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Bourne Bridge Rotary Study

Bourne, Massachusetts

Draft Report - November 2013



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Introduction

BACKGROUND

One of the most serious traffic congestion/safety problems on Cape Cod occurs at the Bourne Bridge Rotary. Traffic congestion at the Bourne Bridge Rotary affects the quality of life for residents of Bourne, visitors to Cape Cod, and emergency response time through-out the Upper Cape. The Bourne Bridge Rotary congestion affects the residents of Bourne throughout the year; traffic is routinely stopped on MacArthur Boulevard and Sandwich Road during winter evening peak hours. This stopped traffic has the additional harmful effect on air quality due to the pollution emitted by idling vehicle.

The congestion at the Bourne Bridge Rotary also has an adverse effect on the economic development of Bourne. Traffic queues from the Bourne Bridge Rotary routinely back-up through Belmont Circle and Scenic Highway (north of the Cape Cod Canal). This traffic congestion deters residents and visitors from visiting Downtown Bourne. A Growth Incentive Zone has recently been designated for Downtown Bourne, but Bourne Bridge Rotary traffic impacts could influence its success. Bourne Bridge Rotary traffic congestion has a negative effect on economic development of the Bourne Bridge Rotary area and MacArthur Boulevard, as well the Falmouth area.

A review of the “Barnstable County Intersections of Critical Safety Concern” (Cape Cod Commission, 2010) lists the Bourne Bridge Rotary as one of eight “Barnstable County Pedestrian Crash Clusters.” Two non-injury pedestrian crashes were listed for the years 2002-2008. Using 2006-2008 data supplied by MassDOT, the Bourne Bridge Rotary is identified as a Barnstable County high-crash location under several criteria:

- Number of Crashes – Rank #8 (71 crashes)
- Equivalent Property Damage Only – Rank #10 (EPDO* 115)
- Crash Rate – Rank #32 (1.21 crashes per million entering vehicles)

**Equivalent Property Damage Only (EPDO) calculation multiplies 1 times the number of Property Damage Only crashes, 5 times Injury Crashes, and 10 times Fatal Crashes.*

The Bourne Bridge Rotary serves as one of two primary interchanges to Cape Cod communities on the south side of the Cape Cod Canal (the other being Interchange 1 south of the Sagamore Bridge). All traffic crossing the Bourne Bridge must pass through this facility. Recent traffic counts collected by MassDOT and the Cape Cod Commission show the Bourne Bridge Rotary serving tens of thousands of motorists throughout the year, with the greatest volumes experienced in the summer:

- Bourne Bridge – 59,665 vehicles per day (July 2010)
- Route 28 (MacArthur Blvd) – 43,308 vehicles per day (July 2009)
- Sandwich Road – 25,952 vehicles per day (July 2010)
- Trowbridge Road – 8,444 vehicles per day (July 2010)



Under the 2013 Unified Planning Work Program, the Cape Cod Commission staff have been tasked with the following study goal:

Develop alternatives that will provide safe and convenient access within the study area for all users of the roadway system including pedestrians, bicyclists, and motorists.

This goal has led to a set of project goals, objectives and criteria established by a study task force – see discussion in “Development of Alternatives” chapter.

STUDY AREA

The primary study area includes the Bourne Bridge Rotary and major approaches:

- Bourne Bridge (Route 25/Route 28)
- MacArthur Boulevard (Route 28)
- Sandwich Road Connector
- Trowbridge Road

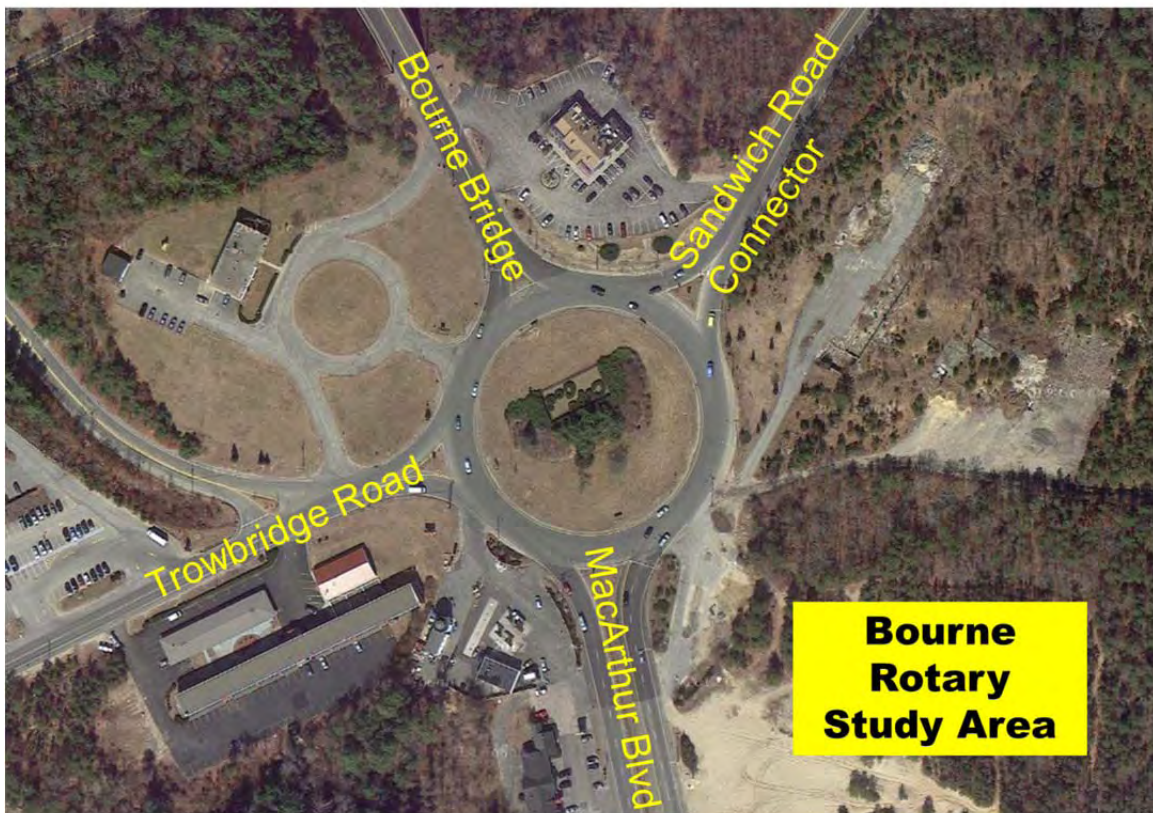


FIGURE 1 - BOURNE BRIDGE ROTARY STUDY AREA

LITERATURE REVIEW

In order to better understand the problems and opportunities for improving traffic flow and safety in the Bourne Bridge Rotary area, CCC staff has prepared reviews and summaries where appropriate from the following planning studies that preceded this current effort:

- The draft *Canal Area Transportation Study* prepared by Rizzo Associates, Inc. for MHD dated December 21, 1998, and the subsequent draft studies done by staff at the Cape Cod Commission, the most recent dated August 22, 2001.

These studies identify the Canal area congestion issues, particularly around the Sagamore Rotary. The 1998 Rizzo Associates study identified the preferred alternative for alleviating that congestion, promoting safety and enhanced air quality with the Bourne- Sagamore Rotary Grade Separation Project, also known as the “flyover.” Construction of the flyover was completed in 2008. Planning studies prepared by the CCC during this timeframe make recommendations based on the land use in the Canal area and Cape-wide development, acknowledging that attempts to address traffic congestion solely through constructing automobile capacity will be inadequate without provision of transportation alternatives and balanced controls on traffic demand.

- “Route 3/Route 6 Sagamore Grade Separation Revised Environmental Assessment/Final Environmental Impact Report” (EOEA #11731) dated October 31, 2003.

This Final EIR is a refinement of the 1998 preferred alternative concept for permitting purposes. Project changes from the DEIR include; relocating the original reconstruction site of the Bourne Fire Station; reconstruction of the Chamber building located at the park and ride lot; refinement of the Herring River Watershed ACEC boundary; and strategies for Congestion Management Systems (CMS) and Transportation Demand Management (TDM) were evaluated.

- “Bourne Scenic Highway Study and Canal Area Study – TransCAD Technical Assistance: Cape Cod Travel Demand Forecasting Model” dated February 2000 – Louis Berger Group, Inc.

This study summarizes the CCC’s response to Mass Highway’s suggested guidance on modeling trip generation for our region; specifically, developing a method to calibrate the MassHighway model with the Cape’s unique summer increases in traffic volumes, and previous models used for both the Bourne Scenic Highway Study and the Canal Area Traffic Study.

- EOEA Build-out Analysis for Cape Cod.



- *Canal Area Traffic Study* dated December 22, 2004 by the Massachusetts Highway Department.

A conceptual study that explores potential strategies to improve traffic flow and safety in the Canal area, prepared in conjunction with Cape Cod Commission studies looking at alternative transportation modes and travel demand management strategies. Low cost retro-fitting of the Bourne Bridge Rotary was the short-term preferred alternative. Long-term strategies included replacing the rotary with a grade-separated interchange, widening Sandwich Road to 4 lanes, and rebuilding all 4 ramps to the Route 6 Exit 1 interchange.

- *Buzzards Bay Village Comprehensive Transportation Plan* study and recommendations, 2007.

This study was conducted by Planning Consultant Wesley Ewell in association with Maguire Group, Inc. One of its key recommendations is reconfiguration of Belmont Circle and the Route 25 access ramps to provide more direct access between the interchange and Scenic Highway. This action would make Scenic Highway a more desirable route to the Mid-Cape Highway than Sandwich Road and consequently reduce traffic through the Bourne Bridge Rotary. It is currently under analysis by MassDOT and earmarked for funding under the State's Transportation Bond Bill.

- "Cape Cod Commission Study Design for Canal Area Long-Range Transportation Study," 2009.

Building on previous transportation planning studies, a draft scope of work was developed to explore recommendations consistent with land use and transportation planning goals identified for the area. Tasks proposed in this study include working with the Upper Cape towns to develop land use scenarios to 2030, develop alternative transportation concepts, identify bridge capacity and maintenance issues and develop a long range improvement plan.

- Project Notification Form, Bourne Rotary Modification, Cape Cod Commission, 2011.

Summary

More than fifteen years of transportation planning and analyses have been developed for the Bourne Bridge Rotary and the Cape Cod Canal area. Low-hanging fruit opportunities to achieve short-term infrastructure improvements, as well as long-range land use, maintenance, and transportation demand management strategies have been well-documented in the studies contained herein.

Existing Conditions

This chapter includes information about traffic flow, safety, and physical characteristic of the Bourne Bridge Rotary.

