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ROUTE 28
SAFETY & TRAFFIC FLOW STUDY
CHATHAM • HARWICH • DENNIS • YARMOUTH

DRAFT
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Cape Cod Commission Transportation Staff
Prepared in Cooperation with the Executive Office of Transportation and Construction,
the Massachusetts Highway Department,
and the U.S. Department of Transportation, Federal Highway Administration

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Executive Summary

Route 28 in the towns of Yarmouth, Dennis, Harwich, and Chatham stretches 28 miles and has traffic levels between 15,000-32,500 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.

An examination of existing and historic data shows traffic volumes within the four towns grew at an average annual rate of 0.64% between 1993 and 2003. The Route 28 crash rate for the whole of Cape Cod was 3.02 crashes per million vehicle miles traveled on average while Route 28 in Yarmouth had one of the highest crash rates on Cape Cod at 4.8 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 Yarmouth.

Population growth has continued between 1990 and 2000. The four towns grew 15.2% while the Cape as a whole grew 19.1% and the state grew by only 5.5%. The distribution of the growth in this decade was as follows: Yarmouth 17.2%, Dennis 15.2%, Harwich 20.5% and Chatham 0.7%.

The towns in the corridor have median ages for their populations that rank among the oldest in the State and on Cape Cod with Orleans the only local town with an older population. The following table includes the median age data and ranking for the towns.

	Median Age	State Ranking	Cape Ranking	% Pop. > 65 yrs
Yarmouth	48.7	7th	5th	30.1%
Dennis	49.4	5th	3rd	28.5%
Harwich	48.8	6th	4th	29.5%
Chatham	53.8	2nd	2nd	34.8%

The 2000 median age for Massachusetts is 36.5 and only 13.5% of the State's population is over 65. Over 23% of Cape Cod's population is over 65. The median age in the United States is 35.3 with 12.4% over 65.

Seasonal population is reflected in the vacant housing figures reported by the Census data collected in April. Vacant housing is likely to be synonymous with vacation housing. This means that houses vacant during the April census are likely to be occupied during the busy summer season – along with their associated traffic impacts. The four towns in the corridor had the following vacant housing rates in April 2000: Yarmouth 30.6%, Dennis 46.8%, Harwich 42.1% and Chatham 53.1%. This compared to the Cape as a whole of 35.5% and the statewide rate of 6.8%. From these figures, the seasonal traffic increase is significant in the corridor, in particular in the eastern three towns.

The significant trend in the seasonal housing is the decrease in the housing vacancy rate over the last 10 years. The rate in the towns has generally declined; Yarmouth -9.1%,

Dennis -10.5%, Harwich -3.8%, and Chatham, the exception, +1.1%. This indicates a significant trend toward the conversion of seasonal homes to year round. This would be expected to result in a similar trend of year round traffic increasing at a greater rate than seasonal traffic.

The permanent traffic counting station located on Route 28, east of Higgins Crowell Road, is in the Corridor and the latest available data for comparing winter (December) and summer (July) traffic volumes are from 1997 and 2003. The winter traffic has grown 6.1% during this six-year period while summer traffic has actually decreased 1.7% in the same period for a growth rate differential of 7.8%.

Based on trends in traffic growth and total delay, traffic delay on Route 28 is expected to increase 76 percent by the year 2013 if nothing is done to the existing roadway and the trend of population and traffic growth continues. However, when a corridor-long program of signal optimization is undertaken, this increase is only 43 percent. These forecasts, based on simulation of the corridor, formed a baseline for comparing the congestion impacts of corridor alternatives.

Alternative Testing

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 28 corridor.

Several alternatives were tested using *Synchro* and *SimTraffic* traffic operations software. Each alternative was designed to represents average summer weekday traffic conditions, 4-5 p.m. Scenarios include:

- Base Year – No Build
- Base Year – Optimized Signals
- Future Year
- Future Year – Optimized Signals

From the Future Year – Optimized Signals scenario, three locations were identified for potential improvements:

- Location 1 – East Main Street (Yarmouth) Roundabout
- Location 2 – George Ryder Road (Chatham) Signalization
- Location 3 – Upper County Road (Dennis) Reconfiguration

The 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 Traffic Safety Toolbox: A Primer on Traffic Safety*, Chapter 28, Institute of Transportation Engineers, 2000; and *Prediction of*

the Expected Safety Performance of Rural Two-Lane Highways, Chapter 5, Federal Highway Administration, 2000.

Conclusions

The traffic flow and safety problems on Route 28 in the four towns need to be addressed. The recommendations of this report include modifications of intersection design at several locations. Managing traffic flow to adjacent land uses through Access Management, improving alternatives to driving such as public transit and bicycle/ pedestrian accommodation, and providing traveler information systems are also recommended. 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
	Roadway			
Route 28 Intersections	**Signal Optimization:** Retime signals and add phases necessary to reduce delay. Improvements include: • Optimization at 6Yarmouth intersections, 2 Dennis intersections, 2 Chatham intersections. • Add left turn phases and modify other phases at 1 Yarmouth intersection	Short Term & Continuing	Mobility	20 - 100
East Main St (Yarmouth)	Replace existing signalized intersection with properly designed roundabout	Medium Term	Safety	330
Upper County Rd & Division St (Dennis)	Remove Upper County Rd signal, turn restrictions, new traffic flow pattern	Medium Term	Safety & Mobility	25
George Ryder Rd (Chatham)	Realign approaching roadways, signalization	Medium Term	Safety & Mobility	450
Route 28 Intersections	Various improvements including upgrades to lane markings, signal heads, access management, pedestrian phases and crosswalks.	Medium Term	Safety & Traffic Flow	25 per intersec -tion
	Public Transit			
Route 28 corridor – Yarmouth to Chatham	**CCRTA Transit Service:** Enhancement & coordination with Hyannis-Orleans "Breeze" route (Green Line).	Short Term & Continuing	Mobility	30 – 60 /year
Route 28 Corridor	Provide bus turnouts and shelters at strategic locations (to compliment local services and destinations)	Medium Term	Mobility	400
	Operations/Management			
Route 28 Intersections	**Opticom System:** Install optical sensors to trigger green phases at signals by emergency vehicles	Short Term & Continuing	Safety	60
Area-wide	**Education:** Information campaigns including media and signage to encourage safe driving and alternate mode use	Short Term & Continuing	Safety & Mobility	up to 262
Route 28 Corridor	**Enforcement:** Highly visible enforcement of speed limits, red light running, etc.	Short Term & Continuing	Safety	5
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	800 +10 /year
Route 28 Corridor	**Access Management:** Increase frontage requirements, provide incentives to share access, increase land conservation.	Medium Term	Safety & Traffic Flow	250-500

Area-wide	**Older Drivers' Recommendations:** incorporate protected left-turn phases, reflective striping, street cleaning, larger lettering on signs, improved and consistent lighting per RPP standards and limitations of unnecessarily distracting signs	Medium Term	Safety	1,480 +50 /year
Route 28	**Permanent Traffic Counting Stations:** Installation of equipment to continuously record traffic flows at 3 locations: • Barnstable/Yarmouth town line • Yarmouth/Dennis town line • Harwich/Chatham town line (west end)	Short Term & Continuing	Traffic Flow	21

A variety of improvements are recommended in the various towns' Local Comprehensive Plans (LCPs) and also should be considered for implementation. A summary of LCP transportation recommendations is included in this report.

1. Introduction

U.S. Route 28 in the towns of Yarmouth, Dennis, Harwich, and Chatham (the "four towns" referred to in this document) is a 28 mile stretch of State Highway serving well over 32,000 vehicles per summer day at some locations. 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

To achieve these goals, it will be necessary to identify areas of current high traffic generation, planned development, and patterns of use. Some of these goals related to problem identification may be better thought of as 'tasks;' however, successful problem identification will support efforts to improve congestion and safety even after implementation of the recommendations of this study are completed.

1.2 Study Area

This section includes information on population and housing and a locus map showing the study area.

1.2.1 Population

The most significant finding 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 (based on median age) in the state are located in on Cape Cod with Orleans and Chatham as the oldest of the 351 communities in the Commonwealth (median ages of 55.5 and 53.9 respectively.) Dennis and Harwich are close behind, ranking 5th and 6th in the state with median ages of 49.4 and 48.8. The percentage of population over 65 in the study area towns are: Yarmouth 30.1%, Dennis 28.5%, Harwich 29.5%, and Chatham 34.8% compared to a statewide average of 13.5%.

Significant growth occurred in the four towns over the last few decades. This growth has continued in the period between 1990 and 2000. See following table for more information.

Table 1 – Total Population Changes 1980-2000

	Year	Yarmouth	Dennis	Harwich	Chatham	All Four Cape Towns - Total Population
Population	1980	19,690	13,545	9,632	6,401	49,668
	1990	21,174	13,864	10,275	6,579	51,892
	2000	24,807	15,973	12,386	6,625	59,791
Changes by Decade	1980-1990	7.5%	2.4%	6.7%	2.8%	5.3%
	1990-2000	17.2%	15.2%	20.5%	0.7%	15.2%

According to the Cape Cod Commission's Geographic Information System department, the four towns comprise an area of 86 square miles, resulting in a density of approximately 695 year-round residents/square mile. However, since 30-53% of the housing in the four towns is estimated to be seasonal and since there are a number of hotels in the area, the density increases significantly in the summer. The estimated total summer population for the four towns is approximately 137,500 people which yields a density of approximately 1,600 people per square mile. The total summer population is expected to reach a density similar to more urban areas.

Several studies and plans have been developed that included analysis and policies for future land use. These include the 1996 *Monomoy Capacity Study*, Local Comprehensive Plans prepared by the four 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 28 corridor, and its major intersections, in Yarmouth, Dennis, Harwich and Chatham. 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 28 corridor.

Build-out scenarios developed in the *Monomoy Capacity Study* include a scenario where the existing ratio of seasonal to year round housing continues and a scenario where a larger percentage of the seasonal housing is converted to year-round use. Current and future land use maps are located in the appendix. These maps show the drastic increase in residential land use and the shift from low-density residential development to higher potential densities at build-out.

Figure 1 – Study Area

Route 28 within the towns of Yarmouth, Dennis, Harwich, and Chatham

The following figure shows the changes in population and housing from 1980 through 2000.

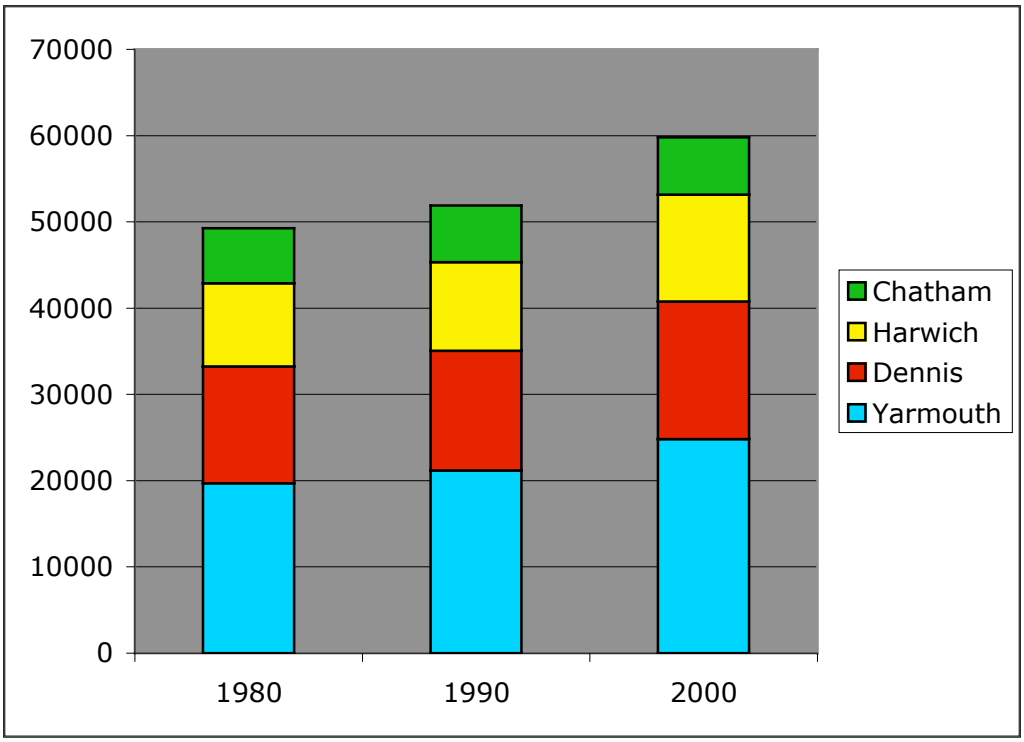


Figure 2 – Population Changes

Sources: Census Bureau, Cape Cod Commission, Dennis Planning Department

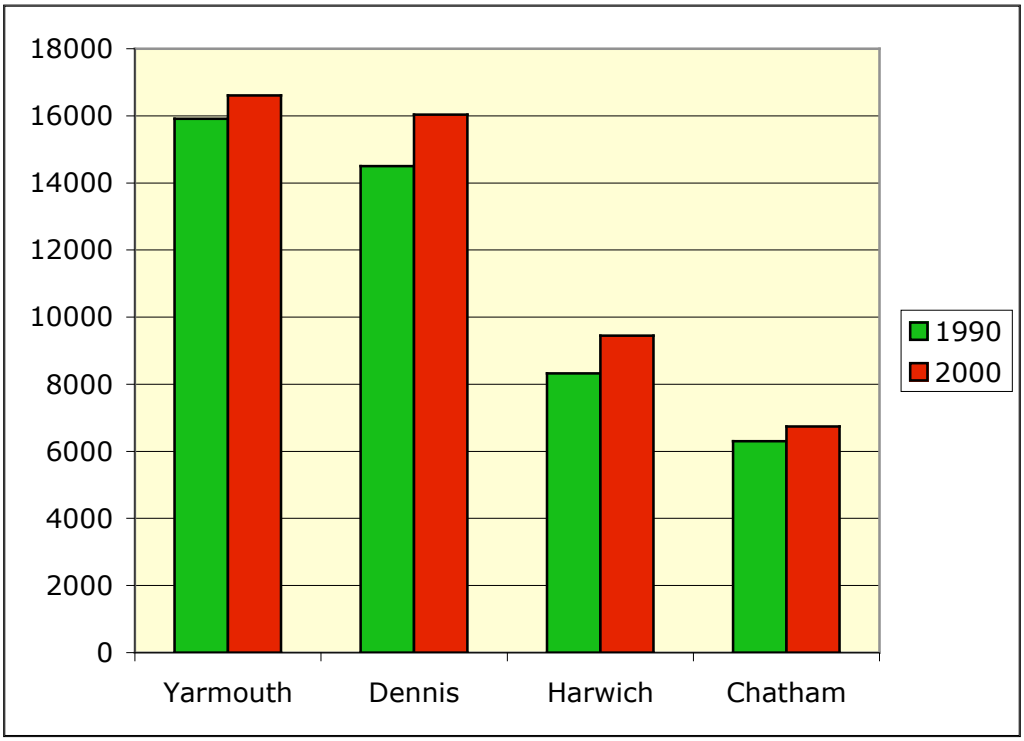


Figure 3 – Housing Changes

Sources: Census Bureau, Cape Cod Commission, Dennis Planning Department

1.2.2 Regional Transportation Plan and Local Transportation Plans

The 2003 Cape Cod Regional Transportation Plan (RTP) is a product of the Cape Cod Metropolitan Planning Organization (MPO) prepared by the transportation staff at the Cape Cod Commission acting on the MPO's behalf. Changes in the MPO structure occurred in November 2005 increasing the organization from four to nine voting members by adding local elected officials.

