Cape Cod Bridges Program

Bourne, Massachusetts

Appendix 3.2
Construction Approach Technical Report

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Submitted October 2025

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
D-B	design-build
MassDOT	Massachusetts Department of Transportation
Program	Cape Cod Bridges Program
SUP	shared-use path

1 Introduction

This Construction Approach Technical Report has been prepared in support of the Draft Environmental Impact Statement for the Cape Cod Bridges Program (Program), in accordance with the following federal statutes, regulations, and guidance:

- National Environmental Policy Act of 1969, as amended, 42 United States Code 4321 et seq.
- *Efficient Environmental Reviews for Project Decisionmaking and One Federal Decision,* 23 United States Code 139.
- Federal Highway Administration's (FHWA) regulations implementing National Environmental Policy Act, *Environmental Impact and Related Procedures* (23 Code of Federal Regulations 771), and corresponding guidance, Technical Advisory (T 6640.8A): *Guidance for Preparing and Processing Environmental and Section 4(f) Documents* (October 30, 1987).

2 Proposed Action

2.1 Purpose and Need

In partnership with the Federal Highway Administration and the New England District of the U.S. Army Corps of Engineers, the Massachusetts Department of Transportation (MassDOT) proposes advancing the Program in the town of Bourne, Barnstable County, Massachusetts.

The purpose of the 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 Bourne and Sagamore Bridges (also known as the Cape Cod Canal highway bridges), which the U.S. Army Corps of Engineers owns, operates, and maintains as part of the Cape Cod Canal Federal Navigation Project. The needs for the Program are as follows:

- Address the deteriorating structural condition and escalating maintenance demands of the Bourne and Sagamore Bridges.
- Address the substandard design elements of the Bourne and Sagamore Bridges, the immediate mainline approaches, and their adjacent interchanges and intersections.
- Improve vehicular traffic operations.
- Improve accommodations for pedestrians and bicyclists.

Attachment 1 provides the existing conditions plans, identified by Study Area quadrant as Sagamore North, Sagamore South, Bourne North, and Bourne South.

2.2 Build Alternative

The Program's Build Alternative would incorporate the U.S. Army Corps of Engineers' Major Rehabilitation Evaluation Report and Environmental Assessment's preferred alternative of replacing both highway bridges with new bridges, each with four through-travel lanes and two auxiliary lanes (in-kind bridge replacement that would be updated to comply with federal and state highway and design safety standards). The Program proposes to replace Sagamore Bridge and Bourne Bridge with parallel, twin tied-arch bridge structures that would be supported on delta frames with an approximate 700-foot mainline span length. At both the Sagamore Bridge and Bourne Bridge crossings, the replacement mainline alignment locations would be offline and inboard of the existing bridges on the side of the canal between the bridges. At both canal crossings, the Program would reconfigure the highway interchange approach networks north and south of Cape Cod Canal to align with the replacement bridges. The replacement bridges and their interchange approaches would accommodate shared-use pedestrian and bicycle paths that would connect to the local roadway network on both sides of Cape Cod Canal in the town of Bourne.

Table 2-1 presents a description of the Program elements/design parameters of the recommended Build Alternative: Replacement Highway Bridges Built to Modern Design Standards. **Figure 2-1 through Figure 2-4** present the recommended Build Alternative by Program quadrant, based on preliminary design plans.

Table 2-1. Design Parameters of the Recommended Build Alternative

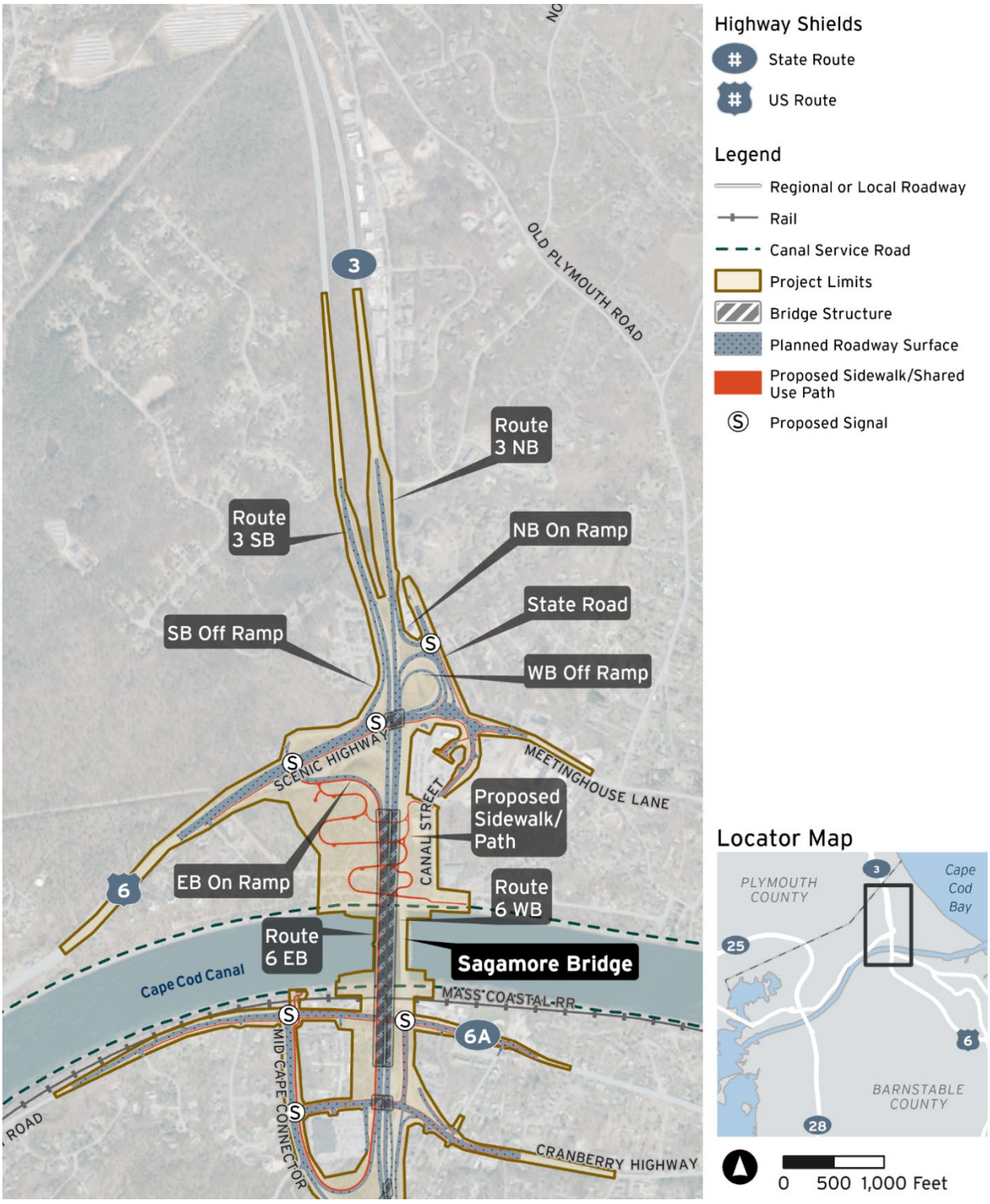
Program Element/ Program Design Parameter	Description
Highway Bridges	Both the Sagamore Bridge and Bourne Bridge would be replaced with new bridges, with each comprising four through-travel lanes and two auxiliary lanes (i.e., an in-kind bridge replacement that would comply with federal and state highway and design safety standards).
Bridge Highway Cross-Section and Shared-Use Path	Each replacement bridge would provide four 12-foot-wide through-traffic lanes (two in each direction), two 12-foot-wide entrance/exit (auxiliary) lanes, a 4-foot-wide left shoulder, and a 10-foot-wide right shoulder. Right and left barriers would be offset an additional 2 feet beyond the limits of the shoulders.
	Each crossing location would include one bidirectional pedestrian and bicycle shared-use path (SUP), separated from vehicular traffic by the shoulder and barrier. The usable width of the SUP would be 14 feet wide on the bridge main span, 20 feet wide on the approach spans, and 12 feet wide minimum on the connecting roadways.
Bridge Clearances	The replacement bridges would maintain the existing vertical clearance of 135 feet above mean high water and account for 3 feet of fluctuations in relative sea level, for a total vertical clearance of 138 feet above mean high water. The replacement bridges would provide a minimum 500 feet of horizontal channel width to be consistent with existing conditions.