The Bourne Bridge Rotary is nearly 400 feet in diameter (from the outside of the circulating roadway), with a circulating lane of over 30 feet in width. While considered by MassDOT to be a single-lane traffic circle, vehicles commonly travel side-by-side around the rotary. Characteristics of the approaching roadways are as follows:

- **Bourne Bridge (Routes 25/Route 28):** undivided roadway with two lanes in each direction on the bridge itself. Route 25 to the north of the bridge is a median-divided highway with three lanes in each direction.
- **MacArthur Boulevard (Route 28):** median-divided highway with two lanes in each direction.
- **Sandwich Road Connector:** one lane in each direction. On the approach to the rotary pavement is wide enough for frequent side-by-side entry by motorists.
- **Trowbridge Road:** one lane in each direction. On the approach to the rotary pavement is wide enough for frequent side-by-side entry by motorists.



BASE YEAR TRAFFIC VOLUMES

For transportation planning purposes, a “30th highest” design hour is used for traffic analyses. This design hour is approximately equivalent to a Thursday in late June from 4-5 p.m. Using a combination of Cape Cod Commission-installed Automatic Traffic Recorder (ATR) data, manual observations, and MassDOT permanent recorders installed at the Bourne Bridge, the following figure shows the traffic patterns at the rotary for base year conditions.

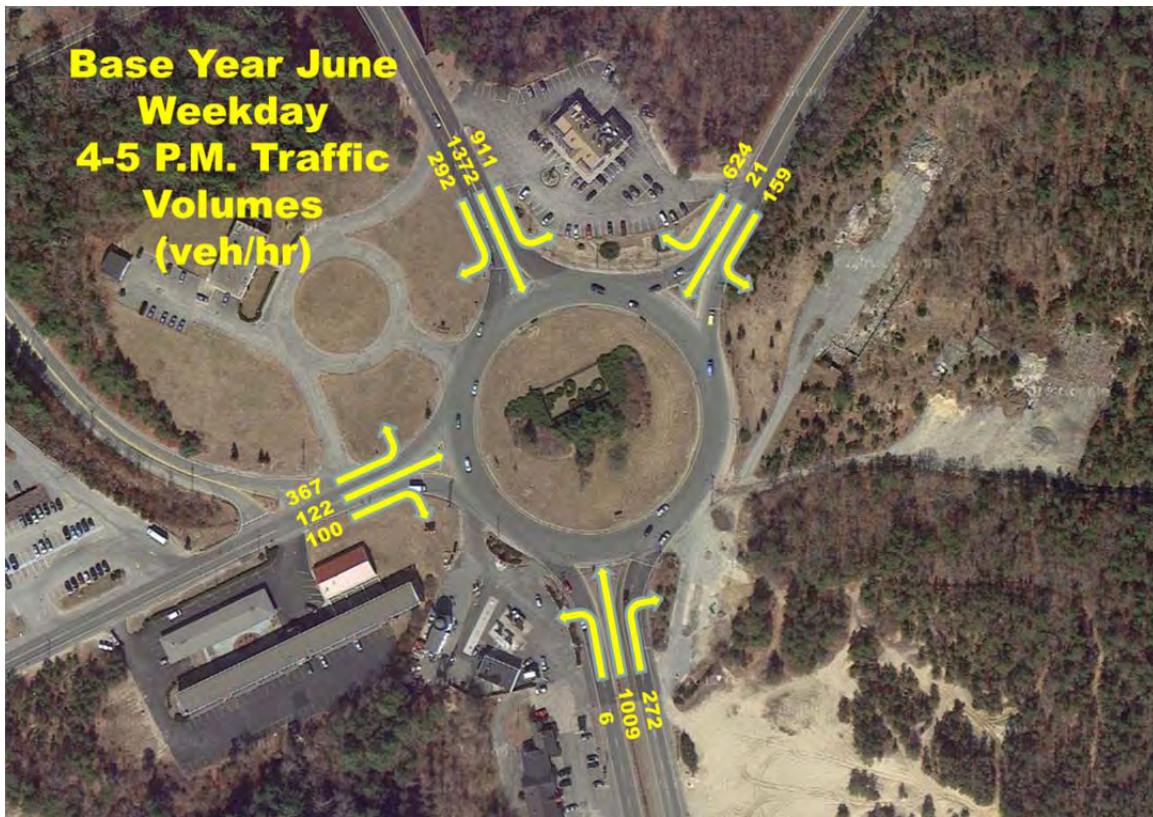


FIGURE 2 - BASE YEAR TRAFFIC VOLUMES



LEVEL OF SERVICE

On the approach legs to the rotary, entering vehicles await gaps in the circulating flow. The table below was developed from an analysis of base-year traffic operations using *Synchro*TM traffic modeling software. Results are given by approach lane at each of the four entering legs. Results include volume-to-capacity (v/c) ratio, seconds of delay per vehicle, length in feet of the 95th percentile queue, and Level of Service (LOS). LOS is a “report card” grade of the quality of service. LOS ranges from LOS A which reflects insignificant delay to LOS F which is considered over-capacity and failing.

TABLE 1 - BASE YEAR LEVEL OF SERVICE (LOS) & QUEUING FOR LANE OF ENTRY AT BOURNE BRIDGE ROTARY

	Bourne Bridge left lane	Bourne Bridge right lane	Trowbridge Road	MacArthur Blvd left lane	MacArthur Blvd right lane	Sandwich Road Connector
v/c Ratio	1.62	1.58	4.71	2.33	2.12	2.59
Delay (s/veh)	298.6	280.4	1730.1	633.9	540.3	747.9
95% Queue (ft)	1998	1906	1819	1471	1370	1894
LOS	F	F	F	F	F	F



SAFETY DATA: CRASH HISTORY

MassDOT undertook a Road Safety Audit (RSA) of the Bourne Bridge Rotary in early 2013. As part of this effort, the Audit included a diagram (shown in the figure on the following page) that identified the type, location, and severity of crashes in the Bourne Bridge Rotary. It is important to note that the recorded number of crashes includes only those that were serious enough to be reported to police, and that it is likely that many more crashes occurred but were not reported.

ROADWAY SAFETY AUDIT: SIGNAGE ISSUES

The RSA team noted that there is very little advance guide signage indicating the street name, route numbers, and/or destinations of the available exits from the rotary. The only guide signage for exits to the rotary are within the rotary itself. This can create confusion, especially among drivers that are unfamiliar with the rotary, since motorists may not know when their exit is approaching until they read a sign located at the exit itself. There is no existing signage that indicates which lane a vehicle should be in if it is exiting the rotary or continuing to circulate. This lack of direction can cause angle crashes between vehicles exiting the rotary from the inside lane and vehicles remaining in the rotary in the outside lane.

Twenty-nine crashes occurred between vehicles exiting the rotary onto Route 28 southbound from the inside lane and vehicles continuing around the rotary in the outside lane. Three similar crashes occurred involving vehicles exiting to Sandwich Road Connector, and one similar crash occurred involving a vehicle attempting to exit to the Bourne Bridge.

Team members also noted that some of the existing guide signage is too small to read, and that some motorists slow down unexpectedly to read guide signage. Guide signage is located along the inside of the rotary, including a sign facing the Route 28 southbound approach to the rotary that indicates vehicles should enter the rotary to access the National Cemetery. This sign is not necessary, as any motorist close enough to read the sign would have no choice but to enter the rotary and it may be distracting to motorists looking for other information.

A second sign, located across from the Trowbridge Road eastbound entrance to the rotary, indicates vehicles should turn left for Route 6 eastbound. This sign is misleading; while continuing to circle the rotary will eventually allow for access to Route 6 eastbound, the sign implies that the turn is imminent, and entering Route 6 eastbound will require a traditional left turn, where in reality, motorists bear right to exit the rotary onto Route 6. The sign is visible to motorists entering the rotary from Trowbridge Road; this may lead to motorists that are unfamiliar with the area turning left into the rotary.

Signage placed on the center island of the rotary distracts motorists from signage along the outside of the rotary.

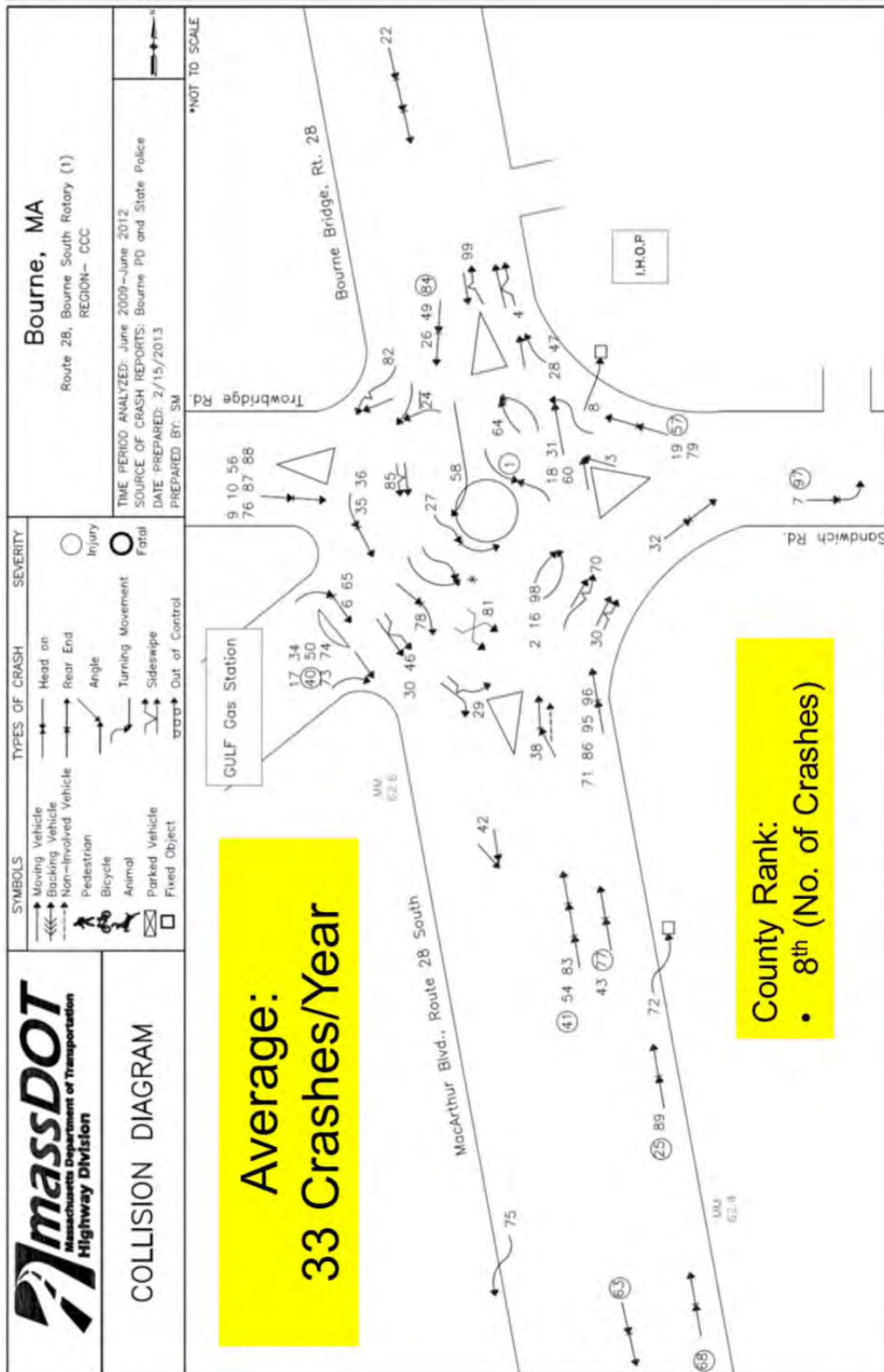


FIGURE 3 - BOURNE BRIDGE ROTARY CRASH HISTORY



RSA team members noted that the posted speed limits along the Route 28 northbound approach to the rotary are very closely spaced. According to speed regulations provided by MassDOT, the speed limit changes from 55 mph to 40 mph approximately 0.36 miles south of the Bourne Bridge Rotary. After another 0.23 miles the speed limit drops again, to 25 mph just 0.13 miles from the rotary, resulting in a 64% reduction in speed over less than a quarter-mile.

