Cape Cod Bridges Program

Purpose and Need Statement

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Submitted to:

United States Department of Transportation
Federal Highway Administration
Massachusetts Division Office

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Table of Contents

List of Tables

List of Exhibits

List of Appendices

1. Program Purpose and Need

The purpose of this document is to define the Purpose and Need Statement for the Cape Cod Bridges Program by providing data regarding the existing bridge's structural deficiencies, substandard bridge and roadway design, and traffic operations. Standards to which the Bourne and Sagamore bridges were initially designed to in the 1930's are provided; and include information regarding structural deficiencies, substandard roadway design, and the high traffic volumes which are experienced on the bridges and their approaching roadways during present day.

1.1 Program Purpose

The purpose of the Cape Cod Bridges Program is to improve cross-canal mobility and accessibility between Cape Cod and mainland Massachusetts for all road users and to address the increasing maintenance needs and functional obsolescence of the aging Cape Cod Canal highway bridges. The Program will improve traffic operations and multimodal accommodations to facilitate the dependable and efficient movement of people, goods, and services across the Cape Cod Canal.

1.2 Program Needs

In order to fulfill the purpose of the Cape Cod Bridges Program, the following transportation-related problems and unsatisfactory conditions need to be addressed within the project area:

- Structural condition of the Bourne and Sagamore bridges and their frequent maintenance requirements
- Substandard design of the Bourne and Sagamore bridges, including the approaches and their interface with the adjacent roadway network, and
- Peak period congestion and traffic operations

Data supporting each of these identified transportation needs is provided below.

1.2.1 Structural Deficiencies and Frequent Maintenance Requirements

Despite ongoing maintenance efforts and major rehabilitation of superstructure components in 1981, these approaching 90-year-old steel truss bridges have deteriorated over time and are now beyond their functional service lives. Both bridges undergo a regular cycle of inspection, consistent with current National Bridge Inspection Standards (NBIS). These routine inspections are conducted to characterize the existing conditions of the deck, superstructure, and substructure, thus allowing the USACE to identify bridge components in need of maintenance, repairs, rehabilitation and/or replacement[1]. Individual bridge components of the deck, superstructure, and substructure are categorized as either "GOOD," "FAIR," "POOR," or "CRITICAL" where these classifications are based on a scale of 0 to 9 (with 0 scoring as a failed condition, and 9 scoring as an excellent condition). A bridge qualifies as structurally deficient if the

[1] "Major Rehabilitation Evaluation Report and Environmental Assessment," Cape Cod Canal Bridges Major Rehabilitation Study, U.S. Army Corps of Engineers, updated March 2020, https://www.nae.usace.army.mil/Portals/74/docs/Topics/Cape%20Cod%20Canal%20Bridges/Reports/FinalMRERDocument.pdf

condition rating is less than or equal to 4 (in poor or worse condition) for the bridge deck, superstructure, or substructure.

Based on latest information available from a routine inspection conducted by USACE in October 2020, the Bourne Bridge was classified as structurally deficient. The deck was in fair condition with a condition rating of 5 due to continuing deterioration in the abutment spans. The superstructure was in poor condition with a rating of 4 due to continuing deterioration of the concrete T-beams, deterioration of gusset plates at truss joints and broken anchor bolts at truss expansion bearings. Gusset plates are considered fracture critical members (FCM), meaning the failure of one of these elements will likely lead to catastrophic failure of an entire span. The substructure was in good condition with a condition rating of 7, although delamination and spalling were noted in the bridge abutment walls. The "structurally deficient" classification does not imply that the bridge is unsafe for travel. However, the classification is an indication that the bridge requires maintenance and repair and eventual rehabilitation or replacement to address existing deficiencies.

Exhibit 1-1 Photos of Fracture Critical Gusset Plate Deterioration (Bourne Bridge 2020)

The Sagamore Bridge was not considered to be structurally deficient as of the latest available inspection conducted by the USACE in 2021. The deck was in fair condition with an overall rating of 5. The superstructure and substructure were also in fair condition with overall ratings of 5. Although the 2021 inspection findings warranted condition ratings of fair for the deck, superstructure and substructure, individual bridge components warranted overall ratings of poor, such as the fracture critical gusset plates and other connection plates.

Exhibit 1-2 Photos of Fracture Critical Gusset Plate Deterioration (Sagamore Bridge 2021)


There are several unrepaired truss joint gusset plates on three spans of the west truss and two spans of the east truss of the Sagamore Bridge that exhibit areas of advanced section loss and deformation due to pack rust. In addition to continuing deterioration, the Sagamore Bridge is vulnerable to fatigue. Fatigue, which is progressive in nature, refers to failure of structural steel members under repeated stress cycles such as traffic loading. The truss spans of the Bourne and Sagamore bridges are fracture critical.

The age of the Bourne and Sagamore bridges, combined with heavy vehicular demands and the corrosive saltwater environment of Cape Cod, necessitates frequent, costly, and escalating maintenance and repairs to maintain the structures in a state of good repair. All repair work on the superstructure and bridge deck requires vehicular lane closures to facilitate contractor activities. Typically, these lane closures restrict travel to one lane in each direction. Historically, temporary lane closures have been in effect for a minimum of approximately nine months during repair contracts. Full closure of the bridge would be required for shorter time periods (about 2 weeks) multiple times during a major rehabilitation to allow replacement of certain critical bridge components, such as interior gusset plates and floorbeams. These prolonged lane restrictions and full bridge closures likely would result in lengthy traffic delays, with congestion extending far beyond the project area.