The MPO for the Cape Cod Region (Barnstable County) is currently composed of nine voting members and an advisory committee. These voting entities include the Cape Cod Regional Transit Authority (CCRTA), the Cape Cod Commission (CCC), the Massachusetts Executive Office of Transportation (EOT), the Massachusetts Highway Department (MHD) and local representation as follows: Barnstable County Commissioner; President of the Town Council of Barnstable; one selectman from Bourne, Falmouth, Mashpee or Sandwich; one selectman from Yarmouth, Dennis, Harwich, Brewster or Chatham; and one selectman elected from Eastham, Wellfleet, Truro or Provincetown. The selectmen are elected by their peers from within each sub-region. The Cape Cod Joint Transportation Committee (CCJTC) serves in an advisory capacity.

The RTP is a fiscally constrained set of programs and projects for the 22 years between 2003 and 2025 developed by the MPO through a public process. The RTP also includes a number of general project categories to accommodate projects as they are identified by studies such as this one. The program categories include:

- Roadway Resurfacing and Rehabilitation
- Bridge Replacement/Reconstruction
- Transit Operating Assistance
- Intersection Improvements
- Bicycle and/or Pedestrian Facilities and Programs
- Access Management Program
- Transit Capital Needs
- Additional Transit Service
- TDM/TSM Program
- New Ferry Service - Water Taxi
- Regional Bicycle Network
- Land Conservation
- Transportation Management Associations (TMAs)
- Cape and Islands Rural Roads
- Route 6A/Scenic Byways
- Intelligent Transportation Systems (ITS)
- Park and Ride Expansion
- Bus Shelter

To qualify for inclusion in the Transportation Improvement Program, a project must first be included in the RTP. The RTP process includes the development of regional goals with which the compatibility of projects is evaluated. The goals and strategies from the 2003 RTP include:

Goal 1 - Maintain the System.
"Preserve and maintain the existing transportation system, emphasizing safety and harmony with the environment."

The following strategies are proposed to support this goal:

- Ensure that adequate funds are reserved for the maintenance and operation of the existing transportation system before new capital projects are considered
- Consider maintenance strategies rather than "improvement" approaches to scenic roadways
- Support maintenance strategies and programs that accommodate safe travel throughout the transportation network, regardless of mode. This includes considerations that encourage bicyclists, motorists, transit riders, and pedestrians to share the transportation network safely
- Improve maintenance of all sidewalks, bicycle paths, and paved road shoulders
- Repave and/or reconstruct and widen where possible original sections of Cape Cod Rail Trail in Dennis, Harwich, Eastham and sections of Brewster
- Repave and/or reconstruct Cape Cod National Seashore bicycle paths

This goal is consistent with the statewide policy of "Fix – it – First".

Goal 2 - Develop alternatives to the automobile.
"Reduce dependence on private automobiles by developing and integrating alternate modes (e.g., rail, bus, ferry, air, bicycle, and pedestrian) into the transportation system and promote substitutes for transportation and systems to better manage transportation options."

The following strategies are proposed to support this goal:

- Promote an information-based consumer-oriented intelligent transportation system (ITS) that encourages travelers to use the most environmentally sensitive and efficient means of travel
- Develop ITS solutions to congested areas such as the Canal area roadway system.
- New transportation projects must consider inclusion of ITS elements such as Variable Message Signs, Highway Advisory Radio, and smart signals that can provide traffic data as well as react to changes in demand
- Promote cooperation among the various transportation agencies which have responsibility for the Cape's transportation system
- Support all forms of transportation demand management strategies for school and work trips, including, but not limited to, Transportation Management Associations, flexible hours, carpooling, bus pass programs, preferential parking and telecommuting

- Develop and market incentives that encourage employers to join Transportation Management Associations
- Encourage coordination between youth transportation, school bus service needs, and public transportation
- Encourage the coordination and communication between human service transportation providers
- Encourage the use of fixed-route transit service rather than paratransit, where possible
- Coordinate public transportation services between regions and between providers.
- Support efficient connections among all transportation modes and facilities to improve these connections
- Provide bicycle racks and/or lockers at park and ride lots, transit centers, and village and town centers that support bicycle networks
- Include consideration of bicycle and pedestrian amenities, paths, lanes, and safety needs in all transportation projects

Goal 3 - Integrate Land Use and Transportation Planning.

"Coordinate land use and transportation decisions to preserve and enhance Cape Cod's character by considering the interrelationship between changes in land use and corresponding changes in transportation demand."

The following strategies are proposed to support this goal:

- Plan transportation improvements which are consistent with the needs and desires of residents and businesses of the region and which are closely coordinated with local historic districts such as the Old Kings Highway, the towns, and the Cape Cod Commission
- Support higher density and affordable housing opportunities in defined concentrated development areas through the provision of public transportation – these high-density areas must also be balanced with open space
- Support parking management principles that reduce transportation demand at employer sites and commercial areas. These policies must consider the needs of the neighborhoods and not shift the burden of parking to residential streets
- Encourage transit-oriented development and provide alternatives to automobile travel by linking land use decisions with transit, bikeway, pedestrian, and park-and-ride investments
- Anticipate future mobility needs, taking into account the projected senior, youth and other potential transit-dependent use facilities. These include proposed or existing retirement communities, schools, and medical facilities

Goal 4 - Develop Transportation options that maintain the Cape's natural environment.
"Ensure the transportation system projects complement and enhance the natural environment of Cape Cod."

The following strategies are proposed to support this goal:

- Develop context-sensitive design measures that support the "Cape Cod Character"
- Emphasize sustainable transportation modes consistent with regional environmental policies
- Ensure that transportation projects contribute to the protection of natural and scenic resources as well as open space
- Encourage the development of designated recreational trails for pedestrians and bicycles
- Avoid, minimize, or mitigate the impact of transportation improvements on parks, recreation areas, historic sites, environmentally sensitive areas, and other scenic and cultural resources
- Include landscaping, pedestrian, and bicycle amenities in all transportation projects, where practical
- Support established village and town centers with a broad range of transportation options

Goal 5 - Advance Environmental Justice.
"Promote the equitable sharing of the transportation system's benefits and burdens including consideration of income, gender, race, age, physical and mental ability, and transit dependency."

The following strategies are proposed to support this goal:

- Support self-sufficiency by providing specialized transportation services
- Ensure that transportation projects do not subject any particular demographic groups, such as seniors, low-income individuals or children to inequitable environmental or financial impacts
- Support programs that address the transportation needs of low income and transit dependant populations such as lifeline transit services
- Identify and address structural and operational barriers to mobility
- Ensure opportunities for all individuals, agencies, and communities to participate in transportation decision-making
- Adopt measures of Environmental Justice for the region and incorporate them in the evaluation and programming of transportation projects

RTP Questionnaire
An RTP questionnaire was distributed at public meetings and via the project website. The questions focused on establishing priorities and defining perceived congestion and safety problems on Cape Cod. The format of the questionnaire focused on two areas: (1) establishing priorities regarding roadway/ alternate modes/ land use, and (2) identifying locations that experience significant congestion and/or safety problems.

The congestion and safety problems identified in the four towns included in this study were:

Regional Congestion:

- Route 28, Yarmouth (ranked 8th)

Survey Responses: Local Congestion Areas

Town	*Ranked 1st*	*Ranked 2nd*
Yarmouth	Route 28	Route 6A/Union St
Dennis	Route 28	Route 28 - Dennis/Harwich TL
Harwich	Route 39/Route 137	Exit 10
Chatham		No survey responses

Survey Responses: Safety Problem Areas

Town	*Ranked 1st*	*Ranked 2nd*
Yarmouth	Route 6A/Union St	Route 6/Exit 7
Dennis	Route 28/School St	Route 28 - Dennis/Harwich TL
Harwich	Exits 10, 11- lefts	Route 39/Route 137
Chatham		No survey responses

The following regional plan priorities were developed from the survey.

Rank	**Priority**
1	Improve public transportation (bus, air, rail, and water transportation)
2	Maintain roads and bridges
3	Make safety improvements
4	Preserve/restore "Cape Cod Character" (do not 'improve' scenic roads)
5	Increase roadway capacity (widening/new roads/new lanes/more signals)
6	Improve New Bedford/Martha's Vineyard ferry service
7	Develop bicycle and pedestrian facilities
8	Address the needs of the aging driver (improve signage, delineation, and lighting)
8	Develop Intelligent Transportation Systems (e.g. real-time traveler information systems)
10	Limit Development/Impose Land Use Controls to reduce future potential congestion
11	Purchase more open space to reduce future potential congestion

1.2.3 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 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

1.2.4 Travel and Transportation Alternatives

State Route 28 is the main route used for traveling along the southern shore of the four towns. Milepost 0.0 is "located" at the Orleans/Eastham Rotary (the other end of Route 28 is found at the New Hampshire border). Due to geography, most if not all Route 28 travel in Chatham is likely to have either an origin or a destination (or both) in town. Moving west, Route 28 carries more and more through traffic, with the largest share, for the purposes of this study, in Yarmouth (serving local travel as well as some travel to the other three towns).

In general, congestion is seasonal occurring between June and August with weekday peak hour traffic volumes of over 1,640 vehicles observed on Route 28 in Yarmouth. Weekday volumes in Yarmouth are estimated to be approximately 26,000 vehicles per day. Traffic volumes within the four towns grew at an average annual growth rate of about 0.6 % per year for the 1993 through 2003 period.

Due to geographic aspects of this area of Cape Cod, roadway and routing alternatives to Route 28 are limited to certain 'backroads' in some of the communities. Other transportation alternatives and services in the area include:

- Regional charter air service between Chatham airport and Boston
- Seasonal passenger ferry service at Saquatucket Harbor in Harwichport to and from Nantucket
- CCRTA's Green Line (Hyannis – Orleans) service travels the length of Route 28 between these communities.

- Plymouth and Brockton—privately operated inter-regional bus service between Boston (including Logan Airport) via Hyannis to Orleans; stops in the study area at the Route 6 exit 10 Park-and-Ride Lot
- The Cape Cod Rail Trail & Chatham Spur: multiuse recreational path originates in Dennis and parallels Route 28 in the study area.

1.3 Study Criteria

Traffic flow and safety were the two criteria used to evaluate the existing conditions and suggested alternatives along the Route 28 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 2003 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 history, 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 performed by Commission staff in recent years. ATRs are traffic sensors (pneumatic tubing 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, as well as the numbers of pedestrians, bicycles, and trucks traveling through the intersection. The turning movement count is the basic input in determining an intersection's performance – known as "Level of Service" or "LOS." Turning movement counts conducted for this study were limited to two hours during peak traffic periods due to budgetary and time constraints.

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' (1999-2001) of crash data. Do to changes in crash reporting methods, the

year 2001 is the currently the most recent year of consistent reporting (crash reporting in some communities for later years may be low by as much as 50% or more).

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 1999-2001 were used to determine the average annual number of crashes for a variety of categories and conditions.

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 28 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. EPDO is used to form a ranking of safety-problem locations – and thereby focus the effort of developing solutions.

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 28 in the four towns.

2.1 Traffic Volumes

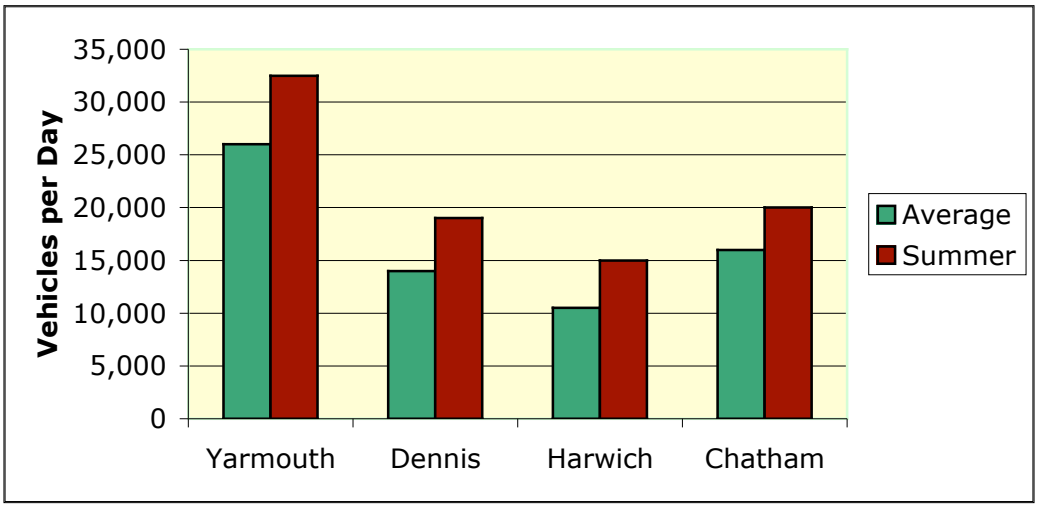
The Cape Cod Commission has been maintaining a database of traffic counts that covers the entire Cape Cod Region for twenty years. Throughout those years, 166 Automatic Traffic Counts (ATR's) have been taken along Route 28 in the four towns. Of those counts, 32 were taken in the last three years (see appendix of ATR's). In addition to the ATR counts, 67 turning movement counts (TMCs) were taken at specific intersections along the Route 28 corridor in the summer of 2003 (see appendix of TMCs). The turning movement counts were generally taken in 2-hour intervals from 4:00 to 6:00 PM and were the basis for the traffic flow model used in this study.

Typical Route 28 traffic volumes within each town are presented in the following table and figures. Observed traffic volumes generally decrease the further out the Cape the counts are taken as the roadway serves fewer and fewer trip generators. Traffic volumes are highest in Yarmouth 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 28 is a major route in the four towns. In Chatham, where traffic levels are at an annual average of 16,000 vehicles per day, "through traffic" is nearly non-existent since almost all of these motorists are likely to have either an origin or destination in Chatham. Please note that 2003 is the 'base year' for the purposes of analysis. Most of the traffic data used in the construction of the traffic model were collected in 2003 – hence the model is calibrated for 2003. Later traffic data, collected as recently as 2005, have been used in the development of this report and validation of the model.

Table 2 – Route 28 Weekday Traffic Volumes

Town	Existing Annual Average Daily Traffic (2003)	Existing Summer Average Daily Traffic (2003)
Yarmouth	26,000	32,500
Dennis	14,000	19,000
Harwich	10,500	15,000
Chatham	16,000	20,000

**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 4 – Existing Average Daily and Summer Daily Traffic

2.2 Travel Times

As part of the Cape Cod Commission's Congestion Management System activities, several travel time studies have been conducted on the corridor. These studies include measurements taken in June or July at during various times of day during recent years. For a complete summary please consult the appendix.