Program Element/ Program Design Parameter	Description
Main Span Length and Bridge Pier Location	The replacement bridges would have a main span length of approximately 700 feet, which would locate the bridge piers at the waterline adjacent to the service road (shoreline piers) into the riprap slope but above the low tide line.
Bridge Deck Configuration	Each replacement bridge would have two separate decks (twin structures).
Mainline Alignment	The mainline alignment locations at both crossings would be offline inboard: the main spans of each replacement bridge would be located outside the footprint of the existing bridge, approximately 10 feet apart and parallel to each other (offline) and on the side of the canal between the existing Sagamore Bridge and Bourne Bridge (inboard). At the Bourne Bridge crossing, both main spans would be east of the existing Bourne Bridge toward Cape Cod Bay. At the Sagamore Bridge crossing, both main spans would be west of the existing Sagamore Bridge toward Buzzards Bay.
Bridge Type	The replacement bridges would be twin tied-arch bridges with delta frames supporting an approximate 700-foot mainline span.
Interchange Approach Network: Sagamore North Quadrant	The Sagamore North interchange approach network would be "Direct Connection to State Road (Option SN-8A)". The interchange approach network would provide a single exit point from a relocated U.S. Route 6/State Route 3. It would remove the Sagamore Bridge northbound off-ramp connection to Scenic Highway/Meetinghouse Lane eastbound and instead would connect to State Road, north of Scenic Highway/Meetinghouse Lane. The remaining ramp connections would remain similar to existing conditions. Signalized intersections along Scenic Highway and Meetinghouse Lane would be modified with two roundabouts to accommodate through-travel and turning movements. The intersection of State Road at State Route 3 northbound would be modified to accommodate the addition of the new State Route 3 northbound off-ramp with installation of a traffic signal. It would provide a SUP on the U.S. Route 6 eastbound main span that would provide connections to the south side of Scenic Highway, Canal Street, and Canal Service Road. SUPs would be provided along the southern side of Scenic Highway and Meetinghouse Lane and along the eastern side of State Road to Homestead Avenue.

Program Element/ Program Design Parameter	Description
Interchange Approach Network: Sagamore South Quadrant	The Sagamore South interchange approach network would be "Westbound On-Ramp Under U.S. Route 6 with Cranberry Highway Extension and Sandwich Road Connector (Option SS-3.1A)." The interchange approach network would include Cranberry Highway Extension and would relocate the westbound on-ramp, so it would share the same entrance point as the eastbound on-ramp off Mid-Cape Connector. It would remove the Cranberry Highway to Sagamore Bridge westbound ramp, and it would provide a new westbound on-ramp connection from Mid-Cape Connector to Sagamore Bridge westbound. Modifications to lane arrangements at the intersections of Mid-Cape Connector with Sandwich Road and Cranberry Highway Extension would accommodate the revised traffic patterns resulting from the extension of Cranberry Highway and relocation of access to U.S. Route 6 eastbound, including modifications to the existing traffic signals. There would be a connection from Cranberry Highway Extension to Sandwich Road east of the new mainline bridge structure (Sandwich Road Extension). A single lane roundabout would be the intersection control at this location. Additionally, west of the new mainline bridge, a single lane roundabout would be provided at the eastern-bound entrance of the existing Market Basket parking lot. Additional improvements would include modified access to Market Basket (Factory Outlet Road) and an access driveway to the former Christmas Tree Shops area. It would provide a SUP on the U.S. Route 6 eastbound main span that would provide connections to Factory Outlet Road, Sandwich Road, and the Canal Service Road. Bicycle and pedestrian improvements would be included on Cranberry Highway. A new connection would be added through Cranberry Highway Extension to Mid-Cape Connector.

Program Element/ Program Design Parameter	Description
Interchange Approach Network: Bourne North Quadrant	The Bourne North interchange approach would be "Directional Interchange (Option BN-14.4b)." The interchange approach would provide a combination of direct connection ramps between State Route 25 and U.S. Route 6. The ramp connecting State Route 25 eastbound to Scenic Highway would be a direct connect ramp, allowing access to Scenic Highway eastbound only. The new flyover ramp connecting Scenic Highway to State Route 25 would allow vehicles to bypass Belmont Circle and would not require an additional traffic signal. This ramp would utilize one of the travel lanes on Scenic Highway and would be a free-flowing movement to reduce congestion. The existing State Route 28 over the State Route 25 bridge would be relocated to widen the bridge to allow for this new southbound to eastbound ramp movement. The existing southbound off-ramp would be revised to be an option lane, improving the geometry and decision sight distance for drivers. The intersection control at U.S. Route 6/Nightingale Road/Andy Oliva Drive would be a single-lane roundabout. It would provide a SUP and a grade-separated crossing for pedestrians and bicyclists via the new flyover ramp over Scenic Highway. The U.S. Route 6 lane configuration would be reduced from four lanes to three lanes, which would provide additional space for multimodal accommodations. It would provide one continuous 12-foot-wide SUP along the south side of U.S. Route 6 connecting to Belmont Circle and a 6-foot-wide sidewalk along the north side of U.S. Route 6.
Interchange Approach Network: Bourne South Quadrant	The Bourne South interchange approach network would be "Diamond Interchange (Option BS-2)." It would eliminate Bourne Rotary and replace it with a grade-separated diamond interchange, allowing through movements on State Route 28 to bypass the intersections with the non-mainline roadways. Both intersections within the diamond interchange would require a roundabout for intersection control (a single-lane dogbone-shaped roundabout). Changes to the Trowbridge Road and Sandwich Road underpass in this option would consist of a multi-lane roundabout at a relocated Upper Cape Cod Regional Technical High School Driveway entrance. It would provide SUP connections to Trowbridge Road, the Cape Cod Canal Service Road, and the Bourne Recreation Area.

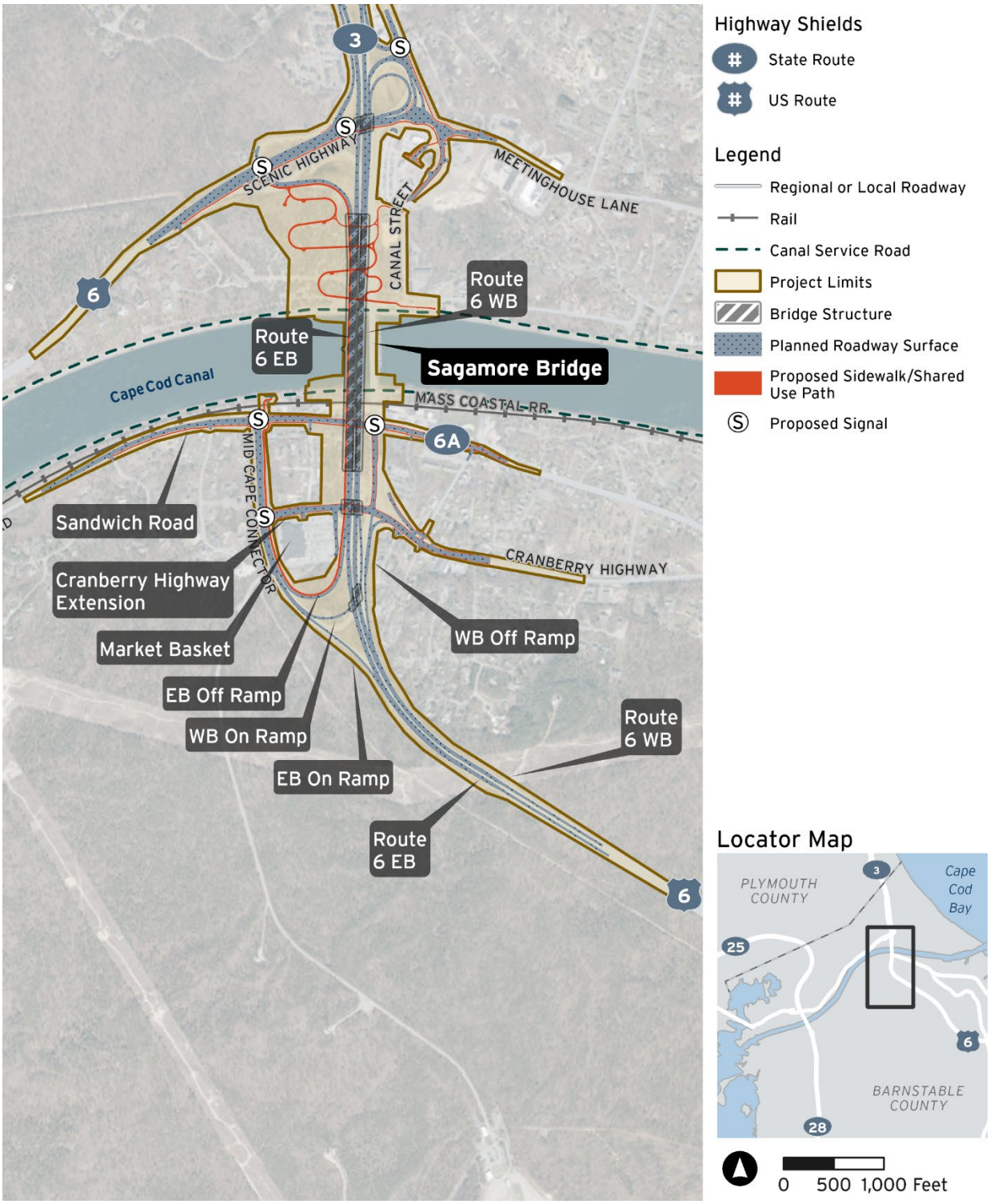
Figure 2-1. Option SN-8A: Direct Connection to State Road (Sagamore North Quadrant)