Exhibit 1-3 Traffic Backup on Route 6 Westbound During Maintenance Work on the Sagamore Bridge

Based on criteria provided in the MassDOT Load and Resistance Factor Design (LRFD) bridge design specifications, the Bourne and Sagamore bridges are designated as “Critical and Essential Bridges,” which must be operational following a natural disaster or other event. The approaching 90-year-old Bourne and Sagamore bridges do not meet current seismic design standards. Given the age and underlying structural deficiencies of the existing bridges, they could be vulnerable to damage from major seismic events or extreme weather-related events.

1.2.2 Substandard Bridge and Roadway Design

The Bourne and Sagamore bridges were constructed in the 1930s to standards that are not in use today. Identical in design, each highway bridge provides four 10-foot-wide vehicular travel lanes (two lanes in each direction) with a double yellow centerline, and a single 5-foot-wide sidewalk. A two-foot-wide safety curb is provided along the side opposite the sidewalk.

Based on roadway functional classification as limited access highways, the 10-foot-wide travel lanes along both bridges are two feet narrower than the 12-foot lane width standard specified by the American Association of State Highway and Transportation Officials (AASHTO). The bridges also lack physical separation between opposing traffic lanes and lack shoulder accommodation to provide refuge for drivers in the event of a vehicle breakdown, emergency, crash, or other incidents. Since the existing bridges do not have shoulders, stopped or disabled vehicles block one or both lanes of traffic, resulting in lengthy traffic delays and public safety concerns due to delayed emergency response. Narrow lanes and the lack of shoulders, and the absence of separation between opposing travel lanes result in frequent reports of sideswipe collisions between vehicles travelling in the same and opposite directions. The lack of shoulders presents additional safety concerns for bicyclists and the absence of barrier separation between the traffic lanes and the existing sidewalk on the Bourne and Sagamore bridges presents safety concerns for all non-motorized bridge users including pedestrians and bicyclists. The single raised 5-foot-wide shared pedestrian and bicycle sidewalks provided along the Bourne and Sagamore bridges do not conform to current Americans with Disabilities Act (ADA) and MassDOT geometric design standards, which limit mobility and accessibility for people who do not own or have access to motor vehicles for cross-canal trips.

Exhibit 1-4 Vehicular and Pedestrian Traffic Crossing the Bourne Bridge

Currently, the Bourne and Sagamore bridges transition abruptly to connecting surface roads since the surface roads are aligned very close to the Canal. The existing right-hand lane in each direction on the Bourne and Sagamore bridges must double as acceleration/deceleration lanes to facilitate vehicles entering and exiting the bridges onto adjoining roadways. A similar situation occurs where the Bourne Bridge ties into the Bourne Rotary with Cape-bound local traffic entering and exiting the rotary, and cross-traffic mixing with bridge-bound and bridge-exiting traffic. Modern highway design guidance, including AASHTO highway and bridge design specifications and MassDOT design standards, require that entrance and exit ramps include auxiliary lanes for entering and exiting traffic to transition into or out of through traffic safely. There are also no pavement markings within the Bourne Rotary to indicate lane use, which might lead to driver confusion and increased risk of vehicle collisions.

Approaching the Sagamore Bridge from the north, one of the two travel lanes along Route 3 southbound is dropped to allow travelers from Scenic Highway to merge onto Route 3 at Exit 1A, reinstating the second travel lane. This substandard roadway geometry contributes to congestion and delays on Route 3 southbound, especially during peak periods. Immediately south of the Sagamore Bridge, Route 6 Exit 55 (formerly Exit 1C) provides access to Sandwich Road for eastbound travelers via the Mid-Cape Connector and to Cranberry Highway for westbound travelers. The geometry of Route 6 Exit 55 westbound (at Cranberry Highway) does not comply with current MassDOT highway design standards due to short acceleration and deceleration lanes, and steep grades approaching the Sagamore Bridge.

The Bourne and Sagamore bridges and their approaches feature steep grades of up to six percent. At a six percent grade, the vertical profile of the bridges is steeper than the four- to five-percent maximum grade typical for a limited-access highway. Because of the steep vertical profile of the bridges and their approaches, it is difficult for vehicles, especially large trucks, to maintain speed. This effect, combined with narrow 10-foot-wide lanes and lack of auxiliary lanes, causes all traffic to slow down in both directions and make abrupt lane changes.

In addition to above referenced substandard roadway design elements, the traffic safety features of the Bourne and Sagamore bridges, including the bridge railing, transitions, approach guardrails and approach guardrail ends, do not conform to current AASHTO or MassDOT Specifications.

1.2.3 Peak-Period Congestion and Traffic Operations

The Bourne and Sagamore bridges were designed and built in the 1930s to serve far lower traffic volumes than those served by the bridges today. Estimates of vehicle traffic volumes during design for new highway crossings of the Cape Cod Canal in the early 1930s ranged from average daily low winter numbers of 1,200 to peak summer Sunday numbers of 4,700.

