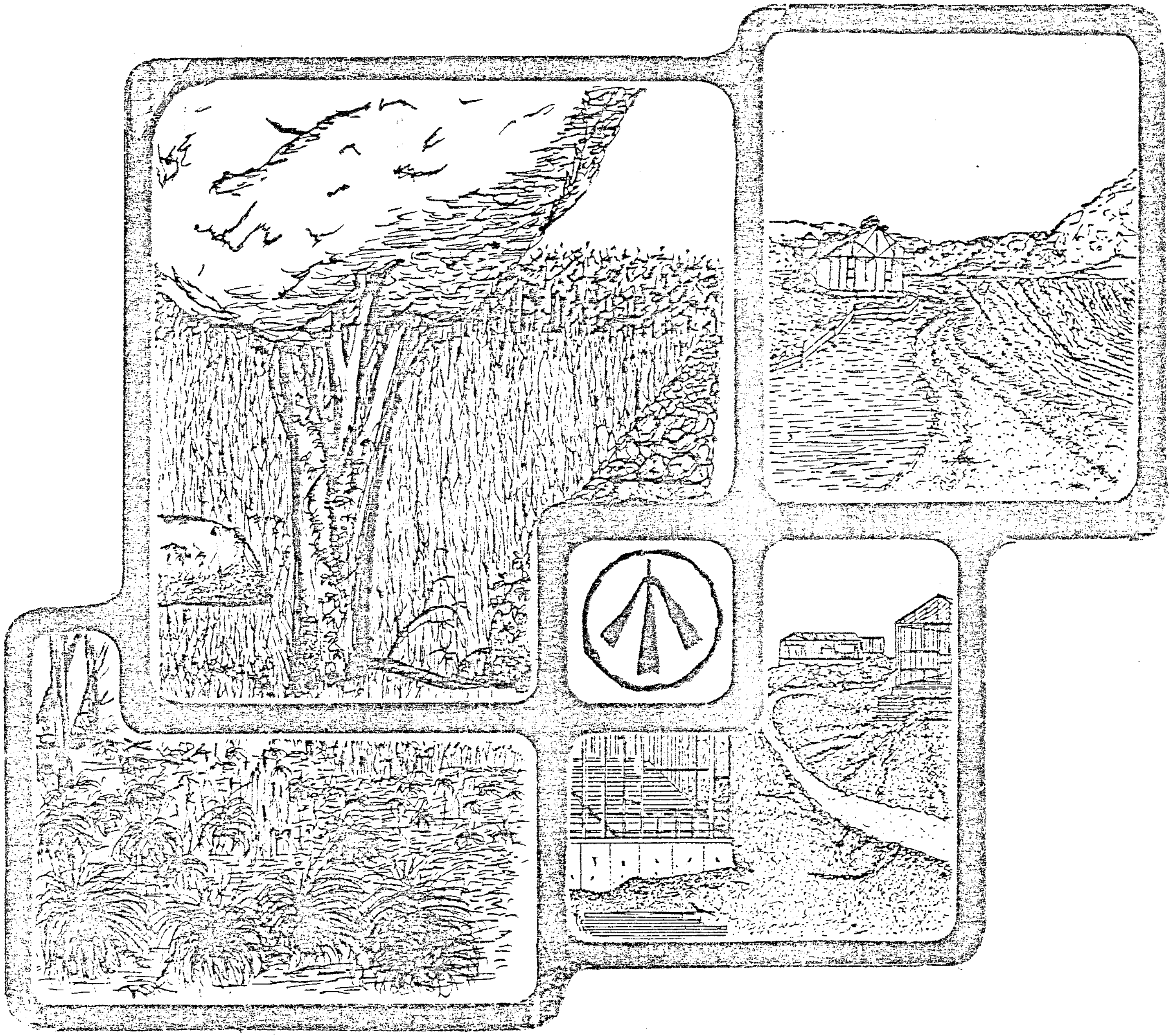
ENVIRONMENTAL REVIEW TEAM REPORT



HOLLY POND
STAMFORD AND DARIEN, CT

KING'S MARK
RESOURCE CONSERVATION & DEVELOPMENT AREA

KING'S MARK
ENVIRONMENTAL REVIEW TEAM REPORT

HOLLY POND
STAMFORD AND DARIEN, CT
MAY 1985

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Environmental Review Team
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The King's Mark Environmental Review Team operates through the cooperative effort of a number of agencies and organizations including:

Federal Agencies
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Department of Health
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Fairfield County Soil and Water Conservation District
Northwestern Connecticut Regional Planning Agency
Valley Regional Planning Agency
Central Naugatuck Valley Regional Planning Agency
Housatonic Valley Council of Elected Officials
Southwestern Regional Planning Agency
Greater Bridgeport Regional Planning Agency
Regional Planning Agency of South Central Connecticut
Central Connecticut Regional Planning Agency
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Housatonic Valley Association

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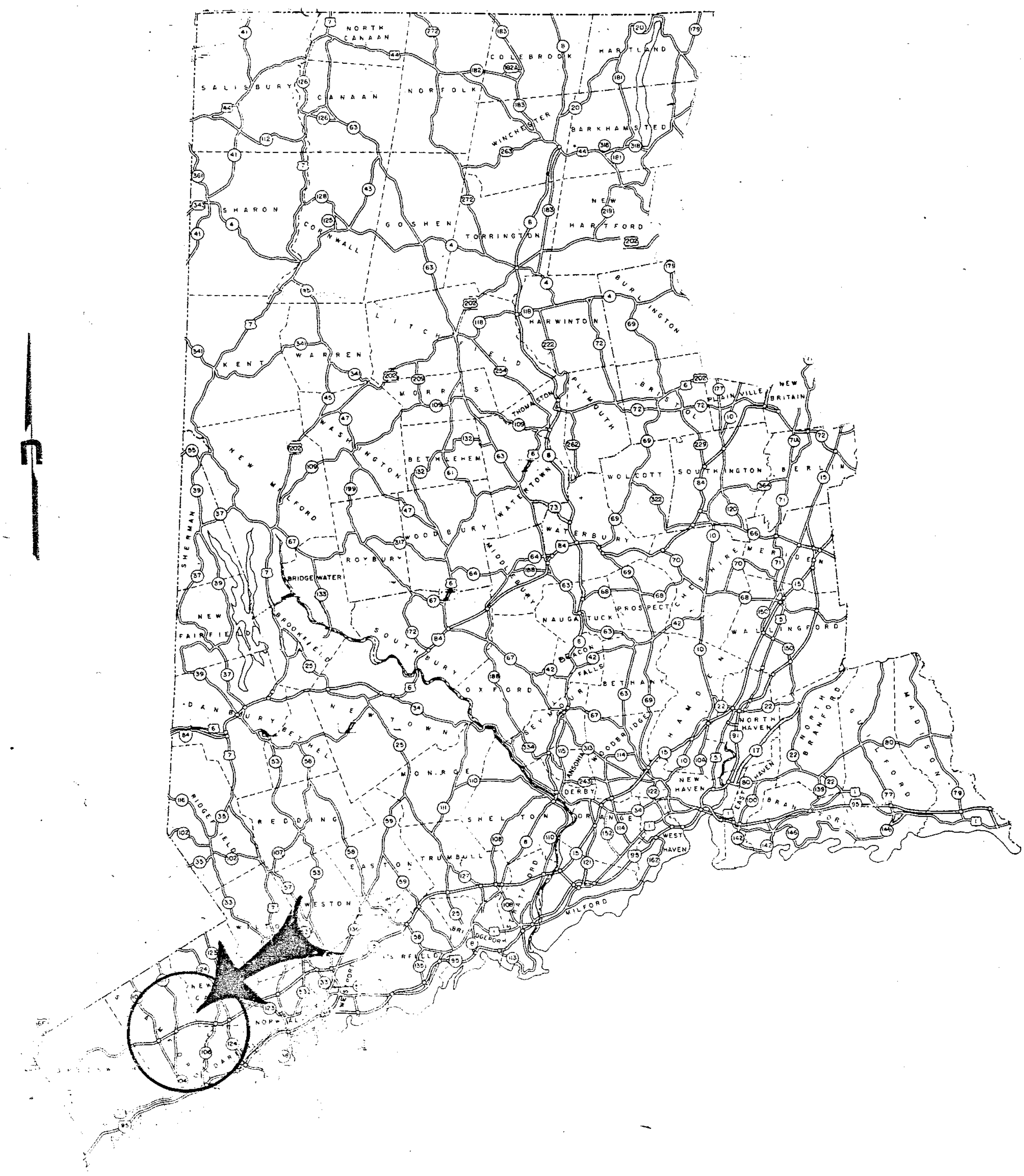


Scale 1" = 10 miles

10 0 5 10 miles

I. INTRODUCTION

Holly Pond is a ± 200 acre coastal embayment located on the border of Stamford and Darien. It is fed by the Noroton River and influenced by the tides of Long Island Sound. The pond is surrounded by residential, commercial, and industrial land uses plus two public beaches and three parks. The pond is a high value recreational and ecological resource in the area and is used by fishermen, water-skiers, hunters, a sailing school, bird lovers, and sightseers.