Source: Massachusetts Department of Transportation, 2024

EB = eastbound, NB = northbound, SB = southbound, WB = westbound

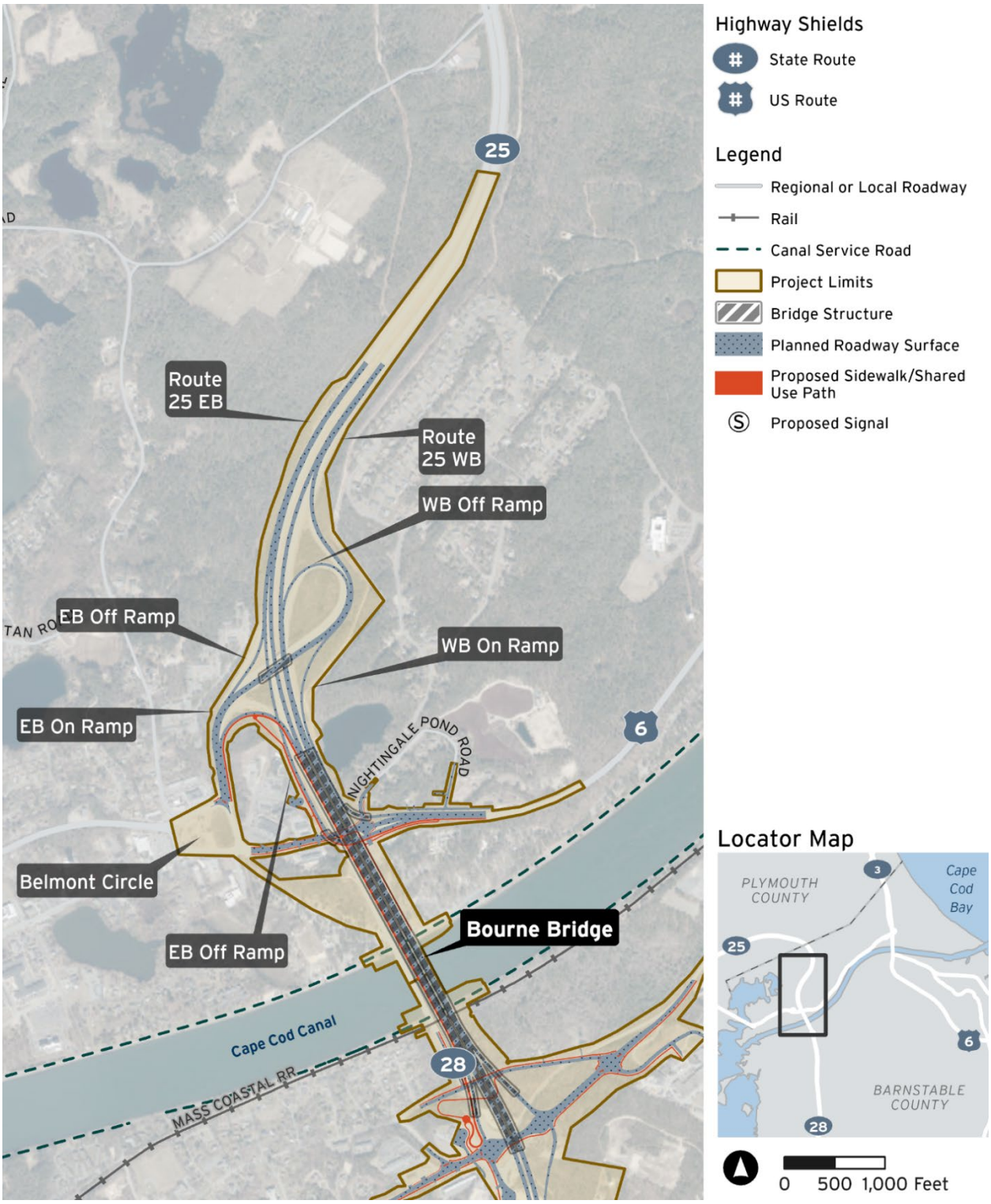
Figure 2-2. Option SS-3.1A: Westbound On-Ramp under U.S. Route 6 with Cranberry Highway Extension and Sandwich Road Connector (Sagamore South Quadrant)



Source: Massachusetts Department of Transportation, 2024

EB = eastbound, WB = westbound

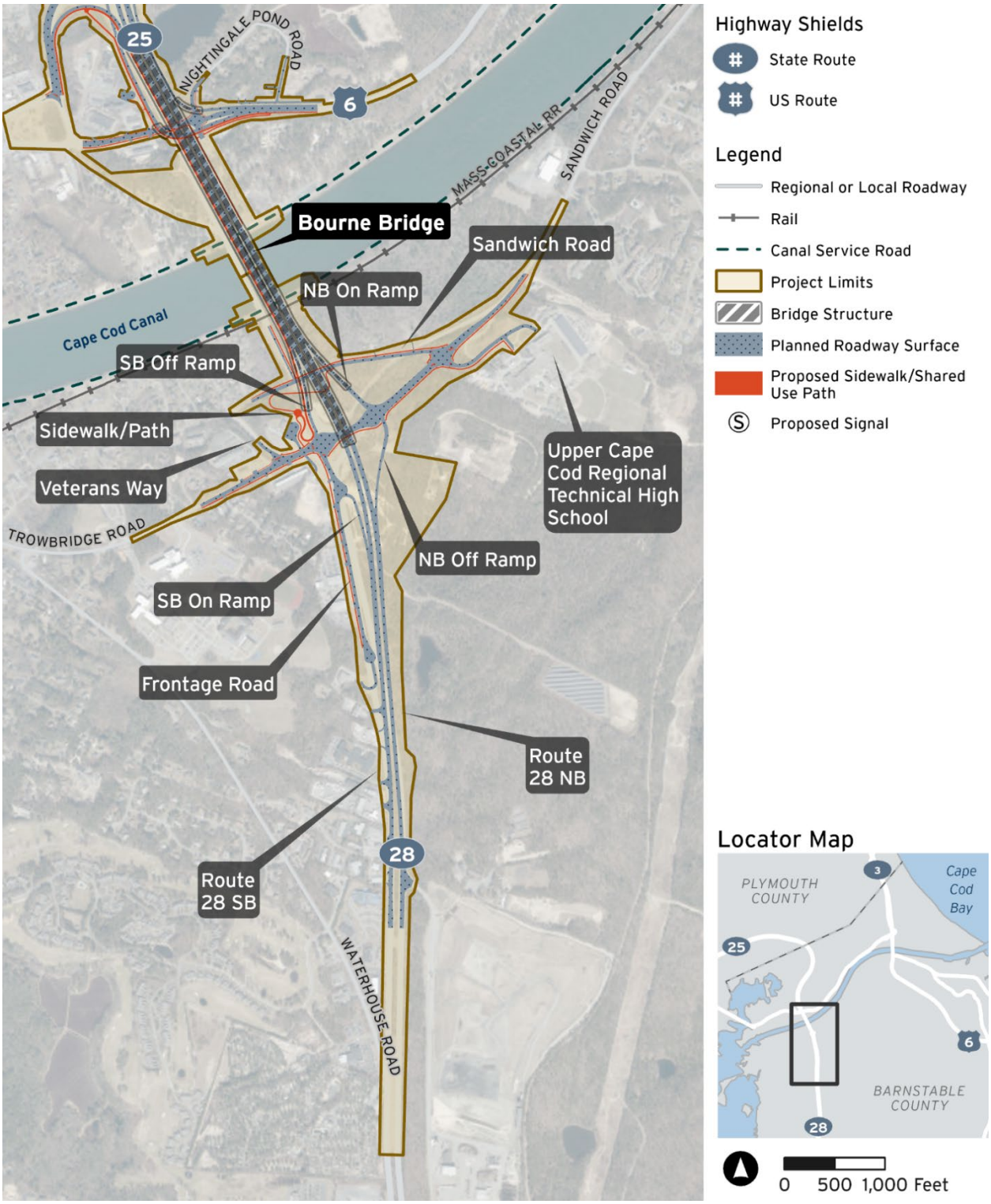
Figure 2-3. Option BN-14.4b: Directional Interchange (Bourne North Quadrant)



