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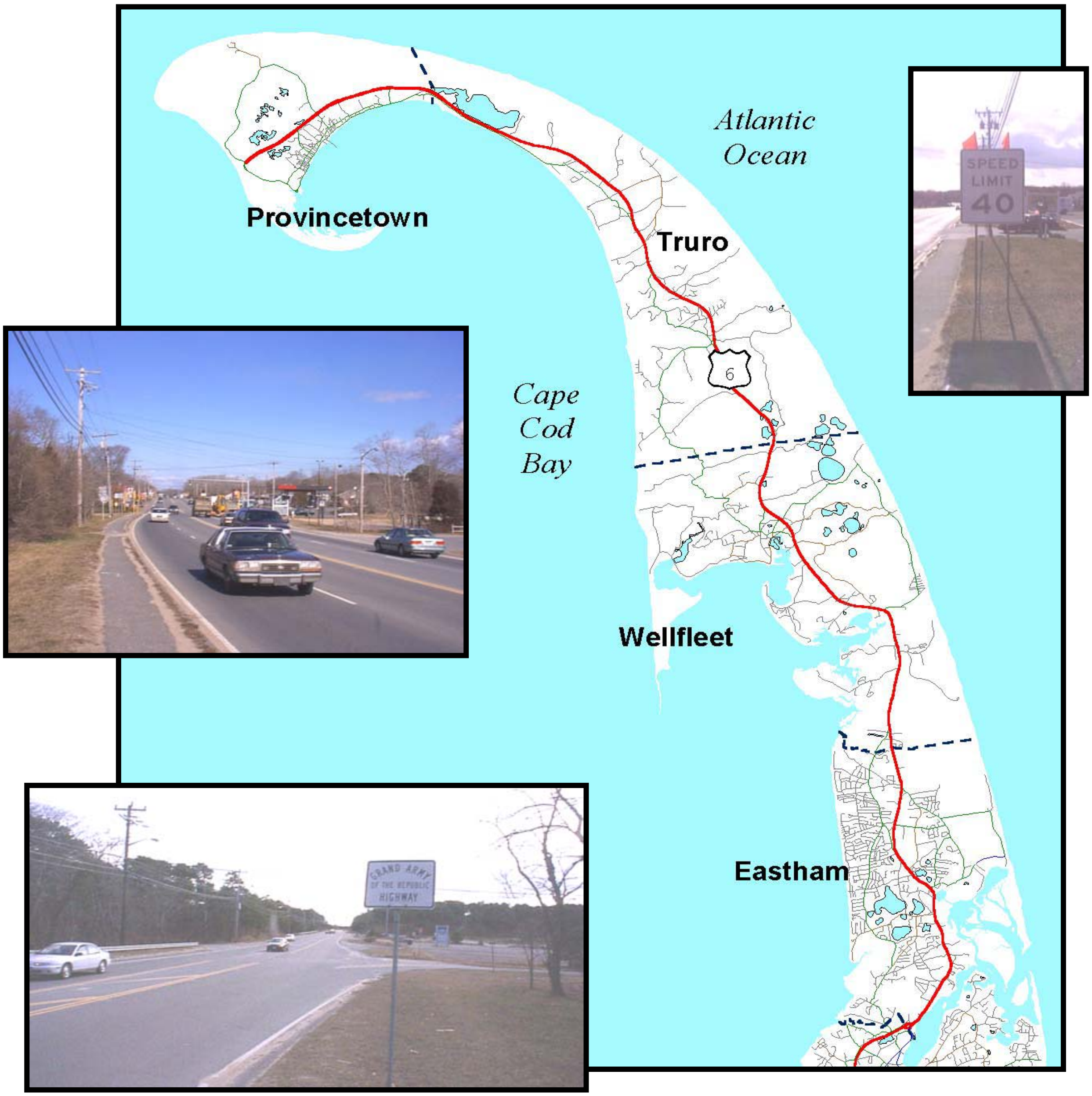
ROUTE 6
SAFETY & TRAFFIC FLOW STUDY
EASTHAM • WELLFLEET • TRURO • PROVINCETOWN



Cape Cod Commission Transportation Staff • March 2004
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the Massachusetts Highway Department,
and the U.S. Department of Transportation, Federal Highway Administration

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Executive Summary

Route 6 in the Outer Cape towns of Eastham, Wellfleet, Truro, and Provincetown stretches 27-miles and services over 30,000 vehicles per summer day. This stretch of highway has some of the highest crash rates on Cape Cod as well as severe traffic congestion problems.

Traffic Flow, Crashes, and Growth

An examination of existing and historic data shows traffic volumes within the four towns grew at an average annual rate of 1.05% between 1991 and 2001. The Route 6 crash rate for the whole of Cape Cod was 0.79 crashes per million vehicle miles traveled on average from 1991-1998 while Route 6 in Eastham had one of the highest crash rates on Cape Cod at 2.17 crashes per million miles of vehicle travel. Heavy and growing traffic volumes coupled with the existing high crash rates for the corridor make the search for and implementation of solutions a high priority, especially in Eastham.

Total year round population for Eastham, Wellfleet, and Truro grew 20.6% between the 1990 and 2000 Censuses, rising to 10,289 in 2000, while Provincetown's year-round population decreased 3.7% to 3,431. The census ranked Eastham and Wellfleet as the 10^{th} and 13^{th} oldest towns in the state with median ages of 47.6 and 47.0. The percentages of population over 65 in the Outer Cape towns are Eastham 26.00%, Wellfleet 21.70%, Truro 17.00%, and Provincetown 17.8% compared to a statewide average of 13.50%.

Of special interest is seasonal housing on the Outer Cape. Based on the 2000 Census figures for occupied versus vacant housing in April 2000, approximately 60% of the housing units on the Outer Cape are likely to be seasonal housing. This estimate, coupled with the large number of hotels in the area, results in a significant population density increase in the summer. The current summer population is estimated to be 98,000 which results in densities close to 3,600 people per square mile (on land outside of the Cape Cod National Seashore) and is expected to reach over 4,100 per square mile at build-out.

Based on trends in traffic growth and total delay, traffic delay on Route 6 in Eastham (from the Orleans Rotary to just over the Wellfleet town line at West Road) is expected to increase 81 percent by the year 2010 if nothing is done to the existing roadway and the trend of population and traffic growth continues. The section of the Route 6 corridor from Brackett Road north to the Wellfleet town line is expected to see the highest increase in delay: from current delay of about 23 seconds to about 51 seconds per vehicle, or about a 122% increase. This forecast, based on simulation of the corridor, formed a baseline for comparing the congestion impacts of corridor alternatives.

Alternative Testing

As a precursor to alternative testing, existing plans being pursued by MassHighway to improve several intersections were examined. These include sight distance improvements, pedestrian and handicap accommodations, updated signal timing/phasing, and updated signals and poles at five locations on Route 6: Governor Prence Road, Samoset Road, Nauset Road, Brackett Road, and Marconi Beach Road. These improvements may be completed by summer of 2004.

Using Federal Highway Administration publications relating to safer roadways, identification of traffic flow problem areas via computer simulation, and public input regarding suggested improvements, several alternatives were identified and analyzed. Each alternative was compared to existing conditions to determine its effect, positive or negative, on improving traffic flow and safety along the Route 6 corridor.

Four alternatives were tested using *Synchro* and *SimTraffic* traffic operations software. These alternatives included intersection improvements such as turning lanes, adding traffic signals, and signal upgrades; changing roadway cross sections such as one through lane with turn pockets; and creating a center barrier for the entire length of Route 6 in Eastham. Below is a complete list of the alternatives modeled using the traffic operations software.

2001 Base: Existing conditions model

2010 Base: Future year traffic conditions model with no roadway changes

2010 A: Intersection Improvements

- Route 6 at Orleans Rotary – stripe 2 lanes entering westbound (approx. 150')
- Route 6 at Samoset Road – new northbound left turn lane on Route 6
- Route 6 at Depot Road – no northbound left turns allowed onto Depot Road from Route 6
- Route 6 at Massasoit Road – new northbound left turn lane on Route 6
- Route 6 at Brackett Road – new southbound left turn lane on Route 6
- Route 6 at Brackett Road – new westbound left turn lane on Brackett Road

2010 B: Intersection Improvements plus signalize Governor Prence Road

Includes all improvements listed in 2010A plus signalization of Route 6 and Gov. Prence Road

2010 C: One Lane section in south Eastham

Involves allowing one through lane northbound and southbound and the creation of turning pockets at key locations from the Rotary to the Eastham post Office area. The layout will likely fit within the existing pavement area

2010 D: Center Barrier

- Involves a continuous center barrier allowing left turns at key areas only
- Included a sensitivity test with 20% less traffic and the continuous center barrier

The above alternatives were tested with the traffic operations software to determine their effects on traffic flow while the impacts on safety were analyzed using typical improvement rates from similar improvements documented in the Federal Highway Administrations' *Access Management for Streets and Highways (1982).*

Conclusions

Alternative B's performance was the most notable. This alternative may produce a 25 percent reduction in delay and is also estimated to reduce crashes by as much as 4.9 per year. This improvement scheme would involve minor land takings and have a potential cost of as much as $800,000 and is therefore considered a long-term option. Other improvements can be done in the short and medium term to improve traffic flow and safety. All of these options are presented in the table on the following page.

The traffic flow and safety problems on Route 6 in the four towns of the Outer Cape need to be addressed. Implementation of these recommendations would provide congestion relief and a greater degree of safety for motorists.

Summary of Recommendations

Location	Improvement/ Description	Time Frame	Benefit	Cost $1,000
Area-wide	**Education:** Information campaigns including media and signage to encourage safe driving and alternate mode use	Short Term & Continuing	Safety & Mobility	N/A
Route 6 Corridor	**Enforcement:** Highly visible enforcement of speed limits, red light running, etc.	Short Term & Continuing	Safety	N/A
Area-wide and in adjacent areas	**Intelligent Transportation Systems:** Dissemination of traffic flow, parking, and safety information in real-time via Highway Advisory Radio, Variable Message Signs, and Internet	Short Term & Continuing	Safety & Mobility	N/A
Route 6 corridor – Orleans to Provincetown	**Orleans to Provincetown Transit Service:** connecting to National Seashore, beaches, etc.	Short Term & Continuing	Mobility	273 to 546
Route 6 and other corridors – Hyannis to Provincetown	**"Attractions" Shuttles:** Provide ride-sharing service for Provincetown excursions, National Seashore, other attractions	Short Term & Continuing	Mobility	N/A
Rt 6 Intersections: Samoset, Brackett, Main, Conwell, Gov. Prence	Various improvements including upgrades to lane markings, signal heads, access management, pedestrian phases and crosswalks. See section 5.2 for more detail.	Medium Term	Safety & Traffic Flow	N/A
Eastham/Orleans Rotary	Improvements to rotary signage and pavement markings at the Rock Harbor Rd entrance	Medium Term	Safety	N/A
Route 6 Corridor	**Access Management:** Increase frontage requirements, provide incentives to share access, increase land conservation, and enforce "No Access" line in Truro/Provincetown	Medium Term	Safety & Traffic Flow	N/A
Area-wide	**Older Drivers' Recommendations:** incorporate protected left-turn phases, frequent restriping and street cleaning, larger signs, improved and consistent lighting	Medium Term	Safety	N/A
Route 6 Corridor	Provide bus turnouts and shelters at strategic locations (to compliment local services and destinations)	Medium Term	Mobility	N/A
Route 6 – Eastham/Orleans Rotary to Eastham post office	Lanes for left turning vehicles plus single through travel lane. Signalization at Gov. Prence Rd	Long Term	Safety & Traffic Flow	567 to 1,717
Provincetown, Orleans	**Local Transportation Centers:** Construction of facilities near MacMillan Wharf and downtown Orleans to provide connections with local and express bus service, information kiosks, etc.	Long Term	Mobility	N/A

1. Introduction

U.S. Route 6 in the towns of Eastham, Wellfleet, Truro, and Provincetown (the "four towns" referred to in this document) is a 27-mile stretch of State Highway servicing, at some locations, well over 30,000 vehicles per summer day. The highway includes some of the highest and most serious crash rates on Cape Cod as well as some severe traffic congestion problems.

The Cape Cod Commission was assigned the task of developing recommendations to improve safety and traffic flow as part of the Commission's transportation planning contract with the Massachusetts Highway Department (which has jurisdiction for the highway.)

1.1 Project Goals

Based on comments received at public meetings, state directives, and transportation planning goals identified in the *Cape Cod Regional Transportation Plan*, the goals of this study were as follows:

- Identify specific locations that experience high crash rates or crash frequency
- Develop recommendations that, if implemented, would reduce crash rates and frequency
- Identify specific locations that experience high levels of traffic congestion
- Develop recommendations that, if implemented, would help ease traffic congestion

1.2 Study Area

1.2.1 Population

The most significant result of the 2000 Census was growth. Population in the Cape Cod region grew 19.1% between 1990 and 2000 to 222,230 people contrasted with a Statewide growth of 5.5%. Cape Cod is the 3rd fastest growing region behind the Islands of Nantucket and Martha's Vineyard which also contribute to the traffic volumes on Cape Cod. Twelve of the 20 oldest communities in the state are located in the region with Orleans and Chatham as the oldest of the 351 communities in the Commonwealth (median ages of 55.5 and 53.9 respectively.) Eastham and Wellfleet are close behind, ranking 10th and 13th in the state with median ages of 47.6 and 47.0. The percentage of population over 65 in the Outer Cape towns are: Eastham 26.0%, Wellfleet 21.7%, Truro 17.0%, and Provincetown 17.8% compared to a statewide average of 13.5%.

Significant growth occurred in the outer Cape towns over the last few decades. This growth has continued in the period between 1990 and 2000 with the exception of Provincetown, which saw little growth from 1980 to 1990 and a slight decline from 1990-2000. See Table 1 for more information.

Table 1 – Total Population Changes 1980-2000

	Year	Eastham	Wellfleet	Truro	Provincetown	Four Outer Cape Towns - Total Population
Population	1980	3,472	2,209	1,486	3,536	10,703
	1990	4,462	2,493	1,573	3,561	12,089
	2000	5,453	2,749	2,087	3,431	13,720
Changes by Decade	1970-1980	69.9%	26.7%	20.4%	21.5%	15.8%
	1980-1990	28.5%	12.9%	5.9%	0.7%	13.0%
	1990-2000	22.2%	10.3%	32.7%	-3.7%	13.5%

According to the Cape Cod Commission's Geographic Information System department, the Outer Cape is an area of 66.4 square miles of which approximately 60% is protected as the Cape Cod National Seashore. The population lives on approximately 27.2 square miles of land outside of the national seashore, resulting in a density of approximately 505 year round residents/square mile. However, since 60% of the housing in the Outer Cape towns is estimated to be seasonal and since there are a large number of hotels in the area, the density increases significantly in the summer. The estimated total summer population for the Outer Cape is approximately 98,000 people which yields a density of approximately 3,600 people per square mile. The total summer population is expected to reach over 4,100 per square mile at "build-out," a density similar to more urban areas.

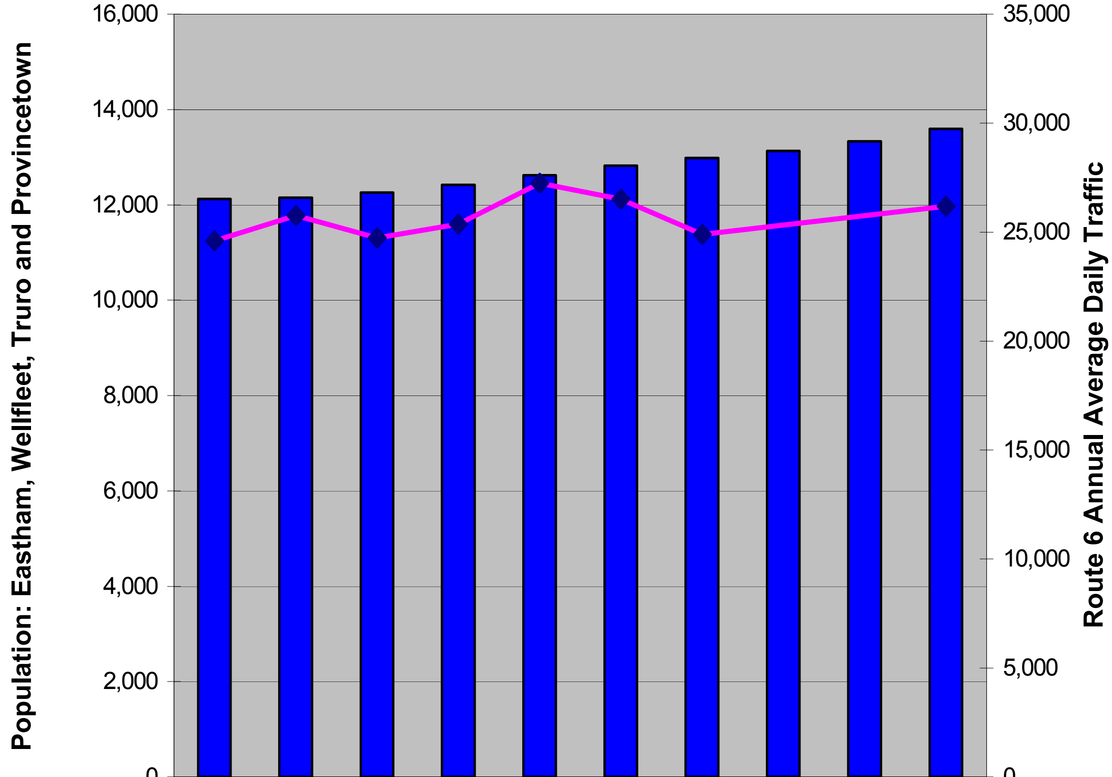
Several studies and plans have been developed that included analysis and policies for Outer Cape future land use. These include the 1996 Outer Cape Capacity Study, the Local Comprehensive Plans prepared by the Outer Cape towns, the Cape Cod Commission's Regional Policy Plan, and a recent build-out analysis for the entire Cape. This study focuses it efforts on the Route 6 corridor, and its major intersections, in Eastham, Wellfleet, Truro and Provincetown. Traffic flow and safety on parallel or intersecting roads is of concern but is not considered in the same level of detail as the Route 6 corridor. The corridor is shown in red on the study area map in Figure 1 and also in detailed maps available in the appendix.

