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DRAFT REPORT

Comprehensive Harbor Management Plan

Chatham, Massachusetts

18 May 1990

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Prepared For:

Town of Chatham, Massachusetts

Prepared By:

Horsley Witten Hegemann, Inc.
Post Office Box 7, 3179 Main Street
Barnstable, MA 02630
(508)362-5570

Aubrey Consulting, Inc.
Suite 2-3
350 Gifford Street
Falmouth, MA 02540
(508)457-0810

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Introduction

The Cape Cod Chronicle

EROSION

HARD vs. SOFT SOLUTIONS

Past experiences make Chatham officials wary of permanent structures

Shellfish shock

Summer may be bleak if closures not reversed

by Tim Wood

CHATHAM –Shellfish Constable Stuart Moore doesn't see the fact that the town's overall shellfish landings have remained constant this year as ... sarily a good thing. Due to state admi... sures of two important, produc... fish that are being ha... more concentrated ... resource.

And if the Mono... are not reopened by t... dollar industry could b...

"If that remains c... effectively," said shellfis...

The impact of last Oc... sures — imposed by the ... F...heries on shellfish bed... ...alth where shoreline... ...not completed — wa... ...ained Moore. Sev... ...Champlain flat... ...d up at abou... ...n mussels ... ...stry afl...

But on... time shellfish... Oyster Pond wi... possibility that C... sometime during the s...

To help ease the situ... director Robert Duncanson ... DMF recently to obtain the wa...

(Con...

Access becomes issue of boat yard parking

By DAVID CURRAN
Cape Cod Newspapers Staff

Assistant to... Charleen ... to ...

...er has not been ...he town.

...t I'm waiting to ... say," Lambert. ... want them to ...nment on the

...rman of the ...s committee, ...eached for ... Lambert ...iscuss the ...rd at its ...y (March

...lan in- ...r re- ... The ... and ...ned ...ced ...ng ...t- ...s

... gravel- ...r to leach ...e environmen- ...nd arrangement than ...phalt, concrete or other hard surfaces that produce road runoff, according to Lambert.

Friends of Trees, Inc. is expected to handle plantings for green space incorporated in Lambert's plan. ■

... affairs ... Friday the ... board has the ...e the handicap ... requirement, but that

Board backs marina for Old Mill Boat Yard

Watercraft bylaw ... be strictly enforced

By DAVID CURRAN
Cape Cod Newspapers Staff

Traffic tickets for Jet Ski riders.

A proposed bylaw regulating the ...se of personal watercraft would give the harbor patrol the authority to issue non-criminal citations ... violators.

If the bylaw is passed at the annual town meeting (Article 42, Section E on the warrant), expect ...rict enforcement, according to ...aterways committee chairman ...ichard Miller.

"We've asked the police de...artment to really step up vigi...nce," Miller told the selectmen ... outlining the bylaw April 10. "Frankly, I'd like to see a whole slew of successful violation citations so we establish record for these waters."

> "The townspeop have given this matter much consideration, a feel that this byl is necessary for preservation of bay..."

Miller said the propos... is a rewritten versior... state's personal watercr... lation. He said it address... problems — speed, pro...

Please tur...

...projects avoid the use of impervious ...

"I can categorically state that we'll not allow

State plans to help with harbor study

...share fr... need... ...in

By DAVID CUR...
Cape Cod Newspapers ...

The state has agre... tribute $55,000 to study ... bility of creating a federal c... in Chatham Harbor.

Leslie Lewis of the state Department of Environmental Management's Division of Waterways confirmed Friday that the agency will match the local contribution to the U.S. Army Corps of Engineers feasibility study. The study carries a total price of $220,000, half of which must be covered by non-federal funds.

All that remains to get the study under way is for the town to decide to provide the remaining $55,000. According to selectmen chairman Andrew Young, the money is available under a two-year-old town meeting appropria... He said the selectmen would ...bly discuss the issue at their ...meeting yesterday (April

...ves of the corps of ...pril 8 with town ... the feasibility ... meeting ... study's ... take ... com- ... begin ... Young

Pleas... page 1...

Friends Of Chatham Waterways Fund Harbor Study Pr...

Chatham's personal watercraft ban is overruled

New state law regulates Jet Ski operation

Closures frustrate shellfish board

New state policy may further cut open areas

By DAVID CURRAN
Cape Cod Newspapers Staff

First it was administrative closures. Now Cape shellfishers have learned of a new interstate policy banning shellfishing near marinas.

Shellfish warden Stuart Moore told the shellfish advisory committee last week that the Interstate Shellfish Sanitation Co...ence policy is scheduled to go into effect July 1. ...that its details have not been finalized.

"You won't be abl... ...inas," Moore summed up

The definition ... docks, slip... said.

> "The good news is (the definition of marina) is not going to (include) mooring areas, which is what we were all afraid of."
> —Stuart Moore

areas open," Moore said, explaining the state, citing staffing and money shortages, does not expect to be able to do the water quality testing necessary to allow the areas to open.

"What bothers me," Moore added, "is right away ...re locked into the fact that they're not going to ..."

...ssed particular concern over the ... Along with essentially all of ...re, the island was ...uality testing

Stage Harbor dredging contract finally signed

CHATHAM—After more than a year of delays, it ...s like the clogged Stage Harbor entrance channel ...nally get dredged this spring.

Army Corps of Engineers has signed a con... ...he work with Maitland Brothers, Inc., a ... Pa., firm working out of New Bedford. ...oy Clark of the Navigation Division at ... England office in Waltham, the ...s forwarded to the company last

...osed to be done last year, but ... deposition of dredge spoil ... areas on Harding's Beach

...eveloped this year when ...nd low bidder for the work, ... Brothers' status as a small busi... ...ed in favor of Maitland Brothers, ...ppealed that decision. Federal regula... the contract to go forward while the ... pending.

...ark said there was also a problem with the Labor Relations Board. Although he did not know the details, he said it was resolved.

Based on a pre-bid survey, the ... dredging 130,000 cubic yards ...

150-foot wide entrance channel, providing a depth of 10 feet at low tide. Shoaling has so constricted the channel that, even at high tide, there is barely a few feet of water in some areas. The Coast Guard was forced to relocate its 44-foot motor lifeboat from Stage Harbor to Saquatucket Harbor in Harwich this winter because it could only navigate the channel a few hours a day.

Since Stage Harbor is a federally-maintained port, the Army Corps will pick up the entire cost of the project, estimated at $626,000, although Clark said that figure could change depending upon the amount of material that must be dredged. He could not say when the work would begin.

"The sooner the better," he commented. "... can't wait for them to start. We're already ... where we wanted to be." The contract sp... the work will be completed 75 days ...

Mark Forest, an aid to C... Studds (D-Cohasset), credi... officials, local fish... the project ... Pet...

Beach access a hot issue

6/1/86

FROM WIRE REPORTS

7/23/87

Chronicle

Waterways Commission stalled on town landing concessions

...ber of calls and letters," ...e added, "It's important f... ...w just how strong the inte...

CHATHAM

Vessel grounding illustrates dredging

U.S. Wildlife and Stage Island residents spar over property access

6/26/86

by Tim Wood

CHATHAM -- A Stage Island property owner... damaging property.

Raymond Caefer, a trustee of the Stage Island

Fishermen Running Out Of Room

6/3/86

Until a few years ago, Chatham's tub trawlers could straighten the spools of their stiff, new nylon fishing line by unrolling it along the old railroad's right of way.

But that strip of uninterrupted space, so perfect for conditioning the miles of line used in commercial trawling, has been appropriated for recreational use by the town.

Likewise, a bike path will cut through a 10-acre lot of private land where trap fishermen used to spread their nets, each measuring up to 200,000 square feet, to dry and mend every fall. And condominiums have usurped a tract of open space once available to them on a lot in West Chatham.

It is a trend, said ... Abreu, that those as... ...n can see ... used by ...tinuing ... other ... the

can't compete with the offers being ... today for these tracts by developers.

"We see a problem arising ... ...d by fishermen to dry their nets a... she said. "It will reach a ... will be sold and he wil..."

Another aspect of ... house lots on the ... being what it is ... she said. "Sto... you would ...

"You ... $100 ... sh...

10/9/86 CCCH

Storm run-offs causing problems Cape-wide

by William F. Galvin

BOURNE–Shellfish closures such as the one ... the Oyster Pond in Chatham are becoming an ... frequent occurrence, members of a state ... subcommittee on storm water run... local officials on Friday.

A hearing on the is... of that subcom... Cahir(D. Bourne... corrective measu... water and shellfis... assist in funding th...

But, while discu... ing funding to take ... water runoff, Chatha... Abreu learned funding m... for assistance in the Oys...

At the end of that meet... of the state Division of Wat... there is legislation in the ...

In re... several w... Committ... to authori... Committee ... among vari... industry.

The appo... ...ttee member... scheduled to ... a week, according ... Selectman Wil... ...nfield, and will include town officials and pri...ate citizens associated with the fishing industry.

The committee's purpose, Mrs Abreu said, would be to help the industry avert a space needs crisis in the future.

"We would look for a space in town that would be accessible to commercial fishermen to continue drying their nets and storing pots," Mrs Abreu said

Five town landings declared substandard

8/28/86

CHATHAM–Massachusetts Secretary of Environmental Affairs James S. Hoyte has issued substandard designations for five town landings, clearing the way for the town to apply for state grants to upgrade the facilities.

The Barn Hill Road landing, Ryder's Cove landing, Crow's Pond landing, Mill Pond landing and the Mitchell River boat launch were declared substandard due to erosion, lack of parking and inadequate launching facilities, according to a letter from Hoyte.

Hoyte refused to grant a sixth designation, however. The Chatham Waterways Advisory Committee had sought the designation for the westerly side of the Morris Island Road dike in order to provide public access to Stage Harbor. Hoyte's letter pointed out that there are too many environmental concerns to allow construction of a town landing at that site.

"The Massachusetts Wetlands Protection Act also protects coastal dunes, beaches, saltmarsh, land containing shellfish and fisheries, all of which abut the dike," Hoyte wrote. "The Chatham Natural Resources Officer has stated that the abutting flats are productive shellfish areas for recreational harvesters. The likelihood of attaining permits for the construction of a boat launching facility and an accompanying parking lot at this site are slim.

"I realize that there is no public launching ramp to Stage Harbor ... However, the sensitive and fragile nature of the coastal resources at the dike rec... a high level of environmental protection over access at this site. For these reasons, I encou... to concentrate your efforts at improving t... existing public town landings," Hoyte ... Waterways Advisory Commi...

...m to ... was ... claimed ... were ...nd that unreas...ble noise ...ps were transported past their

... judge ruled in favor of Mr Koski, ... of lobster pots was a "customary home ...cifically allowed by special permit in Mr ...g district and by the town's bylaws.

...e watched other towns pass bylaws prohibiting ...ge of pots in residential areas," said Mr Bassett. ...nam has traditionally supported its fishing fleet, but ... face as well as the mentality of the town is changing. We are faced with a change, possibly from a commercial fishing industry to a private boat basin."

Trap fisherman Paul Lucas bought 30,000 square feet of industrial property just over a year ago to contain a business that has grown over the past 25 years. But this year, he said, he couldn't have afforded to provide for his own space needs.

"Prices are rising that fast," he said. He, too, mentioned the case of John Koski

INTRODUCTION

The sun sets over the mud flats on Harding's Beach. The air is warm and smells of low tide. Land earlier inundated is now visible and its creatures appear. Here the harbor is rich with varied natural life. Myriads of small fish dart through the shallows at the edge of the marsh. It is a fine thing to live near the water.

I think back to days as a child digging for quahog with a bucket and bare hands. I think about the sea and its changes. I think about the harbor and its changes. I look up and see a vessel grounded at the mouth of Stage Harbor. In time the coast guard arrives.

The beauty and solitude of a walk along Hardings Beach is one of the simple pleasures which Chatham's residents and visitors know. There are other pleasures too, like swimming, fishing and boating in the harbor's waters. The harbor is a source of recreation and livelihood.

Will these opportunities be available for future generations to enjoy?

People ask "why harbor planning?" The newspaper clippings give some indication: shoreline erosion...marinas...shellfish stock...watercraft ban...storm runoff causing problems...town landings declared substandard...beach access a hot issue... Whereas once it seemed that the harbor offered plenty of space and resources for everyone, today conflicts over its use have arisen. Chatham officials and residents are faced with its limitations, and realize that decisions cannot be made without considering their impact on the entire harbor system.

There are several benefits to adopting a harbor management plan. Perhaps the most important is that the information and analyses conducted as a part of this study will allow town officials to better determine the impacts and land and water use decisions on the harbor's activities. Chatham's Stage Harbor supports a variety of uses including recreational boating, swimming and shellfishing. This harbor management plan provides guidance as to how to retain these uses.

The harbor management plan will also allow town officials to better plan for capital improvements. For example, the plan examines the current condition of, and projected need for, various facilities and improvements of the harbor area, such as public fishing piers, pump-out stations, town landings, beaches, etc.

Third, the harbor management plan will ensure that Chatham's goals and objectives for future development will be met. The Massachusetts Waterways Regulations (310 CMR 9.00), is implemented by the Department of Environmental Protection, and oversees waterway and tidal development. These state regulations are currently being revised to better incorporate the development goals of coastal communities. According to proposed revisions to the state regulations, in cases where communities have adopted an approved harbor management plan, waterways licenses will generally only be granted for developments which are consistent with the local plan.

Last, adoption of a harbor management plan may aid the Town of Chatham in receiving federal funding for projects. Under federal law, coastal projects, such as the dredging of Stage Harbor, must be consistent with the policies of the Massachusetts Department of Coastal Zone Management (CZM). The local harbor management plan is considered the local expression of those policies. Therefore, actions and improvements specified in local harbor management plans are more likely to receive federal funding.

This harbor plan defines the issues surrounding use of Chatham's Stage Harbor system. The Stage Harbor complex consists of Stage Harbor, Mitchell River, Mill Pond, Oyster River and Oyster Pond waters, and includes one of Chatham's most productive estuarine systems. These waters, and the land areas which are functionally tied to them, are defined as the Stage Harbor system. In order to address these issues and gain a better knowledge of the interrelationships between activities in the harbor and its surrounding land uses, an inventory and analysis of the natural and man-made resources which make up the Stage Harbor system has been conducted. Based upon scientific analysis and input from town residents, goals for future use of the harbor system have been determined and future actions are proposed. We invite you to read on.

Harbor Issues

Through discussion with town officials and residents, including fishermen and marina owners, the Harbor Planning Committee has identified several issues facing the Stage Harbor system which must be addressed, before its fishing productivity and recreational assets are lost. This harbor plan attempts to resolve these issues.

1. Public Access to the Waterfront

The vast majority of shoreline property in Chatham is privately owned. Intensive residential development has limited both residents' and visitors'

use of the shoreline. Private property rights often extend to mean low water and many beaches are posted against trespassing.

Town Landings

There is a tremendous demand for water-related recreational facilities in the Stage Harbor system: piers, boat launching facilities, moorings, swimming areas. While the Town owns nine landings and numerous other access points to the harbor, the use of these areas is constrained by very limited parking. There have been complaints from some abutting property owners about parking and trespassing on private property, and overuse of some landings has caused damage to dunes and wetlands.

Needed Services

Mooring space is extremely limited, especially in the inner part of Stage Harbor, the Little Mill Pond and the Oyster River. There are also very few mooring facilities available for transient boaters. Other necessary services such as water, fuel, dinghy storage and boat launching facilities are also in great demand. While access to Stage Harbor has been improved considerably by the Town's acquisition of Old Mill Boatyard, provision of necessary services there will require daily staffing. Someone must be available to supervise activities at the pier while the Harbormaster handles his myriad other duties on the water.

2. Navigation and Harbor Safety

Aids to Navigation

The responsibility for navigation and harbor safety in Chatham is divided between three separate entities: the Harbormaster, the Harbor Patrol (Chatham Police) and the United States Coast Guard. The Harbormaster oversees all activities in the harbor. One of his primary responsibilities is maintenance and installation of aids to navigation with authorization from the Coast Guard. Because Chatham has such an extensive network of waterways, and because conditions are so changeable, it is both time-consuming and expensive to manage the maintenance and the required moving of navigational buoys.

Law Enforcement Search and Rescue

The Harbor Patrol is responsible for law enforcement on the water including the 5 mph speed limit which applies throughout the Stage Harbor/Oyster River/Mill Pond area during the summer months. The Coast Guard handles emergency search and rescue operations but they do not routinely tow vessels

in trouble unless it is a life threatening situation. The commercial fishermen generally have to rely on other members of the fleet for assistance since there are few commercial operations on Cape Cod which can tow large fishing boats. There is a need for good communications among Town officials and the Coast Guard, especially regarding overdue vessels.

Moorings

The Stage Harbor system is heavily used for mooring boats. Since the breach in North Beach there has been increasing pressure for moorings in the protected inner harbor areas. The Town has established mooring regulations as part of its Waterways Bylaw. Under these regulations the Harbormaster assigns the location and approves the type and adequacy of every mooring. However, it is difficult to implement an overall mooring plan because seasonal moorings are installed by individuals. The Harbormaster does not have the manpower to supervise installation so actual locations may not conform to a theoretical layout plan.

Conflicts in Use

The Stage Harbor system supports a wide variety of activities including swimming, sailing, windsurfing, waterskiing, jet skiing, pleasure boating, and both commercial and recreational fishing and shellfishing. There are numerous existing and potential conflicts of use in various parts of the harbor. The worst problems with congestion occur in the bottleneck at the channel entrance to Stage Harbor. The use of windsurfers and small sailboats in or near navigational channels can also pose safety hazards in that large motor vessels cannot easily maneuver around smaller craft. Jet skis and waterskiing can create noise problems and safety hazards for swimmers. There is a need to coordinate the location and timing of various activities and to educate users about safe navigational practices.

Dredging

Maintaining adequate water depths for navigation has become a serious problem in several Town waterways. Chatham Harbor and Aunt Lydia's Cove are in need of dredging due to the shoaling from the North Beach breach. Likewise, the channel entrance to Stage Harbor has deteriorated substantially since it was last dredged in 1987 and it needs to be cleared again. The Oyster River has also been slated for dredging for a number of years but funding is not yet available. There may be other parts of the harbor which will require dredging in the future in order to provide adequate depths for launching and operating boats.

Disposal of Dredge Spoil

The permitting process for dredging and disposal of dredge spoil is extremely cumbersome and time-consuming. The Harbormaster and Waterways Committee have spent considerable time and effort securing the necessary permits and funds for various dredging projects. Dredging and disposal of spoils also have to be evaluated in terms of their environmental effects: impact on wildlife habitat and shellfish beds can be significant. This may be of particular concern in the Oyster River.

3. Commercial Finfishing and Shellfishing

Commercial finfishing and shellfishing are a very important element of Chatham's economy. It is estimated that the fishing industry brings in approximately $6.4 million to the Town's economy annually. The majority of Chatham's fishing fleet is based on Chatham Harbor, working out of the municipal Fish Pier. The Fish Pier serves approximately eighty (80) commercial fishing vessels, a fluctuating commercial shellfish fleet of 50-100 vessels, (fleet size determined by season and available shellstock) and two local seafood companies who lease and staff the fish packing houses with an additional space provided at the Pier for independent dealers. In addition, the Fish Pier offers fuel, ice, and water services to both the fishing fleet and hundreds of private sports fishing and pleasure boats. The Fish Pier is also a major tourist attraction in Chatham, providing the only direct viewing of the fish off-loading and packing process on lower Cape Cod.

Breach in North Beach

Changes in water current and sediment deposition resulting from the 1987 breach of North Beach have made use of the municipal Fish Pier increasingly difficult. The channel through the new inlet is treacherous and changeable. Currents in the harbor are more powerful and the Fish Pier and many of the moorings are exposed to ocean swells. This has made docking difficult and boats moored in the harbor are at risk: If they break loose from their moorings, they could be washed out with the tide or smashed up against the rock revetments which now line the shore. The breach has also caused serious shoaling problems in Chatham Harbor and has contributed to the deterioration of the Stage Harbor entrance channel.

Stage Harbor Facilities

Problems with the use of the Fish Pier have placed greater demand on Stage Harbor to provide fishing off-loading and packing facilities. Currently, there are several trap fishing companies which operate out of Stage Harbor, using

the Eldredge Pier and adjacent properties for off-loading of fish. Stage Harbor may be needed as an alternative site for the main fleet if conditions worsen in Chatham Harbor. The winter months are the most difficult for the fishing fleet due to the easterly and northeasterly storms which occur at that time of year. Stage Harbor could serve as an alternative mooring site for the fleet during the winter. This would not conflict with recreational users since it is off-season. However, ice could be a serious problem during a cold winter.

Shellfishing

Shellfishing is not only an important segment of Chatham's economy but it is also one of the key recreational activities offered by this seaside community. The Stage Harbor system is Chatham's primary shellfishery. However, portions of the Oyster Pond and Stage Harbor have been closed periodically to shellfishing due to pollution problems.

In 1989, 259 commercial shellfish permits, 1,236 resident family permits and 335 non-resident shellfish permits were issued by the Town. More than 25,600 bushels of shellfish were harvested for an estimated wholesale value of $1,106,885. The Shellfish Department uses a substantial portion (45-50%) of its operating budget for cultivation, propagation and transplanting of hatchery, natural and contaminated shellstock. It is essential that the resource be protected in the future.

4. Water Quality and Natural Resource Protection

Chatham's waterways and ponds are the Town's greatest asset. Water-related recreation, tourism and fishing are the mainstays of the local economy. Thus, protection of water quality is of paramount importance in preserving Chatham's character and appeal.

Pollution Sources

Over development and resulting pollution threaten the aesthetic and recreational appeal of Chatham's waterways and endanger the productivity of these waters for fishing and shellfishing. Sources of pollution include effluent from failed septic systems in coastal areas, stormwater runoff from roads and parking areas, fertilizers and pesticides used on lawns and golf courses, animal wastes, chemical contamination from careless disposal of household hazardous wastes, and oil and gasoline spills from motorboats and marinas. It is often difficult to detect the sources of contamination and it can be very expensive to correct the problems, once identified.

Stormwater

Stormwater runoff is a major cause of shellfish closures. Stormwater collects oil and gasoline, animal droppings, bacteria and all types of debris from paved surfaces and carries these materials through the collection system into the harbor. This is a particular problem in the Oyster Pond. The storm drainage system for the entire downtown area empties directly into the pond. The eastern end of the pond (approximately 12 acres) is annually closed to shellfishing. The remaining 103 acres is closed during the summer and fall seasons each year.

Shellfish Closures

Part of the problem with shellfish closures relates to the testing methods used by the Massachusetts Division of Marine Fisheries. Test sites are not necessarily located where the shellfish beds are located. If mean fecal coliform counts exceeding 14 organisms per 100 milliliters are found in the water, large areas may be closed to shellfishing. It is not clear that these sweeping closures are warranted. Moreover, there is considerable evidence that wild animals and birds are causing high counts in some areas. This is a source which is difficult to control.

Septic Systems

Failed septic systems in coastal areas are another source of surface water pollution. The Board of Health currently requires that septic systems be inspected prior to transfer of title but this regulation only identifies failed systems when a property is sold. A more comprehensive inspection system is needed with priority given to properties in coastal areas.

There are numerous other sources of water pollution which need attention. Overuse of lawn fertilizers and pesticides near surface water can cause problems. Buffer strips of natural vegetation are needed to filter out nutrients. Sewage discharge from boats is also a potential hazard. Chatham currently has not pump-out facility for marine holding tanks. While there are not many live-aboard boats in the harbor, visiting boats could have a significant effect in the summer. Animal droppings on beaches and in areas which drain towards the harbor are also a real concern.

Public Education

There is a need for public education regarding water quality issues. Residents need to understand how to responsibly use fertilizers and pesticides, where to walk dogs and the necessity of cleaning up after them. Likewise, feeding of

waterfowl should be discouraged. There is also a need to educate both residents and visitors about dumping trash and sewage in the harbor.

Fueling Operations

Finally, fueling operations at the various marinas need to be handled carefully. Tanks must be inspected on a regular basis and the dispensation of fuel should be carefully supervised.

5. Recreational Use of Waterways

The Stage Harbor complex accommodates a wide variety of recreational uses, including sailboat races, swimming, fishing and shellfishing, windsurfing, scuba-diving, water-skiing, jet-skiing and pleasure-boating. There are four private marinas which serve the area: Chatham Yacht Basin, Oyster River Boatyard, Stage Harbor Marine and Mill Pond Boatyard. All the marinas offer basic services: launching, hauling, repairs/maintenance and storage. All but Mill Pond Boatyard have fueling facilities. None of the marinas have pump-out facilities for septic holding tanks. Available parking is variable, depending upon the season. Areas used for boat storage in the winter can often be used for parking during the summer months.