Table 3 – Summary Results from Travel Time Studies

Section	Distance (miles)	Avg. Travel Time (minutes)	Avg. Travel Speed (mph)
Yarmouth eastbound	5.2	11.7	27.2
Yarmouth westbound	5.2	13.5	23.8
Dennis eastbound	3.2	7.3	26.7
Dennis westbound	3.2	7.2	27.5
Harwich (southern) eastbound	5.0	10.0	30.1
Harwich (southern) westbound	5.0	10.5	28.9
Chatham eastbound/northbound	7.3	14.0	31.2
Chatham southbound/westbound	7.3	13.4	32.9
Harwich (eastern) northbound	1.3	2.4	34.0
Harwich (eastern) southbound	1.3	2.3	35.1

2.3 Crash History

This section reviews detailed crash rates and crash records for the four 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 28 crash rate for the whole of Cape Cod is 3.02 crashes per million vehicle miles traveled (according to the *Cape Cod 2003 Regional Transportation Plan*). The national average for crashes per million vehicle miles traveled is 2.41 and the Massachusetts crash rate is 1.06. In contrast, The Route 28 crash rate in Yarmouth was 5.1 crashes per million miles of vehicle travel, much higher than that of the other three towns in the study as shown in the following table:

Table 4 – Route 28 Crash Rates

Town	Route. 28 Miles	Average Annual Daily Traffic (1999-2001)	Average Annual Crashes (1999-2001)	Crashes per mile per year	Crashes per million miles traveled
Yarmouth	5.2	26,000	251	48.3	5.1
Dennis	3.2	14,000	64	20.0	3.9
Harwich	6.3	10,500	59	9.4	2.4
Chatham	7.3	16,000	116	15.9	2.8

Source: Cape Cod Crash & Traffic Data, MHD, 1999-2001 data

Intersection crash rates were calculated using worksheets supplied by MHD 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.

Crash severity information was analyzed to determine each intersection's total Equivalent Property Damage Only (EPDO) score. This 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 30 or more EPDO points and are considered the highest priority.
- 2nd Tier intersections rated between 20 and 29 EPDO points,
- 3rd Tier rated between 15 and 19 EPDO points,
- and 4th Tier intersections rated between 10 and 15 EPDO points. These tiers are intended to help focus the study.

Within Tier 1, a sub-group of the eight most serious intersections was identified. This group had EPDO results greater than 40 points and are indicated in bold type. The following table presents the results of the grouping process.

Table 5 – Equivalent Property Damage Only Ratings by Town

Tier 1 (EPDO>29)		**Tier 2** (EPDO - 20 to 29)	
East Main Street	**Yarmouth**	Baxter Ave	Yarmouth
Main Street*	**Chatham**	Ocean Avenue	Yarmouth
Forest Road	**Yarmouth**	Thomas Path	Yarmouth
Trotting Park Road	**Dennis**	Stony Hill Road	Chatham
Higgins Crowell Road	**Yarmouth**	Division Street	Harwich
Town Brook Road	**Yarmouth**	Crowell Road	Chatham
Depot Street	**Dennis**	Yarmouth Road/Willow Street	Yarmouth
Route 134/Swan River Road	**Dennis**	School Street	Dennis
West Yarmouth Road	Yarmouth	Old Main Street	Yarmouth
Pine Grove Road	Yarmouth	Depot Road	Harwich
George Ryder Road	Chatham	Snow Inn Road	Harwich
South Sea Avenue	Yarmouth	Old Main Street	Dennis
North Main Street	Yarmouth	Sea Street	Dennis
Neptune Lane	Yarmouth	Old Comers Road	Chatham
Standish Way	Yarmouth	Route 137/Meetinghouse Road	Chatham
Camp Street	Yarmouth		
Seaview Avenue	Yarmouth		
Tier 3 (EPDO -15 to 19)		**Tier 4** (EPDO - 10 to 14)	
Springer Lane	Yarmouth	Hemeon Drive	Yarmouth
Wendward Way	Yarmouth	Training Field Road	Chatham
Upper County Road	Dennis	Long Pond Drive	Yarmouth
Old Harbor Road	Chatham	Taffy Lane	Yarmouth
Winslow Grey Road	Yarmouth	Traders Lane	Yarmouth
Pleasant Street	Chatham	Pleasant Bay Road	Harwich
Appleby Road	Yarmouth	Lime Hill Road	Chatham
College Road	Yarmouth	Rosemary Lane	Yarmouth
Cozy Home Terrace	Yarmouth	Ruby Street	Yarmouth
Doane Way	Harwich	Neel Road	Harwich
Lower County Road	Harwich	Sisson Road	Harwich
Shad Hole Road	Dennis	Malabar Road	Chatham
Cockle Cove Road	Chatham	Drews Way	Yarmouth
Old Queen Anne Road	Chatham	Deep Hole Road	Harwich
Pierce Street	Yarmouth	Riverside Drive	Harwich
Wimbledon Drive	Yarmouth	Albumar Circle	Dennis
Brooks Road	Harwich	Wells Hollow	Chatham
Harbor Road	Harwich		

* a.k.a. Chatham Rotary. Does not include Stage Harbor Road data. Uncertain that all these crashes are in fact at the Rotary; may be along "Route 28-Main Street" section between the western Chatham/Harwich townline and the Rotary.

An analysis of the crash records was done for the highest crash rate sub group to determine if any patterns were evident. The following table presents this analysis.

Table 6 – Intersection Crash Analysis

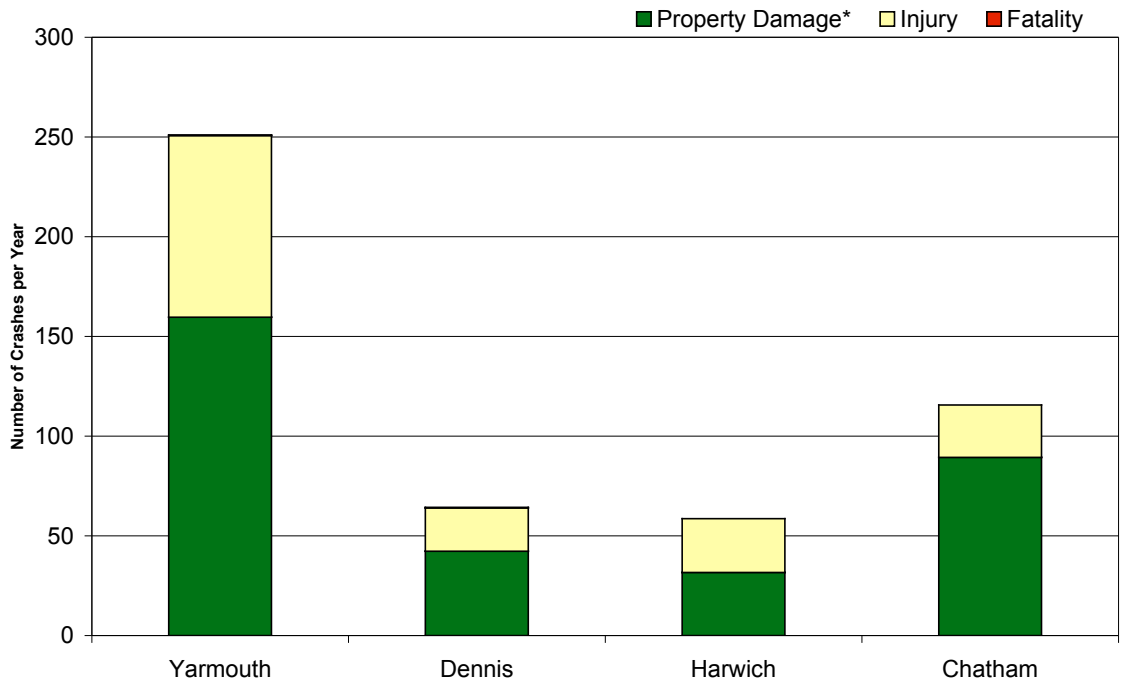
Crash Analysis 1999–2001*

Tier 1 Sub Group			Manner				
Intersection	**Town**	**Crashes**	**Head-On**	**Angle**	**Rear-end**	**Unknown**	
East Main Street	Yarmouth	28	2	12	8	6	No Pattern for Angle Crashes
Signalized			7.14%	42.86%	28.57%	21.43%	Apparent orientation problem in reporting
Main Street**	Chatham	27	0	10	9	8	No Pattern for Crashes
			0.00%	37.04%	33.33%	29.63%	
Forest Road	Yarmouth	20	1	11	7	1	Probable pattern - EB Route 28/EB Forest
Signalized			5.00%	55.00%	35.00%	5.00%	
Trotting Park Road	Dennis	15	1	11	2	1	Probable pattern - WB Rte 28/NB Trotting
			6.67%	73.33%	13.33%	6.67%	
Higgins Crowell Rd	Yarmouth	17	1	4	8	4	No Pattern for Crashes
Signalized			5.88%	23.53%	47.06%	23.53%	
Town Brook Road	Yarmouth	17	1	7	7	2	No Pattern - 1 Ped and 1 Bicycle accident
			5.88%	41.18%	41.18%	11.76%	
Depot Street	Dennis	16	0	14	1	1	Rear-End, Probable Sight-Distance problem
			0.00%	87.50%	6.25%	6.25%	
Rte 134/Swan River Rd	Dennis	17	2	7	8	0	No Pattern for Crashes
Signalized			11.76%	41.18%	47.06%	0.00%	
Sub Group Totals		157	8	76	50	23	
Average			5.10%	48.41%	31.85%	14.65%	

* Latest available comprehensive data from Registry of Motor Vehicles crash records
** a.k.a. Chatham Rotary. Does not include Stage Harbor Road data. Uncertain that all these crashes are in fact at the Rotary; may be along "Route 28-Main Street" section between the western Chatham/Harwich townline and the Rotary.

A variety of detailed crash information is provided in the following charts that are based on 1999-2001 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 Yarmouth 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 and analysis by intersection is the only easily available measure of safety. Most of the Registry's crash records identified along the Route 28 corridor in Yarmouth (and all towns on Cape Cod for that matter) lack sufficient detail to identify the corresponding roadway section where the crashes occurred.

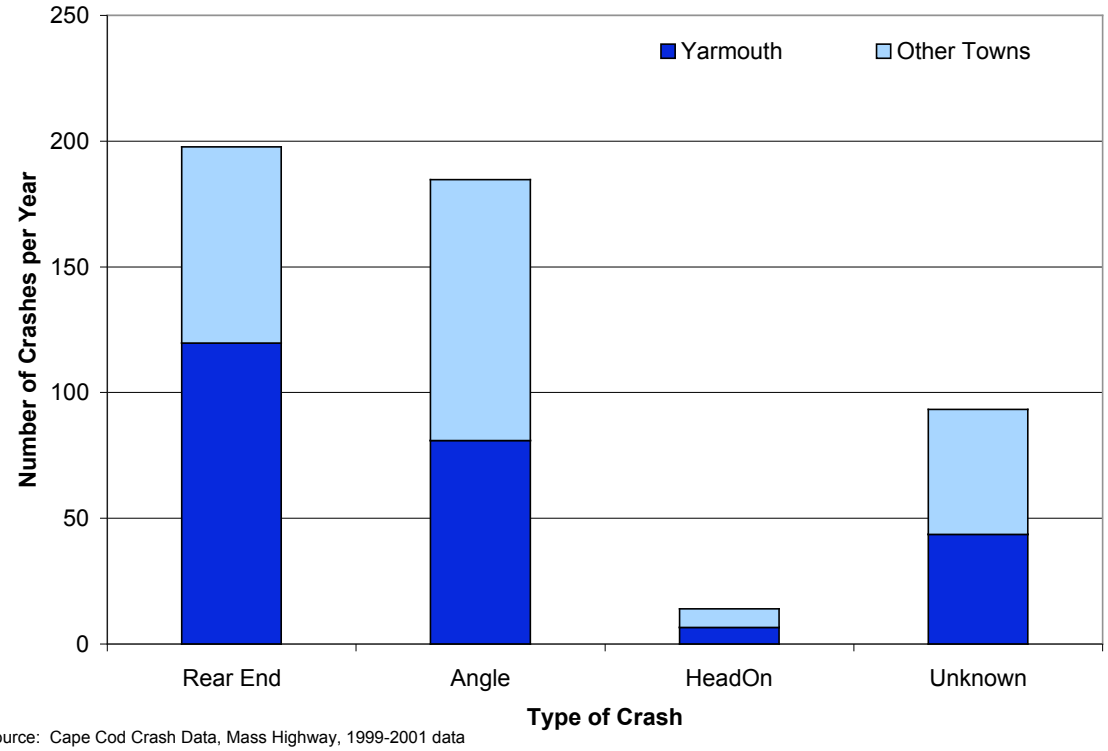


Source: Cape Cod Crash Data, Mass Highway, 1999-2001 data
* Includes "Hit and Run" category

Figure 5 – Crash Severity by Town

The figure above shows the average number of Route 28 crashes per year in each of the four towns. For each town, crash severity is shown in green (PDO - property damage only), yellow (injury), or red (fatality). Yarmouth experienced 160 PDO, 91 Injury, and zero Fatality crashes per year for a total of 251 crashes per year on average. Dennis, Harwich, and Chatham experienced 64, 59, and 116 Route 28 crashes per year on average, respectively.

This data implies that towns that have higher traffic volumes and have more curb cuts on Route 28 (especially Yarmouth) experience substantially higher crash frequencies. This is consistent with research (*Prediction of the Expected Safety Performance of Rural Two-Lane Highways*, FHWA, 2000) which shows that a roadway segment with 30 driveways per mile can experience up to four times as many crashes as a similar roadway segment with no driveways.



Source: Cape Cod Crash Data, Mass Highway, 1999-2001 data

Figure 6 – Crashes by Type

The figure above shows the average number of Route 28 crashes per year in each of four crash types. The lower portion of each bar shows the Yarmouth crashes. Rear End crashes were the most common crash type recorded on Route 28 in the four towns from 1999-2001. There were an average of 120 crashes in Yarmouth and 78 in the other towns for a total of 198 recorded "Rear End" crashes 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). As mentioned regarding the previous figure, these conflicts are consistent with the higher crash rates associated with higher curb-cut densities.