Build-out scenarios developed in the Outer Cape Capacity Study include a scenario where the existing ratio of seasonal to year round housing continues and a scenario where 50% of the seasonal housing is converted to year round. The most recent build-out analysis for the Cape expects build-out to occur around 2025 and it is likely that the Outer Cape towns will achieve build-out earlier. Current and future land use maps are located in the appendix which show the drastic increase in residential land use and the shift from low-density residential development to higher densities expected at build out. The Outer Cape year round population at build-out is expected to be 17,470 to 27,860 and the summer population is expected to be 112,310 to 113,580, depending on the assumed conversion of seasonal housing stock.

Figure 2 shows the changes in population and Route 6 Average Daily Traffic from 1990 through 1999.

Figure 1 – Study Area

(Detailed study area map in appendix)



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Population	12,127	12,154	12,259	12,421	12,621	12,821	12,983	13,130	13,333	13,597
Rt 6 ADT	24,591	25,762	24,733	25,360	27,246	26,502	24,888	NA	NA	26,177

Figure 2 – Population and Route 6 Traffic

Sources: CCC Population Figures for Eastham, Wellfleet, Truro, and Provincetown. CCC Summer Traffic Counts for Route 6 at Eastham/Wellfleet town line

1.2.2 Regional Policy Plan and Local Comprehensive Plans

The Cape Cod Regional Policy Plan (2002) includes three transportation goals:

1) "To maintain an acceptable level of safety on all roads on Cape Cod for all users"
2) "To reduce and/or offset the expected increase in motor vehicle trips on public roadways and to reduce dependency on automobiles"
3) "To maintain travel times and Level of Service on regional roads and intersections and to ensure that all road and intersection construction or modification is consistent with community character, historic, or scenic resources"

Developments of Regional Impact (generally commercial construction/conversion of 10,000 Square Feet or more or housing developments of 30 units or more) are required to meet these goals by complying with 33 Minimum Performance Standards. Some of these requirements have been recognized by the towns in their Local Comprehensive Plans (LCPs) and implemented for projects not under DRI review. These and related LCP strategies make up the basis for several recommendations as presented in section 5.2 of this report. For a complete review of RPP policies and standards, please see RPP section 4.1.2, available from the Commission or on the Internet at:

www.capecodcommission.org/RPP

1.2.3 Travel and Transportation Alternatives

Route 6 is the main—and in some areas the only—route traveling the spine of the Outer Cape. Milepost 0.0 is "located" in Provincetown (the other end of Route 6 is in California), in the vicinity of Herring Cove Beach at the intersection of Route 6A. Naturally, all Route 6 travel in Provincetown has either an origin or a destination (or both) in town. Moving south, Route 6 carries more and more through traffic, with the largest share, for the purposes of this study, in Eastham (serving local travel as well as the other three towns on the Outer Cape).

In general, congestion is seasonal occurring between June and August with weekday peak hour traffic volumes of over 2,700 vehicles observed on Route 6 in Eastham. Weekend volumes are estimated to be approximately 30% higher than the weekday volumes. The corridor's major discrete traffic generators are also seasonal in nature and include the National Seashore and Provincetown attractions such as the whale watch cruises. Traffic volumes within the four towns grew at an average annual growth rate of 1.05% per year for the 1991 through 2001 period.

Due to geographic aspects of the Outer Cape, roadway and routing alternatives to Route 6 are limited. In some areas of Wellfleet and Truro Route 6 is the only north-south route and in other areas of the Outer Cape, alternative north-south routes traverse rural residential areas. Other transportation alternatives in the area include:

- Regional air service between Provincetown airport and Boston
- Ferry service at MacMillan Wharf in Provincetown to and from Boston and Plymouth
- The Provincetown Shuttle—providing public transportation between Truro and Provincetown, including MacMillan Warf
- Plymouth and Brockton—privately operated inter-regional bus service between Boston (including Logan Airport) and Provincetown; makes a number of stops in the study area including Dutra's Store in North Truro where a connection with the Provincetown Shuttle can be made
- The Cape Cod Rail Trail multiuse recreational path originates in Dennis and parallels Route 6 in the study area from the Eastham/Orleans town line to LeCount Hollow Road in Wellfleet (approximately 8 miles)—The bike route (State Bicycle Route 1 also known as the Claire Saltonstall bikeway) then

continues along side roads and bike path segments to North Truro and Provincetown where it follows Route 6A into Provincetown

1.3 Study Criteria

Traffic flow and safety were the two criteria used to evaluate the existing conditions and suggested alternatives along the Route 6 corridor. Improving traffic flow and safety are the major goals of this study and evaluating the impacts on both was paramount in determining viable solutions along the corridor.

Recommended improvements also include elements from the FHWA Older Driver Highway Design Handbook in recognition of the older driving population on Cape Cod. This approach was recommended in the *Cape Cod 2000 Regional Transportation Plan* and includes consideration of improved illumination, signage, and pavement delineation.

The following sub sections include discussions on methodologies to evaluate traffic flow and crash studies, as well as analytical potential and limitations of local Cape Cod crash data.

1.3.1 Traffic Flow

Numerous traffic counts conducted by Automatic Traffic Recorder (ATR) and turning movement counts collected manually were undertaken by Commission staff in recent years. ATRs are traffic sensors (rubber hoses stretched across the roadway) and recorders (battery-operated computers) that record hourly traffic volumes on road links usually over a period of 48 hours or more. Turning movement counts record the number of vehicles turning left, turning right, or continuing straight from each of the approaching roads at intersections. The turning movement count is the basic input in determining an intersection’s performance – known as “Level of Service” or “LOS” (see discussion in the appendix). Turning movement counts conducted for this study were limited to two hours during peak traffic periods due to budgetary and time constraints.

Extensive (more than eight hours of observation) turning movement counts are needed to determine if a particular location meets defined traffic signal “warrants” for signal installation. For this study, the peak hour traffic counts were used for one of the warrants. By relating peak hour information with nearby ATR data, turning movements were factored to more hours which provided data for additional signal warrant analysis. (See section 2.6)

Traffic operations can be evaluated in many different ways. For analysis in this study, a transportation operations analysis software package, *Synchro/SimTraffic* was used to help describe the existing conditions and forecast the effects of future growth and alternatives. These techniques are discussed in detail in Chapter 3.

1.3.2 Safety

A corridor-wide crash analysis was undertaken for this study using the latest available three years' (1998-2000) of crash data. Results are presented in section 2.3.

This study has also used results of several previous efforts which analyzed crash data in the area. The first previous effort was a detailed analysis of individual 1994-1996 police department reports in Eastham, Wellfleet, and Truro. It included crash diagrams for Route 6 intersections which are presented in the appendix. From this effort, specific types of crashes were more thoroughly examined and are discussed in section 2.3.1.

The second previous effort, using 1991-1998 state crash records, identified intersections and roadway segments that experience significant crash rates, as discussed in section 2.3.2.

Massachusetts & Cape Cod Data

Periodically, the Massachusetts Highway Department (MHD) receives crash records from the Registry of Motor Vehicles. Annually, MHD transmits records for Cape Cod towns (usually in mid-Summer) to the CCC. It is customary to analyze records from the most recent three years to identify hazardous locations and safety problems. For this study, records from the years 1998-2000 were used to determine the average number of crashes for a variety of scenarios.

The state's crash records include information for each crash including:

- Date & Hour of the Day
- Severity (e.g., Fatality, Injury, Property Damage Only)
- Type (e.g., Rear-End, Angle)
- Environmental Characteristics (Lighting, Road Surface Conditions, Weather….)
- Street Name (& crossing street for intersection crashes)

The severity information is especially important for assessing the degree of hazard. The state-approved and nationally established concept of "Equivalent Property Damage Only" (EPDO) points was used in this study. By assigning a value of 1 to Property Damage Only crashes, a value of 5 to Injury crashes, and a value of 10 to Fatality crashes, the EPDO system allows total crashes to be evaluated in a single statistic.

Street name information is not standardized in the MHD records, it may include spelling errors, and cross street locations are only sometimes included. Consequently, some of the recorded Route 6 crashes may have occurred at specific intersections (as opposed to crashes unrelated to an intersection). However, only crashes that could be identified to occur at specific intersections were used for the intersection analysis.

2. Existing Conditions

The following sections present information on traffic volumes, crash history, and other items important to documenting the existing traffic and safety conditions on Route 6 in the four Outer Cape towns.

2.1 Traffic Volumes

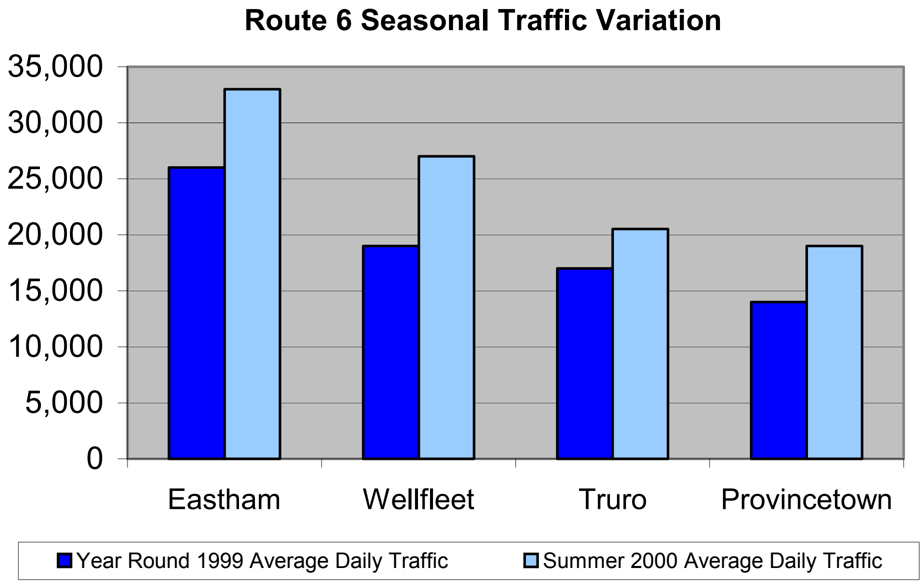
The Cape Cod Commission has been maintaining a database of traffic counts that covers the entire Cape Cod Region for over 18 years. Throughout those years, 106 Automatic Traffic Counts (ATR's) have been taken along Route 6 on the Outer Cape. Of those counts, 15 were taken in the last three years (see appendix of ATR's). In addition to the ATR counts, over 25 turning movement counts (TMCs) were taken at specific intersections along the Route 6 corridor in the summer of 2001 (see appendix of TMCs). The turning movement counts were taken in 2-hour intervals from 4:00 to 6:00 PM and were the basis for the traffic flow model (covered in Section 3.2) of the Eastham section of the corridor.

Typical Route 6 traffic volumes within each town are presented in Table 1 and Figures 3&4. Observed traffic volumes decrease the further out the cape the counts are taken as the roadway serves fewer and fewer trip generators. Traffic volumes are highest in Eastham at an annual average of 26,000 vehicles per day. Many of these motorists are traveling to or from one of the three remaining towns, given that Route 6 is the main route on the Outer Cape. In Provincetown, where traffic levels are at an annual average of 14,000 vehicles per day, "through traffic" does not exist since these motorists have either an origin or destination in Provincetown.

Table 2 – Route 6 Weekday Traffic Volumes

Town	Existing Annual Average Daily Traffic (1999)	Existing Summer Average Daily Traffic (2000)
Eastham	26,000	33,000
Wellfleet	19,000	27,000
Truro	17,000	20,500
Provincetown	14,000	19,000

**Above volumes represent an average of multiple count stations within each town*
Source: Cape Cod Commission traffic counting program



Source: Cape Cod Commission traffic counting program

Figure 3 – Existing Average Daily and Summer Daily Traffic

2.2 Travel Times

During the data collection effort for this study, a GPS unit was used to record travel times for the corridor, once on Tuesday July 24th 2001 and once on Wednesday July 25th 2001. The July 24th travel time run was prior to the peak hour and the July 25th run was recorded during the peak hour (4-5 PM). The data collector traveled the corridor using a standard car-following technique. The GPS recorded time and position from the Orleans Rotary to the Eastham-Wellfleet town line and back. The travel time results in the table below show the start time of each trip and corresponding travel time.

Table 3 – Network Travel Time

	Tuesday July 24, 2001		Wednesday July 25, 2001	
Direction of Travel	NB	SB	NB	SB
Start Time	2:27 PM	2:41 PM	4:45 PM	4:58 PM
Travel Time (min)	9.97	11.25	10.12	9.53
Average Speed	42	40	35	39

The Route 6 corridor was broken into three sections that were used in the traffic operations analysis. The first section is from the Orleans Rotary to Samoset Road, the second from Samoset Road to Brackett Road, and the third from Brackett Road north to the Wellfleet town line. Travel time and speed was broken out by corridor section for both northbound and southbound travel directions. During both northbound runs, the average speed for section two dropped below 35 mph, illustrating some of the delay associated with the Nauset Road signal and queue and possibly some delay related to the Brackett Road signal. During the southbound run on July 24th, the average speed in section two dropped below 35 mph. The results from the two travel time runs by section are given in Table 3.

Table 4 – Network Section Travel Time

Corridor Section: Average Free Flow Speed	Tuesday July 24, 2001		Wednesday July 25, 2001	
	NB	SB	NB	SB
Section One Rotary to Samoset Rd	39.6	40.4	40.5	38.9
Section Two Samoset Rd to Brackett Rd	30.2	32.3	31.6	37.3
Section Three Brackett Rd to Wellfleet TL	42.1	25.1	35.1	38.2

2.3 Crash History

This section reviews detailed crash rates and crash records for the four Outer Cape towns. For a given intersection or corridor, crash rates are calculated by dividing the average annual number of crashes by the number of vehicles using the facility. For presentation purposes, crash rates are typically scaled to "per million vehicles" and are further adjusted to account for mileage of roadway and severity of crashes.

The Route 6 crash rate for the whole of Cape Cod in 1999 was 0.79 crashes per million vehicle miles traveled. In contrast, The Route 6 crash rate in Eastham was 2.17 crashes per million miles of vehicle travel, much higher than the other three towns in the study as shown in Table 4.

Table 5 – Route 6 Crash Rates 1999

Town	Rte. 6 Miles	Average Annual Daily Traffic (1999)	Annual Crashes (1999)	Crashes per million miles traveled
Eastham	6.12	26,000	126	2.17
Wellfleet	8.56	19,000	42	0.71
Truro	9.93	17,000	25	0.41
Provincetown	3.8	14,000	9	0.46

Source: Cape Cod Crash & Traffic Data, MassHighway, 1999 data

Intersection crash rates were calculated using worksheets supplied by MassHighway and are provided in the appendix. The methodology used in calculating intersection crash rates requires adjustment for annual traffic and makes use of crash records that can be attributed to specific intersections. The table below summarizes crash rates at the nine key Route 6 intersections in Eastham:

Table 6 – Selected Route 6 Intersection Crash Rates*

Intersection	Crash Rate*	State Average*	District Average*
Brackett Road	0.411	0.87	0.89
Governor Prence Rd	0.189	0.66	0.67
Kingsbury Beach Rd	0.109	0.66	0.67
Massasoit Road	0.134	0.66	0.67
McKoy Rd	0.109	0.66	0.67
Oak Road	0.220	0.66	0.67
Salt Pond Road (Visitor Center)	0.282	0.87	0.89
Samoset Road	0.347	0.87	0.89
Wampum Road/ Nauset Road N	0.280	0.87	0.89

*Per million vehicles entering the intersection

The calculated crash rates for Eastham's Route 6 intersections are below the MassHighway District and state averages. However, due to the previously discussed limitations of the state crash records, it is possible that all crashes at specific intersections have not been identified and consequently the crash rates may actually be higher.

A variety of detailed crash information is provided in the following charts which are based on 1998-2000 Crash records from the Massachusetts Registry of Motor Vehicles (RMV). In several of the following figures, the bars showing the number of crashes include separate shaded areas for Eastham and the other three towns.

It may be useful to evaluate crashes at a more detailed level, such as the "sections" being used to present traffic flow information, but the limitations of the RMV records make this impractical. Most of the crash records identified along the Route 6 corridor in Eastham (and all towns on Cape Cod for that matter) lack sufficient detail to identify the corresponding section where the crashes occurred.

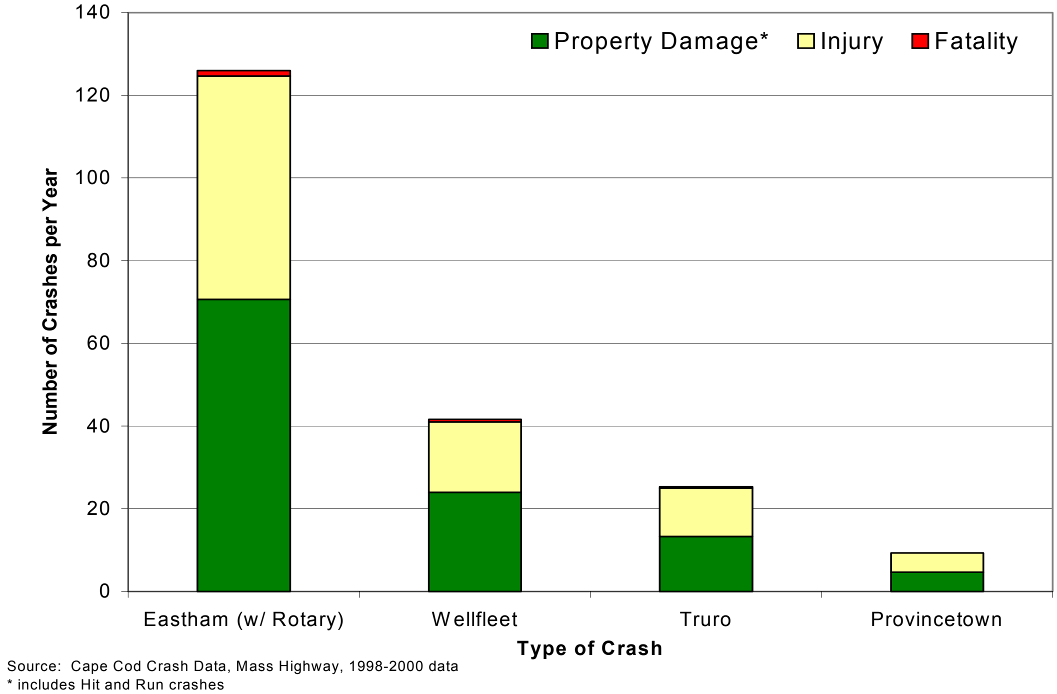


Figure 4 – Crash Severity by Town

The figure above shows the average number of Route 6 crashes per year in each of the four Outer Cape towns. For each town, crash severity is shown in green (PDO - property damage only), yellow (injury), or red (fatality). Eastham experienced 71 PDO, 54 injury, and 1 fatality crash per year on average for a total of 126 crashes per year on average. Wellfleet, Truro, and Provincetown experienced 42, 25, and 9 Route 6 crashes per year on average, respectively.