Exhibit 1-5 Historic Photo of Bourne Bridge Opening in 1935

Today, the Cape Cod Canal highway bridges are used by the 230,000 year-round residents of Barnstable County and the millions of visitors to the Cape each year. The 2019 Average Daily Traffic (ADT) for the Fall (off-peak season) and the Summer (peak-season) on the Bourne Bridge was 46,370 and 57,860, respectively. The 2019 ADT for the Fall (off-peak season) and the Summer (peak-season) on the Sagamore Bridge was 62,020 and 79,560, respectively. These levels are exponentially higher than the volume of traffic projected in the 1930s studies on which the design of the existing Bourne and Sagamore bridges was based.

Heavy traffic volumes on the Bourne and the Sagamore bridges, coupled with the above-referenced substandard roadway conditions, contribute to poor traffic operations during peak travel periods and crash rates that are considerably higher than the statewide average for similar facilities. The Bourne and Sagamore bridges and their approach roadway network within the project area currently operate at appreciable delay during peak travel periods. The concept of Level of Service (LOS) is defined as a qualitative measure based on quantitative model outputs that describe operational conditions within a traffic stream and their perception by the traveling public. LOS is identified based on average delay per vehicle (measured in seconds per vehicle) at local signalized and unsignalized intersections and based on densities on freeway sections and at merge-diverge points (measured in vehicles per mile per lane). LOS is represented using letter grades “A” through “F”, with LOS A representing very low delays and free flow conditions and LOS F representing unacceptable conditions for most drivers and conditions in which vehicle demand generally exceeds roadway capacity. LOS A, LOS B, and LOS C are generally considered acceptable conditions; LOS D is generally considered marginally acceptable conditions; and LOS E and LOS F are generally considered unacceptable to most drivers.

The approaches to the Bourne and Sagamore bridges from both directions operate at poor LOS for all peak hours analyzed under 2019 base year conditions including the Weekday AM Peak Hour (Summer and Fall), the Weekday PM Peak Hour (Summer and Fall) and the Saturday Midday Peak Hour (Summer and Fall). The southbound side of the Bourne Bridge currently operates at LOS F during all peak hours analyzed due to congestion at the Bourne Rotary. Southbound Route 25 approaching the exit for Belmont Circle operates at LOS E and F during the Summer Weekday PM Peak Hour, Fall Saturday Midday peak hour and Summer Saturday Midday peak hour. Northbound Route 28 approaching the Bourne Rotary also operates at LOS F during the Fall and Summer Weekday PM peak hours, in addition to Fall and Summer Saturday Midday peak hours. Westbound Route 6 and Southbound Route 3 approaching the Sagamore Bridge operate at LOS E and F for all peak hours analyzed. Both directions of the Sagamore Bridge also operate at LOS F for all peak hours analyzed. Graphics illustrating LOS for all major freeway sections within the project area under 2019 Base Year conditions during all analyzed peak hours are presented in Appendix A. With projected growth in traffic volumes in future years, operating conditions are expected to worsen over time.

The Bourne and Sagamore bridges experienced a significantly higher crash rate than the MassDOT average crash rate for similar principal arterial roadways during the most recently studied period between January 1, 2017, and December 31, 2019. The MassDOT crash rate for a similar facility is 0.80 crashes per million vehicle miles traveled (MVMT). The Bourne Bridge experienced a crash rate of approximately 1.8 crashes per MVMT or 120 percent higher than the State average crash rate for a principal arterial roadway. The Sagamore Bridge experienced a crash rate of approximately 2.6 crashes per MVMT or 228 percent higher than the State average crash rate for a principal arterial roadway.

Observed crashes by type during the 2017 – 2019 study period can be partially attributed to existing traffic congestion and narrow bridge configuration. The composition of observed crashes by type during the study period is summarized in Table 1-1 below.

Table 1-1 Crash Data Summary by Type - 2017 to 2019

Location	*Rear End*	*Sideswipe Same Direction*	*Sideswipe Opposite Direction*	*Head On*	*Fixed Object/ Single Vehicle Crash*	*Not Reported*	*Total*
Bourne Bridge	*20*	*6*	*11*	*0*	*8*	*0*	*45*
	45%	*24%*	*13%*	*0%*	*18%*	*0%*	*100%*
Sagamore Bridge	*20*	*15*	*6*	*2*	*12*	*1*	*56*
	36%	*27%*	*11%*	*4%*	*21%*	*1%*	*100%*

As shown in Table 1-1, the most common crash type on the Bourne and Sagamore bridges is Rear-End (45 percent and 36 percent of crashes, respectively). Congestion along the bridges contributes to the high rate of rear-end crashes. The second most common crash type on each Bridge is Sideswipe – Same Direction (24 percent and 27 percent of crashes, respectively). This crash type, along with the Fixed Object/Single Vehicle Crash type, can be partially attributed to the narrow 10-foot lanes and lack of roadway shoulders. The Sideswipe – Opposite Direction and Head-On crash types can also be partially attributed to the lack of a median or separation of the direction of travel along each Bridge.

Within the past several years, other identified locations in the immediate area of the Bourne and Sagamore bridges with a history of high crash rates include Belmont Circle, Bourne Rotary, and the intersections of Route 6A at Route 130 and Scenic Highway at Meetinghouse Lane. These high-crash locations identify crash clusters that rank within the top five percent of the Cape Cod Commission's planning region.