For many years, the environmental health of Holly Pond has been threatened by accelerated eutrophication. A state-commissioned study prepared in 1973 by Frederic R. Harris, Inc., recommended that the water quality in the pond could be improved by manipulating the tidal gates at the pond dam and controlling the pollution from upstream sources. Efforts have been taken to control upstream pollution, and the towns of Stamford and Darien are now proposing to manipulate the tidal gates at Holly Pond. Specifically, consideration is being given to opening one or more of the tidal gates to increase the flushing action in the bottom of the pond. Guidance in undertaking this activity was provided in the 1973 Harris study. An excerpt from that study is presented below.

> The gates should be opened on an experimental basis. Monitoring of flow rates and water quality levels in the pond should be carried out simultaneously. Basically, the level of water depression in the pond should be decided giving due consideration to the area of exposed mudflats as compared to resulting water quality.
>
> On the basis of this study, an initial water level drop of 1 foot below the level of the dam should be instituted on a year round basis. The hope is to maintain a generally higher level of water quality. During the winter months, preferably during times of large fresh water inflow, the gates should be opened sufficiently to decrease the overall level of the pond 2-3 feet over a short period, say one week. In the summer, specifically during periods of extreme temperatures, the gates should be closed and the water level in the pond maintained at the present level of the dam. As soon as temperatures drop, the gates should be reopened and the minimum level of one foot below the elevation of the dam reinstituted.
>
> On the basis of the findings contained herein, it is felt that the depression of water level 1 foot will provide a great deal of necessary flushing, while not exposing an undue area of mudflats. It should be pointed out that this elevation is not axiomatic. A trade-off between water quality and mudflats exposure is necessary. If lesser

mudflats are desired, a lesser level of water quality must be tolerated.

It must be noted that the increase in tidal flushing of the system will not halt the eutrophication and overall sedimentation of the pond. The increased flow will probably slow the process, however. In the long term natural processes will fill the pond. The only alternative seems ultimately, to be dredging of the pond.

Holly Pond is recognized both locally and regionally as a significant coastal resource. Both the towns of Stamford and Darien have expressed a sincere commitment to improving the environmental quality of the pond. This is perhaps best reflected in the Town of Darien's Master Plan Revision, which states:

> The most far-reaching management program for a coastal pond should be jointly undertaken between the Town of Darien and the City of Stamford, to the end of improving Holly Pond. This joint effort would include the repair of tidal gates, some dredging, possible improvement of upstream land uses in order to control rate of sedimentation and material being disposed of in the Noroton River, and lastly, exploration of techniques to disperse the large swan population at Holly Pond which is a large source of point pollution. It is likely that without such coordinated management between the two municipalities that the Holly Pond area will become the scene of algae blooms and, in the long run, increase maintenance expenses for both municipalities.

Holly Pond is also recognized as a significant regional resource. To help ensure protection of the pond, the Southwestern Regional Planning Agency has recommended that "the future land use of the shoreline of Holly Pond should be the preservation and continuation of the present residential land use densities in Stamford and Darien".

The towns of Stamford and Darien have recently initiated a number of studies at Holly Pond including sediment analysis; bathymetric mapping; biota, water quality, and sediment analyses from the Oceanic Society; and various engineering reports on dam conditions and hydrology.

The King's Mark Environmental Review Team was requested to assist the towns of Stamford and Darien in their management efforts at Holly Pond by discussing the potential environmental impacts of operating the tidal gates at the Holly Pond Dam as recommended in the Harris study. Specifically, the ERT was requested to review existing data and comment on the possible impacts of the project on

1. fisheries
2. changes in the growth and pattern of tidal wetlands
3. alterations in the pattern and speed of eutrophication (i.e., weed growth) and sedimentation

As a product of this review, the towns also requested guidance on what additional study, sampling and monitoring needs would be helpful to better document and predict the environmental impacts of the project.

The King's Mark Executive Committee considered the town's request and approved the project for review by the Team.

The ERT met and field reviewed the area on December 3, 1984. Team members participating on this review included: Charles Yarish, Marine Biologist, UConn at Stamford; William Warzecha, Geohydrologist, Connecticut Department of Environmental Protection; Tim Visel, Marine Fisheries Specialist, Connecticut Marine Advisory Service; John Trautman, Coastal Ecologist, Fairfield University; Dave Thompson, District Conservationist, U.S.D.A. Soil Conservation Service; Eleanor Mariani, Biological Research Assistant, UConn at Stamford; Richard Carpenter, Planner, Southwestern Connecticut Regional Planning Agency; Marc Beroz, Soil Scientist, U.S.D.A. Soil Conservation Service

Prior to the review day, each team member was provided with a summary of the proposed study, a checklist of concerns to address, and a topographic map of the subject area. During the Team's field review, team members toured the Holly Pond area andmet with representatives from the two towns. Following the field review, individual reports were prepared by each team member and forwarded to the ERT Coordinator for compilation and editing into this final report.

This report presents the Team's findings. It is important to understand that the ERT is not in competition with private consultants and hence does not perform design work or provide detailed solutions to land management problems. The ERT concept provides for the presentation of natural resources information and preliminary land use analyses. All conclusions and final decisions rest at the local level. It is hoped the information contained in this report will assist the towns of Stamford and Darien in making environmentally sound decisions.

If any additional information is required, please contact Richard Lynn, (868-7342), Environmental Review Team Coordinator, King's Mark RC&D Area, Sackett Hill Road, Warren, Connecticut 06754.

*   *   *

II. SUMMARY AND CONCLUSIONS

o Hydrology and Coastal Resources (p 7-13)

Because of the heavy residential, commercial, and industrial development which has occurred in the Holly Pond watershed, various point and non-point pollutants have been introduced to the pond. These pollutants have historically resulted in sediment accumulation, sediment pollution, water quality degradation and accelerated eutrophication. It is presumed there are no point sources of pollution at the current time, however non-point sources are currently contributing to the pond's eutrophic state. As discussed in the text, efforts should be taken to better monitor and control these non-point sources of pollution in the Holly Pond watershed.

Holly Pond is recognized both locally and regionally as a significant coastal resource. The pond receives water directly from its watershed and also from Long Island Sound during periods of high tide. The proposed tidal gate manipulation would facilitate better mixing of the water in the pond. This will serve to improve the environmental health of the pond.

o Aquatic Vegetation (p 14-18)

Restricted circulation in the pond and continued nutrient pollution are accelerating the eutrophication of the pond. This has resulted in the nuisance growth of a variety of aquatic weeds and algae. Dominant species are reflective of eutrophic conditions and are identified in the text. The anaerobic decomposition of this excessive growth can lead to large accumulations of reduced sulfide which can suffocate shellfish and finfish, lead to low environmental water quality, and result in the release of hydrogen sulfide gas which has an offensive "rotten egg" odor

In the opinion of the ERT's Marine Biologist, the proposed opening of the tidal gates will enhance circulation within the pond and also improve water quality within the pond. However, there are a number of ancillary environmental concerns raised by the proposed project. These concerns include 1) the effects of increased nutrient loading on the salt marshes below the dam; 2) the impact of the project on the sediments within the pond, some of which are known to be heavily contaminated; and 3) the spectre of increased seaweed growth on the larger mudflat surfaces exposed as a result of the project. To better track and assess these potential impacts, consideration should be given to implementing a monitoring program at Holly Pond to measure appropriate water quality parameters as well as changes in the macrophyte community.

It is not expected that the proposed tidal flushing will halt the eutrophication of Holly Pond. At best, it may serve to slow the process down. The ultimate solution may either be to open the tidal gates and have increased tidal marsh and productive estuary, or be faced with dredging the pond to increase the recreational value.

- <u>Salt Marsh Flora and Fauna</u> (p 19-24)

The predominant flora and fauna of the tidal wetlands and adjacent upland surrounding Holly Pond are identified in the text. Implementation of the project will likely expand the habitat range of salt-water cord grass <u>Spartina</u> <u>alterniflora</u>. As a result, additional desirable wetland area will become established. One area of concern is that should the proposed project result in a significant drying out of the surrounding marshland, invasion by reed grass (<u>Phragmites</u> <u>australis</u>) will occur. Phragmites contributes little to the detritus food web, has marginal wildlife value, and poses a severe threat as a fire hazard during dry seasons. A number of mitigating measures are suggested in the text to minimize the loss of wetland habitat. Additional research needs are also identified to better document existing conditions and monitor potential changes with project implementation.

- <u>Fishery Resources</u> (p 25-27)

Holly Pond is inhabited by a variety of marine fish species including snapper blues and winter flounder. Currently, the value of Holly Pond for finfish and shellfish resources is limited by nutrient enrichment and resultant oxygen depletion. The proposed project (increasing tidal exchange by opening one or more of the tidal gates) would benefit fishery resources. Implementation of the proposed project would serve to alleviate oxygen debts in the pond and also reduce residence times for nutrients in the pond. As a result, a greater diversity and size range of fish can be anticipated. While the proposed project will improve the fisheries resource at Holly Pond, even greater improvement would result from implementation of a "habitat reclamation program" as discussed in the text.