This data implies towns which serve as throughways for other towns and/or have more curb cuts on Route 6 (especially Eastham) experience substantially higher crash frequencies.

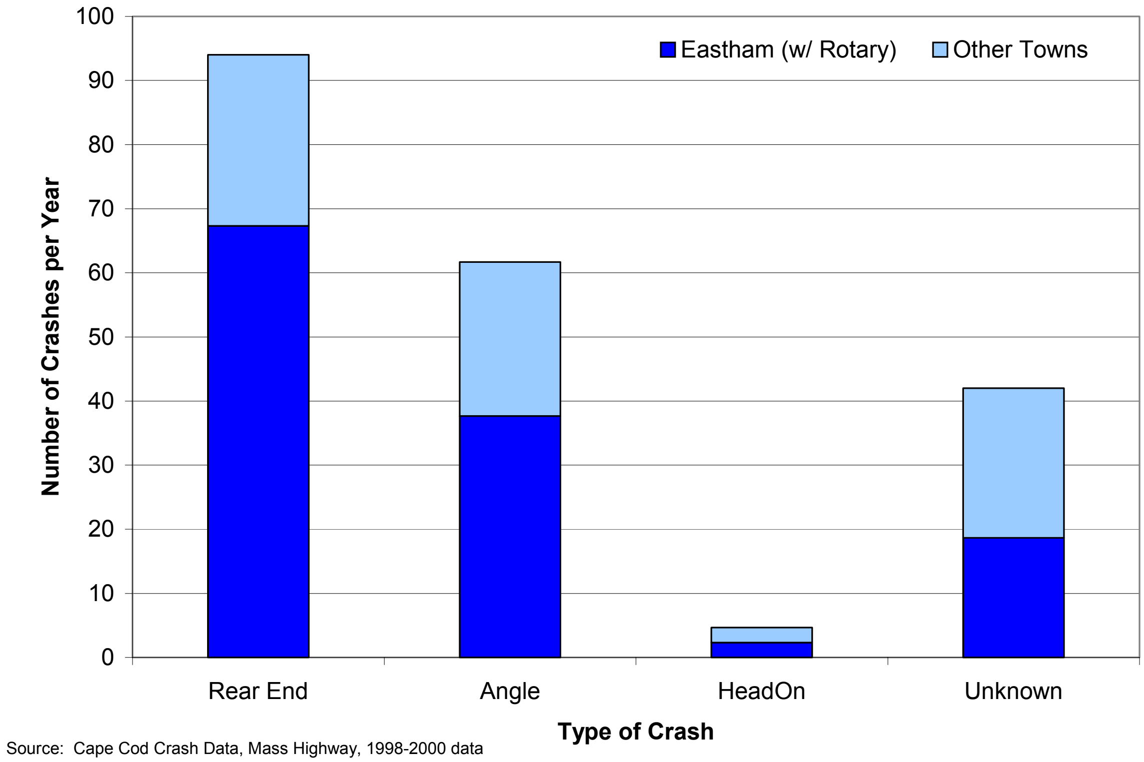


Figure 5 – Crashes by Type

The figure above shows the average number of Route 6 crashes per year in each of four crash types. The lower portion of each bar shows the Eastham crashes. Rear end crashes were the most common crash type recorded on Route 6 in the Outer Cape region from 1998 to 2000. There were 67 in Eastham and 27 in other towns for a total of 94 recorded "Rear End" crashes on average per year.

The implications of these data may be that many of the vehicles engaged in left-turn maneuvers are either creating conflicts for following vehicles (resulting in Rear End crashes) or are directly involved (Angle crashes).

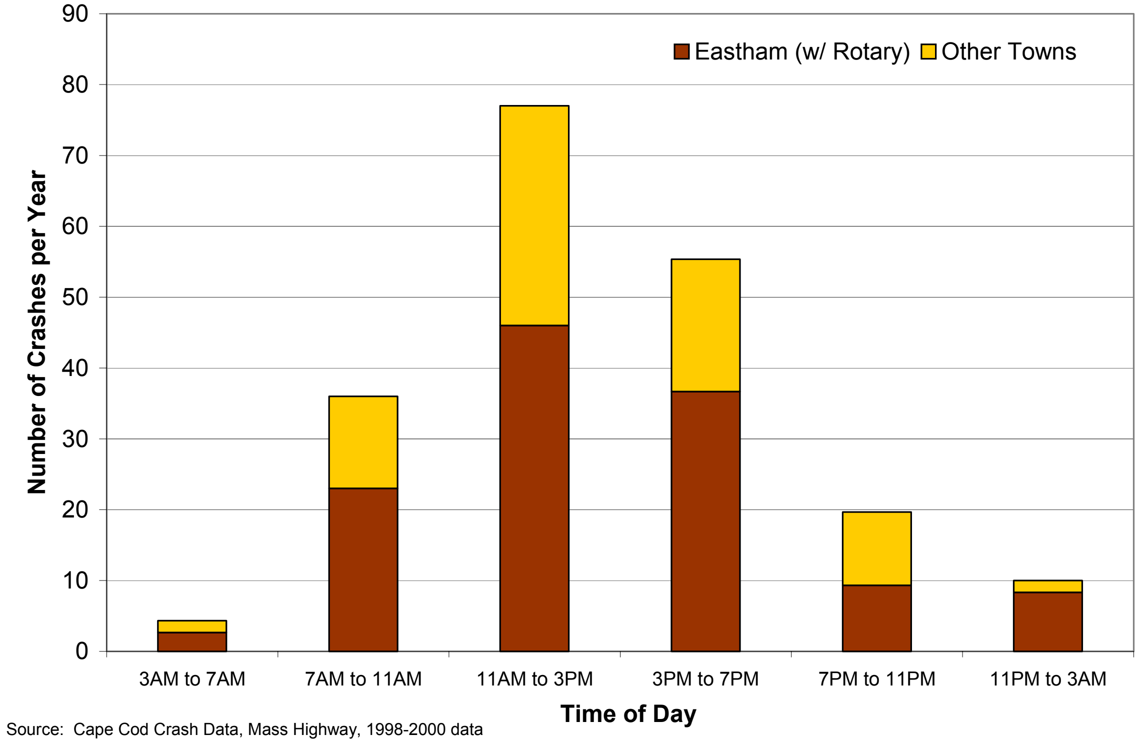


Figure 6 – Crashes by Time of Day

The figure above shows the number of Route 6 crashes on average per year in each of six daily time periods. The lower portion of each bar shows the Eastham crashes. The 11 a.m. – 3 p.m. period contains the largest number of crashes: 46 in Eastham and 31 in other towns for a total of 77 recorded in the Outer Cape on average per year.

According to volume counts conducted for this study, the 11 AM to 3 PM time period is the busiest time of day. The implication of these data is the busiest time of day experiences the highest frequencies of crashes.

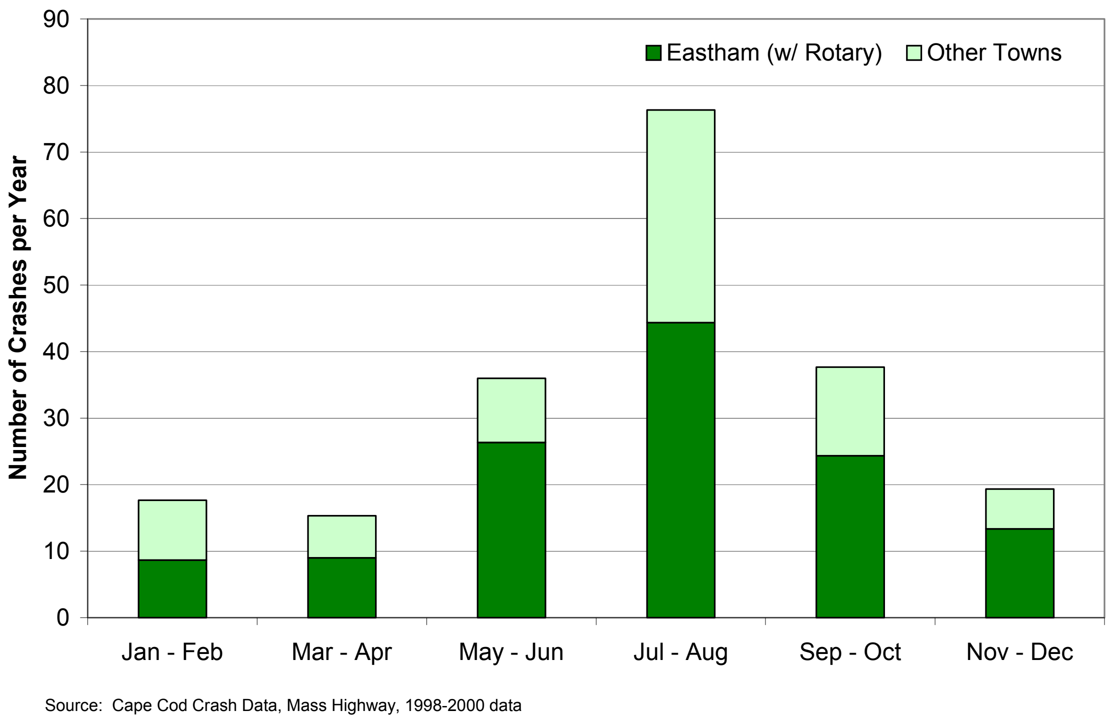
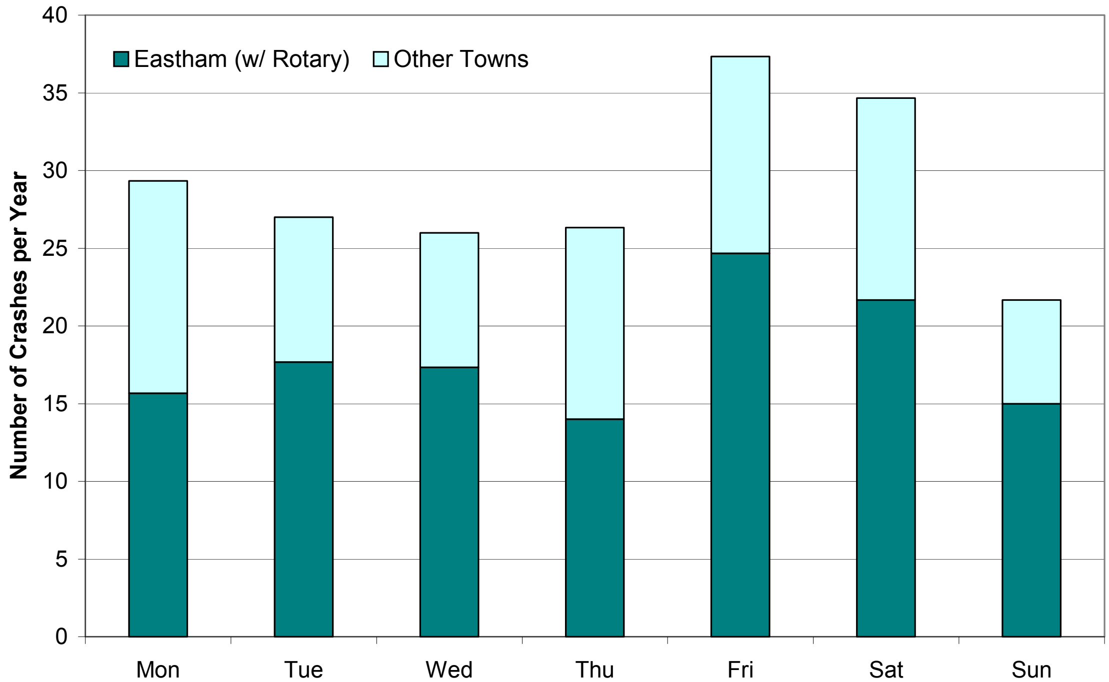


Figure 7 – Crashes by Time of Year

The figure above shows the number of Route 6 crashes on average per year in each of six yearly time periods. The lower portion of each bar shows the Eastham crashes. The combined months of July and August are host to the highest number of crashes: 44 in Eastham and 32 in other towns for a total of 76 crashes per year on average for the Outer Cape towns.

According to permanent traffic count stations on the Cape (but outside of the study area), the months of July and August are the busiest. The implication of these data is that the months with the heaviest travel experience the greatest frequency of crashes. Summer months are highest, with the "shoulder season" months showing frequencies well above the remaining months.

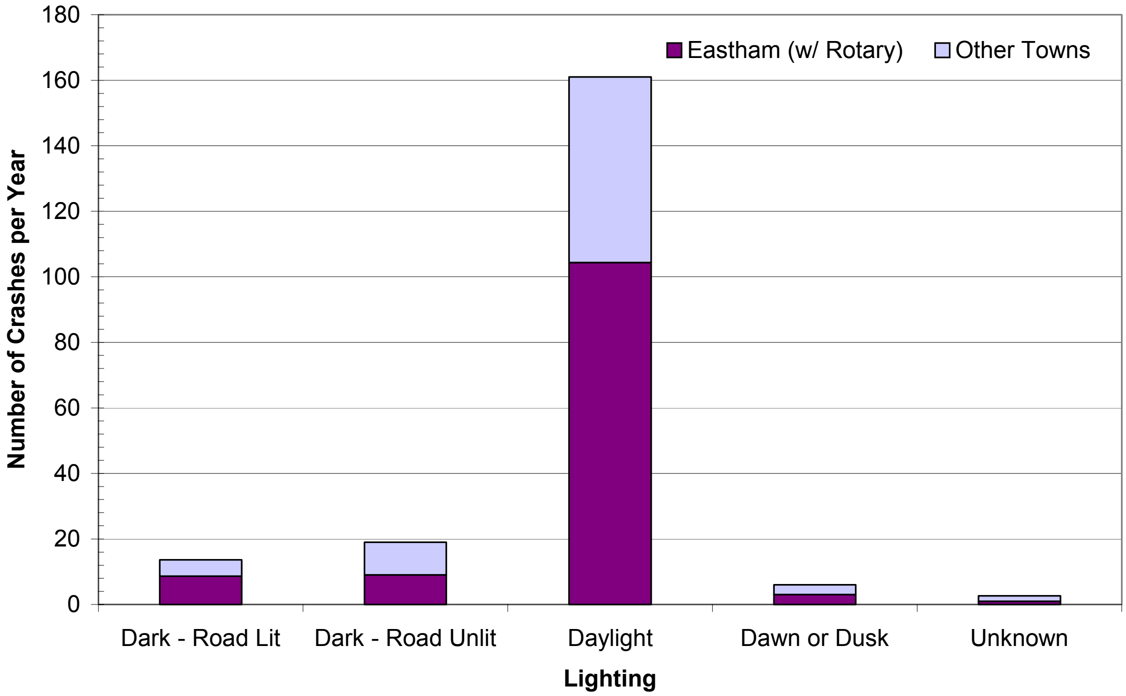


Source: Cape Cod Crash Data, Mass Highway, 1998-2000 data

Figure 8 – Crashes by Day of Week

The figure above shows the number of Route 6 crashes on average per year for each day of the week. The lower portion of each bar shows the Eastham crashes. Friday has the highest number of crashes for any day of the week. The average per year is 25 in Eastham and 13 in other towns for a total of 37 on Fridays. Saturday crashes were a close second with 34 total crashes per year on average.

The implications of these data are that the heavy travel periods during Fridays and Saturdays experience the greatest number of crashes. The lowest crash days, Sundays, are surprisingly low contrasted with Monday through Thursday, which are typically less busy travel days than Sunday.



Source: Cape Cod Crash Data, Mass Highway, 1998-2000 data

Figure 9 – Crashes by Lighting Condition

The figure above shows the number of Route 6 crashes on average per year for various lighting conditions. The lower portion of each bar shows the Eastham crashes. During "Daylight" periods the largest number of crashes were observed. There were an average per year of 104 in Eastham and 57 in the other towns for a total of 161 during "Daylight" lighting conditions.

The implication of these data is that the highest frequency of crashes occurs during seasonal peak travel times—the summer—when traffic levels are higher and daylight hours are longer; and during daylight peak travel times—11 AM to 3 PM.

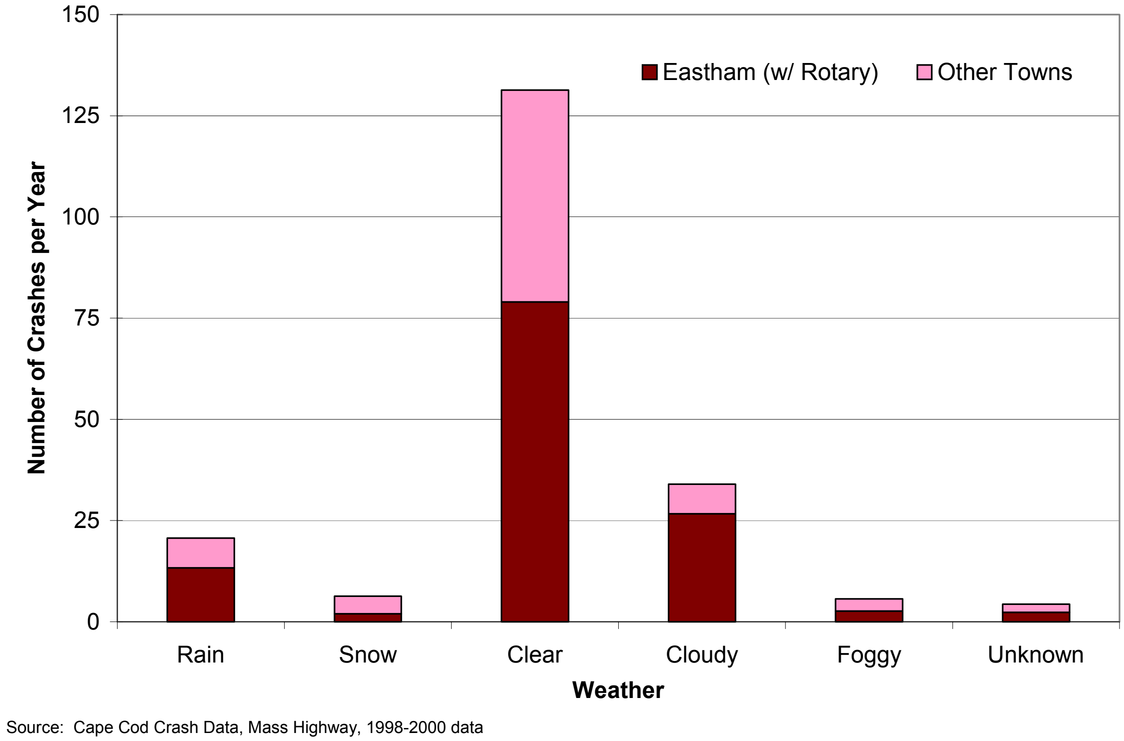


Figure 10 – Crashes by Weather Condition

The figure above shows the number of Route 6 crashes on average per year for various weather conditions. The lower portion of each bar shows the Eastham crashes. There were on average 79 crashes per year on average in Eastham and 52 in other towns' for a total of 131 for the most commonly recorded condition: "Clear."