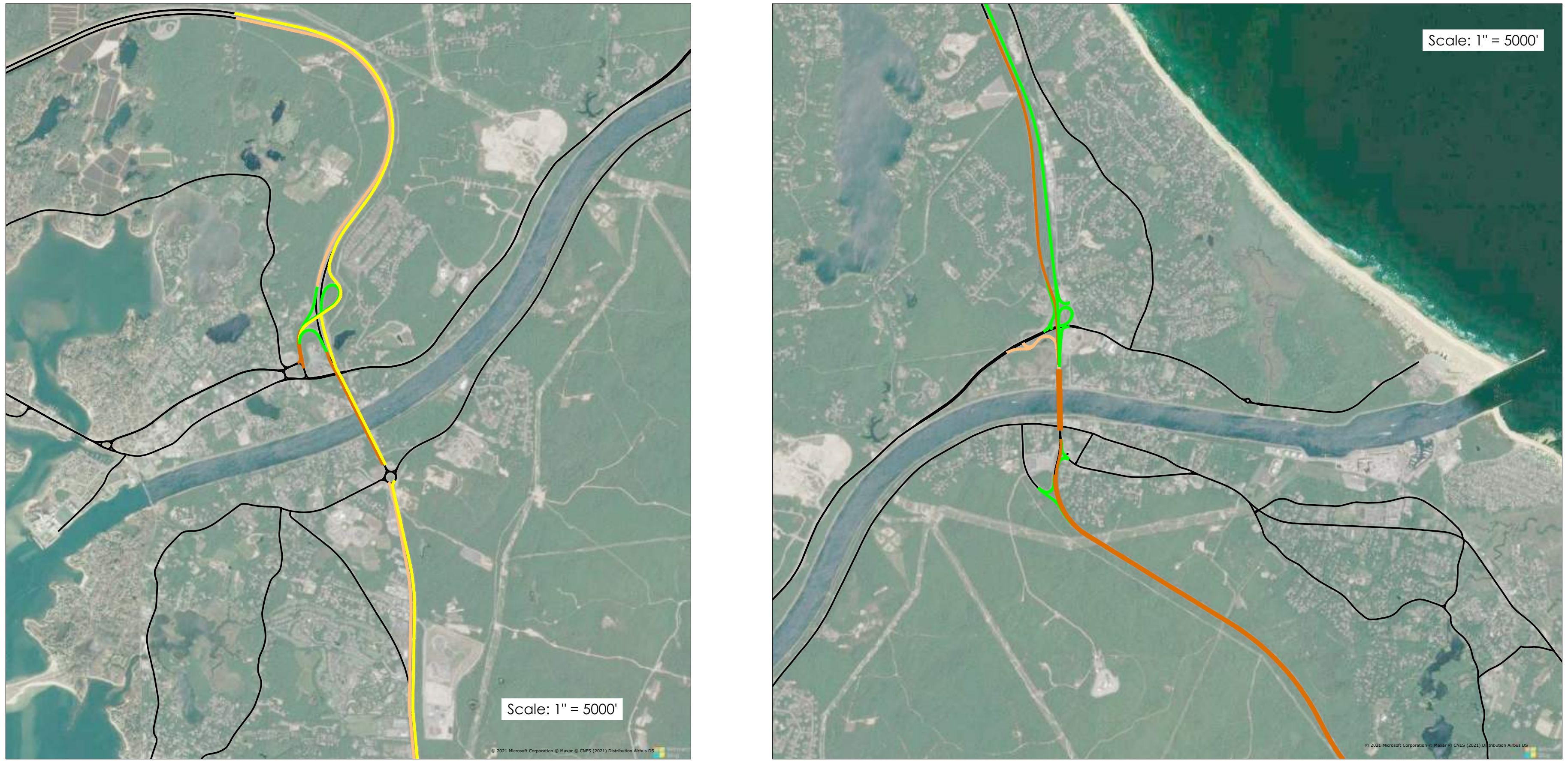
Appendices

Appendix A – Traffic Level of Service Graphics

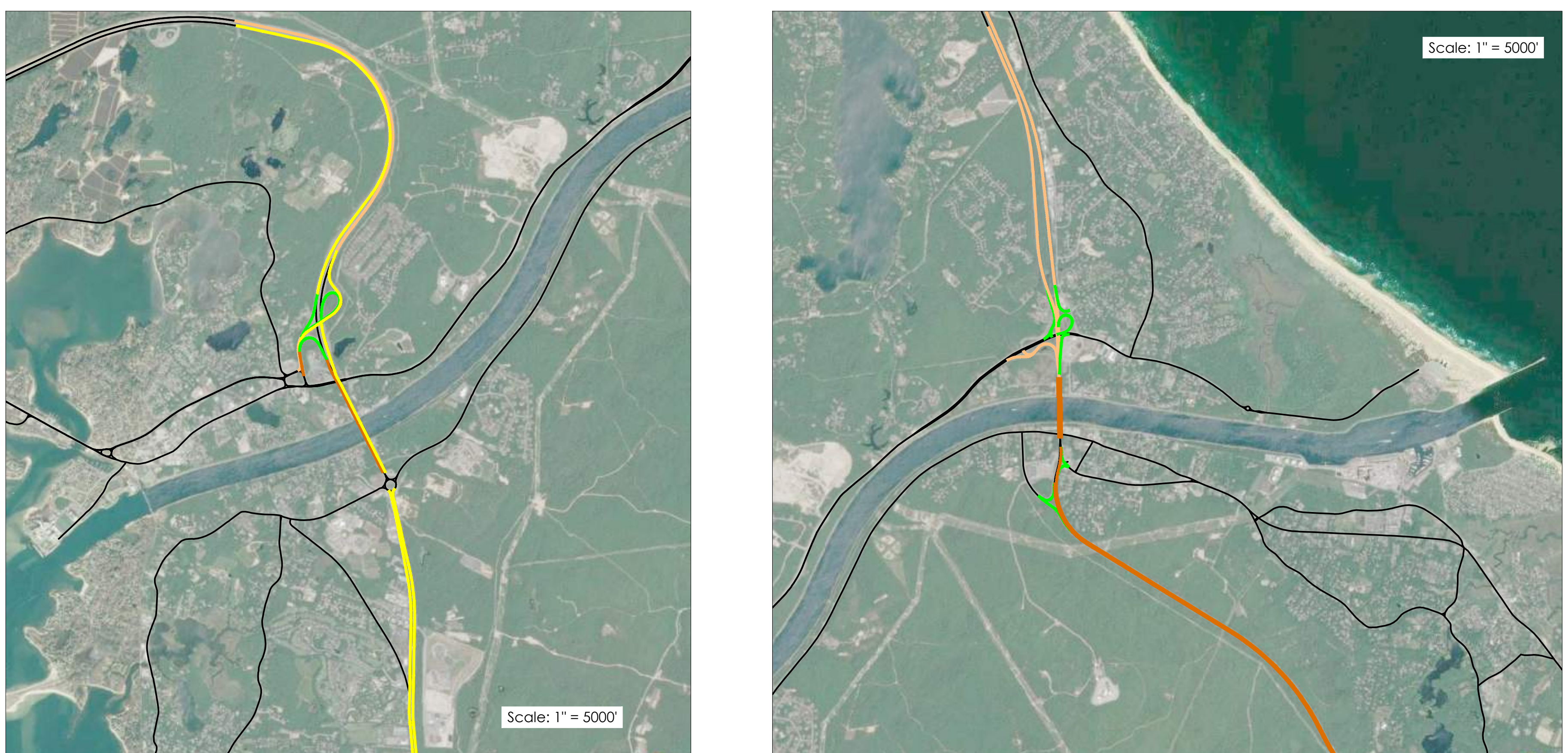
Appendix A

Traffic Level of Service Graphics

FALL WEEKDAY A.M. PEAK HOUR