Marinas

The demand for marina facilities is growing. Virtually all the boatyards have waiting lists for available slips and moorings. While an expansion of facilities may be desirable, the permitting process through local, State and Federal regulations is very cumbersome and time consuming. Moreover, the demand for recreational facilities has to be balanced with natural resource protection. The federal government is now requiring precautionary closures of shellfish beds around marinas, so any expansions must be carefully evaluated in terms of their effects on shellfishing.

Dockominiums

At present there are no dockominiums in Chatham; all of the marinas rent their slips. There is some concern that the extremely high land values along the shore could force conversions to dockominiums, and that marina services could be lost. The dockominium concept provides a quick way to recapitalize a business in the short term. One possible consequence of such a conversion could be an increase in live-aboard vessels in the harbor with the accompanying problem of sewage disposal.

Transient Moorings

At present there are only a limited number of moorings available for transients in Stage Harbor. Visitors entering the harbor can call on Channel 16 and contact either the Harbormaster or Stage Harbor Marine. If an assigned mooring is not being used it is sometimes possible for visitors to use it on a temporary basis. The outer harbor can be used for open anchorage.

Water Transportation

There is limited public water transportation in Stage Harbor, Oyster Pond and Mill Pond. Outermost Harbor Marine in Chatham Harbor offers shuttle transportation to South Beach and Monomoy Island. Stage Harbor Marine offers a launch service within Stage Harbor, and can service the other ponds as needed.

6. Land Use and Visual Character

Water-Dependent Uses

Virtually all of Chatham's shorefront property is residentially zoned. However, there are many existing non-residential uses which depend upon, or at least benefit from, water frontage. The fishing industry utilizes the Municipal Fish Pier, the Bloomer, Powell, Eldredge and Hoyt piers in Stage Harbor, the fish shanties on the Oyster River, and numerous town landings. In the Stage Harbor/Oyster/Mill Pond complex, there are four private marinas: Chatham Yacht Basin, Oyster River Boatyard, Stage Harbor Marine and the Mill Pond Boatyard. In addition, Stage Harbor Yacht Club and Monomoy Yacht Club are based in the harbor. As shoreline conditions and the level of water usage change along Chatham's coastline, demand for water-dependent uses will vary. There is little public land available to meet the changing demand.

Residential Development

There are hundreds of private residential properties which abut the harbor. Density of development varies from neighborhood to neighborhood. On the north side of the Oyster River in West Chatham, and in the old village abutting the Oyster and Mill Ponds, lot sizes are quite small, generally 15,000 square feet or less. Along Bridge Street, Cedar Street, out on Stage Neck and on Morris and Stage Islands, lot sizes are substantially larger, ranging from 20,000 square feet up to several acres in size. There are very few vacant developable lots left on the waterfront. However, there is potential for

numerous small subdivisions and also for redevelopment of existing properties, most notably conversion of seasonal dwellings to year-round use.

Private Piers

At present there are approximately 115 private piers in Chatham. Sixty-seven (67) of these are located within the Stage Harbor/Oyster Pond and River/Mill Pond and Mitchell River area. Private piers pose problems with public usage of the harbor in that they can impede access along the shore, encroach on shellfish beds and obstruct navigation. For this reason the Town's Zoning Bylaw requires new piers to be seasonal. It also limits their length to eighty feet measured from mean high water, and requires that pedestrian passage be provided along the shore. Still, there are numerous pre-existing piers which do not comply with these requirements.

Conservation Lands

In addition to nine public landings, the Town owns several large conservation/recreation parcels within the harbor area. Hardings Beach provides more than 260 acres of open space between the Oyster River, Stage Harbor and Nantucket Sound. However pedestrian access along the inner portion of the Stage Harbor System is limited due to the private ownership of shorefront property.

Views and Vistas

The Morris Island dike provides access to the clamflats of the inner harbor from the east. Oyster Pond Beach provides a supervised swimming area with bathroom facilities. Views of the harbor are afforded from numerous locations along Stage Harbor Road, Champlain Road, Bridge Street and Morris Island Road. The Town has established the Cedar Street/Champlain Road/Bridge Street/Main Street loop as a bicycle route. In addition, these roads and several others near the harbor are designated as Scenic Roads under MGL Chapter 40.

Natural Resources

The Stage Harbor System contains a variety of natural resources offering excellent wildlife habitat. As land development occurs, especially significant natural resources such as wetlands and endangered species habitat are often altered. Many of these resources provide an essential role in maintaining the environmental quality of the Stage Harbor system and its fisheries.

Sea Level Rise

Concern over the possible effects of global warming have grown during recent years. One serious potential problem associated with global warming is an increase in the rate of sea-level rise. As relative sea level rises, wetlands will naturally migrate inland and upland will be lost. As this occurs, shorefront owners will likely demand protection from the sea and wetland migration to protect their property and structures. Wetlands perform an important function in maintaining Stage Harbor's water quality and fisheries.

The risk of damage from coastal storms is very high and will increase as sea level rises. Lands which are currently at low risk may someday be impacted.

Description of the Planning Process

This Harbor Plan is the culmination of 3 years of hard work directed by the Chatham Waterways Committee and Harbor Planning Committee. Chatham's Harbor Planning Process began in 1988 and was instigated by a lecture given by Ms. Barbara Ingrum from the Massachusetts Department of Coastal Zone Management about the merits of harbor planning. Realizing the importance of harbor planning in a town such as Chatham which relies heavily upon its coastal quality, Chatham's Waterways Committee invited representatives of the local special interest groups to meet with them to further discuss the issue. At this joint meeting, all agreed that the Town's harbors merited intensive study. The Harbor Planning Committee was formed in August, 1988. Members of the Harbor Planning Committee include fishermen, property owners, yacht clubs, marinas, town officials, the director of the water quality laboratory, Harbormaster, Wharfinger, and Shellfish Warden.

The Harbor Planning Committe set up a twice-monthly meeting schedule and began work. For the next 1 to 2 years the Harbor Planning Committee wrestled with Chatham's coastal issues. Public hearings have been held throughout the harbor planning process to solicit ideas and support, and hearings have been lively and well-attended. The first question to be resolved was what would be the limits of the study area? Several sessions were held to determine an appropriate area. Four harbor areas were considered: Pleasant Bay, Chatham Harbor, Nantucket Sound and the Stage Harbor/Oyster Pond/Mill River Complex. In the end, the Harbor Planning Committee felt that it should first address the Stage Harbor Complex since this system contained the greatest variety and intensity of use. Following a public hearing held to discuss their harbor selection with residents, the Harbor Planning Committee focussed on defining the harbor's use issues. These issue statements are revised as additional information is gained. The

current issues statements precede this section. A public hearing was held to discuss the harbor's issues with town residents. During the next sessions, the Harbor Planning Committee prepared harbor planning goals and objectives and held a public hearing to gain public feedback.

After the formulation of harbor planning goals and objectives, the Harbor Planning Committee decided that it was time to seek professional help in assessing the Stage Harbor Complex and formulating an action plan. An article was included in the 1989 Town Meeting warrant to raise funds for harbor planning services. This article passed Town Meeting but was defeated in an over-ride. However, through their open planning process, the Harbor Planning Committee had gained considerable town support for its endeavor. A private non-profit organization, the Friends of Chatham Waterways, raised $27,900 from local residents and donated these monies to the Harbor Planning Committee for the hiring of professional environmental science and planning services.

With the promise of funds, the Harbor Planning Committee drafted a Request For Proposals to environmental science consulting firms for harbor assessment and planning services. A joint proposal submitted by Horsley Witten Hegemann, Inc. and Aubrey Consulting, Inc. was accepted.

Since the hiring of Horsley Witten Hegemann, Inc. and Aubrey Consulting, Inc. in October 1989, both firms have worked with the Harbor Planning Committee to conduct a resource inventory and land use analysis, and to estimate future impacts to water quality and ecological systems based upon local land use regulations. With this information, the harbor issues, goals and policies first formulated by the Harbor Planning Committee were revisited and revised. Finally, with the revised goals in mind, a harbor action plan was developed.

Although this plan contains a wealth of information about the harbor system, there are still many issues to be resolved. Therefore, in May 1990 a Town Meeting warrant is proposed to raise funds to complete this Harbor Plan. The Harbor Planning Committee recognizes that just as the Stage Harbor System is constantly changing, so too are the issues facing it. Therefore, this plan is not intended as the end, but rather the beginning.

Coastal Area Functional Boundaries

COASTAL AREA FUNCTIONAL BOUNDARIES

One of the most important tasks in completing a harbor plan for the Stage Harbor system was the selection of the study area itself. This harbor plan attempts to resolve the major issues affecting the use of the Stage Harbor area. The limits of the study area have changed as the Harbor Planning Committee has wrestled with the harbor's use issues. Originally the study area was defined to roughly include Stage Harbor, Oyster Pond and River, Mill Pond, and the Mitchell River and its associated flood plain. However, it became apparent that additional lands were tied to the harbor. After long consideration, the Harbor Planning Committee recognized that the Stage Harbor system functions as a dynamic resource, and the limits of the harbor plan should include all the land area which is functionally tied to the system either environmentally or culturally.

Five environmental and cultural functional study area boundaries have been defined and mapped (see Functional Overlay Maps #1 and 2). These functional boundaries are used to evaluate the impact of future development to the Stage Harbor system. Based upon our understanding of the interactions occurring within and among these functional boundaries, goals and policies for future development of the harbor and its contributing land area were set, and an action plan was developed. The study area is defined as including all lands within the five functional boundaries and is presented in Map 3.

The following is a discussion of the functional boundaries of the Stage Harbor system:

Environmental Boundaries

Ground-water Recharge Area and Viral Buffer Zone

Ground water is a primary source of water which contributes to the Stage Harbor system. Approximately fifty percent of the precipitation which falls on Chatham's land surface infiltrates (recharges) to the underlying ground water system. The ground water flows with the hydraulic gradient and ultimately discharges to a stream, vegetated wetland or directly to the Stage Harbor system waters.

Ground water provides a steady base flow of fresh water to the Stage Harbor system. This input is important in maintaining water quality within the estuary. The estuaries of the Stage Harbor system serve as important nursery

grounds for the harbor's fisheries. Salinity gradients, nutrient (nitrogen and phosphorus) concentrations, and bacterial and viral counts within the Stage Harbor system's waters are directly impacted by the quantity and quality of the incoming ground water. For example, if a large quantity of fresh ground water discharges into the Stage Harbor system, the salinity of Stage Harbor will decrease.

The ground-water drainage area to the Stage Harbor system was mapped utilizing the regional water table map prepared by USGS (1974) and pond water elevations. As these data are very limited in the study area, ground-water drainage divides were inferred based in part on surface drainage patterns.

Storm Water Drainage Watershed Area

Commercial fishing is a fundamental element of Chatham's heritage and economy. Threats to fishing include overfishing, loss of fishing area due to the presence of docks and piers, dredging and filling, and water pollution. As precipitation falls to the ground it either infiltrates into the soil or flows over the land as surface runoff seeking a lower elevation. Surface water runoff flows over parking lots, roads, sidewalks and lawns, and picks up pollutants such as silt, fertilizers, animal wastes, and other organic and inorganic materials. Storm water with its associated pollutants flows to Stage Harbor, Oyster Pond, Mill Pond and its tributaries and associated wetlands.

Since 1984, Oyster Pond has been routinely closed to shellfishing during a portion of the summer, and in 1989 a portion of Stage Harbor was closed to shellfishing for the first time. Testing of culverts at Oyster Pond has linked the influx of pathogens carried to the pond through storm water to shellfishing closures. It is important that the Town monitor the generation of pollutants in land areas which contribute storm water runoff to the Stage Harbor system either through overland runoff or through the Town's storm water drainage collection system.

A USGS topographic quadrangle map (1974) was used to delineate the Stage Harbor system's surface water drainage area. Because runoff travels from higher to lower elevations the limits of the drainage area include land within the topographic divide for the system. However, accuracy of the delineation is limited due to the large scale (1:25,000 or 1 inch = 2080 feet) of the topographic map and the relatively large contour interval (10 foot interval). On-site testing and analysis is needed to more accurately define this area. It is hoped that in the future Chatham will obtain the funds necessary to conduct a more in-depth delineation of Stage Harbor's surface watershed.

Another key element in determining the storm water drainage area is the Town's storm water collection system. Through the use of a storm water collection system, it is possible that an area which would not naturally contribute to the study area will in fact do so, as a result of collecting drainage and piping it into Stage Harbor, Mill Pond, Oyster Pond and their tributaries. The Town does not possess up-to-date information about the location and design of their drainage collection and discharge system. Without this information only a rough delineation of watershed areas is possible. A storm water drainage study is currently underway, and it is hoped that the study will provide this information. Oyster Pond contains a large storm water culvert located next to the swimming beach. Culverts adjacent to Stage Harbor system waters also exist along Bridge Street.

Sea-level Rise/Coastal Storm Hazard Zone

Public concern over the possibility of global warming and climate change have grown during the past decade. One widely discussed potential impact of global warming is an increase in the rate of sea-level rise. Increases in the rate of sea-level rise will have substantial impact on our nation's low-lying coastal areas, many of which are densely built and populated. As sea-level rises, inland areas will become inundated by the sea. Inland areas, and the structures built upon them, will be lost. Chatham's Stage Harbor shorefront areas are generally developed. The results of an increase in sea level are already being experienced in some areas.

Coastal engineering structures have been constructed to combat the rising sea. Modifications to buildings have been made to minimize adverse impacts. However, buildings and roads are still being lost during storms due to the continued encroachment of the ocean. In some areas the problem is not as severe, since beaches are wide enough to prevent waves from reaching the nearby structures. However, with a continued rise in sea level, many of these areas will also be affected.

Aubrey Consulting, Inc. conducted a preliminary analysis of the potential impacts of sea-level rise on the Town of Chatham. As a first step to show potential impacts of sea-level rise. 5 and 10 foot sea-level rise scenarios have been chosen. Due to the lack of scientific knowledge, it is impossible to provide time estimates of when such rises might occur. There is a general consensus in the scientific community, however, that sea-level rise during the next century will be closer to a 2 foot scenario than the 5 foot or 10 foot scenarios. However, these higher scenarios are realistic when tides and storm surges are considered and therefore should be used when evaluating the impact of sea-level rise on development. For example, the 10 year stillwater elevation for Stage Harbor is 5.2 feet (Federal Emergency Management Agency (FEMA), 1985); a 10-year storm coupled with high tides and sea-level rise may

produce water elevations of more than 10 feet. The lower projections suggest a standard for zoning based on realistic oceanic changes. The higher projections identify those areas susceptible to increased flooding potential during storms.

Cultural Boundaries

Viewsheds

Chatham's character is largely defined by its visual assets. Both residents and tourists enjoy Chatham's small town, fishing village atmosphere and natural beauty.

The viewsheds boundary includes those areas which contribute to Chatham's character and aesthetics, such as areas which are accessible to the public by land and water, and provide scenic views of the Stage Harbor system and its bordering lands.

Three methods were used to map critical viewshed areas:

1) the first method relies upon input from the Harbor Management Committee in mapping locations from roads and public lands from which exceptional views can be accessed;

2) in addition to views of the water from the land, residents and visitors which partake of water-related recreational opportunities define Stage Harbor by their views of the land from the water. The most visual and therefore critical land areas are shorefront parcels. The land use map was used to delineate all shorefront property in the Stage Harbor system;

3) a third scenic area in the Stage Harbor system is its natural topography. As one looks from the water to the horizon you see the graceful, natural topography of the land. Any structure which disrupts the continuity of the horizon detracts from the natural beauty of the Stage Harbor system land area. All land within the natural topographical divide of the Stage Harbor system is important in defining the harbor's topographic views. This land area boundary includes all land within the storm water drainage boundary.

Public Access/Ownership Zone

Public access to the water is of vital importance in Chatham since much of its economy depends on water-related activities such as boating, shellfishing and

swimming. Chatham cannot continue to support a shellfishing industry or provide water-related opportunities to all of its residents without the provision of public access.

The public access zone is defined as the landward boundary of individual parcels which are contiguous with the waterfront. The Town's land use map was used to determine which parcels currently have access to the water, and among these, which are privately, versus publicly, owned.

Inventory and Analysis

INVENTORY AND ANALYSIS

As a part of the harbor planning process, information about the Stage Harbor area's natural resources, marine resources, navigational aids and coastal hazards, and land and harbor uses was collected and mapped. The following section describes the natural and cultural resources of the Stage Harbor study area. The resources and land and harbor use patterns provide both constraints to, and opportunities for, future use of the Stage Harbor system. Chatham is located on the southeast corner of Cape Cod, and is surrounded by water: Nantucket Sound to the south, the Atlantic Ocean to the east, and Pleasant Bay to the north. The town has approximately 66 miles of coastline.

Natural Resources

Chatham's natural resources are a major part of theTown's aesthetic appeal and are used for recreational hiking, swimming and boating by its residents and visitors. The beauty of a sunset over Chatham's wetlands and waters is unheralded. In addition to scenic views, the presence of these resources is a constant reminder of the connection between man and his natural environment. Many people seed confirmation of this link between nature and man when visiting Chatham.

The Stage Harbor study area is comprised of a series of estuarine systems which open to Nantucket Sound and contains many valuable natural resources. The most valuable natural resources for the purposes of harbor planning are wetlands, salt and fresh waterbodies, open lands, and rare or especially sensitive wildlife and plant habitats. The value of the Town's water bodies and wetlands to Chatham's shellfish and finfish industry, and their beauty and function in controlling flooding, make them resources worth appreciating and protecting. Much of Chatham's economic prosperity depends upon the viability of these resources.

Wetlands

Chatham's wetlands, estuaries and waterbodies are important for many reasons, including their ability to moderate flooding, to provide pollutant attenuation, to provide habitat for aquatic and terrestrial plants and animals, and for recreational opportunities. For example, wetlands have the capability to store large quantities of water, which reduces peak flows and helps to moderate flooding, thereby preventing storm damage to coastal properties and lessening erosion. Wetlands may lessen water pollution through the uptake or attenuation of nutrients like nitrogen and phosphorus, and heavy metals.

Wetlands and their associated open waters provide important habitat and nursery grounds for animals, birds, shellfish and finfish. The Stage Harbor system waters provide both soft and hard-bottomed substrate, allowing for the proliferation of shellfish. The variety of resource conditions provide in the Stage Harbor system is one important reason for its high productivity. Species such as quahog *(Mercenaria mercenaria)* and soft-shell clam *(Mya arenaria)* seek soft muddy bottom areas, while oysters *(Crassostrea)*and mussels *(Mytilus)* prefer hard-bottom substrate. The system also supports healthy stands of eel grass (*Zostera marina).* Eel grass provides important cover and food for many aquatic species. Chatham's valuable bay scallop industry is dependent upon the health of its eelgrass, since scallops thrive among these beds. The location of hard and soft-bottomed substrates and the location of eelgrass beds was provided by the Chatham Shellfish Department (1989) and is presented on Map 4.

The approximate location of wetlands in the study area is shown on the natural resources overlay map (Map 5). These locations were transferred from aerial photo maps prepared by the Massachusetts Department of the Environment Wetlands Restriction Program (DEM WRP, 1978). Wetlands in the Stage Harbor system are classified by type: salt marsh, dune, shallow fresh marsh, deep marsh, beach, barrier beach, sea cliff, wooded swamp, tidal flat, shrub swamp and cranberry bog. There may be smaller wetlands in the study area that do not appear on the overlay maps completed as a part of this harbor plan since field surveys were not undertaken. Table 1 summarizes wetland types and acreages in the two study area contributing areas (full details are shown in Appendix 1. Acreages were determined by planimetry from DEM WRP maps.

Wildlife

Wetlands and open waters serve as habitat for other riparian and terrestrial species and are known to support many rare and endangered species of plants and animals. The designations threatened, endangered, etc. are terms applied by federal and state agencies. The term "endangered" is applied to native species considered to be in danger of extinction; "threatened" is applied to native species which are rare or declining in number and thought likely to become endangered in the future; "special concern" is applied to native species that may become threatened; and "rare" is a general term for species that are infrequently observed. In Massachusetts, 321 CMR 8.00 lists regulations governing the use of these terms and specifies procedures for the development of species lists naming plants and animals whose abundance fits these categories. The Massachusetts Natural Heritage Program provides lists of such species to interested people.

The study area includes several special natural resources. The entire Harding Beach area falls within estimated habitat for rare wildlife species that occur in wetlands, according to the Massachusetts Natural Heritage Program atlas (1989). The eastern tip of Harding Beach West supports a seabird colony which includes the Piping Plover (Chatham Open Space Plan, 1985). Piping Plover is a threatened species in Massachusetts. Other rare birds that may be found in the study area include: Least, Arctic and Common Terns (special concern), Roseate Tern (endangered), Northern Harrier (threatened). The Town's current Open Space Plan (1985) lists eight rare plant species found in Chatham; some of these may occur in the study area since most are associated with riparian (land adjacent to water) or wetland areas. A portion of the federal Monomoy Wildlife Refuge also falls within the study area and is an important source of wildlife habitat.

The locations of Chatham's terrestrial resource areas generally coincide with two land uses: designated open lands and vacant undevelopable land. This suggests that many of the natural resource areas are already protected from development for dwellings or commercial purposes. However, additional protection may be necessary to prevent the degradation of these resources from other less direct impacts such as the release of stormwater drainage and its associated pollutants into these systems.

Natural Resource Protection

Some protection of natural resource is provided by existing state legislation and local bylaws and regulations. Wetlands, including barrier beaches, beaches, bogs, dunes, fresh marshes, inland or coastal banks, land under any storm water, land with shellfish or fish runs, salt marshes, salt ponds, sea cliffs, shrub swamps, tidal flats, wooded swamps and the like, are protected by the Massachusetts Wetlands Protection Act (1976), and Town of Chatham Wetlands Regulations (1986), administered by the Conservation Commission. The Wetlands Restriction Program was established to provide greater protection of valuable wetland resources. Development restrictions have been incorporated into the property deeds of landowners possessing lands with these resources. The Town of Chatham has established Conservancy Districts through zoning to provide more significant review of development in these areas. Conservancy districts include all wetlands protected by the Wetlands Restriction Program, as well as Chatham's floodplain areas, fresh waterbodies, and any saltwater shoreline areas not otherwise included. The locations of resources designated as Conservancy District were provided through the Town's Conservancy District maps (Nickerson and Berger, 1974) and are shown on Map 5.

Marine Resources

Shellfish

Chatham's Stage Harbor ecosystem has been described as the "bread and butter" of the Town's shellfishing industry. Residents shellfish for recreational and commercial purposes. Commercial harvesting of bay scallops, quahogs, soft shell clams, and mussels occurs throughout Stage Harbor, Mitchell River, Mill Pond, Oyster River and Oyster Pond. Recreational shellfishing takes place throughout the Stage Harbor system. Residents shellfish for quahogs, soft-shell clams, bay scallops, and mussels, as well as oysters which are off-limits to commercial shellfishermen. The general distribution of shellfish in the Stage Harbor system is presented in Map 6.

Quahogs and bay scallops generally concentrate off-shore in the soft muddy bottomed substrate where eel grass is abundant. The quahog and bay scallop are the two primary monetary commercial shellfish species in Chatham. Quahog production has been consistent from year to year making it the fundamental money crop of Chatham's shellfishermen. Map 7 presents the 1989 distribution of quahogs in the Stage Harbor System, as provided by the Town's Shellfish Warden. Quahogs are found in medium to high concentrations throughout most of Oyster Pond, Stage Harbor, Mitchell River and Mill Pond.

Bay scallops have a 2-year life-span and come and go at random in the system. During their peak years, scallops are a valuable cash crop to the shellfishermen of Chatham. Peak years have, in the past, produced as much as 20,000-25,000 bushels of scallops annually in the Stage Harbor system alone. At present prices, such a catch is worth close to $800,000. As word spreads of the tremendous scallop yields, more residents begin commercial fishing. In a peak year, there have been as many as 550 commercial permits sold in Chatham. Map 6 presents the location of bay scallops. Due to their sporadic nature, scallops do not appear annually in all the areas shown on Map 6, but are traditionally found there. Particular scalloping hot spots are the Oyster River, Mitchell River, the Sears Point side of Stage Harbor and the edge of Island Flat.