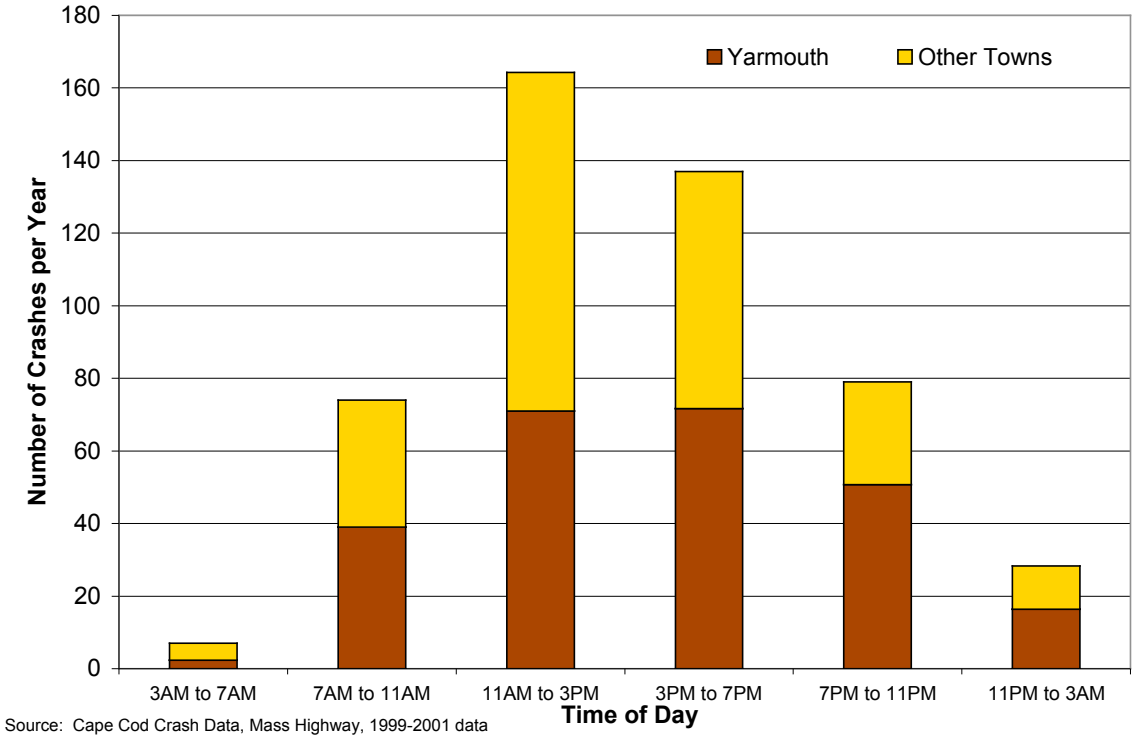
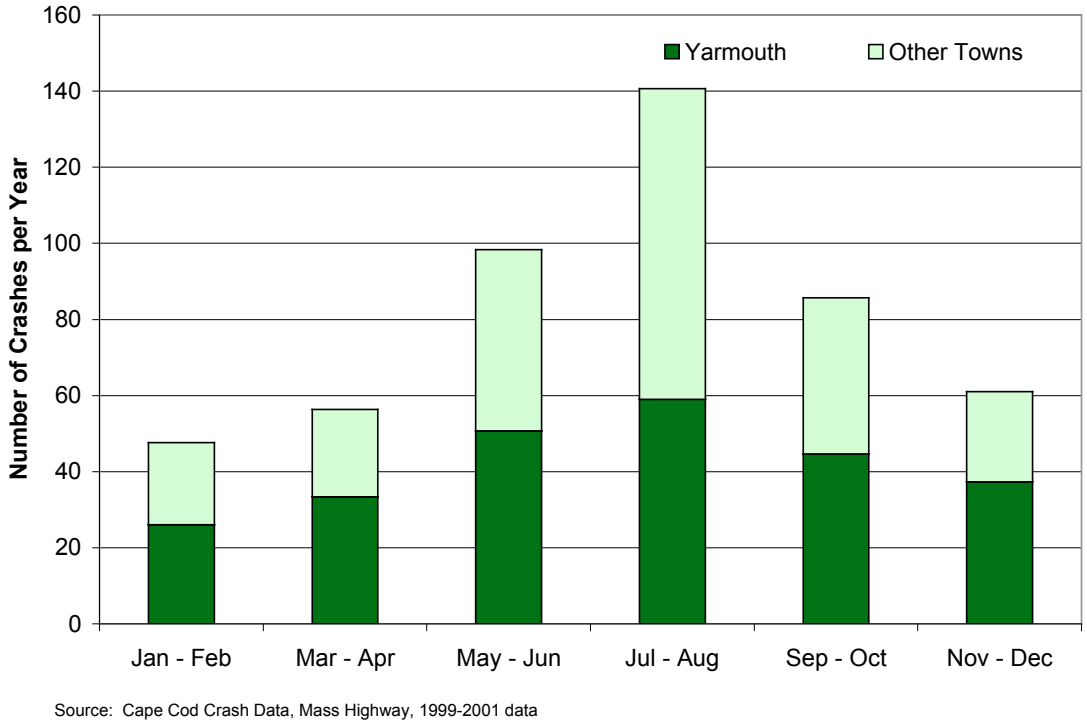


Figure 7 – Crashes by Time of Day

The figure above shows the average number of Route 28 crashes per year in each of six daily time periods. The lower portion of each bar shows the Yarmouth crashes. The 11 a.m. – 3 p.m. period contains the largest number of crashes: 71 in Yarmouth and 93 in other towns for a total of 164 recorded.

The implication of these data is that the busiest times of the day experience the highest frequencies of crashes. Route 28 traffic during the morning peak hour block (7 am – 11 am) is about half that of the following two time blocks, generally becoming busiest after 8 a.m. Traffic during the midday block (11 am – 3 pm) is very busy, as it is probably a combination of visitors' recreation/shopping trips, worker's midday errands, and general business travel.

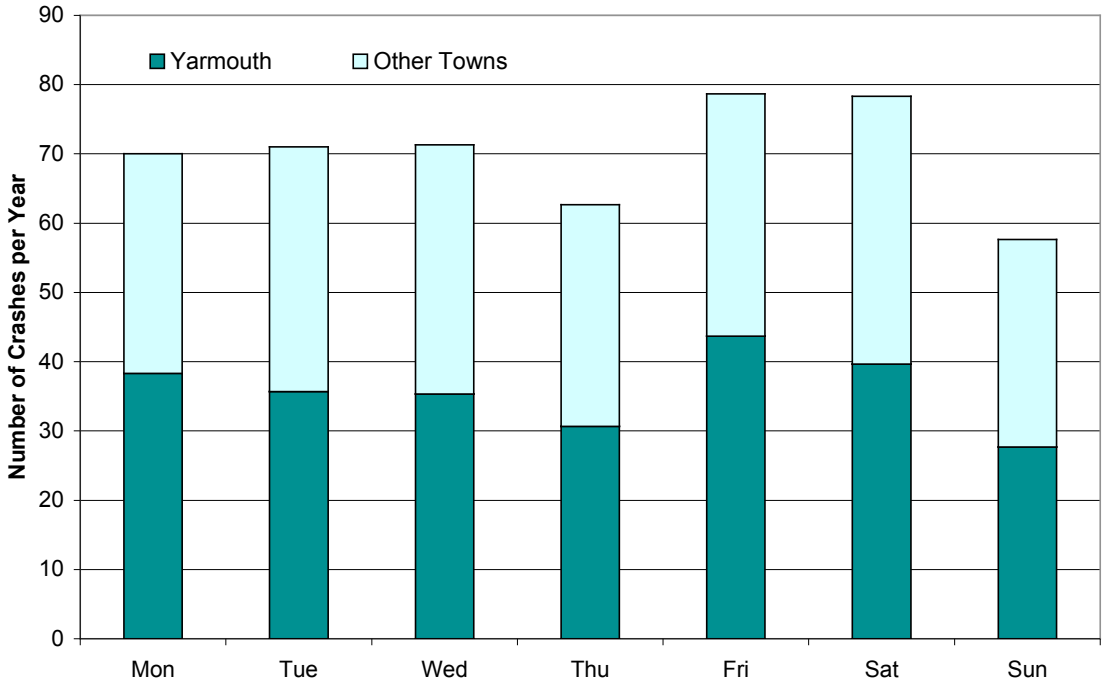


Source: Cape Cod Crash Data, Mass Highway, 1999-2001 data

Figure 8 – Crashes by Time of Year

The figure above shows the average number of Route 28 crashes per year in each of six yearly time periods. The lower portion of each bar shows the Yarmouth crashes. The combined months of July and August are host to the highest number of crashes: 59 in Yarmouth and 82 in other three towns for a total of 141 for the four towns.

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. Some of the summer seasonal crashes may also be related to the higher number of visitors, many of whom are less familiar with the roadway.

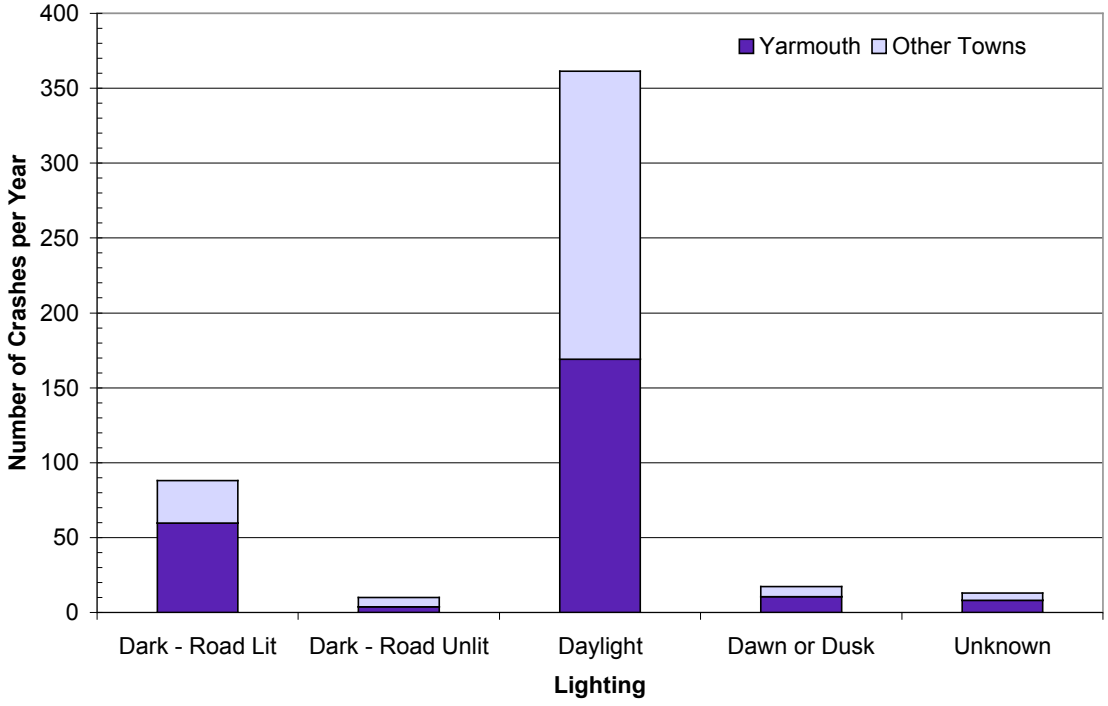


Source: Cape Cod Crash Data, Mass Highway, 1999-2001 data

Figure 9 – Crashes by Day of Week

The figure above shows the number of average number of Route 28 crashes per year for each day of the week in the four study area towns. The lower portion of each bar shows the Yarmouth crashes. Friday, with Saturday as a close second, has the highest number of crashes for any day of the week. There were 44 in Yarmouth and 35 in other towns for a total of 79 recorded on Fridays.

The implications of these data are that the heavy travel periods during Fridays and Saturdays experience the greatest number of crashes. The lowest days, Sundays, are low in contrast with the other days, perhaps due to fewer commuting and shopping trips.

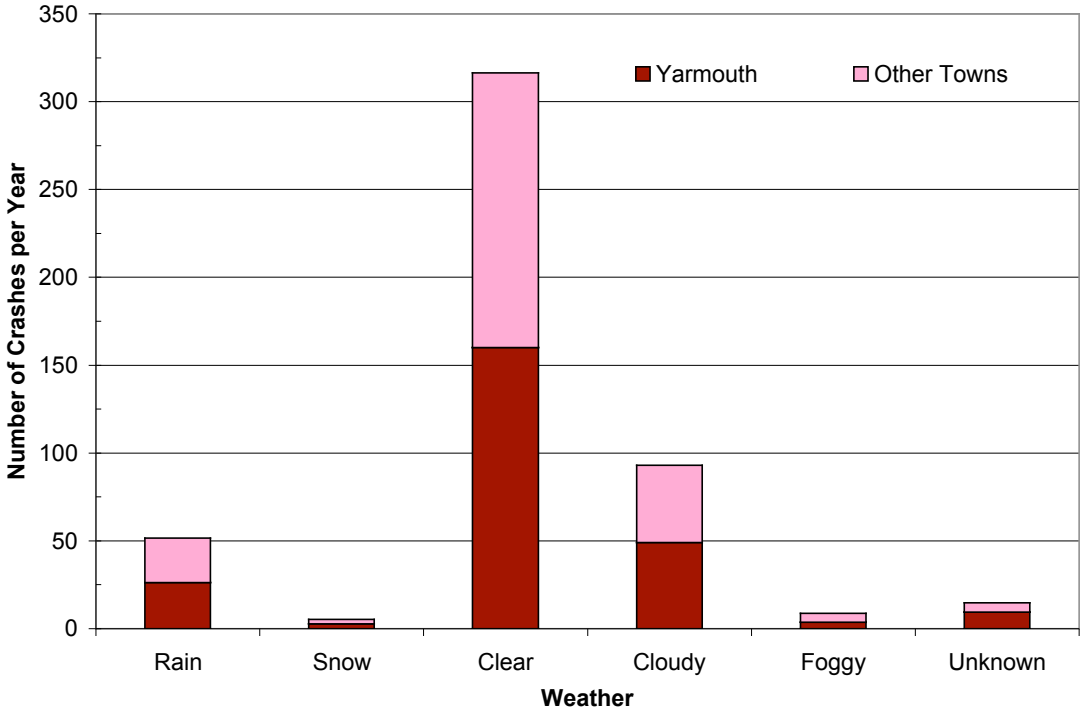


Source: Cape Cod Crash Data, Mass Highway, 1999-2001 data

Figure 10 – Crashes by Lighting Condition

The figure above shows the average number of Route 28 crashes per year for various lighting conditions. The lower portion of each bar shows the Yarmouth crashes. During "Daylight" periods the largest number of crashes were observed. There were 169 in Yarmouth and 192 in the other towns for a total of 361 during "Daylight."

The implication of these data is that the heaviest travel period, which occurs during daylight hours (especially in the summer) experiences the highest frequency of crashes.



Source: Cape Cod Crash Data, Mass Highway, 1999-2001 data

Figure 11 – Crashes by Weather Condition

The figure above shows the average number of Route 28 crashes per year for various weather conditions. The lower portion of each bar shows the Yarmouth crashes. During "Clear" periods the largest number of crashes were observed. There were 160 in Yarmouth and 156 in the other towns for a total of 316 during "Daylight."

The implication of these data is that the greatest amount of travel, which occurs during clear weather conditions, (especially in the summer) experiences the highest quantity of crashes.

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 cases, travel lanes may be eliminated allowing for other public uses such as landscaping

2.4 Pedestrian & Bicycling Environment

Sidewalks and pedestrian crossings are nonexistent in many areas along Route 28. 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.

There are no dedicated bicycling facilities (e.g., bike lanes or paths) along the corridor. Bicyclists have been observed using shoulders (when available), travel lanes, and sidewalks (when available).

