massDOT
Massachusetts Department of Transportation

CAPE COD CANAL
TRANSPORTATION STUDY

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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

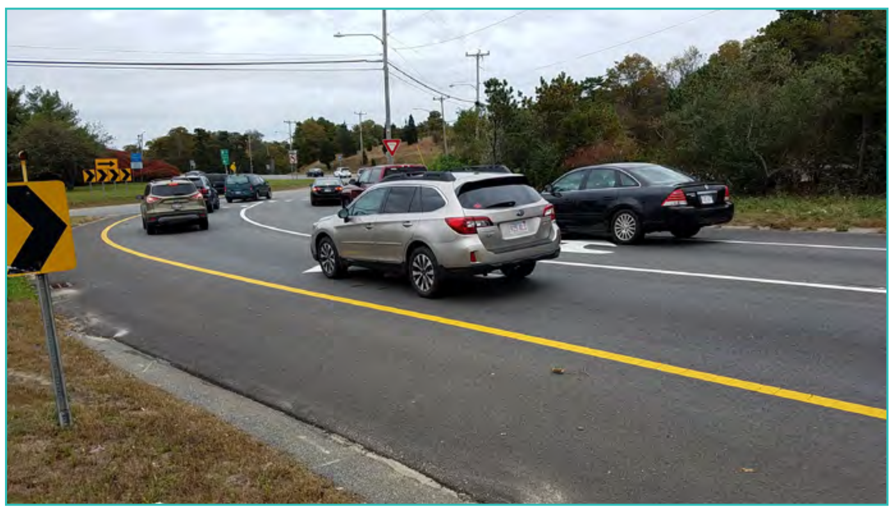
The seven-mile-long Cape Cod Canal was built in 1916 to shorten travel times and improve the safety of ships heading south from Boston and Plymouth. Mass-production of the automobile had only just begun, and roughly 20 years later (in 1935), the newly-constructed Bourne and Sagamore Bridges carried their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

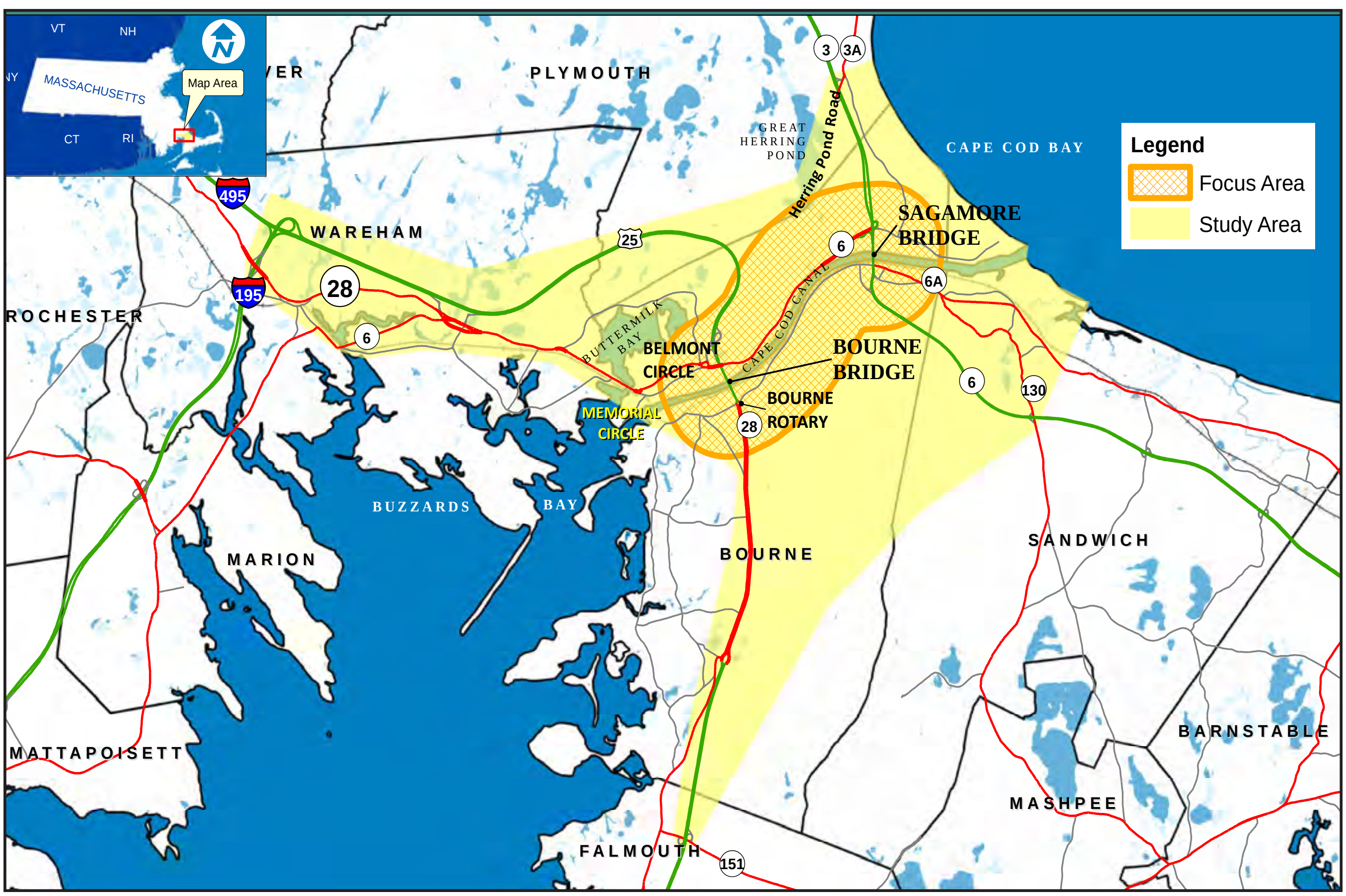
The USACE is currently preparing a 'Major Rehabilitation Evaluation Report' that will determine whether the USACE should continue to perform long-term maintenance on the bridges, or to replace them.

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

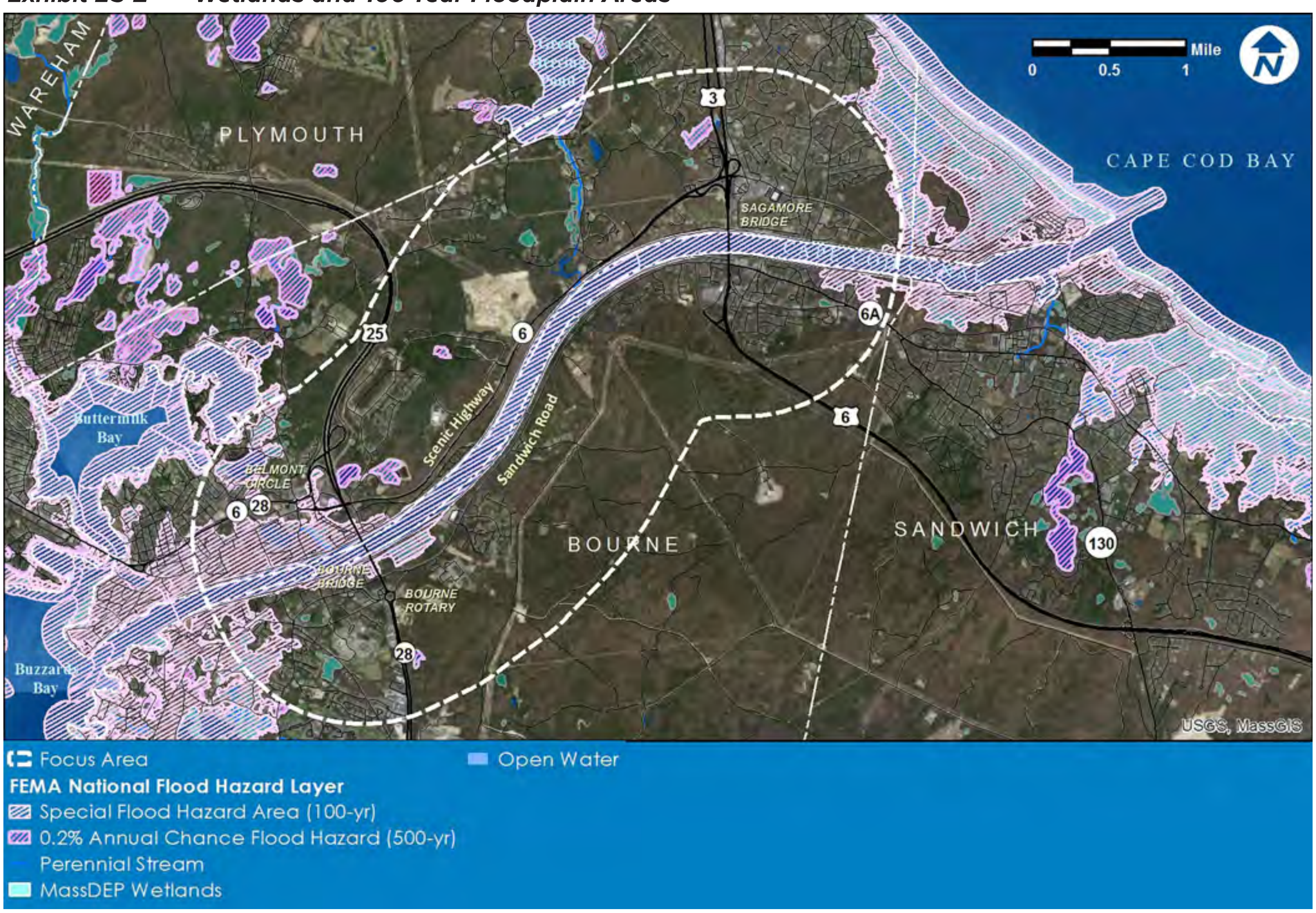
Evaluation Criteria

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.