2.3.1 Detailed Analysis of Accident Reports

The Commission has been investigating safety problems on Route 6 for various traffic studies over a period of several years. In 1997, a detailed analysis of accident reports was undertaken in the towns of Eastham, Wellfleet, and Truro covering 1994-1996. Since Eastham had a very high accident frequency, the second—more detailed—part of the study focused only on Eastham. Commission technicians viewed individual accident reports, one by one, and cataloged the information for further analysis. Despite the age of the analysis, the general pattern of types of crashes is assumed to be applicable for Eastham, since there have not been any major changes in roadway geometry. Efforts to include more up-to-date data would be worthwhile in order to ascertain the effects of factors such as changes in pass-through traffic and increases in year-round population (see discussion in section 1.3.2).

A detailed summary of these crashes is available for review in the appendix. From these reports, percentages of crash types are presented in the following table:

Table 7 – Detailed Accident Report Summary

Detailed Accident Report Analysis Route 6 – Eastham 1994-1996 Reports Source: Eastham Police Department		
Accident Type	Observed	Percent of Identifiable
Rear End	80	67%
Right Angle	19	16%
Left Turn	6	5%
Other	14	12%
Total Identifiable	119	100%
Un-Identifiable	32	
Total	151	

The types of crashes are discussed in the following sections as how they relate to this study:

Rear End Crashes

This type of crash can be due to a number of factors but is primarily caused by vehicles stopped in the travel lane waiting to make a left turn, waiting behind a left turning vehicle, waiting for a stoplight, or during slower stop-and-go travel periods. Right turning vehicles generally do not cause much delay to following vehicles and non-turning vehicles only impede following vehicles while stopping at signals or during slower travel periods. Consequently, the vehicles stopped for left turns and the vehicles which may be stopped behind them is a primary cause of Rear End crashes. If it were possible to eliminate all left turns, it is reasonable to assume that Rear End crashes would be reduced significantly.

Right Angle Crashes

This type of crash occurs between crossing traffic and mainline traffic (e.g., a northbound Route 6 vehicle strikes or is struck by a vehicle entering from a side street). Some of the minor street vehicles involved in this type of crash may be attempting to turn right or to cross Route 6. However, the traffic data show that the crossing movements are a small fraction of all turning movements, and right turning vehicles are unlikely to meet at the right angle specified for this type of crash (a separate listing for "Right Turn" crashes is typical). Consequently, most of this type of crash is probably caused by left turning vehicles. If it were possible to eliminate all left turns, it is reasonable to assume that Right Angle crashes would be reduced.

Left Turn Crashes

As the name implies, this type of crash occurs while one or more vehicles are making left turns. Crashes tend to be more serious (similar to Right Angle) than other crash types since vehicle occupants are more vulnerable in side-impact collisions. Strategies that eliminate or protect left turns would likely eliminate almost all Left Turn crashes.

Other Crashes

This category includes crashes between opposing flows of traffic such as "Head On" and "Side Swipe," as well as other types of crashes. Some of the strategies being considered in this study may help to reduce these types of crashes.

2.3.2 Intersection Safety

When this study was originally being formulated, an extensive Commission effort was made to review the entire database of crashes in the four towns in order to identify priority crash locations. This effort made use of 1991-1998 data. While it covers a longer and earlier period than used in other sections of this report, it is expected that the general traffic patterns and crashes are consistent, and it is assumed to be a useful tool in analyzing crash patterns.

A complete intersection-by-intersection listing is available in the appendix. For each intersection, the numbers of Property Damage Only, Injury, and Fatality crashes are listed. Also included are the number of persons injured and the number of fatalities. The next step was to analyze severity information to determine each intersection's total Equivalent Property Damage Only (EPDO) score. As mentioned earlier, the EPDO score is determined by assigning a value of 1 to Property Damage Only crashes, a value of 5 to Injury crashes, and a value of 10 to Fatality crashes. Scores for all of the intersections with recorded crashes are presented in the appendix as well.

For purposes of prioritizing locations, several "Tiers" have been established: 1st Tier intersections rated 60 or more EPDO points and are considered the highest priority. 2nd Tier intersections rated between 40 and 60 EPDO points, 3rd Tier rated between 30 and 40 EPDO points, and 4th Tier intersections rated between 20 and 30 EPDO points. These tiers are intended to help focus the study.

The table on the following page presents the results of the grouping process. The typical type of crash (e.g., angle, rear end, etc.) is also presented; where no Typical Crash Type is noted, a significant pattern could not be recognized from the accident data.

Table 8 – Priority Intersections

Road Intersection Route 6		Typical Crash Type
Provincetown		
Conwell Street	1st Tier	Angle
Snail Road	2nd Tier	Angle, Rear End
Shank Painter Road	3rd Tier	
Truro		
Arrowhead Road	4th Tier	SB Rt. 6 Rear End
Wellfleet		
Main Street	1st Tier	NB Rt 6 Rear End, NB Rt 6/WB Main
Wellfleet Drive In	2nd Tier	EB Rear End
Marconi Beach Road	3rd Tier	NB Rt 6 Rear End
Village Lane	3rd Tier	Rear End
Old Truro Road	3rd Tier	
Eastham		
Brackett Road	1st Tier	NB/SB Rt 6 Rear End
Samoset Road	1st Tier	NB/SB Rt 6 Rear End, SB Rt 6/EB Samoset
Salt Pond Road	2nd Tier	NB/SB Rt 6 Rear End
Oak Road	2nd Tier	NB/SB Rt 6 Rear End
Governor Prence Road	2nd Tier	
Orleans Rotary	3rd Tier	NB/SB Rt 6 Rear End
Nauset Road	3rd Tier	SB Rt 6 Rear End
McKoy Road	4th Tier	NB Rt 6 Rear End
Massasoit Road	4th Tier	NB Rt 6 Rear End
Kingsbury Beach Road	4th Tier	S/E Angle

Note: NB = Northbound, SB = Southbound, EB = Eastbound, WB = Westbound
1st Tier intersections—60 or more EPDO points
2nd Tier intersections—between 40 and 60 EPDO points
3rd Tier intersections—between 30 and 40 EPDO points
4th Tier intersections—between 20 and 30 EPDO points

2.3.3 Examination of 1st Tier Priority Intersections

The following sections include discussions of problems at the "1st Tier" Intersections described in the previous section.

Figure 11 – View from Conwell Street looking north across Route 6

Conwell Street/Race Point Road (Provincetown) @ Route 6

The Conwell Street intersection with Route 6 is the main signalized intersection in Provincetown, and is the first traffic signal northbound travelers encounter since the Lawrence Street/School Street signal in Wellfleet. (There are no traffic signals in Truro.) Conwell Street, the southern leg of the intersection, serves as a major access street to the downtown area of Provincetown. Race Point Road, the northern leg of the intersection, provides visitors access to the National Seashore's Province Lands Visitors Center and Race Point beach. Consequently, it is a very busy intersection including many bicycle and pedestrian movements as well as vehicular movements.

Both Route 6 approaches consist of three lanes: left-turn and two through lanes. Conwell Street and Race Point Road each consist of a single approach lane: left-turn/through. All four approaches have island separated right turn slip lanes under yield control. Some of the potential inadequacies, issues, and other observations include at the Conwell Street intersection include:

- High-speed mainline Route 6 (especially westbound) traffic is required to stop. Motorists may have trouble evaluating signal status (these signals are of an older, smaller design than those in other areas), and then decelerating properly from highway speeds.
- Worn pavement markings (stop lines) on minor street approaches
- The mainline left turn lanes should be studied and may need to be lengthened. The Route 6 westbound left turn lane is about 315 feet, approximately 190 feet short of the MHD 1997 Design Manual recommended left turn lane length on a four lane highway. The Route 6 eastbound left turn lane is about 250 feet, approximately 195 feet short of the recommended standard. This situation may be contributing to rear-end crashes at the intersection.

Figure 12 – View north along Route 6 at the Main Street (Wellfleet) Intersection

Main Street (Wellfleet) & Route 6

The intersection of Route 6 and Main Street in Wellfleet is a three-way intersection with Main Street serving as the main access to downtown Wellfleet from Route 6. This intersection is in close proximity to a small office/retail complex on the east side (opposite Main Street). Due to the large left-turning volume for northbound Route 6, a dedicated left turn lane has been provided. Route 6 is mostly one lane in each direction in Wellfleet. However, it expands to two lanes in each direction near the Main Street intersection (and at the Marconi Road intersection) to provide additional intersection capacity.

The Route 6 northbound approach consists of three lanes: left-turn only, through, and through/right-turn. Route 6 southbound consists of a left-turn/through and a through/right-turn lane. The Main Street approach consists of a left-turn lane and a separate right turn lane. Potential inadequacies, issues, and other observations include:

- Indication of pedestrian activity with no provision of sidewalks, cross walks or pedestrian phase.
- Northbound and southbound Route 6 through lanes (two lanes each direction) allow for many vehicles to pass through the light during the green phase but also allow for vehicle passing (in either lane) while traversing the intersection, often accelerating for position before the roadway returns to one travel lane.
- The northbound left turn lane should be studied and may need to be lengthened. The left turn lane is about 235 feet, approximately 275 feet short of the MHD 1997 Design Manual recommended left turn lane length on a four lane highway. This situation may be contributing to rear-end crashes at the intersection.

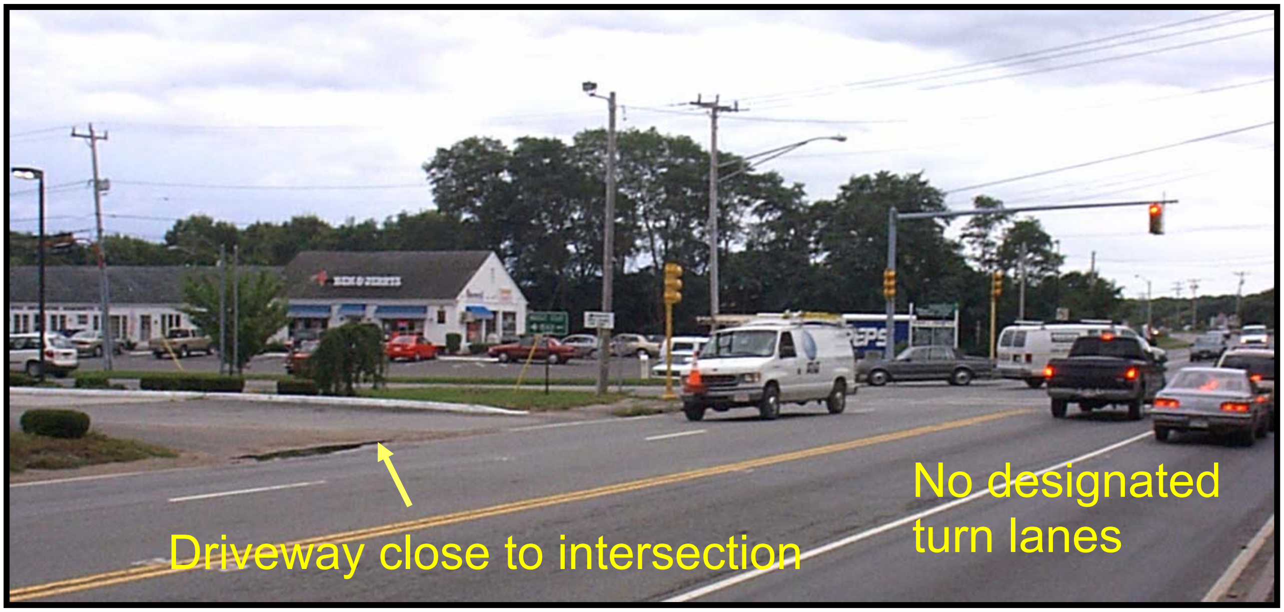


Figure 13 – View along Route 6 southeast toward the Brackett Road Intersection

Brackett Road & Route 6

The intersection of Route 6 and Brackett Road is located in a busy commercial area of North Eastham. Adjacent to and along both north and south approaches there are numerous businesses' access drives. In addition, Brackett Road serves as the main route to Nauset Light Beach in the Cape Cod National Seashore while also providing access to Eastham's industrial area and abutting residential areas.

While no markings are present, current lane usage in both directions on Route 6 consists of a left-turn/through lane and a through/right-turn lane. Both Brackett Road (on the east side) and Old County Road (on the west side) consist of single approach lanes: left-turn/through/right-turn.

Potential inadequacies and other observations include:

- Worn pavement markings (stop lines) on minor street approaches
- Driveway close to intersection
- Left turning traffic blocks through travel for the northbound and particularly the southbound Route 6 traffic
- No turning markings
- Signal heads are small

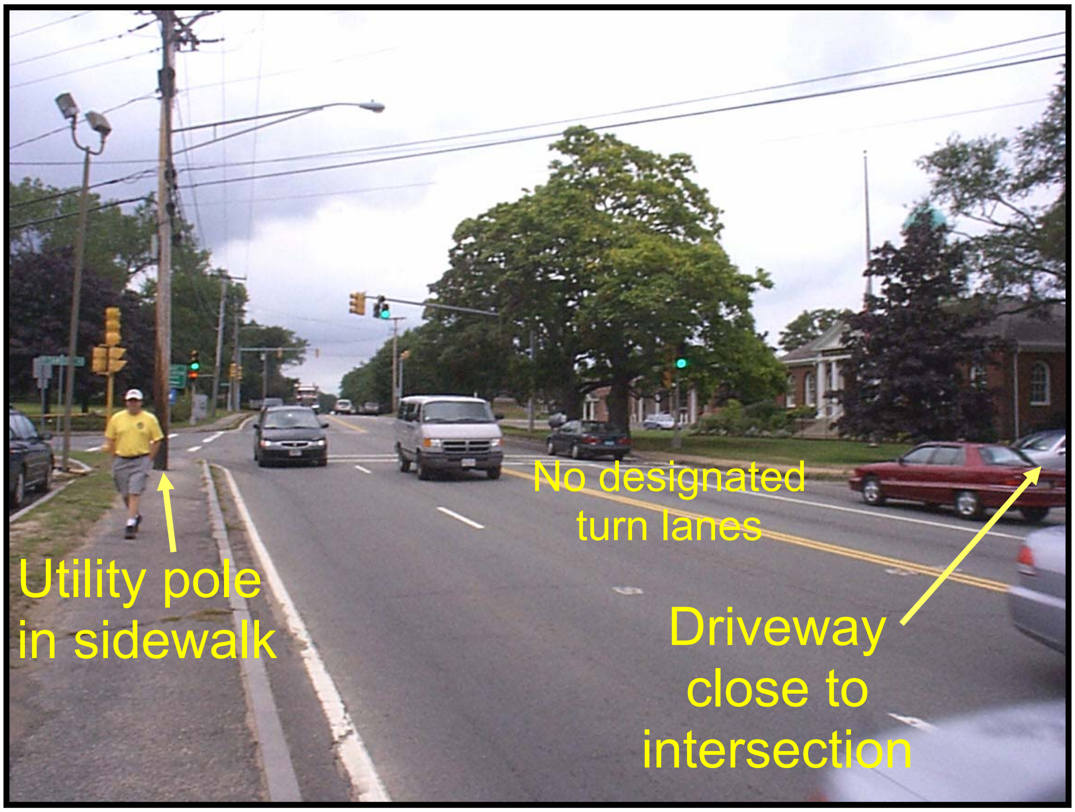


Figure 14 – View along Route 6 north toward Samoset Road intersection

Samoset Road & Route 6

The intersection of Samoset Road and Route 6 is a three-way signalized intersection located in the middle of Eastham adjacent to the Windmill Green. Adjacent to the intersection, located on Route 6, are the Town Hall, Fire Station, and Police Station. This is the first signalized intersection that motorists encounter traveling northbound on Route 6 in Eastham.

Route 6 northbound consists of two approach lanes: left-turn/through and through. Route 6 southbound contains a through lane and a through/right-turn lane. Samoset Road (eastbound) consists of one wide general purpose lane that is often used as two lanes—one left turn and one right turn lane. Potential inadequacies and other observations include:

- Left turning vehicles (Route 6 northbound) block through traffic
- Driveway access close to intersection including Town Hall and town athletic fields
- Undefined curb cut on south side of Samoset Road

2.4 Community Impacts

Changes to the roadway system to reduce traffic congestion or improve safety may have numerous impacts on the community. While not necessarily quantifiable, these may be important enough to require a qualitative analysis. The following issues are explored for each of the alternatives being evaluated:

- Pavement Increase: Certain alternatives may involve additional turning lanes or new road links
- Land Taking: Widening may require taking a portion of land near intersections or roadways
- Rerouting: Certain alternatives may require motorists to travel greater distances to access certain locations
- Pavement Reduction: In some limited cases, travel lanes may be eliminated allowing for other public uses such as landscaping

2.5 National Seashore Visitation

The Cape Cod National Seashore is home to some of Cape Cod's most visited beach, scenic, historic, and recreational destinations. The Seashore experienced about 4.4 million visitations in 2001. The chart in the following figure shows that there has been a decline in recent years from a high of 5.5 million visitations in 1991. Visitations include counts of visitors at many sites throughout the seashore. Each visitor may account for more than one visitation if he/she visits more than one site.

