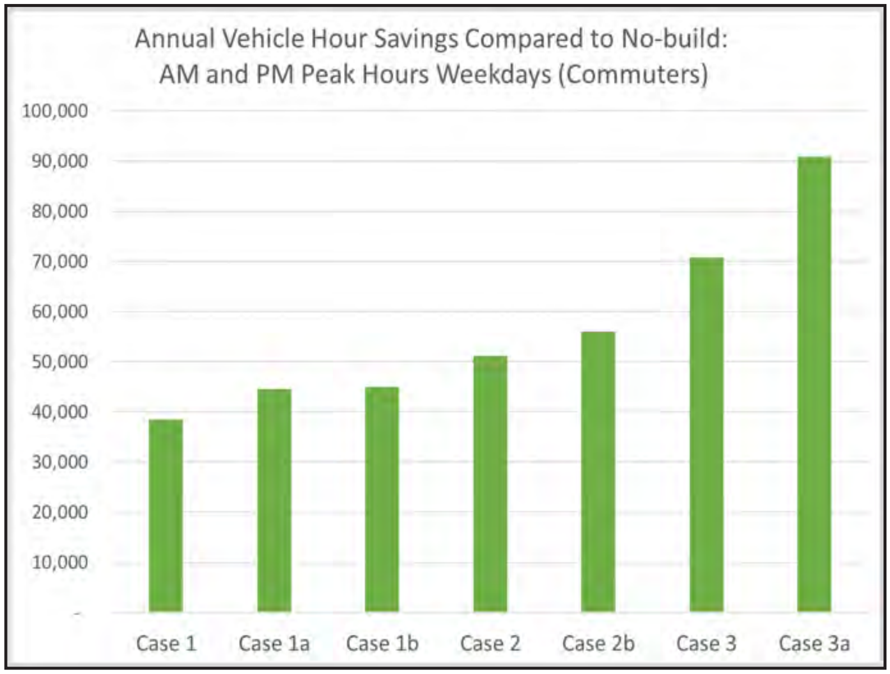


Exhibit 4-41 Annual Vehicle Hours Savings (2040 Weekday AM/PM Peak Periods)

3a. [3] As noted, these reductions in travel times can improve not only commuter satisfaction but also business productivity, including accessibility to a larger labor force, making the Cape more attractive for new businesses and investment to expand existing businesses.

Exhibit 4-42 presents annual vehicle hour savings compared to future no-build during summer weekend days, illustrating the relative merits of each case in facilitating seasonal visitations.[4] The annual vehicle hour savings increases during the summer weekend days as additional transportation improvements are implemented, from 150,000 annual hours of savings for Case 1 to 300,000 hours savings in Case 3A. Case 3A performs best in this comparison, reducing by almost 25% the delays otherwise experienced under no-build. Visitor spending can be boosted with less time (and expense) on the roads as well as the overall quality of their vacation experience. This can improve prospects for return visits as well as their personal and social media communications that might encourage others to visit.

Exhibit 4-43 presents annual vehicle hour savings compared to no-build for all trips, including the non-summer weekday PM and summer Saturdays peak hours, plus non-peak trips

3 There are approximately 21,400 daily commuters, 12,800 (60%) Cape to off-Cape and 8,600 (40%) off-Cape to Cape. On the roadway links for which travel times are measured for this study the improvements will save peak periods travelers between 4% (Case 1) and 9% (Case 3a) of the time they would otherwise spend under no-build in 2040.

4 Peak season weekend days, for the purposes of this analysis, are defined as the 30 weekend days and holidays between Memorial Day and Labor Day.

(therefore, the hours saved for the combination of the 'summer Saturday' and 'AM and PM commute' do not equal 'all trips' in Exhibit 4-43 because there are time periods included for 'all trips' calculation that are not included in either the non-summer weekday PM or summer Saturday peak periods).

The greater level of transportation investment in Cases 2B, 3, and 3A compared to the other alternatives leads to a greater reduction

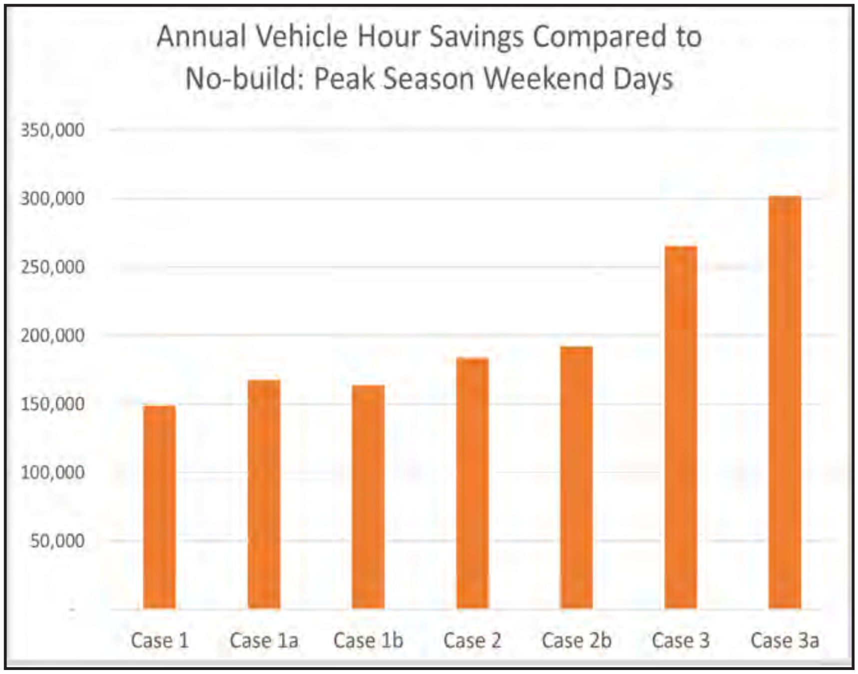
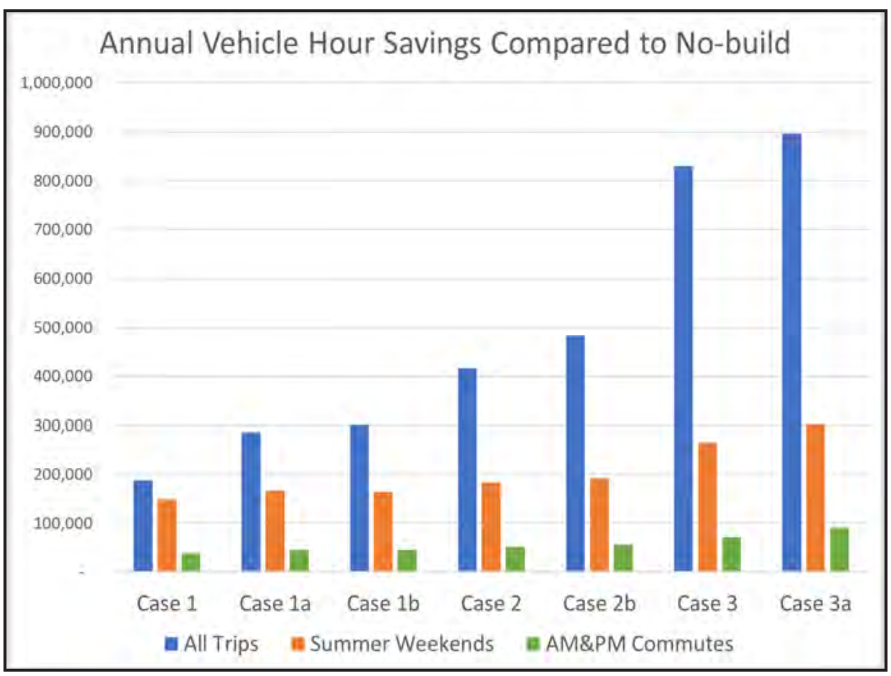


Exhibit 4-42 Annual Vehicle Hours Savings (2040 Summer Saturday Peak Period)

Exhibit 4-43 Annual Vehicle Hour Savings (2040 All Trips)



in travel times when all peak and non-peak trips are considered. For the aggregate annual vehicle hours traveled along the links analyzed in this study, the transportation improvements would save between 1% (Case 1) and 6% (Case 3A) in total travel time compared to the no-build condition in 2040.

As noted, these reductions in travel times can improve not only commuter satisfaction but also business productivity, including accessibility to a larger labor force, making the Cape more attractive for new businesses and investment to expand existing businesses.

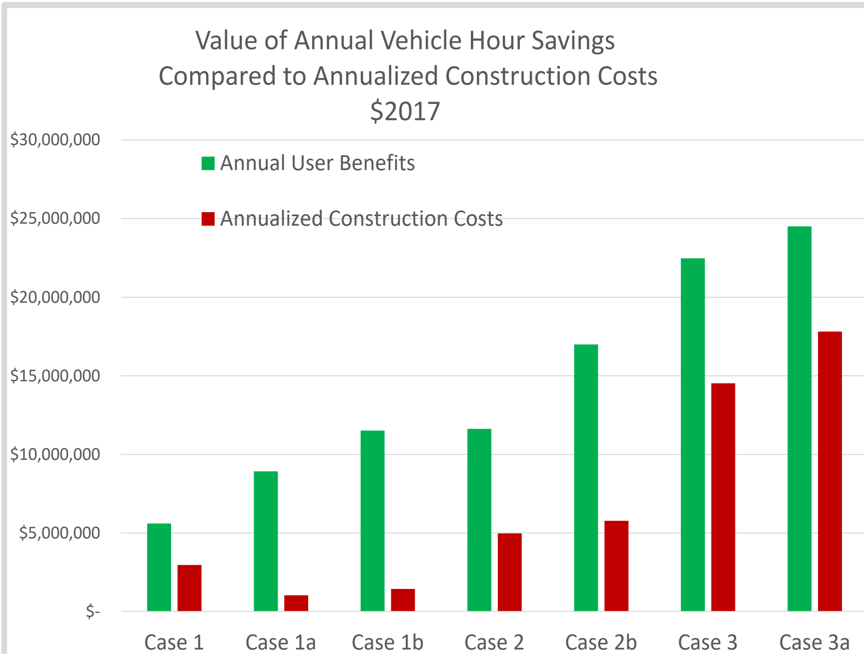
Travel time savings can be assigned per-hour dollar values and compared to annualized construction costs to measure the relative benefits of each alternative to users of the roadways[5]. This "User Benefit/Cost Analysis" is a tool commonly used by the Federal Highway Administration (FHWA) to evaluate funding applications for TIGER grants and other federal-aid projects. It is one measure of the relative merits of transportation projects but is not meant to substitute for the more inclusive evaluations conducted under state/federal environmental review under the Massachusetts Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA). These reviews would include a broader analysis of potential environmental, social, and economic effect.