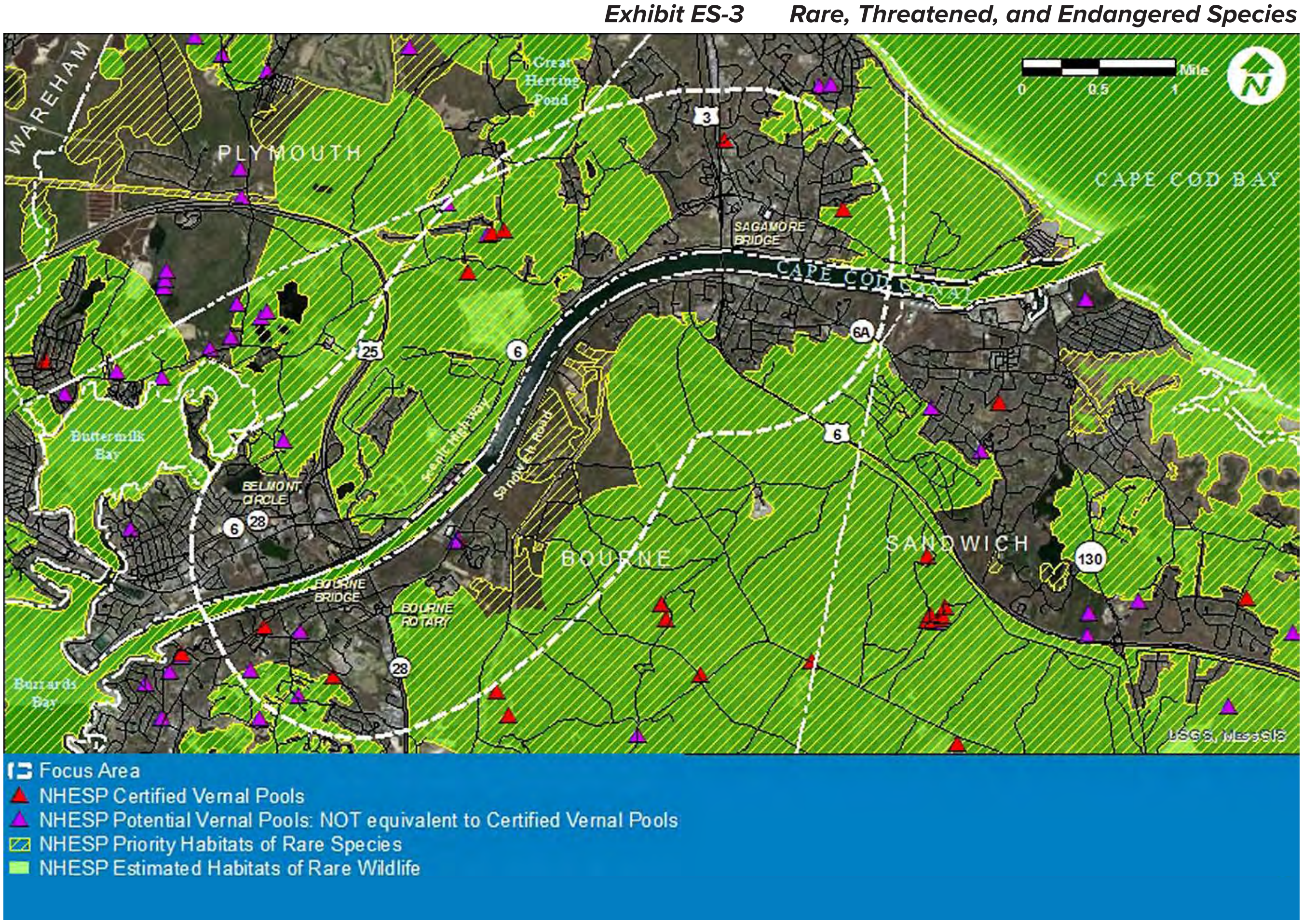
STEP 2: REVIEW & EVALUATE EXISTING AND FUTURE CONDITIONS

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.

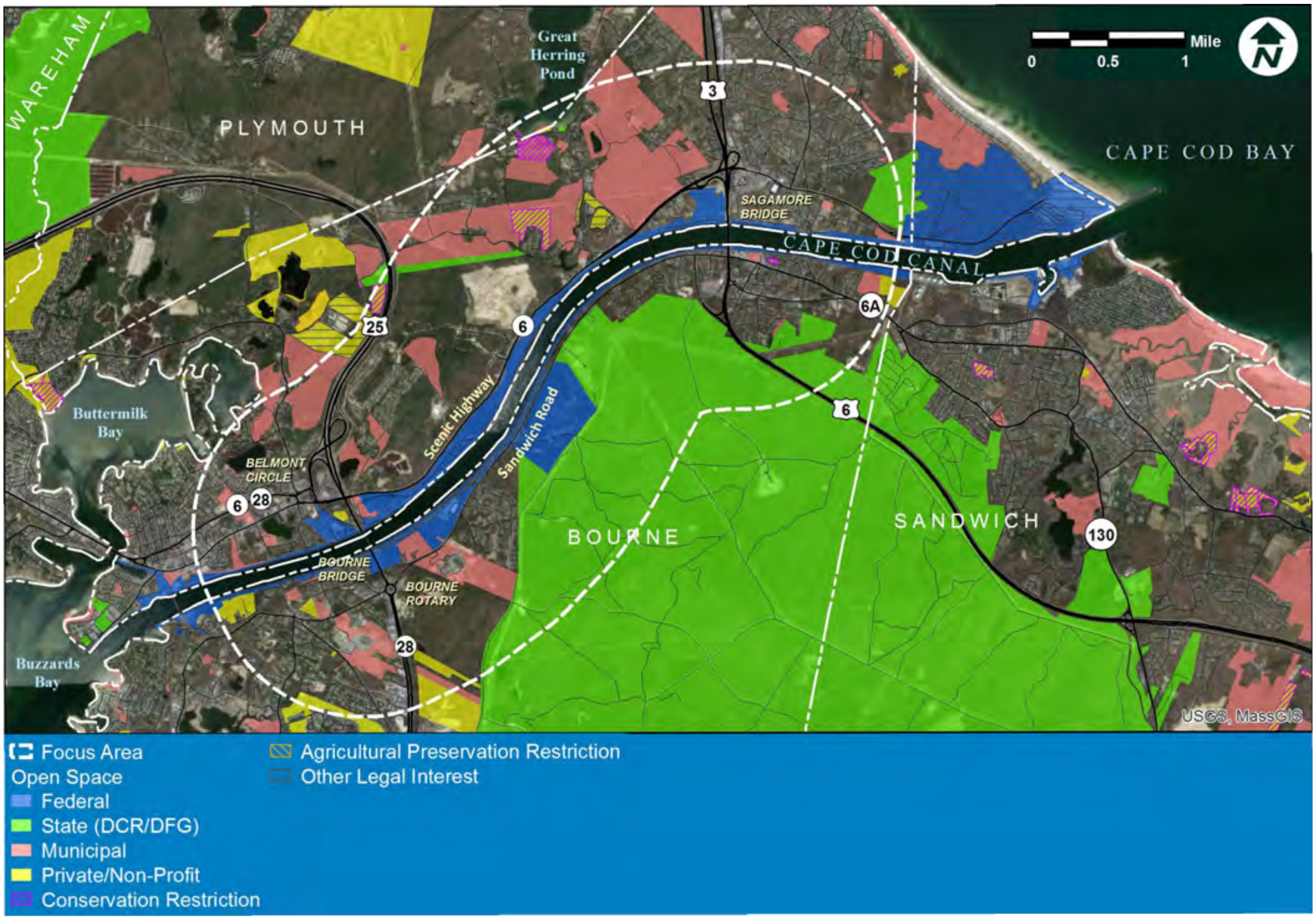
Social Environmental Resources

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:

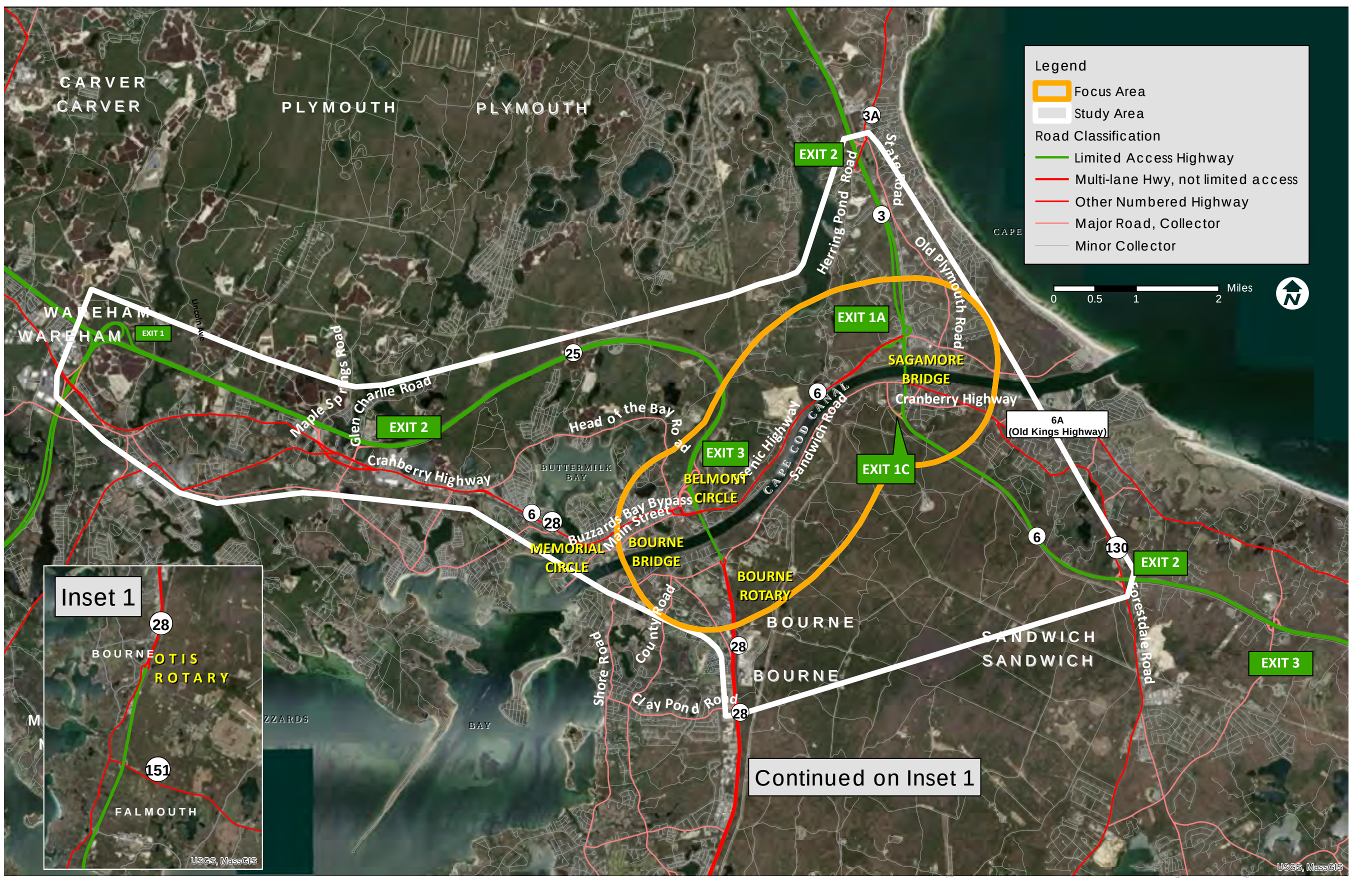
- Route 3/Sagamore Bridge/Route 6 corridor along the eastern side of the study area.
- Route 25/Bourne Bridge/Route 28 corridor along the western side of the study area.

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.

BlueTOAD™ Units.

- **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.

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:

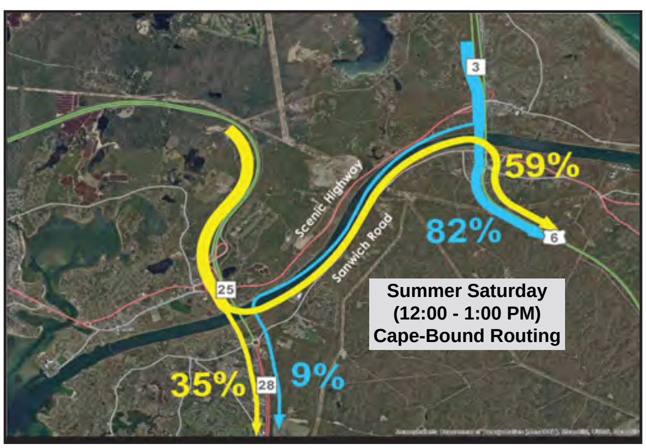
- Major bridges (Sagamore and Bourne Bridges)
- Major highways (Routes 3, 6, 25, 28, and 130)
- Arterial roadways (Scenic Highway, Sandwich Road, and Main Street in Bourne).

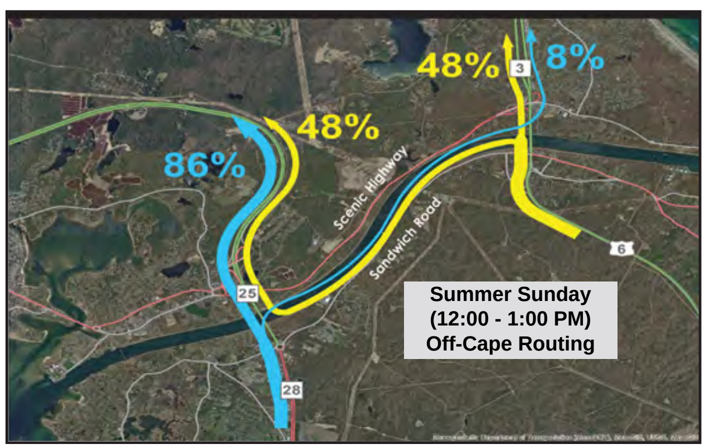
There are substantial seasonal differences in traffic volumes in the study area because Cape Cod is a major summer tourist destination. For example, daily traffic volumes on the Bourne and Sagamore Bridge are 49% and 59% higher in the summer compared to non-summer periods. The Sagamore Bridge generally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

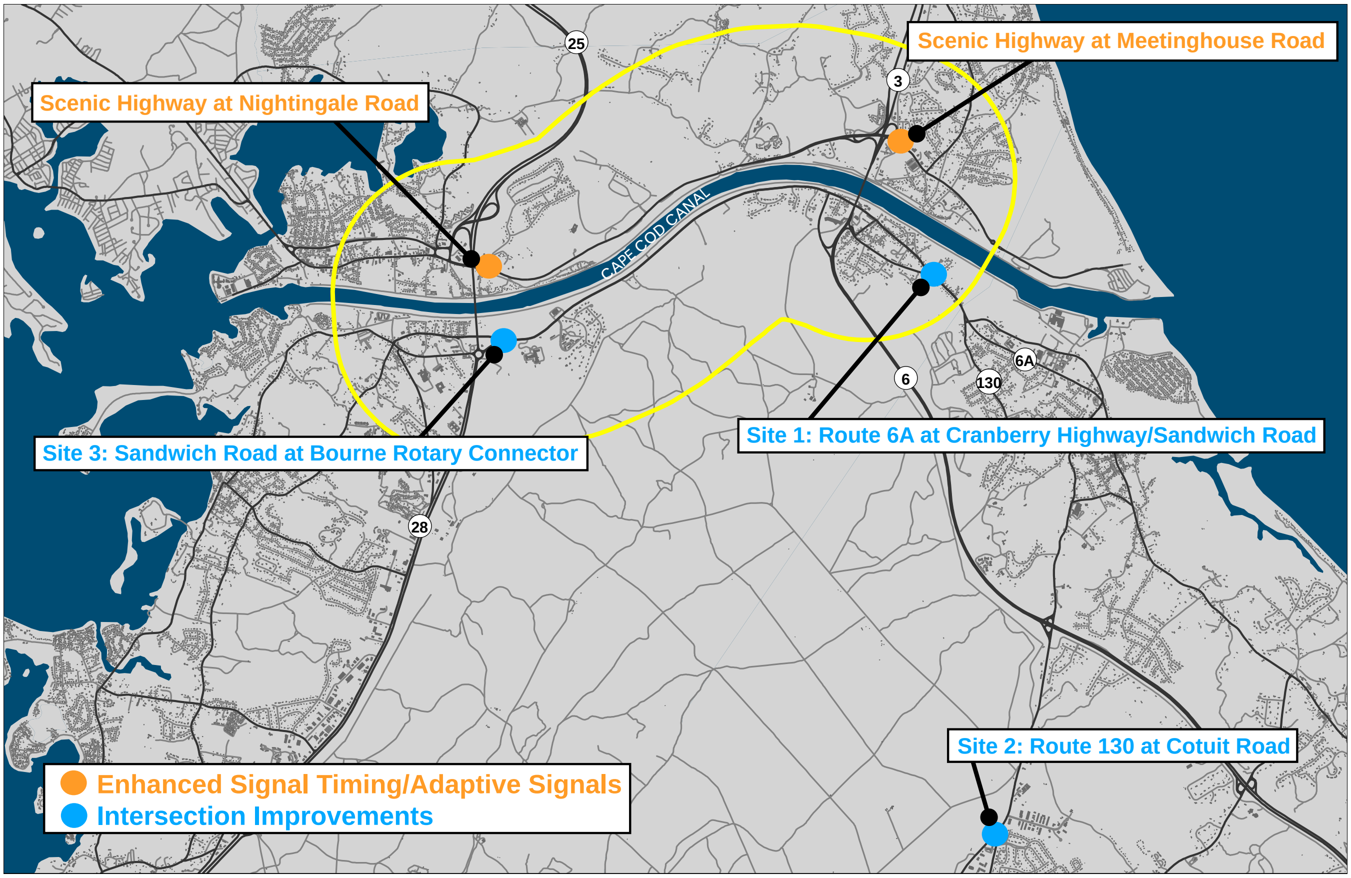
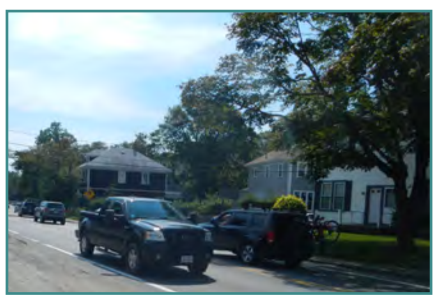
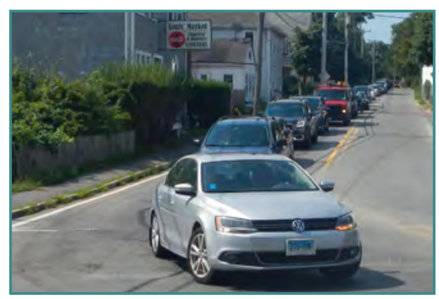