Soft-shell clams, oysters and mussels are interspersed along the hard-bottomed shore areas. Soft-shell clams occur in virtually all the intertidal areas of the Stage Harbor system, and occur in commercially-viable quantities in Oyster Pond, Stage Harbor and Mitchell River. Oysters occur sporadically throughout the system, with the greatest concentrations being in the Mitchell River and east of the harbor inlet. Oysters cannot be commercially harvested in Chatham, but may be harvested by family permit holders during all but the

summer months (May 1-August 31) of the year. Mussels occur sporadically throughout the system. Family permit holders may harvest mussels.

Shellfish predators in the Stage Harbor system include horseshoe crab, moon snails, conches and various crabs and drills.

The Stage Harbor system generally contains exceptional water quality, as evidenced by the viability of its shellfishery. However, problems of water quality exist. The northeast portion of Oyster Pond has been annually closed due to high fecal coliform bacteria counts, and all of Oyster Pond has been seasonally closed during the summer months to shellfishing. Closures at Oyster Pond have been linked to storm water contamination. The Champlain Flat area along Stage Harbor was closed for the first time last year due to high coliform counts. The source of coliform has not been determined.

Changes in shellfish productivity are hard to assess due to the natural fluctuation and variation in size of shellfish grounds, as well as changes in harvesting equipment, quotas and the number of permits issued annually. The largest source of fluctuation in production is the sporadic nature of important monetary species like the bay scallop and soft-shell clam. In contrast, quahog production has been consistent and may in fact be increasing over time. Table 2 and Figure 1 present the number of bushels of shellfish harvested annually in the Stage Harbor system since 1975. Anywhere from 275 to more than 500 commercial permits are issued annually town-wide. A total of 305 commercial permits were solid in 1989. It is estimated that 2,000 resident and non-resident permit holders (or approximately 7,000 people) enjoy shellfishing for food and recreation in Chatham.

Figure 1. Stage Harbor System Shellfish Landings

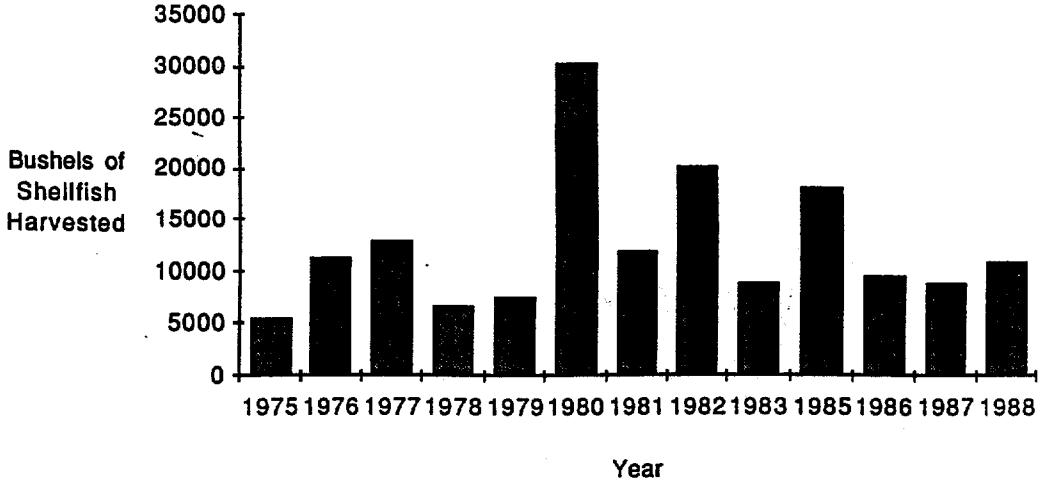


TABLE 2 BUSHELS OF SHELLFISH HARVESTED ANNUALLY

Year[1]	Oyster Pond & River	Stage Harbor	Mill Ponds	Total
1975	503	3,562	1,401	5,466
1976	1,389	8,568	1,314	11,271
1977	4,544	6,827	1,593	12,964
1978	823	4,634	1,312	6,769
1979	648	5,771	1,194	7,613
1980	8,627	19,521	2,267	30,415
1981	995	8,753	2,155	11,903
1982	4,627	13,543	1,985	20,155
1983	798	6,823	1,372	8,993
1985	5,263	10,907	1,960	18,130
1986	1,018	7,829	751	9,598
1987	929	7,395	644	8,968
1988	1,071	9,199	737	11,007

Source: Town Shellfish Department

Shellfish Propagation Program

The high level of shellfish production in Chatham is due both to natural processes and artificial propagation. The Town of Chatham has an extensive shellfish propagation program aimed at increasing the natural productivity of its shellfishing habitat. Through town meeting action and a special act of the legislature, since 1983, 75% of each commercial permit ($150) is put into a special commercial shellfish propagation revolving fund. Monies are used to purchase shellfish stock and supplies, and to conduct shellfish-oriented research. Quahog, oysters and soft-shell clam are currently propagated townwide. The greatest propagation effort is directed toward the cultivation of quahog due to the monetary importance of this species.

Quahog is currently the only propagated species in the Stage Harbor system. Quahog seed have been planted throughout the Stage Harbor water system. In 1989, through an expenditure of $66,000 from the revolving fund, the Chatham Shellfish Department planted 6 million 8-15 millimeter quahog hatchery seeds in the Stage Harbor System. Map 6 presents the location of quahog seeding in 1989.

The Shellfish Constable is responsible for the supervision and maintenance of the propagation equipment and supplies. As of February 1989, the Town

[1]Note: no information available for 1984 shellfish catch

had purchased 24 million quahog seed for townwide propagation. In recent years, it has become difficult to acquire a sufficient amount of shellfish seed from hatcheries. If this situation continues, Chatham may need to consider constructing and operating its own hatchery. The Shellfish Department has begun a reserve hatchery fund to prepare for this need.

Aquaculture

The Stage Harbor system historically had an active aquaculture industry. Private oyster aquaculture grants were active in the Oyster River in the mid-century. However this industry declined as the Chesapeake and New York Oyster became victim to over-fishing, pollution and disease, leading to increased seed costs. Around this time, eel grass also became re-established in the Oyster River leading to a decline in oyster growth and greater difficulty in harvesting. Thus oyster aquaculture ended.

Aquaculture was once again practiced in the Oyster River in the mid-seventies. One private grant holder currently cultivates quahogs and oysters on 3 acres located on the east end of the Oyster River adjacent to Oyster Pond. The location of the grant is shown on Map 6. The aquaculture program has been successful and is expected to continue.

Finfish

The Stage Harbor system serves as nursery grounds for various finfish, and provides great opportunity to the Town's residents and visitors for recreational finfishing. Popular sport species include winter flounder, tautog, bluefish, scup, and striped bass. Anglers fish throughout the Stage Harbor system. In recent years, areas like the bridge on Bridge Street and the sand bar off the Morris Island dike have been especially popular for recreational finfishing.

Coastal Hazards

The natural resources in the study area are dynamic. The shorelines of Stage Harbor, Mitchell River, Mill Pond, Oyster Pond, and Oyster River change with the tides, storms and season. The recent formation of the North Beach Inlet is a clear example of this change. Sea-level rise also leads to shoreline changes.

Coastal management programs are uniquely involved with the protection of lives and property along the coast. Such a program often has the responsibility of controlling coastal development so as to avoid the hazards of storm surge, hurricanes, long-term erosion or accretion, and sea-level rise. Historically, important coastal zone management decisions have been made without the use of vital coastal hazard databases. However, with future

demands on coastal development increasing, it is crucial that new management policies be based on accurate coastal hazard data. Incorporation of these data into coastal management programs will promote decisions and choices whose long-term effects will be beneficial to as many people as possible.

Specific coastal hazards which require careful planning for the Stage Harbor complex include the following: storm related wave activity, long-term shoreline erosion or accretion, sea-level rise, and storm surge and flooding associated with northeasters and hurricanes. Due to its orientation, Stage Harbor is protected by Nauset Spit and Monomoy Island from waves approaching from the Atlantic Ocean. Waves entering Stage Harbor directly from Nantucket Sound are limited to those approaching from the southwest; these waves are commonly generated during the summer months and are associated with low potential energies. Because of the low wave energy, significant trends in long-term shoreline erosion or accretion inside the Stage Harbor system have not been recorded, and will not be addressed in this report. One potential area of concern is the southeast side of the sand dike constructed in 1965-67 connecting Morris Island to Harding Beach. This dike area may be subject to waves from the Atlantic Ocean approaching from the southeast between Nauset Spit and Monomoy Island. Although most waves in this area will break on nearby shoals, it is possible that larger, long-period hurricane generated waves could cause erosion of the dike area. The possibility of direct wave attack on the sand dike will decrease in the future, as the southern portion of Nauset Spit created during the 1987 breach, migrates south toward Monomoy Island.

In order to assess the existence and severity of storm surge and associated wave activity in the Town of Chatham, the Federal Emergency Management Agency (FEMA) conducted a flood insurance study for the Town. This study provides the most accurate and up to date information on flood hazards for the harbor areas examined in this report (Stage Harbor, Oyster Pond, Mill Pond). Results of the FEMA study on flood hazards in the Town of Chatham will be discussed in the following paragraphs.

FEMA Flood Insurance Study

The principal results of the FEMA Flood Insurance Study for the Town of Chatham are a series of nine Flood Insurance Rate Maps. These maps are printed at a scale of 1"=400'. As a part of the current study, information from the Flood Insurance Rate Maps #6-9 were translated onto the Flood Zone and Bathymetry Map of the Stage Harbor, Oyster Pond, Mill Pond complex. This map denotes the 100-year flood boundary as well as the various FEMA flood insurance zones. All elevations shown on these maps are referenced to the National Geodetic Vertical Datum (NGVD) of 1929.

To provide a national standard without regional discrimination, the 100-year flood has been chosen by FEMA as the base flood for flood plain management purposes. The 100-year flood boundary marks areas below which there is a 1% annual chance of flooding (Map 8). The location of the 100-year flood boundary within a given community is determined using a series of sophisticated hydrologic and hydraulic analyses. In the hydrologic analysis, the 100-year stillwater elevation is determined from a synthesis of National Ocean Survey tide gage records and historic high-water mark elevations for major floods. The following storms were used for the Chatham Flood Insurance Study:

September 23, 1938
September 14-15, 1944
August 31, 1954
February, 1978

Hydraulic analyses are then conducted to account for increases in water elevation resulting from wave action. During the hydraulic analysis, wave crest elevations, wave runup, changes in ground elevation, vegetation, and physical features are combined to compute wave envelope elevations associated with the 100-year storm surge. The wave envelope elevations are then added to the 100-year stillwater elevations to determine the elevation of the 100-year flood boundary. This elevation is referred to as the base flood elevation (ft, NGVD). In areas protected from wave action, the elevation of the 100-year flood boundary is simply the 100-year stillwater elevation. The 100-year flood boundary shown on the Flood Insurance Rate Maps, therefore reflects stillwater elevations due to tidal and wind setup effects, and includes the contributions from wave action.

Additional information on the Flood Insurance Rate Maps include flood insurance zones. There are five different categories of flood insurance zones shown on the maps. A zones are special flood hazard areas inundated by the 100-year flood. B zones are flood hazard areas located above the 100-year flood boundary and below the 500-year flood boundary. C zones are areas of minimal flooding located above the 500-year flood boundary. D zones are areas of undetermined, but possible, flooding. V zones are special flood hazard areas inundated by the 100-year flood that have additional velocity hazards associated with increased wave activity. V zones are denoted from A zones when the elevation of the 100-year wave envelope is greater than three feet above the 100-year stillwater elevation. The elevations shown in parenthesis in the A and V zones represent the average base flood elevation in that zone.

Within the Town of Chatham, the following general areas have been designated as V zones: central Stage Harbor, north shore of Stage Harbor, Mitchell River, Oyster Pond River, and the harbor side of West Harding

Beach. These areas will be inundated during a 100-year flood event, and will experience the effects of increased wave activity. The general areas designated as A zones include: Mill Pond, Oyster Pond, and the south and east shores of Stage Harbor. These areas will also be inundated during a 100-year flood event, however, the effects of wave action will be dampened due to sheltering from direct wave attack, or greater distance from the open waters of Nantucket Sound and the Atlantic Ocean.

These maps contain a variety of important information which coastal managers and town officials can use to develop sound floodplain management policies. Mechanisms such as building setbacks, increased construction standards, evacuation planning and development of early warning systems can be used to improve protection of property and life from natural coastal hazards. Minimum setbacks of coastal development from the shoreline reduce damages from flooding and wave action. When development is already located in hazard prone areas, coastal programs can assist in evacuation preparation or even relocation of structures.

Effects of Sea-level Rise upon Wetlands and Future Development of Shoreline Areas

Scientists project a slow rise in sea-level in the future. As the sea rises, land will be lost and lands once thought to be safe from storm hazards will be at risk. Land most susceptible to sea-level rise is presented on Map 1. The major impacts associated with sea-level rise are the loss of uplands and wetlands, saltwater intrusion into groundwater, and changes in river flow and sedimentation. A rise in sea level will have great impact on low-lying vegetated areas such as the salt marshes along Stage Harbor, the Oyster River and Morris Island. These marshes require periodic inundation of sea water but cannot exist where the land is constantly submerged. An increase in the elevation of the ocean may effectively drown these marshes. If the rise is too rapid, these marshes will not be able to keep up with the rising sea and will perish. However, areas newly inundated by a rising sea may evolve into marsh if conditions are suitable. If sea-level rise is slow, marsh areas simply migrate landward; the vegetation grows on the landward side of the marsh but dies on the seaward side. In the Stage Harbor study area, land above the Oyster River or beyond Hardings Beach may become wetland as sea level rises. If no suitable low-lying upland can be inundated due to the presence of coastal protection structures or bedrock, sea-level rise will result in a loss of marsh.

Upland areas will also be impacted by sea-level rise. Unlike marshes, upland cannot respond to sea-level rise by migrating. Loss of upland is irreversible; once the upland is inundated, the land is lost (unless sea level falls). The amount of upland lost is a function of the rise in sea level and local

topography: the lower the land and greater the rise in sea level, the greater the upland loss.

A rise in sea level will impact the salinity of aquifers. In some coastal aquifers, a freshwater lens overlies the more dense saltwater. The saltwater/freshwater interface is a zone of brackish water. The depth to the interface generally increases with distance from the shoreline: the higher the water table (ie., the thicker the layer of fresh water), the deeper the transition zone. A rise in sea level will cause a recession of the shoreline, and thus a recession of the transition zone and a rise in the fresh water/salt water interface. Already many coastal communities suffer from a shortage of freshwater due primarily to overpumping of coastal aquifers. A rise in sea level will likely exacerbate the fresh water problem by causing additional salt water intrusion into fresh water wells.

Existing Land Use and Zoning

The previous sections illustrate that Chatham is blessed with a great variety of natural resources. The type, intensity and operation of land uses in town will have a direct impact upon the integrity of these resources. For example, industry may negatively impact air quality, while residential septic systems may decrease the quality of ground water. The impacts of uses also change seasonally for tourist-related and summer resident-related land uses.

Land uses in the study area include designated open space; municipal uses; semi-public land (such as schools, churches, and cemeteries); industrial and commercial uses (including restaurants, tourist accommodations, entertainment and retail facilities); and residential lands. The land use overlay map (Map 9) presents the location of differing land uses in the study area, and identifies valuable open space parcels and their ownership. The land area which contributes surface water and ground water to the water bodies in the Stage Harbor system was defined earlier. A topographic divide separates the Stage Harbor study area into two sub-contributing areas. One portion of the study area drains into Stage Harbor and Mill Pond, and the other portion drains into the Oyster Pond and River.

The predominant land use in the Stage Harbor and Mill Pond portion of the study area is single and two-family residential development. Commercial development is concentrated along Main Street, with a limited amount on Stage Harbor. There are also a few Town-owned lands in this portion of the study area. Designated open space and vacant undevelopable land parcels (unofficial open space) are common, and large open areas exist south of Bridge Street and west of Stage Harbor Road. Federal land located in the Stage Harbor study area also provide important open space, and include a small

portion of the Monomoy National Wildlife Refuge and a US Fish and Wildlife access parcel on Stage Island.

In the Oyster Pond and Oyster River portion of the study area, commercial uses of land are confined primarily to the Main Street downtown area of Chatham. Several town buildings are located along Main Street, including the town offices. Other than the Harding Beach West peninsula, designated open space and vacant undevelopable parcels near Oyster Pond and River are not large, but are scattered throughout the area. Residential uses include several multi-family developments as well as single family and two-family units.

The Stage Harbor area provides several beautiful views and vistas. Views of the harbor are afforded from numerous locations along Stage Harbor Road, Champlain Road, Bridge Street and Morris Island Road. The Town has established the Cedar Street/Champlain Road/Bridge Street/Main Street loop as a bicycle route. These roads and several others near the harbor are designated as Scenic Roads under MGL Chapter 40. The viewshed boundary shown on Maps 2 and 3 includes those areas which contribute to Chatham's character and aesthetics. The boundary includes areas which are accessible to the public by land and water, and provide scenic views of the Stage Harbor system and its bordering lands. As Chatham grows and redevelops it is important that it be done in a way which will not destroy its natural beauty and fishing village atmosphere.

Existing Zoning and its Impact upon Future Harbor Uses

The existing pattern of land use reflects the zoning of the study area. Chatham's land within the Stage Harbor area is zoned to allow residential, municipal, small business and general business uses. Chatham's industrial park is outside the drainage area to the Stage Harbor system. The location of each zoning district is presented in Map 10.

Shoreline areas located along the Oyster Pond and River, Stage Harbor, and Mitchell River and Mill Pond are zoned either R-20, R-40, or municipal--with the exception of a Small Business district on Bridge Street. Harding's Beach and Harding's Beach Point are owned by the Town of Chatham and are zoned Municipal. Uses allowed in Municipal districts include: agriculture, conservation, fishing, public education, public utilities and facilities, recreation, religion and municipal uses. All other proposed uses require a special permit. The remainder of the shoreline areas in the Stage Harbor system are residentially zoned R-20 or R-40. The Town's R-20 and R-40 districts allow low-intensity fishing, agriculture and residential uses. Additional uses such as group dwellings, kennels and marina/boatyards are allowed with a special permit. Minimum lot size in the R-20 district is 20,000 square feet, and in the R-40 district is 40,000 square feet.

As mentioned earlier, land located along Route 28/Main Street is within the drainage area of the Stage Harbor system and is commercially zoned. Commercial zones include: General Business-GB1, GB2, GB3 and Small Business-SB. The following minimum lot sizes are required:

	Minimum Lot Size
GB1	5,000 sq. ft.
GB2	7,000 sq. ft.
GB3	10,000 sq. ft.
SB	20,000 sq. ft.

Permitted uses in the General Business districts include agriculture, fishing, marina/boatyards, and general retail establishments. Uses such as gas stations, animal hospitals, nursing homes, kennels, light industry and apartments incidental to commercial use are allowed with a special permit. Boarding and rooming houses, and restaurants are allowed under special condition. The Small Business district allows agriculture, fishing, single family homes, public education, religious facilities and roadside stands. Small business such as antique shops, art galleries, gift shops and rooming houses are allowed on special condition. Marinas, boatyards, and dorms are allowed with a special permit.

A Conservancy Overlay District was adopted by town residents to preserve ground water quality, protect coastal and inland waters for shellfishing and fishing, lessen hazard from flood and tide waters, conserve natural conditions, wildlife and open space, as well as to retain other amenities of Chatham. Lands subject to the Conservancy Overlay District include all submerged lands and lands subject to flooding (including land within the 100 year flood plain A and V zones), submerged lands in and under all ponds and wetlands, and areas lying below 2 feet above the natural high water mark of any freshwater pond, lake or watercourse. As was mentioned when discussing the town's natural resources, Stage Harbor's waters and its riparian wetlands, tributaries, and floodplain areas are included in the Conservancy District. In general, only low intensity agriculture; fishing, shellfishing and their associated activities; outdoor recreation; dredging of navigational channels and mooring areas; boat launching ramps; public beaches; and bank stabilization projects are allowed. Approval by the Harbormaster to conduct many of these activities is required. Many water-dependent uses are allowed with a special permit, including: catwalks, ramps, unpaved trails, boat shelters, foot bridges, marina and boatyards, and private boat ramps and beaches. The filling, dumping, draining, excavation, and discharge of hazardous substances and any sewage effluent from private sewage treatment facilities is prohibited in a conservancy district. Residential dwellings are also prohibited. A building setback is established from conservancy districts. In general, there is a mandatory setback of 50 feet from all coastal conservancy districts and 25 feet from inland conservancy districts.

Chatham has also adopted a Flood Plain Overlay District which restricts development in areas prone to flooding. The lowest floor of residential structures cannot be less than the base flood elevation. Non-residential uses must either have their lowest floor at or above the base flood elevation or must be flood-proofed. Land within V-velocity zones cannot be developed unless it is demonstrated that structures will be located landward of the reach of mean high tide.

Harbor Uses

The Stage Harbor system supports a variety of water-dependent uses including: recreational boating, commercial and recreational shellfishing, swimming, and shoreland hiking. Each of these uses in turn demands support facilities such as marinas, boatyards and town landings. Recreational boaters must have a place to launch, moor and repair their boats. Commercial fishermen require water launching access, mooring, packing and loading facilities, winter boat storage areas and boat repair facilities. Swimmers demand that land be set aside for public beaches, and hikers demand shorefront access. Map 11 presents the location of Stage Harbor's water-dependent uses. As the map indicates, many differing uses occur in the same place and rely upon the same resources.

Town Landings

There are nine (9) town landings in the Stage Harbor System which provide either scenic, parking or boating access to the water. Town landings are provided in each waterway or water body in the Stage Harbor System. However, only three landings provide boat launching facilities, and parking at the landings is generally limited. There is no public boat launching facility at any town landings on Mill Pond. The location of town landings is shown on Map 11. Table 3 provides a list of town landings in the system and the facilities which they provide to the general public.

TABLE 3 STAGE HARBOR SYSTEM: TOWN LANDINGS

Landing	Water Body/River	Scenic View	Parking	Boating
Oyster Pond Furlong	Oyster Pond	Y	Y	Y
Vineyard Street	Oyster River	Y	Y	N
Barn Hill	Oyster River	Y	Y	Y
Sears Point	Oyster River	Y	Y	N
Battlefield Road	Stage Harbor	Y	Y	N
Port Fortune	Stage Harbor	Y	N	N
Old Mill Boatyard	Stage Harbor	Y	Y	N*
Eliphamet's Lane	Mill Pond	Y	Y	N
Mill Pond	Mill Pond	Y	Y	N**

Key: Y = yes; N = no
* Boat ramp must be rebuilt
** Pier exists but no boat ramp

Source: Town of Chatham Waterways Committee. Review of Chatham's Town Landings. December 1989.

Town landings are managed by the Board of Selectmen with the advice of the Harbormaster and Waterways Committee. The Waterways Committee recently (December, 1989) disclosed a report reviewing the town's saltwater landings to determine which landings require repairs, maintenance or capital improvements. The report reviewed the adequacy of public access provided at each landing and identified any potential problems of storm water runoff from the landings. The report calls for general maintenance repairs to most of the landings in the Stage Harbor system. The Waterways Committee report concluded that efforts should be made to limit surface water runoff to prevent beach erosion and decrease runoff and its associated pollution impacts. The committee recommends that impervious surfaces be avoided at landings for parking areas. To bolster the level of water-related facilities, the Waterways Committee recommends major capital improvements for the Old Mill Boatyard to allow launching of larger vessels (up to 50'), renovation of the wharf building (which currently include the harbormaster office), and the addition of public floats and dinghy docks. The committee also recommended exploring the possibility of purchasing a private landing along the Mitchell River to provide boat access off Bridge Street (commercial launching is available at Stage Harbor Marine, located on Bridge Street). The only general boat access provided off Bridge Street is privately leased.

Commercial Fishing Piers

Four fishing piers are currently available to commercial fishermen in Stage Harbor for the loading and packing of fish. The location of commercial fishing piers in Stage Harbor is shown on Map 11. All four piers are privately owned. Several trap fishing companies operate outside of Stage Harbor, using these facilities for the off-loading of fish.

The Chatham Municipal Fish Pier, located in Chatham Harbor, has traditionally provided off-loading and packing facilities for the Town's commercial fishermen. With the formation of the North Beach inlet in 1987, use of Fish Pier has become increasingly difficult. The channel through the breach has led to stronger currents exposing many of the moorings to ocean swells. Docking boats for off-loading fish has become more difficult due to heavy wave action and shoaling has led to difficulty in navigating to the pier. Stage Harbor may needed to provide an alternative site for the main fleet if conditions worsen in Chatham Harbor. However, it must be kept in mind that use of Stage Harbor has also become increasingly difficult due to shoaling at the Harbor entrance.