Thirteen rear-end crashes occurred along the Route 28 northbound approach to the Bourne Bridge Rotary, including three that involved three vehicles and four that resulted in personal injury. For comparison, only four rear-end crashes occurred along the Route 28 southbound approach to the rotary. There are no “Reduced Speed Ahead” (W3-5) signs to warn motorists of these changes in the speed limit. According to Manual on Uniform Traffic Control Devices (MUTCD) guidelines, “Reduced Speed Ahead” (W3-5) should be placed in advance of a location where the speed limit decreases by 10 mph or more.

ROADWAY SAFETY AUDIT: PAVEMENT MARKINGS ISSUES

There are no pavement markings within the Bourne Bridge Rotary itself that indicate that it is a (de facto) two-lane rotary. Six sideswipe crashes were reported within the rotary, indicating that motorists may not be aware that the rotary functions as two travel lanes, or are unsure as to where to position their vehicles within the rotary.

There are also no pavement markings within the rotary to indicate lane use. It is unclear as to whether exiting the rotary from the inside lane is permitted at any exit, at the Route 28 exits only, or not at all. As mentioned previously in the *signage* section, 33 crashes involved a vehicle exiting the rotary from the inside lane while a vehicle continued to circulate the rotary in the outside lane. RSA team members also noted that there are no pavement markings along the Trowbridge Road eastbound and Route 6 (Sandwich Road) westbound approaches that indicate the intended number of travel lanes entering the rotary. Each is wide enough for two vehicles to stack at the entrance to the rotary, however, allowing multiple entrance lanes may cause confusion.

ROADWAY SAFETY AUDIT: SIGHT DISTANCE ISSUES

RSA team members noted that the decorative vegetation facing Route 28 southbound traffic entering the rotary, spelling out “Cape Cod,” may be distracting for motorists. It was also noted that the height of the mound in the center of the rotary may make it difficult for motorists to judge the speed of circulating traffic.

During public meetings for this study, attendees also commented that the “Cape Cod” vegetation was distracting. Also, the height and width of the mound made it difficult for motorists to comprehend the configuration of the rotary.



ROADWAY SAFETY AUDIT: ACCESS MANAGEMENT ISSUES

There are four curb cuts that allow direct access to the Bourne Bridge Rotary. The curb cut to The Ultimate Battleground (currently serving as access to a Paintball facility) is not paved and does not have a defined edge. A team member stated that the curb cut often floods, and water flows into the rotary. There are also two curb cuts that serve the Gulf gas station and the American Lobster Mart. Team members noted that the easternmost of the two curb cuts is located extremely close to the Route 28 southbound exit, causing confusion when vehicles exit the Gulf driveway. Eight crashes involved vehicles exiting the Gulf gas station into the rotary; six occurred at the easternmost of the two curb cuts.

Team members also noted that there are currently two driveways to the IHOP along Route 28 northbound, north of the rotary. Team members stated that Route 28 southbound vehicles approaching the rotary often cut across faster-moving northbound traffic in order to access IHOP, and that vehicles turning left out of IHOP onto the Route 28 southbound approach to the rotary often find themselves in the northbound travel lanes waiting for a gap to form in the southbound queue. It was also noted that vehicles often cut through the IHOP parking lot to avoid the rotary.



ENVIRONMENTAL CONDITIONS

The Bourne Bridge Rotary study area contains a number of environmentally-sensitive resources as shown on the figure on the following page. These include a NHESP Priority Habitat (indicated by the yellow shading), FEMA A and V Flood Zone (indicated by red cross-hatching). There is also a nearby pond/wetland to the south just east of Route 28.

The proximity of environmental resources indicate areas that may have more complex permitting and mitigation may be required, or re-design of improvements to avoid impacting these resources altogether. It should be noted that this designation of sensitive resources covers a broad area and that a more detailed investigation may show that the designation may not apply to much of the study area.



FIGURE 4 - SENSITIVE ENVIRONMENTAL RESOURCES



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Development of Alternatives

The development of alternatives for replacement of the Bourne Bridge Rotary is based on an aggressive public participation process in concert with analyses of future conditions and criteria-based evaluations.

PUBLIC PARTICIPATION PROCESS

Cape Cod Commission staff have regularly participated in Transportation Advisory Committee meetings since early 2013. The Committee was established by the Bourne Board of Selectmen to advise the Selectmen on transportation issues affecting the town. Such issues include traffic problems at the Bourne Bridge Rotary, Belmont Circle, and the downtown bypass; pedestrian and bicycle access and connections; coordination with bus and train services; and local road trouble spots.

A concerted effort was made to reach out to area stakeholders including residents and business owners, as well as the general populace. The public meeting series included:

- Tuesday, August 13, 2013, 4 p.m., Jonathan Bourne Public Library – Business Owners
- Thursday, August 15, 2013, 7 p.m., Jonathan Bourne Public Library – Residents
- Wednesday, August 21, 2013, 7 p.m., Upper Cape Regional Technical School – General Public

Highlights of these three meetings are discussed below.

Business Owners Public Meeting (August 13)

At least ten members of the business community attended along with members of Bourne's Transportation Advisory Committee and Commission staff. The discussion focused primarily on two main issues: the need for a third bridge, even though that is a longer term project, and concerns about access to businesses.

The access issue included the current situation of lost business because people can't get in and out of businesses near the rotary during the high traffic volume times, and the fear of new ramps and roadways restricting access to rotary-area businesses. None of the options proposed in the Commission's PowerPoint presentation sparked interest from the attendees; indeed, most of the reactions were negative with the main concern being to maintain access to the area's businesses.



Residents Public Meeting (August 15)

Over 50 people attended, along with members of the Transportation Advisory Committee and Commission staff. With a show of hands at the beginning of the meeting, about half held the opinion that the rotary should be replaced, and much smaller percentages (around five percent) responded that either nothing should be done about the rotary or that something entirely different from a rotary replacement should happen.

The discussion covered several general areas including changes to the Bourne Bridge and to connecting roads. Specifically concerning the bridge, residents suggested putting more signs on the bridge approaches so that people know which lane to be in, slowing the traffic, perhaps putting traffic cameras on the bridge showing drivers' speed, initiating a system for tolls for out-of-state visitors, and developing a system that would "flip" bridge traffic so that in high traffic times the bridge is three lanes southbound and one northbound, or three lanes northbound and one southbound.

The majority of the comments endorsed the idea of improving signage as drivers approach the bridge and marking lanes in the rotary. Other signage could encourage travelers going to Route 6 East to stay on Route 6 ("Scenic Highway") and use the Sagamore Bridge. There was considerable concern about the possibility of an exit road circling behind the State Police station – residents said that the turns would be too sharp for large trucks, the sound of brakes would be intrusive to area residents, and such a road would generally be unsafe and would degrade their quality of life.

Another area of discussion focused on Sandwich Road with a consensus that two lanes is not enough to carry the traffic traveling from the Bourne Bridge to Route 6 East. None of the options proposed in the Commission's PowerPoint presentation sparked interest from the attendees; indeed, most of the reactions were negative with the main concerns being those of the harmful impacts on area residents.

General Public Meeting (August 21)

At least 75 people attended this meeting along with members of the Bourne Transportation Advisory Committee and Commission staff, members of the Bourne Board of Selectmen, Town Administrator Tom Guerino, State Representative Randy Hunt, and CCRTA Administrator Tom Cahir. The comments from this meeting are listed here:

- Make a connection from ISWM to Route 28 South, perhaps at Waterhouse Road. This would eliminate traffic, including employees, going from ISWM into the rotary when the driver wants to go south on 28.
- The main problem is the bridges which are too skinny with too many vehicles.
- Traffic entering the businesses on the rotary slows the traffic.
- Whatever plan is recommended, it must take care of the Town's residents and businesses.
- The signage is inadequate.
- New traffic flow on the Sagamore Bridge is a tremendous benefit for local people; however, better signage is needed to require drivers to stay in their lane until exit.
- Something needs to be done about Belmont Circle.
- How about a grade separation at the rotary; need to separate the traffic movements



- Adjust curb cuts in the rotary. Cars exiting the Gulf station should be allowed to use only the one closer to the bridge, or down past the florist shop.
- The bottleneck is the bridge; when will we see a new bridge?
- Prefer concept B, but shift it onto the state-owned land and away from the businesses.
- “Preferred” option and Cubellis plans both go through our living room. We don’t want this hanging over our heads for 10 years
- Signage is a good idea, placed one and two miles before the bridge so people can sort out where they are going.
- It’s not worth doing anything with the rotary.
- Veterans Way has a steep a drop and a severe turn; hard to believe you can put in a road on Veterans Way; it will impact the neighborhood.
- Support 45 degree curbing rather than 90 degree; radius of road at the IHOP
- Veterans Way is 45 degrees down for 620 feet with a 180 degree turn. It is a hazard and not navigable. Using that plan would reduce property values.
- Not in a hurry to see the rotary go. Best to improve signage, put them earlier on the highway; start with variable message boards in approaches to bridge to modify behavior.
- Think of the impact of doubling Sandwich Road on the young drivers coming out of the Upper Cape Regional Technical School.
- Make a connector with two lanes and reverse the traffic so that it all goes one way with the direction depending on the time of the weekend.
- Get vacant land and save impact on the neighbors; build something that means something for next 100 years, not just interim improvements.
- Improve signage is the message, loud and clear.

Following the meeting, two area residents forwarded a drawing to the Transportation Advisory Committee with their suggestions for modifications to the Rotary. This plan, with adjustments, is included in this report as Concept “I.”