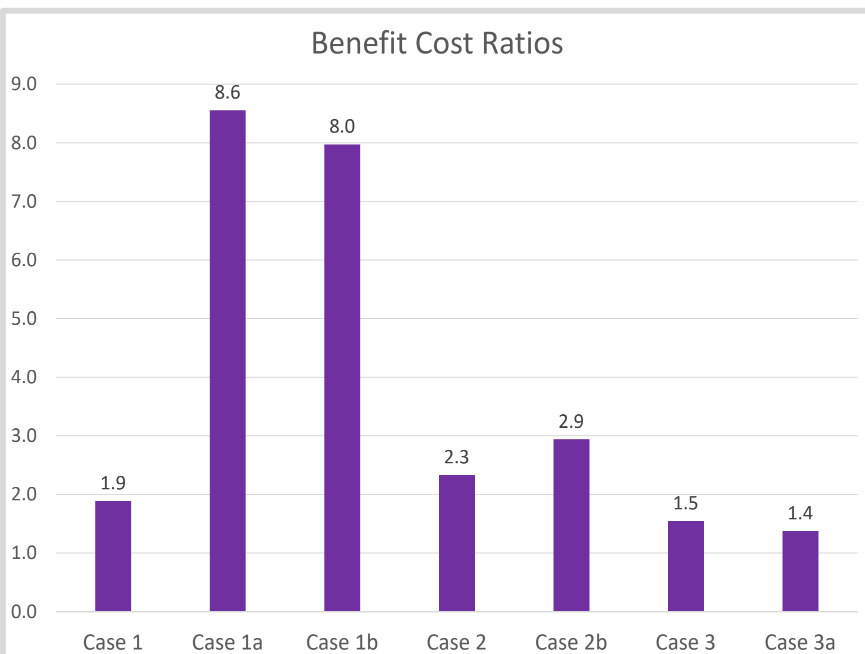
Exhibit 4-44 show the comparison of annual vehicle hour savings values to annualized construction costs. This exhibit demonstrates the favorable cost-benefit ratio of these improvements, ranging from 1.9:1 for Case 1, 7.9:1 for Case 1A, 2.3:1 for Case 2 and 1.4:1 for Case 3A. In each case, the value of travel time savings to users – which include commuters, other personal trips, peak weekends seasonal visitors, and truck trips – substantially exceed the annualized construction costs. The

5 The study team used dollar values for commuter, visitor, and non-business resident trips recommended in USDOT, Office of the Secretary of Transportation, Revised Guidance on Valuation of Travel Time in Economic Analysis, September 27, 2016 and adapted to local wage and income data provided by the Massachusetts Department of Labor & Workforce Development and the US Department of Commerce Bureau of Economic Analysis Regional Economic Information System (2016); and hourly value of freight estimates (assumed at 12% of total trips) from sources in the peer reviewed transportation literature, including Mahady & Lahr, Endogenous Regional Growth through Transportation Investment, National Academy of Sciences, Transportation Research Record, January 2009. Construction costs were estimated by Stantec (October 2018) and annualized over 20 years at a presumed 5% bond rate. Any and all of these analytic assumptions are subject to revision in subsequent project evaluations. The per hour dollar value of trip types used in this analysis are: commuters $32.41; seasonal visitors $19.04; other resident trips $16.20; trucks $90.

higher dollar value of user benefits shown in Cases 1A and 1B is a consequence of its relatively better performance in facilitating peak period commuter trips, which are valued higher than seasonal visitor and non-commuting resident trips[6].

Exhibit 4-44 Annual Vehicle Hour Savings Compared to Annualized Costs





6 The per hour dollar value of trip types used in this analysis (see above footnote for sources) are: commuters $32.41; seasonal visitors $19.04; other resident trips $16.20; trucks $90.

4.11 SUMMARY OF CONCEPTUAL COST ESTIMATES

Conceptual cost estimates were developed for each of the potential transportation improvements. Table 4-42 provides a summary of the conceptual cost estimates by location and Table 4-43 provides a summary of the conceptual cost estimate by case. More detailed conceptual cost estimates, including alternatives not selected for advancement, are provided in Appendix E. The methodology used to develop these costs is described in Section 4.2.2.

The cost estimate for potential roadway improvements and multimodal improvements are presented in Sections 4.4 and 4-11, respectively.

Table 4-42 Summary of Conceptual Cost Estimate by Location

ALTERNATIVES	2017 ($ MILLION)	2030 ($ MILLION)	2040 ($ MILLION)
Scenic Highway to Route 25 WB Ramp	$7	$11	$16
Route 6 Exit 1C Relocation	$30	$51	$75
Route 28 NB Ramp to Sandwich Road and Intersection Signalization	$6	$11	$16
Bourne Rotary Reconstruction (3 signalized intersections)[1]	$11	$18	$26
Belmont Circle Reconstruction	$14	$23	$33
Route 6 Eastbound Travel Lane	$29	$48	$71
Bourne Rotary Interchange[2]	$52	$87	$127
Bourne Bridge Approaches[3]	$51	$84	$125
Sagamore Bridge Approaches[3]	$39	$64	$95

[1] Includes cost of Route 28 NB Ramp to Sandwich Road and Intersection Signalization.
[2] Includes cost of Bourne Rotary Reconstruction (Alternative 2)
[3] Includes approach roadway and bridge relocation and retaining walls

Table 4-43 Summary of Conceptual Cost Estimate by Case

CASE	2017	2030	2040
Case 1	$37	$62	$91
Case 1A	$13	$22	$32
Case 1B	$18	$29	$42
Case 2	$62	$103	$150
Case 2B	$72	$121	$177
Case 3[1]	$181	$299	$441
Case 3A[1]	$222	$368	$542

[1] Includes highway approaches to Bourne and Sagamore Bridges. Does not include cost of replacement Bourne and Sagamore Bridges

4.12 SUMMARY OF POTENTIAL ENVIRONMENTAL, COMMUNITY, AND PROPERTY IMPACTS

A summary of potential impact to environmental and community resources, and public and private property are provided below in Table 4-44 and Table 4-45 by location and by case, respectively. The boundaries of these resources are based on information from the MassGIS database or generated using publicly available information. Potential impact to these resources are based on the conceptual designs for transportation improvements developed and analyzed as part of the study process, and serve as a means to provide an order-of-magnitude understanding of the potential impact and provide a means to compare alternatives to one another.

Table 4-44 Potential Environmental, Community, and Property Impact by Location

LOCATION	ENVIRONMENTAL (ACRES)				COMMUNITY (ACRES)		PROPERTY (ACRES)		
	WETLAND	100-YEAR FLOODPLAIN[1]	RARE SPECIES	WATER SUPPLY (ZONE I/II IWPA[2])	OPEN SPACE	HISTORIC RESOURCES	RESIDENTIAL/ PUBLIC	COMMERCIAL	UTILITY
Route 6 Exit 1C Relocation	0	0	7.2	5.7	0.6	0.2	0.2	0.9	3.8
Scenic Hwy to Route 25 Ramp	0	0	0	0.2	0	0	0	0	0.9
Belmont Circle (3 Leg Roundabout with Signalized Intersection)	0.3	4.7	0	0.5	0.1	0	<0.1	<0.1	0
Belmont Circle (Route 25 Eastbound Flyover)	0.5	5.4	0	0.5	0.1	0	<0.1	<0.1	0
Bourne Rotary (3 Signalized Intersections)	0	0	0	0	0.4	0	0.4	0	0
Bourne Rotary Interchange	0	0	0.2	0	0.4	0	0.3	2.2	0
Route 6 Eastbound - Additional Travel Lane	0	0	3.9	0	0	0	0	0	0

[1] Conceptual impact to 100-year floodplain calculated in acres.
[2] IWPA – Interim Well Protection Area

Table 4-45 Potential Environmental, Community, and Property Impact by Case

CASE (COMPONENTS OF EACH CASE LISTED ON TABLE 4-31)	ENVIRONMENTAL (ACRES)				COMMUNITY (ACRES)		PROPERTY (ACRES)		
	WETLAND	100-YEAR FLOODPLAIN[1]	RARE SPECIES	WATER SUPPLY (ZONE I/II IWPA[2])	OPEN SPACE	HISTORIC RESOURCES	RESIDENTIAL/ PUBLIC	COMMERCIAL	UTILITY
Case 1	0	0	7.2	5.9	0.6	0.2	0.2	0.9	4.7
Case 1A	0	0	0	0.2	0.2	0	0	0	0.9
Case 1B	0	0	0	0.2	0.4	0	0.4	0	0.9
Case 2	0.3	4.7	7.2	6.4	1.1	0.2	0.6	0.9	4.7
Case 2B	0.5	5.4	7.2	6.4	1.1	0.2	0.6	0.9	4.7
Case 3	0.3	4.7	11.1	6.4	1.1	0.2	0.6	0.9	4.7
Case 3B	0.3	4.7	11.3	6.4	1.1	0.2	0.5	3.1	4.7

[1] Conceptual impact to 100-year floodplain calculated in acres.
[2] IWPA – Interim Well Protection Area

4.13 MULTIMODAL IMPROVEMENTS

Improvements to multimodal transportation facilities in the study area were evaluated, including improvements to pedestrian, bicycle, transit, bus, and park-and-ride facilities. This evaluation considered improvements to existing facilities, new connections between existing facilities, and construction of new facilities. The existing multimodal transportation facilities in the study area are described in Section 2.6.

4.13.1 Bicycle/Pedestrian Facility Improvements

There are several high-quality bicycle/pedestrian facilities in the study area including the seven-mile long service roads (bike paths) along the north and south side of the Cape Cod Canal and the 10.6-mile long Shining Sea Bike Path in Falmouth. Route 6A in the study area is a designated bike route (Exhibit 2-45).