SUMMER WEEKDAY A.M. PEAK HOUR



N

NAD 83

LEGEND

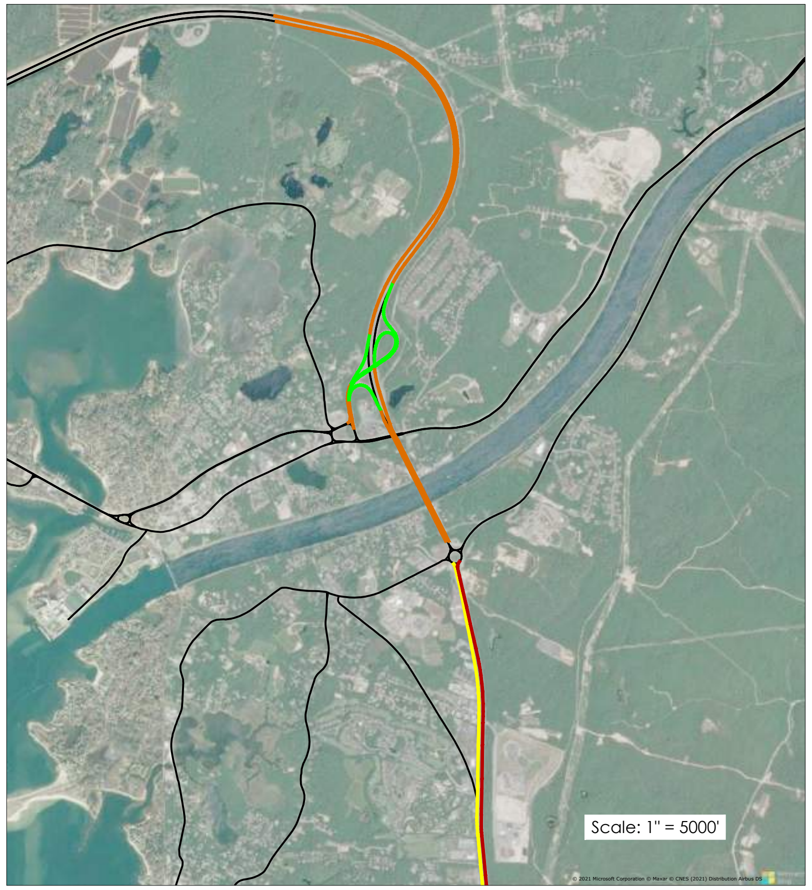
LOS	Density (pc/mi/ln)
A, B, C	<26 for Freeway <28 for Merge-Diverge
D	26 - 35 for Freeway 28 - 35 for Merge-Diverge
E	35-45
F	45-80
F	80-100
F	>100