FUTURE CONDITIONS

Cape Cod Commission staff prepared analyses of conditions at the Bourne Bridge Rotary for the future year 2038. This year was selected to be at twenty years after a potential construction year of 2018. Traffic volumes for the design hour (4-5 p.m., June weekday) are presented in the following figure:

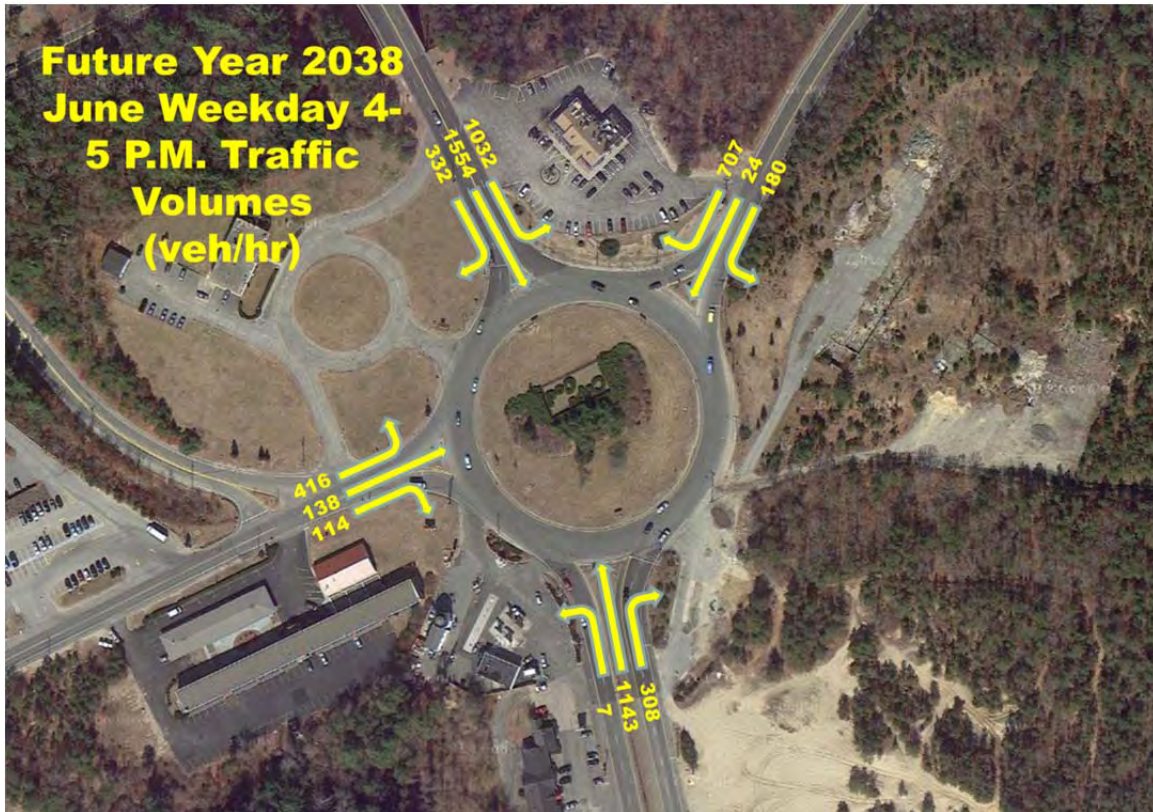


FIGURE 5 - FUTURE YEAR TRAFFIC VOLUMES

On the approach legs to the rotary, entering vehicles await gaps in the circulating flow. The following table was developed from an analysis of base-year traffic operations using *Synchro*TM traffic modeling software. Results are given by approach lane at each of the four entering legs. Results include volume-to-capacity (v/c) ratio, seconds of delay per vehicle, length in feet of the 95th percentile queue, and Level of Service (LOS). LOS is a “report card” grade of the quality of service. LOS ranges from LOS A which reflects insignificant delay to LOS F which is considered over-capacity and failing.



TABLE 2 - FUTURE YEAR 2038 LEVEL OF SERVICE & QUEUING FOR LANE OF ENTRY AT BOURNE BRIDGE ROTARY

	Bourne Bridge left lane	Bourne Bridge right lane	Trowbridge Road	MacArthur Blvd left lane	MacArthur Blvd right lane	Sandwich Road Connector
v/c ratio	1.88	1.83	6.98	3.12	2.70	3.34
Delay (s/veh)	416.0	392.3	2766.7	990.7	799.7	1087.8
95% Queue (ft)	2674	2563	2215	1923	1714	2399
LOS	F	F	F	F	F	F



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SCREENING OF ALTERNATIVES

In 2005 MassHighway released a “Canal Area Traffic Study” that included a number of concepts for improving traffic flow at the Bourne Bridge Rotary.

For the public meetings, five concepts from the MassHighway study were presented along with other alternatives. Some of these concepts had similar features and/or undesirable characteristics such as land use impacts or complicated traffic flow pattern. Based on public comment and input from the task force, two additional alternatives were brought forward for further evaluation and are described among the alternatives listed among the concepts to follow.

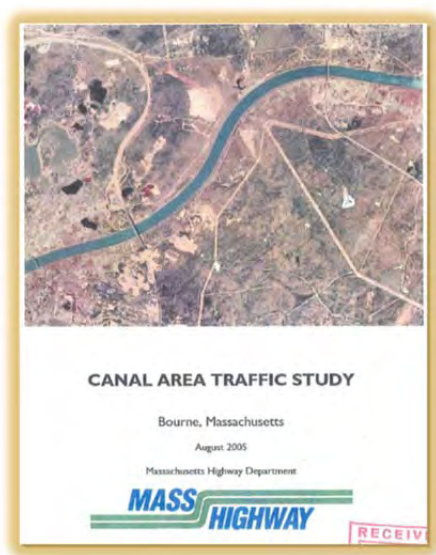


FIGURE 6 - MASSHIGHWAY CANAL AREA TRAFFIC STUDY



CONCEPT A – DIAMOND INTERCHANGE

The simple diamond interchange, shown in the following figure is an alternative best suited for suburban or rural areas. One benefit of this design is the option for future expansion by replacing straight diamond ramps with partial- or full-cloverleaf loop ramps. As can be seen in the figure, a very large area of land is required.

Disadvantages of Concept A include the loss of many of the established businesses in the study area and detrimental impacts to residences on Sandy Lane. This concept would also require substantial private land taking. Concept A also contains a fatal flaw in that the need to stop southbound traffic from the Bourne Bridge waiting to turn left at a signalized intersection onto Sandwich Road at the end of a relatively short ramp would worsen traffic backups at peak times, thereby canceling any possible benefits of this concept.

A Level of Service (LOS) analysis was performed for the heavy-volume signalized intersection of the southbound ramps at Sandwich Road. The intersection would be expected to operate at a good level of service (LOS B). Looking at individual movements, the left turn maneuver from Sandwich Road turning left onto the southbound ramp would experience the greatest delay (LOS D).

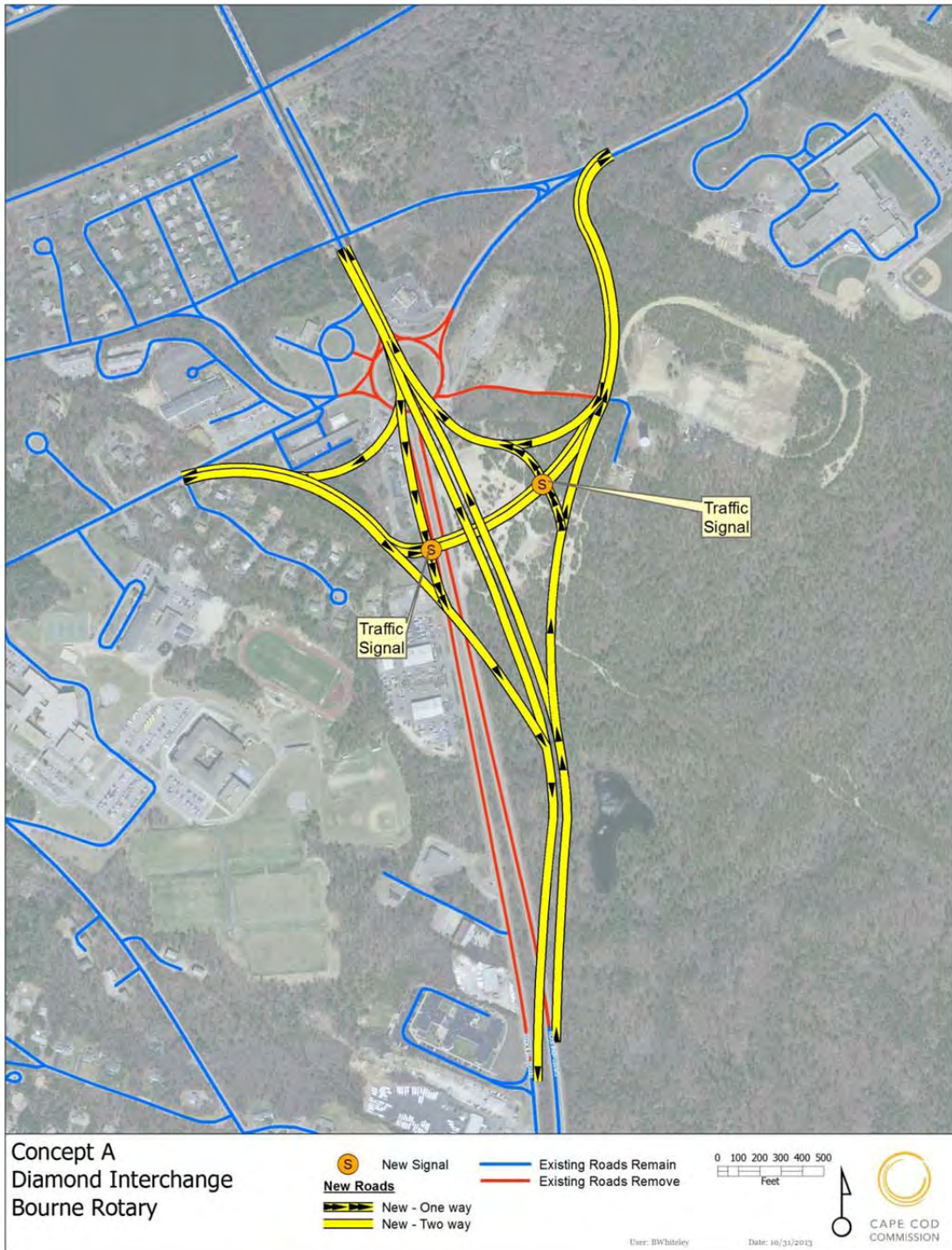


FIGURE 7 -CONCEPT A: DIAMOND INTERCHANGE



CONCEPT B – FULL CLOVERLEAF INTERCHANGE

A Full Cloverleaf interchange provides safety benefits by eliminating left turn maneuvers (these movements are accommodated by the loop ramps). Some items of concern include the creation of weaving areas between the loop ramp exits/entrances, the very large area of land required, and potential conflicts with pedestrians and bicyclists.