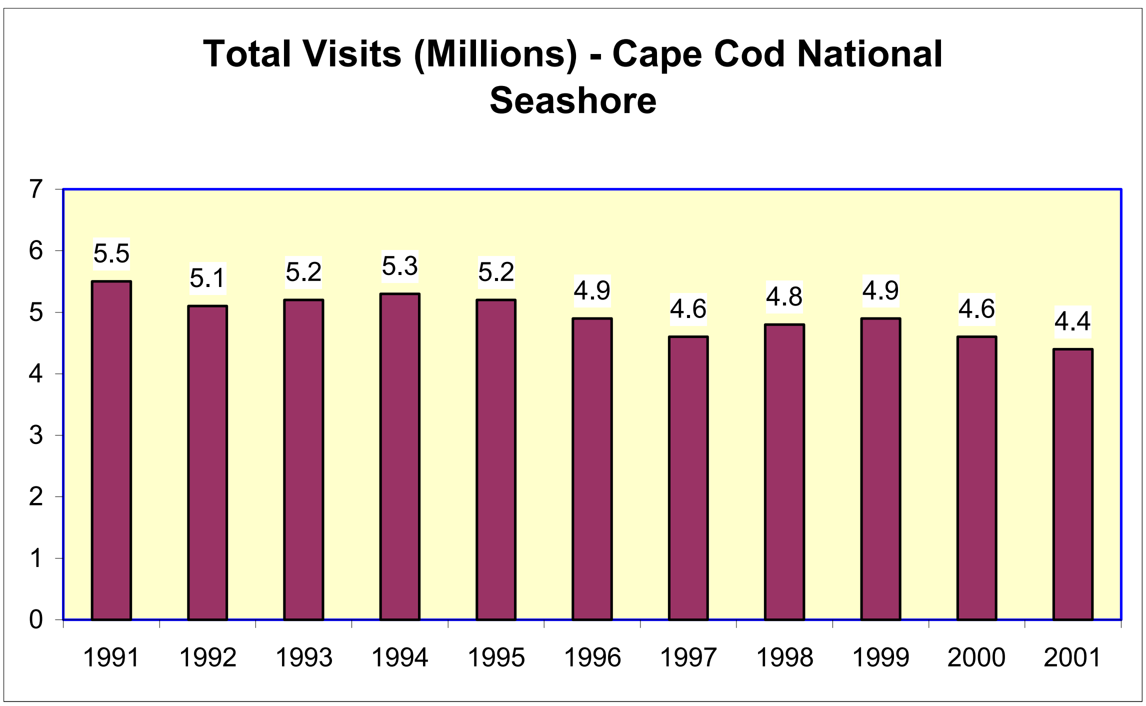


Figure 15 – Annual Visitation to Cape Cod National Seashore

2.6 Signal Warrant Analysis

As mentioned earlier, two hour turning movements were collected and the peak hour was used to review one of the signal warrant's (Warrant 3) applicability to several locations in the study. By relating peak hour information with nearby ATR data, turning movements were factored to more hours which provided data for additional signal warrant analysis (Warrant 1 and Warrant 2). The table below shows a summary of the signal warrant analysis. Detailed information is included in the Appendix.

Table 9 – Signal Warrant Analysis Summary

Roadway Intersections with Route 6	Meets MUTCD Warrant 1 – Eight Hour	Meets MUTCD Warrant 2 – Four Hour	Meets MUTCD Warrant 3 – Peak Hour *
South Eastham Street	No	No	No
Hay Road	No	No	No
Governor Prence Road**	No	No	No
Depot Road	No	No	No
Old State Road	No	No	No
Kingsbury Beach Road	No	No	No
Old Orchard Road	No	No	No
Great Pond Road	No	No	No
McKoy Road	No	No	No
Massasoit Road	**Yes**	**Yes**	**Yes**
Railroad Avenue	No	No	No
Aspinet Road	**Yes**	No	No
Wellfleet Drive-In	No	No	No
Springbrook Road	No	No	No
West Road	No	No	No
Hemenway Road	No	No	No
Hoffman Lane	No	No	No

* Note that this warrant "…shall be applied only in unusual cases. Such cases include, but are not limited to, office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time" and may not be currently applicable.

** Governor Prence Road is recommended to be signalized based on the 1988 study "Route 6 and Governor Prence Road" (by Bayside Engineering Associates for the Massachusetts Department of Public Works). Traffic which currently accesses Route 6 from South Eastham Street and Hay Road would likely use a safer, access-controlled signal at Governor Prence Road instead. With this consolidation, the Governor Prence Road and Route 6 intersection would meet Warrants 1 and 2.

Based on the above information, Aspinet Road and Massasoit Road may both qualify to be signalized, as well as the recommended signalization of Governor Prence Road.

2.7 Pedestrian Environment

Sidewalks and pedestrian crossings are nonexistent in many areas along Route 6. Other problems include lack of snow removal from sidewalks, overhanging vegetation, unused curb cuts crossing sidewalks, and obstacles in sidewalks such as signs and utility poles. See figure below as an example.

Figure 16 – Utility Pole in Sidewalk and Overgrown Vegetation
(West side of Route 6, south of Settler's Trace in Eastham)

3. Alternatives Analysis

3.1 Currently Planned Improvements

There are current MassHighway plans for improvements at five intersections. These improvements are detailed in a 1997 MassHighway report prepared by Vollmer Associates.

Proposed improvements for Route 6 intersections include:

- Governor Prence Road: Vegetation removal and re-grading to improve sight distance on southeast quadrant; install pedestrian wheelchair ramps on northwest quadrant; install crosswalk and stop line on eastbound approach
- Samoset Road: Install new actuation system and update signal timing/phasing including a northbound leading left turn phase; modify Eastham Town Hall entrance drive.
- Nauset Road/Salt Pond Road: Install pedestrian signal heads on west side quadrants; replace existing 8" signal heads with 12" signal heads on Route 6 approaches. *Note: CCC Field Observations indicate that sight distance should be improved for the southbound approach of Route 6 north of the intersection.*
- Brackett Road/Old County Road: relocate existing signal pole and install signal heads, pedestrian head, and button on northeast quadrant; Install 8' signal pole and pedestrian head and button on southeast quadrant; install pedestrian heads and buttons on west side quadrants; inspect and replace controller cabinet as necessary.
- Marconi Beach Road: Install 20' mast arm, signal heads and pedestrian head and button on northeast quadrant; on west side: install pedestrian head and button, replace & service signal head, and install second mast arm and signal heads.

Collectively, the improvements listed above are intended to improve safety for motorists and pedestrians using these intersections. The improvements may be completed by summer of 2004.

3.2 Traffic Flow Modeling

The detailed approach used for modeling roadway alternatives is described here. *Synchro-SimTraffic*, a traffic operations software package from Trafficware, was chosen as the program to analyze operations along the Route 6 corridor. The operations model covered the study area from the Orleans Rotary to just north of West Road in Wellfleet.

The first step in the alternative analysis was to develop a baseline which represents future conditions without improvements. To accomplish this, two-hour turning movement counts (broken into 15-minute intervals) were taken at 25 major intersections along the Eastham and South Wellfleet sections of the corridor. Turning movement counts were collected for each 15-minute period from 4 p.m. to 6 p.m. Peak hour traffic volumes for each intersection were then determined and coded into the model network, resulting in an afternoon peak hour model. The network building process also included coding the lane geometry and corridor speed as well as entering the present signal phasing schemes provided by Mass Highway.

In addition to the major intersections, Commission staff determined that there was a need for driveway or curb-cut-related turning traffic along the corridor to be represented in the base model and all alternatives. In order to quantify this, the numbers of curb cuts between the major intersections were counted. Each curb cut was assigned its corresponding land use code from the Town of Eastham parcel database. Next, a number of peak hour trips were assigned to each parcel using the *Institute of Transportation Engineers'* trip generation rates by land use and local knowledge of specific parcels. This process provided estimated peak hour turning volumes for each curb cut. These curb cut turning movements and general locations were then added to the model to give a more accurate representation of the effect turning vehicles have on the main line traffic flow. This resulted in a network that included the 25 major intersections, the Orleans Rotary, and two curb cut locations (one for western side curb cuts and one for eastside curb cuts) between each intersection.

A primary feature of the Trafficware traffic operations analysis package is a capacity-based analysis with detailed levels of service for individual lane groups and also aggregate levels of service for entire intersections. In addition to the pure capacity analysis functions of *Synchro*, a traffic micro-simulation can be created directly from the *Synchro* model in a companion software module called *SimTraffic*. The *SimTraffic* simulation model generates traffic according to the entered estimated traffic volumes, then simulates each vehicle as it moves through the network—shifting lanes, stopping for signals, making turns, and ultimately exiting the network. Output includes detailed and aggregate information on travel time and delay along the modeled corridor.

There are many different "measures of effectiveness" or MOEs that are available to the analyst when using traffic analysis software packages. The most common of these MOEs is the level of service analysis. Level of Service (LOS) is one way to quantify the relative congestion of a facility by giving it a grade of A-F (A being best and F being worst—see the appendix for more information). The key factor in determining the LOS for an intersection, both signalized and un-signalized, is the delay (in seconds) each vehicle experiences. For example, as the roadway or intersection becomes more congested, delay increases and the level of service decreases. Delay is also available as an MOE or an output to measure network performance and is used later in this report to compare alternatives. (Letter grade LOS information is not reported in this study, but is directly related to vehicle delay estimates.)

After processing, certain measures of effectiveness (MOEs) were extracted for each alternative and compared. Specifically, the Commission compared a number of MOEs including total delay (in hours), delay per vehicle (in seconds), total travel time (in hours), and average speed. These MOEs were compared in three different ways. First "Network Total" MOEs were compiled for the entire model network including all curb cuts, side streets, and every link and node represented in the model network. Next "Intersection Total" MOEs were compiled by extracting all the delay at all the approaches of all intersections represented in the model network. This group did not include curb cuts and rotary links. (A complete list of the intersections analyzed can be found in the appendix.) Finally three different "Corridor Section" MOEs were also analyzed. The first corridor section is from the Rotary north to Samoset Road, the second from Samoset Road to Bracket Road, and the third from Bracket Road to the end of the model network located north of West Road in Wellfleet. The corridor section MOEs do not include the impacts from rotary links, side streets, or the curb cuts, yet offer an insight to the impacts of alternatives on the mainline itself.

Three randomly generated simulations for each *Synchro* model were produced using *SimTraffic*. Traffic is allocated to the entrances of the network based on a distribution over the time length of the simulation. A random number seed can be entered that changes the distribution of traffic entering the network (but maintains total hourly volume counts) as well as other random events in the simulation. Using three different random number seeds, the base year and each alternative was simulated in *SimTraffic* three times. The results were averaged to quantify the performance of each network and to account for random fluctuations in traffic patterns.

Simulation results for the base year 2001 existing conditions "Network Totals" provide a starting point:

Table 10 – Base Year Traffic Performance

	Total Delay (hours)	Delay / Vehicle (seconds)	Total Travel Time (hours)	Average Speed (Mph)
2001 Base Year Network	335	146	812	25

**Note: delay/travel time/speed is for all vehicles in the entire network*

Once the base model was complete, the next step in alternatives testing was to create and run a future year condition. The growth rate for the corridor was determined by summarizing historic Automatic Traffic Recorder data from CCC and MassHighway traffic counting programs from 1991 to 2001. This growth rate assumes past annual growth of 1.05% per year will continue for the next 9 years. The figure below shows the growth factor equation.

$$\text{Growth Factor} = (1+.0105)^9 = 1.098$$

Figure 17 – Growth Factor Equation

Future volumes were estimated by applying this factor to the existing Base Year volumes. Using the estimated future volumes, the same process was used to evaluate the impacts on traffic and delay. Again, three simulations were performed and the results averaged and extracted. Average delay per vehicle along the corridor increased, almost doubling (80%), with consequential travel time increases of 37% and average system speeds dropping 4 mph. This 2010 base year model provides the condition from which alternatives were developed and tested.

Table 11 – Base & Future Traffic Performance

	Total Delay (hours)	Delay / Vehicle (seconds)	Travel Time (hours)	Average Speed (mph)
2001 Base Year Network	335	146	812	25
2010 Base Year Network	604	247	1112	21

**Note: delay/travel time/speed is for all vehicles in the entire network*

The flow chart below presents the alternatives described in the sections to follow:

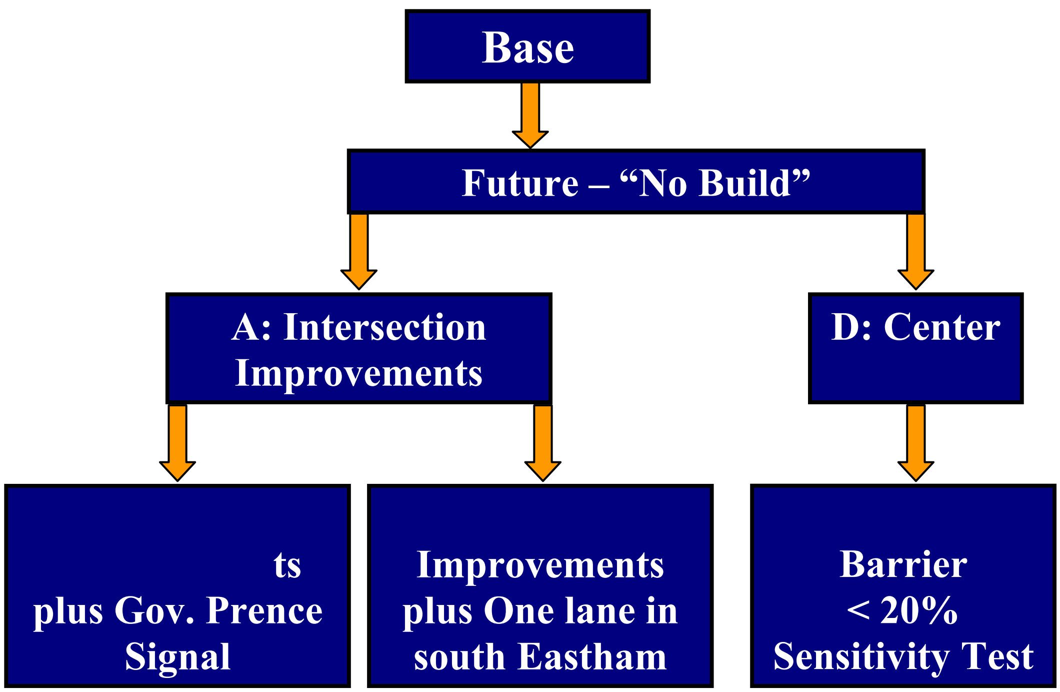


Figure 18 – Flow Chart of Alternatives

3.3 Alternative A – Multiple Intersection Improvements

After analyzing the performance of the future year traffic volumes on the existing road network, certain intersection improvements were bundled together to form alternative A. Some of these intersection improvements were recommended locally through the public meeting process and others were developed after viewing the effects of the future traffic volumes on the existing road network. They include the list of improvements below:

- Route 6 @ Orleans Rotary – stripe 2 lanes entering westbound (approx. 150')
- Route 6 @ Samoset Road – new northbound left turn lane on Route 6
- Route 6 @ Depot Road – no northbound left turns allowed onto Depot Road
- Route 6 @ Massasoit Road – new northbound left turn lane on Route 6
- Route 6 @ Brackett Road – new southbound left turn lane on Route 6
- Route 6 @ Brackett Road – new westbound left turn lane on Brackett Road

Orleans Rotary

The first network improvement considered was on Route 6 at the Orleans Rotary. A short section of westbound Route 6 was widened from one to two lanes as the roadway approaches the rotary. This 2-lane section gives vehicles the ability to take better advantage of available gaps in the rotary traffic.

Route 6 and Samoset Road

The next intersection improvement considered was at Samoset Road which is a signalized intersection. The intersection had a large number of northbound left-turning vehicles: an average of 106 summer-weekday-peak-hour left turns in 2001. As mentioned in *Currently Planned Improvements,* signal phasing changes have been recommended for this location which include incorporation of a leading left turn phase. The proposed alternative compliments the recommended signal upgrade by adding a designated left turn lane and a protected, rather than leading, phase for the northbound left. The Highway Capacity Manual recommends an exclusive left turn lane where fully protected left-turn phasing is provided or where 100 or more peak hour vehicles are expected to make a left turn. Also, the MassHighway Design Manual indicates an exclusive left turn lane is justified where accident experience, existing traffic operations, and engineering judgment indicate a significant hazard or capacity problem. Given the left turn volume, accident experience, and congestion problems at this location, an exclusive left turn lane is justified. Although right of way constraints exist here, the improvement was still tested. The improvement would allow for less blocking of the through traffic by the route 6 northbound lefts and an overall safer and protected left turn at the signal.

Route 6 and Depot Road

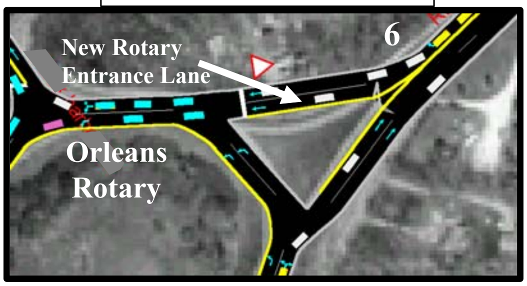
Also for this alternative, no left turns were allowed from Route 6 onto Depot road, the next intersection immediately north of Samoset Road. This is to prevent blocking northbound through traffic. Drivers seeking to make a left turn onto Depot Road would have the benefit of a protected left turn signal and turning lane at Samoset Road. Because of this, the northbound left-turning vehicles (13 during the peak hour) assigned to turn into Depot Road were reassigned to the Samoset Road intersection northbound left turn movement.

Route 6 and Massasoit Road
Continuing north, the next improvement is the addition of a left turn storage lane for northbound left turns at the intersection of Route 6 and Massasoit Road. About 143 vehicles on average made this turn in the summer peak hour of 2001. This volume in the future grows to 157 vehicles. In the 2010 simulation, this movement was noted to cause significant blocking of Route 6 northbound traffic and the addition of a left turn storage lane was also recommended strongly by local Eastham boards. Also, the Highway Capacity Manual recommends exclusive left turn lanes where the left turns are 100 or more vehicles per hour. The MassHighway Design Manual indicates an exclusive left turn lane is justified where accident experience, existing traffic operations, and engineering judgment indicate a significant hazard or capacity problem. Given the left turn volume and accident experience at this location, an exclusive left turn lane is justified.

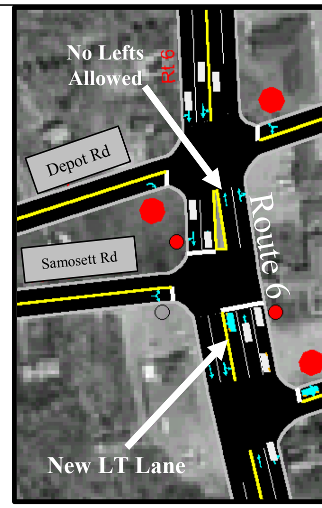
Route 6 and Brackett Road
Finally, Alternative A includes modifications at Brackett Road. Much like the Samoset Road alterations, the southbound Route 6 traffic that seeks to turn left onto Brackett Road (76 vehicles in the 2001 summer peak hour) was given a designated turning lane and signal phase. The Highway Capacity Manual recommends exclusive left turn lanes where fully protected left-turn phasing is provided. Also, the MassHighway Design Manual indicates an exclusive left turn lane is justified where accident experience, existing traffic operations, and engineering judgment indicate a significant hazard or capacity problem. Given the signal phasing, accident experience, and congestion problems at this location, an exclusive left turn lane is justified. In addition to this, two approach lanes were coded for Brackett Road: one designated as a left turning lane and the other as a shared right turn and through lane. Right of way constraints exist but the addition of left turn storage at both of these locations allows for safe storage of the turning vehicles and greater flow of traffic through the intersection due to less blocking. A significant amount of delay and blocking was observed at this location in the future base year simulation and the improvements were made in order to identify benefits to intersection performance and the network performance.