3. Transportation Planning: Local & Regional Efforts

There are a number of regional and local planning efforts that have transportation implications for the Route 28 corridor. For example, in Dennisport (west of the Harwich town line) a revitalization effort is underway. The proposed "Growth Incentive Zone" (GIZ) may concentrate development along and near this section of Route 28 – coupled with a reduction in future development in other parts of Dennis. The goals of a GIZ include locating compatible land uses in a manner that is conducive to walking and is easily supported by transit.

The items in this chapter are based on the four towns' Local Comprehensive Plans (LCPs). LCPs are developed in conformance with the Cape's Regional Policy Plan.

3.1 Local Comprehensive Plans (LCPs) and Regional Policy Plan

The Local Comprehensive Plans for the four 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 planning decisions by the towns to help preserve the capacity and improve the safety of the Route 28 corridor.

There are four sections (one for each town) that outline each town's transportation planning in its LCP. These sections are followed by general land use, transportation-related land use, transportation/development review policies, and access management recommendations.

3.1.1 Yarmouth Comprehensive Plan

The transportation component of the Yarmouth Local Comprehensive Plan was endorsed in April 2000. The plan calls for a reduction of dependence on the automobile through a balanced approach to transportation that follows a sensible land use and growth management policy that includes the following actions and conditions:

1. Provides a source of funding for desirable transportation projects
2. Requires new development to mitigate impacts in a manner consistent with Yarmouth's natural, scenic, and historic resources
3. Promotes safe access to roadways and property through controlled driveway and intersection spacing
4. Promotes land, air and marine based alternatives to automobile travel
5. The need for a suitable land use and growth management policy at the local level cannot be over-emphasized – without such controls, travel demands will

outpace transportation improvements, resulting in deterioration of many of the values that have made Yarmouth extremely desirable

The Yarmouth segment of Route 28 is a federal aid principal arterial and under MHD jurisdiction. The roadway averages 70 curb cuts per mile and most of the adjacent land uses are commercial.

Yarmouth LCP Transportation Goals and Objectives

Goal #1 – Promote a transportation system that is multi-modal and encourages safe, effective alternatives for travel, reduces demand for single occupant vehicles, and maximizes the integration of all modes.

Goal #2 – Develop a transportation plan in concert with the local comprehensive plan's elements such as the economic, land use, and open space plans, that is compatible with the Regional Policy Plan, the plans of neighboring communities, and the State's plans and policies.

Goal #3 – Create a transportation system that provides safe and efficient arterials for through movement, and movement to major commercial and business centers, that minimizes unnecessary traffic through neighborhoods.

Goal #4 – Develop a transportation system that is cost effective and affordable, but maximizes the use of federal and state transportation funds, incorporates private financing, and minimizes town expenditures.

Goal #5 – Implement actions that enhance the historic, environmental, and natural resources of the Town while minimizing the negative impacts on these resources.

Recommended Town Actions

A. The Town should establish a traffic impact assessment and mitigation program to identify and mitigate the impacts of new developments and redevelopment on the transportation system.
B. The town should adopt thresholds for review of traffic impacts of proposed projects within the zoning or site plan review by-law.
C. The Town should adopt access management guidelines.
D. The Town should evaluate parking requirements.
E. The Town should consider developing impact fees for transportation improvements that are consistent with the Regional Policy Plan and the Local Comprehensive Plan.
F. The Town should adopt zoning by-law amendments and land use plans to ensure that the future transportation needs of the Town are consistent with the future capacity of the transportation system.

Future Growth

Relative to Route 28, the area that has the most potential for growth at build-out is between Traders Lane and Parkers River where 223,000 square feet of

commercial/industrial growth is expected. Growth, to a lesser degree, is anticipated in the entire segment of the Route 28 corridor from approximately Town Brook Road to Forest Road and will generally be commercial and industrial. This area will include 371,000 square feet of development or 29% of the commercial/development expected at build-out for the Town. Peak hour traffic volumes are expected to increase 27% in this area at build-out.

Future Conditions

An analysis of average total delay was done for the signalized and unsignalized intersections in the Yarmouth roadway analysis network. The analysis along Route 28 indicated that several of the intersections will include LOS movements of F, generally these are movements crossing or turning onto Route 28.

The most significant problems at unsignalized intersections were identified at Town Brook Road and Seaview Ave. other intersections with LOS of F for one leg included Camp Street, and West Yarmouth Road. Only one signalized intersection on Route 28 in Yarmouth had delay problems in the future, Main Street which also has an existing LOS of F.

Crash Summary

The LCP included crash data for 1995 to 1997 and of the 18 intersections selected with an average of 5 or more reported accidents annually, 8 were on Route 28. These included East Main Street (10.6), Forest Road (9), North Main Street (7.3), West Yarmouth Road (7.3), Town Brook Road (6.3), Standish Way (5.6), Higgins Crowell Road (5), and South Sea Ave. (5). The only Route 28 fatality in the three-year analysis period occurred at Town Brook Road.

Yarmouth LCP Recommended Transportation Plan

The target year for the Yarmouth's LCP recommendations is 2015. The following recommendations relate to the Route 28 corridor.

Roadway

- A major focus of the long-range plan is to develop management plans and capacity enhancement actions to improve the operations, safety, pedestrian/bicycle environment, and aesthetics of Route 28.
- Study the feasibility of extending Buck Island Road to Yarmouth Road in Barnstable to enhance internal east-west travel.
- Focus new rehabilitation efforts on key north-south roadways including Forest Road, West Yarmouth Road, Seaview Avenue, Winslow Grey Road, and South Sea Avenue.
- Develop a set of guidelines and policies related to Access/Curb Cut Management for the major arterials serving the commercial areas

- Address eleven most critical safety deficient locations that include:
  - Route 28 at East Main Street
  - Route 28 at West Yarmouth Road
  - Route 28 at South Sea Avenue
  - Route 28 at Seaview Avenue
- Continue emphasis of system management as developed in the BYTS Plan, particularly the Congestion Management System Plan and its use of technology to monitor and manage the roadway system

Bicycle/Pedestrian

- Enhance pedestrian movement along major pedestrian corridors such as Route 28 and Seaview Avenue.
- Continue the completion of the off-road east-west bicycle trail

Transit Service

- Provide shelters, recognizable signs along public transit route
- Explore new public transit route along Station Avenue corridor, connect with existing Route 28 bus.
- Work with the business community and transit authority to effectively market and advertise the transit service.

Transportation Demand Management

- Provide improved advanced travelers information, particularly with regard to summer beach parking.
- Develop effective guide signing to major sections of Town and key facilities including recreational areas and bicycle routes.
- Develop economic and development incentives to encourage larger parcels, which can then be developed as mixed use with amenities, to further encourage alternative modes and a reduced number of vehicular trips.

<u>Recommended Action Items – In the Route 28 corridor</u>

- Town priorities:
  - Better signals on Route 28, particularly at Berry Ave., South Sea Ave., Forest Rd., and Old Main St.
- Recognize that any solution to Route 28 problems (where the right of way varies from 40 to 60 feet) requires innovative solutions such as:
  - Prohibit left turns except at intersections with traffic signals.
  - Reduce the number of streets that intersect with Route 28.
  - Furnish lodging places with bus and trolley schedules and encourage patrons to use public transportation.
  - Provide attractive bus stop shelters with seating and schedule information.
  - Extend summer bus service to Sea Gull Beach.
  - Encourage shared access points and prohibit multiple curb cuts at single sites.
  - Minimize curb cuts through changes in zoning bylaws and other incentives.

- Encourage parking solutions that favor access from side streets (examples include; Great Island Plaza, Molly's and Colonial Candle, Boch Village and South Yarmouth Post Office).
- Stripe key intersections (or better still, provide landscaped medians) to provide stacking lanes.
- Realign the intersection of Winslow Grey Road and South Sea Avenue. Install a traffic signal at West Yarmouth Road, replacing the one currently at Winslow Grey Road.
- Provide additional public parking at Packet's Landing and the Old Drive-In property.
- Develop an alternate route to Hyannis. One possibility is extending Buck Island Road.
- Encourage economic redevelopment that positively impacts traffic flow such as upgrading motel sites and conference centers.

- Support the development of sidewalks, bike paths and walking trails Examples include:
  - Complete the development of sidewalks on Route 28.

- Work closely with the Cape Cod Commission and the Towns of Barnstable and Dennis on areas of regional concern.
  - Access to Barnstable Municipal Airport
  - Location of increased parking at the Airport.
  - Coordinated bus schedules

3.1.2 Dennis Local Comprehensive Plan

The Dennis local comprehensive plan draft – dated November 7, 2001 includes a transportation section. Key elements of this transportation section include the inventory of existing facilities and services and an analysis of current and forecasted problems. Recommended implementation items for improving transportation include:

Roadways

- Implement Pavement Management System
- Intersection and roadway improvements – Conduct needed traffic studies, review current traffic count locations and recommend changes to better monitor and manage changing traffic patterns.
- Assessment of impact fee programs to ensure development is mitigating negative impacts of development fully.
- Assessment of speed limits on Town roadways and work with State and regional officials to adjust them accordingly. Speeds on roadway should be monitored closely.

Public Transportation

- Work with the CCRTA and Cape Cod Commission to evaluate effectiveness of local transit service including route modifications, increased frequency, improved marketing, and reduced fare policies (including free fares) to boost ridership on local services.

Parking

- Study the potential effectiveness of Intelligent Transportation Systems technology (such as variable message signs) to better manage capacity of beach parking and beach related congestion.
- Assess the need for parking capacity increases in conjunction with assessments of supporting transportation system capacity.

Pedestrian and Bicycle

- Conduct bicycle route planning in conjunction with the Cape Cod Commission.
- Work with the Cape Cod MPO to incorporate bicycle and pedestrian facilities in all roadway reconstruction projects on regional roadways, where feasible.
- Continue annual allotment as part of the Capital Improvement Program for sidewalk improvements.
- Develop prioritized list of sidewalk and bicycle network improvements.

Land Use

- Adopt Development of Significant Impact traffic thresholds to require appropriate traffic mitigation.
- Adopt Access Management bylaw.
- Assess impact of zoning on economic development and the transportation system. Direct growth toward established village centers.
- Adopt a sign ordinance to specify appropriate size, scale, and quality based on zoning district and speed of roadways.
- Revise sight distance requirements for driveways to be based on speed of adjacent roadways.

Proposed Land Use and Transportation Policies

- Implement Village Center zoning districts to distinguish uses that are compatible with existing village centers from other uses in the GCII zone. The Village Center zone should encourage village and pedestrian scale development. Distinct provisions could apply in the areas of parking (amount, location, and screening/buffering), setbacks (maximum as well as minimum setbacks possibly allowing zero lot line development), lot sizes (development of smaller lots allowed), and sidewalks and bicycle parking.

- Review, revise (as appropriate) then adopt the Model Bylaw on Access Management developed by the CCC. Important aspects of this bylaw should include connections between parking lots, and guidelines for the number of driveways and maximum widths. Connections between parking lots to allow passage between adjacent land uses without using the roadway system.

Specific Dennis LCP Recommendations

Intersection Improvements

The draft Dennis local comprehensive plan identifies a number of areas for improvement with respect to safety and capacity. In the Route 28 corridor the high accident intersections, based on 1992-1996 crash data compiled by the Dennis Police Department, include:

- Route134/Route 28 – vehicles turning left from Swan River Road colliding with vehicles traveling south on 134 were the predominate crash scenario. A protected left turn phase was recommended.
- Route 28/Sea Street – no apparent crash pattern was evident.
- Route 28/Depot Street – all of the collisions reported were angle type crashes with the majority involving vehicles traveling south from Depot Street. Investigation into the need for signals at this intersection was recommended.
- Route 28/Trotting Park Road - no apparent crash pattern was evident.
- Route 28/School Street - no apparent crash pattern was evident.
- Route28/ Shad Hole Road - no apparent crash pattern was evident.
- Route 28/Fisk Street - no apparent crash pattern was evident.

Congestion levels were also measured and although the roadway system was at or below capacity in the winter, in many areas demand exceeded capacity during summer peak periods. Areas of concern include the portion of Route 28 between the Yarmouth town line and School Street where demand exceeds capacity during the summer peak periods and is at capacity during winter peak periods. The projected growth in traffic demand is also expected to exceed capacity along Route 28 in the summer between Trotting Park Road and Route 134 and be at or above capacity between Yarmouth and Route 134 during winter peak periods.

Congested intersections were also identified and during the summer the most congested intersections along Route 28 include Route 134, School Street, and Main Street/Trotting Park Road. Future conditions indicate the intersection of Route 28 and Depot Street will also be congested.

Two specific intersection improvements to address capacity issues for Route 28 were recommended by the LCP to address current needs.

- Route 134/Route 28/Swan River Road – currently significant widening is prohibited due to right of way constraints. It was recommended that the electric sub-station located on the northeast corner be relocated and a turn lane

for westbound Route 28 traffic be added along with an updated signal system incorporating pedestrian accommodations.

- Route 28/School Street – this intersection is stop sign controlled and, based on traffic volumes, a traffic signal is warranted.

Access Management

Access management issues were also identified for Route 28. The number of commercial and residential driveways, as well as their design and spacing, directly affects the quality of traffic flow and safety. The 3.2 mile stretch of Route 28 in Dennis that was surveyed has 233 curb cuts (excluding road intersections). This is an average density of 73 curb cuts per mile – the other Dennis roadways surveyed averaged approximately 44 curb cuts per mile.

One area identified for access management was Route 28 in DennisPort between Center Street and Division Street. Potential changes identified included closures, width reductions, and consolidation of driveways. More study was recommended.

Pedestrian and Bicycle Recommendations

A number of missing sidewalk segments were identified in the LCP and a number of recommended improvements to the existing sidewalk network were recommended. These recommendations in the Route 28 corridor included:

- Add approximately 1150' of sidewalk along Route 28 opposite Riverway Street to Allain Way.
- Add approximately 3400' along Route 28 from near Route 134 to near Benny's.
- Add approximately 350' along Route 28 from near Dunkin Donuts in DennisPort to just west of Mill Street.
- Add approximately 300' along Sea Street from just south of Route 28.
- Add approximately 300' along School Street from Route 28.
- A large portion of the sidewalks along Route 28 were identified as being in poor condition and it was suggested that they be programmed for replacement along with the elimination of gaps.

An improved bikeway network ranked high on the list of items supported by residents. As in most areas, most existing bicycle routes share the roadway with automobiles. Route 28 is one of the areas without a separate bicycle facility in the corridor and many sections of this roadway do not have paved shoulders. It was suggested that adding paved shoulders where they are absent would significantly improve conditions for cyclists.

Land Use Recommendations

There should be a distinction between the zoning in DennisPort village and along points west of it along Route 28. Zoning in DennisPort should encourage pedestrian scaled development. Larger developments can be accommodated but rather than using "big box" buildings, smaller masses of connected buildings are recommended.

3.1.3 Harwich Local Comprehensive Plan

The Harwich Local Comprehensive Plan dated May 2000 included a number of transportation initiatives to define future projects. The fundamental concern however was preservation of community character. The plan suggests consideration of improvements including road alterations, bike lanes, and sidewalks in village centers and appropriate bike and pedestrian facilities for safe access and linkage between village centers was suggested. These improvements, transit, and reductions in the ultimate population and commercial development potential are expected to minimize congestion levels town-wide.