- <u>Erosion and Sedimentation</u> (p 28)

Watershed sources have historically contributed vast quantities of sediment to the Noroton River and Holly Pond. Currently, however, the river banks appear stable and there are no signs of recent sediment accumulating in the river channel. It appears therefore that erosion of stream banks and subsequent sedimentation is not a significant problem at Holly Pond.Effective implementation of Connecticut's new erosion and sedimentation control law should help control future sources of erosion and sedimentation within the watershed.

With respect to the erosion of mudflats exposed during the proposed drawdown, the Team's District Conservationist does not expect this to be a serious problem due to the minimal bottom grades in this area.

III. HYDROLOGY AND COASTAL RESOURCES

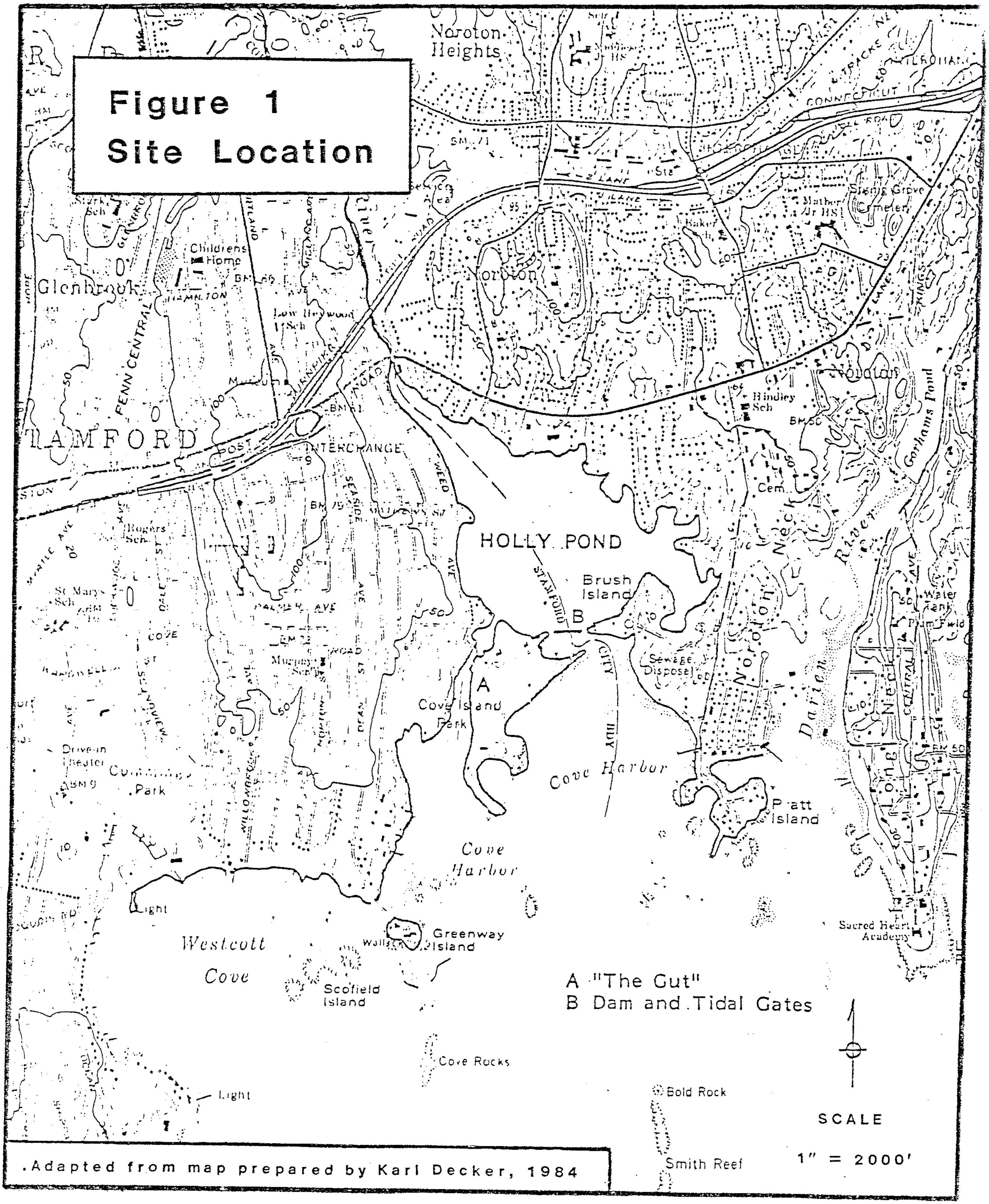
Holly Pond is a relatively shallow, artificially constricted coastal embayment located partly in the town of Darien and partly in the city of Stamford. The pond has a surface area of about 200 acres. It is influenced by both salt and freshwater. The Noroton River, which enters the pond at the northern end is the main source of freshwater, while Long Island Sound contributes the saltwater. The main outlet for Holly Pond is controlled by tidal gates of "guillotine type" which span the southern limits (see Figure 1). A secondary outlet for the pond is through a narrow man made passageway (known as the "gut") that connects the pond with Cove Harbor. This area is presently used as a marina and boat launch site. According to a 1836 Coast and Geodetic Map, a third outlet for Holly Pond meandered through a marshy area in the eastern part of Holly Pond. This marshy area was located between Brush Island and Noroton Neck in the town of Darien. Based on a subsequent Coast and Geodetic Map, dated 1886, this outlet is illustrated to have been constricted or cut off at some undetermined point after 1836 in order to provide access to Brush Island.

The major freshwater inflow to Holly Pond is the Noroton River, which enters the northern end of the pond through a culvert passing under U.S. Route 1. At this point, the Noroton River drains an area of approximately 11.9 square miles or 7,616 acres (see Figure 2).

The Noroton River and Holly Pond watershed has been heavily developed for residential, commercial and industrial uses. The land surrounding the pond is characterized mainly by gentle to moderately steep slopes, which overlie glacial till and stratified drift deposits. Both till and stratified drift are glacial sediments. Till, which was deposited directly by a former ice sheet consists of a nonsorted mixture of particles ranging in size from clay to large boulders. Stratified drift, on the other hand consists of well-sorted to poorly-sorted rock particles and fragments that were laid down by glacial meltwater streams. Sands and gravels are the major component of stratified drift. Stratified drift deposits overlie bedrock mainly on the Darien side of Holly Pond.

As indicated by the accompanying coastal resources map (see Figure 3), tidal and freshwater wetland soils occupy isolated areas around the shoreline of the pond. The most extensive wetlands are found along the eastern side of Holly Pond. In comparing the 1886 Coast and Geodetic map with the accompanying coastal resources map of Holly Pond, a large percentage of the wetland areas delineated on the 1886 map still exist to date. The shoreline of Holly Pond, therefore, has not changed dramatically since the 1886 Coast and Geodetic Map was published.