After coding all of the above changes, this alternative network underwent three iterations of traffic simulation, each with a different random number seed as explained earlier. Then results (MOEs) were extracted, averaged, and are presented in Chapter 4. A more detailed analysis of the intersection level effects can also be found in the appendix.

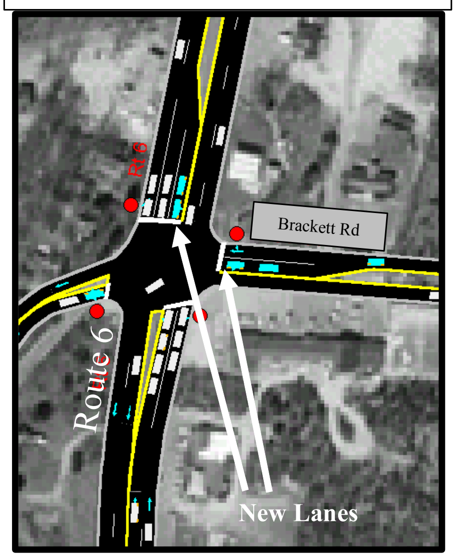
Rt 6 and Orleans Rotary
Route 6 SB
New Rotary Entrance Lane



Route 6 and Samoset Road
Route 6 NB New Left Turn Lane
No Left Turn Allowed at Depot Rd



Route 6 and Brackett Road
Route 6 SB New Left Turn Lane
Brackett Rd WB New Left Turn Lane



Route 6 and Massasoit Road
Route 6 NB New Left Turn Lane

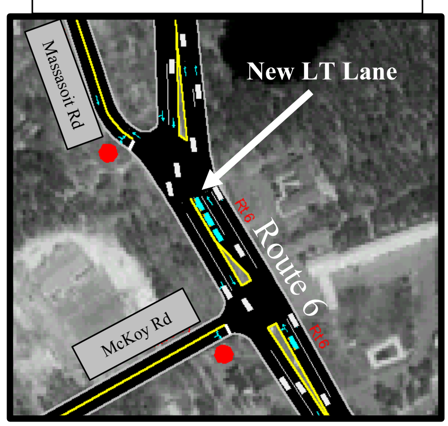
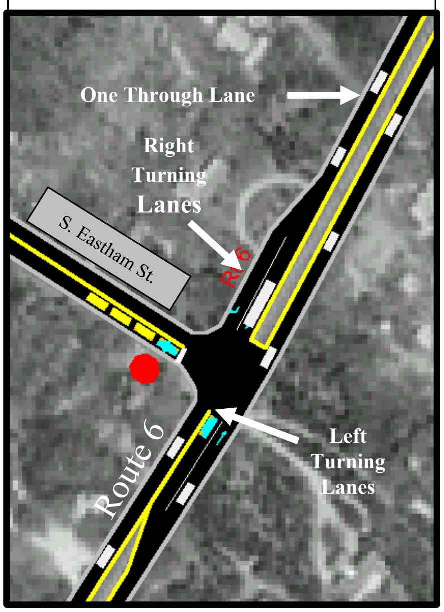


Figure 19 – Alternative A: Intersection Improvements

3.4 Alternative B – Multiple Intersection Improvements plus Signalizing Governor Prence Road

The second alternative simply builds on Alternative A, described in the previous section, by adding a traffic signal to the Governor Prence Road intersection on Route 6. The signal was added and set up as an actuated uncoordinated traffic signal which was then optimized with *Synchro* to produce the most appropriate phasing plan. Alternative B was simulated and the results extracted for analysis. The signal produced some additional delay per vehicle, at the intersection, based on traffic delay associated with the light. The results can be seen in Chapter 4 and details are given in the appendix.

One Lane Route 6 in south Eastham



3.5 Alternative C – Multiple Intersection Improvements plus One Lane/Turning Lanes in south Eastham

Alternative C, also an offshoot from Alternative A, makes one significant change to the network: reducing the through lanes of Route 6 in south Eastham to one through lane with protected left hand turning lanes and right turn lanes at intersections and curb cut locations. This roadway concept was supported heavily at initial local discussions.

Figure 20 – Alternative C: One Lane Section with Turning Lanes

This one-lane concept would run from the Orleans Rotary to just north of Hoffman Lane—in the area with the service stations and the Eastham Post Office, south of Samoset Road. Through traffic would have one travel lane in each direction and opposing left turn lanes would be added to remove all left turners on Route 6, both northbound and southbound, from the mainline through road. Right turning lanes would also be added at intersections allowing a deceleration space for the northbound and southbound right-turning motorists wishing to exit the roadway. Although this alternative does not determine the exact design of such a cross section, the concept allows for the modeling of its effects on traffic. (This alternative does not include a traffic signal at Governor Prence road.)

3.6 Alternative D –Center Barrier

Alternative D, or the Center Barrier concept, deviated farthest from the existing conditions. The concept of allowing no left turns along the corridor was supported locally and an artificial center barrier was modeled to test this policy. This alternative includes allowing no left turns from the Orleans Rotary all the way into Wellfleet at the West Road intersection.

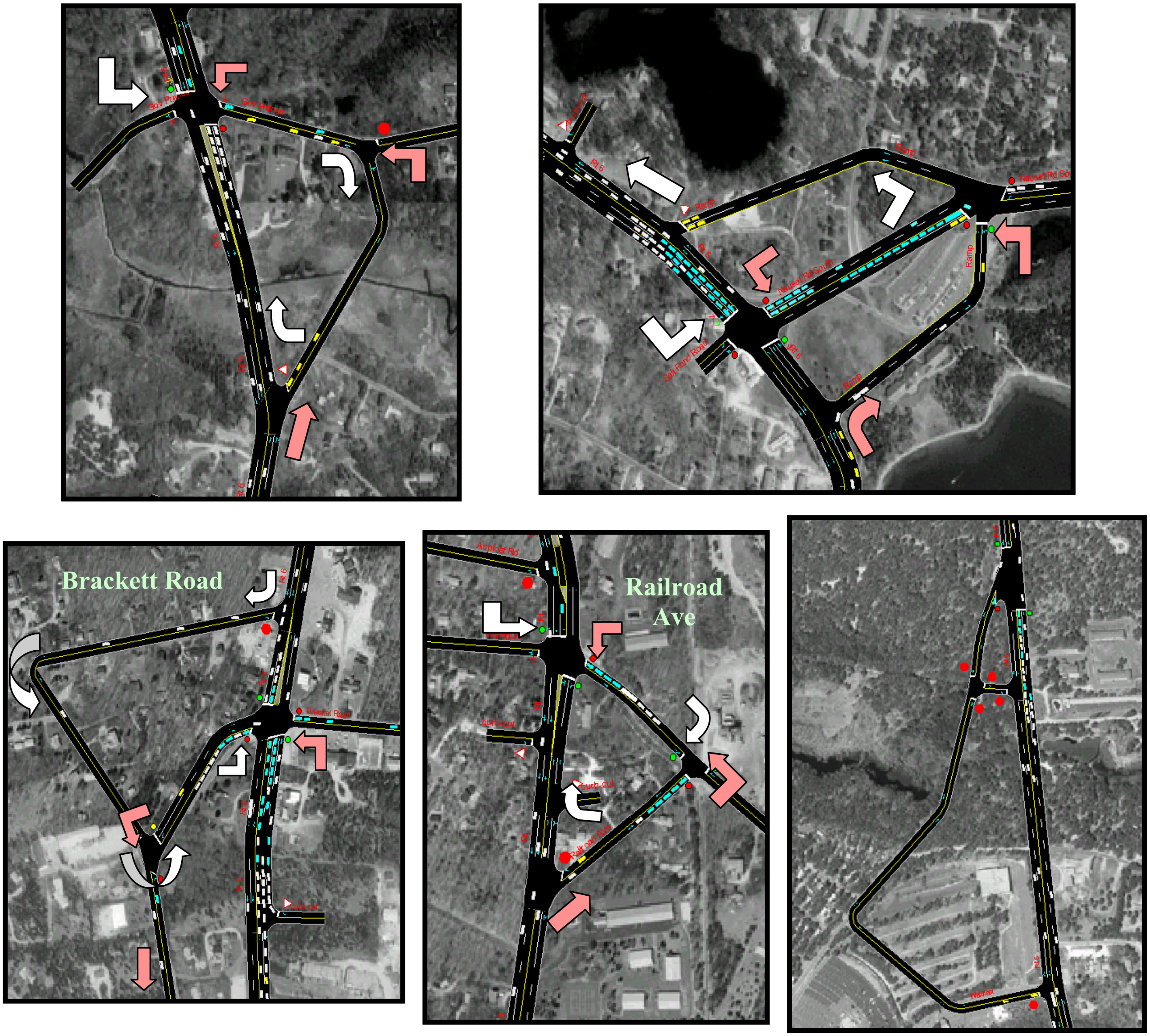


Figure 21 – Alternative D: Center Barrier Turning Areas

In order to apply this concept, designated turning areas were identified and developed in order to allow the redirection of traffic necessary to reach particular destinations. A total of five designated turn areas were set up to handle this function. From south to north they are the Orleans Rotary, Governor Prence Road, Salt Pond Road, Brackett Road, and the West Road area in Wellfleet. The rotary already acts as a turn around location but other locations need signals and road links to operate effectively. A signal would be added at Route 6 and Governor Prence Road, the Samoset Road signal would be removed, and all other signals in Eastham would remain. This center barrier, allowing left turns only at the four signalized intersections in Eastham, creates a complex traffic flow scenario. The schematics in figure 21 show how travel was allowed to redirect itself at the designated turning areas. Southbound traffic wanting to access areas on the eastern side of the corridor would be rerouted via the white traffic flow arrows. In contrast, northbound traffic seeking to access the western side of the corridor would be rerouted via the red traffic flow arrows. Traffic can, of course, also reverse direction at the rotary at the southern end of the corridor.

This complex redirection of travel along the corridor produced some extended trips and higher volumes of traffic due to the rerouting. In comparing the traffic volumes at three locations, the redirection and extended trips increased traffic as much as 20 percent. The longer trip lengths and inability to make left turns may deter some of the current traffic that uses the corridor. As an exercise in testing the sensitivity of the network, a hypothetical scenario was developed. Assuming that travelers "learn" to avoid unnecessary rerouting and plan trips efficiently, and that land use adapts to the change in accessibility, a sensitivity test of the Center Barrier with a 20 percent traffic reduction was conducted to test the effects on delay and travel time.

3.7 Intelligent Transportation Systems

Intelligent Transportation System (ITS) applications include a wide range of options to improve transportation. Currently the National Seashore is developing access strategies that include ITS components. These components propose variable message signs and local advisory radio. The planning for this system has involved the Massachusetts Highway Department and has included discussions that could lead to a Cape-wide ITS.

The National Seashore program could begin as early as 2005. A pilot program, which placed a variable message sign at the Salt Pond Visitors Center during the summer of 2002, was very successful. Provincetown has also used variable message signs successfully during major events to advise motorists of parking availability and street closures.

This alternative includes supplementing the National Seashore information systems to provide motorists advanced notice of traffic conditions and alternatives such as public transportation. Such systems would also be used for incident management to route traffic away from or around accidents, construction, and road closures. ITS is also being considered for emergency management. For example, ITS could help direct motorists to shelters in the case of a weather emergency.

ITS recommendations and further discussion are provided in Chapter 5. No modeling of the effect of ITS on traffic was conducted.

3.8 Public Transit

In June of 2002 the *Cape Cod Five-Year Public Transportation Plan* was published with three recommendations significant to the Rte. 6 corridor in the Outer Cape. These included the development of service between Orleans and Provincetown, local transportation centers in Orleans and Provincetown, and the establishment of shuttles to serve Outer Cape attractions (such as whale watch cruises) from the mid and upper Cape. The shuttles would use existing parking facilities underutilized in the summer season and on weekends to allow remote parking and a convenient point to board shuttle buses. The concept of joint ticketing was also recommended to allow one ticket to serve for transportation and attractions.

Several other recommendations were made including bicycle improvements and improvements to the water transportation system that could have some impact on the Outer Cape transportation system. Improved public transit would reduce the need for automobile travel, increase personal mobility for the non-driving public, and would be a key component to be promoted by Intelligent Transportation Systems. Public Transit recommendations are presented in Chapter 5. No modeling of the effect of transit on traffic was conducted.

3.9 Route 6 Bypass

One alternative examined early in the study development was a new Bypass roadway for Route 6 in the vicinity of Brackett Road. This concept was generated from local input and was initially analyzed as a potential roadway scheme. This new roadway was coded as the main through roadway between Old Orchard Road and a conceptual new intersection location north of Oak Road. Crossing Brackett Road, the bypass would use all of Holmes Road (a street parallel to Route 6) and new roadway sections north of Brackett Road. As part of this roadway scheme, two new traffic signals would be added: one at the Old Orchard Road/Route 6 Bypass intersection and one north of Oak Road at a new northern intersection of the Bypass and Route 6. The remaining section of Route 6 (parallel to the new Bypass link) would be retained for local access to existing developments and the speed reduced to mimic a local traffic scenario.

This concept was the only alternative that involved a large new roadway scheme. After developing and displaying a preliminary model in Eastham, it was not subjected to further examination due to the substantial impacts to the community, large land taking requirements, and uncertainties regarding land use controls and driveway relocations. In addition to these constraints, the public opinion that supported the generation of this alternative was also responsible for its elimination. Therefore, its effects on traffic flow and circulation were never quantified.

3.10 One Lane Route 6

Another alternative that received some preliminary analysis was a one-lane alternative for the entire Route 6 corridor through the town of Eastham (similar to alternative C). This alternative was set up to test one through lane per direction (both northbound and southbound) with protected left-turn pockets at major intersections and curb cut locations along the corridor. Preliminary analysis of this alternative revealed many conflicts in the Brackett Road and Eastham Post Office areas due to high left-turning volumes along those sections of the corridor. In those situations the one through lane slowed traffic significantly and extensive blocking was observed. It was because of the resulting queues and delay that the alternative was not pursued further. In contrast, the roadway scheme seemed to have some merit in south Eastham where the curb cuts are more residential, less concentrated, and do not generate as much turning traffic. Consequently, this one lane concept was incorporated into Alternative C in the area where benefits were realized and then subject to the full analysis using the traffic simulation method.

4. Comparison & Evaluation

After simulation of all of the alternatives, it was necessary to bring results together to analyze and compare the relative impacts on traffic flow and safety. Results were compiled in three ways: network totals, Route 6 mainline (section) totals, and intersection totals.

4.1 Traffic Flow

The entire network (modeled road network) includes the Route 6 corridor mainline, all side streets, and their intersection approaches from the Orleans/Eastham Rotary to West Road in Wellfleet. The chart below shows the total delay (in hours) for both the entire network and the Route 6 mainline for alternatives compared to the baseline forecast.

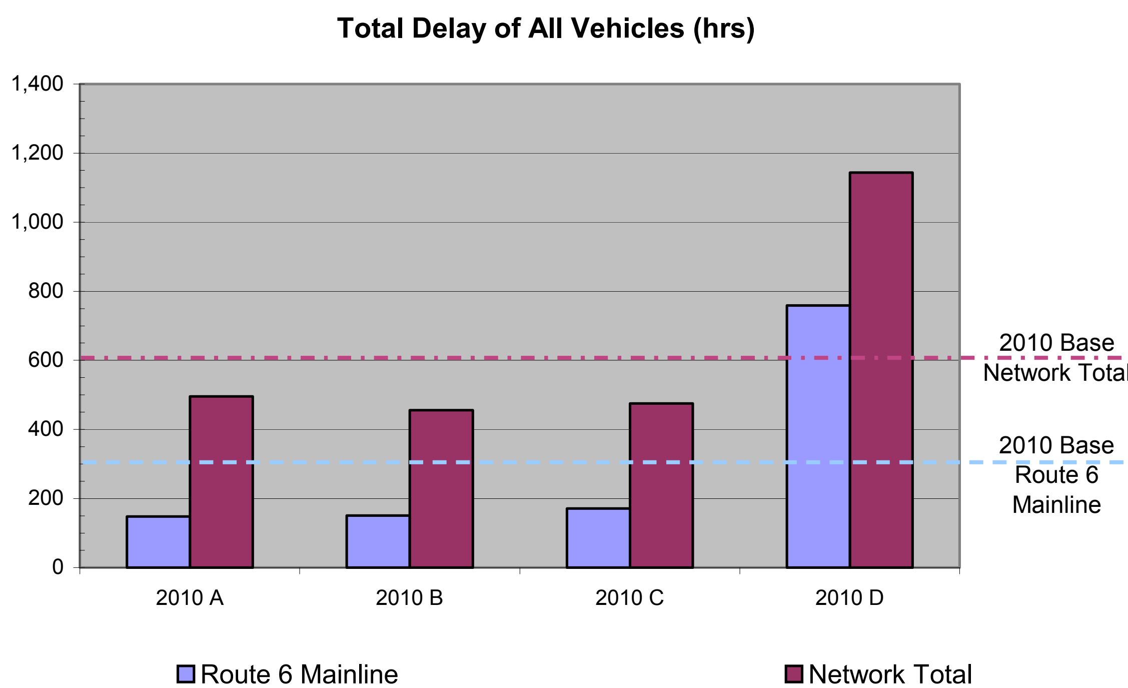


Figure 22 – Total Network and Route 6 Mainline Delay

Some data highlights are:

- Alternative A has a 50.4 percent reduction in the amount of corridor delay and an 18 percent reduction in total network delay when compared to the 2010 base network.

- Alternative B offers roughly the same amount of savings along the corridor (49 percent) but a slightly increased savings in overall network delay (25 percent).

- Alternative C, which includes the one lane section in south Eastham coupled with the intersection improvements from Alternative A, offers both a network delay savings and a corridor delay savings, very similar to both alternative A and B.