Section VIII – Community Facilities includes traffic projections and a wide array of other transportation-related findings. The following items related to the Route. 28 Corridor are included in a December 10, 1992 document referred to in the LCP.

Accidents
Accident records from 1/89 to 6/92 were examined and intersections with 4 or more accidents were identified. The following intersections on Route 28 and Route 39 (and number of accidents) were identified, using an average of 3 accidents per year, the high accident location were:

Route 137/39 (26 total accidents), Route28/Snow Inn/Freeman (21 total accidents), Sisson Road/Route 28 (19 total accidents), Route 28/Belmont Road/ Depot Street (13 total accidents), Depot Street/Route 39 (12 total accidents), Route 28/Brooks Road (12 total accidents), South Street/Route 28/ Ayer Lane (11 total accidents), and Route 28/Uncle Venies/Depot Road (11 total accidents).

The only Route 28 corridor fatalities listed occurred at Route 28/Snow Inn/Freeman and Route 28/Lothrop Avenue (7 total accidents).

Intersection Deficiencies
The LCP cataloged intersections with identified deficiencies. Identified geometric or driver-error deficiencies related to the high-accident intersections listed above were as follows:

Route 137/39 – Lane markings and design; Route 28/Freeman – sight distance; Sisson Road/Route 28 – failure to stop/yield; Route 28/Belmont Road/Depot Street – failure to stop; Depot Road/Route 39 – poor sight distance to west; Route 28/Brooks Road – speed of cars going around curve; South Street/Route 28/ Ayer Lane – limited turning movement from south; Route 28/Uncle Venies/Depot Road – failure to stop/speed/sight distance; and Route 28/Lothrop Avenue – limited turning movement.

No specific project recommendations were made for the Route 28 corridor. The Route 28 Corridor study was referenced in section 7.2.1.2 (A) that states “Work with Transportation Department of Cape Cod Commission and MHD to produce adequate designs for relevant segments of Route 28 pursuant to findings of Route 28 corridor study

and other relevant studies." The responsible Town agencies identified included the Board of Selectmen (lead), Traffic Safety Committee, Town Engineer, and the Division of Highways Maintenance. This effort was to begin following the adoption of the plan which occurred May 2, 2000.

Public transportation was addressed in 7.2.3 and a town committee was to be formed by the Board of Selectmen. The committee was to examine the financial, market, legal, licensing, and operational aspects of establishing fixed route transit service by one or more mini-buses and/or the Cape Cod Regional Transit Authority.

3.1.4 Chatham Local Comprehensive Plan

The Chatham Comprehensive Long Range Plan was approved at the May 2003 town meeting. One of the primary issues that Chatham feels needs to be guarded against is the "increased dominance of the automobile encouraging strip development, requiring more parking lots, undermining the character of neighborhood centers and threatening the safety of pedestrians and bicyclists."

Route 28 is adjacent to many of the defined neighborhoods in Chatham and some of the land use policies developed in the plan address deficiencies in the Route 28 corridor. Prevalent among these recommendations was improvements to public amenities and safety for pedestrians.

Transportation goals were identified for the community facilities including areas of Route 28. Section 2.4-A includes the goal "Work with the state Highway Department to include improvements proposed by the town in the reconstruction of Route28". These improvements included:

- Traffic signal installation and reconfiguration – Route 137
- Safety improvements at George Ryder Rd., Barn Hill Rd., Old Queen Anne, Crowell Rd., the rotary, and Stony Hill Rd.
- Addition of bus stop shelters at neighborhood centers: South Chatham, West Chatham, The Cornfield, Crowell Rd., Veterans Field, and North Chatham.
- Vehicular access control modifications at commercial properties to meet local, state, and regional guidelines.
- Sidewalks meeting Americans with Disabilities Act requirements on both sides of Route 28 within neighborhood centers. Where possible, maintain a grassed buffer between the sidewalk and the roadway.
- Accommodation for bicycles.
- Drainage improvements
- Addition of pedestrian level lighting, benches, and trees.
- Enlargement of culverts at the Muddy River, the Herring Run, and Frostbite Creek consistent with Comprehensive Wastewater Plan.

Other Route 28 initiatives included in the transportation goals were:

- Use signs to encourage visitors to enter town via Route 137 and Route 28 rather than Old Queen Anne.

3.1.5 General Land Use LCP Recommendations

- The four towns' 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.

3.1.6 General Land Use - Related LCP Transportation Recommendations

- Development of access management by-laws; development of collector roads linking commercial developments with Route 28; additional left turn lanes along Route 28 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 28 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.

3.1.7 General Transportation/Development LCP 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).

3.1.8 General Access Management LCP Recommendations

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 a later section of this report.

3.2 Barnstable-Yarmouth Transportation Study (BYTS)

This local comprehensive transportation study was done performed between 1992 and 1995. The BYTS study limits overlap the Route 28 Safety and Traffic Flow Study at the west end. The overlap covers Route 28 from the Barnstable town line to just east of Winslow Grey Road. The study was organized into two technical memoranda – a review of previous reports/data and recommendations.

Volume I - Previous Studies

A number of previous studies were identified in the current study area. Recommendations from some of these studies may still be relevant. These include the following:

- Route 28/South Sea Avenue/Winslow Grey Road
  Two options have been presented at this location
  - maintain existing geometry but optimize signal timing and phasing
  - Optimize signals and restripe Route 28 to provide two travel lanes in each direction.
- Higgins Crowell Road/Buck Island Road

Upgrade the signal configuration and timing at this location.

- Buck Island Road/Town Brook Road

Widen the east and westbound approaches in order to provide additional pavement width for exclusive left turn, also widen the northbound approach to provide an exclusive right turn lane.

- Camp Street/Route 28

Consider the installation of a traffic signal.

- Route 28/East Main Street and Higgins Crowell Road/Route 28
  Existing signals should be updated and retimed.
- West Yarmouth Road/Route 28

The stop bar and stop line should be better defined. The possibility of prohibiting left turns from West Yarmouth Road should be considered.

Volume II – Recommendations

This volume of the BYTS study included the following relevant recommendations for potential roadway improvements in Yarmouth:

Intersections:
Route 28/Town Brook Road – minor geometry, signal
Route 28/Camp St. – minor geometry
Route 28/South Sea Ave. – minor geometry, upgrade signal, and retime
Route 28/Higgins Crowell Rd. – minor geometry, upgrade signal, and retime
Route 28/East Main St. – upgrade signal
Higgins Crowell/Buck Island – minor geometry, upgrade signal
W. Yarmouth/Buck Island – Improve signal timing

Roadway Construction:
Extend Buck Island Rd. to Willow Street and signalize this intersection. This was identified for further study.

4. Alternatives Analysis

This chapter presents information on the analyses techniques and assumptions used in analyzing the Route 28 corridor. Several alternatives were examined beginning with a "baseline" (existing conditions) and an "optimized" scenario. Measures of effectiveness (e.g., delay) are presented for each alternative as well as the percentages of improvement.

4.1 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 28 corridor. The operations model covers the Route 28 study area in the four towns.

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 33 major intersections along 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 minor road and driveway 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 each town's 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 over thirty major intersections and at least two curb cut locations (one for northern-side curb cuts and one for southern-side 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* 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. A key factor in determining an MOE 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 quality 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.

Level of Service (LOS) is another 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.

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. (A complete list of the intersections analyzed can be found in the appendix).

Multiple 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 one-hour time period 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 different random number seeds, the base year and each alternative was simulated in *SimTraffic* at least 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 2003 existing conditions "Network Totals" provide a starting point. The following table presents delay information for the entire network. "Total Delay" represents the summation of all of the individual vehicles' delay in the entire network. When this number is divided by all of the vehicles in the network the result is the "Delay/Vehicle." "Total Travel Time" is the summation of all of the vehicles' individual travel time. "Average Speed" is the average of all vehicle's individual results.

Table 7 – Base Year No-Build Traffic Performance

	Total Delay (hours)	Delay / Vehicle (seconds)	Total Travel Time (hours)	Average Speed (Mph)
Base Year No-Build	999	187	1,979	15.9

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

Levels of Service at signalized intersections are presented in the following table. In this table "Delay" refers to the average delay per vehicle in seconds. Level of Service ranges from "A" (best) to "F" (worst).

Table 8 – Base Year No-Build Signalized Intersection Performance

Intersection	**Town**	**Avg. Delay (seconds/veh.)**	**Level of Service**
East Main St (Rt 28 movements)	Yarmouth	104	F
East Main (E. Main St. movements)	Yarmouth	7	A
Higgins Crowell Rd	Yarmouth	63	E
Winslow Gray Rd	Yarmouth	19	B
South Sea Ave	Yarmouth	25	C
Long Pond Dr	Yarmouth	15	B
Forest Rd	Yarmouth	25	C
N Main St/Old Main St	Yarmouth	55	D
Route 134	Dennis	17	B
Upper County Rd	Dennis	89	F
Division St	Dennis	32	C
Crowell Rd/ Depot St/ Queen Anne Rd	Chatham	22	C
Old Harbor Rd/ Shore Rd	Chatham	11	B

The following flow chart presents the process used in developing alternatives.

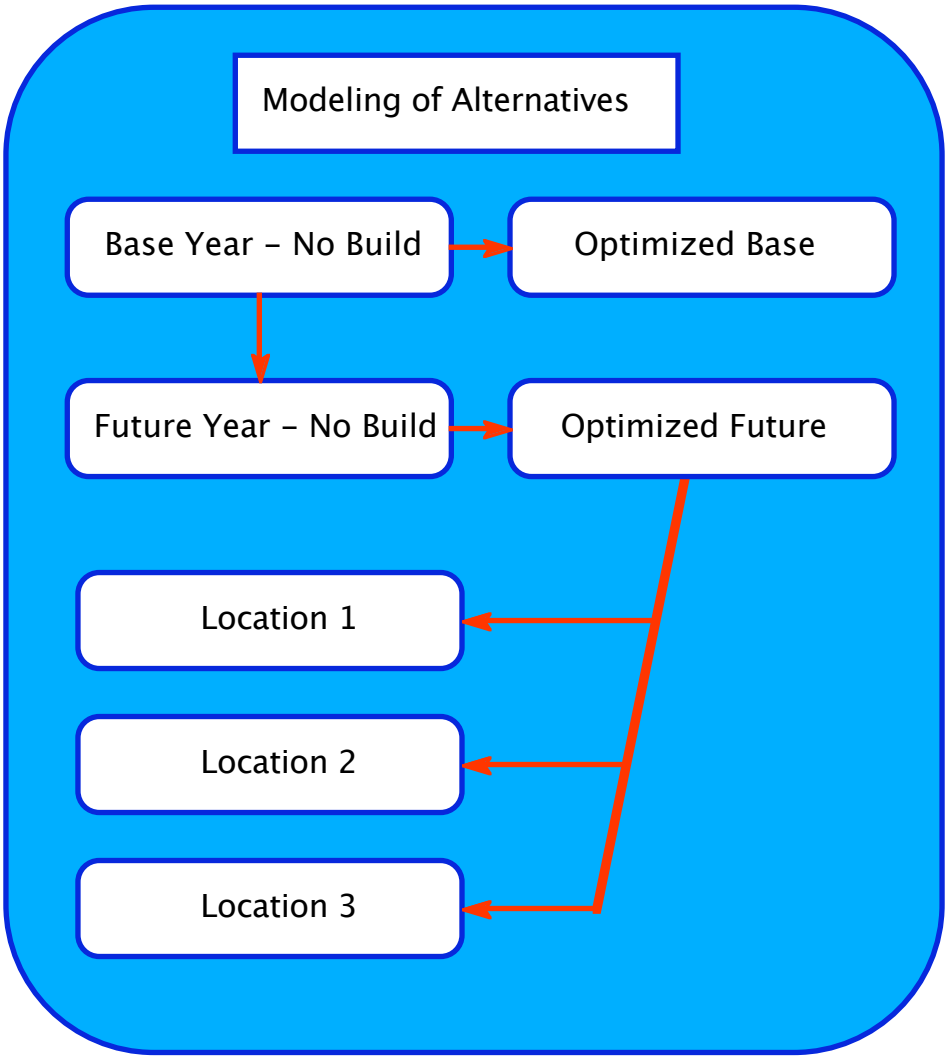


Figure 12 – Flow Chart of Alternatives

The Synchro analyses were developed from a "Base Year – No Build" scenario. This scenario represents a typical summer weekday, 4-5 p.m., using 2003 traffic data. From this starting point, two variations were developed:

Optimized Base

This alternative represents the effects of retiming traffic signals and adding/deleting phases at the corridor's signalized intersections. The optimization feature of the Synchro software was used along with engineering judgment and public input to analyze signalized locations and implement changes in order to minimize traffic delay. Since signal retiming is a relatively low-cost and non-intrusive means of improving traffic flow, this technique will form an important recommendation of this study (and should be

performed periodically). Optimization was included in all alternatives (expect for the Future Year no-Build) as an important factor in traffic operations.

The optimization procedures assumed a maximum cycle length 100 seconds. Each signal was modeled as actuated and uncoordinated. The following table lists the modeling modifications used in the optimization.

Table 9 – Optimization Modifications

Location	Town	Modification
East Main St	Yarmouth	Optimization using Synchro to lowest overall delay
Higgins Crowell Rd	Yarmouth	Optimization using Synchro to lowest overall delay
Winslow Gray Rd/South Sea Av	Yarmouth	Optimization using Synchro to lowest overall delay
Long Pond Dr	Yarmouth	Optimization using Synchro to lowest overall delay
Forest Rd	Yarmouth	Optimization using Synchro to lowest overall delay
N. Main St/Old Main St	Yarmouth	Added protected leading eastbound and westbound left turn phases, kept eastbound and westbound permitted left turns, changed southbound left turns to protected and permitted, optimization using Synchro to lowest overall delay
Route 134	Dennis	Optimization using Synchro to lowest overall delay
Upper County Rd/Division St	Dennis	Optimization using Synchro to lowest overall delay
Crowell Rd/Depot Rd/Queen Anne Rd	Chatham	Optimization using Synchro to lowest overall delay
Shore Rd	Chatham	Optimization using Synchro to lowest overall delay

The estimated cost of optimization would be $2,000–$1,000 per intersection, or a total of $20,000–$100,000.

The following table shows the expected performance of the signalized Route 28 intersections after optimization.

Table 10 – Optimized Base Year Signalized Intersection Performance

Intersection	Town	Avg. Delay (seconds/veh.)	Level of Service
East Main St (Rt 28 movements)	Yarmouth	41	D
East Main (E. Main St. movements)	Yarmouth	6	A
Higgins Crowell Rd	Yarmouth	30	C
Winslow Gray Rd	Yarmouth	21	C
South Sea Ave	Yarmouth	20	C
Long Pond Dr	Yarmouth	13	B
Forest Rd	Yarmouth	24	C
N Main St/Old Main St	Yarmouth	31	C
Route 134	Dennis	15	B
Upper County Rd	Dennis	29	C
Division St	Dennis	25	C
Crowell Rd/ Depot St/ Queen Anne Rd	Chatham	22	C
Old Harbor Rd/ Shore Rd	Chatham	10	B

Future Year No-Build

This alternative maintains the current physical road geometry and traffic signal phasing/timing and includes a 10-year growth estimate of traffic volumes. Traffic volumes were factored by an annual rate of 1.035% (or a factor of 1.1085 for ten years). This factor represents the historic ten year growth rate for the period (1994-2004). This scenario represents a typical summer weekday, 4-5 p.m., in the year 2013.