Figure 1
Site Location



.Adapted from map prepared by Karl Decker, 1984

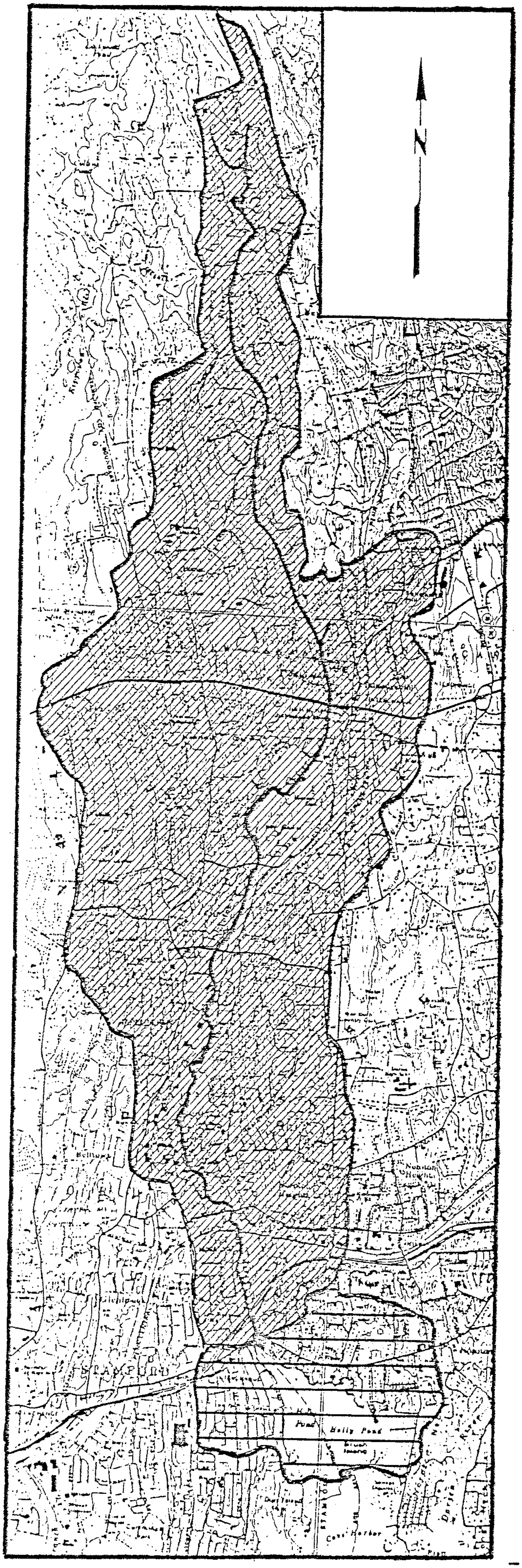


Figure 2
Watershed Area

Noroton River Watershed

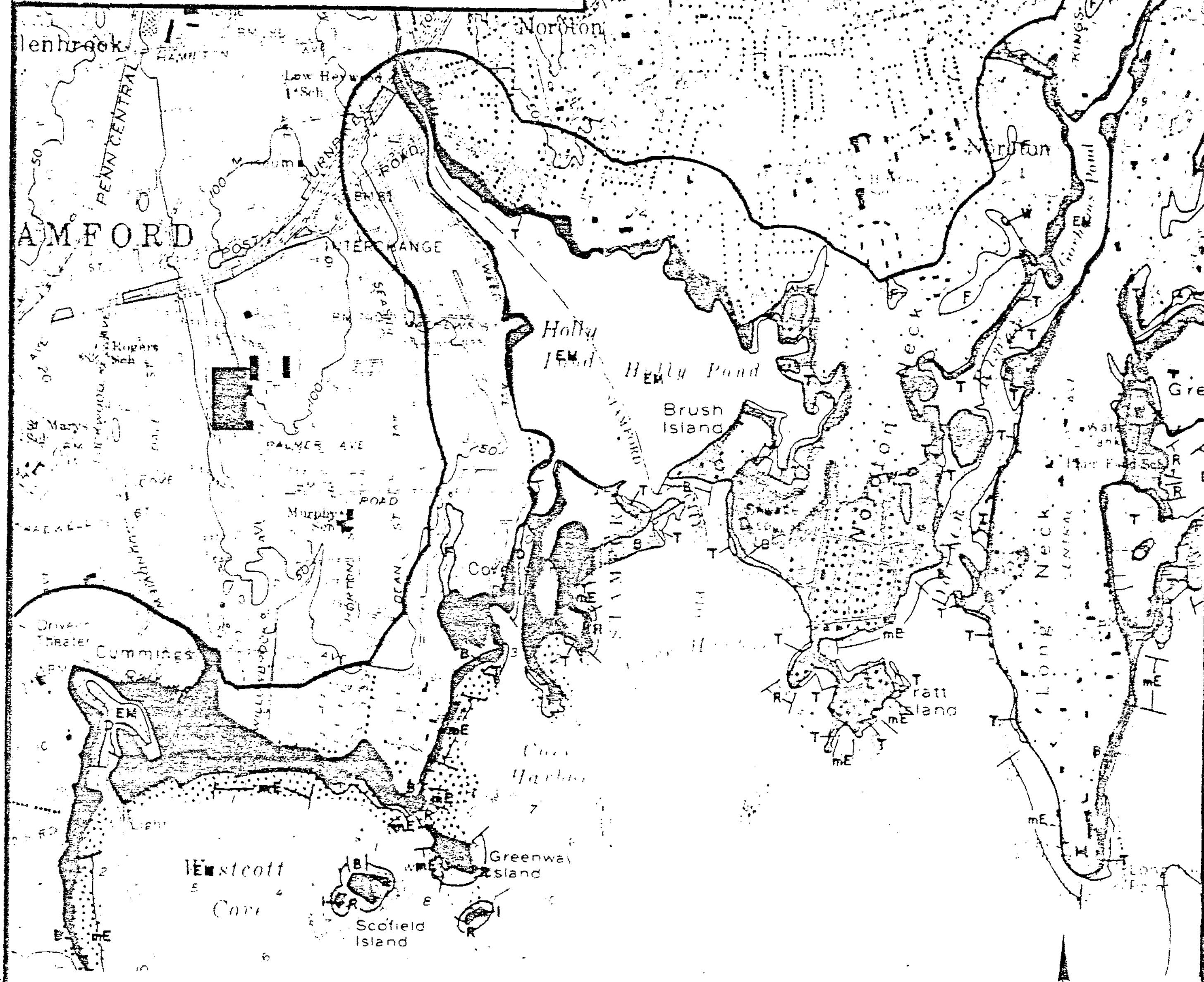
Holly Pond watershed

● Point of outflow

SCALE

1" = 5000'

Figure 3
Coastal Resources



LEGEND

EM - Estuarine embayment

T - Regulated tidal wetlands

F - Freshwater wetlands and undesignated tidal wetlands

B - Beaches and Dunes

D - Developed shorefront

Coastal flood hazard area

SCALE

1" = 2000'

Adapted from "Coastal Resources" Map (1979), prepared by Coastal Area Management Program, CT DEP

Bedrock underlying or outcropping in the area surrounding Holly Pond as well as the Noroton River watershed consists primarily of granitic gneisses and medium-grained schists. "Gneisses" and "schists" are crystalline, metamorphic rocks. As such, these rocks were geologically altered by great heat and pressure at one time deep within the earth.

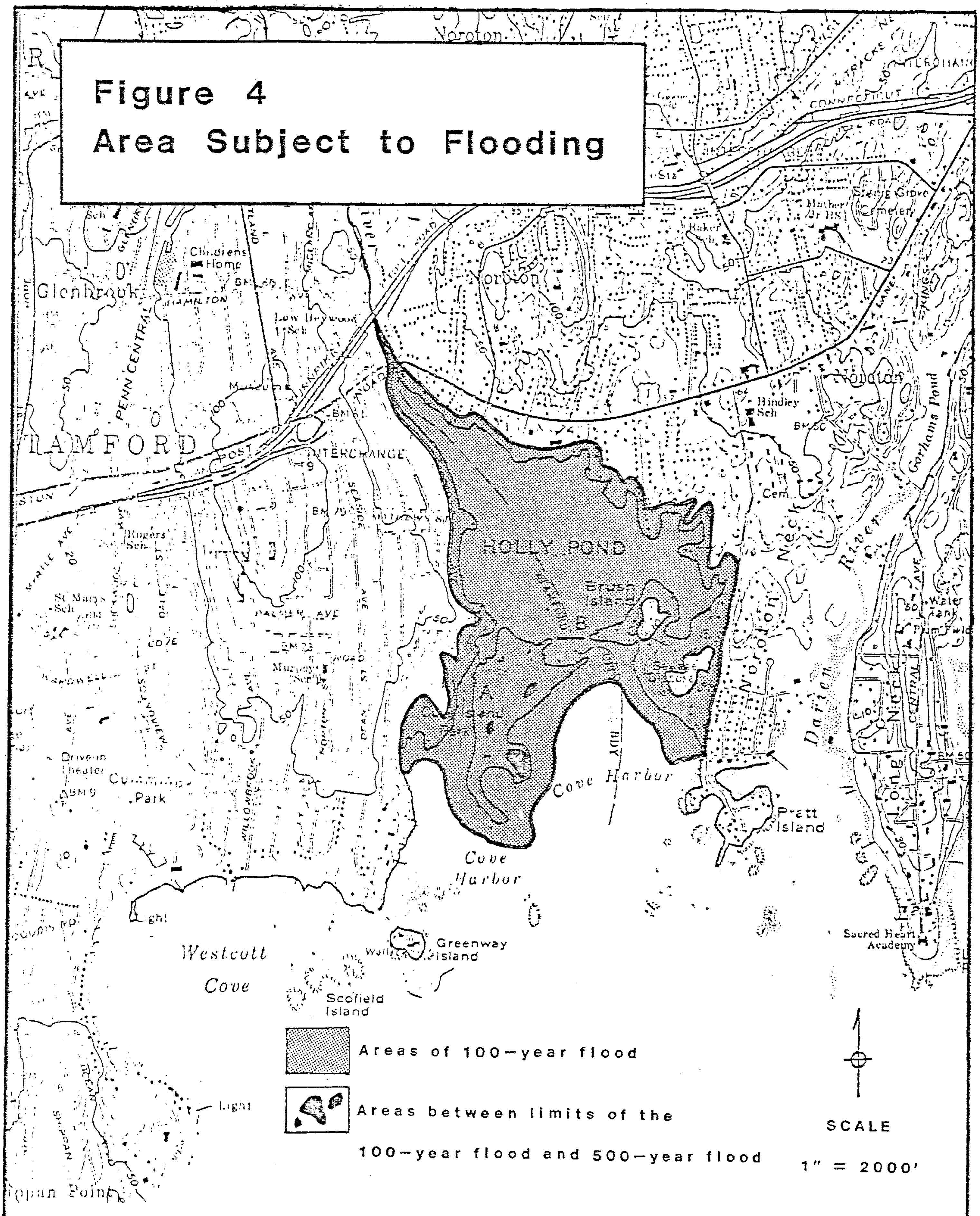
Holly Pond is recharged by precipitation, but the path may be direct or indirect. Rainfall onto the pond would be the shortest route. Rainfall in the form of surface runoff may also pass overland to the pond or to inlet streams. Finally, water may move into and through the ground, being discharged downslope into a spring, wetland, river or directly into the pond. As a result, the quality of the pond's water depends upon both the initial quality of the rainfall and the route the rainfall takes to reach the pond. As indicated above, tidal flows also influence the water quality in the pond. The tidal fluctuation of Holly Pond is controlled by a dam which has inoperable tidal gates at its southern boundary.