Marina and Pleasure Boat Facilities

There are six private marinas in Chatham which provide a variety of services to both recreational boats and the commercial fishing fleet, four of which are located in the Stage Harbor study area: the Chatham Yacht Basin, Stage Harbor Marine, Mill Pond Boat Yard, and Oyster River Boat Yard. Services include boat launching, hauling, repairs/maintenance and storage. With the exception of the Mill Pond Boatyard, all have fueling facilities. Private marinas provide 124 slips and 95 moorings:

Marina	Slips	Moorings
Chatham Yacht Basin	75	24
Oyster River Boatyard	23	23*
Stage Harbor Marina	26	38
Mill Pond Boatyard	0	10

* Some of these are T-floats which handle 2 boats

Source: Harbor Planning Committee. Harbor Planning Issues: Recreational Use of Waterways. 1989.

Parking at the private marinas is variably available, depending upon the season. Areas used for boat storage in the winter can often be utilized for parking during the summer months. It is estimated that the four marinas in the Stage Harbor/Oyster Pond complex can accommodate as many as 160 cars

in the peak of the summer. None of the marinas have pump-out facilities for septic holding tanks.

Moorings

Most commercial and recreational boats are kept on moorings since the shallow nature of the Stage Harbor system requires that boats be left in deeper areas where they will stay afloat at low tide. The Town of Chatham provides moorings located throughout the Stage Harbor system. As mentioned in the previous section, moorings are also provided at private boatyards and marinas. Most large recreational boats and commercial fishing boats are moored in Stage Harbor and the Oyster River. Oyster Pond is less intensely used. Mill Pond's mooring areas are used by smaller recreational boats (usually under 20 ft long) such as small skiff or inboard/outboard boats due to its limited access. Although there is a drawbridge to the entrance of Mill Pond making it possible to bring in larger vessels, it is inconvenient to do so. Therefore, boat size is generally limited to allow clearance under the drawbridge (listed at 8 feet height).

The Harbormaster (or the Assistant Harbormaster) assigns the location of moorings in Chatham's waters. A mooring map is provided which divides the Stage Harbor system into several sections. Each owner of a mooring is assigned a location. Map 11 presents the designated mooring sections and gives a general indication of the concentration (number of moorings/total area) of moorings in each section.

The following table lists the number of moorings provided by the Town of Chatham in the Stage Harbor System:

	# Public Moorings
Oyster River	259
Oyster Pond	95
Stage Harbor	341
Little Mill Pond	54
Mill Pond	64
Mitchell River	49
Total	862

Source: Chatham Permit Department. December, 1989.

The assigned location of a mooring cannot be transferred without the approval of the Harbormaster or Assistant Harbormaster. There is currently a long waiting list for moorings in Stage Harbor and Oyster River.

Chatham relies on several sources to provide moorings to its visitor boaters. Visitors entering the harbor can call on Channel 16 and contact either the Harbormaster or Stage Harbor Marine. Under the direction of the Harbormaster, it is usually possible for visitors to temporarily use assigned moorings which are not in use. The Monomoy Yacht Club has five moorings in Stage Harbor for visitor use. Under emergency situations the Coast Guard has one mooring available to visitors. If no moorings are available in the inner harbor, the outer harbor can be used for open anchorage.

Private Piers

The Stage Harbor system has a total of 67 private piers. The location of piers was provided by members of the Harbor Planning Committee and is shown on Map 11. Private piers can limit public use of the harbor since they restrict access along the shore, encroach on shellfish beds and obstruct navigation. Table 4 presents the number of pier structures within each river or water body in the Stage Harbor system:

TABLE 4 LOCATION OF PRIVATE PIERS

Water Body	Number
Mill Pond and Mitchell River	17
Stage Harbor	17
Oyster Pond River	22
Oyster Pond	11*
Total	**67**

Source: Town of Chatham Harbor Planning Committee, 1990.
* One additional pier proposed

Recreational Uses

Stage Harbor waters are a popular location for water-contact sports including swimming, waterskiing, windsurfing and jet skiing (see Map 12). There is only one public swimming beach in the Stage Harbor system, located on Oyster Pond off Stage Harbor Road. Oyster Pond Beach provides a supervised swimming area with bathroom facilities. The Park Department provides lifeguard service and swimming lessons for children during the summer months. There is ample public parking available. Waterskiing is only permitted in Oyster Pond. Windsurfers are seen throughout the Stage Harbor system. There has recently been controversy over the allowance of jet skiing in Chatham. Jet skiers are currently allowed throughout the Stage Harbor systems where the speed limit permits. The Waterways Committee

regulations currently mandate a 5 mile speed limit and require that watercraft cannot generate a wake throughout all Stage Harbor's waters, except Oyster Pond.

Analysis of Harbor Use and Waterfront Access

Chatham's Stage Harbor system supports a diversity of co-existing public and private uses. Recreational boating, boat mooring, skiing, swimming, finfishing and shellfishing take place in the Harbor's waters. These uses in turn generate demand for waterfront access and services and facilities such as town landings, marinas, boatyards, lodging, restaurants, and seasonal housing. With each mooring and fishing permit issued comes increased demand for these facilities and greater congestion of the water.

Harbor Congestion

All of the various uses in the harbor compete with each other for space. Maps 11 and 12 present the locations of the differing harbor uses. When these maps are overlaid, it is apparent that many of the harbor system's uses occur in the same place, leading to increasing congestion and the risk of accidents in the harbor area, especially within Stage Harbor and the Oyster River.

In an effort to maintain safety, the Waterways Commission has adopted regulations limiting speed limits throughout most of the Stage Harbor system during summer months. Due to the high level of harbor use, it is essential that the safe zone regulations (no swimming, windsurfing, diving, water-skiing, anchoring or scuba diving) be observed and enforced.

The following is a brief description of how each harbor use contributes to the congestion of the harbor system.

Skiing

Water-skiing and jet-skiing are only conducted in Oyster Pond due to speed and wake limitations throughout the remainder of the system waters, but pose problems in the Oyster Pond for two reasons. First, in the summer months, the pond is heavily used and there are safety hazards between skiers, swimmers and other boats. Skiers pose problems to fisherman as they have been known to be careless and have disrupted fishing nets and lines. Second, the noise generated by outboard engines and jet skis may become annoying to residents of the pond area. There are also safety and environmental problems associated with jet skis because they can operate in very shallow water near swimmers, piers and shellfishing areas.

Sailing

Sailboat racing is a long-established use in Stage Harbor but with increasing congestion in the inner harbor, the race courses have had to be altered. The children's Sprites are too small to be raced outside the harbor, but the Yacht Club has moved many of the cat boat and day-sailor races outside. Therefore, there remains the need to ensure safety during the sprite races. There is also a continuing need to educate young sailors to stay clear of the channel and large boats which cannot maneuver easily. It may be necessary to coordinate race schedules with high tide so that the less congested outer harbor area could be used.

Swimming

Swimming is a use which for safety reasons typically does not co-exist with other uses of the harbor such as boating, water skiing and jetskiing. The public swimming beach on Oyster Pond is off-limits to other uses. Any future public swimming areas will be off-limits to watercraft.

Boating

Congestion has increased with the number of commercial and recreational boat increases. Of particular concern is the storage or mooring of boats. In the summertime the large number of moorings have led to the loss of open water. Waterskiing and sailing require large areas of open water to maneuver.

Chatham currently does not regulate the location of the harbor system's various water uses. The allowable intensity of water uses is limited through the permitting system administered by the Town's Harbormaster and Shellfish Warden. However, there is no clearly defined procedure for determining the maximum acceptable intensity of each use. For example, mooring permits are generally issued so long as there appears to be room for the boat itself. However the impact of that boat upon water quality, congestion and service demand is not considered.

Adequacy of Public Access to the Water and Water-related Support Facilities

All of Stage Harbor's public water uses require some form of access to the water itself. The long waiting lists for moorings and the congestion of the town's landings suggest that the level of public water access and its associated support industries is not adequate to meet demand. For example, although nine public landings exist in the Stage Harbor complex, the landings are small and boat launching facilities and parking are limited. A recent Waterways Committee report reveals that several town landings currently require repair, maintenance and capital improvements.

Public access to the water is of vital importance in Chatham since much of its economy is dependent upon water-related activities. Map 2 illustrates the study area's public access zone which was defined to include the landward boundary of all land parcels which are contiguous with the waterfront. The access zone illustrates which lands in the Stage Harbor complex provide access to the system's waters. Most shorefront parcels are privately owned. This means that there are limited land opportunities for the general public to reach the water.

The public access zone can be used for planning purposes to earmark new land acquisitions, and to decide where to accommodate new demands for town landings, etc. For example, as a result of the shoaling and storm surges which have occurred since the North Beach breach occurred two years ago, Fish Pier may not be useable as a fish off-loading station in the future. As a result, there is increasing pressure on the Town to provide an alternative fish processing facility in Stage Harbor. The access zone presents the location of land parcels which are currently available to provide this facility.

The access/ownership zone illustrates that there is little potential for public pedestrian shoreline access throughout most of the inner harbor area, unless access easements are acquired, since the majority of the harbor's shoreline is privately owned.

In addition to the need for land access, there is also considerable demand for in-water access which is not met. Boaters require locations to moor their boats. Most boats in Chatham's Stage Harbor complex are moored on private moorings whose locations are designated by the Harbormaster. To a lesser extent boats are moored at marinas and docks. There is currently a waiting list for mooring locations in Stage Harbor and the Oyster River. Many private docks are located in the Stage Harbor system. However there is debate as to whether the use of docks should be encouraged since they may decrease shoreland access, can impede navigation and may encroach on shellfish beds located along the shore.

Navigation and Harbor Safety

Bathymetric Data

Bathymetric maps of the Stage Harbor system will provide an invaluable resource for future management decisions. Accurate bathymetric data are required for safe navigation of many types of vessels, ranging from commercial fisherman, to pleasure boaters, to safety and rescue vessels operated by the United States Coast Guard and local harbor patrol. In areas which experience rapidly changing shoals and water depths, the lack of up-to-date bathymetric maps can compromise the safety of boaters, sometimes resulting in the loss of life. Additionally, the acquisition of bathymetric data can help to identify problem shoal areas which require dredging, and are

often used to identify the need for maintenance dredging in channel areas. If allowed to develop unchecked, large shoal areas can affect the water circulation and tidal flushing in small harbor areas such as the Stage Harbor complex.

As a part of the current study, bathymetric data from the National Oceanic and Atmospheric Administration (NOAA) Nautical Chart #13229 were translated onto the Flood Zone and Bathymetry Map of the Stage Harbor, Oyster Pond, Mill Pond complex. Bathymetric data collected by Braman Engineering during December, 1989 in Oyster Pond River were also translated onto the Flood Zone and Bathymetry Map; these data provide a more accurate representation of water depths in this area. The Flood Zone and Bathymetry map produced for this study shows water depths in feet, and is referenced to Mean High Water (MHW).

Since the water depths in Stage Harbor, Oyster Pond, and Mill Pond (taken from the NOAA chart) have not been updated since February, 1985, it is likely that many inaccuracies exist in these data. This is especially true in light of the breach through Nauset Spit in January, 1987 which has resulted in significant changes in the shoaling rates and patterns of the Chatham area. The U.S. Army Corps of Engineers has documented rapid shoaling and constantly changing water depths in the Chatham Harbor area following formation of the breach. Increased shoaling rates have also been documented in the approach channel to Stage Harbor. Even though there have been no reported cases of increased shoaling inside Stage Harbor as a result of the breach, it is certain that the entrance to Stage Harbor will continue to show higher than average shoaling rates for the next 5 to 20 years.

Dredging Needs

Persistent shoaling conditions in the approach channel to Stage Harbor create navigation hazards for recreational and commercial vessels that utilize the harbor. Since the area is a summer resort which is dependent on water related activities, in addition to a well established harbor for a large fleet of commercial and recreational boats, a safe and navigable passage into the harbor is an important concern for many users. Past shoaling problems have also interfered with activities of the Coast Guard in providing protection and assistance to boaters.

Since the approach to Stage Harbor is a Federally authorized channel, the U.S. Army Corps of Engineers is responsible for maintaining navigable depths through the channel. The authorized dimensions of the channel are 150 feet wide and 10 feet deep at Mean Low Water (MLW); construction of the channel was completed in 1965-1967. Maintenance dredging of the entrance channel has been required since 1970 in order to maintain the project depth. Table 5 shows the history of maintenance dredging at the approach channel to

Stage Harbor. By dividing the volume of material dredged by the total number of years between dredging operations, the data in Table 5 have been converted to annual shoaling rates in Table 6.

TABLE 5 MAINTENANCE DREDGING - STAGE HARBOR, MA

Year	Volume Dredged (cu yd)
1970	30,700
1973	24,000
1974	21,000
1976	8,500
1977	7,000
1978	52,000
1984	120,100
1987	117,000

TABLE 6 ANNUAL SHOALING RATES - STAGE HARBOR, MA

Year	Volume Dredged (cu yd/yr)
1967-1970	10,000
1970-1973	8,000
1973-1974	21,000
1974-1976	4,000
1976-1977	7,000
1977-1978	52,000
1978-1984	20,000
1984-1987	39,000

The shoaling rates presented in Table 6 clearly indicate a wide range of annual shoaling patterns. This is in part due to the variation in frequency of high energy storms during the time periods considered. High wave and strong current activity during these high energy events typically causes an increase in sediment transport and shoaling rates. Another major factor affecting the annual shoaling rates is the frequency of dredging. For example, a channel which is dredged annually or bi-annually will tend to have a higher annual shoaling rate than the same channel which is dredged less frequently. This is true because the maximum rate of shoaling occurs right after dredging since the channel is deeper than the surrounding area, and it tends to trap all sediment crossing the inlet. As the channel shoals, more sediment is by-passed around the inlet and the shoaling rate decreases. Even though the frequency of dredging can significantly affect channel shoaling rates, the need to maintain navigable water depths in the channel usually dictates when maintenance dredging must occur.

One trend shown in Tables 5 and 6 is that the quantity of shoaled material in the Stage Harbor approach channel has increased with time. Although dredging records were not available for Stage Harbor since formation of the 1987 breach in Nauset Spit, it is clear that increased sediment transport and shoaling as a result of the breach will only exacerbate the problem at Stage Harbor.

The preceding paragraphs have discussed the frequency and need for dredging in the approach channel to Stage Harbor. As mentioned before, the U.S. Army Corps of Engineers is responsible for maintaining this navigation channel. Should there be a need to dredge inside the Stage Harbor complex, either to mitigate shoaling problems or to allow construction of new facilities, a variety of dredging options are available for the Town of Chatham. Alternative dredging methods include the following: hydraulic, sidecast, and mechanical dredging (hopper or clamshell). The disposal alternatives are either for open water disposal or upland disposal.

State Permitting Requirements for Harbor Development

Several permits are required from local, state and federal agencies before any dredging or harbor development can begin at Stage Harbor. The exact permitting requirements depend largely on the scope of the project. Below are described the agencies likely to be involved if work below high water is proposed.

Agency: Conservation Commission Permit: Order of Conditions

A Notice of Intent (NOI) must be filed for any project that will remove, fill, dredge of alter any Area Subject to Protection Under the Wetlands Act. These areas include beaches and land under the ocean. Engineering plans must be included with the NOI illustrating the dimensions and extent of the proposed project. The NOI is reviewed by the Conservation Commission; a public hearing is held at which time the project proponent can discuss the proposed project with the Commission and any other interested parties. An Order of Conditions is issued by the Conservation Commission either approving or denying the project. If the project is approved, there may be restrictions or guidelines to which the proponent must adhere.

Agency: DEP, Wetlands Protection Program Permit: Superseding Order of Conditions

The Southeast Region of the Department of Environmental Protection (DEP) reviews Orders of Conditions issued by the Chatham Conservation Commission. They or any other interested party (including the project proponent) can appeal an Order of Conditions. If this occurs, the DEP undertakes a more formal review and issues a Superseding Order of

Conditions. Any person may request an adjudicatory hearing if they feel the Superseding Order is inconsistent with the Wetlands Act.

Agency: DEP, Waterways Regulation Program Permit: Chapter 91 License

A Chapter 91 License is required for "projects in, on, over and under tidal waters seaward of the mean high water mark". Detailed engineering plans, drawn to the required specifications, must accompany the permit application. The Chapter 91 License cannot be issued until an Order of Conditions has been received.

Agency: DEP, Division of Water Pollution Permit: Water Quality Control Certification

A Water Quality Certification is required to assure that the dredging and disposal will be in compliance with State standards and policies. Results of chemical and grain size analysis of the dredged material, in addition to engineering plans, must be included as part of the permit application.

Agency: Army Corps of Engineers Permit: Section 404

A permit from the Army Corps of Engineers (ACE) is required for any construction, dredging and/or filling within waterways and wetland areas. The landward limit of the ACE's jurisdiction is typically the high water mark. The NOI generally can be submitted to the ACE as the permit application. Additional, engineering plans may be needed.

There may be permitting requirements in addition to those described above. For example, some Towns have zoning ordinances which restrict certain activities (such as beach nourishment or dredging) in selected areas. Therefore, approval from additional agencies may be needed. Additionally, if the project exceeds thresholds established by the Massachusetts Environmental Policy Act Unit (MEPA), an Environmental Notification Form (ENF) must be submitted to MEPA and a Consistency Statement must be filed with the Massachusetts Coastal Zone Management (MCZM). Examples of thresholds which, if exceeded, will warrant the filing of an ENF and Consistency Statement include:

a. The issuance of a Superseding Order of Conditions permitting any dredging, filling, altering or removal of one-half acre or more of land under the ocean.

b. Dredging, including maintenance dredging, or disposal of 10,000 cubic yards or more of material.

c. Licensing of the construction of new marinas having 50 or more slips or of the additions to existing marinas involving an increase of 50 or more slips.

d. Filling, dredging, construction, rip-rapping, or otherwise directly altering 500 feet or more of waterway bank.

After reviewing the ENF, MEPA determines whether or not an Environmental Impact Report (EIR) is required for the proposed project. The MEPA review of the ENF (and EIR if it is required) must be completed before most of the other permits described previously can be issued.

Water Quality

Land use activities produce pollutants which may be captured in surface runoff during storm events and enter surface waters or infiltrate into ground water. Direct ground water pollution may also occur with land use, for example, via subsurface septic systems. Therefore, changes in land uses in the surface watershed and ground-water drainage area of the Stage Harbor system will impact its water quality. A decrease in environmental quality may lessen the aesthetic and recreational appeal of Chatham's waterways and the productivity of its shellfisheries and finfisheries. Such a decrease would negatively impact Chatham residents and visitors. Therefore, the maintenance of the Stage Harbor system's water quality is essential.

According to the Town's shellfish department, the major threats to Chatham's shellfishing are overuse of the resource and water pollution. Sources of water pollution include stormwater runoff from roads and parking areas; release of sewage effluent to ground water and to surface waters from failed septic systems located in coastal areas; fertilizers and pesticides used on lawns and golf courses; animal wastes; chemical contamination from careless disposal of household hazardous wastes; and oil and gasoline spills from motorboats and marinas. These pollution sources are discussed further below.

Stormwater

Stormwater runoff directly enters the Stage Harbor system from various sources including storm drains, boat ramps, roof runoff, and parking areas at town landings. The stormwater drainage collection system for Chatham's downtown area empties directly into Oyster Pond. The eastern 12 acre portion of Oyster Pond is annually closed to shellfishing. The remaining 103 acres of Oyster Pond are closed during the summer and fall seasons of each

year. These closures of Oyster Pond has been linked to stormwater contamination.

Map 13 was prepared by the Town's Water Quality Laboratory and presents the location of stormwater outlets to the Stage Harbor System. A stormwater committee is currently mapping Chatham's stormwater drainage system as a first step in finding alternatives to the Town's existing management of stormwater.

Storm water runoff indirectly enters the Stage Harbor system through rivers, streams, and wetlands. Recent sanitary surveys identify numerous creeks, ditches and culverts which drain wetlands and uplands and discharge into the Stage Harbor system (Duncanson and Sherwood, 1989 a,b,c,d). These surveys indicate, however, that discharging creeks and wetlands probably only have negative impacts at 3 locations in Stage Harbor. These three sampling locations yielded high coliform bacteria counts, but the cause is not certain. In Oyster Pond, discharging creeks, ditches and culverts do have a negative impact.

Sewage

Septic systems are another source of water pollution. Sewage effluent enters the Stage Harbor system through ground water. Where septic systems fail and sewage backs up at the land surface, effluent may also travel in overland runoff, conveying nutrients, bacteria and viruses to the Stage Harbor system. Inputs such as these decrease water quality in the harbor system. Map 13 presents the portions of the study area which depend on on-site septic systems for sewage disposal. Chatham downtown buildings, as well as buildings located along the northeast portion of Oyster Pond and northwest portion of Mill Pond are sewered. Chatham is currently under a sewer moratorium imposed by the Massachusetts Department of Environmental Protection. Therefore, additional public sewer hookups are not anticipated in the immediate future.

Sewage discharge from boats is also a potential water quality hazard. Chatham currently has no pump-out facilities for holding tanks on boats, but hopes to remedy this through installation of a pump-out facility at the Old Mill Boatyard. Funding for the pump-out station has been obtained and town officials are working to obtain the necessary permits. The actual number of boats with heads is limited: in 1989, only eight percent of the 862 boats with town mooring permits possessed a sewage holding tank. It is estimated that only 1 or 2 live-aboard boats moor in the Stage Harbor system in the summer. Since no pump-out facilities are available, it is likely that boaters are dumping their wastes directly into the harbor and ocean waters. On-shore toilet facilities are provided at Stage Harbor Marine and the Old Mill Boatyard.

Fertilizers and Pesticides

Fertilizers and pesticides are used by residents to maintain lawns and are a source of nutrient loading to ground water and surface water. Homeowners and lawn care companies may minimize impacts due to fertilizer and pesticide use through using smaller applications of slow release fertilizers and applying fertilizers when the likelihood of rain is small.

Animal Wastes

Animal wastes (including dog and waterfowl excrement) are common pollutants of Chatham's beaches and waters. No large-scale sources of animal wastes such as horse farms or dog kennels exist in the Stage Harbor system, however, in the summertime, the number of dogs becomes a problem. During the sanitary survey conducted in June 1989, water quality contamination from bird wastes was noted at several locations: under the Bridge Street bridge and near the old Coast Guard house in Stage Harbor, throughout Oyster Pond, and near several water quality monitoring stations in the Oyster River. Waterfowl concentrate throughout the Stage Harbor system at different times of the year.

Household Hazardous Waste

Household hazardous wastes enter the ground water and surface water through the dumping of cleaning solvents, paints and oils into toilets, stormwater drains and into the ground. These sources of water contamination are best controlled through public education.

Marinas

Marinas are a major source of hydrocarbons due to improper fueling operations. Fuel tanks must be inspected on a regular basis to detect leaking, and fueling operations should be closely supervised to prevent careless practices. Town officials are currently working with marina owners to replace underground gasoline tanks with above-ground holding tanks. Hazardous materials have been identified at the Mill Pond Boatyard, located on Mill Pond (Duncanson and Sherwood, 1989a). The quantities of hazardous materials at the boatyard are small and consist of oils, paints, grease, resins, etc. Most of these materials are located inside the Boatyard's workshop. During the Town's most recent sanitary survey, drums of resins and various chemicals were also found along Stage Harbor (Duncanson and Sherwood, 1989d). Hazardous materials were identified at four locations, including two marinas, along Oyster River (Duncanson and Sherwood, 1989c).