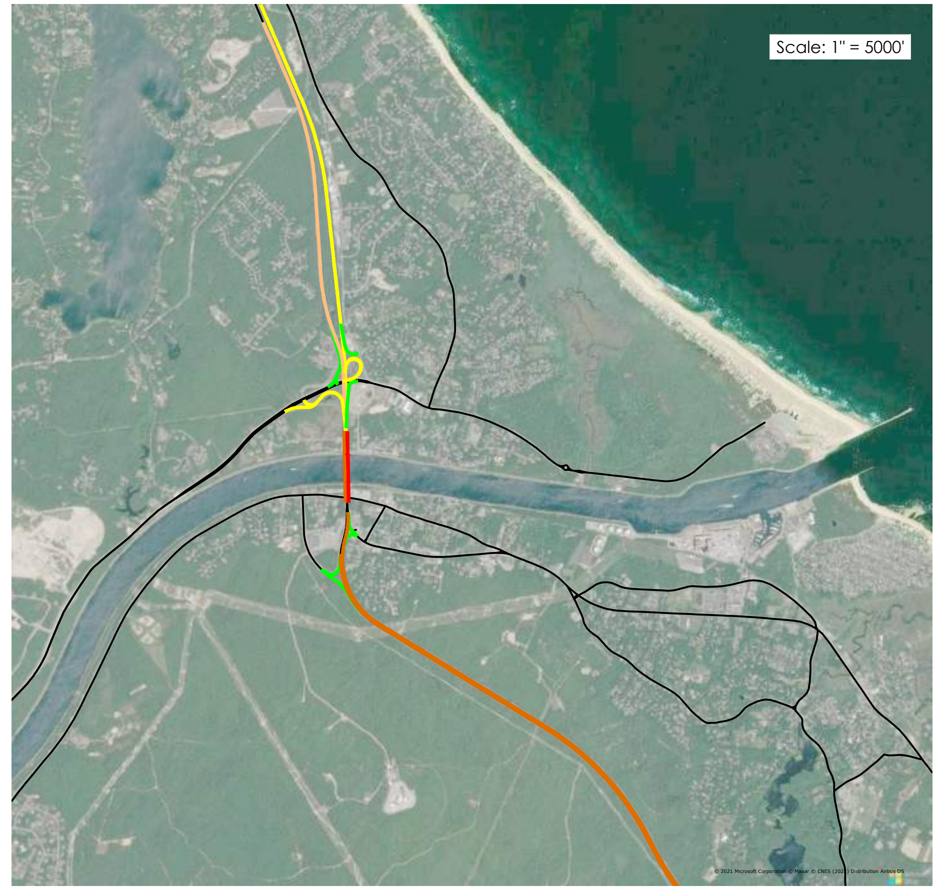
Cape Cod Canal Program Management

Bourne Bridge and Sagamore Bridge Density,
Fall and Summer AM
Peak Hour

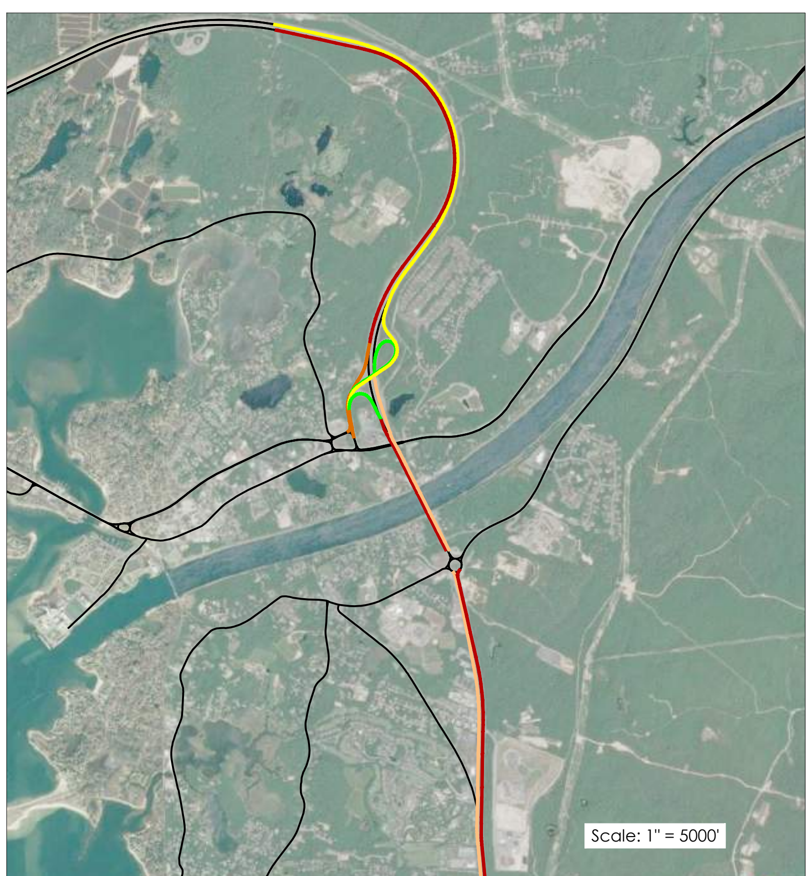
2019 Baseline Conditions

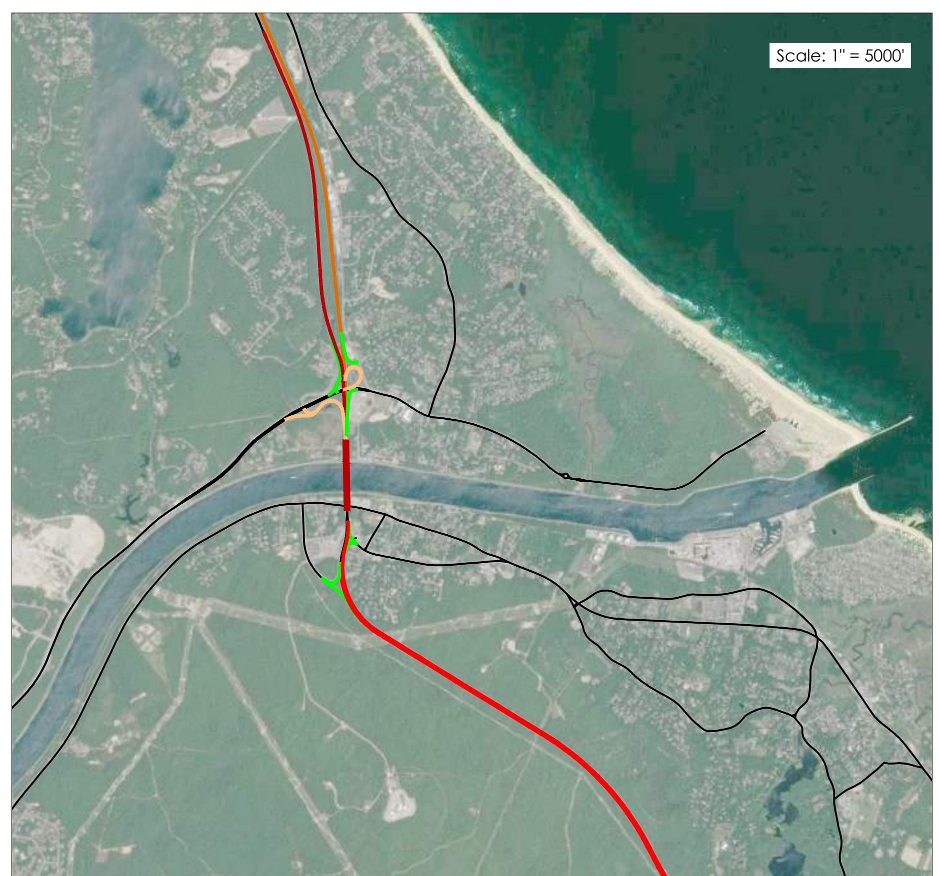