Currently ongoing improvements to bicycle/pedestrian facilities in the study area include the development of a shared-use path adjacent to the Service Road in Sandwich (a state project scheduled for 2022 construction) and the reconstruction and widening of portions of the Shining Sea Bikeway in Falmouth (municipal project, scheduled for 2020 construction).

The Cape Cod Commission completed a feasibility study in 2017 of the Bourne Rail Trail – a bike trail that would connect the north end of the Shining Sea bikeway to the Cape Cod Canal bike path. There is strong local support for this trail from state senators and representatives, the boards of selectman in Bourne, Falmouth, and Sandwich, and the 'Friends of the Bourne Rail Trail' advocacy group.

Exhibit 4-45 New Bicycle/Pedestrians Connections to Cape Cod Canal Bike Trail

Bicycle/Pedestrian Improvements

The following section presents potential improvements to bicycle and pedestrian facilities in the study area.

Improved Bicycle/Pedestrian Connections to Canal Service Roads

While there are several accessible connections to the Canal service roads (bike paths) from the local roadway network or parking lots, there are also notable areas that lack an accessible, ADA-compliant connection to the service road. Access and use of the Canal service road by all users could be improved through the construction of new accessible connections to the service road from the local roadway network.

Gaps in the accessible connections to the Canal service road were identified both north and south of the Canal. Three potential locations were identified to provide access to the service road from local roads, including new connections from Pleasant Street and the Bourne Ball Field, (south of the Canal in Bourne) and at Old Bridge Road on the north side of the Canal in Bourne (Exhibit 4-45).

Pleasant Street, Bourne

Location: Pleasant Street in Bourne is south of the Canal and east of the Sagamore Bridge. The new connector path to the service road would be to the west of 39 Pleasant Street.

Challenges: While this new connection to the Canal service road would not impact any regulated environmental resources, it would require a minor acquisition of private property and close coordination with the USACE (owner of the Canal service road) and the MBTA to allow a crossing of the Cape Cod Rail Line adjacent to the Canal service road.

Conceptual Cost Estimate: $25,000 (2017 costs)

Bourne Ball Field, Bourne

Location: The Bourne Ball Field is located at 861 Sandwich Road in Bourne. The Ball Field is south of the Canal, east of the Sagamore Bridge. An informal 125-foot long path currently exists, which extends from Pleasant Street, crossing the Canal rail line, to the Canal service road.

Challenges: While this new connection to the Canal service road would not impact any regulated environmental resources, it would require close coordination with the USACE and the MBTA to allow a crossing of the Cape Cod Rail Line adjacent to the Canal service road.

Conceptual Cost Estimate: $50,000 (2017 costs)

Old Bridge Road, Bourne

Location: Old Bridge Road is accessed from Main Street in Bourne, north of the Canal and west of the Bourne Bridge. An informal 125-foot long path currently exists, which extends from Pleasant Street, crossing the Canal rail line, to the Canal service road.

Challenges: This new connection to the Canal service road would require the filing of a Notice of Intent with the Bourne Conservation Commission, as it is within the 100-year floodplain of the Canal. It would require close coordination with the USACE to allow access to the Canal service road.

Conceptual Cost Estimate: $20,000 (2017 costs)

Improved Bicycle/Pedestrian Access to and Across the Cape Cod Canal

Residents and visitors in the study area would benefit from improved bicycle/pedestrian facilities crossing the Canal on the Sagamore and Bourne bridges. The existing Canal bridges each have five-foot wide sidewalks on one side of the bridge but generally lack suitable sidewalk connections between the bridges, the local roadway system, and the Canal bike path. As the travel lanes on the bridges lack roadway shoulders, vehicles travel right next to the existing sidewalk. The proximity of vehicles to pedestrians on the bridge sidewalk creates discomfort for some pedestrians, discouraging sidewalk use. Viewing platforms and benches for pedestrians are also lacking along the bridges' approximately 2,000-foot length. The lack of roadway shoulders also results in the bridges being unsuitable for bicycle travel.

Several potential locations to improve bicycle/pedestrian travel across the Canal were evaluated. While the facilities on the bridges themselves cannot be updated at this time, the sidewalks that approach the bridges could be widened and reconstructed to meet ADA-compliance. Further, gaps in the sidewalk network could be completed to allow for an uninterrupted sidewalk access across the Canal to the local roadway network or the Canal bike path. Specific improvements at the Sagamore and Bourne Bridges are described below.

Location: Sagamore Bridge Area (Exhibit 4-46)

North of the Sagamore Bridge: reconstruct and widen existing 800-foot sidewalk from Canal Road (at the Sagamore Park and Ride lot) to the north side of the Sagamore Bridge.

South of the Sagamore Bridge: Construct 1,000 feet of new ADA-compliant sidewalk adjacent to the east side Route 6 and Cranberry Highway from the south end of the existing sidewalk to Adams Street. To provide a connection to Sandwich Road, construct a shared-use path along Adams Street. Since Adams was converted in 2015 to one-way (south) travel only, additional paved space exists for use as a shared-use path. From the north end of Adams Street (at Sandwich Road), an additional crosswalk connection could be made to the Canal Bike Path using the Bourne Ball Field connector.

Conceptual Cost Estimate: $3.9 million (2017 costs)

Location: Bourne Bridge Area (Exhibit 4-47)

North of the Bourne Bridge: Construct a 1,200-foot-long ADA-compliant sidewalk from the east side of Belmont Circle (shopping plaza entrance drive) to the north side of the Bourne Bridge.

Conceptual Cost Estimate: $800,000 (2017 costs)

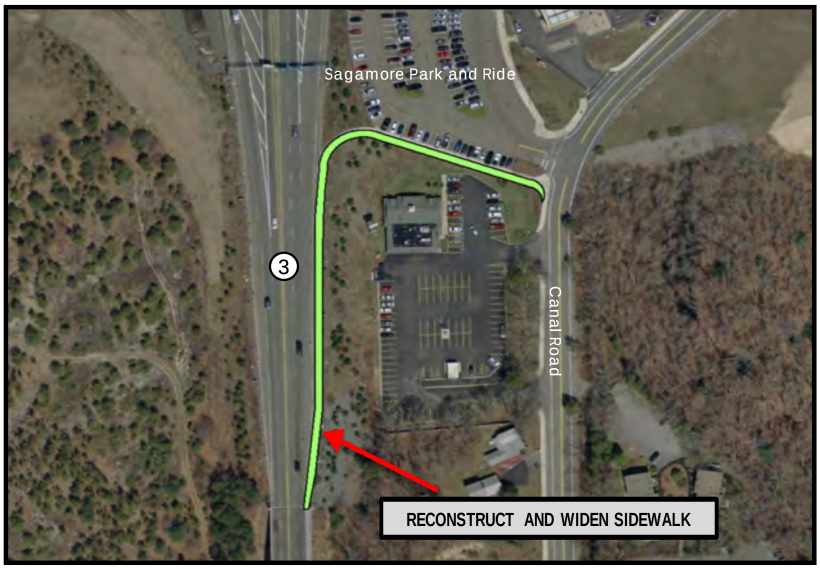
South of the Bourne Bridge: A bicycle/pedestrian improvement project was completed by MassDOT during the summer of 2017, when MassDOT constructed a 750-foot long extension of the

Text continues on page 4-120.

Exhibit 4-46 Bicycle/Pedestrian Connections at Sagamore Bridge

Desired Bicycle/Pedestrian Access over Sagamore Bridge

Bicycle/Pedestrian Access over Sagamore Bridge (North of Canal)



Bicycle/Pedestrian Access over Sagamore Bridge (South of Canal)

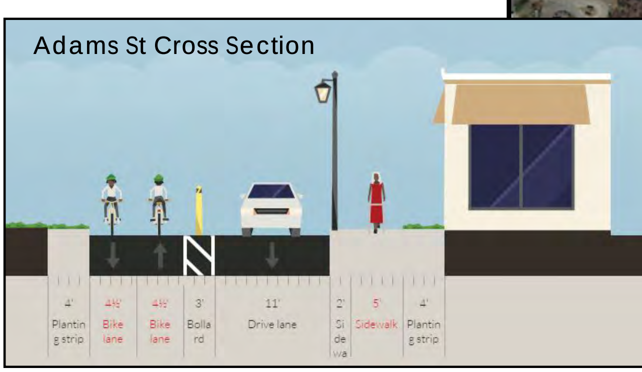
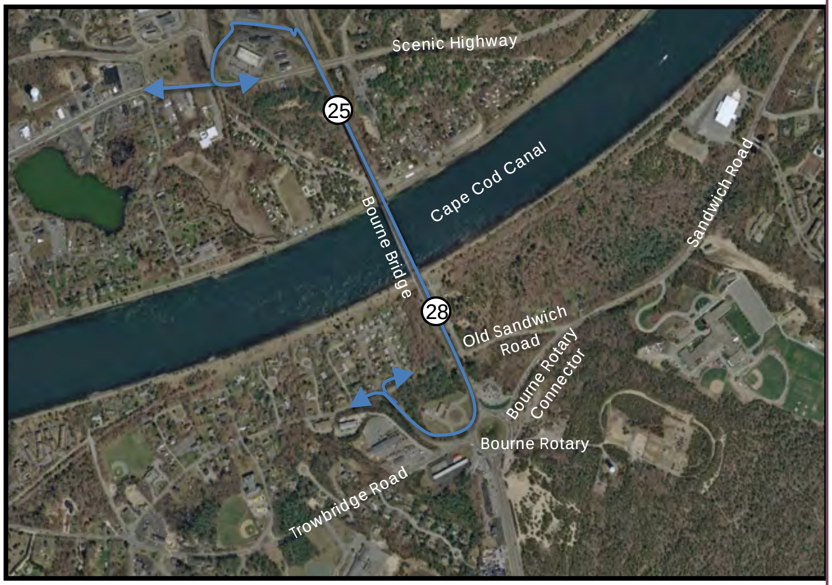