Disadvantages of Concept B include the loss of many of the established businesses in the study area and detrimental impacts to residences on Sandy Lane. This concept would also require substantial private land taking.

The Full Cloverleaf concept is shown in the following figure.

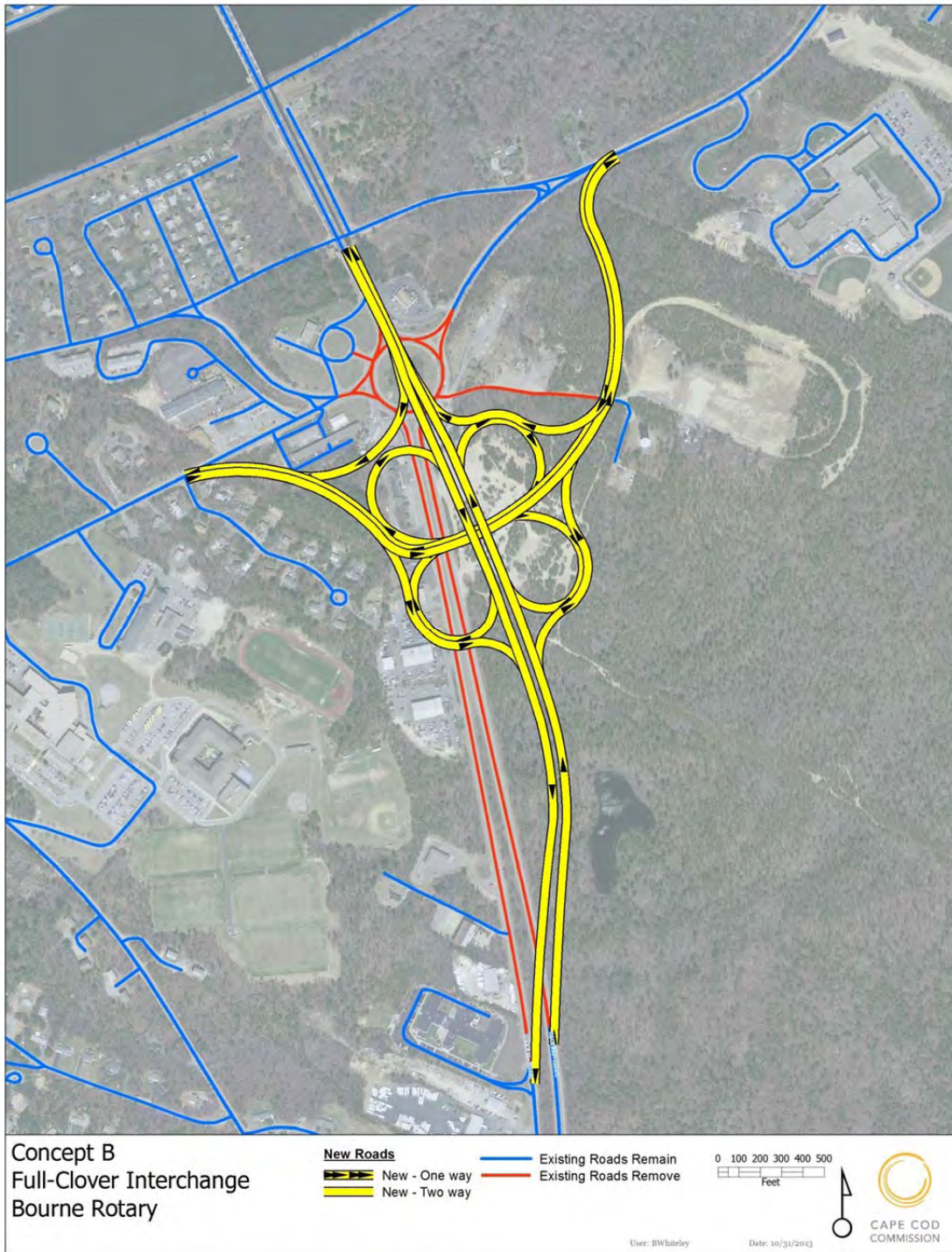


FIGURE 8 - CONCEPT B: FULL-CLOVERLEAF INTERCHANGE



CONCEPT C – LOOP RAMP & SLIP RAMP, 1 OVERPASS

Concept C was identified in the 2005 MassHighway study as a lower (relative) cost scheme to improve traffic operations at the Bourne Bridge Rotary. This concept includes the following features summarized in the 2005 study:

- Low-cost, minimum build retrofit to Bourne Bridge Rotary
- Replaces Bourne Bridge southbound-to-Sandwich Road Connector rotary movement with a connection via a loop ramp to Sandwich Road under the Bourne Bridge
- Closes the Bourne Bridge Rotary's eastbound exit to Sandwich Road Connector
- Diverting all Bourne Bridge southbound-to Sandwich Road Connector rotary movements to the loop ramp/Sandwich Road requires improvements to accommodate the increased conflicts at the Sandwich Road/Sandwich Road Connector intersection. There are two basic approaches:
 - A traffic signal at Sandwich Road/Sandwich Road Connector (low cost, near-term option) OR
 - A grade-separated connection from Sandwich Road eastbound; due to the roadway grades, a tunnel connection is recommended (higher cost, medium-term option).

Disadvantages of Concept C include strong neighborhood opposition to the loop ramp, outweighing any cost advantage. This concept also does not eliminate the rotary circle, therefore minimizing any safety advantage. Furthermore, it would completely block all pedestrian and bicycle access to the bridge unless an overpass or tunnel were included, and such a structure would increase the cost and complexity of the plan.

Concept C is shown in the following figure.

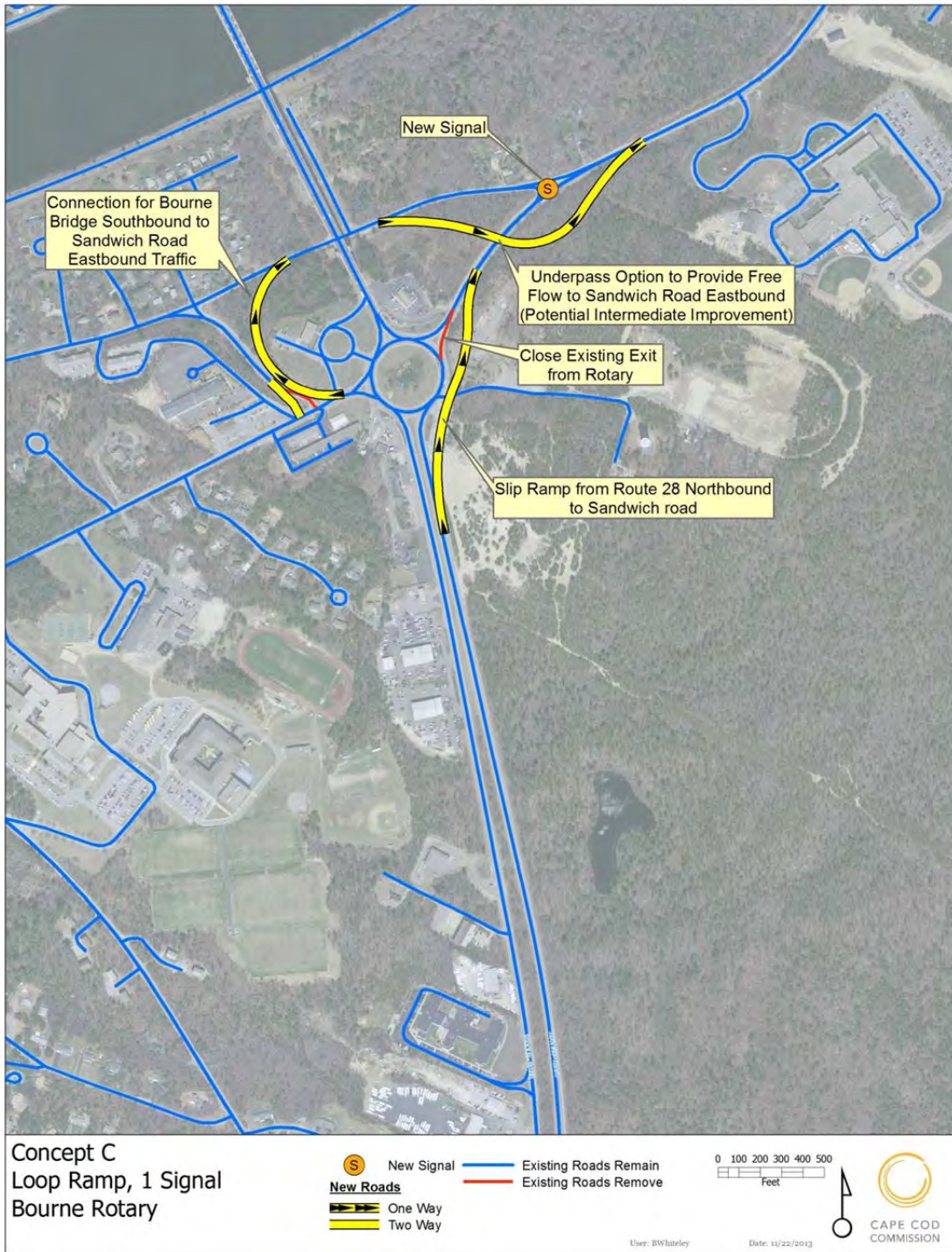


FIGURE 9 - CONCEPT C: LOOP RAMP, 1 SIGNAL



CONCEPT F – LEFT-HAND RAMPS, 2 SIGNALS

Concept F was identified in the 2005 MassHighway study as a more comprehensive scheme to replace the Bourne Bridge Rotary with an interchange. A summary provided in the 2005 study is as follows:

Concept F includes a southbound frontage road parallel with the Route 28 southbound mainline in order to better manage ramp access and local access. This southbound frontage road would have a lower design speed than the Route 28 mainline, and would enable better local access to and from the existing land uses abutting Route 28 southbound.

Concept F has direct highway ramp connections from Route 28 northbound to a relocated Sandwich Road Connector eastbound, from the relocated Sandwich Road Connector westbound to Route 28 northbound, and from Route 28 southbound to the relocated Sandwich Road Connector eastbound. The latter ramp is a left-exit ramp off of the Route 28 southbound highway mainline.

Concept F also includes the Trowbridge Road-Sandwich Road Connector underpass beneath the new Route 28 mainline. This new roadway provides direct connections between Sandwich Road Connector and Trowbridge Road, as well as access to the southbound on-ramp, which first merges onto the southbound frontage road. The frontage road then merges onto Route 28 southbound.

Most of the major movements accommodated by Concept F are replaced by relatively direct connections, particularly the movements among the three main rotary legs: Bourne Bridge, MacArthur Boulevard, and Sandwich Road.

Concept F also provides convenient connections from Trowbridge Road to Route 28 southbound, via the new frontage road. However, the other connections between Route 28 and Trowbridge Road become more difficult. Connections from Route 28 northbound and southbound to Trowbridge Road, and from Trowbridge Road to the Bourne Bridge northbound, require a circuitous route via the relocated Sandwich Road Connector and Sandwich Road.