Source: Massachusetts Department of Transportation, 2024

EB = eastbound, WB = westbound

Figure 2-4. Option BS-2: Diamond Interchange (Bourne South Quadrant)



Source: Massachusetts Department of Transportation, 2024

NB = northbound, SB = southbound

3 Introduction to the Program's Construction Approach

This technical report presents the following construction scenarios for the Program based on preliminary design. MassDOT evaluated these construction scenarios in consultation with a construction specialist. MassDOT expects to contract the Program as a design-build; note that the design-build team could propose different construction means and methods.

3.1 Overview of Design-Build Construction Method

MassDOT will be using a "Best Value" design-build (D-B) procurement method for the construction of the Program, pursuant to Chapter 149A of the Massachusetts General Law. As described in **Chapter 1, Introduction**, the Program is planned to be delivered in two phases, with the Sagamore Bridge Project as Phase 1 and the Bourne Bridge Replacement Project as Phase 2.

A D-B process is a construction delivery system that combines design and construction services within a single contract. A "best value" method is one that that provides the highest overall value to MassDOT, considering both cost and quality. Section 15 of Massachusetts General Law Chapter 149A defines quality as the basis on which MassDOT will evaluate the elements of a project that MassDOT has determined are most important, including, for example, quality of design, innovative approach, constructability, life-cycle and other long-term maintenance costs, maintenance of traffic, aesthetics, environmental impacts, local impacts, traveler and other user costs, service life, and time to construct.

The D-B method can provide substantial time savings compared to the more traditional design-bid-build approach, which typically involves three sequential project phases consisting of the:

1. Design Phase, in which MassDOT contracts separately with a design firm for project design development, progressing from preliminary to final design, and preparation of construction documents.
2. Bid Phase, when the construction documents are available for general contractor review and pricing (bidding).
3. Build or Construction Phase, when the project is built by the selected (the lowest bid) contractor.

The sequential nature of the design-bid-build project delivery method can result in project delays as construction cannot begin until the design and procurement phases have been completed.

By awarding one contract under the D-B procurement method, there is no bidding phase or delay between the final design and construction phases. In addition to accelerating project delivery by integrating the design and construction phases, other benefits of the D-B procurement method include greater cost and schedule control through the use of incentives and disincentives, close collaboration between the design and contractor that can promote development of innovative design and construction methodologies to reduce environmental- and traffic-related impacts to the maximum

extent feasible, and reduced overall project risk as the D-B entity is responsible for the design and construction under a single contract.

The Best Value D-B procurement method is a two-phase selection process, which begins after MassDOT issues public notice of a project and solicits and receives Letters of Interest from proposers. In Phase 1, MassDOT will create a short list of qualified D-B entities (proposers) based on the responses to its Request for Qualifications. In Phase 2, MassDOT will receive technical and price proposals from the short list of proposers based on its Request for Proposals. MassDOT will then award the construction contract to one proposer (a D-B team) based on Best Value, the highest overall value to MassDOT, considering quality and cost. Given the scale of the Program and the environmental resources within and abutting the Program Limits, MassDOT's evaluation of technical proposals will incentivize environmental mitigation strategies, which may include alternative designs or construction methods that minimize impact.

Under the D-B procurement method for the Program (Phase 1 Project), MassDOT's advertised construction contract (Request for Proposal) will provide the Base Technical Concept, defined as approximately 25% level of design, to establish the minimum baseline requirements that must be equaled or exceeded by the D-B team. The awarded D-B team will be required to complete final design and construct the Phase 1 Project in compliance with regulatory permits and approvals, and within the timeframe determined by the project schedule. Also, the D-B team must adhere to the Project Management Plan, Quality Management Plan, Site Control Plan, Construction Staging Plan, Noise and Dust Control Plans, Health and Safety Plan, and all other applicable laws, negotiations, regulations, ordinances, and other requirements, taking into account the right-of-way and other physical constraints affecting the Program. Further, all final Program design and construction components will be reviewed by MassDOT and performed in accordance with MassDOT Design Standards and criteria, specifications, and contract administration practices.

MassDOT will secure all necessary environmental approvals and clearances based on the Program's Base Technical Concept. By selecting the D-B procurement methodology for the Program, MassDOT shares responsibility for environmental compliance with the D-B team. Accordingly, the D-B team, in coordination with MassDOT, will be responsible for obtaining any amendments to environmental approvals/clearances necessitated by any proposed deviations from the Base Technical Concept.

3.2 Program Timeline and Durations

Pending the completion of National Environmental Policy Act environmental reviews and receipt of federal and state permits and approvals, anticipated in spring 2026, MassDOT proposes to initiate the Program's design-build procurement and construction process in fall 2026. Construction activities for the replacement Sagamore Bridge and Bourne Bridge are expected to occur over the course of eight to ten years, respectively. Construction of Sagamore Bridge would begin first, followed by Bourne Bridge once funding is secured. It is currently planned that construction of the replacement Bourne Bridge would commence one year following commencement of replacement Sagamore Bridge construction. However, timing of construction sequencing is dependent upon funding.

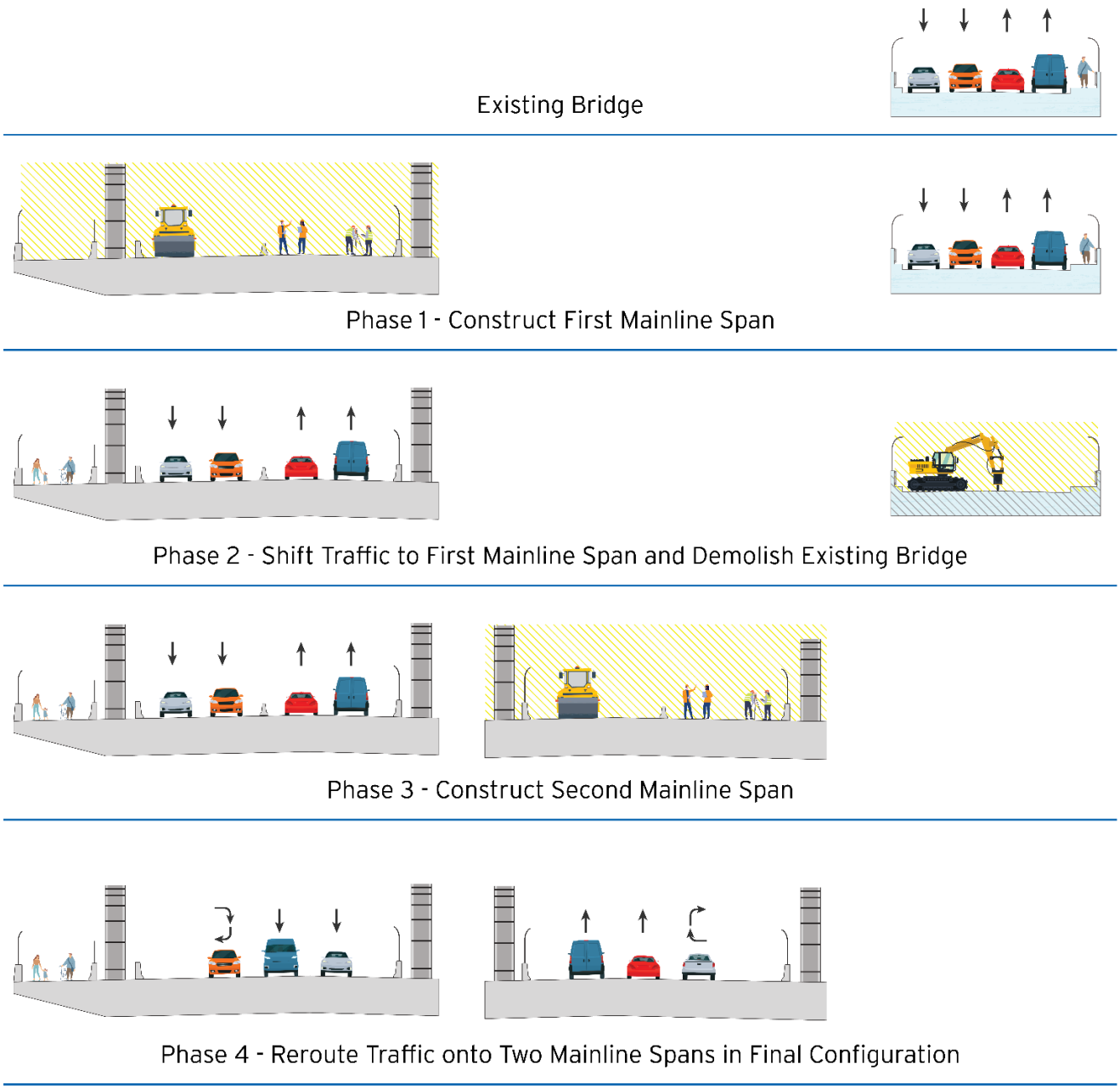
3.3 Program Milestones and Phasing

There are four key milestones for the Program's bridge and interchange network phasing:

- Phase 1 – Construct the first mainline span and approaches, consisting of the eastbound mainline at the Sagamore Bridge crossing and the northbound mainline at the Bourne Bridge crossing.
- Phase 2 – Shift all traffic off the existing bridge and onto the new mainline structure and demolish the existing bridge.
- Phase 3 – Construct the second mainline span and approaches, consisting of the westbound mainline at the Sagamore Bridge crossing and the southbound mainline at the Bourne Bridge crossing.
- Phase 4 – Reroute the traffic onto the two mainline spans in the final configuration and open connections to the shared-use path (SUP) over the canal and supporting path network.

Figure 3-1 presents a simplified schematic of the bridge construction sequencing approach. The proposed Sagamore Bridge crossing is shown; the Bourne Bridge crossing would have a similar approach.

Figure 3-1. Proposed Bridge Construction Sequencing Approach



Source: Massachusetts Department of Transportation, 2024

4 Early Action/Initial Construction Activities

For each Program quadrant, early action work/initial construction activities would include the following:

- Tree removal
- Right-of-way takings/structure demolition
- Mobilization/Establishment of approximate limits of work
- Utility relocations (including electric, sewer, potable water, gas, and telecommunications)
- Construction of temporary SUP connections (where needed), consisting of a minimum 6-foot-wide sidewalk for temporary multimodal access.

This section provides an overview of tree removal, structure demolition, and establishment of project limits. **Section 4.8, Property Acquisition, Displacement, and Relocation**, and **Section 4.19, Utilities and Services**, in the Draft Environmental Impact Statement documents describe the property acquisition process and utility relocations, respectively.

4.1 Tree Removal

MassDOT would conduct tree removal as an initial construction activity. Tree removal would be required within designated areas to allow for bridge construction and laydown, roadway and SUP construction, highway and ramp widening, construction of stormwater management basins, and embankment and slope construction.

The total approximate acreage of tree removal would be 132.14 acres, divided among the four Program quadrants, as follows:

- Sagamore North quadrant: 38.77 acres
- Sagamore South quadrant: 23.83 acres
- Bourne North quadrant: 23.83 acres
- Bourne South quadrant: 45.71 acres

MassDOT would use its standard specifications to conduct tree removal, which would include clearing and grubbing, tree trimming, tree removal, and stump removal.[1] In preparation for tree removal, an arborist would develop a tree-removal plan. The plan would include inspecting the area of trees to determine the safest option for tree removal, such as identifying where trunks fall and options for lowering trees via rope, crane, or bucket etc., and identifying how tree pieces would be hauled out after cutting to avoid damaging trees that are outside of the designated cut area. When possible, tree

[1] Massachusetts Department of Transportation. 2024 Standard Specifications for Highway and Bridges. Subsections 101 through 105. https://www.mass.gov/doc/2024-standard-specifications-for-highways-and-bridges-division-ii-construction-details/download

removal by climbing is preferred. Tree removal would include removal of all brush, trees, stumps, and roots within the designated area, including dead, dying, and diseased trees, previously fallen trees, branches, uprooted stumps, and other debris. Tree-removal equipment can vary based on the size of the area required to be cleared, the terrain type, ease of access, density of vegetation and timeline; however, the following equipment may be used:

- Versatile equipment (such as excavators, bulldozers, skid steer loaders, tractors, and backhoes) that can clear land
- Specialized equipment (such as stump grinders, brush mowers, and string trimmers)
- Mulchers to clear underbrush, small trees, and leftover fencing (mulching attachments can be used with machines like tractors, skid steers, and excavators).

MassDOT would employ multiple mitigation measures, minimization measures, and best management practices to reduce impacts to federally listed and proposed species with the potential to occur in the Action Area, including implementing time-of-year restrictions on tree clearing. Trees would not be cleared from March 15 through November 30 on the Cape Cod side of Cape Cod Canal and from April 15 through October 31 on the mainland side of Cape Cod Canal.

4.2 Individual Structure Removal

To demolish the existing bridges and construct the new bridges, including the realignment of the mainlines, MassDOT would acquire properties and demolish existing structures. Up to 28 structures are anticipated to be demolished within the Project Limits.

Prior to structure demolition, MassDOT would conduct building inspections. The Program would follow Massachusetts Division of Fisheries and Wildlife (MassWildlife) guidance in developing exclusionary measures to ensure that bats are not present in or are removed from structures.[2] Prior to structure demolition, building inspections would be conducted.

Demolition of existing structures on properties acquired by MassDOT could be completed prior to commencement of the Program construction contract(s).

4.3 Mobilization and Establishment of Project Limits of Work

MassDOT would establish project limits of work within the four Program quadrants to accommodate bridge and roadway construction, retaining wall construction, installation of stormwater management features, construction access, and equipment laydown and staging areas.

Attachment 2 provides schematics of the following:

- Approximate bridge and mainline construction limits of work

[2] Massachusetts Division of Fisheries & Wildlife. 2020. Massachusetts Homeowner's Guide to Bats. (7th edition) https://www.mass.gov/doc/massachusetts-homeowners-guide-to-bats/download

- Equipment staging concepts for bridge and mainline construction

Attachment 3 details anticipated limits of tree clearing. **Table 4-1** presents the total acreage of land alteration due to the Program, consisting of the following:

- Tree clearing
- Alteration to existing pavement, such as mill and overlay and roadway reconstruction
- Alteration to previously disturbed areas, such as implementation of stormwater management best management practices

Table 4-1. Program Land Alteration

Program Quadrant	Tree Clearing (acres)	Alterations to Existing Pavement (acres)	Alterations to Previously Disturbed Areas (acres)	Total Land Alteration (acres)
Sagamore North	38.77	18.04	17.98	74.79
Sagamore South	23.83	20.76	17.27	61.87
Bourne North	23.83	21.70	41.20	86.73
Bourne South	45.71	14.27	23.03	82.41
Total	**132.14**	**74.77**	**99.48**	**306.39**

5 Construction Sequencing and Traffic Management

5.1 Program Goals

The construction sequencing and traffic management goals for each phase of the Program area are as follows:

- Remove traffic off the existing bridge as soon as possible.
- Maintain existing roadway and ramp connections throughout the duration of construction.
- Avoid the need for construction detours.
- Reduce or minimize traffic shifts.
- Reduce schedule delays by providing large work zones at the bridge sites.
- Design temporary roadways at 10 miles per hour less than the existing roadway design speed.
- Maintain pedestrian and bicycle connectivity access equal to or better than existing conditions throughout the duration of construction.