FALL WEEKDAY P.M. PEAK HOUR





SUMMER WEEKDAY P.M. PEAK HOUR





N

NAD 83

LEGEND

LOS	Density (pc/mi/ln)
A, B, C	<26 for Freeway <28 for Merge-Diverge
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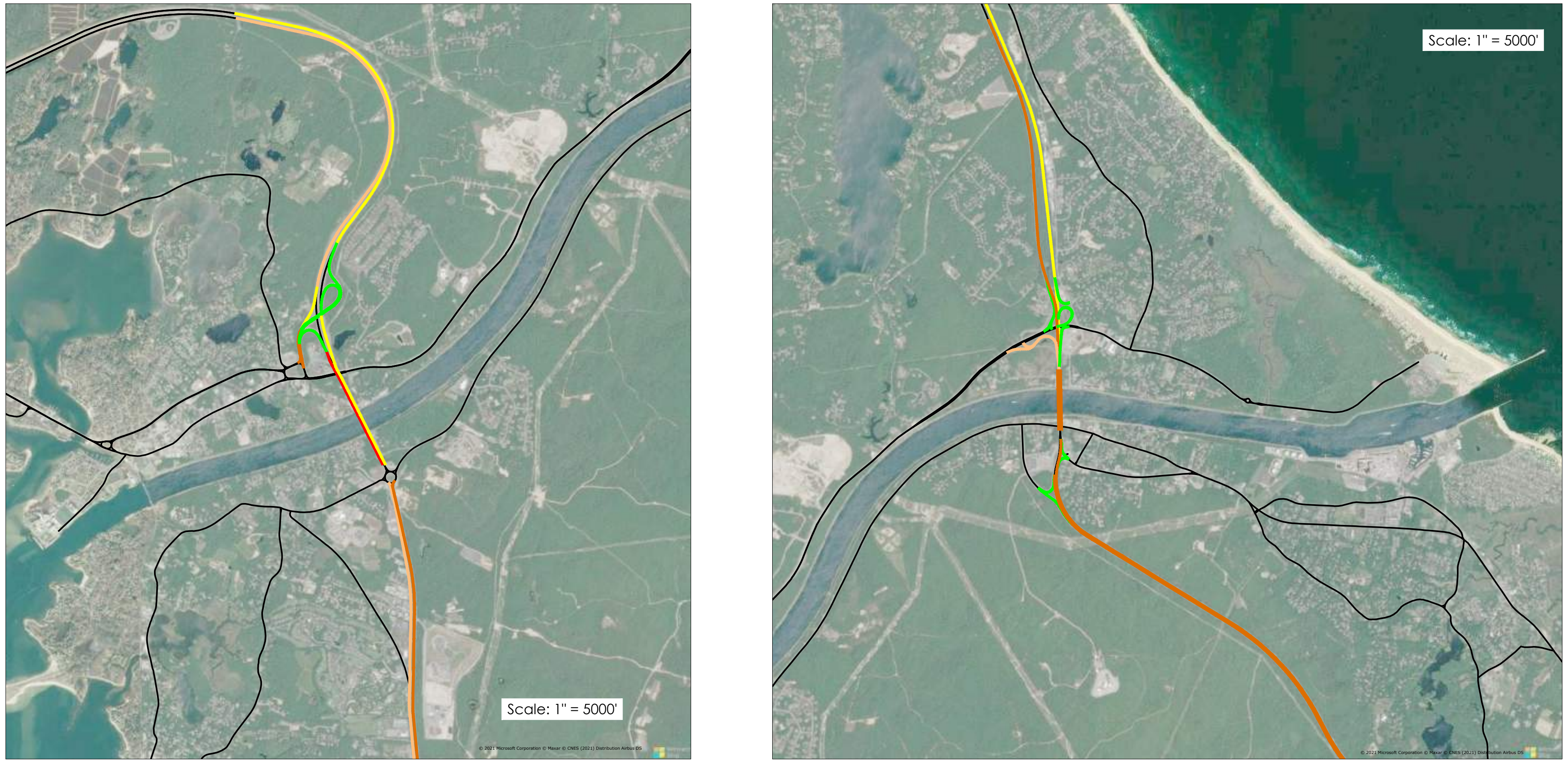
F	45-80
F	80-100
F	>100