Because of the heavy residential, commercial and industrial development which has occurred in the Holly Pond watershed, various point and non-point pollutants have been introduced to the pond. These pollutants have historically resulted in sediment accumulation, sediment pollution, water quality degradation and accelerated eutrophication. It is presumed there are no point sources of pollution such as pipes discharging sewage or other domestic or industrial wastes directly into the pond or river at the current time. However, non-point sources of pollution such as erosion and sedimentation, sewage discharges from malfunctioning septic systems around the pond, automobile related contaminants, urban runoff, leaf litter, water-fowl feces, lawn and garden fertilizer, etc., may currently be contributing to the pond's eutrophic state. It should be pointed out that most homes surrounding Holly Pond have been connected to public sewers. Efforts should be taken to eliminate additional non-point sources of pollution, such as those mentioned above, within the Noroton River and Holly Pond watershed. Some of these controls might include (1) eliminating any malfunctioning or discharging septic systems in the watershed, (2) requiring comprehensive erosion and sediment control plans for new construction within the Noroton River and Holly Pond watershed, and (3) minimizing road sanding on state and town roads within the watershed.

Circulation patterns structured by the dam at the mouth of the Noroton River have created stagnant conditions at times, and are responsible for much of the pond's eutrophic nature. It has been estimated that with a conservative depth of five feet, it would take the Noroton River almost 245 days to flush the embayment.

In addition to the major problem of restricted flushing and poor circulation patterns, there is a relatively rich source of

Figure 4
Area Subject to Flooding



.Note: boundary lines are approximate: adapted from Flood Insurance Rate Maps, 1982 nitrogenous compounds being added in the upper reaches of the pond (region 7, Figure 5). During numerous visits to the site, hundreds of mute swans, geese and ducks, as well as other domestic and wild waterfowl were observed. Presumably these birds are being fed by visitors and residents of the pond area. The continuous input of nitrogenous compounds from the waterfowl has caused several undesirable seaweeds to flourish. It is suggested that this situation is another major constituent adding to the eutrophic conditions of the Holly Pond embayment.

Flood insurance rate maps have been prepared by the Federal Emergency Management Agency for the town of Darien and city of Stamford in 1982 and 1985, respectively. An adaptation of these maps is shown in Figure 4.

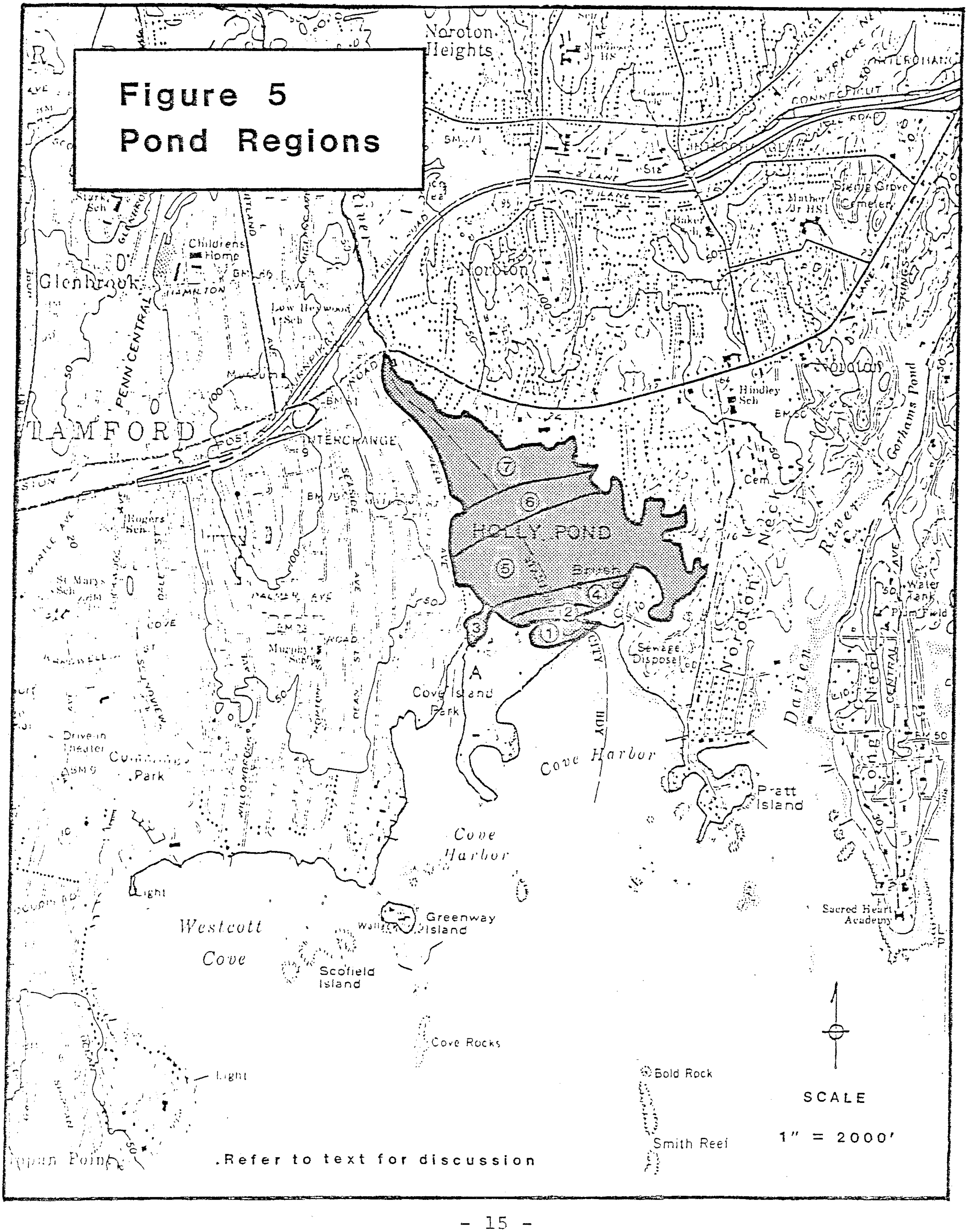
To conclude, Holly Pond receives water directly from its watershed and also from Long Island Sound during periods of high tide. The proposed tidal gate manipulation would facilitate better mixing of the water in the pond. Enhanced mixing of the pond`s waters will serve to improve the environmental health of Holly Pond.

IV. AQUATIC VEGETATION

Salt marshes have been established on the fringes along the Darien side of Holly Pond over the past 50 years as a result of increased siltation from river runoff and import of Long Island Sound sediments. These areas are characterized by the saltwater cordgrass (Spartina alterniflora) at the water's edge, with salt-meadow grass (Spartina patens) dominating the zone above and in many instances Phragmites australis encroaching from the upland border. Saltmarshes along the Stamford shores are small and narrow, with the exception of the ones below the dam and in the area known as the "gut". Although each of these marsh areas seems to be dominated by the aforementioned vegetation, there is a high abundance of seaweeds on the marsh surface. The seaweeds casually observed during the site inspection on the mudflats of the marshes included: Ulva rotundata and Ulva lactuca (species of sea-lettuce), Fucus vesiculosus (rockweed), and mats of intertwined species of Enteromorpha (E. torta, E. flexuosa, E. intestinalis and E. clathrata), Rhizoclonium riparum and Cladophora albida. The upper surfaces of the high marshes were dominated by Vaucheria spp. and the blue-green alga Lyngbya confervicola.

It should be noted the macrophyte (seaweed) community of Holly Pond changes both temporally and spatially. Temperature, light, salinity, nutrients, water movement, and substrate are among some of the major parameters that influence the horizontal and seasonal distribution of the seaweeds in this estuary. The following is a preliminary survey which was undertaken during site visits to the pond in December, 1984. Dominant species are given along with some phenological data which has been accrued by team member Dr. Charles Yarish and his graduate students over the past 8 years. The following green seaweeds were present in Region 1 (Figure 5) at a site just beneath the dam: Ulva rigida, U. lactuca, Enteromorpha linza, E. intestinalis, Blidingia minima, Ulvaria oxysperma, and Urospora penicilliformis. Many of the rocks and cobbles in this area were covered by young plants of each of these algae. U. rigida and U. lactuca are usually found year around, although in very cold winters (extreme ice cover and scouring) U. rigida disappears by migrating into the deep waters of Long Island Sound. Another large sheet-like green alga, Monostroma grevillei, is widespread in this region in late winter and early spring. Species of Blidingia and Ulvaria are common year around (perennial), whereas Urospora is only found in late fall to early spring (annual). The brown algae in this region are represented by Fucus vesiculosus, Ectocarpus siliculosus and Ralfsia-like crusts. Fucus is part of the perennial flora of the region and may grow on either rock substrate or even the culms of Spartina alterniflora. Petalonia fascia, Scytosiphon lomentaria and Punctaria plantaginea are all quite common later in the winter and early into the Spring. The dominant red

Figure 5
Pond Regions



seaweeds at this site included only a few taxa because of the high light levels and lack of enough fixed substrate: *Gracilaria tikvahiae* and *Agardhiella subulata* were attached to many of the shell fragments in this region. In the deeper waters of the channel *Chondrus crispus* (Irish Moss), species of *Polysiphonia* and *Ceramium rubrum* are part of the perennial flora.