The Future Year No-Build alternative was then modified in a similar manner as the Base Year scenario.

The following table presents delay and Levels of Service for the study area signalized intersections – projected to the year 2013.

Table 11 – Future Year No-Build Signalized Intersection Performance

Intersection	Town	Avg. Delay (seconds/veh.)	Level of Service
East Main St (Rt 28 movements)	Yarmouth	143	F
East Main (E. Main St. movements)	Yarmouth	8	A
Higgins Crowell Rd	Yarmouth	127	F
Winslow Gray Rd	Yarmouth	28	C
South Sea Ave	Yarmouth	33	C
Long Pond Dr	Yarmouth	17	B
Forest Rd	Yarmouth	31	C
N Main St/Old Main St	Yarmouth	68	E
Route 134	Dennis	22	C
Upper County Rd	Dennis	163	F
Division St	Dennis	58	E
Crowell Rd/ Depot St/ Queen Anne Rd	Chatham	29	C
Old Harbor Rd/ Shore Rd	Chatham	12	B

Optimized Future

In the same manner as modifications made to the Optimized Base, this alternative represents the effects of retiming traffic signals and adding/deleting phases at the corridor's signalized intersections. As before, these modifications were made to optimize flow and reduce delay and congestion.

The Optimized Future scenario was the basis for analyzing physical alternatives and new signalization. Each "Location" was analyzed individually.

The following table presents delay and Levels of Service for the study area signalized intersections – projected to the year 2013 – that have been optimized for efficient operation.

Table 12 – Optimized Future Year Signalized Intersection Performance

Intersection	Town	Avg. Delay (seconds/veh.)	Level of Service
East Main St (Rt 28 movements)	Yarmouth	70	E
East Main (E. Main St. movements)	Yarmouth	6	A
Higgins Crowell Rd	Yarmouth	38	D
Winslow Gray Rd	Yarmouth	29	C
South Sea Ave	Yarmouth	27	C
Long Pond Dr	Yarmouth	15	B
Forest Rd	Yarmouth	30	C
N Main St/Old Main St	Yarmouth	41	D
Route 134	Dennis	18	B
Upper County Rd	Dennis	50	D
Division St	Dennis	33	C
Crowell Rd/ Depot St/ Queen Anne Rd	Chatham	29	C
Old Harbor Rd/ Shore Rd	Chatham	11	B

The following sections contain discussions for improvements at the three "Locations." These locations where selected for this analysis based on observed queuing and congestion problems and crash history. Consideration was also given to the opportunity for improvement based on right-of-way availability, adjacent intersections' impacts, and vehicle travel patterns (turning movement demands).

Due to the substantial impact of widening the entire (or major segments) of the corridor, analysis of four travel lanes was not performed. While greater traffic volumes can be accommodated in the additional travel lanes, left-turn maneuvers from side streets and driveways become difficult, and pedestrian crossings can become hazardous.

4.1.1 Location 1 – East Main Street (Yarmouth) Roundabout

After reviewing the traffic flow patterns, queuing, and congestion at the East Main Street (Yarmouth) intersection, it became apparent that a roundabout configuration might alleviate some of the traffic flow problems. The existing intersection (see the following figure) has three major roadways, each with roughly similar traffic volumes. Route 28 connects on a curve (East Main Street is directly aligned with the east leg of Route 28).

Figure 13 – East Main Street Intersection – Existing Configuration

As can be seen in above figure, there are numerous channelizing islands and angled roadways for motorists to maneuver through or around. In comparison, the geometry of a properly-designed roundabout encourages low-speed entry, circulation, and exit that is consistent for each approaching roadway. In certain circumstances roundabouts can have significantly improved operations in comparison to signalized intersections. The main advantage of roundabouts is continuous flow – there is no "all-red phase" (where all traffic must stop at a signalized intersection). A correctly designed roundabout encourages consistent lower speeds of all users – a safer option – versus the wide range of operating speeds at a signalized intersection (containing a mixture of stopped vehicles

and high-speed through traffic). The following figure shows a concept of a roundabout intersection at East Main Street.

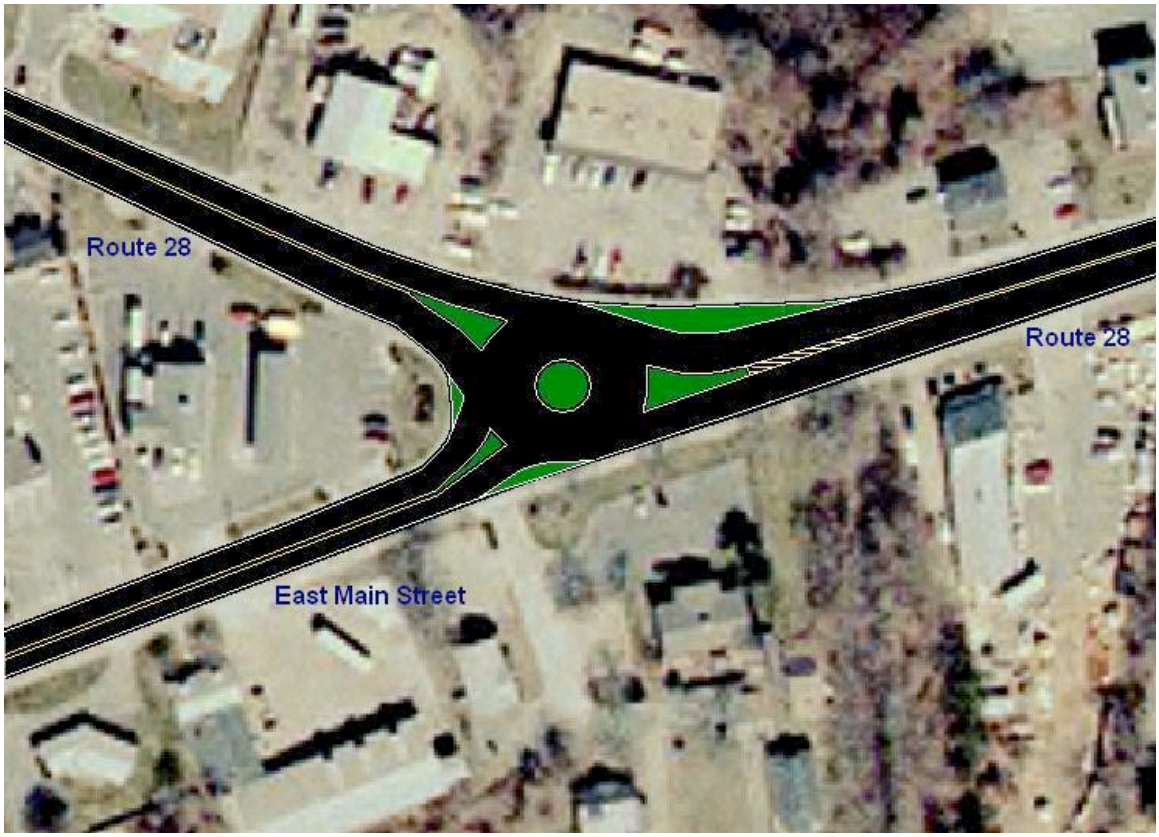


Figure 14 – East Main Street Roundabout

The estimated cost of this improvement may be $330,000.

4.1.2 Location 2 – Upper County Road (Dennis) Reconfiguration

Traffic operations on Route 28 at the intersection of Division Street intersection are complicated by the close proximity of Upper County Road. The traffic signals at these two intersections are coordinated to avoid having vehicles excessively queuing between them and to provide safe passage for all movements through the two intersections. See the following figure for an overview of the intersections. Route 28 is the main roadway (from the left-bottom of the photo to the right-hand side. Division Street is a north-south road on the right-had side of the photo. Upper County Road enters from the left side of the photo and aligns with Route 28).

Figure 15 – Upper County Road & Division Street Intersections – Existing Conditions

The improvement concept shown in the following figure, involves the removal of the signal at Upper County Road. All Upper County Road south/eastbound traffic would be directed to Telegraph Road. The segment of Upper County Road between Telegraph Road and Route 28 would be one-way for north/westbound travel only.

Figure 16 – Upper County Road & Division Street Intersections - Reconfigured

The estimated cost of this improvement may be $25,000.

4.1.3 Location 2 – George Ryder Road (Chatham) Signalization

Traffic operations at this intersection are currently complicated by the offset approaches of George Ryder Road's north and south legs, the nearby commercial driveways, and the relatively heavy Route 28 traffic volumes.

Figure 17 – George Ryder Road Intersection – Existing Conditions

This alternative includes a realignment of the south leg of George Ryder Road to match the north leg and signalization of the intersection as shown in the following figure.

Figure 18 – George Ryder Road Intersection - Reconfigured

The estimated cost of this improvement may be $450,000.

4.2 Intelligent Transportation Systems

Intelligent Transportation System (ITS) applications include a wide range of options to improve transportation. In a nearby area, 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 2006. A pilot program, which placed a variable message sign at the Salt Pond Visitors Center during the summers of 2002-2005, was very successful. Chatham has also used variable message signs successfully during major events to advise motorists of parking availability and street closures.

This alternative includes supplementing the proposed 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 the final chapter. No modeling of the effect of ITS on traffic was conducted. However, a study of ITS benefits by the U.S. Department of Transportation (see appendix) shows:

- a traveler information system in Cincinnati is estimated to reduce fatalities by 3.2%.
- pre-trip departure notification in the Washington D.C. area can reduce early/late arrivals and save 40% of users $60 or more per year in lost time.
- Users of Smart Traveler in Boston are estimated to have reductions of the air pollutants of NOx by 1.5% and VOCs by 25% .

Example costs for an ITS program may be around $800,000 based on $200,000 for Highway Advisory Radio and four Variable Message Signs at $150,000 each. Administering internet information might add another $10,000 per year.

4.3 Public Transit

The *5-Year Plan for Transit on Cape Cod*, published in June 2002 recommended increasing service along the Route 28 corridor on the Hyannis to Orleans RTA bus route. The service improvements proposed included additional fall and winter service for the Hyannis to Orleans bus route and additional Sunday service. These additional runs will supplement existing service by increasing morning and evening peak service. Additional coordination of the RTA schedules with private bus and ferry providers was also recommended.

The estimated costs of providing additional service are as follows:

4 Round Trips	$30,342
6 Round Trips	$45,513
8 Round Trips	$60,684

Figure 19 – Cape Cod RTA "Green Line" Bus Route

Flex Service

Proposed to begin in May 2006, the Flex service is a combination of Demand Response and Fixed Route service that will serve seven Outer Cape Towns including Harwich. The currently proposed route will include a short portion of Route 28 between Sisson Road and Bank Street. This will allow transfers to occur between the Flex and the Hyannis to Orleans Route (Cape Cod RTA's "Green Line", shown in the above figure as the"H2O Line") as well as the ferries that operate from Saquatucket Harbor.

Orleans Local Transportation Center

A proposed study of the Cape Cod Transit Task Force will identify a site location for a local transportation in Orleans to help coordinate services such as the Flex, the Hyannis/Orleans service, and the Plymouth and Brockton inter regional bus service. This site will help to make public alternatives for travel more viable.

Other recommendations include bicycle improvements and improvements to the water transportation system that could have some impact on the four towns' 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. An ITS-related proposal to benefit public transit users is an "Estimated Time of Arrival" (ETA) service. ETA gives updates to waiting patrons via electronic message boards installed at transit stops. Information includes the estimated time of arrival of the next bus (and the subsequent bus if applicable).

Public Transit recommendations are presented in this report's final chapter. No modeling of the effect of transit on traffic was conducted.

5. 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 28 mainline (section) totals, and intersection totals.

5.1 Traffic Flow

The entire network (modeled road network) includes the Route 28 corridor mainline, all side streets, and their intersection approaches. 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. Total traffic flow performance is presented in the following table. The terms are:

- "Total Delay," expressed in hours, is the sum of all delay of all vehicles on all parts of the Route 28 corridor during the study hour, including side street and curb cut approaches.

- "Delay/Vehicle," expressed in seconds, is the average delay per vehicle during the study hour on the entire network.

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

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

It is important to remember that the results are affected by the starting conditions. Since the amount of traffic using the corridor does not vary for the alternatives, alternatives which are estimated to result in greater delay may in fact divert traffic to alternate routes (where available). Conversely, alternatives which are estimated to reduce delay may attract vehicles from these alternate routes. Therefore, some of the benefits (or penalties) estimated by this modeling effort for the Route 28 alternatives may in fact be distributed to the adjacent road system (modeling efforts used in this study do not account for these effects).

In the following table, showing a summation of all delay of all vehicles in the network, provides a starting point for looking at the impacts at individual intersections.

Table 13 – Summary of Traffic Delay

Entire Network	Total Delay (hours)	Delay / Vehicle (seconds)	Travel Time (hours)	Average Speed (mph)
Base Year – No Build	**999**	**187**	**1,979**	**15.9**
Optimized Base	**827**	**152**	**1,817**	**17.4**
Future Year – No Build	**1,761**	**318**	**2,778**	**11.7**
Optimized Future	**1,427**	**249**	**2,469**	**13.5**

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

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.

5.2 Safety Improvement

To help quantify the benefits of various safety treatments, resources included The Traffic Safety Toolbox: A Primer on Traffic Safety, Chapter 28, Institute of Transportation Engineers, 2000; and Prediction of the Expected Safety Performance of Rural Two-Lane Highways, Chapter 5, Federal Highway Administration, 2000. These reports include discussions on various vehicular access treatments and predictions of "Accident Reduction."

The table on the following page shows the expected changes in safety at three "Location" intersections.

Table 14 – Safety Prediction at Selected Intersections

Intersection	E Main St (Yarmouth)	Upper County Rd (Dennis no-build)	Upper County Rd (Dennis, build)	Geo. Ryder Rd (Chatham)
Major ADT	20,066	13,816	15,975	16,602
Minor ADT	6,876	2,254	0	1,075
EPDO/yr	21	6.3	**	11
Base Configuration	Signalized	Signalized		Unsignalized
Build Configuration	Roundabout		Unsignalized**	Signalized
Base Crash Prediction*	2.00	n/a		1.61
Build Crash Prediction*	1.52		n/a	1.25
Prediction Measure	Injury Accidents Per Year (1)	**	**	Injury Accidents Per Year (1)
Crash Reduction	24%		100%	22%
Build EPDO/yr	16		0**	9

* Crash Prediction Notes:
(1) Predicted "Injury Accidents/Year" source:
The Traffic Safety Toolbox: A Primer on Traffic Safety, Chapter 28, Institute of Transportation Engineers, 2000.
(2) Predicted "Accidents Per Year" source:
Prediction of the Expected Safety Performance of Rural Two-Lane Highways, Chapter 5, Federal Highway Administration, 2000.
**Minor street entry is eliminated

Based on the characteristics of traffic flow, traffic control, and geometry at the East Main Street (Yarmouth) intersection, a reconfiguration of this signalized intersection as a roundabout many yield a 24 percent reduction in crashes. The number of Equivalent Property-Damage-Only (EPDO) crashes is estimated to drop from 21 per year to 16 per year. This results from the reduction in speed-differential and conflict points at the existing signalized intersection to the continuous, lower uniform speed of a properly designed roundabout.