Cape Cod Canal Program Management

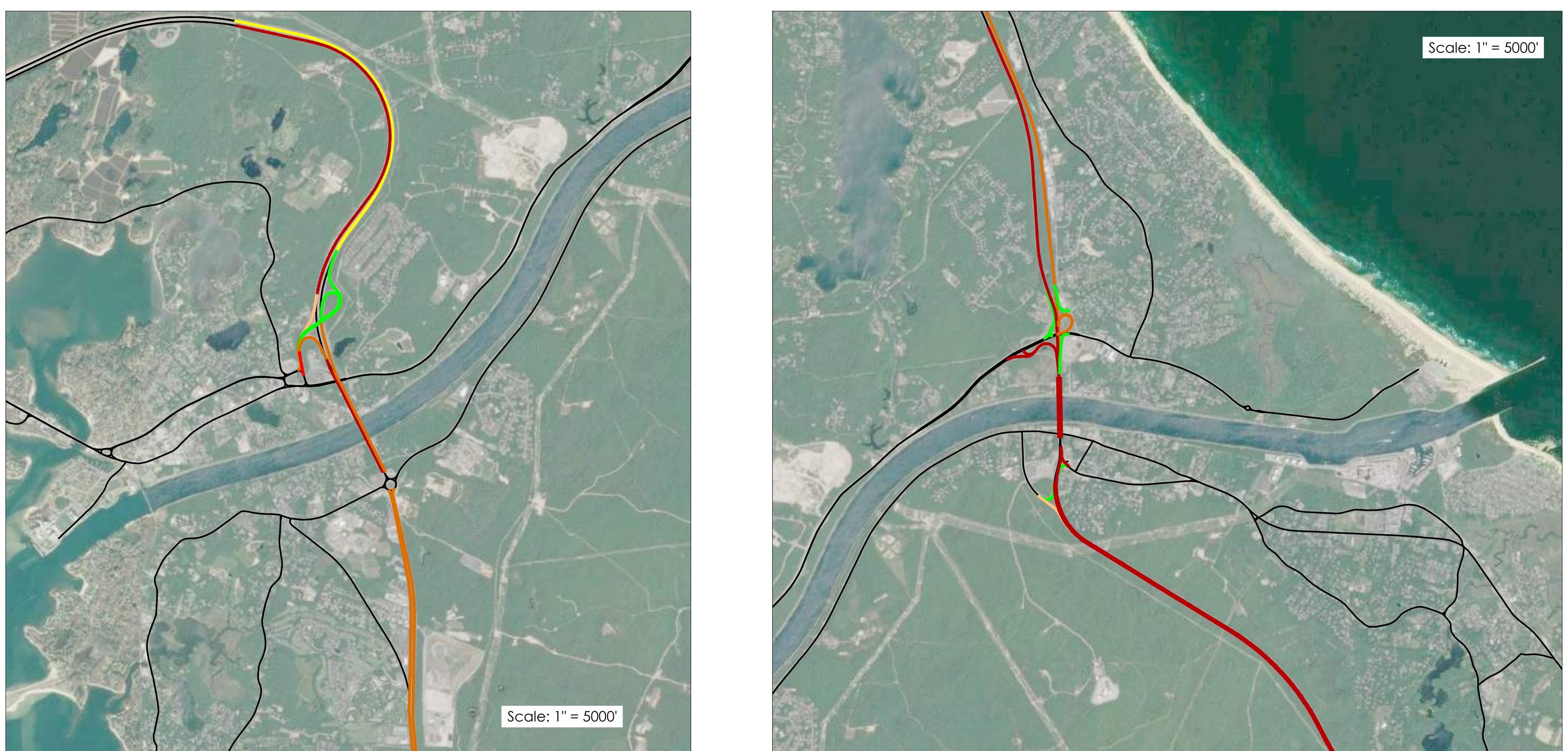
Bourne Bridge and Sagamore Bridge Density, Fall and Summer PM Peak Hour

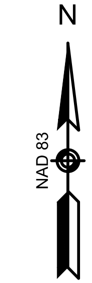
2019 Baseline Conditions

FALL SAT PEAK HOUR



SUMMER SAT PEAK HOUR





LEGEND

LOS	Density (pc/mi/ln)
A, B, C	<26 for Freeway <28 for Merge-Diverge
D	26 - 35 for Freeway 28 - 35 for Merge-Diverge
E	35-45
F	45-80
F	80-100
F	>100

Cape Cod Canal Program Management

Bourne Bridge and Sagamore Bridge Density, Fall and Summer SAT Peak Hour

2019 Baseline Conditions