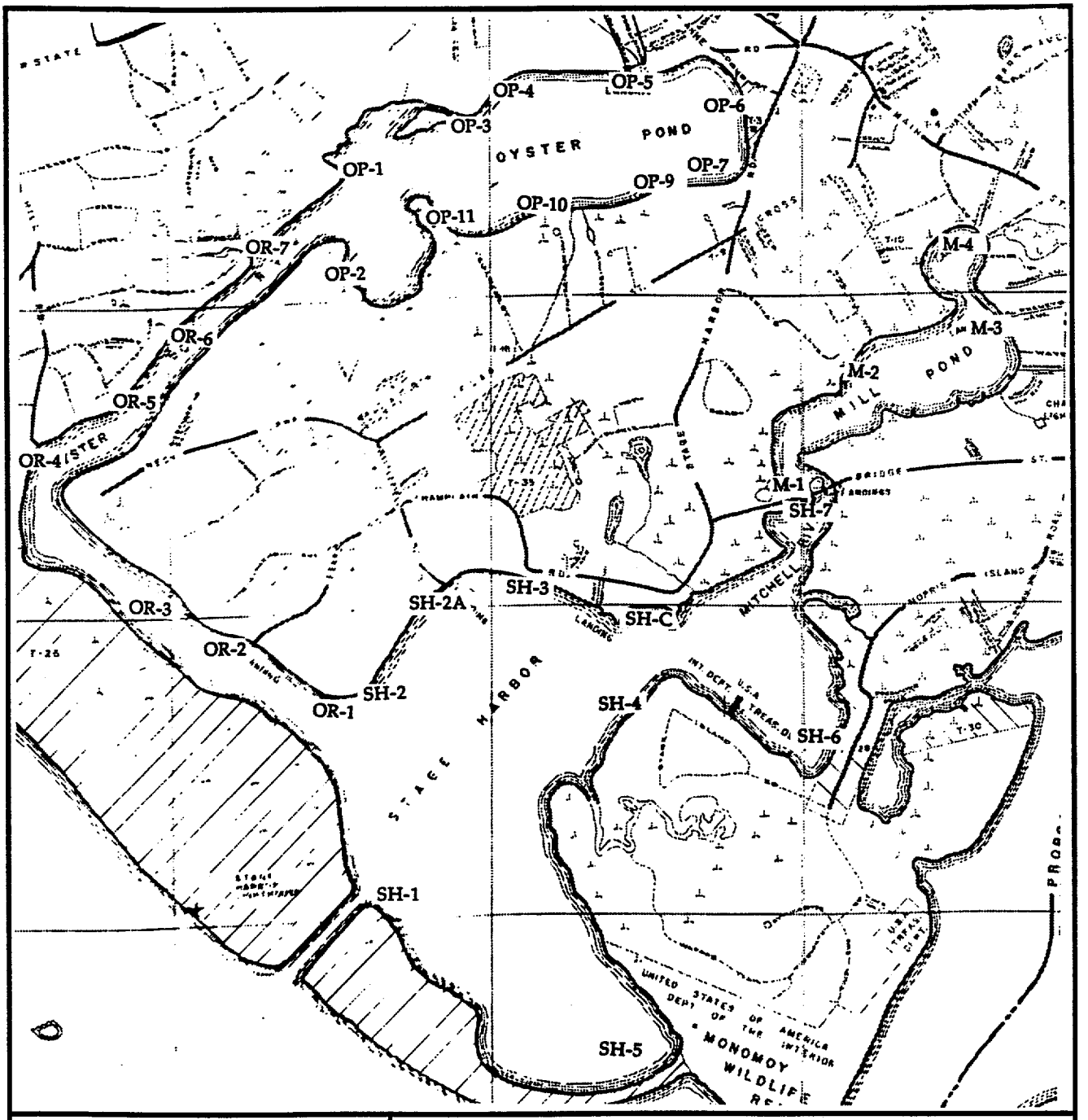
Water Quality in the Stage Harbor System

Existing water quality data for the Stage Harbor system is limited. Available data focus on the coliform group of bacteria, which is used in the Commonwealth's regulatory system to monitor shellfishing areas. Coliform bacteria have been selected as indicator organisms representative of a broader range of pathogenic organisms. Fecal coliforms are a subset group thought to be derived more specifically from the intestinal tract of warm-blooded organisms. They are relatively easier and less costly to test for than other bacteria and viruses. However, they may not accurately portray the potential health risks associated with contaminated waters. Most notably, viruses behave differently than coliform bacteria in the environment. For instance, viruses survive longer in colder temperatures, whereas coliform bacteria thrive in warmer temperatures. Current water quality standards require that average fecal coliform counts be less than 14 organisms per 100 milliliters (ml) of water sampled and less than 10% of the samples may have 43 or more organisms/100 ml.

The locations of sampling stations in the Stage Harbor system are presented in Figure 2. Water quality data for fecal coliforms has been compiled for the 1984-1989 period (see Table 7). These data indicate that, in general, the 14 organisms per ml maximum water quality standard, based upon a geometric mean calculation, is being met throughout the Stage Harbor estuarine system. Station OP-7P in Oyster Pond exceeds this standard but is a stormwater discharge sampling point, and the sampling location does not overlie active shellfish beds. Therefore, it should be viewed as documentation of a source of contamination, but not an indicator of unsafe shellfish conditions in Oyster Pond.

On the other hand, several stations in Oyster Pond exceed the standard of no more than 10% of samples with $\geq$ 43 organisms/100 mls. Based upon these data, the shellfish beds have been closed from 1 June to 30 November since 1985. Fecal coliform counts during the open season meet water quality standards. It is believed that stormwater entering the system from two stormwater culverts located at Oyster Pond Furlong and Stage Harbor Road is the major contributor to the closing of these waters.

Chatham's residents and officials recognize that the continued maintenance of water quality in the Stage Harbor system is essential for the livelihood of the shellfish industry. In the 1988 Town Meeting, $25,000 was appropriated to begin study of the town landings, storm drains and catchbasins which impact shellfishing grounds. In 1985 a part-time water quality laboratory opened in reaction to Oyster Pond's shellfish closing. This has evolved into a full-time laboratory headed by a full-time director who oversees seasonal monitoring of salinities and coliform concentrations at sampling stations throughout the Stage Harbor system. The laboratory has recently been awarded funds to



Key:

SH-1 Sampling Location

Chatham Harbor Study
Chatham, MA

FIGURE 2. WATER QUALITY SAMPLING LOCATIONS IN THE STUDY AREA

N

Source: Chatham Town Laboratory (1990)

HWH, Inc.

Table 7. Water Quality Summary: Fecal Coliforms in Harbor Areas*

Station Location	Number of Stations	Stations with Geo. Mean under 14 org./ml**	Stations over 43/100 more than 10%, (%)***
Stage Harbor	9	all	SH-7, 25% SH-C, 17%
Mitchell River, Mill Pond	4	all	none
Oyster River	7	all	OR-7, 13.3%
Oyster Pond	13	all but OP-7P	OP-3, 22.2% OP-6, 18.2%# OP-7, 20.0%# OP-8, 12.5%# OP-5P, 33.0%# OP-7P, 58.3%#

During open season (Dec.-May), only OP-7P (37.5%) exceeds the 43/100 standard

*Based on data from Town of Chatham Water Quality Laboratory
**Fecal coliform: geometric mean most probable number is not to exceed 14 organisms per 100 ml of water
***Fecal coliform: not more than 10% of the samples are to exceed a most probable number of 43 organisms per 100 ml
#In permanently closed area

expand monitoring to include nutrient analysis. It is anticipated that nitrogen and phosphorus levels will be monitored for the first time in the summer of 1990.

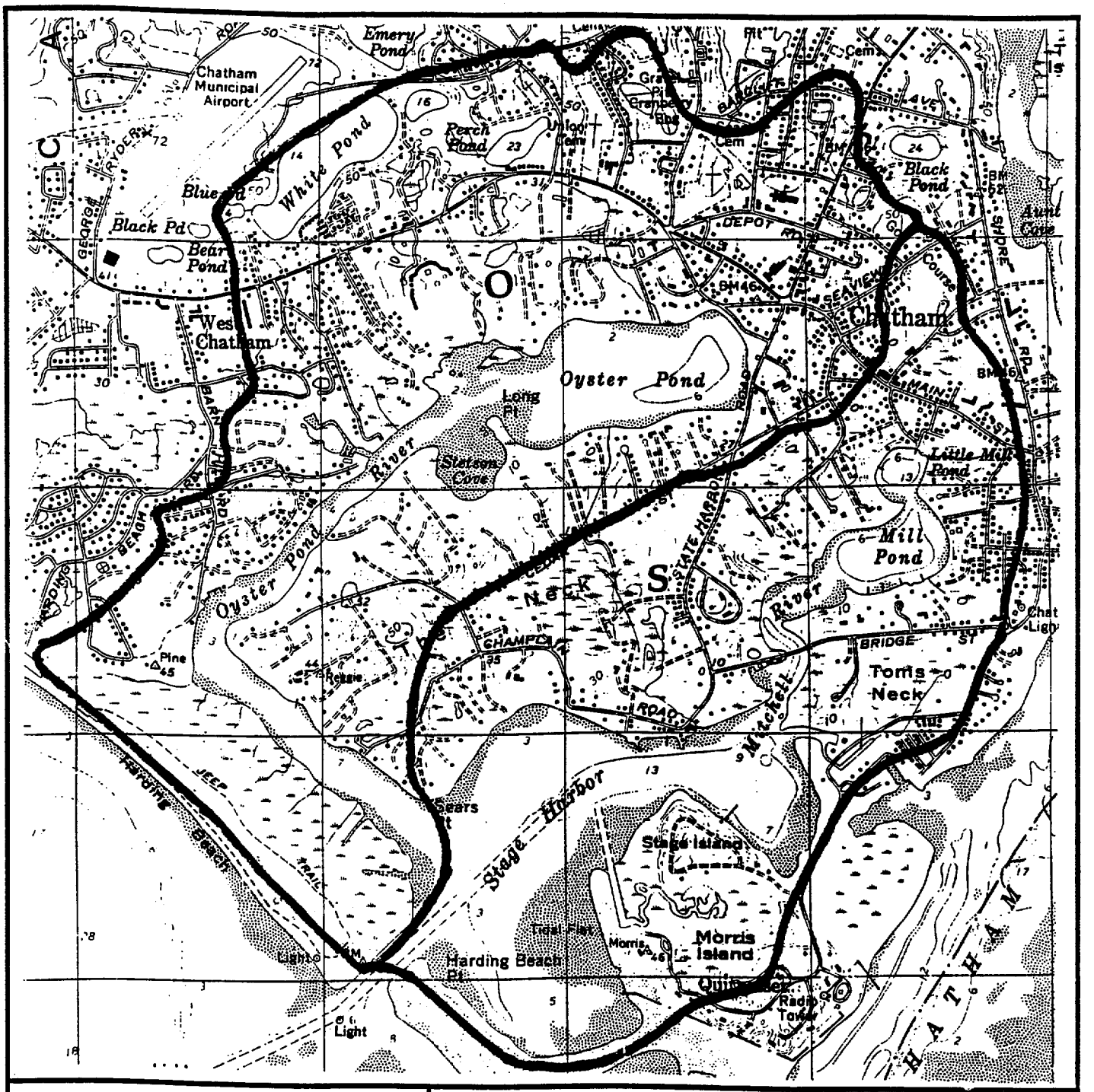
Extent of Future Development and Potential Impacts to Harbor Resources

In order to evaluate the impacts of both existing and potential development on Chatham's harbor resources, a complete buildout/developable lot analysis was conducted for lands located within the ground water recharge area and surface water drainage area to the Stage Harbor system. The methodology used to delineate these contributing areas was described earlier in this report. Map 3 and Figure 3 present the ground water recharge area and surface watershed boundaries.

A buildout analysis was used to determine existing and potential levels of development within the study area, based on the Town's current land-use regulations. Commonwealth land-use enabling legislation within Massachusetts dictates that once a community programs itself through zoning and subdivision control, it is tied into a development "blueprint" which is difficult to alter. This blueprint frequently results in land development which exceeds the assimilative capacity of ground and surface water resources, particularly with respect to nitrogen loading. A particularly difficult issue to resolve in controlling land-use within critical areas, is that of pre-existing lots protected from zoning changes by the state zoning act (MGL Chapter 40A, Section 6). Moreover, once a definitive subdivision plan has been filed with the local planning board, the property owner is protected from any new zoning changes for a period of 8 years. Consequently, recharge areas to surface and ground water resources may contain numerous small, vacant lots, which, if developed, could result in significant degradation in water quality.

Buildout Methodology

A "buildout analysis" is conducted to determine the level of development which would occur if a town was "builtout" according to zoning. The study area used for the buildout analysis is a combination of the ground-water recharge areas and the surface water drainage areas to Stage Harbor, Mitchell River, Mill Pond and Oyster Pond and River. Land within both the surface watershed and ground-water recharge areas is included because water and its associated pollutants may enter the Stage Harbor system through surface or underground routes. For example, inputs from sewage may travel in ground water, while runoff from pavement and roofs may travel overland and release pollutants directly into the waterbodies. Due to study area topography, two sub-drainage areas contribute to the Stage Harbor system: 1) that area draining to Oyster Pond/River, and 2) that area contributing directly to Stage Harbor/Mitchell River/Mill Pond. Therefore, impacts to the Stage Harbor system were evaluated for both sub-study areas: The study area boundaries are shown in Figure 3.



250 1000 3000
500 0 2000 feet

Key:

O Oyster Pond/River Sub-study Area

S Stage Harbor/Mitchell River/ Mill Pond Sub-Study Area

Chatham Harbor Study
Chatham, MA

FIGURE 3. STUDY AREA BOUNDARIES

N

Source: Chatham Topographic Quadrangle (USGS 1974)

HWH, Inc.

For the two sub-study areas, the analysis followed a two step process. First, existing levels of development were documented, based on 1989 assessor's maps and records, and the town land use overlay map. The buildout potential was then estimated to evaluate saturation development conditions based on Chatham's zoning regulations. Buildout potential depends on frontage, lot size and other requirements set forth in the town zoning regulations. Minimum lot sizes specified in the Town's zoning bylaw range from 5,000 to 40,000 square feet, depending on the zoning district. Table 8 lists lot size and frontage requirements for each district in the study area.

TABLE 8 MINIMUM LOT SIZE AND FRONTAGE BY ZONING DISTRICT

Zoning District	Minimum Lot Size	Minimum Frontage	Zoning
R-40	40,000 square feet	150 feet	Residential
R-20	20,000 square feet	100 feet	Residential
SB	20,000 square feet	125 feet	Commercial
GB-3	10,000 square feet	100 feet	Commercial
GB-2	7,000 square feet	50 feet	Commercial
GB-1	5,000 square feet	50 feet	Commercial

Based on these requirements, the potential for future development was assessed. On a lot-by-lot basis, the following were counted:

a) existing residences

b) vacant buildable lots (vacant lots not large enough to allow subdivision, but large enough for construction of one dwelling)

c) unbuildable lots (including private conservation lands and lands not buildable due to wetlands, small size, or lack of access)

d) subdividable lots (parcels large enough to allow division into 2 or more lots under zoning for the relevant district)

e) town-owned lots

f) commercial lots.

Setback requirements were also considered in the buildout analysis. Commercial parcels not on sewer were examined to determine their current use, and the size of restaurants (number of seats) and motels (number of units) was determined. Assumptions used in the buildout are as follows:

a) Lots falling partially into the study area boundaries are counted if at least half the lot is within the bounds, or if, due to shape and/or location of lot, septic systems are expected to be located in the study area.

b) The land-use map is more up to date than individual assessor sheets. However, if the land-use map does not indicate that a parcel is residentially developed but a house is shown on the assessor sheet, the house is counted.

c) Parcels designated "group" are checked to determine their number of units; if their land-use code is"1090" (mixed single and multiple housing), 4 houses are assumed.

d) Subdivision of land is based on acreage and frontage requirements, and in a general sense, setback requirements. On lots requiring an access road, 15% of the acreage is subtracted for the road.

e) All land uses are assumed to be year-round.

Results of the buildout analysis are summarized in Tables 9 and 10, details are shown in Appendix 2.

TABLE 9 SUMMARIZED RESIDENTIAL BUILDOUT DATA

	Oyster River/Pd.	Stage Harbor/ Mitchell R./ Mill Pd.	Entire Study Area
Existing residences (sewered)	1213 (178)	526 (36)	1739 (214)
Existing commercial parcels (sewered)	148 (86)	53 (27)	201 (113)
Town-owned parcels (sewered)	34 (3)	22 (1)	56 (4)
Unbuildable parcels	178	117	295
Single buildable lots (no potential for further subdivision)	202	74	276
Subdividable parcels	49	26	75
Additional residences provided through subdivision	149	61	210
Total potential increase in residences	351	135	486

TABLE 10 STUDY AREA OPEN SPACE INFORMATION

	Oyster River/Pond (acres)	Stage Harbor/ Mitchell R./ Mill Pd. (acres)	Entire Study Area (acres)
Total size of contributing area	1,614	1,341	2,955
Amount of open space land in contributing area	324	223	547
Percent of open land	20%	16%	18%
Amount of open water in contributing area	275	154	429
Percent of open water	17%	11%	14%
Total open space (land and water)	599	377	976
Percent of Total Open Space	37%	28%	33%

Extent of Existing Development and Potential for Future Development

The buildout analysis indicates that, while the Oyster Pond/River and Stage Harbor/Mitchell River/Mill Pond sub-study areas are close in size, the Oyster Pond/River sub-area includes proportionately more of the existing development. For example, of the 1739 existing residences in the study area, approximately 70% are in the Oyster Pond/River sub-study area. This is due in part to the dense development in the Waveland/Vineyard/Bayview Street area, as well as to the group housing located off Main Street (Pilgrim Village, Waterview Colony and Oyster Pond developments) and Barn Hill Road (several units listed under the name "Hunter"). Although this area contains the greatest proportion of development, many low density areas exist. The Oyster Pond and River sub-area also contains a significant amount of open space land (324 acres or 20% of the sub-area).

The Stage Harbor/Mitchell River/Mill Pond sub-study area contains approximately 30% of the total number of existing units, with the most dense development occurring along Main Street and east of Mill Pond. The least densely developed area in the sub-area is near Sears Point. Approximately 16% of the area's land is open space.

Only 12% of the total existing residences in the study area are on sewer, with a greater percentage of the sewered lots found in the Oyster Pond/River sub-study area (83%) than in the Stage Harbor/Mitchell River/Mill Pond portion (17%). This suggests that sewage effluent from existing development may be an important source of nutrients in ground water.

The Oyster Pond/River sub-study area also includes a proportionately greater number of commercial lots than the Stage Harbor/Mitchell River/Mill Pond sub-study area. Commercial land-uses such as restaurants and motels generate large quantities of sewage which must be serviced either through public sewer or on-site sewage disposal systems. Roughly one-half of the commercial lots in both Stage Harbor/Mitchell River/Mill Pond and Oyster Pond/River are sewered, including the elementary school and the small "downtown" shops.

The buildout analysis was used to estimate the number of additional residential units and the amount of commercial square footage which may still be built on lands within the Stage Harbor system contributing area. At maximum buildout, 2,225 total residences are expected, based on existing zoning regulations. Of the additional residences projected for saturation conditions, slightly more than half in both sub-study areas would occur on buildable lots, while fewer than half would result from further subdivision of existing lots. Seventy percent of total future residential development will fall within the Oyster Pond/River sub-study area, where more of the land is zoned for smaller lots (20,000 square feet versus 40,000 square feet). Residentially, the Oyster Pond/River sub-study area is currently 78% developed: the Stage Harbor/Mitchell River/Mill Pond sub-study area is 80% developed; and overall, the study area is 78% developed.

There are several "unbuildable parcels" in the Stage Harbor system contributing area. The category "unbuildable parcels" includes private conservation land, wetland area, and parcels which are too small to be developed. In many instances, small lots are owned by the same person who owns abutting land, where a residence has been built. Although the Oyster Pond/River sub-study area includes more unbuildable parcels than the Stage Harbor/Mitchell River/Mill Pond sub-study area, the size of such parcels varies, thus number and acreage of unbuildable parcels for the two sub-study areas are not directly comparable.

Subdividable parcels are scattered throughout the study area, but the majority lie between Oyster Pond/Oyster River and Stage Harbor. The Oyster Pond/River sub-study area includes 71% of all potential new residences resulting from subdivision. The largest subdividable parcels are 8-10 acres in size. At buildout, as many as 210 new residences are expected in the entire study area as a result of land subdivision.

There are currently 56 town-owned parcels in the study area, with 60% (34 parcels) found in the Oyster Pond/River sub-study area. Most town-owned parcels are used for open space and recreation, although a few are used for community

purposes such as the Atwood House and the Boy Scout Hall. Town land in the study area includes 28 acres of cemetery.

Occupancy rates may be used to estimate the number of additional people which will be supported by the increased residential units. For this study, 2 occupancy rates were used: 3 people per unit and 1.86 people per unit. The first occupancy rate is based on a Cape Cod Planning and Economic Development Commission value determined for Cape Cod (CCPEDC, 1978). The second occupancy rate was determined specifically for Chatham by its Town Planner in 1989, and is based on the number of housing units and corresponding population in Chatham, and incorporates seasonal occupancy changes in the town.

At buildout, a total residential population of 6,675 people is expected in the entire Stage Harbor contributing area if a rate of three (3) people per unit is used; 4,139 people are expected with an occupancy rate of 1.86. Existing population counts are 5,217 and 3,235 for occupancy rates of 3 and 1.86, respectively. These numbers do not include people who live in a residence that is combined with a commercial use. Therefore, it should be recognized that commercial expansion may also cause some population growth.

The level of commercial expansion possible in the Stage Harbor contributing areas was also considered. Lots in the older Main Street downtown area are small and densely developed. Due to parking, setback and height considerations, it is unlikely that lots in this area would be further developed for commercial purposes. However, significant expansion west of the Main Street rotary is possible. All of this western area is in the Oyster Pond/River sub-area. Therefore, environmental impacts of future commercial expansion will be felt by Oyster Pond and River.

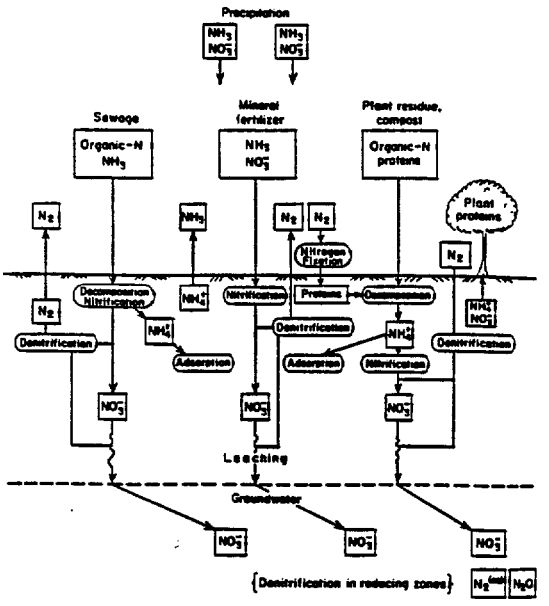
It is not so much the level of expected growth which is at issue, but the impacts this growth will have on the harbor and associated resources. Besides adding nutrient inputs to ground water via waste water, increased population will place greater demands on municipal services and facilities. Commercial businesses may expand to serve the new residents; new businesses may be constructed. As open land is lost and the population grows, increased demand for recreational resources is likely, possibly demanding additional town landings, parks, beaches, moorings, shellfishing areas, etc.

Since the study area is nearly 80% developed, it is likely that much of the impact to natural resources from development-oriented pollutants has already occurred, although it may not yet be apparent. Often, there is a lag time for products of development, such as nutrients from septic systems, to reach the resources which they will impact. For example, it may take 10-15 years for nitrate-nitrogen to travel in ground water from the most northern portions of the study area to the Oyster Pond and River.

oxygenated (anaerobic) conditions and is readily adsorbed by soil particles in the unsaturated oxidized zone above the water table. Once in the saturated zone, however, ammonium-nitrogen may travel long distances under anaerobic conditions. Ammonium-nitrogen is the primary form of nitrogen in septic system effluent and in wetland soils. Nitrite-nitrogen (NO_2^-) is an unstable form and is usually present in very small quantities as it is rapidly transformed into nitrate-nitrogen. Nitrate-nitrogen (NO_3^-) is characteristic of oxygenated (aerobic) conditions and is highly mobile in ground water. In this form, nitrogen may travel long distances with little attenuation.

Nitrogen transformations are complex, bio-physio-chemical processes. Figure 4 illustrates some common nitrogen processes. The process by which organic nitrogen is transformed to ammonium-nitrogen is called *mineralization* or *ammonification*, and occurs under both aerobic and anaerobic conditions. The process whereby ammonium-N is transformed to NO3-N is called *nitrification* and occurs under aerobic conditions. *Denitrification* is the process by which nitrate-nitrogen is converted to gaseous forms (such as N_2 or nitrous oxide) and released to the atmosphere. Denitrification occurs under anaerobic conditions, particularly within wetland soils. The opposite transformation, whereby atmospheric nitrogen is converted to ammonium-nitrogen, is called *nitrogen fixation*, and is performed by bacteria and blue-green algae.