Similar assemblages of seaweeds are found above the dam (Region 2, Figure 5) growing on the marsh surfaces, mudflats or on the rocks. In the deeper cuts of the dam structure, the kelp, *Laminaria saccharina*, were seen for the first time in the early Spring of 1983. This is indicative of improving water quality in the Sound. Young plants were also observed during the site visit in December thereby indicating the dominant influence in this area of Long Island Sound. Fringing the dam area were rocks covered by *Fucus vesiculosus* and in sheltered areas *Ascophyllum nodosum* (knotted wrack). It should be noted the latter brown seaweed is a perennial form which may survive for up to ten years and in some areas of the world it is a standard pollution monitoring organism, as it is a concentrator of heavy metals. The green alga, *U. rigida*, disappears from this site as it prefers open coastal conditions. However, in the summer the walls of the dam structure may be covered with *U. lactuca* which may be growing on the established mussel population.

In the area known as the "gut" (Region 3, Figure 5) the diversity of many of the algal species is rather low, primarily due to the lack of substrate. The mudflats and marshes are covered by species of *Enteromorpha intestinalis*, *Ulva lactuca* and *U. rotundata* which are indicative of a nutrient rich estuarine environment. Towards the mouth of the "gut", *Chondrus crispus* and several species of *Polysiphonia* are prevalent, if substrate permits. However, it is the green seaweeds which dominate this region.

As one proceeds up the estuary into Region 4 (Figure 5), the importance of the green algae increases. On the surfaces of the salt marshes of this region and extending into Region 5, *U. rotundata* predominates along with the mat forming green algae previously mentioned. The mats show increased prominence of *E. clathrata*. The shift in the green algae is even more apparent in Regions 5-7. *U. lactuca* is found up to and including Region 5, but has rarely been seen much past Region 6. In Region 5, still another *Ulva* species may be found, *U. curvata*. It is this *Ulva* species which will penetrate the upper reaches of the pond into Region 7. It has the ability to withstand extremely low temperatures coupled with decreasing salinities. Preliminary evidence suggests high temperatures may limit its own distribution in Holly Pond.

In Region 6 (Figure 5), extreme salinity fluctuations may be found (0-26^{o}/Oo, according to records by Dr. Yarish in 1980-1981). In addition, the combination of large quantities of leaf litter, nutrient loading by the waterfowl, and increased seaweed productivity (i.e., algal cover is quite substantial in this region especially in the summer and fall months) presents a potentially serious problem yearly. There appear to be layers of leaf litter that alternate with the decomposing algal mats and salt marsh vegetation. The algal mats consist of sheets of Ulva, sheets of the free floating marsh variety of a brown seaweed called Petalonia fascia, the red algae Agardhiella Gracilaria and Polysiphonia harveyii. In the fall when the leaf litter enters the water it is layered down with little breakdown due to the cold temperatures. In the spring and summer, light levels and nutrient loading support good growth of the aforementioned seaweeds. At night when the plants respire, the large mass of seaweeds consumes the dissolved oxygen (D.O.), severely depressing the D.O. levels in the water and the underlying decaying leaf litter and sediment. Excessive growth causes die-offs, whereby, the plant material sinks to the bottom. This appears to be a "capping off" of the underlying layers, thereby forming anaerobic conditions. The anaerobic decomposition leads to large accumulations of reduced sulfide, especially in the warm summer months. This oxygen deficit will suffocate shellfish and finfish and lead to low environmental water quality. In addition, hydrogen sulfide may be released resulting in an offensive "rotten egg" odor. A casual observation between a study completed in May, 1981 and in December of 1984, indicated an extremely large surface area being covered by a species of Ulva in this region. These observations suggest that the eutrophic conditions of Holly Pond may be becoming more severe.

Region 7 (Figure 5) is characterized by having muds usually exposed at low tides. It is an area where there is more riverine influence, and few seaweeds survive. Mixed assemblages of blue-green algae dominate and include the following species: Lyngbya, Calothrix, Rivularia, Phormidium, Dermocarpa and Nostoc. These forms are usually associated with excessive nutrient loading, high levels of organics, poor water circulation and inevitably anaerobic conditions. On the stone walls abutting this region there is a narrow zone of the green algae, Blidingia minima and Ulothrix sp.

Opening the Dam

The opening of the dam poses numerous environmental questions that need to be addressed. For example:

- What will be the effects of increased nutrient loading on the salt marshes below the dam? Will the increase of nutrients in this area cause blooms of species of Ulva and Enteromorpha on the mudflats and the marshes if the tidal gates are not closed in the summer? If there is an increase in growth of this seaweed, will it be of such magnitude to prohibit oxygen exchange at low tide? Recent studies have demonstrated rapid mortality of crab larvae when subjected to exudates of Ulva sp. in combinations with low oxygen concentrations. Therefore, proper operation of the tidal gates must be insured in the summer months to protect the character of the salt marshes below the dam.

o Will the increased flushing of the pond remove some of the very heavily contaminated sediments? From inspection of the data presented, caution should be exercised in this regard due to the high levels of copper, chromium and zinc in the sediments. At this point, it does appear that there is little chance of the polluted sediment being disturbed by tidal drawdowns of less than one foot, if indeed the hot spots are limited to the upper reaches of Region 5 (Figure 5, near site #4) as reported.

o What will happen to the community above the dam in Holly Pond? Will the larger mudflat surfaces be followed by increased seaweed growth, especially that of Enteromorpha and Ulva? There is sufficient evidence in the literature which shows these algae are usually light limited in an estuarine situation. It is likely that increased mudflat exposure will be followed by increased growth of these potentially harmful seaweeds even if the nutrients are flushed out in the winter months. As a result, care should be taken as to how much of the mud surface should be exposed.

o If the tidal gates are open, is there a minimum period of time to possibly maximize the potential winterkill of seaweeds in the pond? Is there a critical period of exposure to extreme low temperatures which can be discovered from laboratory experiments to enhance planning of drawdowns. Again the literature indicates that many marine algae have increased capacity to tolerate low temperatures if they are exposed to low salinities. Dr. Charles Yarish (Marine Biologist for this ERT study) is convinced that short drawdown periods will not be as effective as long ones for improved water quality in the summer months. In addition, Dr. Yarish maintains that the tidal flushing will not halt the eutrophication of Holly Pond. At best, it may serve to slow the process down for this particular embayment. The ultimate solution may either be to open the tidal gates and have increased tidal marsh and productive estuary, or be faced with dredging the pond to increase the recreational value of this locale.

Consideration should be given to initiating a monitoring program prior to the opening of the tidal gates. A baseline study which quantifies the present seaweed community is needed. However, due to the time constraints of the proposed operation, a monitoring program should at least be in place when the tidal gates are opened. Monthly monitoring should be employed to monitor the macrophyte communities in different regions of the pond, as well as the appropriate environmental parameters (e.g.,temperature, light, salinity, nutrients and selected heavy metals in the perennial algae). The duration of such a project should be for at least two years in order to adequately reflect any modifications in the Holly Pond ecosystem.

V. SALT MARSH FLORA AND FAUNA

Biological Investigation

A field survey was conducted December 4-11, 1984 by John R. Trautman (Coastal Ecologist for this ERT study) to identify the predominant flora and fauna of the tidal wetlands and adjacent upland surrounding Holly Pond. Results were then grouped by municipality and ecological association.

Legend: S = Stamford
D = Darien
1 = Cord Grass Fringe
2 = Creek Bank and Ditches
3 = Salt Meadow
4 = Impacted Wetland
5 = Marine Fringe
6 = Transition Area
7 = Upland

FLORA:

Salt-Water Cord Grass	Spartina alterniflora	D,S	1, 2, 3
Salt-Meadow Grass	Spartina patens	D,S	3, 5, 6
Spike Grass	Distichlis spicata	D	3
Black Grass	Juncus gerardi	D	3, 6
Water Hemp	Acnida cannabina	D	2, 3
Samphire	Salicornia europaea	D	2, 3
Halberd-Leaved Orach	Atriplex patula	D,S	2, 3, 4,5
Sea Blite	Suaeda maritima	D	3, 5
Sand Spurrey	Spergularia marina	D	3, 5
Sea Lavender	Limonium carolinianum	D,S	3, 5
Common Saltwort	Salsoli kali	D,S	5
Seaside Gerardia	Gerardia maritima	D	3