5.2 Design Standards

MassDOT has established design standards for the following to be maintained throughout construction:

- Mainlines
  - Lane Configuration – 2 lanes minimum in each direction
  - Travel Lane Width – 11-foot minimum
  - Shoulder Width – 0-foot minimum on structure; 2 feet preferred; 1-foot minimum at-grade
  - Vertical Clearance – Maintain existing vertical clearance as a minimum.
- Ramps
  - Travel Lane Width – 11-foot minimum
  - Inside Shoulder Width – 2 feet preferred; 1-foot minimum
  - Outside Shoulder Width – 2 feet preferred; 1-foot minimum
  - Total Ramp Width – 18-foot minimum to accommodate emergency vehicles
  - Entrance/Exit Ramp Design – Taper style ramps preferred; parallel style where necessary.
- Local Roads
  - Travel Lane Width – 10-foot minimum
  - Shoulder width – 2 feet preferred; 1-foot minimum

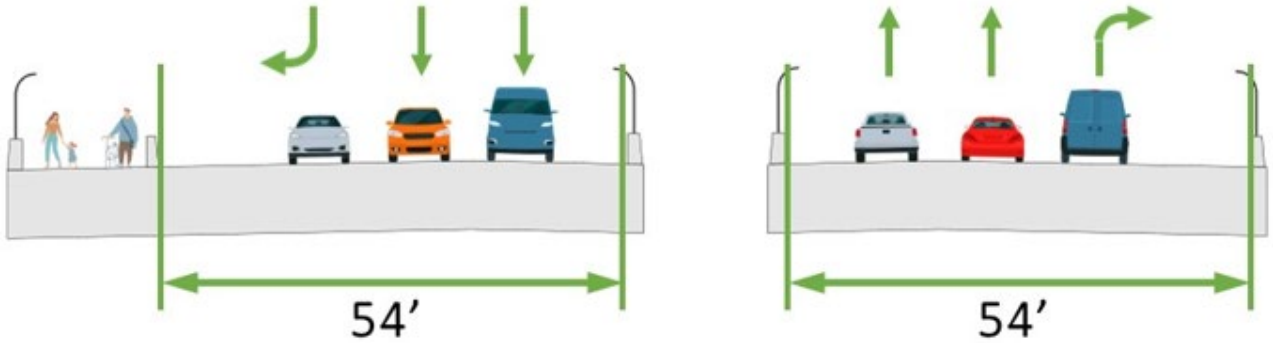
5.3 Summary Description

The replacement bridges would be constructed offline (outside of the existing footprint) and a maximum of 250 feet inboard of the existing highway bridges. Sagamore Bridge would be replaced first followed by Bourne Bridge. At each site, the inboard main span (inboard bridge) would be constructed first. At the Sagamore Bridge site, this would be the westernmost bridge, which would ultimately carry traffic onto Cape Cod. For the Bourne Bridge site, this would be the easternmost bridge, which would ultimately carry traffic off Cape Cod. After construction of the first new span, all traffic would be shifted onto it so the existing bridge can be demolished, and the second main span (bridge) can be constructed. **Figure 5-1** presents a highway bridge typical section in the temporary condition; the inboard span would contain all through traffic, leaving the existing bridge without traffic prior to its demolition. **Figure 5-2** presents a typical highway bridge section following construction completion, with both spans operational and traffic rerouted in the final configuration.

Figure 5-1. Highway Bridge Typical Section, Temporary Condition (First Bridge with all Through Traffic)

Source: Massachusetts Department of Transportation, 2024

Figure 5-2. Highway Bridge Typical Section, Completed Construction



Source: Massachusetts Department of Transportation, 2024

5.3.1 Bridge Construction

To enable the demolition of the existing Sagamore Bridge and construction of the westbound mainline bridge, all traffic would be shifted onto the proposed eastbound mainline built in the preliminary phases. To do this, while also maintaining two lanes of traffic in the eastbound and westbound directions, a combination of temporary crossovers and pavement widening would be needed. Furthermore, when traffic is on the proposed eastbound mainline structure, the typical section needs to be reduced to two 11-foot lanes in each direction, with two 2-foot shoulders, and separated by temporary median barrier. While all traffic is on this eastbound structure, demolition of the existing bridge and construction of the proposed westbound mainline bridge can occur without conflicts.

To enable the demolition of the existing Bourne Bridge and construction of the southbound mainline bridge, all traffic would be shifted onto the proposed northbound mainline built in the preliminary phases. To do this, while also maintaining two lanes of traffic in the northbound and southbound direction, a combination of temporary crossovers and pavement widening would be needed. Furthermore, when traffic is on the proposed northbound mainline structure, the typical section would be reduced to two 11-foot lanes in each direction, with no shoulder, and separated by temporary barrier. This section would allow the space for four lanes of traffic and the temporary pedestrian path. While all traffic is on this northbound structure, demolition of the existing bridge and construction of the proposed southbound mainline bridge can occur without conflicts.

5.3.2 Interchange Approach Construction Phasing

The following provides a general approach to construction phasing for the four quadrants based on preliminary design. Note that there are some activities that cannot occur before previous activities are completed (critical path construction activities); however, there may be an opportunity to construct other activities that do not have critical predecessor tasks. These non-critical-path construction activities could occur earlier than indicated herein. Additionally, as indicated in **Section 3**, the design-build team could propose different construction phasing, as well as different means and methods.

5.3.2.1 Sagamore North Quadrant

Eleven construction phases are proposed for the Sagamore North quadrant. In Phase 1, existing traffic patterns would be maintained, with a potential one-lane traffic and minor lane or shoulder closings at specific locations. Phases 2 through 11 would require revised traffic patterns. Milestone construction points would be reached at the end of Phase 4 and Phase 8. At the end of Phase 4, the U.S. Route 6 eastbound bridge over Cape Cod Canal including approaches must be completed. At the end of Phase 8, the U.S. Route 6 westbound bridge over Cape Cod Canal, including approaches, must be completed. Phases 10 and 11 consist of construction closeout and construction completion.

- Phase 1 - Construct the proposed U.S. Route 6 eastbound bridge over the canal, including U.S. Route 6 eastbound approaches and portions of State Route 3 mainline/ramps, while maintaining existing traffic patterns.
- Phase 2 - Continue constructing the mainline and State Route 3 on- and off-ramps with tie-ins at State Road.
- Phase 3 - Phase 3 work would be confined to the Sagamore South quadrant; no work would occur within the Sagamore North quadrant.
- Phase 4 - Construct the embankment and remaining portion of new State Route 3 southbound.
- Phase 5 - Construct portions of the U.S. Route 6 westbound mainline. Shift eastbound traffic to the newly constructed U.S. Route 6 eastbound outside shoulder; maintain westbound traffic on the existing bridge. Construct Sagamore Bridge permanent SUP along the U.S. Route 6 eastbound mainline crossing.
- Phase 6 - Construct the remainder of U.S. Route 6 westbound off-ramp, including completion of the bridge over Scenic Highway, a portion of State Route 3 northbound, remainder of State Route 3 northbound, and State Route 3 northbound on-ramp.
- Phase 7 - Demolish existing bridge structure and remove existing mainline and ramps. Begin construction of new U.S. Route 6 westbound bridge and final structural sections of State Route 3 northbound. The SUP would be fully online at the end of Phase 7.
- Phase 8 - Continue construction of new U.S. Route 6 westbound bridge and approaches.
- Phase 9 - Remove temporary crossovers, construct permanent median barrier, and remove temporary State Route 3 northbound bypass. Construction of SUP would be complete.
- Phase 10 - Begin Project closeout (landscaping, punch list, etc.), including removing temporary widening of State Route 3 southbound off-ramp and installing guardrail.
- Phase 11 - Construction complete.

5.3.2.2 Sagamore South Quadrant

Eleven construction phases are proposed for the Sagamore South quadrant. In Phase 1, existing traffic patterns would be maintained. Phases 2 through 9 would require revised traffic patterns. Milestone construction points would be reached at the end of Phase 4 and Phase 8. At the end of Phase 4, the

U.S. Route 6 eastbound bridge over Cape Cod Canal including approaches must be completed. At the end of Phase 8, the U.S. Route 6 westbound bridge over Cape Cod Canal, including approaches, must be completed. Phases 10 and 11 consist of construction closeout and construction completion.

- Phase 1 - Construct proposed U.S. Route 6 mainline and ramps eastbound bridge over canal including eastbound approaches and portions of Route while maintaining existing traffic patterns.
- Phase 2 – Construct temporary U.S. Route 6 temporary mainline and ramp crossovers.
- Phase 3 – Construct proposed U.S. Route 6 eastbound and on ramps.
- Phase 4 - Construct remainder of the U.S. Route 6 westbound and on- and off-ramps and temporary cross over from U.S. Route 6 westbound to U.S. Route 6 eastbound.
- Phase 5 - Construct a portion of U.S. Route 6 westbound and westbound on-ramp.
- Phase 6 - Construct permanent U.S. Route 6 westbound off-ramp and Cranberry Highway Extension.
- Phase 7 - Demolish existing bridge structure. Remove existing mainline and ramps. Begin construction of new U.S. Route 6 westbound bridge.
- Phase 8 - Continue construction of new U.S. Route 6 westbound bridge and approaches.
- Phase 9 - Remove existing crossovers and finalize mainline and ramp entrance construction.
- Phase 10 - Begin Project closeout (landscaping, punch list, etc., including installing guardrail.
- Phase 11 - Construction complete.