Exhibit ES-8 Local Intersection Improvement Locations

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

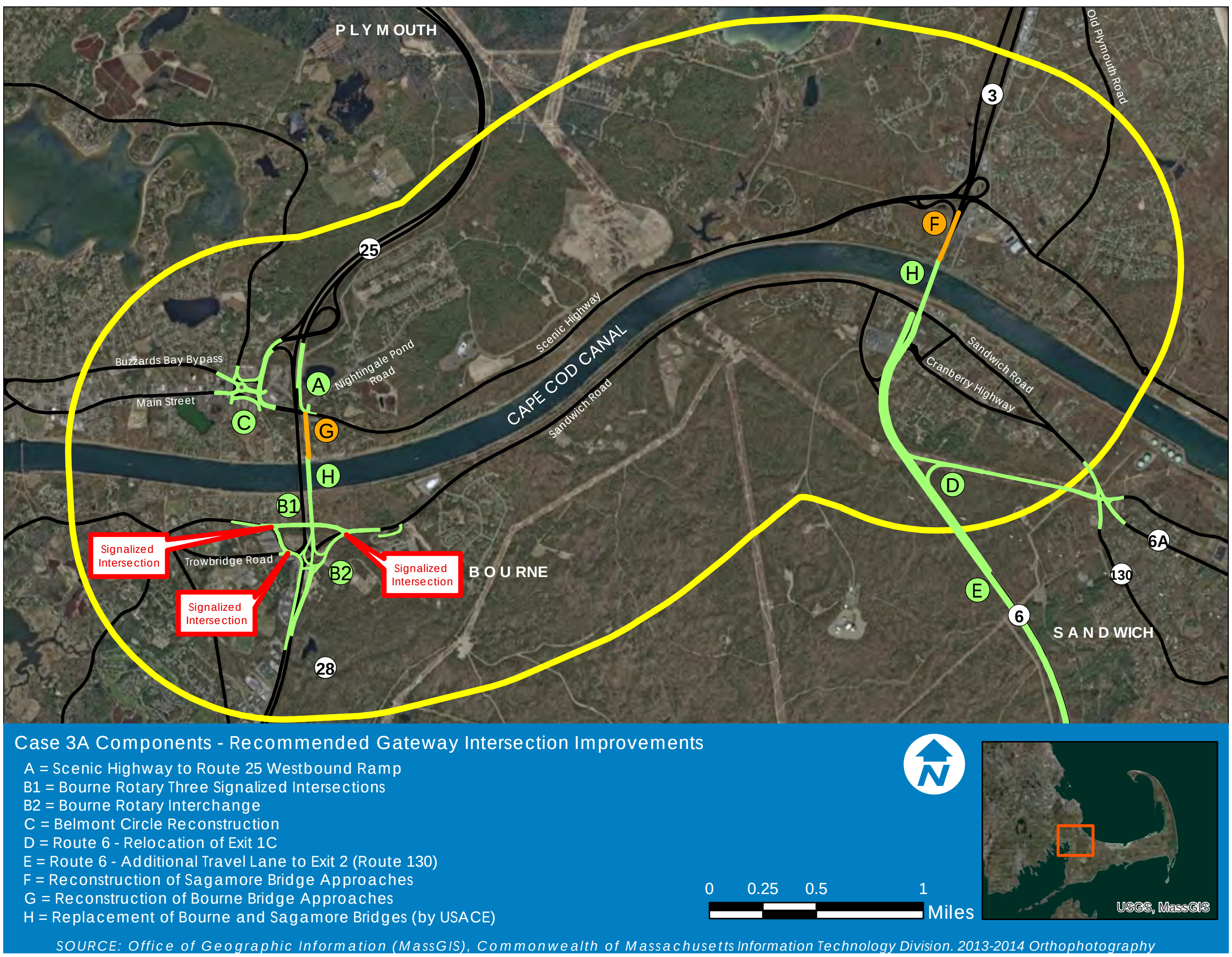
Multiple alternatives were evaluated at the gateway intersections to determine their effectiveness at improving traffic operations and consider their potential impact on environmental resources and property (Exhibit ES-10). The following sections describe the alternatives evaluated at the gateway intersections.

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



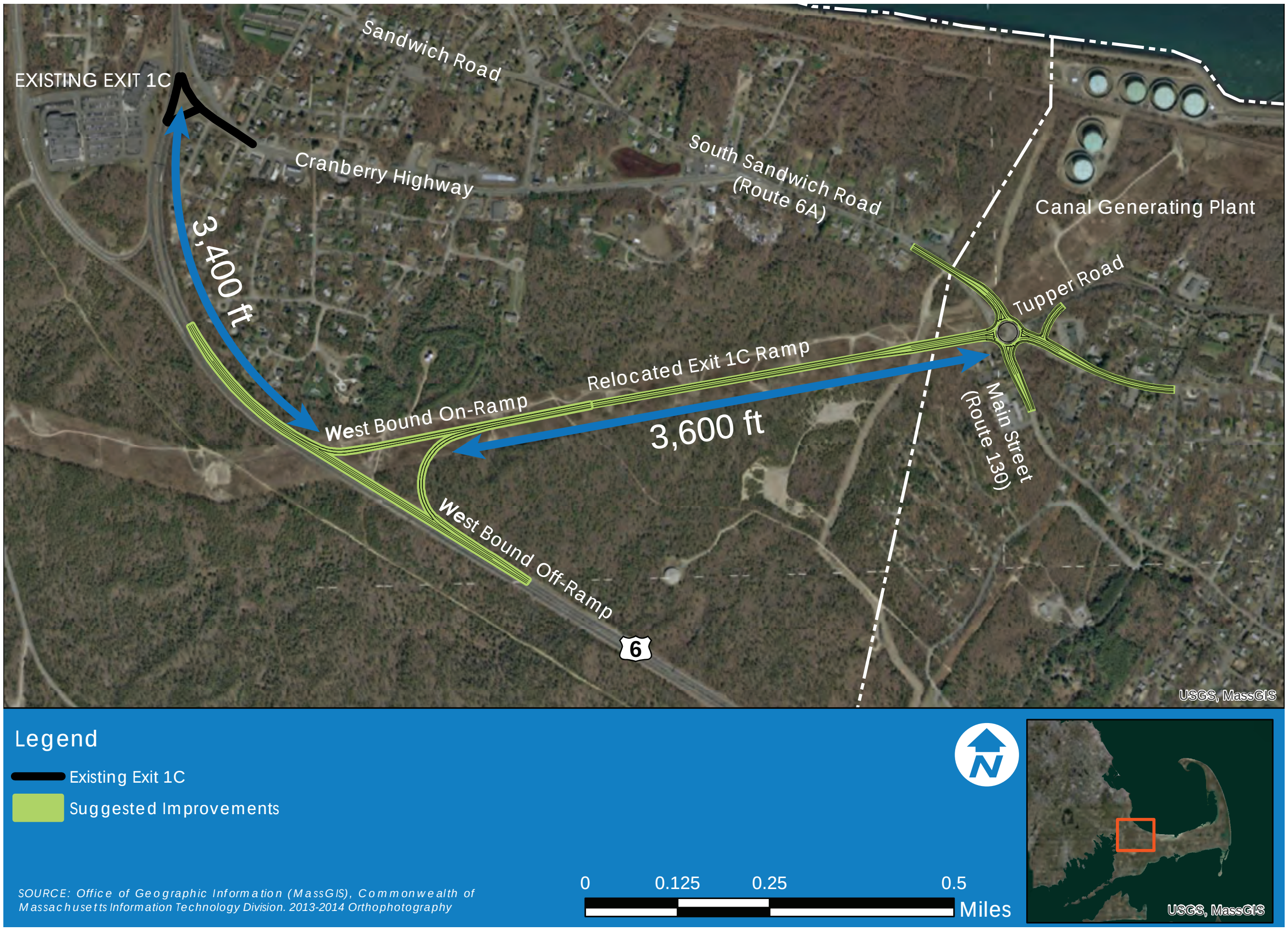


Exhibit ES-11 Relocation of Route 6 Exit 1C

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.