Disadvantages of Concept F result from several flaws. First, the concept would create a triple-split coming off the Bourne Bridge which would be very confusing to motorists unfamiliar with this area. Second, the concept would require construction of an expensive overpass structure solely to accommodate the connection between Trowbridge and Sandwich Roads, even though this connection carries a low volume of traffic, which could be handled by the existing road under the bridge without requiring any upgrades. Finally, it would require full acquisition of the CanalSide Commons site, which recently sold at a distress sale for \$10 million.

Concept F is shown in the following figure:

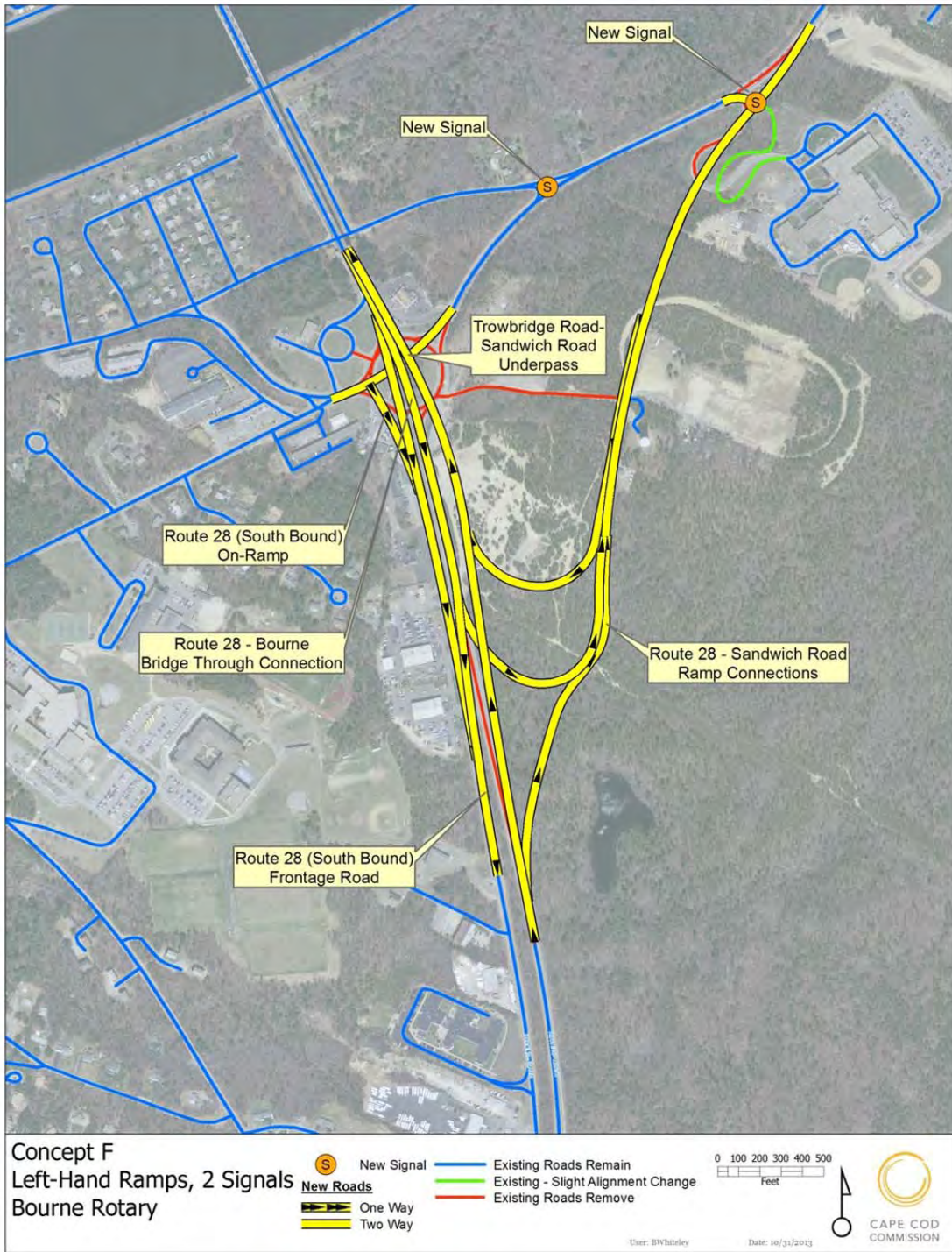


FIGURE 10 - CONCEPT F: LEFT-HAND RAMPS, 2 SIGNALS

CONCEPT I – LEFT-HAND RAMPS, 1 SIGNAL

Concept I was suggested by neighborhood resident Julie Munson at the public hearing, and refined by Transportation Advisory Committee chairman Wesley Ewell. The following description of Concept I was developed by Mr. Ewell and edited for this report.

This concept provides uninterrupted flow of traffic over the two main routes: between the bridge and MacArthur Boulevard, and between the bridge and Sandwich Road. The relatively tight curves on the ramps connecting Sandwich Road to the bridge are consistent with the posted 40 mph speed limit.

The links between Trowbridge Road and both Sandwich Road and the bridge appear to be disconnected, but actually follow the routes that most local drivers now use to avoid the rotary. This apparent disconnect should eliminate any incentive for non-resident traffic, especially trucks and intercity buses, to use County and Waterhouse Roads, as they do now.

Under this concept, the current southbound lane of MacArthur Blvd. becomes a local access road between Trowbridge Road and Atlantic Car Wash. The new southbound lane would be slightly elevated coming off the bridge and then split, with one lane connecting with Sandwich Road and the other continuing south on a new alignment until it reconnects with the existing alignment near the car wash. This section would widen to two lanes soon after the split.

The northbound lane of MacArthur Blvd. would veer off the current alignment at the bottom of the hill near the car wash, and follow a new alignment, at a slightly lower elevation, to rejoin the existing alignment at the bridge. All of the new ramps to the bridge, and the new ramp between MacArthur Blvd. and Sandwich Road, would be single lane.

A short section of Sandwich Road would be shifted back to its original alignment leading to a jug-handle intersection and new traffic lights at the Upper Cape Tech driveway. The existing connector between Sandwich Road and the rotary would be abandoned, along with the rotary and a portion of the northbound lane of MacArthur Blvd.

The single big disadvantage to this plan is that it would no longer be convenient for the Peter Pan buses to interchange at the Trowbridge Road location. One solution to this problem would be to locate the bus station to a new commuter parking lot in the center of Belmont Circle, as shown in the 2007 Bourne Comprehensive Transportation Plan.

Concept I is shown in the following figure.

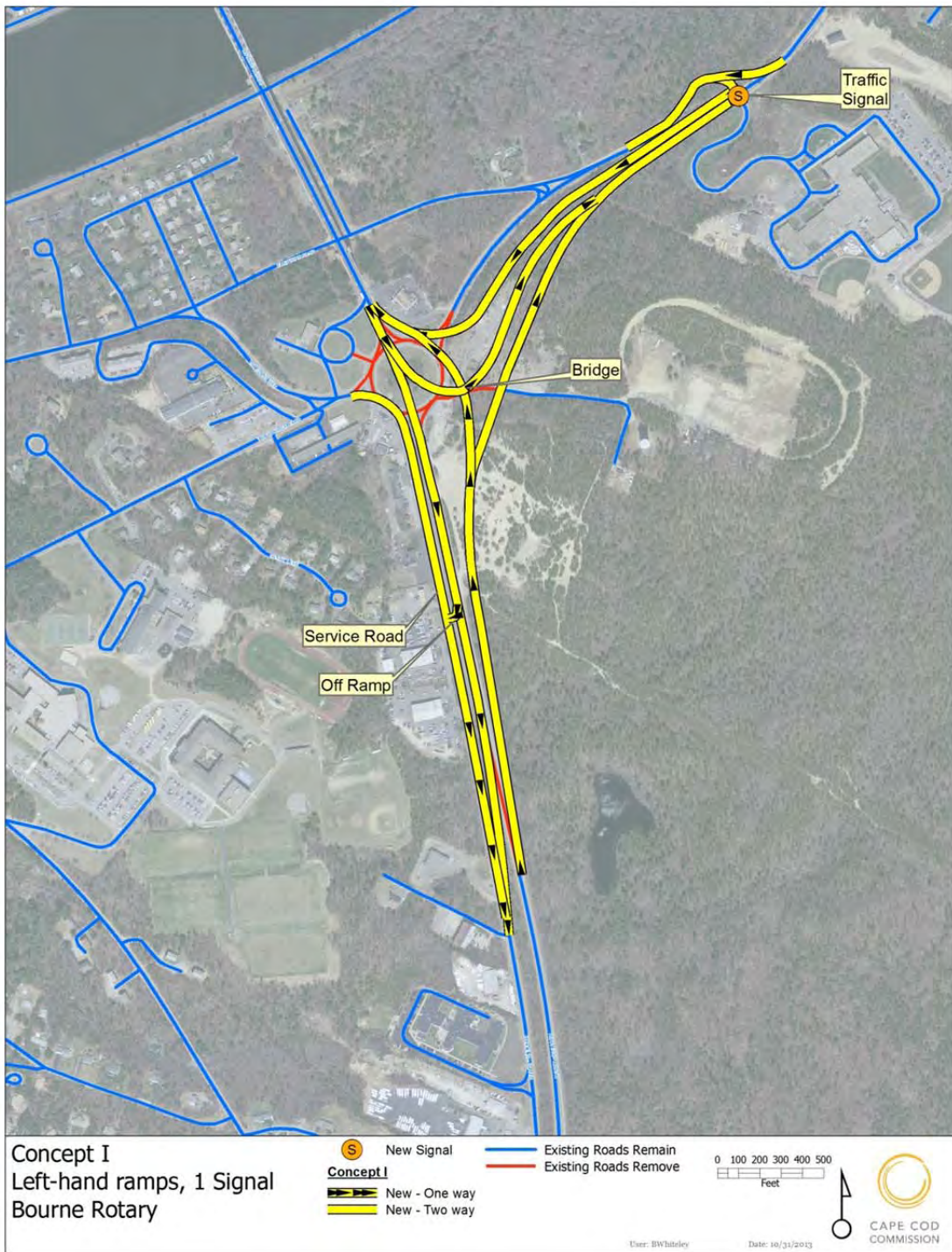


FIGURE 11 - CONCEPT I: LEFT-HAND RAMPS, 1 SIGNAL



EVALUATION OF ALTERNATIVES

The Concepts that have advanced from the screening process were evaluated by the task force in consultation with CCC staff for positive (benefits), negative (detriments) or no (neutral) impacts. The magnitude of each impact was considered, ranging from “minor” through “moderate” to “major.” The following table identifies the colors and symbols used in the evaluation tables. Green circles represent “benefits,” red squares represent “detriments,” and diamond shapes represent “neutral” impacts. Unshaded circles and squares are classified as “minor,” half-shaded circles and squares are classified as “moderate,” and solid-shaded circles and squares are classified as “major.”