FIGURE 4 COMMON NITROGEN PROCESSES



Source: Freeze and Cherry, 1979.

The buildout analysis results have important implications for both the assessment of nitrogen contamination of ground and surface water, and for the development of appropriate regulatory approaches in controlling growth in the Stage Harbor complex. Growth brings increases in pollutants that may impact harbor resources such as shellfish and swimming beaches, as well as demands for infrastructure and access that, in turn, lead to impacts on natural and cultural resources in the study area. Current limitations to development include zoning, health regulations, subdivision rules and regulations, and wetlands protection regulations. It is important for the Town of Chatham to carefully plan for future development, so that any further increases are as environmentally benign as possible.

Implications for Water Quality and Ecological Systems

A principal contaminant of concern to coastal waters, such as those associated with the Stage Harbor system, is nitrogen. Nitrogen is commonly considered the nutrient which regulates the extent of plant growth within coastal waters. This means that, to a large extent, increases in nitrogen concentrations will result in increases in algal and macrophyte (water weed) populations. While algae and macrophytes are important components of the coastal ecosystem, excessive growth can be detrimental. For example, the proliferation of epiphytic algae (those species which grow on the surface of macrophytes) can disrupt the photosynthetic processes of eelgrass. Declines in eelgrass populations may lead to a loss of important habitat for finfish (such as winter flounder) and shellfish (such as bay scallop). Extreme conditions resulting from high nitrogen inputs can lead to anoxic (oxygen-depleted) aquatic conditions, noxious odors and fish kills.

The primary sources of nitrogen to the Stage Harbor system are land uses within the surface watershed and ground-water recharge area. Storm water drainage and inflowing ground water are the primary routes of nitrogen transport into the estuaries.

A nitrogen loading analysis was conducted to evaluate nitrogen impacts from development on Chatham's harbor resources. This analysis was used to determine historical, existing and potential nitrate-nitrogen inputs to ground water, based on results of the buildout analysis (described previously). The study area used for the nitrogen loading analysis is the same as that used for the buildout, i.e. the ground water recharge areas and surface water drainage areas for Oyster Pond/River and Stage Harbor/Mitchell River/Mill Pond subareas (Figure 3). Nitrogen inputs may travel overland or in ground water, therefore both drainage routes are included in the study area. The nitrogen loading analysis, including assumptions, rationale, and parameters, is described in detail below.

Nitrogen is present in surface and ground water environments in four primary forms, including organic nitrogen, ammonium-nitrogen, nitrite-nitrogen and nitrate-nitrogen. Organic nitrogen consists of a variety of soluble, colloidal and particulate forms. Ammonium-nitrogen (NH_4^+) is characteristic of poorly

Nitrogen as a Contaminant

Although all forms of nitrogen are critical components of natural systems, nitrogen can cause water quality degradation if present in excessive quantities. In drinking water supplies, elevated nitrate-nitrogen levels can cause an illness in infants, variously known as infant cyanosis, methemoglobinemia or "blue-baby syndrome," caused by the alteration of hemoglobin and subsequent problems with oxygen transport. In addition, high nitrate-nitrogen levels have been linked to the formation of carcinogenic nitrosamines. To reduce potential health risks, both the U.S. Environmental Protection Agency (EPA) and Massachusetts Department of Environmental Protection (DEP) have established a drinking water standard of 10 milligrams per liter (mg/l) nitrate-nitrogen. A statistical analysis of ground-water samples collected on Long Island, NY, demonstrated that when median nitrate-nitrogen concentrations were 6 mg/l, 10% of the samples exceeded the 10 mg/l drinking water standards (Porter, 1978). To account for this variability, the Cape Cod Planning and Economic Development Commission (CCPEDC) and numerous Towns across the commonwealth have established a more conservative concentration of 5 mg/l as a planning guideline.

In aquatic systems, elevated nitrogen levels may cause excessive plant growth and other symptoms of eutrophication. Nitrogen is generally considered to be the limiting nutrient for growth in most marine systems. The precise relationship between nitrogen loading and marine productivity has not been well documented and varies widely, depending on the physical and biological characteristics of a given system (water depth, flushing rate, sediment type, extent of bordering wetlands, dominance of phytoplankton versus macroalgae, etc.). Despite this variability, several efforts have been made to establish critical nitrogen levels for aquatic systems.

Wetzel (1975) identified a range of 0.5 to 1.1 mg/l as a total nitrogen concentration that may cause eutrophication (an increase in the productivity level of a waterbody) in freshwater ponds and lakes. Nielson (1981) also identified a range of critical nitrogen concentrations of 0.32 to 1.0 mg/l, based on data from a number of estuaries. Based on this range, the Town of Falmouth had selected a critical concentration of 0.75 mg/l as its initial planning guideline for coastal ponds and estuaries in 1988. A subsequent series of studies conducted on various saltwater coastal ponds throughout the Town of Falmouth has shown that ponds with nitrogen levels currently at or above the 0.75 mg/l level often show signs of cultural eutrophication. Based on this information and the Nielson publication, the Town of Falmouth has since revised its standards to reflect existing and potential uses of the Town's various ponds and estuaries. The new standards range from 0.32 mg/l for high quality coastal ponds, to 0.50 mg/l for intermediate areas, to 0.75 mg/l for heavily used, commercial areas.

Sources of Nitrogen

Nitrogen originates from a variety of natural and anthropogenic (human-related) sources, including sewage, fertilizers (residential and agricultural), road runoff, precipitation, landfills, wildlife and sediments. A discussion of published loading rates for these sources is provided below.

Sewage:

Sewage-derived nitrogen may be produced by a variety of sources, including sewage treatment plants, septage lagoons, on-site sewage disposal systems, exfiltration from leaking sewer mains and combined sewer overflows (CSOs). In Chatham, on-site sewage disposal systems are the primary source of nitrogen to most surface and ground-water resources, as is shown in the bar charts (Figures 5-8) presented on pages 68 and 69 of this report.

The quantity of nitrogen produced by a given on-site sewage disposal system is a function of the volume and concentration of the effluent discharged, which, in turn, is dependent on the per capita water usage and the occupancy rate. Daily rates of water use may range from 36 to 150 gallons per day (GPD) per person (EPA, 1980; Nelson et al., 1988) with average rates on the order of 50 to 75 GPD. In estimating sewage flow rates, however, it is important to differentiate between the amount of water actually used and the amount ultimately discharged to ground water as sewage flow. Typically, 20% of the water used may be lost through evaporation or transpiration during irrigation and other outside uses (Nelson et al., 1988). For the purpose of this study, a ground water discharge rate of 55 GPD per capita was used for sewage flow.

Average occupancy rates used for this study were, as described in the buildout section: a) a rate of 3 people per unit and b) a rate of 1.86 people per unit.

A review of the literature indicates that nitrogen concentrations in raw sewage may range from 20 to 100 mg/l. Once sewage enters a properly functioning septic system however, some removal of this nitrogen occurs both within the septic tank and within the soils below the leaching area. Several studies have indicated that between 30 to 60% of the nitrogen may be removed in this way (Porter, 1978; Andreoli et al., 1980). Thus, when estimating loading rates from on-site sewage disposal systems it is important to use nitrogen concentrations in effluent discharging from the leaching area. Data from the literature on total nitrogen concentrations in effluent sampled either from the leaching area or from ground water immediately below the leaching area are summarized in Table 11.

TABLE 11 TOTAL NITROGEN CONCENTRATIONS IN SEPTIC SYSTEM EFFLUENT

Source	Concentration
Bouma et al., 1972	30 mg/l
Walker et al., 1973	40 mg/l
Dudley and Stevenson, 1973	14 mg/l
Magdoff et al., 1974	31 mg/l
Reneau, 1977	23 mg/l
Brown and Assoc , 1980 (summary)	37 mg/l
Ellis, 1982	34 mg/l
Canter and Knox, 1986 (summary)	40 mg/l
Nelson et al., 1988 (summary)	34 mg/l

A critical review of these reports, particularly the more recent ones, suggests that an average effluent concentration of 40 mg/l is a conservative yet defensible value to use in evaluating water quality impacts of on-site sewage disposal. This value was used in our analyses.

Fertilizers:

Fertilizers applied to residential lawns, golf courses, and cranberry bogs all contribute nitrogen to ground and surface waters. The pathway may be either direct, via surface runoff, or indirect, via gradual leaching to ground water. The amount of fertilizer that ultimately leaches into ground water is a function of the type of ground cover, soil characteristics, climate, type of fertilizer used, application rate, and the degree of irrigation/rainfall. Typical leaching rates for lawns and other turf areas are summarized in Table 12.

TABLE 12 LEACHING RATES FOR FERTILIZERS APPLIED TO TURF AREAS

Reference	% Leached
Brown et al., 1977	27%
Chichester, 1977	8%
Dowdell and Webster, 1980	5%
Mancino, 1983	4%
Nelson et al., 1980	43%
Starr and DeRoo, 1981	1%
Brown, 1982	6%
Hesketh, 1986	17%
Morton, 1988	8%
Petrovic, 1988	10%

Based on this review, an average leaching rate of 30% was selected as a conservative value for residential lawns and golf courses. The typical lawn size for a given lot will vary widely depending on overall lot size, residential character, and individual preferences. Few quantitative studies have been conducted of average lawn sizes. Long Island and Barnstable County studies have used an average lawn area of 5000 square feet. More recently, a survey conducted as part of the Yarmouth Water Resources Protection Plan documented an average lawn size of 4350 square feet on half acre lots (Nelson et al., 1988). For this study, an average lawn size of 6000 square feet was used for residences in both the R-20 and R-40 districts, based on discussion with the Town Planner. See Table 15 (page 62) for lawn sizes used for the commercial portions of the study area (0-750 sq. ft.).

Fertilizer application rates are similarly difficult to quantify. The Cape Cod and Long Island studies used an average annual application rate of 3 pounds per 1000 square feet (SF), whereas the Yarmouth survey documented a lower average annual application rate for homeowners (2.8 lbs/1000 SF) and a higher annual application rate for professional lawn maintenance companies (4.7 lbs/1000 SF). For this study, an average annual application rate of 3 lbs/1000 SF was used.

Although golf courses tend to be intensively maintained, fertilizer applications are carefully controlled and the use of slow-release fertilizers is commonplace. This finding is supported by a preliminary review of data collected for four golf courses on Cape Cod, as part of the CCPEDC golf course monitoring program. According to this data, average nitrogen application rates at golf courses range from 2.2 lbs/1000 SF for fairways and roughs to 4.0 lbs/1000 SF for greens. The Town has recently negotiated to purchase the only golf course in the study area (associated with Chatham Bars Inn). The course will be fertilized only in fairways, green and tee areas, all at a rate of 3 lbs/1000 SF.

Fertilizer applications to cranberry bogs are carefully controlled by bog owners, as cranberry plants are sensitive to high nitrogen levels. Excessive nitrogen levels during the spring months induce leafy growth in cranberry plants, at the expense of later fruit production. To avoid this, plants are not usually fertilized until after the plants bloom, sometime in July. A recent, detailed study of a series of cranberry bogs located north of Buttermilk Bay, in the Town of Bourne, suggests that cranberry bogs contribute approximately 15.8 lbs of nitrogen/acre/year (Teal and Howes, 1989). This loading rate is lower than previous estimates (10-40 lbs/year, Deubert, pers. comm., 1989), probably because bogs provide an ideal environment for the process of denitrification and some of the nitrogen used in berry production is removed from the system through harvesting. The study area includes one managed cranberry bog located in the Oyster Pond/River sub-study area.

Pavement and Roof Runoff:

Sources of nitrogen in pavement runoff include precipitation, soil erosion, leaf litter, street dirt and litter, and animal waste. Nitrogen concentrations in road runoff can vary by an order of magnitude, depending on spacing between storms, the intensity and duration of a storm, and the timing of sample collection. The highest nutrient concentrations are generally found in the "first flush". A summary of typical road runoff values published in the literature is provided below.

TABLE 13 TOTAL NITROGEN CONCENTRATIONS IN ROAD RUNOFF

Reference	Total Nitrogen Concentration
Koppelman, 1982	1.49 mg/l
Howie and Waller, 1986	1.13-2.15 mg/l
Lager et al., 1968	3-10 mg/l
Loehr, 1974	3 mg/l
Schmidt and Spencer, 1986	2.04 mg/l

For the purposes of this analysis, a nitrogen concentration of 2.0 mg/l in road runoff was used. For roof runoff, a nitrogen concentration of 0.75 mg/l was used (Nelson et al, 1988). Roads in the study area were calculated as 15% of the upland area, i.e. the total area as measured on the Town land-use map, minus open water areas (also measured on the land-use map) and minus wetland areas (measured on the DEM Wetland Restriction Program maps).

Precipitation:

Nitrogen concentrations in precipitation vary regionally. Published values for the Massachusetts/New England area are summarized in Table 14.

TABLE 14 NITROGEN CONCENTRATIONS IN PRECIPITATION

Location	Reference	Form*	Loading Rate
Yarmouth, MA	Wright-Pierce, Inc., 1987	TN	0.74 mg/l
Falmouth, MA	Valiela and Costa., 1978	TN	8.0 kg/hectare
Truro, MA	Frimpter et al., 1988	NO	30.26 mg/l
Quabbin Res.	Frimpter et al., 1988	NO_3-N	0.47-.56 mg/l
Long Island, NY	Flipse et al., 1984	TN	0.87 mg/l
Long Island, NH	Koppelman, 1982	TN	0.82 mg/l
Lit Review	Loehr, 1974	TN	0.73-1.27 mg/l

*TN = total nitrogen, NO_3-N = nitrate-nitrogen, NO = nitrous oxide

As precipitation falls on vegetated areas, much of the dissolved nitrogen is taken up by vegetative cover and within the root zone, and thus does not leach into the underlying aquifer. This theory is supported by ground water data produced by the Barnstable County Health and Environmental Department. Of the 5,559 ground water samples analyzed between 1980 and 1986, twenty-five percent contained less than 0.05 mg/l nitrate-nitrogen. Many of these low-nitrogen samples were collected from wells in undeveloped areas, suggesting that natural background levels of nitrate-nitrogen in ground water on the Cape Cod area are approximately 0.05 mg/l or less. This value was used in our analysis as being representative of natural background conditions. Natural area in the study area, not included on individual lots, was measured from the Town land-use map, and including land designated as unbuildable and as open space. Cemetery areas were included with natural land, since they are not fertilized in Chatham.

The following table (Table 15) shows lot sizes and assumptions that were used in our analysis regarding percentages of the lot that were lawn, roof, driveway and natural area. The first entry shows values used for residential portions of the study area. The next two entries show the lot size and percentages taken as average for existing commercial areas in both the Stage Harbor/Mill Pond and Oyster Pond/River sub-study areas. The last entry shows the assumptions used as limits for hypothetical expansion of commercial areas in the Oyster Pond/River section of the study area. The numbers were selected based on Chatham's zoning requirements, discussion with the Town Planner and Harbor Planning Committee, and HWH experience.

TABLE 15 LOT SIZES AND PERCENTAGES USED FOR THE STUDY AREA

Land-use, Location	Average Lot Size	% Lawn (sq. ft.)	% Roof (sq. ft.)	% Parking (sq. ft.)	% Natural Area (sq. ft.)
Residential, Oyster Pond/R. and Stage Harbor/ Mitchell R./ Mill Pd.	30,000 sf	20% (6000)	6% (1800)	2% (600)	72% (21600)
Commercial, Oyster Pd./R.	15,000 sf	5% (750)	20% (3000)	25% (3750)	50% (7500)
Commercial, Stage Harbor/ Mitchell R./ Mill Pond	6,000 sf	5% (300)	50% (3000)	35% (2100)	10% (600)
Commercial, Oyster R./Pd. Expansion Limits	15,000 sf	0% (0)	25% (3750)	35% (5250)	40% (6000)

Nitrogen Loading Analysis

The nitrogen loading rates used in our analyses were selected on the basis of the literature review outlined above, and also to correspond with a recently calibrated nitrogen loading model developed for the Town of Yarmouth (Nelson et al., 1988). These loading rates are summarized in Table 16. Restaurants and motels in the study area which are not on sewer are listed in Appendix 2, with their number of seats and/or number of units.

TABLE 16 NITROGEN LOADING VALUES

Source	Concentration	Loading Rate	Flow/Recharge
Sewage	40 mg N/liter	(6.72 lbs N/Person-yr) Restaurants @35 GPD/seat Motels @ 110 GPD/ unit Churches @ 0.42 GPD/seat	55 gallons/person-day
Fertilizer (Lawns)		(0.9 lbs N/1000 sq ft-yr)	18 inches/year
Fertilizer (Cranberry Bogs)		(16 lbs N/acre)	18 inches/year
Pavement Runoff	2.0 mg N/L	(0.42 lbs N/1000 sq ft-yr)	40 inches/year
Roof Runoff	0.75 mg N/L	(0.15 lbs N/1000 sq ft-yr)	40 inches/year
Natural Land (including cemeteries)	0.05 mg N/liter	(.005 lbs N/1000 sq ft-yr)	18 inches/year

Once nitrogen has entered the ground water system, ultimate nitrate-nitrogen concentrations can be calculated using a simple mass balance equation, in which nitrogen levels are a function of the annual rate of nitrogen loading and the annual rate of dilution through recharge. Sources of recharge to ground water include precipitation, surface runoff from impervious areas and artificial recharge from on-site sewage disposal. Recharge rates used in the nitrogen loading analysis are summarized in Table 16.

The mass balance equation used to predict nitrate-nitrogen concentrations in ground water is as follows:

Nitrate-nitrogen (mg/l)=

$$\frac{\text{(Annual nitrogen loading from all sources in lbs/year)(454,000 mg/lb)}}{\text{(Annual recharge from all sources in liters)}}$$

Using this equation, nitrate-nitrogen concentrations in ground water within each sub-study area and for the study area as a whole, were calculated. Loading was calculated for existing conditions and several buildout scenarios, as follows:

I) 1974 approximate conditions.

II) Existing conditions.

III) Residential buildout with no commercial expansion.

IV) Residential buildout conditions with some commercial expansion. The Main Street area east of the rotary was assumed to be at saturation, due to parking, frontage, lot coverage, and setback requirements. Hence, in our analysis, commercial expansion was only allowed west of the rotary. This scenario estimates conditions if 50% of the commercial businesses west of the rotary were to expand to the maximum allowed by existing zoning.

V) Residential buildout conditions with expansion of 100% of the commercial businesses west of the rotary.

VI) Commercial expansion as in V, residential expansion to meet the Chatham Board of Health 10 mg/l nitrate-nitrogen limit, back-calculated to give number of additional people provided bedroom space within this limit. This back-calculation assumes no change in roof, lawn, natural area or pavement acreages. Thus, this scenario would represent house additions through adding more stories.

Each scenario was analyzed for nitrogen loading using the two occupancy rates discussed earlier--3 people per house and 1.86 people per house. In the nitrogen loading analysis, 1974 structure counts from the USGS topographic map were also used, to give an historical perspective. The 1974 data are not directly comparable to existing or buildout scenario loading estimates, due to differences in counting methodology. Predicted nitrogen loading in the study area is summarized in Table 17. The calculations are shown in Appendix 2. Figures 5-8 (shown on pages 68 and 69) graphically show the percentages of nitrate-nitrogen supplied by the various sources, including sewage, lawns, pavement and roof runoff, natural area, the golf course and cranberry bogs. Under all scenarios, sewage is the primary source of nitrogen input, with roofs, natural areas, the golf course and cranberry bogs contributing the least nitrogen. The total nitrogen inputs are diluted by recharge. Using the equation shown earlier (page 63), nitrate-nitrogen concentrations in ground water are estimated. These concentrations are shown in Table 17.

TABLE 17. SUMMARIZED NITROGEN LOADING IN POUNDS/YEAR BY SOURCE AND SCENARIO

Oyster Pond/River, at 1.86 people per house

Scenario	1974	Existing	Buildout	50% Comm.	100% Comm.	Res. Exp.	
Source							
Sewage	10161	17438	21809	23657	25310	90378	
Lawns	5183	6650	8546	8446	8446	8446	
Pavement	2598	3379	3468	3658	3753	3753	
Roofs	279	394	489	530	554	554	
Natural	153	257	242	243	244	244	
Bogs		155	155	155	155	155	
Golf Course		189	189	189	189	189	
Total	**18374**	**28462**	**34898**	**36878**	**38651**	**103719**	**N lbs/yr**

Oyster Pond/River, at 3 people per house

Scenario	1974	Existing	Buildout	50% Comm.	100% Comm.	Res. Exp.	
Source							
Lawns	5183	6650	8546	8446	8446	8446	
Pavement	2598	3379	3468	3658	3753	3753	
Roofs	279	394	489	530	554	554	
Natural	153	257	242	243	238	238	
Bogs		155	155	155	155	155	
Golf Course		189	189	189	189	189	**N lbs/yr**
Total	**8213**	**11024**	**13089**	**13221**	**13335**	**13335**	

Stage Harbor/Mitchell River/Mill Pond at 1.86 people per house

Scenario	1974	Existing	Buildout	50% Comm.	100% Comm.	Res. Exp.	
Source							
Lawns	2422	2855	3584			3584	
Pavement	2404	2463	2497			2497	
Roofs	125	166	202			202	
Natural	136	126	120			120	
Golf Course		119	119			119	
Total	**5087**	**5729**	**6522**			**6522**	**N lbs/yr**

Stage Harbor/Mitchell River/Mill Pond at 3 people per house

Scenario	1974	Existing	Buildout	50% Comm.	100% Comm.	Res. Exp.	
Source							
Lawns	2422	2855	3584			3584	
Pavement	2404	2463	2497			2497	
Roofs	125	166	202			202	
Natural	136	126	120			120	
Golf Course		119	119			119	
Total	**5087**	**5729**	**6522**			**6522**	**N lbs/yr**

STUDY AREA TOTAL

Scenario	1974	Existing	Buildout	50% Comm.	100% Comm.	Res. Exp.
at 3/house	**13300**	**16753**	**19611**	**13221**	**13335**	**19857**
at 1.86/house	**23461**	**34191**	**41420**	**36878**	**38651**	**110241**

TABLE 18 ESTIMATED NITRATE-NITROGEN CONCENTRATIONS IN GROUND WATER UNDER VARIOUS DEVELOPMENT SCENARIOS

Scenario 1: Occupancy Rate: 1.86 people per unit	**Oyster Pond/ Oyster River**	**Stage Harbor/ Mitchell R./ Mill Pd.**	**Overall Study Area**
1974* approximate	3.44	2.40	2.98
Existing (1989)	3.47	3.31	3.41
Buildout/no commercial expansion	4.15	4.07	4.12
Buildout/50% commercial expansion west of rotary	4.29	---**	4.22
Buildout/100% commercial expansion west of rotary	4.40	---	4.29
Buildout/100% commercial expansion west of rotary, residential expansion to accommodate (#) more people	10.00 (9,747)	10.00 (4,855)	10.00 (14,602)
Scenario 2: Occupancy Rate: 3 people per unit			
1974* approximate	4.41	3.07	3.82
Existing (1989)	4.33	4.09	4.24
Buildout/no commercial expansion	5.24	5.08	5.19
Buildout/50% commercial expansion west of rotary	5.35	---	5.26
Buildout/100% commercial expansion west of rotary	5.44	---	5.33
Buildout/100% commercial expansion west of rotary, residential expansion to accommodate (#) more people	10.00 (8,175)	10.00 (4,140)	10.00 (12,315)

*A ten- to fifteen-year flow time is estimated between the upper part of the watershed and Stage Harbor. Therefore, the 1974 nitrogen loading estimates may be representative of current (1989) water quality conditions within the receiving waters.
**No value because the Stage/Harbor/Mitchell River/Mill Pond portion of the study area does not include any commercial property west of the rotary on Main Street.

According to this analysis, past and existing nitrate-nitrogen levels in ground water in the Oyster Pond/River and Stage Harbor/Mitchell River/Mill Pond sub-study areas are below the federal 10 mg/l drinking water limit as well as below the CCPEDC 5 mg/l guideline. Even under buildout conditions, the 10 mg/l guideline is not exceeded, and if the 1.86 people per unit occupancy rate is used, the 5 mg/l concentration is not exceeded until existing residential units are expanded.

The increase in predicted nitrate-nitrogen concentrations in ground water between 1974 and existing (1989) conditions using either occupancy rates is approximately 0.4 mg/l or 13%. Between existing and buildout with 100% commercial expansion west of the rotary, the increase in loading is 0.9-1.1 mg/l, or 26%. A much larger increase, 136% to 193%, is expected if expansion of existing residences is considered. The effect of expansion of commercial interests is minor: 100% commercial expansion represents only a 3-4% nitrate-nitrogen increase in ground water over residential buildout without commercial expansion.