Salt Marsh Aster	*Aster tenuiforius*	D	2 3
Salt Marsh Aster	*Aster subulatus*	D	2 3
Marsh Elder	*Iva frutescens*	D	1, 2, 3,4
Grounsel-Tree	*Baccharis halimifolia*	D	3, 4, 6
Seaside Goldenrod	*Solidago sempervirens*	D,S	4, 5, 6
Common Reed	*Phragmites australis*	D	4, 6
Japanese Knotweed	*Polygonum cuspidatum*	D	4 5 6
Bayberry	*Myrica pensylvanica*	D	6, 7
Switchgrass	*Panicum virgatum*	D	6
Seaside Wild Rye	*Elymus virginicus*	D	6
Smooth Sumac	*Rhus glabra*	D	6
Poison Sumac	*Rhus vernix*	D	6, 7
Nightshade	*Solonum dulcamara*	D	5, 6, 7
Poison Ivy	*Rhus radicans*	D	6, 7
Common Greenbrair	*Smilax rotundifolia*	D	7
Virginian Rose	*Rosa virginiana*	D	6
Japanese Honeysuckle	*Lonicera japonica*	D	6, 7
Eastern Red Cedar	*Juniperus virginiana*	D	6, 7
Quaking Aspen	*Populus tremuloides*	D	6
Silky Dogwood	*Cornus obliqua*	D	7
Gray Birch	*Betula populifolia*	D	6
Black Birch	*Betula lenta*	D	7
Tree-of-Heaven	*Ailanthus altissima*	D	7
Black Gum	*Nyssa sylvatica*	D	7
Canadian Hemlock	*Tsuga canadensis*	D	7
Black Cherry	*Prunus serotina*	D	7
Red Maple	*Acer rubrum*	D	7

Sugar Maple	*Acer saccharum*	D	7
American Beech	*Fagus grandifolia*	D	7
Red Oak	*Quercus rubra*	D	7
Pin Oak	*Quercus palustris*	D	7
White Oak	*Quercus alba*	D	7
Swamp-White Oak	*Quercus bicolor*	D	7
Scrub Oak	*Quercus ilicifolia*	D	6, 7
FAUNA:			
Ribbed Mussel	*Geukensia demissus*	D,S	1, 2
Marsh Fiddler Crab	*Uca pugnax*	D,S	1, 2
Fiddler Crab	*Uca minax*	D	1, 2
Purple Marsh Crab	*Sesarma reticulatum*	D	1, 2
Black-Fingered Mud Crab	*Eurypanopeus depressus*	D,S	1, 2
Green Crab	*Carcinus maenas*	D,S	1, 2
Blue Crab	*Callinectes sapidus*	D,S	1, 2
Common Grass Shrimp	*Palaemonetes vulgaris*	D,S	1, 2
Amphipods	*Gammarus locusta*	D,S	1, 2
Horseshoe Crab	*Limulus polyphemus*	D,S	1, 2
Sand Worm	*ereis virens*	D,S	1, 2
Blood Worm	*Glycera* sp.	D,S	1, 2
Salt Marsh Snail	*Melampus bidentatus*	D	3
Mud Snail	*Ilyanassa obsoletus*	D,S	1, 2
Rough Periwinke	*Littorina saxatilis*	D	3
Silverside Minnow	*Menidia menidia*	D,S	1, 2
Shiner	*Menidia beryllina*	D,S	1, 2
Fourspine Stickleback	*Apeltes quadracus*	D,S	1, 2

Common Mummichog	Fundulus heteroclitus	D,S	1, 2
Striped Killifish	Fundulus majalis	D,S	1, 2
American Eel	Anguilla rostrata	D,S	1, 2

Environmental Impacts

It is anticipated that the depression of the mean low water level in Holly Pond by 1.0-1.5 feet will have a significant environmental impact on four ecological associations within the wetland areas. It should be noted however that not all the impacts will be negative or deleterious.

1. If the tidal gates are removed, altered, or manipulated to produce a mean low water level which is 1.0-1.5 feet below the present mean low water level, this will increase or expand the overall tidal range within the pond. That is to say that the differential between mean high water (MHW) and mean low water (MLW) will become greater. As this occurs, the habitat range of *Spartina alterniflora*, which lies between MLW and MHW, will also expand provided there is suitable soft substrate for colonization. As a result, the cord grass fringe will grow seaward and additional wetland area will become established. This will also apply to creek banks and the sides of ditches -- but to a lesser extent, since the area suitable for colonization may be limited.

2. By creating a MLW level that is 1.0-1.5 feet below the present MLW, it is possible that a "drawdown" could occur. With the MLW level lower and for a longer duration of time, water held in the marsh peat could be drawn or drained off. Over time, this could dewater the marsh substrate and eventually dry out the marsh. As this happens detritus-producing vegetation (*Spartina alterniflora*, *S. patens*, *Distichlis spicata*, *Salicornia* sp.) would be lost and replaced by species which appear to contribute less significantly to the detritus food web of salt marshes and estuarine waters.

3. If the marsh continues to dry, invasion by reed grass (*Phragmites australis*), which favors drier areas, will occur. It should be noted that *Phragmites* presently exists at several locations and its encroachment onto altered wetland areas can be evidenced. *Phragmites*' dense pattern of cover works rapidly to exclude the ecologically more significant species, and it quickly reduces the diversity of wetland vegetation. This process could be accelerated by the fact that the Holly Pond area receives an average of 43.79 inches of precipitation annually. This precipitation might wash or leach the salt from the marsh substrate, alter the chemical composition of the wetland soil, and make the salt meadow even more suitable for colonization by *Phragmites australis*. As *Phragmites* becomes dominant, its 10-14 foot stems continue to dry out the marsh by acting as siphons as they draw water to the upper reaches of the plant. Due to the large volume of leafy material the plants

produce, a severe seasonal fire hazard is created during dry periods. The result is that a high quality, detritus-producing salt meadow habitat is lost. Its replacement is an ecologically inferior impacted wetland dominated by Phragmites australis. Reed grass contributes little to the detritus food web, has marginal wildlife value, and poses a severe threat as a fire hazard during dry seasons. Because of this, wetlands dominated by Phragmites australis have come under increasing pressure for economic development.

Mitigating Measures

1. To minimize the loss of wetland habitat, the innocuous destruction of wetlands by neighborhood and backyard dumping of grass clippings, leaves, and brush could be halted by surveillance, enforcement, and possible prosecution.

2. If there has to be a trade-off in favor of improved water quality over the loss of wetland habitat, perhaps an impacted wetland in another part of town could be restored or rehabilitated.

3. To mitigate the loss of valuable wetland habitat due to the encroachment or expansion of Phragmites australis, transition areas could be planted with seed-producing grasses and wildlife enhancement species. Although this will not replace the loss of detritus-producing wetland vegetation, it will provide food, cover, and nesting to a variety of birds and animals.

4. If there is a loss of wetland habitat due to the expansion or encroachment of undesirable vegetation, the community may decide to restore or rehabilitate the impacted area. This can be successfully accomplished by "skimming" or removing the unwanted vegetation with light machinery. After skimming, salt marsh vegetation can be transplanted to and sustained on the new marsh surface.

Additional Research Needs

1. A field survey of wetland flora and fauna should be conducted during mid-to late spring to identify any seasonal ecological components that were not present during the December investigation.

2. Areas which presently support cord grass fringe, salt meadow, and Phragmites australis should be measured and mapped in detail for use as base line information. Permanent reference points should be established for comparison measurements and mapping in the future.

3. A comprehensive review of climatic data should be very helpful in determining under what conditions manipulation of the water level would be most beneficial.

4. Prior to the manipulation of the water level in Holly Pond, soil samples should be collected from areas of salt meadow and Phragmites australis. These would be analyzed for moisture content. Periodic and seasonal monitoring would be necessary to determine if wetland areas were drying out. Also monitoring pipes could be implanted in wetland areas to determine if the water table beneath the marsh surface was fluctuating or if a drawdown was occurring.

VI. FISHERY RESOURCES

Holly Pond is a brackish body of water having salinities that are generally above the tolerance levels of freshwater species of fish. Holly Pond may at varying times be inhabited by a variety of crustacea and marine fish species such as blue crabs, green crabs, mummichogs, striped killfish, sheepshead minnow, Atlantic silverside, tidewater silverside, fluke, menhaden, snapper blues, and winter flounder.

The importance of estuarine environments, such as Holly Pond, to finfish and shellfish species is well documented in the scientific literature. Coastal salt ponds and embayments provide critical habitats for estuarine-dependent species, especially those that require spawning and juvenile development. Connecticut estuaries provide nursery areas for commercially and recreationally important species, such as winter flounder, Pseudopleuronectes americanus, blue shell crabs, Callinectes sapidus, soft shell clams, Mya arenaria, American oyster, Crassostrea virginica, and many others. Connecticut has lost the usefulness and value of many estuaries, salt ponds and embayments, both as a result of destruction by filling activities and degradation by accelerated eutrophication. It is not surprising that recorded landings for the above species have fallen sharply in Connecticut and are today but a fraction of earlier catches (Blake, et al, 1984). Degraded intertidal and tidal flats have reduced shellfish setting opportunities in many coastal towns. Reduced oyster setting has been shown to be a result of organic debris accumulating on these tidal areas containing oyster beds (Visel, 1984).

The value of Holly Pond for finfish and shellfish resources is limited by nutrient enrichment and resultant oxygen depletion. Some winter flounder are still caught near the tide gates where flushing is greater and most likely oxygen debt reduced. Soft shell clams also were found near the pond tidal entrance, probably for the same reason. At the present time,nutrient enhanced vegetation growth and low oxygen levels can severely restrict these finfish and shellfish resources. Increased tidal circulation would reduce oxygen debts, especially in the summer, and help restore or sustain current finfish and shellfish populations.