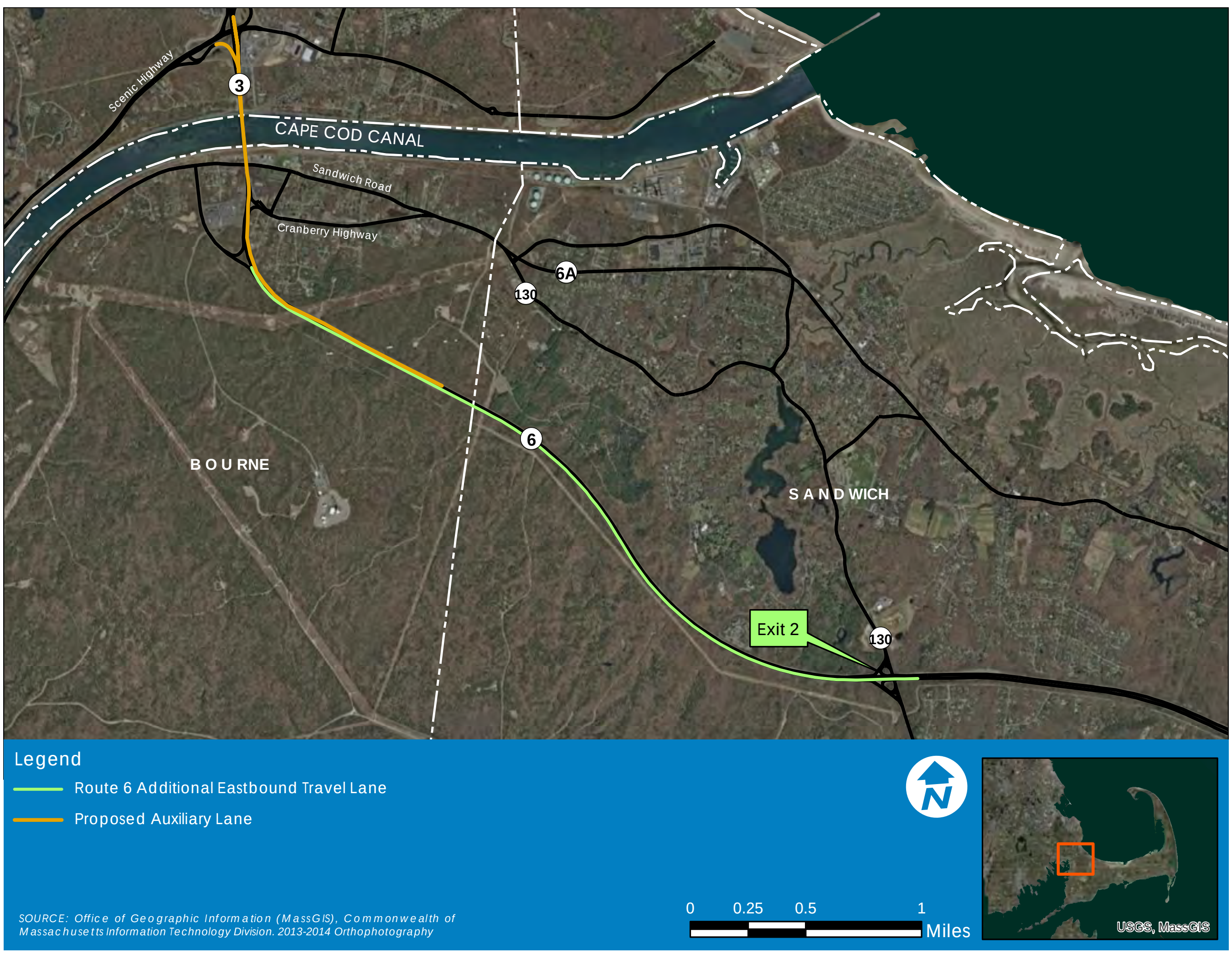
Therefore, the relocation of Route 6 Exit 1C from its existing location at the base of the south end of the Sagamore Bridge was evaluated. The selection of a new location for the Exit 1C interchange would need to be informed by existing land uses adjacent to Route 6 (residential neighborhoods, state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

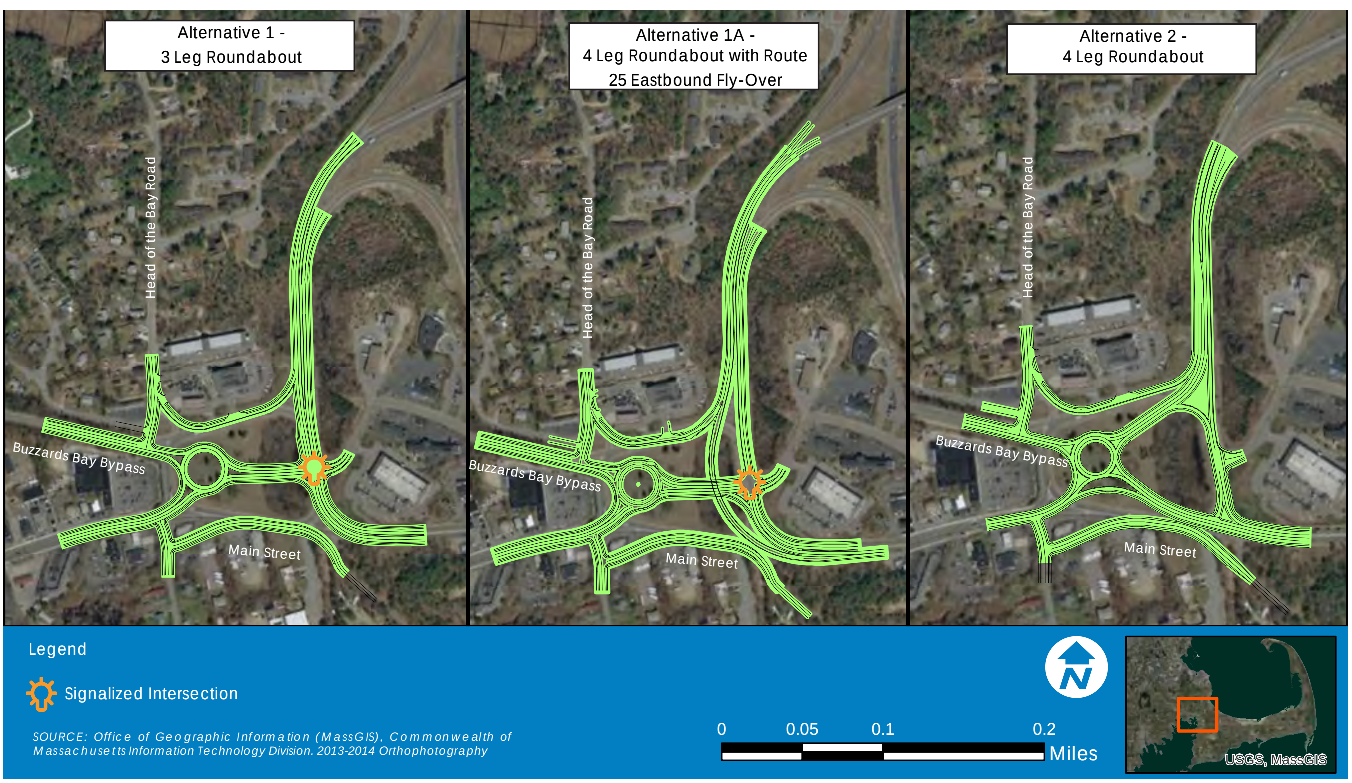
Each of the three alternatives for the reconstruction of Belmont Circle would impact a moderate amount of wetland resources and 100-year floodplain. Open space and residential and commercial property acquisitions may also be required.

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

SOURCE: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division. 2013-2014 Orthophotography

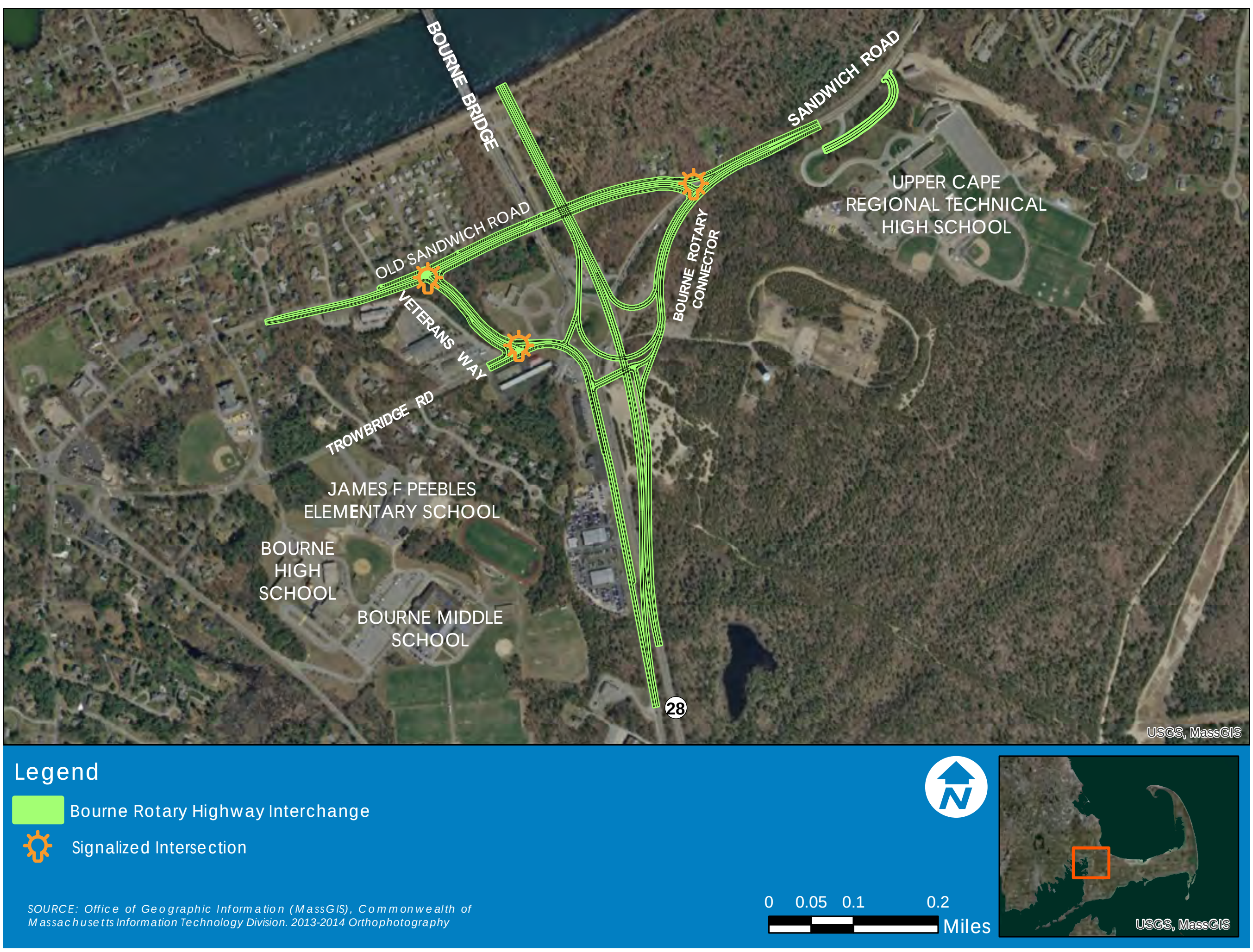
Bourne Rotary Interchange

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).