Residential expansion is primarily limited by Chatham's Board of Health regulations which limit loading to 10 mg/l nitrate-nitrogen per house. Other Town regulations may also limit expansion, such as those requiring setback distances from streets, abutting houses and wetlands, and the building height maximum. Using the Board of Health limit of 10 mg/l, nitrogen loading calculations were conducted in reverse to determine the additional number of people that could be expected if this limit were met. These back-calculations, shown in Appendix 2 and summarized in Table 18, show that bedrooms for 12,000-15,000 more people could be added to the study area, depending on which occupancy rate is used. This estimate is approximate, because only changes in nitrogen loading due to sewage flow were considered. Changes in the amount of lawn, pavement, or roof size were not considered.

An increase of 12,000-15,000 people may be an overestimate since it is based upon applying the Board of Health limit of 10 mg/l of nitrogen loading to the entire study area. In reality not all lots will be expanded since some lots will not meet zoning size and setback considerations and cannot be expanded to a size which generates this level of nitrogen loading.

FIGURE 5. NITROGEN SOURCES IN STAGE HARBOR/MITCHELL RIVER/MILL POND SUB-STUDY AREA AT OCCUPANCY RATE 1.86

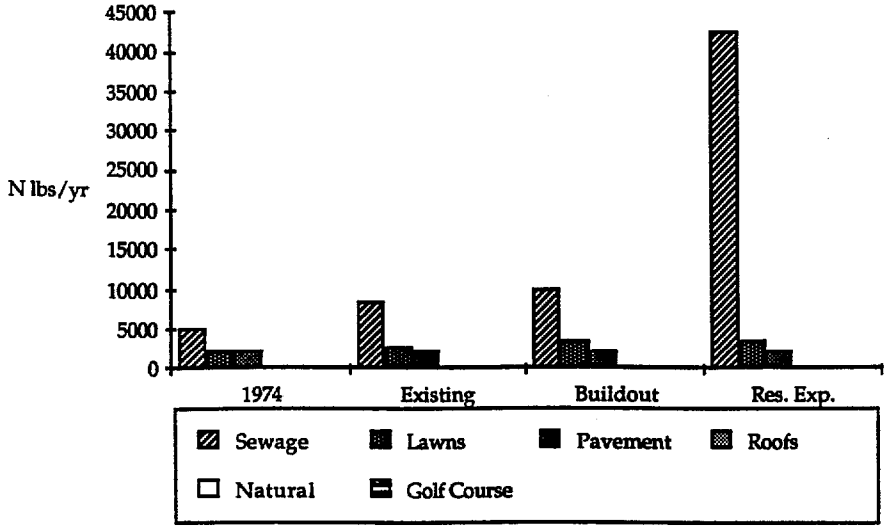


FIGURE 6. NITROGEN SOURCES IN STAGE HARBOR/MITCHELL RIVER/MILL POND SUB-STUDY AREA AT OCCUPANCY RATE 3

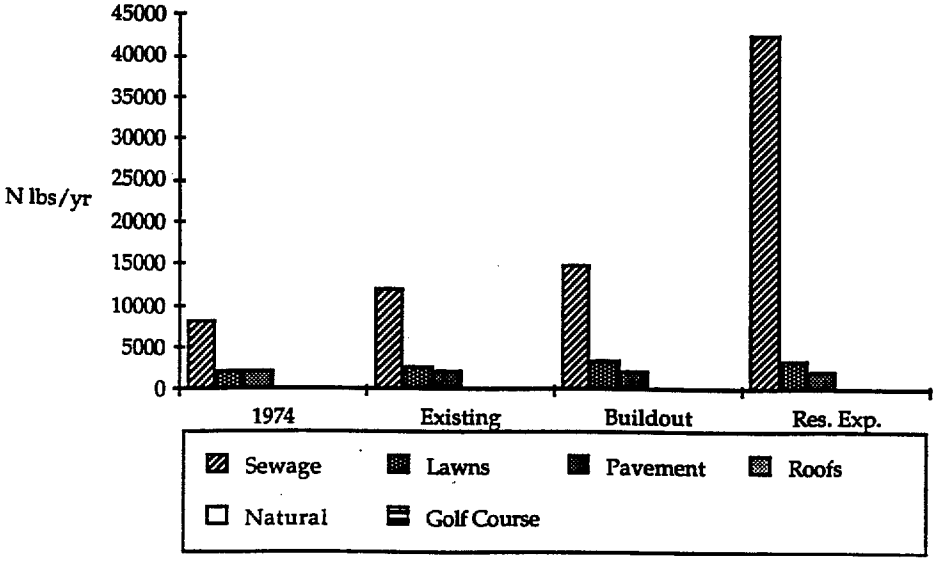


FIGURE 7. NITROGEN SOURCES IN OYSTER POND/RIVER SUB-STUDY AREA AT OCCUPANCY RATE 1.86

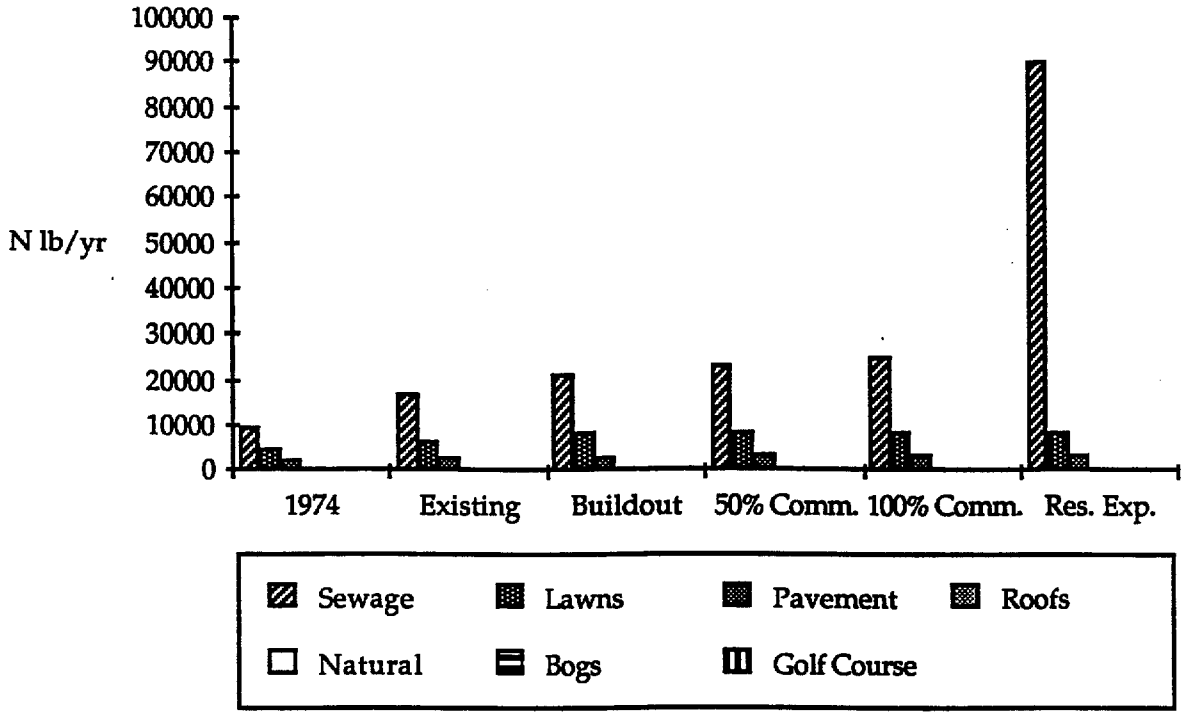
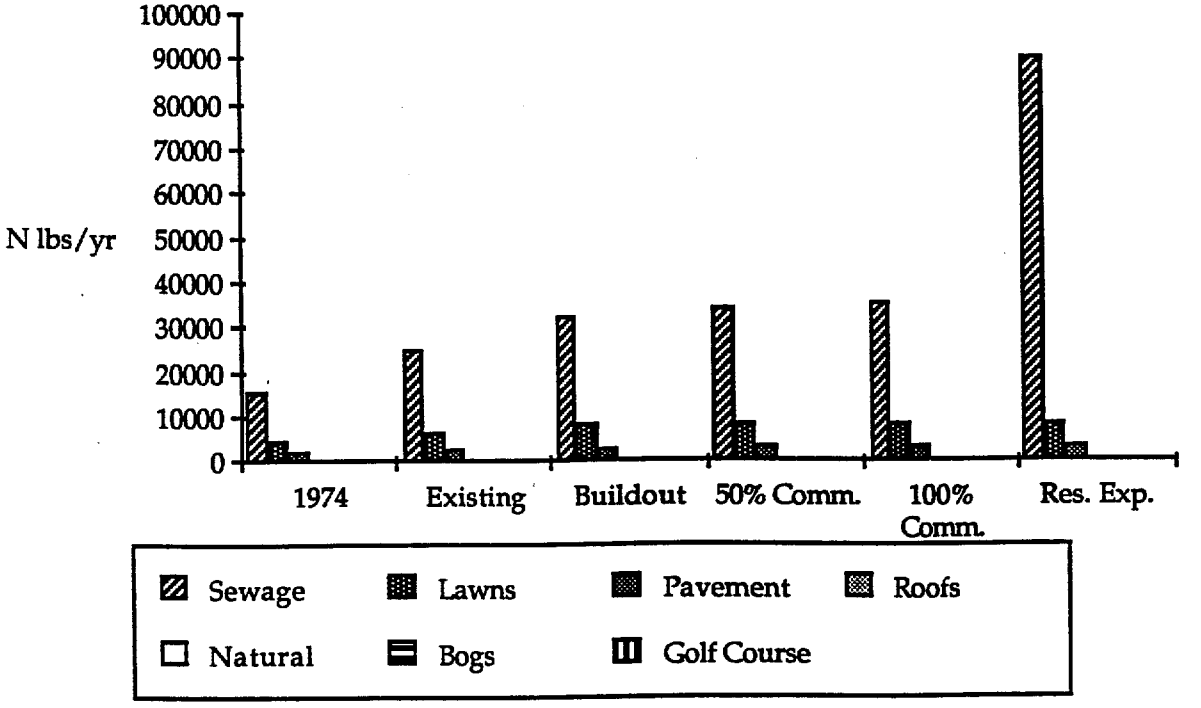


FIGURE 8. NITROGEN SOURCES IN OYSTER POND/RIVER SUB-STUDY AREA AT OCCUPANCY RATE 3.0



Under none of the nitrogen-loading scenarios is the federal drinking water limit exceeded. However, under all the scenarios, the recommended nitrogen limit for marine ecosystems (0.75 mg/l) is exceeded. The calculated loading estimates nitrate-nitrogen in ground water, which is likely to be greater than the concentration in the Stage Harbor system waters since tidal flushing will dilute the nitrogen inputs. The extent of flushing will be determined in a later phase of this study. Attenuation and uptake of nitrogen inputs by vegetation within the study area are also likely to occur, and may further decrease final nitrate-nitrogen concentrations in harbor water.

As was mentioned earlier, elevated nitrogen levels in estuaries can lead to increased productivity of algae, including species which attach to eelgrass and contribute to declines in eelgrass populations. Increases in phytoplankton populations can have other detrimental effects on the ecosystem, including reduced water clarity and shellfish population decreases. Exact links between elevated nitrogen levels and changes in marine ecosystems are not known.

Since impacts to the Stage Harbor system waters, rather than water potability, are the focus of this study, the loading calculations suggest that nitrogen management may be necessary in the study area. Not only may nitrogen inputs to the harbor system increase beyond acceptable levels, but a large population increase is also possible. These additional people, along with current harbor users, will place increased demands on the estuarine resources for swimming, boating, shellfishing and finfishing.

The calculations predict loading of nitrate-nitrogen to ground water under various future development scenarios. Inputs of bacteria and viruses are also a concern for the swimming areas and valuable shellfish beds in the study area. Bacteria and viruses generally do not travel long distances in ground water, but are more likely to enter the estuaries via stormwater runoff or from shoreline septic systems.

To summarize, nitrogen inputs to ground water are not problematic for drinking water supply, but may be for the harbor ecosystem.

Impacts of Public Water Uses on Harbor Resources

Many of the uses of the Stage Harbor system (including its shellfishing industry) generate negative environmental impacts. The following text and Table 19 reviews each major water use and discusses its impacts to the harbor's water quality and resources.

Shellfishing and Finfishing

Chatham fishermen depend on a highly productive shellfishery, while shellfish productivity in the Stage Harbor system depends on the quality of the aquatic

environment. Any uses which lessen the environmental quality of the Stage Harbor system also lessen the harbor's ability to support a fishing industry.

Fishermen also depend on a variety of support facilities including public access, boat mooring, boat repair and storage, and off-loading facilities. These facilities are common sources of pollution, and have been documented by the Town's Waterways Committee and water quality laboratory as potential sources of pollution to the Stage Harbor system. The use of motorized boats by fishermen contributes metals and hydrocarbons to the water, and as of 1990, marinas are closed to shellfishing. Ironically, shellfishing negatively impacts the shellfishery through dependence upon these support industries and motors. This example illustrates the complexity of use conflicts in the Stage Harbor system.

Recreational Boating

As with shellfishing and finfishing, recreational boaters depend on many services including boat mooring, repair and storage, and fueling areas, which are all potential sources of pollution.

The use of motorized boats and the lack of a pump-out station make boaters themselves a potential source of pollution, since boaters may contribute to bacterial and viral contamination through the release of sewage into the water. As was mentioned earlier, Chatham is currently seeking ways to provide a pump-out facilities at the Old Mill Boatyard.

Boaters demand open water and adequate navigation channels in and out of the Harbor. Because of the highly variable nature of Chatham Harbor's sediments, the harbor's channel must routinely be dredged to maintain navigable channels. Dredging stirs up sediments, destroys aquatic vegetation and may kill aquatic life. Therefore, at least in the short-term, dredging will lessen the environmental quality of the harbor and the level of fish production.

Swimming

Swimming areas typically have high bacterial counts and should not be shellfished. Parasitic outbreaks (such as swimmer's itch) result in swimming closures. Swimming demands relatively good water quality for health reasons, and aesthetic appeal.

Waterskiing and Jetskiing

The opportunity to waterski and jetski is limited in the Stage Harbor system due to speed restrictions imposed by the Town's waterways regulations (5 miles per hour). Oyster Pond is the only area within the study area which allows the higher speeds necessary for these uses. As is true for all motorized uses within the Harbor, pollutants associated with boat and jetski motors are generated.

TABLE 19 IMPACTS OF USES ON HARBOR RESOURCES

Water Use	Needs	Impact on Marine Resources/Water Quality
Boating	Boat Repair	Potential source of water pollution
	Fueling Stations	Release of metals and hydrocarbons to water
	Motors	Release of metals and hydrocarbons to water
	Navigation Channels	Dredging resulting in sediment suspension and loss of aquatic life
	Sanitary Facilities	Release of sewage into water due to lack of pump-out facility
Swimming	Sanitary Water	Release of bacteria and viruses
	Open Water	Weed control may disrupt ecosystem
Waterskiing and Jetskiing	Motors	Release of metals and hydrocarbons to water
	Fueling Stations	Release of metals and hydrocarbons to water

Due to the lack of information about metals, hydrocarbons and nutrients in the harbor, the impact of these uses upon water quality is unknown. Stage Harbor currently experiences problems of congestion and safety due to the intense level of use. The Town must balance the type and intensity of uses with their impact on natural resources, aesthetics, and recreational quality.

Sediment Transport and Tidal Flushing

A beach and related tidal inlet may receive sand from a variety of sources, and lose sand through a number of mechanisms as well. Major sources of sand generally are longshore sand transport into a region, bluff or dune erosion, stream or river input, onshore sand transport, biogenous or hydrogenous sediments (such as shells, corals, etc.), beach nourishment, and sometimes windborne sediments. Major sinks of sand can be longshore sand transport out of a region, offshore sand transport (including transport through submarine canyons), sand mining, windblown transport into dunes, and loss into estuaries or lagoons (via tidal inlets). Some, but generally not all, of these processes are active along a particular stretch of beach. If a source of sand is terminated abruptly, beach erosion may result. Similarly, if a new sink is introduced, the beach may erode.

The major source of sediment entering the Stage Harbor area comes from longshore sand transport on Harding Beach. The net direction of sediment transport along East Harding Beach is toward the west, or toward the entrance to Stage Harbor. The source of sediments transported along this beach are the coastal bluffs of Morris Island, which are continually being eroded by tidal currents in Chatham Harbor. Erosion of the Morris Island bluffs can be expected to increase as the new inlet migrates to the south, exposing Morris Island to direct wave attack from the Atlantic Ocean. Sediments eroded from the Morris Island bluffs are transported westward toward Stage Harbor, and during flood dominated tidal cycles, these sediments may be carried into Stage Harbor, however most of the littoral drift is deposited in the entrance channel to Stage Harbor.

Tidal Circulation and Flushing

Studies of the ecology of tidally influenced estuaries are in part based on a knowledge of the exchange of fresh and saltwater between the inlet/estuarine system and the open ocean. The distributions of salinity and dissolved oxygen are controlled by this tidal flushing. Additionally, the distribution of planktonic organisms, eggs spawned within the estuary, and pollutants introduced by nearby towns are also controlled by the exchange of fresh and saltwater. In short, the distribution of any material which is dissolved or suspended in the water column is determined by the circulation of fresh and saltwater and by the exchanges between various parts of the estuary. These exchanges, and the resulting distributions, are related in a regular way over short periods of time to oscillations in the daily tide, and over longer periods of time to fluctuations in river and stream flow.

To quantify the exchange of fresh and saltwater between an estuary and the open ocean, one must determine the residence time of the estuary, or the average time that a particular waterparcel spends in the estuarine system. This residence time is commonly referred to as a flushing or turnover time and can be defined by the following equation:

$$t = \frac{V + P}{P} T \qquad (1)$$

where

t = flushing time (hours)
V = low tide volume of estuary (cubic feet)
P = tidal prism of estuary (cubic feet)
T = tidal period (hours)

By multiplying by the tidal period in equation (1), the flushing rate is converted from the number of tidal cycles to an hourly value. This flushing rate method assumes that the estuary is completely mixed and that there is no vertical stratification within the water column. Because of this assumption, the flushing times calculated in this manner are somewhat lower than those calculated using other methods, since the tidal volume introduced during the incoming tide is in general not completely mixed with the low tide volume.

Equation (1) was used to provide a preliminary estimate for the flushing rate of the Stage Harbor/Oyster Pond/Mill Pond system. The low tide volume of the estuary was determined by multiplying the total surface area of the estuary at low tide by an average water depth at low tide. The tidal prism was calculated by multiplying the total surface area of the estuary at mean tide by the average tidal range. The period of tidal oscillation at Stage Harbor is 12.42 hours. These calculations for Stage Harbor indicate a flushing rate which ranges from 2 to 4 days (4 to 8 tidal cycles). It should be noted that this is only a preliminary estimate of flushing within the system, and that contributions of freshwater from local streams or drainage ditches have not been included. Additionally, considerations of channel geometry and distance from the harbor mouth have not been incorporated. These factors can more easily and accurately be included through the use of numerical computer models.

As mentioned above, the distribution of dissolved or suspended material in the water column is determined by the circulation of fresh and saltwater, and by the exchanges between various parts of the estuary. The distribution of bottom sediments however, are related more to the development of asymmetries in the daily estuarine tide. These asymmetries take the form of unequal duration and/or unequal magnitude of ebb and flood tidal flows. For example, some inlet/estuarine systems are characterized by longer ebb tides than flood tides. However, the volume of water flowing during the ebb and flood tides is approximately equal. Consequently, there is a tendency for higher current velocities during flood tide than during ebb tide (since the same volume of water is flowing but for a shorter duration); such systems are termed flood-dominant. Other systems show the opposite duration asymmetry; the flood tides are of longer duration than the ebb tides. Therefore, these is a tendency for stronger ebb currents (ebb-dominant). These different senses of asymmetry have important implications for estuarine sediment transport, and long-term estuarine/tidal inlet stability.

Estimates of tidal asymmetries (duration and magnitude) for the Stage Harbor complex cannot be made with the available data. These calculations require measurements of tidal elevation and current velocity for approximately one 15-day period inside the Stage Harbor area. No data of this type has been collected at the study site.

Analysis of Land-use Regulations which pertain to Water Quality

The Stage Harbor area currently experiences seasonal problems of poor water quality for the purpose of shellfishing due to high bacterial levels in Oyster Pond and the Champlain Flat area of Stage Harbor. Due to insufficient information about the Stage Harbor system's water circulation, the impact of future land development on the Stage Harbor environment cannot be fully evaluated. However, the impact of known sources of pollution can be minimized through land-use regulations.

Several regulatory, non-regulatory and legislative options to protect water quality are available to the Town of Chatham. Regulatory strategies include tools which are adopted through zoning bylaws, subdivision rules and regulations, health regulations and wetlands protection regulations. The following is an analysis of existing regulations in Chatham which relate to protection of water quality.

Zoning Bylaw

The maximum permissible intensity of development is dictated through Chatham's zoning bylaw. The intensity and type of land development has direct bearing upon the level of pollutants which will be generated. The nitrogen loading analysis indicates that the level of nitrate-nitrogen in the ground water of the Stage Harbor contributing area will increase over time. Depending upon the extent of water flushing in the harbor, nitrogen levels may exceed recommended levels for estuarine systems in the future. Excessive nitrogen concentrations could lead to a decline in eelgrass beds and associated shellfisheries.

The Town's water quality laboratory has identified additional sources of pollution such as marinas and boatyards, gasoline stations, and animal wastes. The Town of Chatham currently allows marinas, boatyards and dog kennels in most zoning districts, either by right or with a special permit, within the Stage Harbor contributing area. Gasoline stations are allowed in the General Business district with a special permit. Due to the potential threat to water quality which these uses signify, Horsley Witten Hegemann, Inc. (HWH) recommends that marinas, boatyards and dog kennels be permitted only with a special permit throughout the contributing area. Performance standards for these potentially threatening uses should be adopted to regulate their impacts.

In addition to typical use and intensity regulations, Chatham has adopted many innovative regulations geared toward ensuring better environmental protection. Construction-related soil erosion can be a significant source of water pollution. Chatham is one of few towns in Massachusetts which attempts to control erosion levels during construction. According to the Town's zoning bylaw, the building inspector can require erosion controls on any land within 300 feet of a conservancy district. Conservancy districts include features such as wetlands, water bodies and water courses. Due to the importance of controlling erosion and sedimentation of

Chatham's waters, HWH recommends that clear criteria be adopted indicating under what circumstances controls should be imposed, and what type of control measures are necessary.

Chatham regulates development in its Flood Plain District. Due to sea-level rise, lands located within the Flood Plain District are expected to change over time. The Town may wish to amend its zoning bylaw to require that the effects of sea-level rise be considered before issuing any development permits for structures lying within the sea-level rise zone.

The Town's zoning bylaw requires site plan review for most proposed commercial, industrial and multi-family residential developments to facilitate better site design, and to minimize negative impacts associated with development. Although the procedures established for site plan review are helpful, to aid in the decision-making process HWH recommends that the Town require an environmental and community impact assessment to be submitted with all applications. Specific criteria should be established for approval. To minimize water quality impacts, HWH further recommends the Town require that: 1) all stormwater drainage be retained on-site through natural infiltration wherever possible; 2) erosion and sedimentation measures be used during construction; and 3) no negative impact occur to water supply, water quality or resources designated as conservancy district.

Subdivision Rules and Regulations

Subdivision regulations "fine-tune" zoning bylaws since they focus less on land-use and more on engineering concerns such as street construction, utility placement and traffic patterns within individual subdivisions.

Subdivision rules and regulations typically provide guidelines for drainage control. The release of stormwater into the Stage Harbor system has been documented as a major source of water pollution. Most storm water generated in the downtown commercial district is piped directly into the Stage Harbor system waters. Changes in subdivision regulations cannot amend the current situation, however, they can lessen the impacts of future potential development. Therefore, HWH recommends that no newly developed areas be served by a town stormwater collection system which discharges to the Stage Harbor system.

Chatham's subdivision rules and regulations currently do not encourage on-site retention of storm water drainage or the use of natural infiltration to treat stormwater flow. HWH recommends that Chatham require that all stormwater generated by proposed development be retained on-site by natural infiltration wherever possible, to ensure that the amount of storm water entering directly into the Stage Harbor system waters (either directly or through the Town's storm water collection system) does not increase.