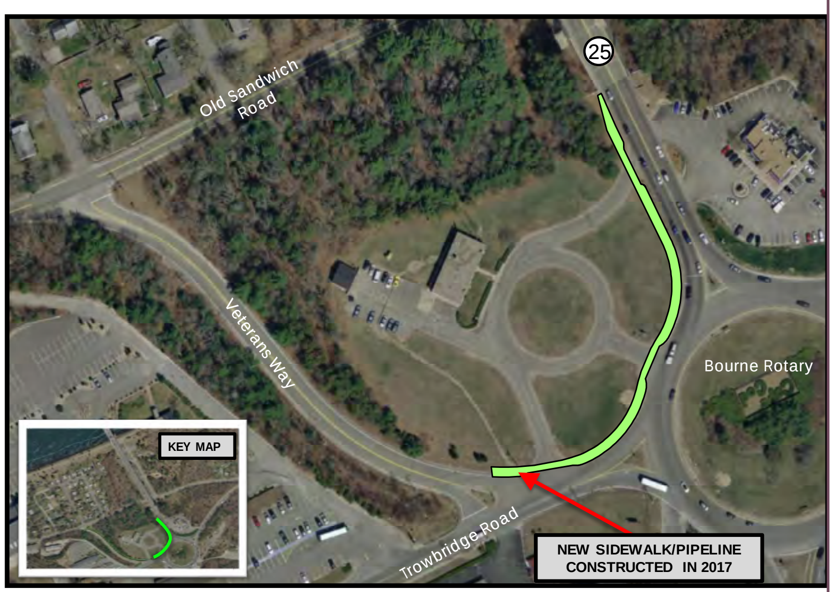
Exhibit 4-47 Bicycle/Pedestrian Connections at Bourne Bridge

Desired Bicycle/Pedestrian Access over Bourne Bridge



Bicycle/Pedestrian Access over Bourne Bridge (North of Canal)

Bicycle/Pedestrian Access over Bourne Bridge (South of Canal)



sidewalk on the south side of the Bourne Bridge. This 10-foot wide sidewalk wraps around the state police barracks property to the intersection of Veterans Way and Trowbridge Road.

Improved Bicycle/Pedestrian Accommodation along Bus Routes

Multimodal travel in the study area could be enhanced through improvements in bicycle and pedestrian facilities along bus routes. This is an important part of an overall effort towards creating an integrated multimodal transportation system.

Several key bus routes in the study area, including those along County Road and Route 151 along the Bourne Run bus line and Route 6A, Route 130, Service Road, and Quaker Meeting House Road along the Sandwich Line. The roadways along these bus routes lack consistent ADA-compliant sidewalks, roadway shoulders suitable for bicycle travel, bus shelters, and bike racks.

4.13.2 Multimodal Transportation Center

Multimodal centers provide commuters and other travelers with free and secure parking when transferring to carpool or transit services. These centers are beneficial for reducing the cost of daily commutes and reducing traffic volumes by limiting single-occupant vehicle travel. A transportation center, such as the Hyannis Transportation Center, generally provides vehicle parking, bike racks, indoor areas to purchase transit tickets, public bathrooms, visitor information, and vending. A simpler transportation center (a Park & Ride lot) typically provides parking and a bus shelter.

As noted in Section 2.6.9, there are two Park & Ride lots along the Route 3/Route 6 corridor, including the 377-space Sagamore lot located north of the Cape Cod Canal at Route 3 Exit 1A (the Route 3/Route 6 [Scenic Highway]) interchange in Bourne and the 365-space lot at Route 6 Exit 6 in Barnstable. These lots are serviced by the Plymouth & Brockton (P&B) Bus Company, which operates daily bus routes from Hyannis to Boston. Local bus connections to the Park & Ride lots are provided by the Cape Cod Regional Transit Authority (CCRTA).

A new Park & Ride lot at Route 6 Exit 2 (Route 130) would reduce traffic volumes by providing additional commuter parking.

These lots are heavily used by commuters and are often at or near capacity. A mid-week occupancy count, conducted at the Sagamore lot in October 2016, found the lot was 99% occupied.

The feasibility of constructing an additional Park & Ride lot along Route 6 between the existing lots at Exit 1A in Bourne and Exit 6 in Barnstable was evaluated.

A new lot at Exit 2 (Route 130) was determined feasible because MassDOT owns sufficient land at the southwest quadrant of the interchange, there are no wetland resources present, and the P&B bus line and CCRTA Sandwich line already pass by this location. Furthermore, the western terminus of the upcoming Service Road shared-use path is Route 130 at this location. The hilly topography of this parcel may initially limit the size of the lot to approximately 100 cars, but a larger lot could be constructed with additional site grading (Exhibit 4-48).

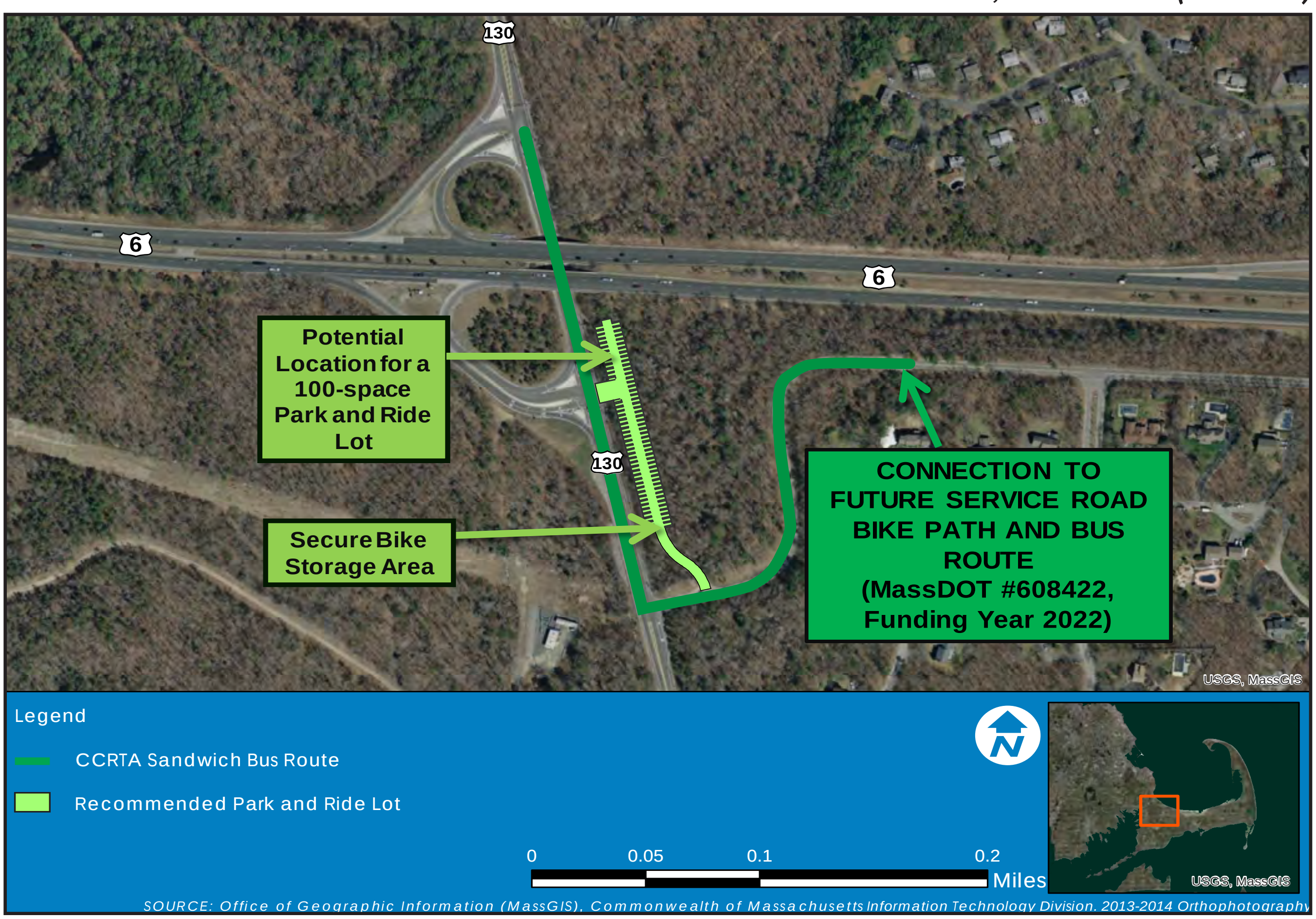
Conceptual Cost Estimate

The conceptual cost for the Park & Ride lot at Route 6 Exit 2 is provided in Table 4-46, by construction year. More detailed conceptual cost estimates are provided in Appendix E.

Table 4-46 Route 6 Exit 2 Park and Ride Lot - Conceptual Cost Estimate by Build Year

	2017 ($ MILLION)	2030 ($ MILLION)	2040 ($ MILLION)
Park and Ride Lot	2.8	4.6	6.8

Exhibit 4-48 Park & Ride Lot, Route 6 Exit 2 (Route 130)







DRAFT FOR REVIEW - SUMMER 2019

CAPE COD CANAL TRANSPORTATION STUDY

Prepared by:

Stantec

CONTENTS

EXHIBITS

TABLES

Study Recommendations

The recommendations for the Cape Cod Canal Transportation Study are based on the ability of the potential transportation improvement alternatives to meet the study's goals and objectives. As defined in Chapter 1, the goals and objectives of this study are:

Goals

- Improve transportation mobility and accessibility in the Cape Cod Canal area and provide reliable year-round connectivity over the Canal and between the Sagamore and Bourne Bridges.

Objectives

- Improve multimodal connectivity and mobility across the Canal to avoid degrading quality of life on the Cape.
- Ensure that cross-Canal connectivity does not become a barrier to reliable intra community travel within Bourne and Sandwich.
- Create a reliable multimodal connection across the Canal to assure public safety in the event of an emergency

evacuation of portions of the Cape and accommodate first responders trying to reach the Cape.

The alternatives that best met these goals and objectives were determined through a combination of analytical methods and an extensive public participation process.

5.1 EVALUATION CRITERIA

Alternatives were compared to the future no-build transportation conditions on their ability to meet the evaluation criteria established with input from the Working Group at the onset of the study (Chapter 1, Table 1-1). These evaluation criteria were developed with the aim of advancing the study's goals and objectives and consist of various measures of an alternative's impact on the following categories:

- transportation
- safety
- environmental and community resources
- economic development

Review of an alternative's performance compared to the future no-build condition provides an opportunity to gain a complete understanding of an alternative's potential benefits and impacts prior to making study recommendations.