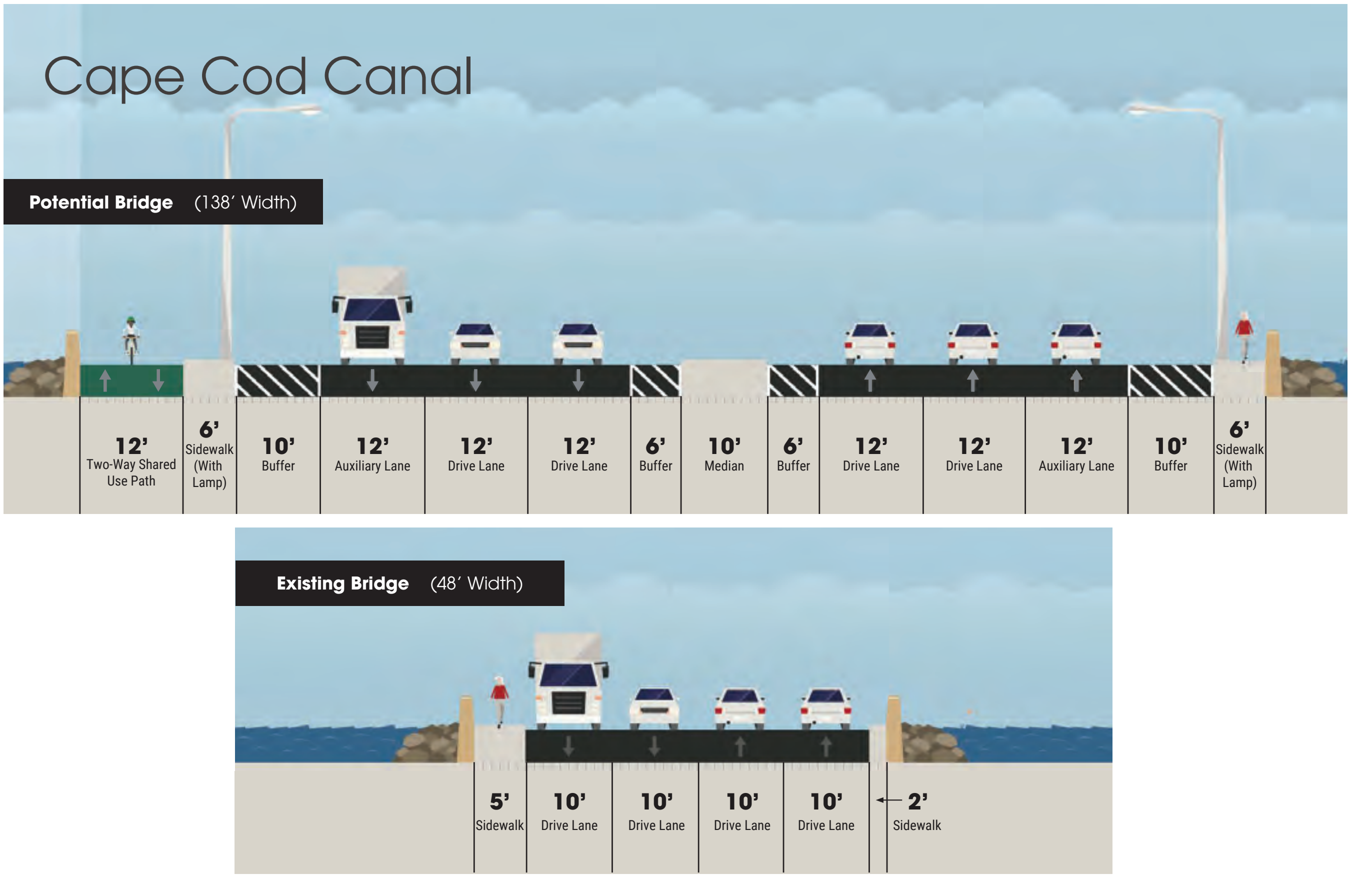


Exhibit ES-17 Potential Cross Section of Replacement Canal Bridges

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.