Board of Health Regulations

Sewage disposal is an important issue in the Town of Chatham. The DEQE (now the DEP) has determined that an increased level of use of the Town's public sewage treatment facility would threaten the quality of Chatham's public water supply. Consequently, no additional sewer expansion or hook-ups were to be allowed. Therefore, the Town is currently under a sewer moratorium and septic systems must be installed to treat any new developments or expansions.

Chatham has adopted several innovative health regulations to reduce the impact of sewage on water quality. The Town has adopted health regulations which are more stringent than Title 5 to guide septic system location and impact on water quality. Chatham's Board of Health requires that for all subsurface disposal systems designed to dispose of sewage flows equal to or greater than 2,000 gallons per day (gpd), it must be demonstrated that a conservative drinking water quality standard of 5 mg/l nitrogen will be met downgradient of the property limit, and that surface water standards will be met for ponds (.05 mg/l phosphorus), and estuaries and salt ponds (0.5 mg/l nitrogen). These nitrogen and phosphorus loading restrictions pertain to any applicable development in the Stage Harbor contributing area, but exempt single family development, since single family homes typically do not generate 2000 gpd of sewage flow. The buildout analysis demonstrates that under existing conditions nitrogen concentrations in ground water may be approximately 3-4 mg/liter (see Table 17). The resulting concentrations within the Stage Harbor estuarine system depend upon the flushing rate and are currently unknown.

The impact of sewage generated by single family and multi-family development is controlled through a separate nitrogen loading regulation which requires that sewage generated as a result of development may not result in average concentrations of nitrogen exceeding a limit of 10 mg/l on the property as a whole. Two-bedroom, single-family homes are exempt from this regulation. The buildout scenario indicates that given this loading limit, considerable expansion of residential development is still possible. As a result of residential expansions being limited to a ground water loading limit of 10 mg/l nitrogen, the level of nitrogen in ground water within the Stage Harbor contributing areas and the Harbor is expected to rise in the future.

The maintenance of septic systems is frequently overlooked. The result is typically an overloading of solids moving to the leaching facility and subsequent clogging and sewage failure. Such failures may result in the surface break-out of sewage and more direct transport of sewage derivatives to the coastal waters. Chatham is one of few communities in Massachusetts which require open inspection of existing on-site sewage treatment systems upon real estate transfer. In general, any systems found to be inadequate must be upgraded or repaired before property may be transferred.

Wetlands Regulations

As described in the natural resource inventory, wetlands serve an important role in maintaining Stage Harbor's water quality and in supporting its fisheries. The Wetlands Protection Act protects wetlands for eight statutory interests including: 1) protection of public and private water supply; 2) protection of ground water supply; 3) flood control; 4) storm damage prevention; 5) prevention of pollution; 6) protection of land containing shellfish; 7) protection of fisheries; and 8) protection of wildlife habitat.

Many Massachusetts communities have enacted non-zoning wetlands bylaws. This practice has been upheld by the Massachusetts Supreme Judicial Court. The Court has recognized that the State Zoning Act and Wetlands Protection Act serve as the minimum level of wetlands protection. The Town of Chatham has adopted a wetland bylaw and regulation which set forth a public review and decision-making process to oversee activities having an impact on the Town's wetlands. These regulations expand the interests protected by the Wetlands Protection Act to specifically include water quality in the numerous ponds of the Town, and erosion and sedimentation control. Additional provisions to further strengthen the regulations could include a requirement to account for sea level rise in delineating the upland boundaries of coastal wetlands.

Waterways Regulations

Chatham's Waterways Commission oversees use of the harbor system waters. Water uses are restricted by the Commission through its bylaws and regulations to maintain harbor safety and navigation. For example, no wake zones are posted throughout most of the Stage Harbor system waters. The location of moorings is also overseen through procedures specified in the bylaws. Given current problems with water congestion, it is recommended that these bylaws be amended to include specific procedures for determining the location and intensity of uses allowed.

Implications of Future Development

Through its zoning bylaw, the Town of Chatham has established a development program which dictates the level of future development in the Stage Harbor system contributing area. As the Town's seasonal and year-round populations grow, residents will probably place increased demand on the Town to provide water-related recreation, as well as harbor-oriented services such as parking, boating and pedestrian access, and boat docks and moorings.

The buildout analysis conducted for the Stage Harbor reveals that the majority of development possible in the Stage Harbor contributing area has already taken place. However, further residential and commercial development is still possible. This increase in growth will translate into considerable demand for public access to

the harbor's waters. Current water use conflicts suggest that the harbor's use is near or at capacity. Therefore, Town officials must weigh the impacts of providing greater access with impacts to water quality, recreational quality/congestion, and shellfishing.

The key question facing Chatham's officials is the harbor's carrying capacity. Uses such as marinas and motor-boating significantly decrease the potential for other uses such as shellfishing. Activities such as recreational boating and mooring increase congestion and decrease potential use of open water for swimming. Chatham must resolve the dilemma of how to ensure that each competing use may continue within the harbor complex. In order to resolve use conflicts in the Stage Harbor system's waters, Town officials and residents must clearly define what they want the harbor to be.

Goals and Policies for Resolving Harbor Issues

GOALS AND POLICIES FOR RESOLVING HARBOR ISSUES

Public Access to the Waterfront

ISSUE:

There is tremendous demand for access to the shoreline and water. The majority of shoreline in the Stage Harbor system is privately owned and is in residential use. As a result, there is little shorefront property available for water-dependent uses such as marinas, fishing piers and swimming areas. Although the town owns nine landings, the use of these areas is limited by parking constraints. Mooring space is limited in portions of the Stage Harbor waters.

GOAL: Maintain and improve public access to the harbor area.

POLICIES:

1. Maintain an adequate number of access points located throughout the Stage Harbor/Oyster Pond/Mill Pond area.

2. Acquire available properties which are suitable for expansion of existing Town landings.

3. Carefully design access and parking so as to minimize negative impacts on vegetation, natural landforms and water quality.

4. Preserve and protect water-dependent uses and facilities in shoreline areas.

5. Balance the demand for greater access to the waterfront with its impact upon environmental quality and marine resources.

6. Develop and improve the facilities at Old Mill Boatyard and selected Town landings to serve the public's water access needs.

7. Maintain the outer harbor as an open anchorage.

Navigation and Harbor Safety

ISSUE:

The Chatham Harbormaster, Harbor Patrol (Chatham Police) and United States Coast Guard are responsible for navigation and harbor safety. However, assistance is only provided to boaters in life threatening situations, and boaters generally have to rely on other members of the fleet for assistance as there are few commercial operations on the Cape which can tow large boats.

The entrance to Stage Harbor must be routinely dredged to maintain navigation. Changing shoreline processes influence the demand for dredging. For example, shoaling at the channel entrance to Stage Harbor has increased with the formation of the North Beach inlet .

The Stage Harbor system supports a wide variety of activities including swimming, sailing, windsurfing, waterskiing, jet skiing, pleasure boating, and both commercial and recreational fishing and shellfishing. There is a need to coordinate the location and timing of activities to lessen congestion and maintain harbor safety. Harbor users must be educated about safe navigational practices.

A. GOAL: Maintain and enhance the navigability of the Stage Harbor/Oyster Pond/Mill Pond complex.

POLICIES:

1. Work with State and Federal officials to ensure continuous maintenance dredging of the Stage Harbor channel entrance and the entrance to the Municipal Fish Pier.

2. Carefully control the location of moorings and piers so as to provide an efficient use of space as well as to minimize encroachment on navigational channels and open water recreation areas.

B. GOAL: Ensure harbor safety and encourage a balance of different uses.

1. Continue to coordinate with the U.S. Coast Guard to ensure effective placement of aids to navigation, and timely response to emergency situations.

2. Encourage a balance of uses within the harbor area which combines commercial and recreational uses with a sensitivity to fragile ecological areas.

3. Promote safe navigational practices through public education and enforcement of safety regulations.

4. Mitigate potential conflicts of use, segregating incompatible activities where necessary.

Commercial Fishing and Shellfishing

ISSUE:

Fishing and shellfishing are an important element of Chatham's economy, and are a source of recreation. The fishing industry requires support facilities (marinas and packing facilities) and high levels of water quality. Problems with the use of Fish Pier have resulting in greater demand for fishing facilities in Stage Harbor, however there is little land to accommodate this need. The Stage Harbor system experiences pollution problems and is closed periodically to shellfishing. The Shellfish Department aids local shellfish production through the cultivation, propagation and transplanting of hatchery, natural and contaminated shellstock.

GOAL: Protect the viability of the commercial fishing and shellfishing industries, recognizing these activities as an essential part of Chatham's economy and character.

POLICIES:

1. Recognize the interdependence of Chatham Harbor and Stage Harbor and ensure adequate navigability of both harbors.

2. Provide adequate mooring space for the commercial fishing fleet in the future, recognizing that the size of the fleet may fluctuate from year to year.

3. Protect shellfish beds from incompatible activities and/or development.

4. Correct existing problems with stormwater, septic systems and related pollution which have led to shellfish closures.

5. Provide the necessary support services for the fishing community.

6. Continue the cultivation, propagation and transplanting of shellfish to ensure a healthy shellfish resource in the future.

7. Work with the Massachusetts Division of Marine Fisheries and the U.S. Food and Drug Administration to improve testing methods for shellfishing areas.

Water Quality and Natural Resources

ISSUE:

Chatham's local economy depends upon water-related recreation, tourism and fishing. All of these activities depend upon maintaining the quality of the town's waters. This report has identified several sources of pollution which must be minimized, including: septic systems, stormwater runoff, fertilizers and pesticides, animal wastes, chemical contamination, oil and gasoline spills, and the dumping of sewage into the water.

GOAL: Protect the quality of the Stage Harbor system for the purposes of fishing, shellfishing, wildlife habitat, recreation and related uses.

POLICIES:

1. Identify and correct existing sources of water pollution.

2. Establish a long-term water quality monitoring program.

3. Balance the need for water access with its impact on water quality, wetlands, wildlife habitats and fisheries and minimize disturbance to these resources.

4. Educate the general public about the impacts which land and water uses and activities have upon water quality.

5. Update Town bylaws and regulations to better protect waterways from further incompatible development.

6. Coordinate with State and local officials to ensure adequate drainage design for road improvements.

7. Develop performance standards to minimize pollution from boat fueling and maintenance operations.

Recreational Use of Waterways

ISSUE:

The demand for recreational use of the water is growing. This demand for recreational facilities has to be balanced with natural resource protection. Virtually all the boatyards have waiting lists for available slips and moorings, and there is a long waiting list for town-designated moorings in Stage Harbor. There is currently no procedure for determining the capacity of the harbor for moorings, as well as other water uses. Dockominiums have been established in other areas of Cape Cod, and there is concern that the extremely high land values along the shore could force the conversion of marina services to dockominiums. Water transportation is limited.

GOAL: Encourage a broad range of recreational uses in the harbor while ensuring safety and environmental protection.

POLICIES:

1. Maintain and enhance the private marina operations in the harbor.

2. Support expansion of existing marinas where plans are safe and environmentally sound including considerations such as parking, drainage, fueling and so forth.

3. Guide the location of different recreational uses so as to prevent conflicts.

4. Discourage dockominiums and live-aboard vessels in the harbor.

5. Maintain a limited number of Town moorings for use by transient vessels.

Land Use and Visual Character

ISSUE:

Nearly all of the shorefront property in the Stage Harbor system is residentially zoned. According to the buildout analysis conducted as a part of this study, approximately 78% of the study area is built out. As shoreline conditions and the level of water usage change, demand for water-dependent uses in the Stage Harbor complex may increase. Chatham's zoning regulations currently allow the construction of seasonal private piers. Newly constructed piers must meet standards to lessen their impact on shellfish beds, shoreline access and navigation. However, many pre-existing piers remain.

Chatham's views and vistas serve to define its character. Views and vistas are provided both from the land and water in the Stage Harbor system. Publicly accessible views of the water are possible from several roads and the Oyster Pond Beach. Once on the water, boaters and swimmers view the land. The character of shorefront property is an important element in defining land vistas.

The Town owns nine public landings and several tracts of conservation land. These lands provide access to the water, and environmental protection. However, pedestrian access along the inner portion of the Stage Harbor system is limited. The Stage Harbor system contains a variety of natural resources which offer important wildlife habitat. As the harbor area is developed, it must be conducted in a way which maintains these important resources.

Concern over global warning and the impacts of sea level rise is growing. As sea level rises, wetlands will move inland or will be lost. Property once thought to be safe from coastal storms may be at risk.

GOAL: Encourage a mixture of water dependent and water related uses along the shorefront, preserving both public access and environmental quality as well as the economic viability of water-related industries.

POLICIES:

1. Determine the environmental carrying capacity of the Stage Harbor system and regulate land uses in the contributary area to a level which the environment can support.

2. Maintain and protect the Town's open space resources around the harbor; Hardings Beach, the conservation lands off Morris Island Road, Oyster Pond Beach, etc.

3. Carefully control the number, design and location of private piers within the harbor.

4. Provide adequate area for the storage of marine-related equipment: boats, lobster pots, nets, buoys, etc.

5. Maintain and protect existing fishing and shellfishing facilities in the Stage Harbor system.

6. Encourage and support the activities of the local yacht clubs.

Action Plan

ACTION PLAN

The success of a plan is ultimately measured by its implementation. To achieve the goals and objectives set forth, specific actions must be taken. This section of the report outlines a series of recommended actions designed to carry out the plan.

ZONING BYLAW (Public hearing and two-thirds vote required at Town Meeting).

- **Stage Harbor Watersheet Overlay Zoning Districts** - Divide the Stage Harbor system into the following overlay districts. Where two or more districts overlap, the strictest provisions shall apply.

	Area Covered	Restrictions
1. Shellfishing	Entire Stage Harbor system containing shellfish	Priority Areas: - prohibit boats with through-hull heads - prohibit use of boat motors made prior to 1972 in non-commercial vessels* Secondary Areas: - prohibit boats with through-hull heads
2. Swimming	Oyster Pond Public Beach, Harding's Beach	- prohibit boating and jetskiing
3. Waterskiing & Jetskiing	Oyster Pond	- limit to deeper areas to avoid resuspension of sediments - no moorings
4. Boat Mooring	Stage Harbor System Waters	- prohibit boats with through-hull heads - restrict mooring density based upon size constraints and estimated fecal coliform concentrations - prohibit use of Tributyltin (TBTs) as biocides in anti-fouling paints
5. Marine Industry	Existing marina and commercial fishing facilities	- spill contingency plan/equipment required - require pump-out facilities - storage of toxic and hazardous materials to be registered and approved by the Board of Health - evaluate demand for increased marina services and its impact on shellfishing prior to issuing development permits
6. Navigation	Existing channels	- setback moorings from navigational channels
7. Sailing Races & Lessons	Stage Harbor System waters	- schedule location and times with Harbormaster

* Outboard motors manufactured prior to 1972 are less efficient than newer models at recycling uncombusted fuels and, therefore, result in greater hydrocarbon discharge to waters.

- **Stage Harbor Overlay Watershed Protection District** - The ground-water drainage/surface watershed map should be adopted as an overlay district. The following restrictions shall apply to new uses and change of uses within the district.

  Note: Existing lots and structures are grandfathered from zoning amendments (MGL, Chapter 40A, §6).

- Density shall be limited to no more than 330 gallons/day of design sewage flow per acre of upland (this standard may be modified by the Board of Health when a more definitive analysis of critical nutrient loading rates and harbor flushing has been completed).

- Structures with water views of the Stage Harbor System shall be regulated by architectural standards as promulgated by the Town of Chatham. Examples of standards which might be applied are the King's Highway Historic District (Route 6A) and the Town of Nantucket.

<u>SUBDIVISION RULES AND REGULATIONS</u> (Planning Board public hearing and vote required.) (These regulations could apply town-wide.)

- Require new subdivisions, where possible, to infiltrate drainage on-site, preceded, wherever possible, by a vegetated swale.

- Where new subdivisions will result in increased stormwater runoff off-site (to existing stormwater drainage systems), an impact fee will be assessed for upgrading of the existing (and receiving) stormwater system to include vegetated detention basins, vegetated swales and, where possible, infiltrating catch basins.

- Require new subdivisions of a specified size (for example five lots or greater) and all non-residential uses to prepare an Environmental Impact Assessment. Sensitive environmental receptors on and adjacent to the site should be identified. Sensitive receptors may include the following resources: ground water, surface waters, wetlands, coastal banks and dunes, shellfishing beds, endangered and threatened species habitat. The existing condition of these sensitive receptors should be described and impacts to sensitive receptors should be assessed and mitigation measures should be proposed.

- Improve water quality protection and maintain the Harbor's aesthetics through regulating certain aspects of site design by requiring vegetated buffer zones, natural landscaping, and reduction of impervious areas.

<u>HEALTH REGULATIONS</u> (Board of Health vote required, public hearing recommended.) Many of these regulations could be accepted town-wide.)

- **Toxic and Hazardous Materials Handling Regulations** - All businesses shall register any products containing toxic and hazardous materials in quantities greater than 50 gallons or 25 pounds (dry weight) with the Board of Health. The Board shall then inspect businesses to ensure proper storage, handling and disposal of these

materials. Secondary containment (bermed impervious floors) and/or holding tanks will be required for chemical storage and usage areas. This regulation will be particularly useful in minimizing the risks of spills at marinas along the Stage Harbor system and businesses located in the downtown area serviced by the stormwater systems.

- **Septic System Setbacks** - Septic systems (new or expanded-design flow) shall be set back 300 feet from coastal wetlands (defined as the resource areas noted in 310 CMR 10.00 except "lands subject to coastal storm flowage"). A variance process will allow petitioners to conduct on-site ground water flow testing (slug test and water table gradient) to meet a performance standard of 120 days travel time to coastal waters. This standard is based upon the ability of viruses to migrate from septic systems through ground water toward coastal waters.

- **Upland Lot Area Requirements** - Applications for new septic systems and expansions in design flow for existing septic systems shall be approved to a maximum flow of 330 gallons/day of design sewage flow per acre of upland lot area. (This standard may be modified by the Board of Health when a more definitive analysis of critical nutrient loading rates and harbor flushing has been completed. Exemption: Lots held in single ownership at the effective date of this regulation, provided that other provisions of 310 CMR 15.00 and other Town of Chatham Health Regulations are met.

- **Septic System Maintenance** - To prevent septic system failures, surface breakouts and the use of acids/solvents to unclog leaching facilities, septic systems shall be inspected on a tri-annual schedule, and pumped and/or repaired if necessary. Inspections and pumping shall be performed by Town staff and/or contractors. Fees for this service shall be charged by the Town to owners of septic systems (approximately $50/year).

<u>WETLANDS REGULATIONS</u> (Notice and public hearing, followed by Conservation Commission vote required)

- An additional wetland resource area called "reserve area" shall be added to the existing regulations. These "reserve areas" shall be defined as those land areas where existing wetland resource areas can be expected to migrate based upon a 5-foot sea level rise. The "interests, values and performance standards" for these reserve areas shall be the same as those attributed to the existing wetland resource areas located directly seaward of the reserve areas.

- Prohibit the direct discharge of surface runoff from roads and other impervious areas to wetlands and watercourses.

- Encourage applicants to limit the extent of paving within 100-foot buffer zones to wetland resource areas and to use permeable paving materials wherever possible.

- Specify strict erosion and sedimentation controls for construction activities proposed within the 100-foot wetland resource buffer zone.

- Restrict/prohibit the extent of lawn area allowed within buffer zones to coastal wetlands and waterways.

WATERWAYS REGULATIONS

- Limit the number/density of moorings based upon anticipated bacterial levels and the presence of priority shellfishing beds. Applications for commercial fishing vessels should be given the highest priority.

- Require marinas to provide pump-out facilities (based upon the Edgartown Marine, Inc. (Martha's Vineyard) example). Multiple marinas may pool resources to maintain one pump-out facility.

- Incorporate the expense of providing a pump-out facility at the Old Mill Boatyard into the fee schedule of mooring permits.

- Require permits for sailing school and sailing races to be coordinated safely with other boating activities.

NON-REGULATORY STRATEGIES

- **Stormwater Drainage** - Existing stormwater drainage which discharges directly to coastal wetlands should be upgraded to minimize pollutant loading to the Stage Harbor system. Horsley Witten Hegemann, Inc. recommends that the Town explore the feasibility of modifying direct discharges to include constructed wetlands and/or wet detention basins. Where limited land is available, wet detention basins can be designed and constructed on small parcels of land by targeting their design on treating the first flush, during which the majority of pollutants are discharged.

- **Pump-out Facilities** - The current plans for marine sanitation pump-out facilities should be implemented. The Town may wish to consider a free-of-charge collection service by utilizing a launch service-type vessel. Edgartown Marine, Inc. provides this service and is an example of success.

- **Impact Fees** - Under the authority of the Cape Cod Commission (CCC) legislation, the Town of Chatham has the ability to assess impact fees for new development. To exercise this authority, a Regional Plan must be prepared by CCC and the Town of Chatham must develop a plan consistent with the regional plan. Impact fees could then be applied to development (both new structures and expansions) to provide the necessary funding for upgrades to the stormwater drainage system and water quality monitoring.

- **District of Critical Planning Concern (DCPC)** - HWH recommends that the Town of Chatham petition the Cape Cod Commission to designate the Stage Harbor system protection area (based upon the ground-water/surface watershed drainage areas) as a District of Critical Planning Concern. This designation would require that only development that does not adversely affect the DCPC may proceed. Single-family homes will normally be exempt. The Cape Cod Commission will be accepting DCPC nominations in September 1990.

- **Public Parking Facilities** - HWH recommends that the Town of Chatham evaluate the feasibility of expanding parking facilities, where overflow parking is impacting private lands, through acquiring lands located adjacent to public access locations.

- **Oyster Pond Harborfront Park** - To improve public access and to more directly connect Chatham's downtown business district with the waterfront, the Town may wish to evaluate options for re-development of the Oyster Pond municipal facilities. For example, a portion of the existing parking areas could be replaced with additional buildings to possibly include a visitors'/public education facility oriented toward the preservation of coastal zone resources and the Stage Harbor System. Pedestrian and parking access could be improved by gaining rights-of-way to connect Main Street to the harborfront. Boat, bicycle, and walking tours could originate from this facility. A waterfront restaurant and specified shops could also be leased as an additional option.

- **Commercial Fishing Facilities** - Due to the impacts of the North Beach breach and its impact upon the Chatham Harbor commercial fishing facilities, HWH recommends that the Town of Chatham further evaluate the feasibility of developing seasonal (winter) facilities within Stage Harbor. A pier at the Old Mill Boat Yard should be considered in this evaluation.

- **Land Acquisitions For Public Access** - Wherever possible, the Town of Chatham should purchase shorefront property for conservation, recreation and public fishing access. The Town should explore the feasibility of acquiring land (fee sale and less-than-fee sale) for the development of a public shorefront walking trail along the Stage Harbor System. The existing beach area on Oyster Pond may provide a primary point of access to the waterfront from downtown Chatham.

- **Education** - The Town should implement a public education program for users of the Stage Harbor System. Topics should include navigation and public safety; chemicals and hazardous materials storage, handling and disposal; pollution control (i.e. septic system maintenance, animal wastes, fertilizers and pesticides, pump-out facilities, prop dredging, etc.); and the importance of public access.

- **Assistant Harbormaster** - Hire an Assistant Harbormaster to maintain navigational buoys, oversee installation of moorings, supervise activities at the Old Mill Board Yard property, and assist in coordinating the location and timing of water uses and educational Harbor safety classes.

- **Water Quality Monitoring** - Conduct seasonal water-quality monitoring of Stage Harbor System water to document long-term water quality trends. Nitrogen, metals, and petroleum hydrocarbons should be added to the analytical parameters tested.

- **Chatham Lighthouse** - Work with U.S. Coast Guard to maintain Chatham Station and Lighthouse.

IMPLEMENTATION STRATEGIES

- **Establishment of a Stage Harbor Management Commission** - The Town may wish to establish a Stage Harbor Management Commission to: 1) oversee implementation of the Harbor Plan; 2) oversee the review and update of the Harbor Plan; 3) review all proposed development within the Stage Harbor Study Area to assure consistency with the Harbor Plan and distribute advisory recommendations to appropriate Town Boards and Commissions; 4) develop and administer educational programs; 5) assist the Waterways Commission in preparing mooring plans and dredging plans; and 6) oversee water quality monitoring of Stage Harbor System waters.

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