5.2 EVALUATION METHODOLOGY

The recommendations for roadway improvements are based on the effectiveness and potential benefits and/or impacts of the various suite of improvements evaluated under the travel analysis model cases. A matrix was developed to compare each of the travel analysis model cases against the future no-build conditions. This evaluation matrix characterizes the transportation performance or potential environmental or property impact category based on either quantifiable data (using existing data or data produced for this study) or subjective qualitative measures.

The matrix uses different symbols to indicate minor, moderate, or substantial benefits or impact. If no impact or benefit is anticipated (or an environmental resource is not present) a neutral symbol is used. The specific definitions used to differentiate minor, moderate, or substantial impact to environmental resources are provided in Exhibit 5-1.

The complete Evaluation Matrix is provided in Exhibit 5-2. Ultimately, review of the completed evaluation matrix and consultation with the Working Group and the public, aided MassDOT's decision-making process to identify which Case to recommend for advancement into MassDOT's project development process.

Exhibit 5-1 Alternatives Evaluation Matrix – Definition of Benefit and Impact Ratings

Alternatives Evaluation Matrix Legend				
Category	**Benefit Levels**			
	◇	○	◒	●
Safety (Emergency Vehicle Response Time) **Bicycle/Pedestrian (facilities or access)**	**Neutral**	**Minor or No Impact**	**Modest Benefit**	**Substantial Benefit**
	Impact Levels			
	◇	○	◒	●
	Neutral (No impact or resource not present)	**Minor or No Impact**	**Modest Impact**	**Substantial Impact**
Wetlands			5,000 SF - 1 acre of wetlands	> 1 acre of wetlands
Rare Species			> 1 acre of work in rare species habitat	Requires a Conservation Management Permit
Area of Critical Environmental Concern (ACEC)			Impacts land within ACEC	Impacts wetlands within ACEC
100-Year Floodplain			Moderate fill within 100-year floodplain	Substantial fill within 100-year floodplain
Water Supply Protection Areas			Impact to land in DEP IWPA or Zone II	Impact to land in DEP Zone I or ORW
Air Quality/Public Health			Modest reductions in idle time/queueing	Substantial reductions in idle time/queueing
Open Space			Acquisition of open space land	Acquisition of open space affecting or active recreational facilities
Historic Resources			Impacts historic parcel or historic district	Adverse Effect on historic property
Land Use/Economic Development			Modest impact to residential, commercial, or utility-owned property	Substantial impact to residential, commercial, or utility-owned property

Exhibit 5-2 ***Evaluation Matrix – Comparison of Travel Analysis Model Cases***

Alternatives Evaluation Matrix																		
Category			2040 Future No-Build		Case 1		Case 1A		Case 1B		Case 2		Case 2B		Case 3		Case 3A	
			Rating	Data	Rating	Data / % Change from 2040 No-Build (000's)	Rating	Data / % Change from 2040 No-Build (000's)	Rating	Data / % Change from 2040 No-Build (000's)	Rating	Data / % Change from 2040 No-Build (000's)	Rating	Data / % Change from 2040 No-Build (000's)	Rating	Data / % Change from 2040 No-Build (000's)	Rating	Data / % Change from 2040 No-Build (000's)
Traffic	Vehicle Hours Traveled	Annual	◇	16.3 mil	○	530	○	659	◒	860	◒	1,070	◒	1,290	●	1,306	●	1,390
Traffic	Average Delay at BC & BR (mins)	Summer Sat	◇	6.8	○	6.5	◒	5.4	◒	5.1	◒	4.3	○	6.7	◒	7.9	●	3.7
Traffic	Average Delay at BC & BR (mins)	Fall PM	◇	3.4	◒	2.5	◒	2.6	●	1.0	●	0.6	●	0.4	●	0.5	●	0.2
Category																		
Safety / Emergency Response Time					○		○		◒		◒		◒		◒		●	
Bike / Ped (Safety and New Facilities)					◇		○		◒		◒		◒		●		●	
Environmental	Wetlands (acres)				○	0.0	○	0.0	○	0.0	◒	0.3	◒	0.5	◒	0.3	◒	0.3
Environmental	Rare Species (acres)				●	7.2	◇	0.0	◇	0.0	●	7.2	●	7.2	●	11.1	●	11.3
Environmental	100-yr Floodplain (acres)				◇	0.0	◇	0.0	◇	0.0	◒	4.7	◒	5.4	◒	4.7	◒	4.7
Environmental	Water Supply (Zone I/II,IWPA) (acres)				◒	5.9	○	0.2	◇	0.0	◒	6.4	◒	6.4	◒	6.4	◒	6.4
Community	Open Space (acres)				◒	0.6	○	0.2	○	0.2	◒	1.1	◒	1.1	◒	1.1	◒	1.1
Community	Historic Resources (acres)				◒	0.2	◇	0.0	◇	0.0	◒	0.2	◒	0.2	◒	0.2	◒	0.2
Property Impacts	Residential (acres)				○	0.2	◇	0.0	◇	0.0	○	0.5	○	0.6	○	0.6	○	0.5
Property Impacts	Commercial (acres)				◒	0.9	◇	0.0	◇	0.0	◒	0.9	◇	0.0	◒	0.9	◒	0.9
Property Impacts	Utility (acres)				●	4.7	◒	0.9	◒	0.9	●	4.7	●	4.7	●	4.7	●	4.7
Economic Impact					◒		◒		◒		●		◒		●		●	
2030 Cost ($ millions)						**60**		**20**		**30**		**100**		**120**		**300**		**370**

5.3 MULTIMODAL TRANSPORTATION IMPROVEMENT RECOMMENDATIONS

Multimodal transportation improvements were recommended for study area bicycling and pedestrian facilities, multimodal facilities, and roadways. The following sections describe these recommendations.

5.3.1 Bicycle and Pedestrian Improvements

Recommendation: Improve and expand bicycle and pedestrian facilities in the study area to encourage greater use of non-motorized transportation by residents and visitors.

The specific bicycle and pedestrian improvements recommended include the three categories of improvements listed below. These recommended improvements are described more fully in Section 4.13.1.

1. **New ADA-compliant pedestrian connections to the Cape Cod Canal Bikeway at three locations (Exhibit 4-45):**
    - Bourne Ballfield, Bourne;
    - Pleasant Street, Bourne; and
    - Old Bridge Road, Bourne.
2. **Improve bicycle and pedestrian connections to/from local roadways over the Canal at both the Sagamore and Bourne Bridges (Exhibit 4-46 and 4-47).**
3. **Improve bicycle/pedestrian accommodation along roadways in the study area, especially along bus routes, by providing:**
    - Accessible sidewalks and crosswalks;
    - Pedestrian signal phases at intersections;
    - Shelters at bus stops;
    - Bicycle racks;
    - Wayfinding signage; and
    - Bicycle accommodations in roadway shoulders.

These improvements could be stand-alone improvements or incorporated into a roadway improvement project.

Benefit: Improved and expanded bicycle and pedestrian facilities would encourage non-motorized travel and enhance recreational opportunities for residents and visitors. These improvements would advance the study goal of creating and improving multimodal mobility in the Cape Cod Canal area.

5.3.2 Multimodal Improvements

Recommendation: Develop a new Multimodal Transportation Center (with 100-space park and ride lot) at the Route 6 Exit 2 (Route 130) interchange.

Benefit: Additional park and ride facilities will encourage more travelers to use bus service and reduce single-occupant car travel. These improvements would advance the study goal of creating and improving multimodal mobility in the Cape Cod Canal area.

The location of a park and ride lot at the Route 6 Exit 2 (Route 130) interchange is desirable since it is owned by MassDOT and does not contain any regulated environmental resources. Additionally, the western terminus of the planned Service Road shared-use path is at this location.

5.4 ROADWAY IMPROVEMENTS

Recommendations for improvements to the study area roadway system were selected based on the travel model analysis and potential impact to environmental and community resources and public and private property. The recommendations are presented in two groups:

- Local intersection improvements, and
- Gateway intersection improvements (larger improvements).

The project development period for these projects will vary based on project complexity. Larger, more complex projects require a longer period to complete the design, environmental review and permitting, and (if required) land acquisition processes. For example, new highway ramps could require extensive coordination with local utility providers to ensure uninterrupted service and safety during the relocation of their equipment (if necessary).

To enhance multimodal accessibility, MassDOT will evaluate improvements to pedestrian, bicycle and transit facilities at each location. For pedestrians, these improvements may include accessible sidewalks, crosswalks, and signal systems. Bicycle improvements include separated bicycle lanes, marked bicycle lanes on roadway shoulders, and accessible connections to regional bicycle paths. These pedestrians and bicycle facility improvements enhance access to transit facilities.

As appropriate, transportation system design will incorporate Intelligent Transportation System (ITS) improvements to provide real-time traveler information, weather conditions, work-zone management, and emergency management information.

Close coordination between MassDOT and USACE will continue regarding the rehabilitation or replacement of the Canal Bridges and (as necessary) the relocation of the roadway and bridge approaches to these bridges.