TABLE 3 – CRITERIAL EVALUATION SYMBOLS

Evaluation Matrix Legend

	Minor	Moderate	Major
Benefits			
Detriments			
Neutral			

CRITERIA

The following tables provide the evaluation of the screened concepts for each of the criteria used in the study.

Bourne Rotary Replacement ♦ Evaluation Criteria		
Goal	Improve Safety for all Users within the Study Area	
Objective	Evaluation Criteria	Source/Comments
Reduce quantity and severity of accidents	Estimated crash reductions for various treatments	FHWA
Improve safety for bicyclists, pedestrians, and motorists	Number of conflict points	Concept plans
Make road use "user -friendly"	Directional signage, pavement markings, separation of high-speed traffic from low speed	Complete streets guidance
Support evacuation routes	Cape Cod Emergency Traffic Plan	MEMA/Mass. State Police
Goal	Improve Mobility within and Access to the Study Area	
Objective	Evaluation Criteria	Source/Comments
Improve access for emergency vehicles	Lane widths, increased paved shoulders	AASTHTO and MassDOT Guidelines
Improve traffic flow in and around the study area	Travel Times, Delays, Level of Service Analysis	Modeling
Improve bicycle and pedestrian access to the Bourne Bridge	Connections and signage	Local & Regional bike planning efforts
Improve through connections to local and regional bicycle networks	Increase Pedestrian and Bicycle Modes within the Study Area	Sidewalks and Multi-Use Path, ADA Compliance
Provide options to reduce congestion and improve mobility	Number & service capacity of alternate modes	CCRTA, MassBike
Goal	Improve Economic Opportunities	
Objective	Evaluation Criteria	Source/Comments
Minimize traffic impacts on businesses in the study area	Number of businesses affected by concept plan and business turnover	Concept plans and County Business Patterns
Provide improved access for current and potential businesses in the study area	Potential curb cuts, change in traffic volumes along business frontage	Concept plans, traffic operations estimates
Goal	Decrease Impacts to Residential Neighborhoods	
Objective	Evaluation Criteria	Source/Comments
Reduce the use of local streets by through traffic	Reduced Traffic Congestion, Loss of Residential Neighborhood	Synchro, GIS Mappings of Existing Neighborhood
Improve pedestrian and bicycle access to and from local neighborhoods	Sidewalk and bicycle facilities (bike lanes, shoulders, multi-use paths) connected to neighborhoods	Concept plans
Improve access to and from local neighborhoods	Functional connections from regional road network to neighborhood streets	Concept plans
Goal	Support Land Use, and Cultural and Scenic Interests	
Objective	Evaluation Criteria	Source/Comments
Provide bicycle and pedestrian access to the Canal's multi-use paths	Design standards	MassDOT Design Guide
Support local land use goals	Bourne Local Comprehensive Plan - Land Use Goals	Bourne Local Comprehensive Plan
Goal	Reduce Impacts to the Natural Environment	
Objective	Evaluation Criteria	Source/Comments
Minimize impacts on the natural environment	Acres of New Disturbance to Woodland, Meadow, etc.	Regional Policy Plan, Local Conservation Commissions
Minimize impacts on water resources	Acres of Disturbance to Contributing Area to Public Supply Wells	Regional Policy Plan - Water Resources Classification, Time of Travel Flow Paths
Minimize impacts on rare species	Acres of Impacts to Rare Species Habitat	Natural Heritage & Endangered Species Program
Minimize impacts on wetlands	Acres or Square Feet of New Disturbance to Wetlands or Buffer Areas	Local Conservation Commissions
Improve air quality	Emissions of VOCs and NOx	Traffic Volumes, Delays, Modeling
Goal	Improve Transportation Choices Within The Study Area	
Objective	Evaluation Criteria	Source/Comments
Provide public transportation facilities	New/Improved bus stops, new/improved bus routes	CCRTA, Concept plans
Facilitate access to rail service	Travel time to rail depot, potential new station	Traffic modeling, Concept plans
Facilitate access to local and interregional bus services	Travel time to bus stops	traffic modeling
Goal	To Evaluate Project Costs and Impacts	
Objective	Evaluation Criteria	Source/Comments
Reduce construction costs	MassDOT cost estimating	MassDOT
Reduce right-of-way impacts within study area	Number of properties affected and square feet of impact	Concept Plans



PROJECT EVALUATIONS

The Cape Cod Commission transportation staff met with the Bourne Transportation Advisory Committee (Task Force) and staff from other Commission departments (planning, economic development, water resources, and natural resources, historic preservation) to develop evaluations of the five concepts. A draft evaluation matrix was discussed and refined with and approved by the Task Force. Evaluations are shown in the following table.



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Bourne Rotary Replacement Study

Evaluation of Concepts

Goals:		Improve Safety for all Users within the Study Area				Improve Mobility within and Access to the Study Area				Improve Economic Opportunities		Decrease Impacts to Residential Neighborhoods		Support Land Use, and Cultural & Scenic Interests		Reduce Impacts to the Natural Environment					Improve Transportation Choices within the Study Area			To Evaluate Project Costs & Impacts		
Concept	Reduce quantity & severity of crashes	Improve safety for bicyclists & pedestrians	Make road use "user-friendly"	Support evacuation routes	Improve access for emergency vehicles	Improve traffic flow in & around the study area	Improve bicycle & pedestrian access to the Bourne Bridge	Improve through connections to local and regional bicycle networks	Provide options to reduce congestion & improve mobility	Minimize traffic impacts on businesses in the study area	Improve access for current & potential businesses in the study area	Reduce the use of local streets by through traffic	Improve pedestrian & bicycle access to & from local neighborhoods	Improve access to & from local neighborhoods	Provide bicycle & pedestrian access to Canal paths	Support local land use goals	Minimize impacts on the natural environment	Minimize impacts on water resources	Minimize impacts on rare species	Minimize impacts on wetlands	Improve air quality	Provide public transportation facilities	Facilitate access to rail service	Facilitate access to local & inter-regional bus services	Reduce construction costs	Reduce right-of-way impacts within study area
A Diamond Interchange	●	□	●	●	○	○	□	○	●	■	■	●	◇	○	◇	□	□	◇	■	□	●	■	◇	■	■	■
B Full Cloverleaf	●	□	●	●	○	●	□	□	●	■	■	●	◇	□	◇	□	□	◇	■	□	●	□	◇	□	■	■
C Loop Ramp & Slip Ramp, 1 overpass	□	■	○	○	●	●	■	■	●	□	◇	■	■	■	■	■	□	◇	□	◇	○	□	◇	◇	●	●
F Left-hand ramps, 2 Signals	●	◇	○	●	◇	○	□	□	○	□	□	●	◇	□	◇	□	□	◇	■	□	●	□	◇	□	■	□
I Left-hand ramps, 1 Signal	●	●	●	●	○	●	◇	○	●	●	●	●	◇	□	◇	●	□	◇	□	◇	●	□	◇	□	●	●

Evaluations

Benefits : ○ Minor ● Moderate ● Major

Detriments : □ Minor □ Moderate ■ Major

Neutral : ◇

ADDITIONAL CONSIDERATIONS

In addition to the major changes considered in the above rotary replacement schemes, several smaller-scale and related issues are discussed below.

INTERIM IMPROVEMENT

In 2011, the engineering firm BETA Group, Inc. developed a striping and signage plan to improve traffic flow and safety at the Bourne Bridge Rotary. The plan was presented in a memorandum that included the following observations:

- **Pavement Markings** – There are currently no pavement markings to delineate travel lane assignments entering or within the rotary. The Sandwich Road westbound approach and Trowbridge Road eastbound approach have no lane lines to indicate a two lane configuration, although both approaches do operate as two lanes and sufficient width exists to accommodate two lanes. There are faded yield lines several feet from the rotary.
- **Merging** – There was confusion exhibited by drivers entering the rotary not knowing where they should drive within the rotary. Vehicles entered at various points within the rotary. In addition, although Sandwich Road westbound is marked as a one-lane approach, a very high percentage of vehicles exiting Sandwich Road were observed maneuvering alongside/around a vehicle waiting to enter the rotary in order to turn right onto Route 28 northbound. The Trowbridge Road eastbound approach had a similar occurrence, where vehicles maneuvered to form two lanes entering the rotary.
- **Weaving** – Due to the wide pavement area within the rotary, vehicles within the rotary travelled in no particular pattern. Drivers moved from the outside to inside of the rotary at many different locations. At all points within the rotary weaving occurred. Since there are currently no lane marking and no advanced signage to direct drivers, there is confusion when entering and maneuvering within and exiting the rotary.
- **Pavement Width** – Based on GIS aerial information, it appears the pavement width of the rotary varies from approximately 40 to 46 feet around the rotary. The pavement area is open and without markings. Also, both the northbound and southbound Route 28 approaches to the rotary have approximately 32 feet of approach width, and both Trowbridge Road eastbound and Sandwich Road westbound have approximately 26 feet approach widths.
- **Queuing** – Queuing problems were observed on all approaches to the rotary, in particular the Route 28 northbound and southbound approaches and Sandwich Road westbound approach. At least 500' of queuing on these approaches were observed.
- **Access Management** – There are four driveway openings and areas with no curb definition within the rotary. The high number of openings along the rotary compounded the operational safety of the rotary. The driveways created



- additional merging and diverging points within the weaving sections of the rotary. A few near-miss accidents were observed as vehicles tried to enter the rotary at the gas station driveways.
- **Advanced Signage** - There are very limited advanced guide/destination and lane use signs approaching the rotary. The lack of these devices supports confusion as traffic approaches the rotary. Multi-lane approaches also create confusion due to the lack of signage and pavement markings to channelize drivers into the proper lane. The guide signs within the rotary appear adequate.

Based on field observations and the data compiled, BETA recommended the following conceptual improvements:

Signage

- Provide a Circular Intersection (W2-6) and Traffic Circle (W16-12P) sign on each approach in advance of the rotary to indicate the presence of the rotary.
- Provide advanced overhead destination signs (D1-5a) on the Route 28 northbound and Route 25 southbound approaches. Destination signs supply the road user with destination information as they approach the rotary.
- Provide ground mounted destination signs (D1-3d) for the Route 28 Bourne Bridge southbound approach, Sandwich Road westbound approach and Trowbridge Road eastbound approach. The Route 28 southbound destination sign may be placed in advance of the bridge in order to provide adequate advanced notice of the upcoming rotary.
- Provide Lane Control signs (R3-8) in advance of the rotary in order to indicate permitted movements per lane.

Pavement Markings

These much-needed pavement markings will wear quickly and require period reapplication, probably each spring.