- Alternative D, the center barrier, stands out as failing to reduce delay, likely due to the increased travel cause by driver's needing to change directions and double-back to get to their destinations. The theoretical sensitivity analysis of Alternative D where traffic is reduced 20% showed similar Route 6 mainline performance as alternatives A-C but better results for the network total.

A complete listing of the percent improvement or degradation along the corridor and on the network as a whole is shown for all alternatives in the appendix.

Taking the concept of mainline analysis a step further, the Route 6 mainline was split up into three sections for further analysis. The three sections are listed below and accompanied by their results:

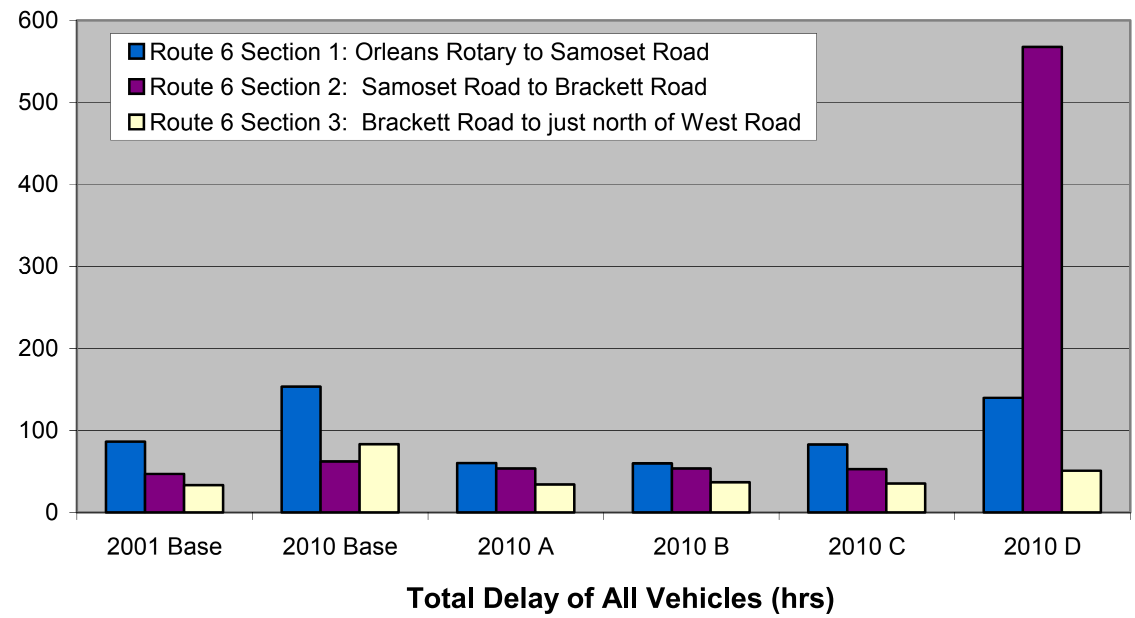


Figure 23 – Route 6 Mainline Delay by Section

- The chart above indicates Section 1 of the corridor, the southern most section of Route 6 in Eastham, experiences the most delay in all alternative cases except the center barrier alternative D. This is expected, since this section handles the most traffic.

- The over 100% increase in Section 3 delay from the base year to 2010 indicates this section will be impacted the most by future traffic if nothing is done. Most of the delay increase along this corridor section is attributable to the expected 158 percent increase in total delay at the Brackett Road intersection. In Alternatives A and B, the addition of capacity at this location significantly reduces this delay.

- In Alternative D, the center barrier corresponds with a break down in section 2 of the corridor.

Total intersection traffic flow performance generated by the various alternatives is presented in Table 12. It is a summary of traffic performance on each approach roadway of each intersection and does not include curb cuts, side streets, and some mainline links. The terms are:

- "Total Delay," expressed in hours, is the sum of all delay of all vehicles at all study intersections along the Route 6 corridor from South Eastham Street in Eastham to West Road in Wellfleet during the study hour.

- "Delay/Vehicle," expressed in seconds, is the average delay per vehicle during the study hour at all intersection approaches.

- "Travel Time," expressed in hours, is the total amount of time, including delay time, all vehicles spend traveling through the intersections during the study hour.

- "Average Speed," expressed in miles per hour, is the average speed of all vehicles through all of the intersections in the network during the study hour.

Table 12, although a summation of all intersections, provides a starting point for looking at the impacts at individual intersections in the network. Tables of delay, time, and speed at all individual major intersections for all alternatives tested are available in the appendix.

Table 12 – Summary of Traffic Delay for Alternatives at Intersections

All Inter	Total Delay (hours)	(seconds)	Travel Time (hours)	Average Speed (mph)
2001 BASE	70	96	170	25
2010 BASE (Future No-build)	159	206	267	22
A: INTERSECTION IMPROVEMENTS	86	122	197	25
B: INTERSECTION IMPROVEMENTS + SIGNAL GOV. PRENCE	81	115	190	25
C: INTERSECTION IMPROVEMENTS + ONE LANE IN SO. EASTHAM	89	124	197	23
D: CENTER BARRIER		373	407	17
E: CENTER BARRIER <20%	102	137	196	25

**Note: delay/travel time/speed is for all vehicles in all intersections in the network*

Some highlights of the analysis are as follows:

- In 2010 if nothing were done (i.e., Future No Build), modeled delay per vehicle (at all intersections) is projected to increase by 115 percent, causing a 57 percent increase in travel time and a 12 percent reduction in the average speed.

- When the signal improvements bundled in Alternative A are introduced, a 46 percent reduction in total intersection delay over the Future No Build scenario is forecast.

- Alternative B (adding a traffic light to the bundled package of Alternative A), reduces overall intersection delay by an additional 3 percent over Alternative A and by 49 percent over the 2010 Base.

- Alternative C reduces delay over the 2010 base by 44 percent with a 26 percent travel time savings.

- The center barrier alternative (Alternative D) increases delay 89 percent over the 2010 base. This increase is largely due to drivers forced to loop around designated turning areas and reverse direction to reach their destination causing traffic volumes to rise by roughly 20 percent. When this volume increase is coupled with the projected future year volume, the delay per vehicle almost doubles. With no left turns allowed on the corridor, the average speed is expected to increase but this does not offset the increased delay resulting in an increased travel time of 53 percent.

- If a center barrier (Alternative D) is built, a number of drivers may alter their travel patterns and choose not to use the Route 6 corridor due to their inability to make left turns along the Eastham section. As mentioned above, Alternative D shows Route 6 traffic may increase by roughly 20 percent due to necessary re-routing. Combining Alternative D with 20 percent less base traffic to represent a shift in driving patterns, shows a 36 percent reduction in delay when compared to the Future No Build and a 14 percent increase in average speed. However, it is uncertain whether assumption of a 20 percent traffic reduction is reasonable.

The testing of all the alternatives shows each offers different benefits and different costs in terms of delay, travel time, and speed. The tables and charts in this section offer some results on the performance of the future year traffic and the conceptual alternatives. Additional detailed information and performance reports are included in the Appendix. However, traffic flow is not the only measure on which these alternatives were evaluated. Each alternative has impacts on the community and safety as discussed in the following sections.

4.2 Safety Improvement

To help quantify the benefits of various safety treatments, Federal Highway Administration's (FHWA) guide *Access Management for Streets and Highways* (1982) was consulted. The FHWA guide includes discussions on various vehicular access treatments and predictions of "Accident Reduction."

Data used by the guide include the number of driveways per mile, highway traffic volume, and driveway traffic volume. Alternatives being considered in this study have similar characteristics to two of the FHWA guide's techniques:

"Technique A-1: Install median barrier with no direct left-turn access"
"Technique D-3: Install alternating left-turn lane"

A result of the crash analyses performed for the study shows Route 6 in Eastham experiences about 21 crashes per mile annually. Based on the parameters of the Route 6 corridor in Eastham, Technique A-1 is predicted to result in an annual reduction of 8.1 crashes per mile. Technique D-3 is predicted to result in an annual reduction of 5.1 crashes per installation. Safety improvement is included in the evaluation matrix discussed in the next section.

4.3 Costs

Costs for the alternatives were estimated based on a summary of costs for highway construction projects in Massachusetts. Where Massachusetts cost data were not available, data supplied by California DOT was utilized and adjusted to reflect local conditions. The cost data was adjusted to account for traffic control, supplemental work (drainage and utilities), and contingencies. These cost items would be further defined and estimated more precisely if the alternatives and design elements are developed further. The cost summary is given below in Table 13.

4.4 Evaluation Matrix

The following table presents a comprehensive evaluation of major issue areas: traffic flow, safety, community impacts, and cost.

Table 13 - Evaluation Matrix

Alternative	**Total Delay (hours)**	**Predicted Annual Crash Reduction**	**Pavement Increase?**	**Pavement Decrease?**	**Land Taking?**	**Re-Routing?**	**Cost $1,000's**
Future No Build	604						
A: Multiple Intersection Improvements	496	4.6	Possible		Possible	Minor	417
B: Multiple Intersection Improvements + Signal Gov. Prence	455	4.9	Possible		Possible	Minor	717
C: One Lane/Turning Lanes	475	45.4	Possible	Potential	Possible	Minor-moderate	567-1,717
D: Center Barrier	1143	48.6	Likely		Likely	Major	9,000
E: Center Barrier <20%	249*	48.6	Likely		Likely	Major	9,000

*(*assumes a 20 percent reduction in traffic volumes)*

5. Conclusions & Recommendations

The following sections include a summary of recommendations that range from minor/non-structural to major changes in the roadway system.

5.1 The 3 E's: Education, Enforcement, and Engineering

Improvements to traffic flow and safety are most successful and sustainable when all three "E" ingredients are present. These are discussed in the following sections:

5.1.1 Education

Information campaigns are important in helping motorists understand how to use the roadway safely. Such a campaign would use media outlets, roadway signage, and other community outreach efforts to deliver the message that people using Route 6 need to be cautious, obey traffic laws, and drive defensively.

Messages could include information targeting different users at different stages of travel:

- Pre-Trip: Newspaper, magazine, internet, and other sources could give an overview of travel on the corridor for speed limits, turn restrictions, and route planning; best times to travel; and alternative modes of transportation.
- En-Route: Variable message signs and highway advisory radio could help travelers decide among a choice of destinations (e.g., different National Seashore beaches may have full parking lots), and remind travelers of safety issues such as negotiating a rotary.
- Along the Corridor: Signage to support safe & efficient travel regarding speed limits, directions to destinations, etc.

A number of improvements that could be quickly implemented include installation of new signs, replacement of existing signs with larger signs where appropriate, and pavement markings. MassHighway, as the responsible agency, should consult with the towns of the Outer Cape to provide better signs for schools and beaches. In addition, a sign inventory may be needed as a follow up to this study by identifying excess signage or insufficient signage along the corridor. Additional recommendations on signage and information systems are presented in several of the following sections.

5.1.2 Enforcement

The Eastham Police Department and the Massachusetts State Police have dedicated significant time and cost in reducing hazardous driving behaviors. Visible enforcement of speeding and traffic control laws is designed to increase motorist awareness. Continuing and increased efforts in enforcement will help to prevent future safety problems and crashes. The Eastham Police have indicated the number of crashes along

Route 6 in 2001 was lower than in previous years. This type of enforcement effort could be pursued in other towns to help improve the safety along the corridor.

5.1.3 Engineering

As mentioned earlier, MassHighway has plans in place for improvements at five intersections along Route 6. These improvements are engineered to improve safety for motorists and pedestrians and may be completed by the summer of 2004. Many of the other recommendations listed in this Chapter involve engineering solutions. Engineering improvements to eliminate traffic conflicts, remove turning traffic from through lanes, and eliminated bottlenecks would help to reduce traffic delay and vehicle emissions as well as improve safety for the motoring public.

5.2 Recommendations for Selected Intersections & Rotary

This section contains suggestions to improve safety and traffic flow at Route 6 "priority intersections" (discussed in Chapter 2) and other intersections. General safety improvements that are relevant to all tiers of the priority list are also included. Also included in this section are improvements to the Orleans Rotary and its intersection with Rock Harbor Road.

5.2.1 Samoset Road: Eastham - *[priority intersection]*

In support of MassHighway's scheduled improvements, or to be included in later improvements at this intersection, the following suggestions are offered based on the issues identified in Chapter 2:

- Implement access management (move town hall curb cut to southernmost point of the parcel)
- Extend curbing on Samoset Road (south side) from Route 6 to the west for 30 feet
- Study and consider installing a northbound exclusive left turn lane

5.2.2 Massasoit Road: Eastham

For later improvements at this intersections, study and install a northbound exclusive left turn lane to reduce rear-end crashes and to reduce traffic congestion cause by northbound vehicles awaiting southbound gaps to make left turns.

5.2.3 Brackett Road: Eastham - *[priority intersection]*

In support of MassHighway's scheduled improvements, or to be included in later efforts at this intersection, the following suggestions are offered based on the issues identified in Chapter 2:

- Repaint Stop Line on Brackett Road approach
- Replace signal heads with larger units for improved visibility
- Add pedestrian phase and signal
- Study and consider installing a southbound exclusive left turn lane

- Study and consider installing a westbound exclusive left turn lane

5.2.4 Main Street: Wellfleet - *[priority intersection]*

The following suggestions are offered based on the issues identified in Chapter 2:
- Add pedestrian crosswalks, phase, and signal
- Replace signal heads with larger units for improved visibility
- Shorten right lane at Route 6 northbound approach to match length used for southbound approach
- Study and lengthen northbound Route 6 left turn lane to meet MHD criteria

5.2.5 Conwell Street: Provincetown - *[priority intersection]*

The following suggestions are offered based on the issues identified in Chapter 2:
- Replace signal heads with larger units for improved visibility
- Repaint stop lines on minor street approaches
- Provide "Red Signal Ahead" warning for Route 6 approach from Truro
- Study and lengthen Route 6 left turn lanes to meet MHD criteria

5.2.6 Governor Prence Road: Eastham

Signalization is recommended. Reasons include:
- The 1988 Study: "Route 6 and Governor Prence Road" prepared for Massachusetts Department of Public Works by Bayside Engineering Associates
- Safety concerns
- Would allow pedestrians & cyclists to safely cross Route 6 (Cape Cod Rail Trail is approximately 1/2 mile to the west)
- Would improve access to the heavily visited Fort Hill (CCNS) area
- Would create gaps in traffic stream for nearby roadways and driveways
- Would allow northbound vehicles to reverse direction via right turns via Gov. Prence Road Extension and left turn at new signal
- Would include turn restrictions for safe traffic flow (per 1988 study)
- 1997 Vollmer study recommends a detailed study and functional design report of the intersection to verify that the intersection meets MUTCD warrants for a traffic signal. Specifically, the Vollmer study did not include peak summer weekend traffic accessing the Fort Hill CCNS area. The Vollmer study also did not account for traffic which currently avoids this intersection due to safety and congestion issues.
- Is supported by Cape Cod National Seashore (letters to MassHighway dated 6/8/1998 and 12/4/2001)
- Is supported and called for by the public

5.2.7 West Road: Wellfleet

Signalization may be necessary at this location and further review is justified. Traffic exiting Wellfleet Drive-In/Theater/Flea Market complex would be directed to West Road for access to Route 6 northbound.

5.2.8 Orleans Rotary: Orleans/Eastham

The Orleans Rotary serves several roadways with varying characteristics. The following items are suggested to improve traffic flow as guidance for motorists entering the rotary.

Signage and Lane Markings

The signage shown in the following figure is recommended for installation within the rotary's central island, facing motorists as they enter the rotary. This is a state-approved sign, photographed near Medford, Mass.

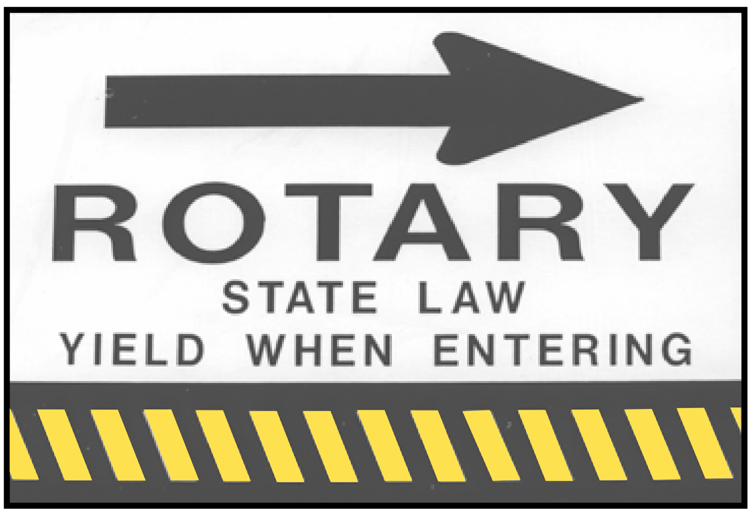
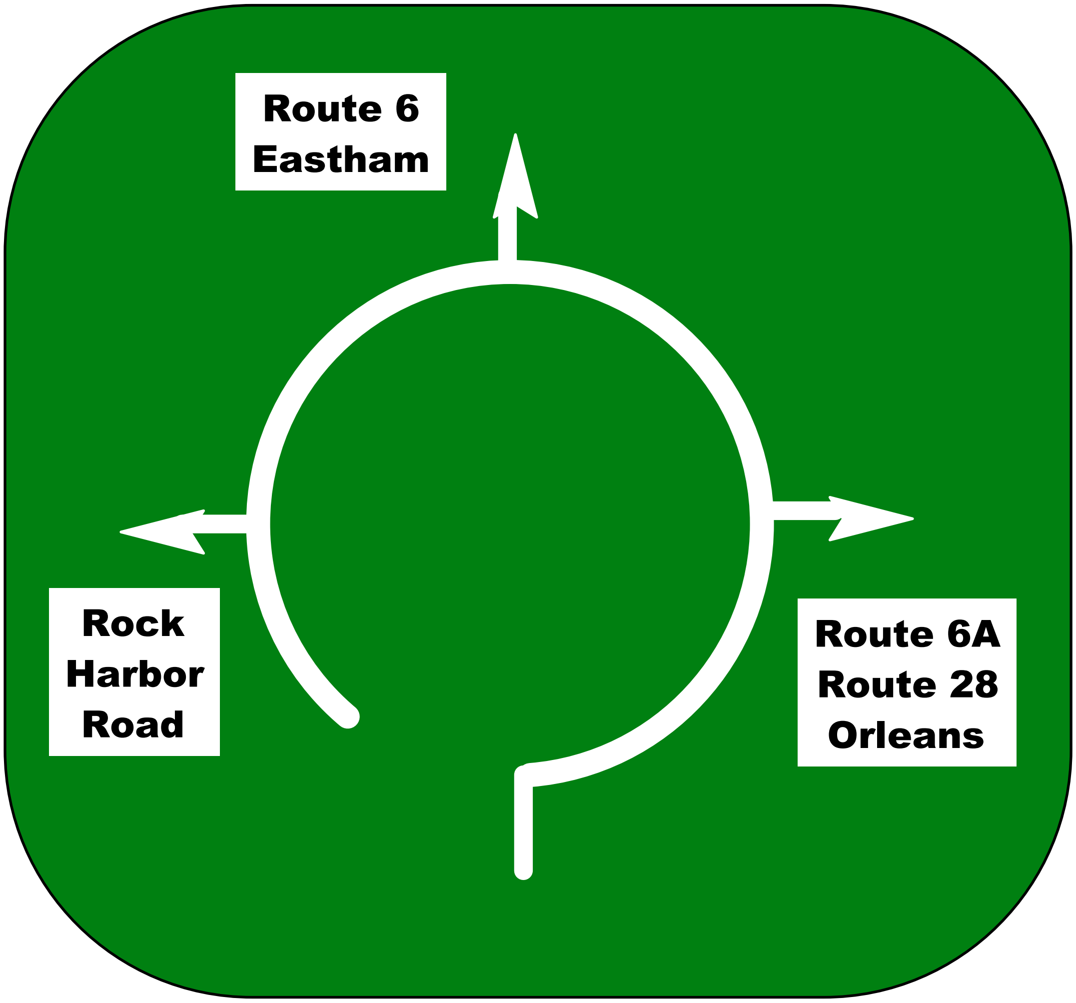


Figure 24 – Recommended Rotary Entrance Signage

As a further reminder to motorists, it is recommended that "Yield" pavement markings be installed on each approach to the rotary.