5.4.1 Local Intersection Improvements

Recommendation: The recommended local intersection improvements include advancing several intersection improvement projects into the project development phase. As described in Section 4.4 and shown on Exhibits 5-3 and 5-4, these intersection improvements include the following potential transportation projects:

Signal timing improvements at two intersections:

1. **Scenic Hwy/Meeting House Lane at State Road/Canal Road; and**
2. **Scenic Highway at Nightingale Road.**

Intersection Improvements at three intersections

1. **Route 6A (Sandwich Road) at Cranberry Hwy;**
2. **Route 130 at Cotuit Road; and**
3. **Sandwich Road at Bourne Rotary Connector.**

Exhibit 5-3 Recommended Local Intersection Equipment Improvements

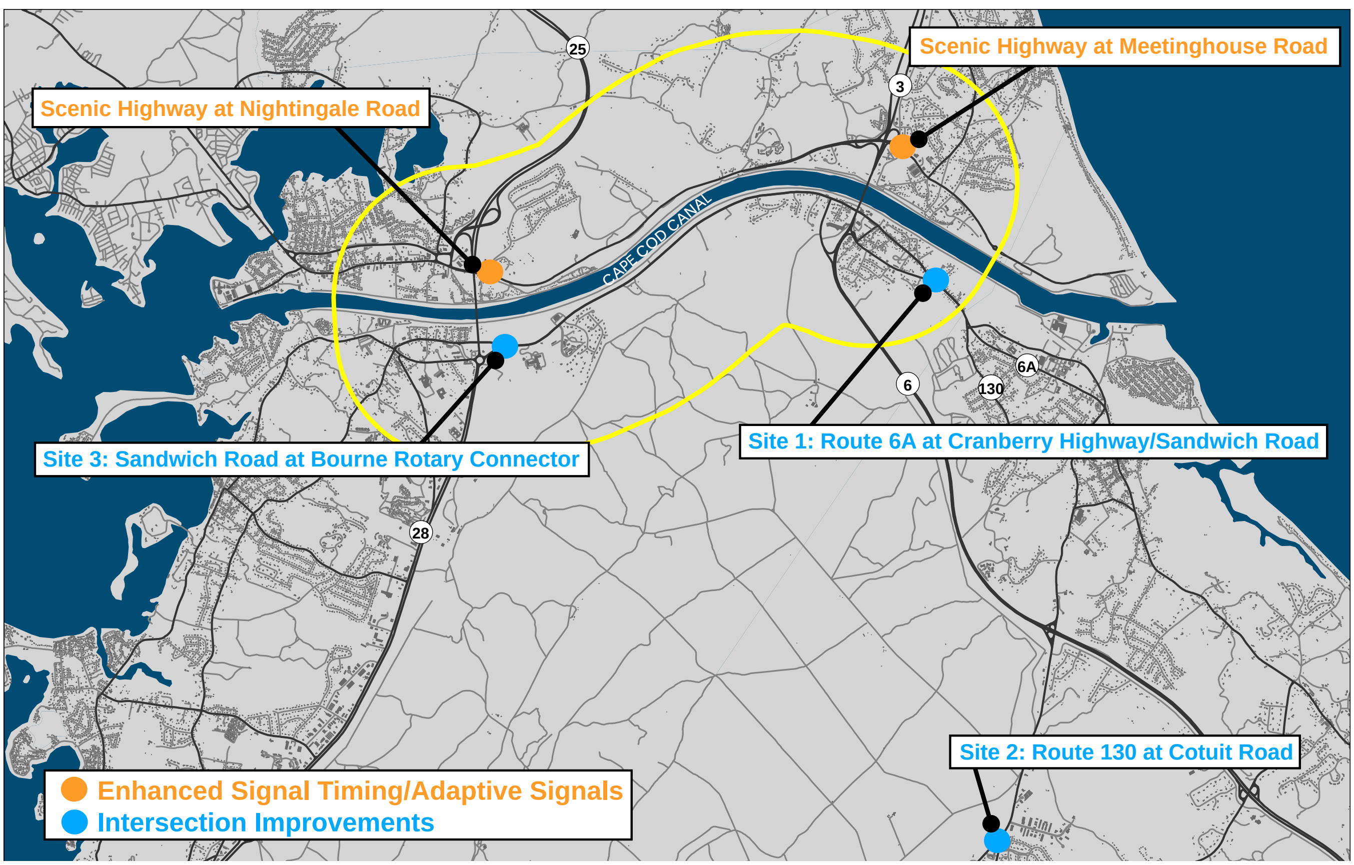


Exhibit 5-4 Recommended Local Intersection Reconstructions

Site 1
Route 6A (Sandwich Road) at Cranberry Highway

Site 2
Route 130 at Cotuit Road

Site 3
Sandwich Road & Bourne Rotary Connector

Benefit: These intersection roadway improvements represent a lower-cost method to reduce congestion and improve safety at key study area intersections. These improvements would advance the study goal of improving transportation mobility and accessibility in the Cape Cod Canal area.

5.4.2 Gateway Intersection Improvements

For each of the Travel Analysis Model Cases, the study team evaluated the results of the traffic analysis and the potential benefit or impact on the various evaluation criteria categories, as shown on the evaluation matrix (Exhibit 5-2).

In coordination with the Working Group, the components of Case 3A were identified as the transportation improvements that would most effectively satisfy the study's goals and objectives.

As described in Section 4.9 and shown on Exhibit 5-5, Case 3A includes the following improvements:

Table 5-1 Components of Case 3A - Recommended Gateway Intersection Improvements

LOCATION ON EXHIBIT 5-5	RECOMMENDED GATEWAY INTERSECTION IMPROVEMENT
A	Scenic Highway to Route 25 Westbound Ramp
B	Bourne Rotary Interchange
C	Belmont Circle Reconstruction
D	Route 6 – Relocation of Exit 1C
E	Route 6 – Additional Travel Lane to Exit 2 (Route 130)
F	Reconstruction of Sagamore Bridge Approaches
G	Reconstruction of Bourne Bridge Approaches
H	Replacement of Bourne and Sagamore Bridges (By USACE)

Case 3A was identified as the recommended set of transportation improvements because they would most effectively satisfy the study goals and objectives. Case 3A would:

- Provide the greatest long-term improvement in accessibility and mobility for Cape Cod residents, employers, and visitors;
- Provide a reliable multimodal transportation system to assure public safety in the event of an emergency evacuation of Cape Cod;
- Focus on improving existing infrastructure, thereby minimizing potential property takings and impact to natural and social environmental resources; and
- Accommodate the rehabilitation or replacement of the Canal bridges, envisioned as having two travel lanes and one auxiliary lane in each direction.

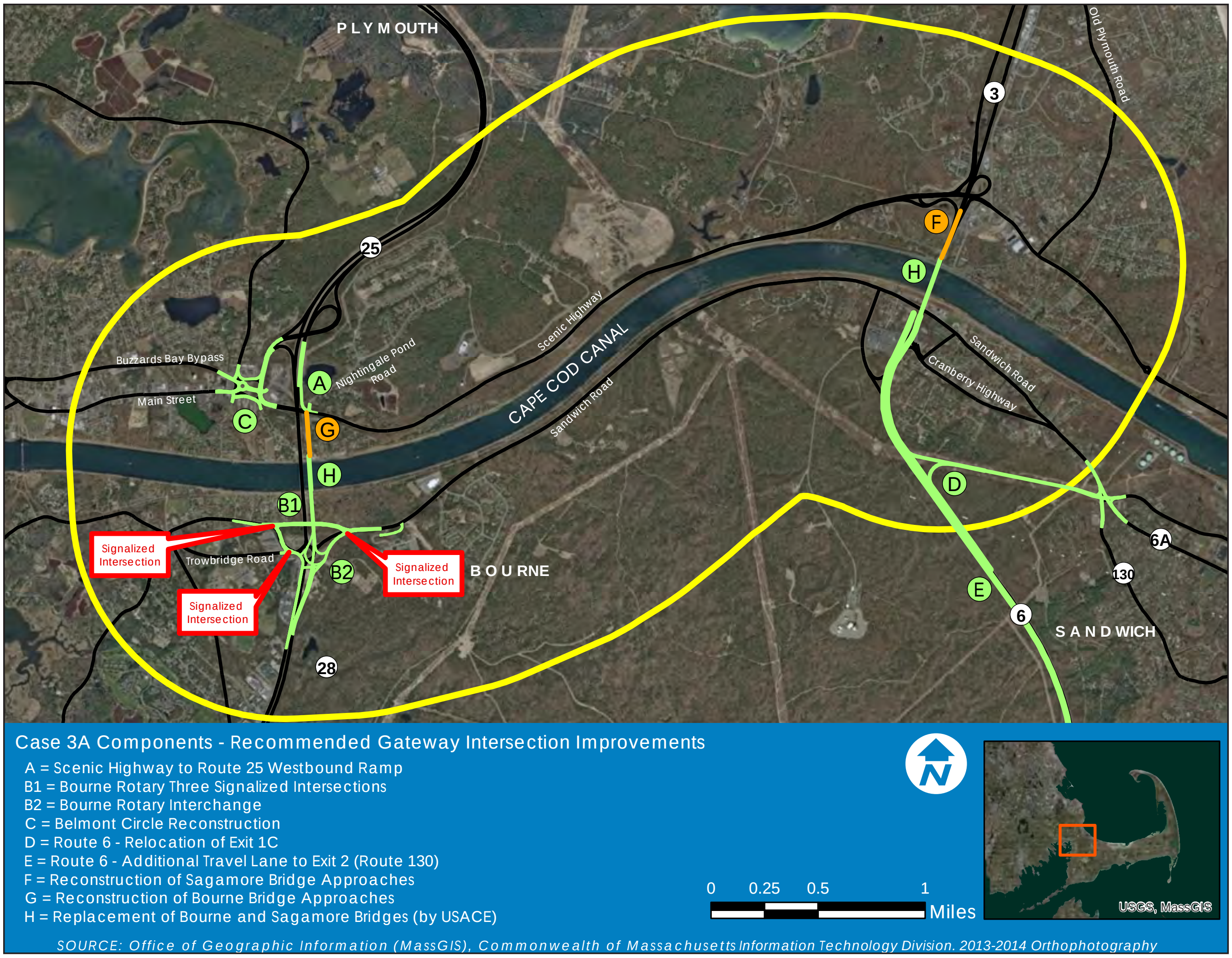


Exhibit 5-5 Components of Case 3A - Recommended Gateway Intersection Improvements

Potential Case 3A Stages:

The Case 3A improvements could be advanced as a single project or, as described below, through a series of up to four project stages. These potential stages could be combined into fewer stages or completed in different combinations of improvements. However, the benefits to advancing the Case 3A improvements in stages include:

- Lower financial commitment during any single construction period;
- Reduced community disruption;
- Independent benefit will be provided for each project stage;

- Benefits to transportation system increase as each successive stage is implemented;
- Each stage is compatible with other stages, resulting in no wasted transportation dollars;
- If desired, portions of certain stages could be combined.

Below is a description of four potential Case 3A stages.

Stage 1

1. **Scenic Highway to Route 25 westbound on-ramp (Component A on Exhibit 5-5)**
2. **Bourne Rotary – Three Signalized Intersections (Component B-1 on Exhibit 5-5)**

Benefit of Stage 1: Implementation of the Stage 1 improvements would substantially reduce delays at Both Belmont Circle and Bourne Rotary, especially during the non-summer weekday peak periods.