- Provide fish-hook lane use arrow pavement markings on each approach in advance of entering the rotary.
- Provide yield lines across all approach lanes at the intersection.
- Provide wide dotted white extension lines of the circulatory roadway edge line on all approaches to the rotary.
- In order to minimize the width of pavement within the rotary, provide a yellow edge line with diagonal yellow crosshatch markings, varying in width, along the central rotary island in order to narrow the width of open pavement and create a consistent 30' wide travel area
- Provide an exclusive right-turn only lane on the Sandwich Road westbound approach and Trowbridge Road eastbound approach to the rotary. The exclusive turn lanes will help alleviate merging confusion.
- Provide a combination of solid and dashed pavement markings to create two 15' travel lanes with lane use arrows in order to clearly define movement within, as well as entering and exiting the rotary. The advanced destination and lane use signs coupled with the pavement markings will help to create safer overall traffic operations at the Bourne Bridge Rotary.



A detailed example of a diagrammatic sign is shown below and should be installed on Route 25 southbound and Route 28 northbound in advance of the Bourne Bridge Rotary.



D1-5

FIGURE 12 - DIAGRAMMATIC SIGN EXAMPLE

The following figures show the proposed interim pavement markings and signage improvements.

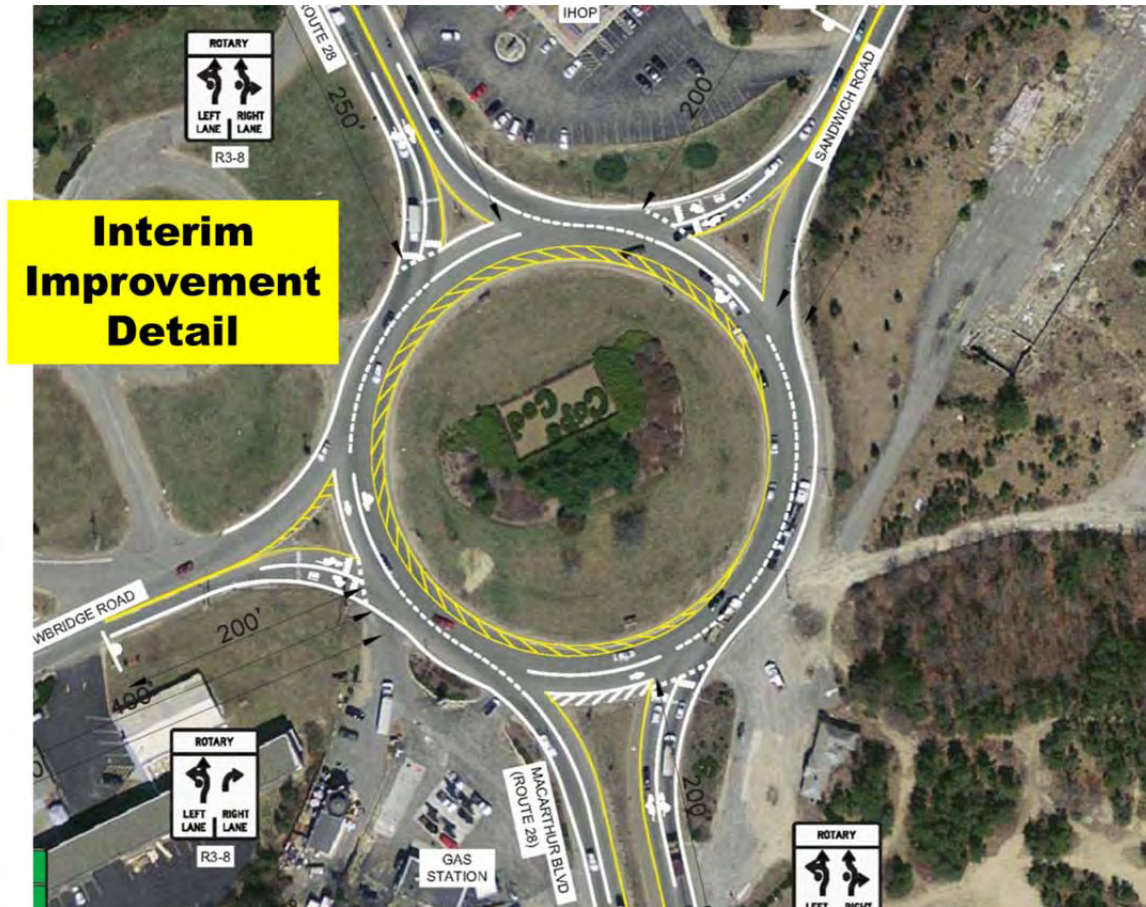


FIGURE 14 - DETAIL OF PAVEMENT MARKINGS - INTERIM IMPROVEMENT

BICYCLE/PEDESTRIAN ACCESS

The Cape Cod Canal, maintained by the U.S. Army Corps of Engineers, includes access roads on both sides of the canal. These access roads are used by the Corps for canal maintenance activities. In addition, the access roads are open to the public for use by bicyclists and pedestrians for recreation and transportation.

In 2013, the Cape Cod Regional Transit Authority launched the “Cape Flyer” – a seasonal weekend passenger rail service with a stop in Buzzards Bay. An innovative feature of the Cape Flyer service is the provision of a “bicycle car” in the trainset. This car provides for secure transportation and amenities such as bicycle pumps and maintenance tools. Bicyclists disembarking in Buzzards Bay who wish to travel southward to Falmouth to make use of such facilities as the Shining Sea Bike Path must first cross the Bourne Bridge (as pedestrians walking their bikes over the bridge on a six-foot wide sidewalk).



At the entrance of Route 28 to the Bourne Bridge Rotary the bridge sidewalk disappears and bicyclists and pedestrians are faced with entering the state police property (faced with a sign stating “no vehicular access”) on the west or (unheard of) entering the rotary itself.

The following figure presents a proposed bicycle route from the Bourne Bridge to Shore Road along Sandwich Road. From Sandwich Road bicyclists and pedestrians are provided with access points to the Cape Cod Canal path; from Shore Road, an on-road bicycle route connects to Falmouth.

The red line shows a potential alternate facility along the frontage of the state police property in lieu of the use of the police driveway. It should be noted that there currently is a “No Entry” sign at the police driveway.

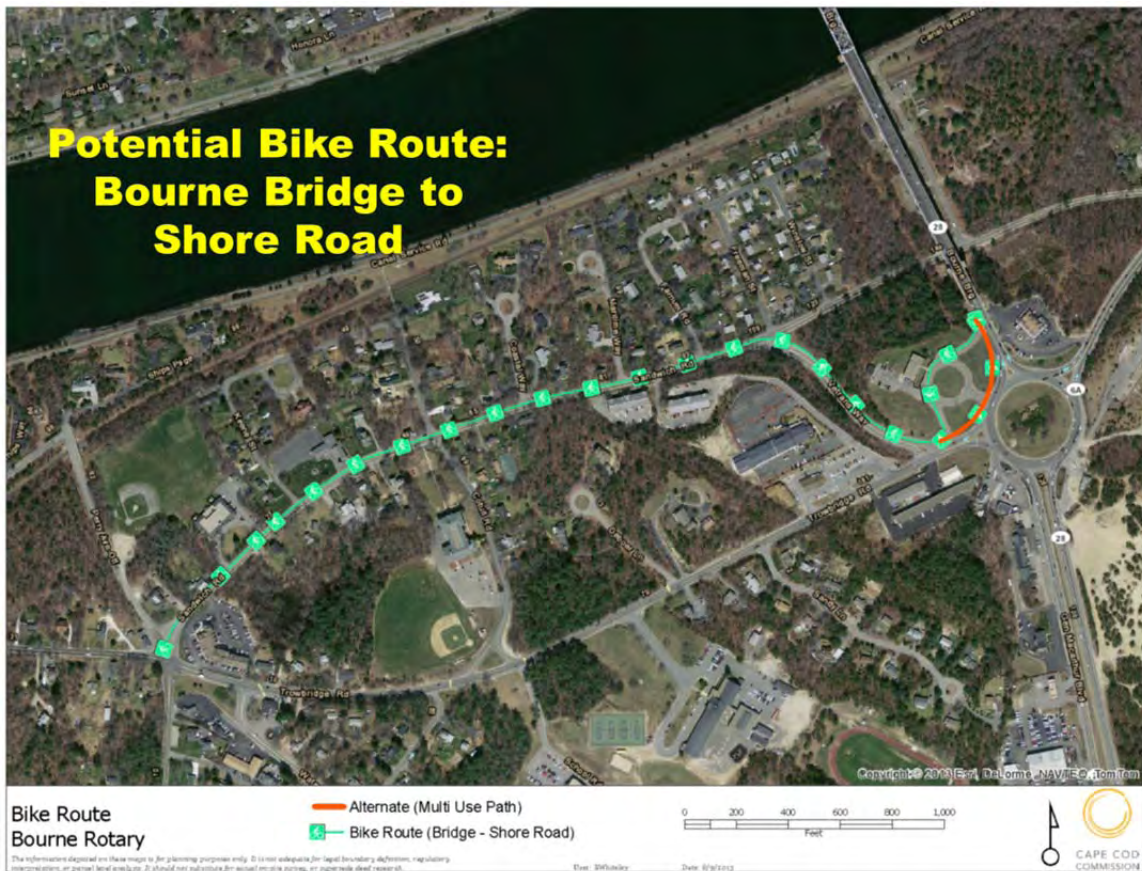


FIGURE 15 - POTENTIAL BIKE ROUTE TO BOURNE BRIDGE

Conclusion/Summary of Recommendations

Improvements in traffic flow and safety at the Bourne Bridge Rotary will necessarily need to be implemented in a phased approach. Recommendations of this study are therefore broken into near-, mid-, and long-term timeframes.

NEAR-TERM IMPROVEMENTS

Near-term improvements are solutions that are relatively inexpensive, do not require major permitting, and can be implemented in 0-3 years:

- Install directional signage on Route 25 southbound and Route 28 northbound in advance of the Bourne Bridge Rotary
- Improve signage within the rotary
- Install pavement markings within the rotary and approaches to improve lane control and safety
- Eliminate selected curb cuts at the IHOP restaurant and Gulf gas station
- Ease road curve and angle curbs at IHOP corner
- Add multi-use path from the Bourne Bridge to Veterans Way

MID-TERM IMPROVEMENTS

Mid-term improvements are solutions that require design and engineering or significant traffic management efforts. Mid-term improvements are expected to be implemented in 3-6 years. It is expected that the proposed reconfiguration of Belmont Circle and associated Route 25 ramps immediately to the north of the Bourne Bridge would be completed during this timeframe and would facilitate the following objectives:

- Encourage down-Cape traffic to use Scenic Highway
- Discourage truck use of Sandwich Road

LONG-TERM IMPROVEMENTS

Long-term improvements are solutions that require extensive design and engineering and permitting. Long-term improvements are expected to take more than six years to be implemented:

- Replace Bourne Bridge Rotary with an interchange that, to the greatest extent possible, uses existing roads and locates all new construction to the east of Route 28

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