Additional informational signage would assist motorists in planning their path through the rotary. The graphic in the following figure is based on examples used at "Roundabouts" in other parts of the U.S. and at the Airport Rotary in Barnstable, Mass. By listing the exiting roadways on a diagram, motorists are reminded or informed in advance of the rotary. Once in the rotary, new motorists may count the exiting roadways and can prepare to exit safely.

Figure 25 – Example of Diagrammatic Rotary Signage



Rock Harbor Road Entrance

The entrance of Rock Harbor Road at the Orleans Rotary is complicated by the need to serve another roadway section, known as Smith Lane. While the vast majority of traffic is traveling between the rotary and the main section of Rock Harbor Road, occasional traffic uses Smith Lane. The traffic control allowing free movements to Smith Lane gives a small number of vehicles right-of-way over the heavier movements, creating confusion and conflicts.

It is recommended that signage and striping as shown in the following figure be installed.

Figure 26 – Improved Signing and Lane Marking at Rock Harbor Road / Orleans Rotary

Summary of Rotary Improvements

- Stripe double yellow line from Rock Harbor Road to the Rotary
- Improve "Do Not Enter" signs on rotary at Rock Harbor Road
- Install "YIELD" marking on pavement entering rotary
- Improve Rotary Yield signs per design used in Medford, MA or other similar nationally accepted signage
- Consider adding entry flaring (which allows for two vehicles to enter during a gap in the traffic stream) for the westbound approach of Route 6. A discussion of this concept is available in *Roundabouts: An Information Guide* (FHWA, June 2000).

5.3 Long Term Roadway Configuration

Although improvements to signage, ongoing enforcement of driver behavior, and engineering improvements to key intersections may both improve safety and traffic flow, significant physical improvements may be needed in the long term. For example, Chapter 4 shows that a one-lane section in south Eastham may offer additional delay savings and may also reduces crashes. Although other considerations may affect the viability of this alternative, it demonstrates long term review of major roadway changes is warranted.

5.4 Local Comprehensive Plans (LCP's) and Regional Policy Plan

The Local Comprehensive Plans for the four Outer Cape towns and the Regional Policy Plan developed for Cape Cod were reviewed to confirm that the improvement recommendations of this study are consistent with local and regional planning policies. Several common transportation policies were found that are consistent with the recommendations of this study. In addition to the transportation policies, common development and land use policies that reduce traffic impacts are listed below. It is recommended that these LCP policies be emphasized in future decisions by the Outer Cape towns to help preserve the capacity and improve the safety of the Route 6 corridor.

5.4.1 Land Use Recommendations

- The Outer Cape LCP's encourage compact development such as cluster development and, where appropriate, mixed-use residential/commercial development. This type of development should be given preference by the towns in order to minimize further land consumption and to protect open space. Compact, mixed-use developments reduce the need for trips outside the development area and this study, in particular, supports policies such as these.

- The towns should amend zoning by-laws to add language on curb cut control.

- The towns should amend zoning by-laws to establish a multi-category threshold that would trigger special permit review of large traffic-generating commercial and mixed-use developments (if not subject Cape Cod Commission review).

- The towns should amend zoning by-laws to create a definition of strip development and make it a prohibited use in tables of regulations.

- The towns should develop a zoning amendment that provides incentives for shared access to developments by way of reduced side lot lines at the juncture of two lots sharing access and/or reduced parking requirements.

5.4.2 Land Use-Related Transportation Recommendations: Route 6 Corridor

- Development of access management by-laws; development of collector roads linking commercial developments with Route 6; additional left turn lanes along Route 6 at locations where signalization may be needed in the future. This work should include cost estimates and funding sources, such as property tax revenue, new development impact fees, and state transportation funds.

- Transportation improvements for Route 6 should include incorporating changes to reduce the number of conflicts with access, and adjusting land use in the Towns to eliminate the need for additional through lanes.

- The Towns should identify areas in need of curb cut reductions and/or access improvements and make recommendations for the accomplishment of these reductions to the Massachusetts Highway Department. In addition, a Site Plan Review process that addresses curb cut reductions and access control should be developed.

5.4.3 Transportation/Development Review Policies

- The transportation section of several LCP's and the RPP define the future minimum performance standard or Level of Service (LOS), as defined by the Highway Capacity Manual, adjacent to development or redevelopment as LOS C based on summer peak hour traffic volumes. Development or redevelopment should not degrade LOS below this level and where existing LOS is below this, the development or redevelopment should maintain or improve the existing LOS.

- Other policies in the LCP's promote alternative transportation, and development of bicycle and pedestrian amenities. Specifically mentioned items to be provided by development are bus turnouts, taxi stands, park and ride lots, and related facilities. Bicycle and pedestrian improvements include maintaining historic footpaths, establishment of links to regional bicycle networks, and bikeways between existing subdivisions.

- Sidewalks and pedestrian crossings are nonexistent in many areas of the corridor. Development of pedestrian amenities as well as better maintenance and considerations for existing facilities must be considered. These considerations include plowing snow from sidewalks, brush and tree trimming, removal of unused curb cuts, and maintaining obstacle free corridors (for example, locating signs and utility poles so they do not obstruct sidewalks).

5.4.4 Access Management

Access management is essential to many of the recommendations presented above. It organizes traffic movements to make better use of existing roadway capacity which results in continued economic viability of adjacent land development. The LCP's recognize the importance of consolidating driveways, limiting curb cuts, and shared parking facilities and driveways. Additional measures include right turn only access and egress, development of appropriate driveway and roadway spacing guidelines, collector roads, regulation of maximum driveway widths, and controlled left hand turns via medians and signals. Access Management recommendations are discussed further in the next section.

5.5 Access Management Program

An ongoing priority is to implement and continue to use principles of access management when reviewing land use decisions. This program would include

- Frontage Requirements: increasing the minimum frontage required for property development, redevelopment, and subdivision along Route 6 would alleviate some future safety concerns and may help to reduce the future intensity of traffic generation.

- Incentives to Share Access: for adjacent parcels, combining and therefore reducing the number of driveways would improve safety. Financial incentives or partial relief of zoning requirements (e.g., smaller shared sideline setbacks, allowing increased lot coverage) should be considered.
- Land Conservation: public acquisition and protection of parcels along Route 6 would eliminate these parcels' future safety and traffic impacts.
- Limit Access: Enforce "No Access" line for property with frontage along sections of Route 6 in Truro and Provincetown

5.6 Recommendations Related to Older Drivers

A relatively large and increasing percentage of Outer Cape drivers are 65 years of age and older. Many of this steadily increasing proportion of drivers will experience difficulty in operating a motor vehicle as they age. This increasing difficulty will, in many cases, overwhelm the wisdom gained from lifetime driving experience.

Most Cape Cod intersections are at grade. Based on Federal Highway Administration crash statistics for age 80 and older drivers, more than 50% of fatal crashes occur at intersections, compared with 24% or less for drivers up to age 50. Based on observation, typical at-grade intersection difficulties for older drivers include:

- Left Turns – older drivers often lack sufficient caution and have poor position on the road during the turn.
- Stopping – older drivers often fail to stop, fail to make complete stops at stop signs, and have stops that were jerky or abrupt.

The following suggestions are recommended as considerations for roadway improvements to address the elderly population. Many of these recommendations are from FHWA's *Older Driver Highway Design Handbook*, January 1998, which should be consulted for more details. The Handbook includes other recommendations and guidelines that should be considered in Cape roadway design; but their use should also be tempered with maintaining the character of Cape Cod's roadways:

- Incorporate protected left turn phases into signalized intersections—The protected "green arrow" left hand turn has been identified as an important improvement for older drivers.
- Maintain delineation through more frequent reapplication of lane/shoulder markings and street cleaning
- Improve signage standards to include larger lettering (some larger street signs have recently been installed on Route 6 in Eastham)
  - Improve lighting level standards, in particular at intersections, while taking into account community character and spill-over effects. Standards need to include consistency of illumination as well as level of illumination. Nighttime

driving is associated with a higher crash risk for all drivers. The effects of aging on sight are particularly compounded during darkness.

- Give consideration to placing utilities underground and installing breakaway safety poles for lighting.
- Extend "all-red" clearance phases for signalized intersections

5.7 Intelligent Transportation Systems (ITS)

Traveler information provided by variable message signs is recommended as part of the ITS alternative introduced in section 3.7. Proposed Route 6 variable message signs should likely be located

- East of exit 9 to advise eastbound motorists of conditions along Route 6 in the lower Cape and beyond as well as outline transportation alternatives including the mini transportation center currently being discussed for the Orleans area.
- North of the Orleans Rotary to advise northbound motorists of transit alternatives that would include remote parking and beach shuttles. Roadway congestion and parking availability would also be displayed.
- West of the Orleans Rotary to advise westbound motorists of roadway conditions and congestion approaching and at the bridges.

Input for the traffic and parking conditions will need to be provided by a system of remotely accessed cameras and, at select locations, loop detectors to monitor traffic volumes and speeds. This information would be available on the World Wide Web and through *SmarTraveler* to allow trip planning based on real-time traffic conditions.

The ITS components proposed here, those proposed for the National Seashore, and other components of a Cape-wide ITS would be operated by MassHighway. Initially, the ITS system would be operated locally. As the system expands and joins with other proposed systems, ITS functions would migrate to a Southeastern Massachusetts ITS control center.

5.8 Public Transportation

Several recommendations have been developed for the study area as part of the *Cape Cod Five-Year Public Transportation Plan* discussed in Chapter 3.

5.8.1 Orleans to Provincetown Transit Service

The Orleans-Provincetown proposal is a bus route which will run from the center of Orleans, along Rt. 6 past the National Seashore to Provincetown (and return). Connections could include the National Seashore Salt Pond Visitor Center and beaches, and the Provincetown-Truro Shuttle. Research suggests there is a significant market for residents, tourists, and workers who need access to retail and commercial facilities especially at either end of this route, but are presently under-served. Moreover, during public meetings in Eastham, it was noted over 40 percent of the year round residents of the five Outer Cape towns are over 60 years of age. It was stated that local and express transit throughout the Outer Cape will be a necessary component in meeting the mobility needs of residents, especially the elderly.

Currently, local routes are being proposed on a town-by-town basis to serve local attractions, seasonal housing, hotels, neighborhoods, schools, and activity centers. These routes are being designed with seasonal and year round needs in mind. They will be integrated with the larger regional routes such as the proposed Orleans to Provincetown route and the private intercity bus service.

Orleans-Provincetown corridor cost estimates (given below) are based on 325 operating days (service 6 days a week and Sundays during the summer) and an 80-mile service per round-trip. Estimates are given from a minimum of four round-trips to a maximum of eight round-trips per day. At the present time, it appears regulatory issues exist regarding private carrier operating rights along this corridor. The designation of an operator of this route is expected to be the subject of negotiation.

Estimated Services & Annual Costs:	4 Round-trips	6 Round-trips	8 Round-trips
Orleans-Provincetown Corridor	$273,078	$409,617	$546,156

5.8.2 "Attractions" Shuttles

Another proposal is to provide ride-sharing services that would be marketed to "whale-watchers" heading for Provincetown excursions as well as to other Outer Cape attractions such as the National Seashore. These potential customers generate thousands of vehicle miles of travel throughout Cape Cod. The cost of parking lots in Provincetown sends drivers cruising the streets to find the very few non-metered spots adding to the downtown traffic congestion. By creating a service that allows individuals to access reliable and timely service from major locations in the mid- and Outer-Cape starting in Hyannis to the various private whale-watching operations and other attractions, there should be a significant reduction in vehicle traffic. One such recommendation is to introduce a shuttle bus program operating from the Hyannis Transportation Center to the Barnstable Park and Ride, and ultimately to Provincetown that would also make intermediate stops. Although this would not eliminate Route 6 congestion, it would represent an initial attempt in achieving a longer-term goal of moving people into higher occupancy vehicles.

To be effective, the program needs to operate on cooperative agreements between a private bus company or the Cape Cod RTA, parking providers, and Outer Cape attractions. The program will be most effective if joint ticketing can be implemented successfully. As an example, an individual could park at a Hyannis area parking facility, board a shuttle to one of the various whale-watching locations, and board a guide boat all on one ticket. This allows for connectivity throughout the program that benefits customers, businesses, and local residents who would have a less congested transportation system.

5.8.3 Local Transportation Centers

The key to improving public transportation is connecting existing services and coordinating existing and proposed services. This process requires a physical facility to allow these coordinated connections to occur. The centers would be designed to support the public and private transportation services in the area and would have amenities such as information kiosks, shelter, restrooms, and bicycle storage facilities and, where appropriate, parking.

Two areas in the Outer Cape are expected to require transportation centers to support public transportation. These facilities would be in addition to the recently completed Hyannis Transportation Center, and would be developed at a much smaller scale. The recommended facilities are to be located in the following areas:

MacMillan Wharf: This facility would serve as a linkage between the expanding ferry service at the wharf, local transit service, express bus service, and potential shuttle services. The facility has promise to be developed as a joint private/public partnership with the local chamber of commerce, local businesses including whale watch companies, and the National Oceanic and Atmospheric Administration (NOAA).

Orleans: This facility would provide transfer options and connections between modes, and increase accessibility to the National Seashore and Provincetown. The connections envisioned are between the existing Hyannis to Orleans Line, the proposed service between Provincetown and Orleans, and the proposed shuttle services to Outer Cape attractions.

5.8.4 Roadway & Intersection Improvements

In the design of intersections and roadway improvements, amenities such as bus turnouts and passenger waiting areas must be considered. Provision of such amenities should also be included in all new development and encouraged for existing businesses and activity centers, where appropriate.

The locations of these improvements should be coordinated with the long range planning for Outer Cape future transit service (currently underway) as well as with local comprehensive plans to support planned activity centers. The development of attractive connections between planned local services and the more regional services such as the Plymouth and Brockton service will be important in the success of transit for the Outer Cape.

5.9 Action Plan

The following table presents a summary of recommendations to improve traffic flow and safety along Route 6 in the four towns. All Short Term recommendations are carried forward into the Medium Term and again to the Long Term. Likewise, recommendations from the Medium Term are carried forward to the Long Term. Each recommendation is further catalogued according to its likeliness to affect the physical roadway and intersections; changes to public transit service; need for communications and distribution of information necessary for systems management; or planning initiatives within the region.

Table 14 - Summary of Recommendations

Location	Improvement/ Description	Time Frame	Benefit	Cost $1,000
Area-wide	**Education:** Information campaigns including media and signage to encourage safe driving and alternate mode use	Short Term & Continuing	Safety & Mobility	N/A
Route 6 Corridor	**Enforcement:** Highly visible enforcement of speed limits, red light running, etc.	Short Term & Continuing	Safety	N/A
Area-wide and in adjacent areas	**Intelligent Transportation Systems:** Dissemination of traffic flow, parking, and safety information in real-time via Highway Advisory Radio, Variable Message Signs, and Internet	Short Term & Continuing	Safety & Mobility	N/A
Route 6 corridor – Orleans to Provincetown	**Orleans to Provincetown Transit Service:** connecting to National Seashore, beaches, etc.	Short Term & Continuing	Mobility	273 to 546
Route 6 and other corridors – Hyannis to Provincetown	**"Attractions" Shuttles:** Provide ride-sharing service for Provincetown excursions, National Seashore, other attractions	Short Term & Continuing	Mobility	N/A
Rt 6 Intersections: Samoset, Brackett, Main, Conwell, Gov. Prence	Various improvements including upgrades to lane markings, signal heads, access management, pedestrian phases and crosswalks. See section 5.2 for more detail.	Medium Term	Safety & Traffic Flow	N/A
Eastham/Orleans Rotary	Improvements to rotary signage and pavement markings at the Rock Harbor Rd entrance	Medium Term	Safety	N/A
Route 6 Corridor	**Access Management:** Increase frontage requirements, provide incentives to share access, increase land conservation, and enforce "No Access" line in Truro/Provincetown	Medium Term	Safety & Traffic Flow	N/A
Area-wide	**Older Drivers' Recommendations:** incorporate protected left-turn phases, frequent restriping and street cleaning, larger signs, improved and consistent lighting	Medium Term	Safety	N/A
Route 6 Corridor	Provide bus turnouts and shelters at strategic locations (to compliment local services and destinations)	Medium Term	Mobility	N/A
Route 6 – Eastham/Orleans Rotary to Eastham post office	Lanes for left turning vehicles plus single through travel lane. Signalization at Gov. Prence Rd	Long Term	Safety & Traffic Flow	567 to 1,717
Provincetown, Orleans	**Local Transportation Centers:** Construction of facilities near MacMillan Wharf and downtown Orleans to provide connections with local and express bus service, information kiosks, etc.	Long Term	Mobility	N/A