At the George Ryder Road (Chatham) intersection, a conversion from unsignalized to signalized operations is expected to reduce EPDO crashes from 11 per year to 9 per year – about 22 percent.

The proposed improvement at Upper County Road (Dennis) would in effect, eliminate the signalized intersection. Route 28 through movements would be retained (as well as westbound traffic exiting to Upper County Road) but there would be no side-street entering traffic. The 6.3 EPDO per year that are predicted to be eliminated at this intersection may be partially offset by the increase in traffic at Telegraph Road/Hall Street (only one crash reported in the period 1999-2001: property damage only, angle).

5.3 Costs

Costs for many of the alternatives were estimated based on 2003 Contract Cost Data which is a summary of costs for highway construction projects in Massachusetts. 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 in the table below. Costs for each location are shown in the Evaluation Matrix in the next section.

As a general program to improve intersections beyond the recommendations of this report, it is assumed that development of a program that includes necessary studies and improvements may cost $25,000 per intersection.

5.4 Evaluation Matrix

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

Table 15 – Evaluation Matrix

Alternative	Total Delay (hours)	Predicted EPDO/yr Crash Reduction	Pavement Change?	Land Taking/ Permit Issues?	Re-Routing?	Cost $1,000's
Future Optimized	1,427					
Loc. 1 – E. Main Roundabout (Yarmouth)	1,460	5	Reconfig-ure, some increase	minor	no	330
Loc. 2 – Upper County Rd/ (Dennis)	1,477	6	no	no	yes	25
Loc. 3 –Geo. Ryder Rd. Signal (Chatham)	1,479	2	no	minor	no	450

6. Conclusions & Recommendations

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

6.1 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:

6.1.1 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.

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 and routes, 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. MHD, as the responsible agency, should consult with the four towns 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. For a 10-year program, costs may be up to $262,000. This is based on installation of 20 signs at $500 each; media advertisement design at $2,000, running ads at $2,500 each for 10 ads per year.

6.1.2 Enforcement

The towns' police departments 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.

Red light cameras and photo-radar have been found successful in other parts of the country in identifying hazardous vehicles and increasing driver awareness. These technologies use video and/or roadbed sensors to detect violating vehicles; roadside cameras are used to record license plates with the violation data (e.g., the speed the vehicle is traveling through the red signal, how long the red signal was showing before the vehicle entered the intersection, etc.). A police officer than reviews the information for accuracy and issues a citation for the violator.

At this time, legislation would be necessary to issue citations. In the meantime, these systems could be used to identify patterns of violation (times of day, days of the week etc.) to help focus the enforcement effort.

To support this program, it is assumed that for the signage costs alone, 10 signs at $500 each would cost $5,000.

6.1.3 Engineering

Many of the 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.

6.2 Optimization

The single largest improvement in traffic flow was found when the signal timing patterns throughout the network were retimed for efficiency. This was true of the existing base year scenario and – when adjusted to the future traffic patterns – equally true for the future scenario. It is a central recommendation of this study that signal optimization be performed in the near term and revisited periodically. This recommendation is especially attractive since character-changing construction can be delayed or avoided.

6.3 Recommendations for Selected Locations

Three locations on Route 28 have been identified for potential improvement. For further discussion on details of proposed changes, please see the previous chapter.

• East Main Street (Yarmouth). Replace signalized intersection with roundabout.
• George Ryder Road (Chatham). Align southern leg for four way operation, signalize.
• Upper County Road (Dennis) Remove signal, re-direct entering traffic to Telegraph Road.

6.3.1 Minor roadway changes

From observations of Route 28 traffic, it was noted that at many locations there was sufficient pavement width for motorists to make "creative" maneuvers. These circumstances were included in the development of the Synchro traffic model. The following items are suggested for implementation as appropriate – through pavement markings and modest additions of pavement width:

Table 16 – Intersection Modifications for Synchro Modeling

Intersection	Town	Modification
East Main Street	Yarmouth	• Mark Route 28 eastbound past East Main for 2-lanes with appropriate merge section to one lane • Extend eastbound Route 28 approach to include 2-lanes
Town Brook Road	Yarmouth	• Add southbound Town Brook Road right turn lane • Add westbound Route 28right turn lane
Higgins Crowell Road	Yarmouth	• Add southbound Higgins Crowell Road right turn lane
Winslow Gray Road	Yarmouth	• Add southbound Winslow Gray Road left turn lane
South Sea Avenue	Yarmouth	• Add northbound South Sea Avenue left turn lane
Route 134	Dennis	• Add short Route 28 eastbound and westbound left turn lanes and northbound Swan River Road left turn lane
George Ryder Road	Chatham	• Align roadways (northbound and southbound George Ryder Road approaches) • Add eastbound and westbound Route 28left turn lanes • Add southbound and northbound George Ryder Road right turn lanes
Old Queen Anne Road	Chatham	• Add southbound Old Queen Anne Road right turn lane
Crowell Road, Depot Road, Queen Anne Road	Chatham	• Add eastbound and westbound Route 28 short protected left turn phase at end of through phase • Add eastbound and westbound Route 28 short left turn lanes • Add northbound Queen Anne Road short right turn lane
Old Harbor Road, Shore Road	Chatham	• Add eastbound Route 28 right turn lane
Old Comers Road	Chatham	• Add northbound Route 28 short left turn lane

6.4 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 subdivisions along Route 28 would alleviate some future safety concerns, reduce turning conflicts, 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 and/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 28 would eliminate these parcels' future safety and traffic impacts.
- Limit Access: Enforce "No Access" line for property with frontage along sections of Route 28 where particularly close to intersection of public roads.

A program including education and some municipal projects may cost around $500,000.

6.5 Recommendations Related to Older Drivers

A relatively large and increasing percentage of 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.

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 to include larger lettering (some larger street signs have recently been installed on Route 28 in Yarmouth and Harwich).
- 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.
- Consider extending "all-red" clearance phases for signalized intersections.

The total cost of implementing such recommendations may be $1,480,000. This is based on $50,000 per year for sweeping and striping, $1,000,000 for improved lighting, and revisions to traffic signals at $40,000 for each intersection.

6.6 Intelligent Transportation Systems (ITS)

Traveler information provided by variable message signs is recommended as part of the ITS alternative introduced earlier in the report. A proposed variable message sign that would affect the study area should likely be located as follows:

- Route 6 east of exit 9 to advise eastbound motorists of conditions along Route 28 in the lower Cape and beyond as well as outline transportation alternatives including the mini transportation center currently being discussed for the Orleans area.

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* (or similar provider) 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 jointly operated by MHD. 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.

6.6.1 Opticom System

To improve public safety response times, an Opticom System for signalized intersections is recommended. This system includes detectors installed near the signal heads. When an Opticom-equipped emergency vehicle approaches the intersections, it broadcasts an infrared signal to the detector. This information is passed on to the signal controller which gives a priority green signal to the approaching emergency vehicle (and shows red

phases to the other approaches). Priority can be assigned highest to ambulances and fire trucks. Lower priorities can be assigned to police vehicles and lowest priorities can be assigned to public transit vehicles.

Costs of installing Opticom are assumed to be $5,000 per signalized intersection for a total of $60,000 for the twelve installations.

6.6.2 Permanent Counting Stations

As a resource for transportation planning and potential for use in real-time traffic monitoring, it is recommended that permanent traffic counting stations be installed at three locations. These include:

Route 28 at the Barnstable/Yarmouth town line
Route 28 at the Yarmouth/Dennis town line (Bass River bridge)
Route 28 at the west side of the Harwich/Chatham town line

Costs of adding permanent counting stations are estimated at $7,000 per location for a total of $21,000.

6.7 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.

6.7.1 Cape Cod Five-Year Public Transportation Plan

This five-year plan calls for easily implemented improvements within the context of the existing public transportation network. It encompasses both operating and limited capital improvements, and builds on current plans and proposals, forming the basis for a more comprehensive, longer-range 25-year plan.

The focus of this plan began with improving public transit. However, alleviating congestion on Cape Cod requires a multi-modal system-wide approach that addresses both intra- and inter-regional travel and considers public policy and institutional issues. Another critical component to planning the Cape's public transportation resources is consideration of its geographical and economic relationship to Martha's Vineyard and Nantucket. The growth in travel to and from the Islands requires the implementation of effective strategies, which will result in the efficient management of public transportation resources both on and off the Cape, to move people more efficiently and result in less congestion.
As with any public transportation plan, challenges exist specific to the area or region, which must be addressed. For Cape Cod, its unique geography along with its historical and environmental conditions require that this plan address:

- Providing traveling choices to meet the needs of a rapidly expanding year round population;
- Facilitating connections between various travel modes;
- Supplying alternative services between Cape Cod and other regions, including the Islands of Martha's Vineyard and Nantucket;
- Ensuring that any infrastructure investments are in keeping with the character of Cape Cod and the Islands, and are supported by a majority of the public; and,
- Meeting Health and Human Services mobility needs for access to employment, healthcare, social services, family support tasks, and education.

The plan focuses on meeting intra-regional and inter-regional travel requirements. It is vital to recognize that planning for Cape Cod and the Islands must be undertaken to include a larger regional context including Boston, New England, and the New York City metropolitan area. This distinction is made to ensure that the mobility needs of Cape Cod and the Islands' year round residents are addressed while planning is conducted to help alleviate the increasing levels of congestion, as more people have discovered Cape Cod and the Islands as year-round retirement, and vacation destinations.

Included in the plan were several recommended projects that may impact congestion and safety in the portion of Route 28 examined by this study. These recommendations include:

"Attractions" Shuttles
One relevant proposal is to provide ride-sharing services that would be marketed to "whale-watchers" or "seal watchers" heading for Chatham and Provincetown excursions from the mid-Cape area as well as to other Lower/Outer Cape attractions such as the National Seashore. These potential customers generate thousands of vehicle miles of travel throughout Cape Cod. By creating a service that allows individuals to access reliable and timely service from major locations in the mid-Cape starting in Hyannis to the various private whale-watching operations and other attractions, there could be a significant reduction in vehicle traffic.

To be effective, the program needs to operate on cooperative agreements between private bus company(s) 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.

Local Transportation Centers
Another 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 proposed 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.

A proposed transportation center in the Outer Cape may divert traffic from the study corridor by helping to provide viable options to driving. This facility would be in addition to the recently completed Hyannis Transportation Center, and would be developed at a much smaller scale in 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 Route 28 Hyannis to Orleans (Green Line) CCRTA service, the proposed service for the Outer Cape (Flex), and the proposed shuttle services to Outer Cape attractions.

6.7.2 Flex Service

This service began as a recommendation from the Cape Cod Five-Year Public Transportation Plan as a conventional Provincetown-Orleans bus service. The CCRTA and the Cape Cod Transit Task Force have been refining this proposed Outer Cape bus service. The service will consist of a flexible route concept called route deviation and include the following seven towns: Provincetown, Truro, Wellfleet, Eastham, Orleans, Brewster, and Harwich.

Route deviation is a transit design concept that allows for service based on a fixed route with scheduled stops along the way. A certain amount of schedule time is added between time points to allow deviation from the route to pick people up on a demand response basis. The service, expected to begin operation in May 2006, will include a short portion of Route 28 between Sisson Road and Bank Street. This will allow transfers to occur between the Flex and the Hyannis to Orleans Route as well as the ferries that operate from Saquatucket Harbor.

6.8 Roadway & Intersection Improvements

In the design of intersections and roadway improvements, amenities such as bus turnouts and passenger waiting areas must be considered as well as sidewalks, bicycle lanes, and bicycle-activated traffic signals. 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 four towns' 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 four towns.

The estimated cost of providing transit turnouts and shelters may be $400,000. This is based on 16 turnouts at $5,000 each and 16 shelters at $20,000 each.

6.9 Action Plan

The following table presents a summary of recommendations to improve traffic flow and safety along Route 28 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.

Summary of Recommendations

Location	Improvement/ Description	Time Frame	Benefit	Cost $1,000
	Roadway			
Route 28 Intersections	**Signal Optimization:** Retime signals and add phases necessary to reduce delay. Improvements include: • Optimization at 6Yarmouth intersections, 2 Dennis intersections, 2 Chatham intersections. • Add left turn phases and modify other phases at 1 Yarmouth intersection	Short Term & Continuing	Mobility	20 - 100
East Main St (Yarmouth)	Replace existing signalized intersection with properly designed roundabout	Medium Term	Safety	330
Upper County Rd & Division St (Dennis)	Remove Upper County Rd signal, turn restrictions, new traffic flow pattern	Medium Term	Safety & Mobility	25
George Ryder Rd (Chatham)	Realign approaching roadways, signalization	Medium Term	Safety & Mobility	450
Route 28 Intersections	Various improvements including upgrades to lane markings, signal heads, access management, pedestrian phases and crosswalks.	Medium Term	Safety & Traffic Flow	25 per intersec -tion
	Public Transit			
Route 28 corridor – Yarmouth to Chatham	**CCRTA Transit Service:** Enhancement & coordination with Hyannis-Orleans "Breeze" route (Green Line).	Short Term & Continuing	Mobility	30 – 60 /year
Route 28 Corridor	Provide bus turnouts and shelters at strategic locations (to compliment local services and destinations)	Medium Term	Mobility	400
	Operations/Management			
Route 28 Intersections	**Opticom System:** Install optical sensors to trigger green phases at signals by emergency vehicles	Short Term & Continuing	Safety	60
Area-wide	**Education:** Information campaigns including media and signage to encourage safe driving and alternate mode use	Short Term & Continuing	Safety & Mobility	up to 262
Route 28 Corridor	**Enforcement:** Highly visible enforcement of speed limits, red light running, etc.	Short Term & Continuing	Safety	5
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	800 +10 /year
Route 28 Corridor	**Access Management:** Increase frontage requirements, provide incentives to share access, increase land conservation.	Medium Term	Safety & Traffic Flow	250-500

Area-wide	**Older Drivers' Recommendations:** incorporate protected left-turn phases, reflective striping, street cleaning, larger lettering on signs, improved and consistent lighting per RPP standards and limitations of unnecessarily distracting signs	Medium Term	Safety	1,480 +50 /year
Route 28	**Permanent Traffic Counting Stations:** Installation of equipment to continuously record traffic flows at 3 locations: • Barnstable/Yarmouth town line • Yarmouth/Dennis town line • Harwich/Chatham town line (west end)	Short Term & Continuing	Traffic Flow	21

A variety of improvements are recommended in the various towns' Local Comprehensive Plans (LCPs) and also should be considered for implementation. A summary of LCP transportation recommendations is included in this report.