5.3.2.3 Bourne North Quadrant

Five construction phases are proposed for the Bourne North quadrant. In Phase 1, existing traffic patterns would be maintained; lane or shoulder closures may be required on some roadways. Phases 2 through 5 would require revised traffic patterns. Milestone construction points would be reached at the end of Phases 3, 4, and 5. At the end of Phase 3, the northbound mainline would be open and the northbound on-ramp from U.S. Route 6 would be open. At the end of Phase 4, the southbound off-ramp to U.S. Route 6 would be open. At the end of Phase 5, the southbound mainline structure would be open with the final traffic patterns.

- Phase 1 - Construct temporary pavement on mainline, including temporary crossover for mainline traffic shifts, temporary widening for mainline traffic shifts, temporary pavement for ramp movements. Begin construction of northbound mainline structure and relocate stormwater interceptor.
- Phase 2
  - Phase 2A - Continue construction of northbound mainline structure, proposed structure over State Routes 25/28, portions of northbound on-ramp from U.S. Route 6, and temporary southbound on-ramp over existing mainline.

  - Phase 2B - Demolish portion of existing northbound mainline and northbound on-ramp. Continue construction of northbound mainline structure and temporary northbound off-ramp.
  - Phase 2C - Demolish remaining portion of existing northbound mainline, northbound off-ramp, and east portion of existing structure over State Routes 25/28. Construct remaining portion of northbound mainline structure, temporary pedestrian path, and northbound on-ramp structure over Nightingale Road.
- Phase 3 - Demolish existing mainline, including structure over U.S. Route 6 and southbound on-ramp. Begin construction of southbound mainline structure, southbound off-ramp to U.S. Route 6 over U.S. Route 6, southbound off-ramp to U.S. Route 6 over Andy Oliva Drive, and SUP connection.
- Phase 4
  - Phase 4A - Demolish west portion of existing structure over State Routes 25/28. Construct portion of southbound mainline and portions of southbound off-ramp to Belmont Circle.
  - Phase 4B - Demolish existing southbound off-ramp. Construct remaining portion of northbound on-ramp from Belmont Circle.
  - Phase 4C - Construct remaining portion of southbound on-ramp.
- Phase 5 - Construct remaining portion of southbound mainline, southbound off-ramp to U.S. Route 6, and portions of the SUP. Begin Project closeout (landscaping, punch list, etc.), including installing guardrail.

5.3.2.4 Bourne South Quadrant

Seven construction phases are proposed for the Bourne South quadrant. In Phase 1, existing traffic patterns would be maintained; lane or shoulder closures may be required on some roadways. In Phase 2, existing traffic patterns would be maintained, with some exceptions; lane or shoulder closures may be required on some roadways. Phases 3 through 6 would require revised traffic patterns. Milestone construction points would be reached at the end of Phase 3 and Phase 5. At the end of Phase 3, the northbound mainline would be open. At the end of Phase 5, the southbound mainline would be open. Construction would be completed with the final traffic patterns in Phase 7.

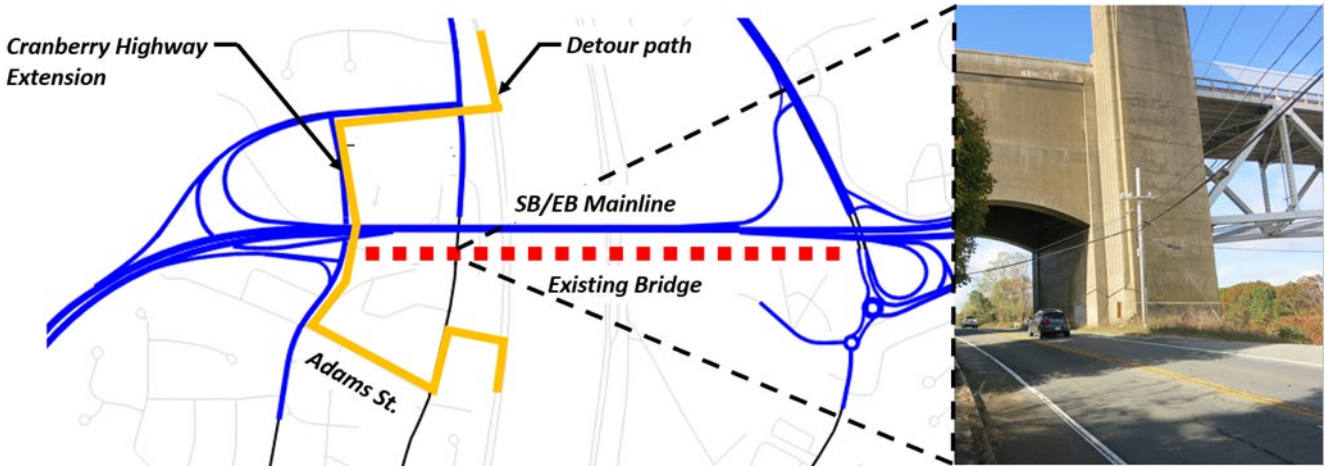
- Phase 1 - Construct proposed northbound mainline, northbound on-ramp bridge, northbound off-ramp, eastern portion of Trowbridge Road, and roundabout at Sandwich Road intersection, and temporary mainline crossover.
- Phase 2 - Construct proposed northbound on-ramp approach roadway, temporary southbound off-ramp U-turn, and Trowbridge Road through existing rotary.
- Phase 3 - Construct portion of proposed southbound mainline. Begin demolition of existing Bourne Bridge.
- Phase 4 - Construct portion of proposed southbound mainline, on-ramp, off-ramp, and portions of the SUP.
- Phase 5 - Complete construction of Trowbridge Road.

- Phase 6 - Construct proposed Frontage Road and complete remaining portions of Trowbridge Road and Sandwich Road. Begin Project closeout (landscaping, punch list, etc.), including installing guardrail.
- Phase 7 - Construction complete.

5.3.3 Pedestrian and Bicycle Connections

Maintaining pedestrian and bicycle connectivity during construction would be a priority. The phasing for pedestrian and bicycle connectivity has been sequenced to maintain the existing condition until a time when pedestrian and bicycle traffic can be transferred to the proposed bridge. Temporary connections may be required to maintain the east–west connections between the bridges and Canal Service Roads to allow pedestrians to travel to and from either side of the bridge as they do in the existing condition. The existing bridges would not be demolished until these temporary connections are completed. **Figure 5-3** provides an example of a temporary connection required during demolition of the existing bridge abutment.

Figure 5-3. Example of Temporary Shared-Use Path Connection



Source: Massachusetts Department of Transportation, 2024

EB = eastbound, SB = southbound

6 In-Water Construction Activities

6.1 Overall Approach and Durations

MassDOT would conduct in-water construction in multiple phases. Work would begin with the temporary installation of supportive structures such as trestles, cofferdams, bulkheads, bollards, docks, and dolphins as well as shoreline riprap removal and dredging to prepare for barge use and construction of the first bridge (main span). This would be followed by construction of the first bridge. After construction of the first bridge, the temporary works enabling demolition would be installed; MassDOT anticipates these to include trestles, containment cells, dolphins, and other items similar to

the temporary works for bridge construction. Demolition of the existing bridge and piers would occur once the enabling temporary works are in place. Following demolition, additional temporary works to support the construction of the second bridge would be installed; these would be similar in nature to those used for construction of the first bridge. Construction of the second bridge would occur once the temporary works that enable it are in place. Lastly, removal of temporary structures, and restoration of intertidal and subtidal fill/riprap would conclude the in-water construction portion of the Program.

For each bridge, in-water work within the north and south quadrants is anticipated to occur concurrently. The estimated durations of Program elements are based on evaluations conducted in coordination with a construction specialist. Durations may vary based on the D-B team's construction means and methods or based on contract packaging.

Construction of the in-water temporary works, drilled shafts, and substructures at the canal delta piers would require approximately two years for each new span. Construction of the delta frames using cranes on work trestles or cranes on land near the shoreline would require approximately one year for each new main span. Erection of the delta frames using cranes on work trestles or cranes on land near the shoreline would require six months for each new main span.

Four canal closures, each lasting approximately three to five days, would be required to allow float-in of the new bridge arches. Demolition of the existing bridge arch spans would require approximately nine months per bridge and demolition of the existing piers would require approximately six months per bridge. Two canal closures, each lasting approximately three to five days, would be required to allow float-out of the existing deconstructed bridge arches.