Challenges of Stage 1: Construction of a new highway on-ramp from Scenic Highway to Route 25 westbound would require the use of land containing natural gas lines, requiring close coordination with the utility provider and potential relocation of the gas lines. At Bourne Rotary, close coordination would be required to accommodate the relocation of the Technical High School driveway and for work adjacent to the state police barracks.

Stage 2

1. **Belmont Circle – Three-Leg Roundabout with Signalized Intersection (Component C on Exhibit 5 5)**

Benefit of Stage 2: This would further reduce delay at Belmont Circle and Bourne Rotary, especially during non-summer peak periods. Improvements to bicycle and pedestrian accommodations would improve access between the businesses and residential areas west of Belmont Circle in Bourne and Scenic Highway, the Canal bike trail, and the Bourne Scenic Park Campground.

Challenges of Stage 2: The reconstruction of Belmont Circle would impact regulated wetlands and floodplain, requiring the filing of a Notice of Intent with the Bourne Conservation Commission and appropriate wetlands avoidance and mitigation. Maintaining access to local business during construction would also be a priority.

Stage 3

1. **Relocation of Route 6 Exit 1C (Component D on Exhibit 5-5)**

2. **Route 6 – Additional Eastbound Travel Lane to Exit 2 (Route 130) (Component E on Exhibit 5-5)**

Unlike Stages 1 and 2, Stage 3 is not interrelated with the other Case 3A improvements and could be built at any time and improve traffic conditions. The full benefit of these improvements would be realized with a replacement Canal bridge in place. It is assumed that the relocation of Exit 1C will be required when the Sagamore Bridge is replaced.

Benefit of Stage 3: Would reduce delay on Route 6 westbound during both summer and non-summer peak periods. Delays are substantially reduced on Route 3 southbound when these improvements are combined with the replacement of the Sagamore Bridge.

Challenges of Stage 3: The relocation of Exit 1C and the additional eastbound travel lane on Route 6 would result in approximately 7.2 acres and 3.9 acres of disturbance to rare species habitat, respectively. These projects would require close coordination with the Massachusetts Natural Heritage and Endangered Species Program, including the preparation of a Conservation Management Permit with appropriate impact mitigation.

The relocation of Exit 1C would also require close coordination with the electrical utility provider, Eversource, to ensure that the use of 3.8 acres of their land for the roadway project is compatible with their long-term plans.

Stage 4

1. **Replacement of Bourne and Sagamore Bridges (by USACE) (Component H on Exhibit 5-5)**

2. **Reconstruction of Bourne and Sagamore Bridge Approaches (by MassDOT) (Components F & G on Exhibit 5-5)**

3. **Bourne Rotary Interchange (by MassDOT) (Component B-2 on Exhibit 5-5)**

Stage 4, combined with the other three project stages, would complete the implementation of the Case 3A transportation improvements.

Benefit of Stage 4: The implementation of the Stage 4 transportation improvements at the Sagamore Bridge area would substantially reduce delay on both Route 6 westbound and Route 3 southbound during both summer and non-summer peak periods.

With the reconstruction of the Bourne Rotary as a highway intersection, the Stage 4 improvements would eliminate nearly all delay at the Bourne Rotary during both the non-summer and summer peak periods. While Belmont Circle still experiences moderate delay during the summer peak period, Case 3A results in the greatest annual vehicle-hour savings than all other cases.

Challenges of Stage 4: The replacement of the Bourne and Sagamore Bridges and related approach work would be a large-scale project requiring state and federal environmental planning studies and other major environmental permits. The environmental planning, permitting, and design phase will require close and sustained coordination between MassDOT, the USACE, and Cape Cod stakeholders.

Table 5-2 Recommended Multimodal Transportation Improvements

TRANSPORTATION MODE	RECOMMENDED IMPROVEMENT	LOCATION	MAJOR STAKEHOLDERS	COST ($ MILLION)
MULTIMODAL				**2017 COST**
New bicycle/pedestrian connections to Canal bike trail		Various locations in Bourne	Town of Bourne / MassDOT / USACE	$25K - $50K per location
Bicycle/Pedestrian Facility Improvements		Sagamore Bridge Approaches / Adams Street	MassDOT / USACE	3.9
Bicycle/Pedestrian Facility Improvements		Bourne Bridge Approach (north)	MassDOT / USACE	0.8
Bicycle/Pedestrian accommodation along bus routes: add sidewalks /crosswalks / roadway shoulder /bike racks / bus shelters		Various locations along bus routes in Bourne & Sandwich	Towns of Bourne and Sandwich / MassDOT	Varies by location
Park and Ride Lot		Route 6 Exit 2 (Route 130)	MassDOT	2.8
LOCAL INTERSECTION ROADWAY IMPROVEMENTS				**2017 COST**
Route 6 at Cranberry Highway		Bourne	Town of Bourne / MassDOT	0.6
Route 130 at Cotuit Road		Sandwich	Town of Sandwich / MassDOT	1.0
Sandwich Road at Bourne Rotary Connector		Bourne	Town of Bourne / MassDOT	1.9
GATEWAY INTERSECTION ROADWAY IMPROVEMENTS (CASE 3A IMPROVEMENTS[1])				**2030 COST**
Scenic Highway to Route 25 Westbound Ramp			Town of Bourne / MassDOT	11
Belmont Circle Reconstruction			Town of Bourne / MassDOT	23
Bourne Rotary Interchange[2]			Town of Bourne / MassDOT	87
Route 6 Exit 1C Relocation			Town of Bourne / MassDOT	51
Additional Travel Lane on Route 6 Eastbound to Exit 2			Towns of Bourne and Sandwich / MassDOT	48
Sagamore Bridge Approaches[3]			Town of Bourne / MassDOT / USACE	64
Bourne Bridge Approaches[3]			Town of Bourne / MassDOT / USACE	84

1 Case 3A assumes the prior replacement of the Sagamore and Bourne Bridge by the USACE.
2 Includes cost of Bourne Rotary Reconstruction (Alternative 2, Three Signalized Intersections).
3 Includes approach roadway and bridge relocation and retaining walls.

The location and conceptual cost of all recommended transportation improvements are provided in Table 5-2.

5.5 IMPLEMENTATION

This section describes the steps involved in advancing the recommended projects through MassDOT's project development and design process. Although some steps occur simultaneously, they generally occur in the order presented. These steps include project planning, initiation, design, environmental permitting, right-of-way process, programming (funding), procurement, construction, and assessment.

5.5.1 MassDOT Project Development and Design Process

The development of transportation improvements is a complex decision-making process that involves many stakeholders, decision makers, and reviewing agencies. All projects developed by or with the involvement of the MassDOT Highway Division are guided by the eight-step process outlined in Chapter 2 of the MassDOT Highway Division's Project Development and Design Guide. This process guides a proposed transportation improvement from concept through design and construction and is designed to ensure that projects meet their stated goals and objectives.

This project development process is a requirement for all projects involving the MassDOT Highway Division, including projects in which the Highway Division is the project proponent, is responsible for project funding, or controls the infrastructure in question (projects on state highways). In the case of projects involving roadways or other infrastructure and property under the jurisdiction of Cape Cod municipalities, project development and implementation are the municipality's responsibility. Examples of recommendations falling under municipal jurisdiction include local roads and signalization improvements, sidewalk/ADA improvements, and other pedestrian/bicycle infrastructure.

The eight major steps that constitute the MassDOT Project Development and Design Process are outlined below and range from the first steps of identifying a project need toward greater refinement of the project's focus, design details, and ultimately toward implementation. The first two steps, Needs Identification and Planning, are addressed in this study.

Step 1: Needs Identification

For each of the locations at which an improvement is to be implemented, MassDOT leads an effort to define the problem, establishes project goals and objectives, and define the scope of the planning needed for implementation. To that end, MassDOT completes a Project Need Form (PNF), which states in general terms the deficiencies or needs related to the transportation facilities or locations. The PNF documents the problems and explains why corrective action is needed. The information defining the need for the project would be drawn primarily from this planning study. At this point in the process, MassDOT also meets with potential project participants to allow for an informal review of the project. For the transportation improvements recommended in this study, potential participants include the Cape Cod Commission, the U.S. Army Corps of Engineers (USACE), local elected officials, community members, and the other stakeholders that have participated in the public engagement process for this study.

The PNF is reviewed by the MassDOT Highway Division office whose jurisdiction includes the location of the proposed project. For the improvements recommended in this study, this is the District 5 office. MassDOT would also send the PNF to the Cape Cod Commission, the regional Metropolitan Planning Organization (MPO), for informational purposes. The outcome of this step determines whether the project requires further planning, whether it is already well supported by prior planning studies, and therefore whether it is ready to move forward into the design phase or whether it should be dismissed from further consideration.

Step 2: Planning

This phase would likely not be required for the implementation of the improvements proposed in the Cape Cod Canal Transportation Study, as this study should constitute the outcome of this step. However, the purpose of this implementation step is for the project proponent to identify issues, impacts, and approvals that may need to be obtained so that the subsequent design and permitting processes are understood.

The level of planning needed varies widely based on the complexity of the project. Typical tasks include the following: define the existing context, confirm the project need, establish goals and objectives, initiate public outreach, define the project, collect data, develop and analyze alternatives, make recommendations, and provide report documentation. Likely outcomes include consensus on the project definition to enable it to move forward into environmental documentation (if needed) and design or a recommendation to delay the project or dismiss it from further consideration.

For this study, continued coordination with the USACE will be critical to properly define future projects and the responsibilities of each agency related to design, permitting, and construction.

Step 3: Project Initiation

At this point in the process, the proponent, MassDOT Highway Division, completes a Project Initiation Form (PIF) for each improvement, which is reviewed by the MassDOT Project Review Committee (PRC) and the MPO, in this case the Cape Cod Commission. The MassDOT PRC is composed of MassDOT staff members including the Chief Engineer, each District Highway Director, representatives of the Project Management, Environmental, Planning, Right-of-Way, Traffic, and Bridge Departments, and the Federal-Aid Program Office (FAPRO).