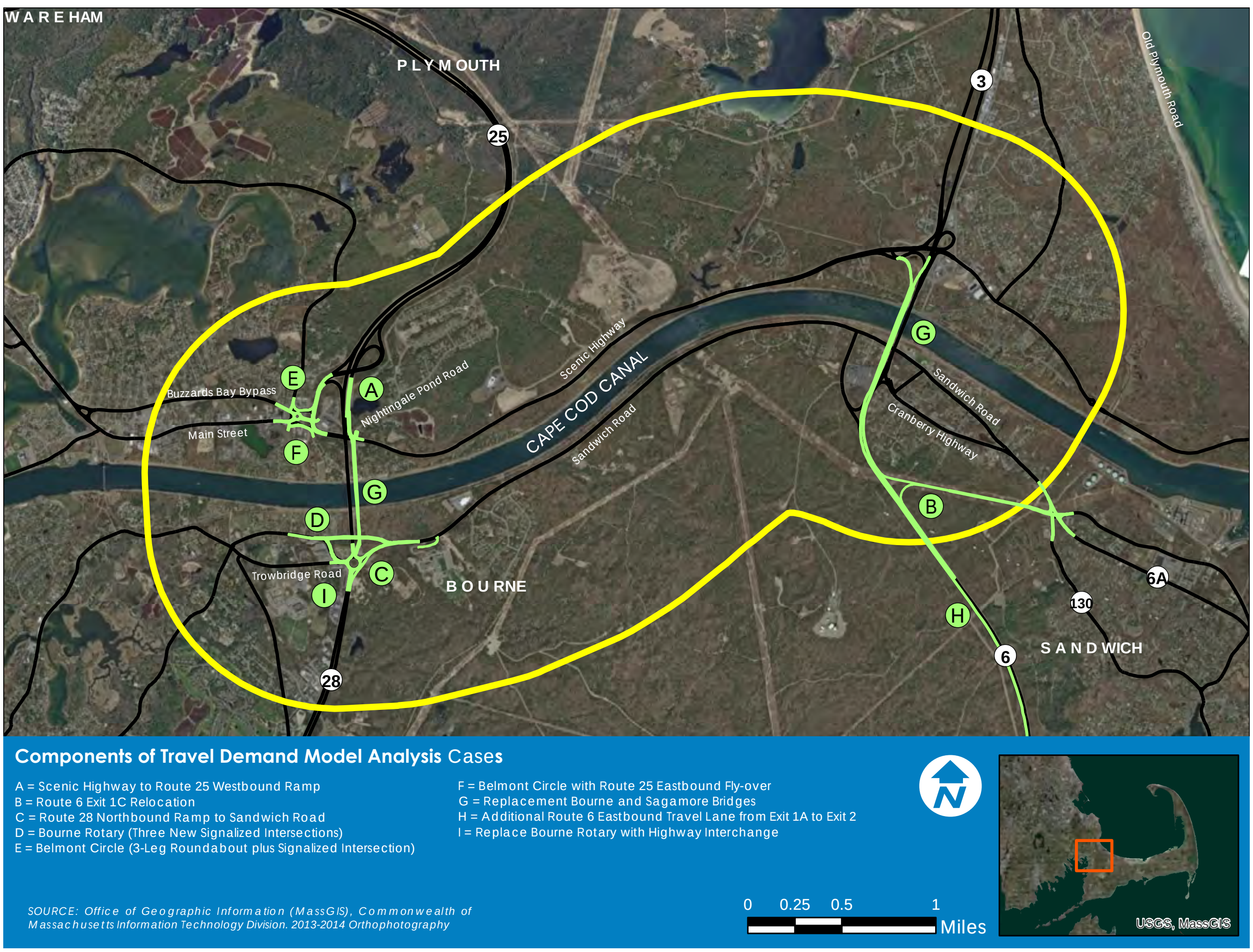
Case Analysis Findings

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

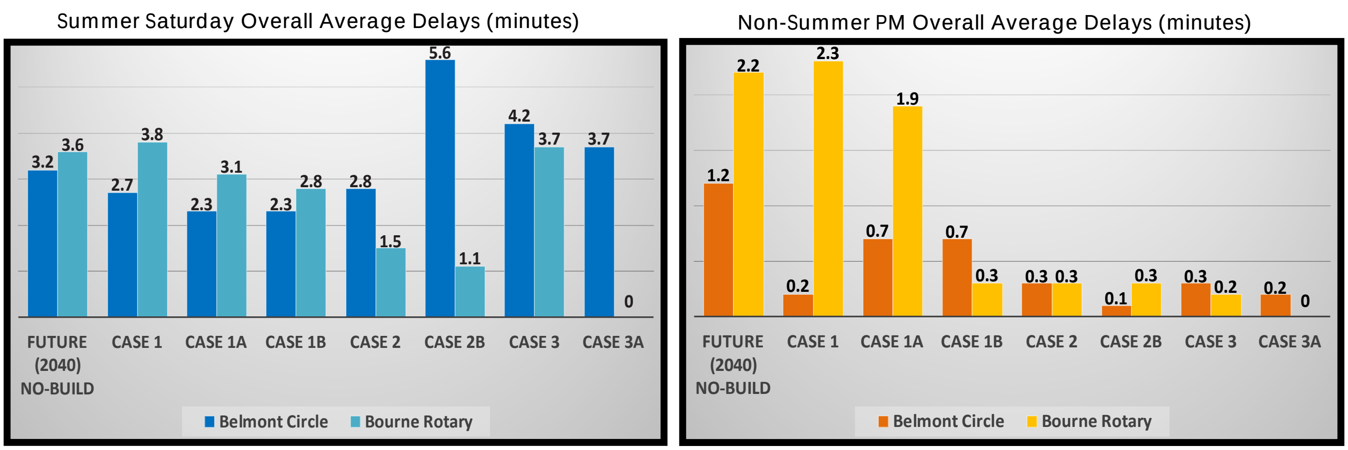
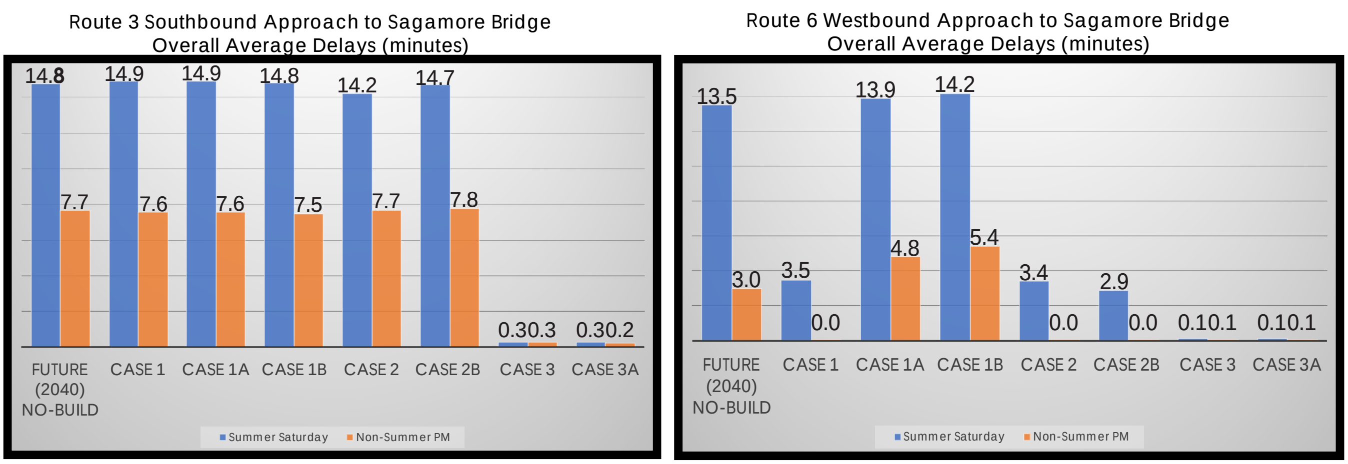


Exhibit ES-19 Average Non-Summer and Summer Delay - Belmont Circle and Bourne Rotary

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**				

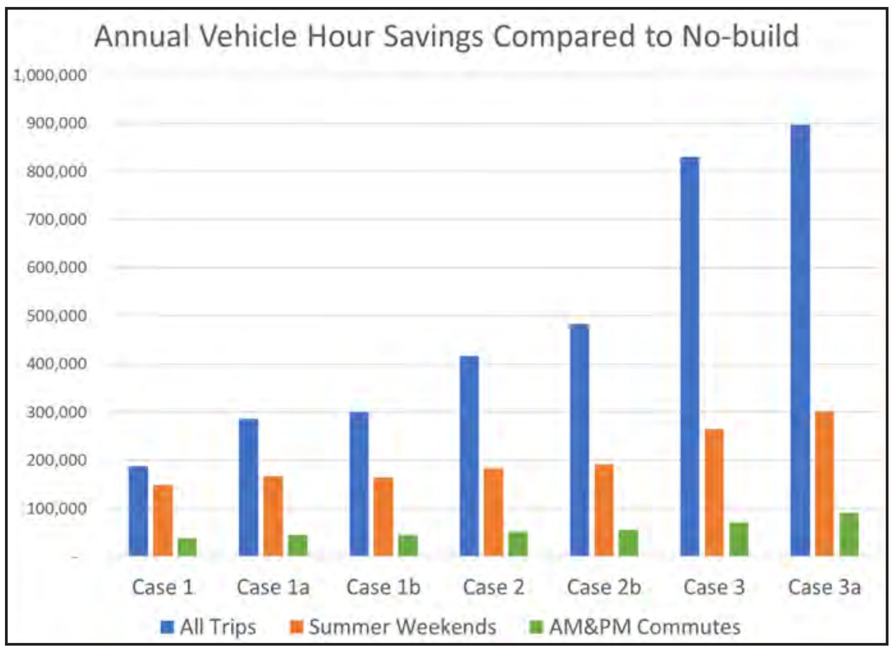
Notes:
LOS E and LOS F movements for the existing and future no-build problem locations are ***bold***
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.
Data not available for Case 3A at Bourne Rotary. As a highway interchange, analysis at this location was 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]Conceputal 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		Alternatives Evaluation Matrix: 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
	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
	Rare Species (acres)			●	7.2	◇	0.0	◇	0.0	●	7.2	●	7.2	●	11.1	●	11.3
	100-yr Floodplain (acres)			◇	0.0	◇	0.0	◇	0.0	◒	4.7	◒	5.4	◒	4.7	◒	4.7
	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
	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
	Commercial (acres)			◒	0.9	◇	0.0	◇	0.0	◒	0.9	◇	0.0	◒	0.9	◒	0.9
	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**

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)