Attachment 4 provides schematics of in-water work activities proposed on both sides of the canal at the bridge crossing sites, including conceptual plans for temporary works, general construction layout, and construction vessel layout.

6.2 Temporary Works

In preparation for bridge construction and demolition, existing shoreline riprap would be removed to allow for installation of sheeting and piles that are needed for the temporary works. The temporary works within each quadrant may include the following:

- Cofferdams constructed of sheeting around the proposed new bridge pier locations
- Containment cells constructed of sheeting around the demolition zone of the existing bridge piers
- Sheeting along the approximate high tide line to create upland work areas, potentially reinforced with tiebacks through the sheeting and into land
- Sheeting below the high tide line to create a bulkhead for contractor use, potentially reinforced with tiebacks through the sheeting and into land
- Docks constructed of sheeting and fill for mooring construction barges
- Pipe pile-supported trestles to support construction and demolition of the new and existing bridge piers, respectively

- Pile-supported dolphins to assist with construction vessel mooring
- Pipe piles in key locations to support the cofferdams surrounding the existing and proposed bridge piers
- Temporary riprap at the base of the construction trestles to protect them from scour during construction

While it is anticipated that most temporary works would not be contained, depending upon the contractor's means and methods, some of the work could be contained within the same containment cell that is used for pier demolition, including the portion of the temporary trestle that overlaps with the existing pier and some of the trestle supporting structure such as driven piles or columns resting on the remaining footings of the existing pier.

6.3 Dredging

In-water dredging may be required along the toes of the bulkheads and between the docks to provide sufficient draft for vessels to approach the bulkheads and moor at the docks. Dredging may be conducted using cutterhead suction dredges or clamshell excavation dredges. Temporary fill may be placed between the shoreline and bulkhead sheeting to create the bulkhead and within the dock sheeting to complete the docks. The cofferdams for construction of the new bridge piers are expected be excavated in the wet prior to sealing. The cofferdams would subsequently be dewatered prior to pier construction. Water pumped from the cofferdams would be maintained in settling basins prior to being pumped back into the canal.

6.4 New Bridge Construction

The following describes the current preliminary design for the bridge piers. At each bridge site, two new permanent canal-side pier structures would be installed in the intertidal and supratidal riprap zones of each bank, for a total of four piers per site. The foundations of each pier would consist of eight drilled shafts with steel casings filled with reinforced concrete. Construction of the new bridge piers may be conducted from floating shoreline barges moored to the temporary dolphins, from land, or from a temporary trestle over the footing and cofferdam. All work on the pier foundations and footings would be contained within the temporary cofferdams. After pier construction, the steel delta frames would be erected from cranes near land on the work trestle. Once the delta frames are ready to receive them, the main span bridge arches would be floated in and permanently installed over the canal using construction barges over the course of approximately three to five days per bridge. The float-in of the main span arches would require full closure of Cape Cod Canal throughout the duration of the operation and cannot be halted or paused once commenced. After bridge construction is complete, riprap would be placed on the three waterward sides of the pier bases for protection.

Each bridge would have two new permanent canal-side pier structures installed in the terrestrial and intertidal riprap zones of each bank, for a total of four piers per bridge. Steel sheeting would be installed via vibratory or impact hammering to create a cofferdam around the proposed pier locations for soil containment and dredging within the cofferdam.

Pier construction and steel erection may be conducted using floating shoreline barges, which may require temporary dolphins to reduce barge movement in the fast-flowing canal. Pier installation would require dredging in the intertidal zone.

6.5 Existing Bridge Demolition

The main spans of the existing bridges are proposed to be cut and lowered onto barges, similar to the float-in process. The lowering and float-out process would occur over the course of approximately three to five days per bridge. The float-out would require full closure of Cape Cod Canal and cannot be halted or paused once commenced.

At each bridge site, the existing two concrete pier columns in the intertidal and/or subtidal zones would be enclosed by a containment cell and demolished into the containment cell. Demolition of the above-water portions of the existing bridge piers may entail cutting or hoe-ramming. Demolition of the bases of the existing concrete bridge piers may include saw-cutting, hoe-ramming, and excavation of the canal bottom to expose the pier base. Demolition would be controlled to minimize debris falling into the canal outside the containment cell. Some demolished materials may be lifted away by crane, and some may be reduced to rubble in the containment cell. Rubble would be removed from the containment cell in the wet. The footprints of the existing piers would be allowed to recover to the surrounding canal bottom habitat.

6.6 Construction Vessels

MassDOT estimates that the Program would require as many as four work barges and two delivery barges in each quadrant at any time during daily marine-based construction activities. Each work or delivery barge may require a dedicated tug. Up to four support launch vessels may also be required in each quadrant. Work barges are anticipated to be spud barges with six spuds per barge. **Table 6-1** provides the estimated number and sizes of the types of construction vessels required for day-to-day marine-based construction activities.

Table 6-1. Proposed Vessels Employed in Day-to-Day Marine Operations for the Program

Description Program-wide at Any Time During Construction	Quantity Per Construction Quadrant	Approximate Size
Work barges (6 spuds per barge)	4	40 feet x 80 feet
Delivery barges	2	60 feet x 180 feet
Tugs	6	65-foot to 105-foot overall length
Support launches	4	To be determined
Total Vessels per Quadrant	**16**	**40 feet x 80 feet and larger**

Note: This table does not include the work vessels required for arch float-in and float-out operations.

In addition to the estimated 16 construction vessels that would be used daily for in-water construction work, other vessels would be required for the float-in of replacement bridge main spans over three to five days and the float-out of the demolished existing bridge main spans over three to five days (total of six float-in or float-out operations for the entire Program). These short-duration activities would require a different configuration of barges and support vessels and would be separate from the daily marine-based operations. While the specific size and number of these work vessels have not yet been determined, MassDOT estimates that each float-in or float-out operation would require two large barges in the canal, with an approximate size of 60 feet x 160 feet each. Up to six tugs of the sizes identified in **Table 6-1** could be required to control the barges during float-in and float-out; up to eight support launches may also be used. Additional work barges of the type identified in **Table 6-1** are expected to be required during float-in and float-out as well. The float-in and float-out operations are exclusive of day-to-day operations.

7 Site Maintenance and Restoration

Throughout the duration of construction, MassDOT will incorporate mitigation measures into the Program to minimize adverse effects of in-water-based and land-based disturbance through permits, special provisions, and guidance documents, as well as its Standard Specifications for Highways and Bridges.

7.1 Water-Based Restoration

Upon completion of in-water work, all temporary support structures will be removed, and the areas will be restored to preconstruction conditions to the maximum extent practicable. The fill placed against the various temporary works will be excavated, and areas previously excavated will have fill returned to match the preconstruction contours. The temporary riprap at the base of the construction trestles will be removed. All temporary works will be removed or cut off below the mudline, including sheeting used to construct the cofferdams, barge docks, and bulkheads, and the pilings used to construct the mooring dolphins and support the cofferdams. Sheeting and pipe piles may be removed using a vibratory pile driver or by torch cutting below the mudline. Torch cutting the sheeting and pipe piling will require in-water excavation to reach below the mudline. Once all temporary works are removed, the canal bottom will be dredged to prepare the areas for final riprap installation. Riprap initially removed to allow installation of the temporary works will be returned to the quadrants to complete the Program area restoration. The riprap condition upon completion of the Program is anticipated to be similar to the existing riprap condition, except that additional riprap may be added around the new piers for protection.

7.2 Site Maintenance and Land-Based Restoration

Throughout the duration of construction, MassDOT would incorporate mitigation measures into the Program to minimize adverse effects of land-based disturbance through permits, special provisions, and guidance documents, as well as its Standard Specifications for Highways and Bridges.

The Program's Construction Stormwater General Permit will contain multiple measures to reduce adverse effects from construction, including, among other control measures, the requirement to stabilize disturbed areas immediately when construction has ceased and will not resume for more than 14 days.

For trees that would not be cleared, MassDOT has issued extensive guidance for tree preservation, including plant protection fencing for public places and staging or other construction activity near desirable vegetation. As applicable, MassDOT will use plant protection fencing to minimize impacts to visual natural resources.

Following completion of the land-based construction activities, acquired areas that are not used for the State Highway Layout will be restored to pre-existing conditions to the maximum extent practicable. There will be instances where site restoration could occur following completion of that specific phase of the Program, such as Trowbridge Road and the new entrance to the Upper Cape Regional Technical High School in the Bourne South quadrant, where the proposed construction would be offline.