The PIF documents the project type and description, summarizes the project planning process, identifies likely funding and project management responsibility, and defines a plan for interagency and public participation. First, the PRC reviews and evaluates the proposed project based on the MassDOT's statewide priorities and criteria. If the result is positive, MassDOT Highway Division moves the project forward to the design phase and to programming review by the MPO. The PRC may provide a Project Management Plan to define roles and responsibilities for subsequent steps. The MPO review includes project evaluation based on the MPO's regional priorities and criteria. The MPO may assign a project evaluation criteria score, a Transportation Improvement Program (TIP) year, a tentative project category, and a tentative funding category.

Given transportation funding constraints, prioritization of the recommendations for implementation will need to be established regionally by the Cape Cod Commission, member communities, and MassDOT, in particular for the gateway intersection improvements recommended in Section 5.4.2.

USACE Coordination

MassDOT will continue to coordinate with the USACE related to the development and permitting of the transportation improvements in the Canal area and their efforts to secure federal funding for the assumed replacement of the Bourne and Sagamore Bridges.

Step 4: Public Outreach, Environmental Permitting, Design, and Right-of-Way Process

This step has four distinct but closely integrated elements: Public Outreach, Environmental Documentation and Permitting, Design, and Right-of-Way Acquisition. The outcome of this step is a fully designed and permitted project ready for construction.

The sections below provide more detailed information on the four elements of this step of the project development process.

Public Outreach: Continued public outreach in the design and environmental process is essential to maintain public support for the project and to seek meaningful input on the design elements. The public outreach is often in the form of required public hearings (conducted at the 25% design milestones) but can also include less formal dialogue with those interested in and affected by a proposed project.

Given the size and complexity of the transportation improvements recommended in this study, on-going public outreach meetings are anticipated with the public, the study Working Group, local elected officials, and other stakeholders.

Environmental Planning and Permitting: The MassDOT Highway Division will be responsible for identifying and complying with all applicable federal, state, and local environmental laws and requirements. This includes determining the appropriate project category for both the Massachusetts Environmental Protection Act (MEPA) and the National Environmental Protection Act (NEPA).

As the Canal bridges are owned by the USACE, they have responsibility for the environmental documentation and permitting of the assumed replacement of the Canal bridges. However, in certain circumstances, projects involving multiple federal agencies (in this case, the USACE and the Federal Highway Administration [FHWA]), a lead federal agency is identified to manage the environmental planning and permitting process.

Environmental documentation and permitting are typically completed in conjunction with the Preliminary Design phase described below.

Design: The MassDOT project development process involves three major phases of design. The first is Preliminary Design, also referred to as the 25% submission. The major components of this phase include a full survey of the project area, preparation of base plans, development of basic geometric layout, development of preliminary cost estimates, and submission of a functional design report. Preliminary Design is often completed in conjunction with Environmental Planning and Permitting. The next phase is Final Design, which is also referred to as the 75% and 100% submissions. The major components of these phases include preparation of a subsurface exploratory plan (if required), coordination of utility relocations, development of temporary traffic control plans through construction zones, development of final cost estimates, and refinement and finalization of the construction plans. Once Final Design is complete, a full set of Plans, Specifications, and Estimates (PS&E) is developed for the project.

Right-of-Way Acquisition: A separate set of Right-of-Way plans is required for any project that requires land acquisition or easements. These plans are developed concurrent with the 25% and 75% highways design plans and must identify the existing and proposed layout lines, easements, property lines, names of property owners, and the dimensions and areas of estimated takings and easements.

Step 5: Programming (Identification of Funding)

Programming, which typically begins during the design phase, can occur at any time during the process, from planning to design. In this step, which is distinct from project initiation, the project proponent requests that the MPO include a project from the Regional Transportation Plan in the region's annual Transportation Improvement Plan (TIP) development process. The proponent requesting the project's listing on the TIP can be the community or one of the MPO member agencies (the Regional Planning Agency, MassDOT, or the Regional Transit Authority). The MPO considers the project in terms of state and regional needs, funding availability, project readiness, evaluation criteria, and compliance with the Regional Transportation Plan. If the MPO decides to include the project in the TIP, it is first included in the Draft TIP for public review and then in the Final TIP. A project does not have to be fully designed for the MPO to program it in the TIP, but generally a project has reached 75 percent design to be programmed in the year-one element of the four-year TIP.

While securing funding through the MPO's TIP process is important, the cost of some of the larger the improvements recommended in this study are well beyond the level of funding the MPO typically has to allocate to projects in this region. Additional funding sources must be identified to advance these projects. As noted, the USACE would be responsible for securing federal funding for the assumed replacement of the Bourne and Sagamore Bridges.

Step 6: Procurement

Following project design and programming of a highway project, the MassDOT Highway Division publishes a request for proposals, which is also often referred to as being "advertised" for construction. MassDOT then reviews the bids and awards the contract(s) to the qualified bidder with the lowest bid.

Step 7: Construction

After a construction contract is awarded, MassDOT Highway Division and the contractor develop a public participation plan and a temporary traffic control plan for the construction process.

Step 8: Project Assessment

The purpose of this step is to receive constituents' comments on the project development process and the project's design elements. MassDOT Highway Division can apply what is learned in this process to future projects. The Project Development and Design Process steps detailed above, along with their effect on the project schedule and typical durations associated with each step.

5.5.2 Project Delivery Methods

The following sections describe three common project delivery methods for highway projects. MassDOT and the USACE would be responsible for selecting the project delivery method that best balances cost, risk, construction schedule, and inconvenience to the residents and visitors to Cape Cod.

Design-Bid-Build (D-B-B)

The project development process described previously is based on a conventional project delivery method, commonly referred to as "Design-Bid-Build" (D-B-B). The essence of the D-B-B process is that the project is designed to the PS&E level and then advertised for construction, i.e. the design and construction are carried out sequentially. Under this scenario, the engineer of record (designer) and the construction contractor are two separate contracting entities.

Design-Build (D-B)

The design-build project delivery process is a method to deliver a project in which the design and construction services are contracted by a single team. This process occurs after the completion of the environmental planning and 25% design phase. This type of project delivery process often takes less time than a traditional design-bid-build process because design and construction process happen at the same time.

Public-Private Partnership (P3)

An infrastructure P3 is generally a method of project delivery in which a private entity designs, constructs, finances, and manages a facility in exchange for a portion of the funds generated or through availability payments. In the case of a highway P3 project, the funds generated by the project are generally the tolls charged to users of the facility. A benefit of this type of project delivery process is that the project owner (in this case, MassDOT) does not have to fund the design or construction of the project.

5.5.3 Environmental Considerations

This section provides a summary of the environmental documentation, review, and permitting that would need to be conducted for any alternative to be implemented. Any project will need to follow the project development design process (Step 4), which includes identifying and complying with all applicable federal, state, and local environmental laws and requirements. This includes determining the appropriate project category for MEPA and NEPA. Expected environmental policy acts and permitting application and reviews are discussed below but may vary depending upon actual project design and impacts.

Environmental Policy Acts

Both the Massachusetts and National Environmental Policy Acts (MEPA and NEPA) require an evaluation of a range of alternatives to identify the alternative that meets the project's purpose and need with the least impact to social and natural environmental resources. Mitigation for all environmental impacts must be identified. Based on the scope of the anticipated highway improvements, it is anticipated that MEPA review will at least consist of an Environmental Notification Form (ENF) and a Draft and Final Environmental Impact Report (EIR). Similar thresholds apply to NEPA where a full Environmental Assessment (EA) or Environmental Impact Statement could be warranted for this project.

Environmental Reviews/Permits

Local, state, and federal agency regulatory agencies will review proposed activities with respect to applicable environmental laws and regulations. The following state and federal regulatory agency reviews and permits would likely be required for the recommended projects:

State Agency Review/Approval

- Massachusetts Environmental Policy Act

- Massachusetts Wetlands Protection Act (WPA) – Wetlands Notice of Intent (NOI)
- Massachusetts Division of Fisheries, Natural Heritage and Endangered Species Program review
- Massachusetts General Law Chapter 21E and the Massachusetts Contingency Plan (MCP) (hazardous materials review)

Federal Agency Review/Approval

- National Environmental Policy Act
- Section 404 Permit – U.S. Army Corps of Engineers (USACE) General Permit
- Section 401 of the Federal Clean Water Act – 401 Water Quality Certification
- Section 106 National Historic Preservation Act (managed by the Massachusetts Historical Commission (MHC))
- Endangered Species Act – Section 7 review
- Environmental Protection Agency (EPA) Construction Stormwater General Permit

5.5.4 Climate Change Considerations

MassDOT has a goal of reducing transportation vulnerabilities and adapting infrastructure for current and future climate change impacts. MassDOT has completed several studies and has a number of active projects underway that will help to better assess the potential impacts of climate change and severe weather to the Commonwealth's transportation infrastructure. A summary of MassDOT's Climate Change Resiliency pilot projects and statewide mapping products can be found on their website using this link: https://www.mass.gov/info-details/climate-change-resiliency#additional-resiliency-projects-underway-.

In addition, MassDOT, through the Executive Office of Energy and Environmental Affairs, (EEA) and the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, is also working with other state and federal agencies to develop statewide policies and best management practices to adapt to climate change hazards and improve resiliency.

MassDOT is also reviewing its internal policies and procedures to integrate resiliency into the planning and project development processes. While those policies and procedures are being developed, projects are being reviewed on a case-by-case basis.

A high-level vulnerability assessment of the study area focused on flood risk, revealed that several roadways near the western end of the Canal and Buttermilk Bay are within the 100-year flood zones and will increasingly be vulnerable to flooding with forecast sea level rise and increasing storm intensity. These roadways include portions of Main Street, Buzzards Bay Bypass, and Belmont Circle in Bourne and Cranberry Highway and Head of the Bay Road in Wareham. At the eastern side of the Canal, portions of Scusset Beach Road and Route 6A are within the 100-year flood zone. MassDOT will incorporate increased flood risk while designing transportation improvements in these areas.

5.5.5 Implementation Summary

As part of this study, several multimodal transportation improvement projects have been outlined. It is recommended that all of these improvements should be considered for project development. It is imperative that municipal leadership from Bourne and Sandwich, as well as the Cape Cod Commission, area Chambers of Commerce, members of the broader community, the USACE, and MassDOT continue to coordinate and further define the most appropriate and urgent projects. In addition, continued support from local and regional stakeholders in advancing high-priority projects is critical to successfully implementing this agenda. These local priorities should inform time lines and programming for each improvement to proceed to project development.