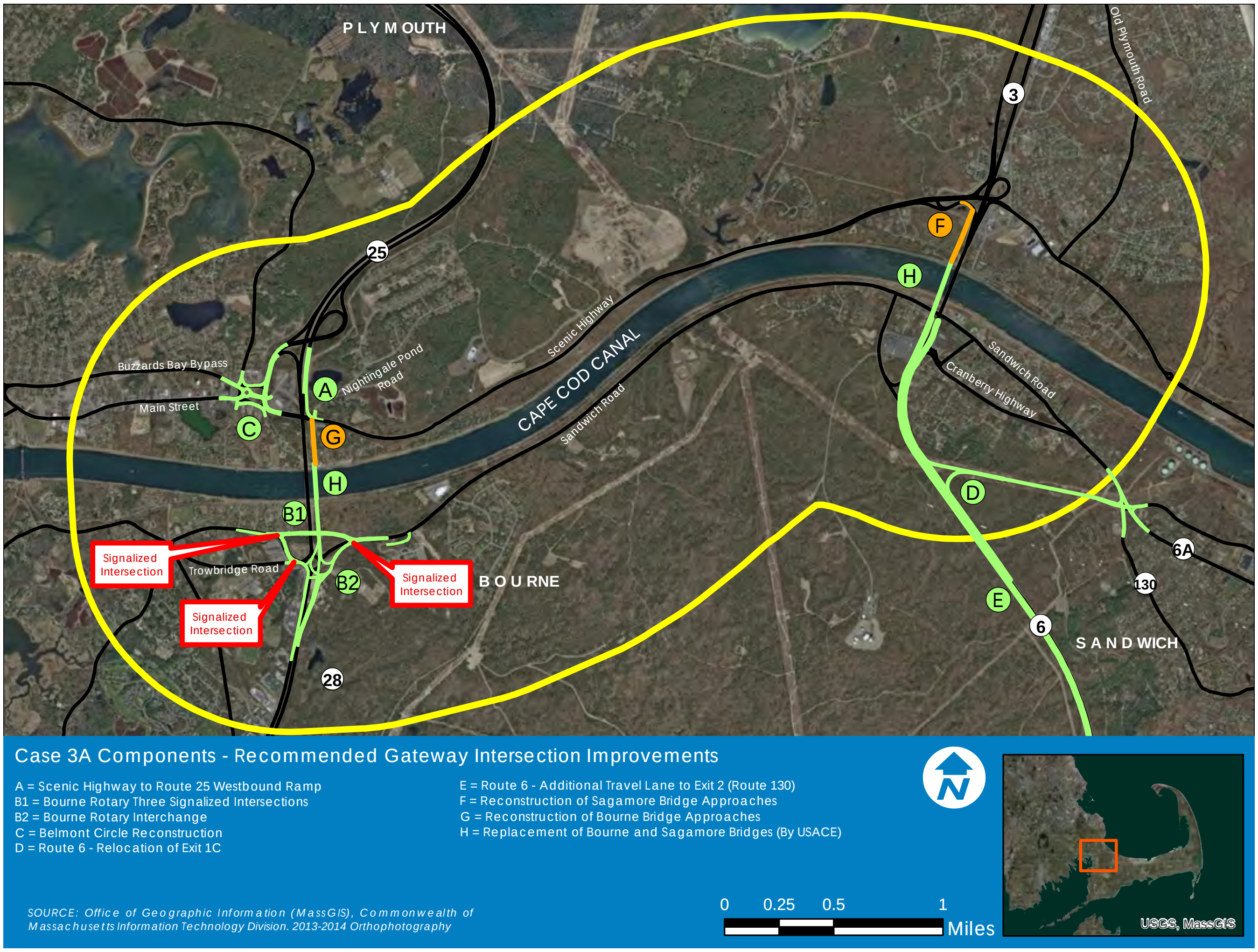


Exhibit ES-24 Recommended Gateway Intersection Improvements – Case 3A

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

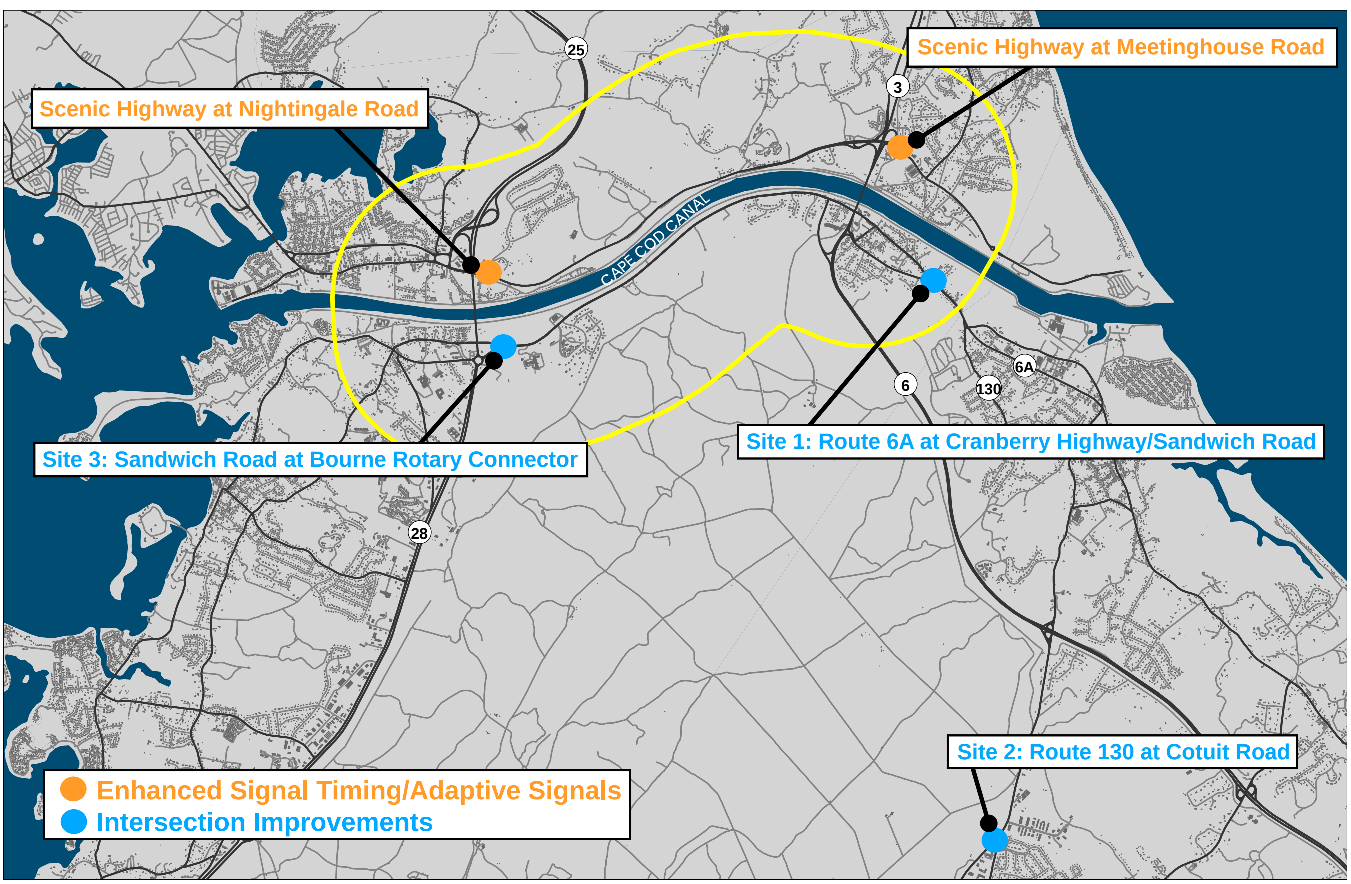
The recommended local intersection improvements include advancing several intersection improvement projects into the project development phase (Exhibits ES 25 and ES-9). These intersection improvements include:

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

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.

Top: Bicyclists on the Canal bike path road.

Bottom: Pedestrians and recreational fishing on the Canal.

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.**

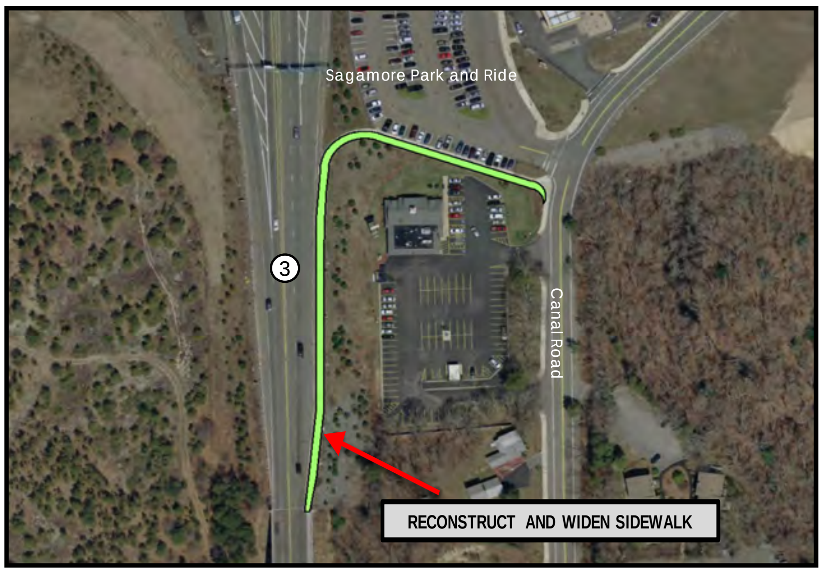
Benefit

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)

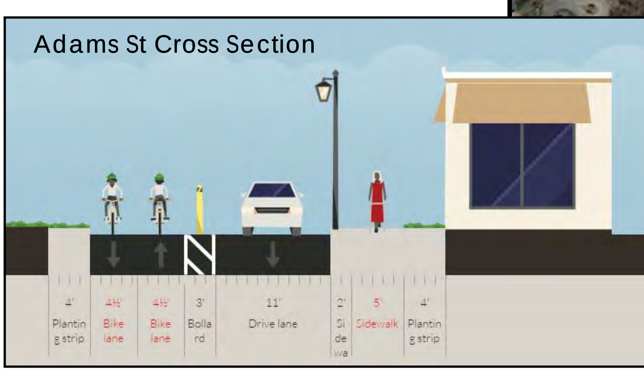
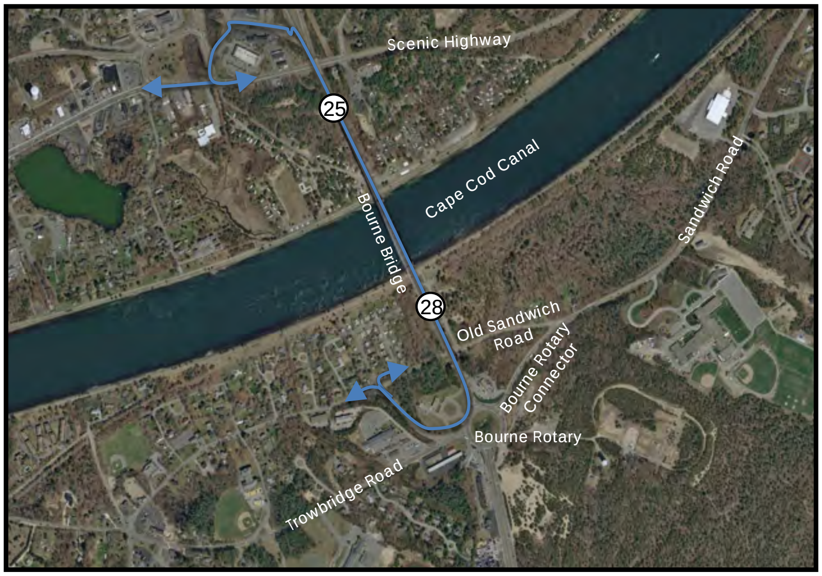


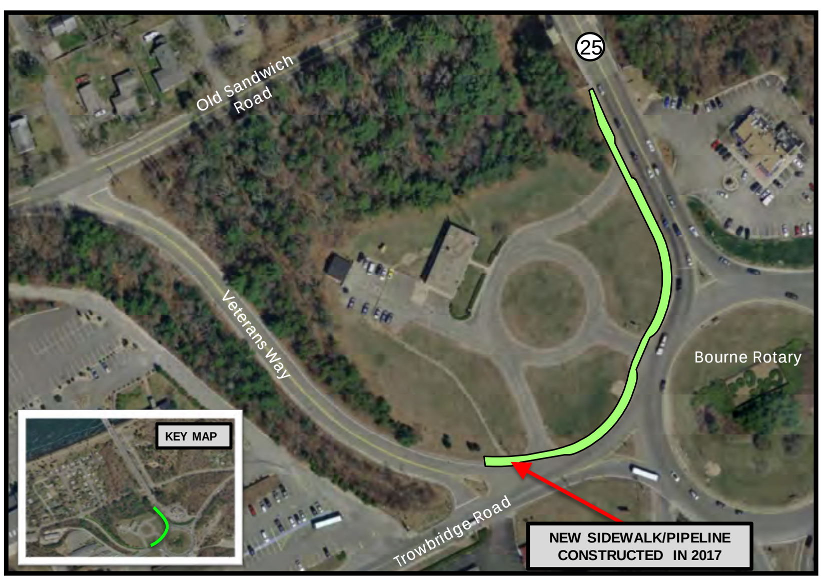
Exhibit ES-27 Enhanced Bicycle-Pedestrian Access at Bourne Bridge

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.