The two conditions that appear to be significantly degrading to Holly Pond are reduced tidal circulation and flushing, and nutrient enrichment from pollution. As discussed in the two examples below, these factors can have a significant effect on the fisheries population of an estuary.

1) Lee (1980), in a report on Rhode Island salt ponds, states:

Eutrophication. Pollution from excessive fertilization is also considered to be a major problem in the ponds, particularly in coves where circulation is sluggish. It is thought that nuisance algae are increasing because of increased nutrients coming into the ponds from surrounding residential developments. Flounder fishermen report that algae are becoming more and more dense on the pond bottom and fouling their nets. Trawls come up with about 12 bushels of algae with each bushel of flounder, even though most of the algae passes through the 4-1/2 inch mesh in the net. The abundance of algae is not only an impediment to fishing. When the temperatures rise in late summer, oxygen is used up by decomposing algae, making it scarce for bottom-dwelling organisms. When oxygen levels are very low, young flounder either leave the pond or die of suffocation. After oxygen levels are depleted, toxic hydrogen sulfide is often produced, causing the rotten egg smell that lurks over mud flats and back coves. The increased algal growth may be making the pond environment less hospitable as a nursery and spawning area for a variety of fish and shellfish.

2) Johnson (1984) reports on the impacts of *Ulva lactuca*, or sea lettuce, in Mumford Cove in Groton, Connecticut. *Ulva lactuca* is also present in Holly Pond. Below is a summary of her findings:

A species of green macroalgae, *Ulva lactuca* (commonly referred to as sea lettuce), can reach densities greater than 1000 g dry wt. m-2 in Mumford Cove, Groton, Connecticut, a shallow, nutrient enriched estuary. The biomass of the alga in the system was mapped over a 15-month period, August 1983 to October 1984, and the data show high growth of the plant in the late spring and fall with an annual productivity of 644 g C m-2 yr-1. This is 3 to 10 times higher than most systems. This seaweed has a luxury uptake of nitrogen (3% of total dry weight) and can effectively remove all the nitrogen load into the cove from the sewage treatment plant located at the head of the estuary and freshwater inflow during spring, summer and fall. I conducted 24 hour surveys in control areas with no seaweed and in the *Ulva lactuca* beds and found that the seaweed can alter the dissolved oxygen (0.1 - 20+ ppm), pH (6.9 - 8.6) and redox (-24 - 402 mV) regimes of the surrounding water column. Bioassays of the response of crab larvae to low oxygen tensions, 0.5 + 0.3 ppm, caused a decline in larval activity (movement), but there was no mortality over an 8 hour period. *Ulva lactuca* produces a water soluble toxin which causes 100% mortality of crab larvae after 12 to 21 days. No crabs survived the molt into megalopa. Mortality in the controls was 5 - 32% after the megalopa molt. When water in which the _Ulva_ was grown was purged to low oxygen tensions, 0.4 ppm, there was 100% mortality of the crab larvae in 13 - 40 minutes. Caging experiments in and out of _Ulva lactuca_ beds in Mumford Cove found there was significantly higher mortality of crab larvae in the seaweed beds (70%) than the control sites (5%) after 24 hours. Chemical analysis of the toxin shows it to be hydrophyllic, soluble non-labile and probably low molecular weight. Thus, the growth of this nuisance alga in eutrophied estuaries is having a large impact on the chemistry and community structure of these systems.

Reduced tidal flushing and/or nutrient enrichment of estuaries has also been association with increased levels of fin rot (necrosis) on winter flounder.

The rapid growth of sea lettuce (_Ulva_) in a salt pond (Green Pond, West Falmouth, Cape Cod) created anerobic conditions which resulted in the death of winter flounder, over 400 bushels of soft shell clams, and blue crabs.

The impact of the proposed project (increase tidal exchange by opening one or more of the tidal gates) on Holly Pond would benefit fishery resources. Not only would this alleviate oxygen debts, but it may also reduce residence times for nutrients in the pond.

While the proposed project will improve the fisheries resources at Holly Pond, even greater improvement would result from the implementation of a "habitat reclamation program" at the pond. Such a program might include

1) reduction of nutrient loading,

2) mechanical removal or harvesting of excess vegetation,

3) dispersal of unreduced organic debris from oxygen depleted regions to oxygen-sufficient areas to complete aerobic respiration,

4) dredging and containment programs for Holly Pond, and

5) aeration-oxygenation of pond sediments.

In preparing a long-term management plan for Holly Pond, consideration should be given to the above management alternatives.

VII. EROSION AND SEDIMENTATION

As addressed in a 1983 report by Anderson Nichols (ANCO, Phase 1), Holly Pond has historically been subject to significant sedimentation from watershed sources. These sources have included storm sewer outfalls, industrial and residential development, shoreline filling around the perimeter of the pond, and sand and gravel operations. All of these sources have contributed vast quantities of sediment to the Noroton River system and subsequently to Holly Pond.

Noroton River drains to Holly Pond. The lower 3 miles of the river flows through a very urbanized area. The majority of the soils here have been altered by man. Cuts and fills have been made along the river which have changed the characteristics of the original, naturally occurring soils.

This stretch of river was spot-checked for signs of stream bank erosion since any erosion that occurs here would contribute sediment into Holly Pond. No erosion problems were found. The river banks appear stable.

There were also no signs of recent sediment accumulating in the river channel. This indicates that any sediment reaching the river is flushed out during peak stream flows. Any sediment washed down the river ends up in Holly Pond, precipitating in the vicinity of the U.S.Route 1 bridge.

One source of sediment in the watershed is road sand. Sand spread on the streets during the winter months is washed to storm drains leading to the Noroton River. This sand is eventually carried to Holly Pond.

With respect to erosion of mudflats exposed during the proposed draw down, the Team's District Conservationist does not expect this to be a serious problem. There may be some channeling from the outfall of storm sewers to the new low water elevation, but with the minimal bottom grades, this will not create a significant problem.

To conclude, it appears the physical causes of the problems at Holly Pond -- erosion and sedimentation -- have subsided through an evolutionary process and the current concerns are chemical and biological manifestations of causal impacts.

VIII. ADDITIONAL RESEARCH SUGGESTIONS

The towns of Stamford and Darien, in requesting this ERT study, asked the ERT to identify what additional research at Holly Pond would be desirable to better track the impact of the tidal gate manipulation. As discussed previously in this report, consideration should be given to:

1) Monthly monitoring of the macrophyte community in different regions of the pond.

2) Monthly monitoring of the following environmental parameters within the pond: temperature, light, salinity, nutrients, selected heavy metals.

3) Conducting a field survey of wetland flora and fauna during mid-to-late spring to identify any seasonal ecological components that were not present during the ERT's December investigation.

4) Measuring and mapping in detail any areas which presently support cord grass fringe, salt meadow, and *Phragmites australis* for use as base line information. Permanent reference points should be established for comparison measurements and mapping in the future.

5) Performing a comprehensive review of climatic data would be very helpful in determining under what conditions manipulation of the water level would be most beneficial.

6) Collecting soil samples from areas of salt meadow and *Phragmites australis* prior to the manipulation of the water level in Holly Pond. These should be analyzed for moisture content. Periodic and seasonal monitoring would be necessary to determine if wetland areas were drying out. Also monitoring pipes could be implanted in wetland areas to determine if the water table beneath the marsh surface was fluctuating or if a drawdown was occurring.

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IX. APPENDIX

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3) Visel, Timothy C. "Shellfish Management Procedures for Connecticut Municipalities and Other New England Towns". Masters thesis, University of Rhode Island, 1984

4) Blake, Mark M. and Smith, Eric M. "A Marine Resource Management Plan for the State of Connecticut". Department of Environmental Protection, July 1984

ABOUT THE TEAM

The King's Mark Environmental Review Team (ERT) is a group of environmental professionals drawn together from a variety of federal, state, and regional agencies. Specialists on the team include geologists, biologists, foresters, climatologists, soil scientists, landscape architects, recreation specialists, engineers, and planners. The ERT operates with state funding under the aegis of the King's Mark Resource Conservation and Development (RC&D) Area - a 47 town area in western Connecticut.

As a public service activity, the team is available to serve towns and developers within the King's Mark Area --- free of charge.

PURPOSE OF THE TEAM

The Environmental Review Team is available to help towns and developers in the review of sites proposed for major land use activities. To date, the ERT has been involved in the review of a wide range of significant activities including subdivisions, sanitary landfills, commercial and industrical developments, and recreation/open space projects.

Reviews are conducted in the interest of providing information and analysis that will assist towns and developers in environmentally sound decision-making. This is done through identifying the natural resource base of the project site and highlighting opportunities and limitations for the proposed land use.

REQUESTING A REVIEW

Environmental Reviews may be requested by the chief elected official of a municipality or the chairman of an administration agency such as planning and zoning, conservation, or inland wetlands. Requests for reviews should be directed to the Chairman of your local Soil and Water Conservation District. This request letter must include a summary of the proposed project, a location map of the project site, written permission from the landowner/developer allowing the team to enter the property for purposes of review, and a statement identifying the specific areas of concern the team should address. When this request is approved by the local Soil and Water Conservation District and the King's Mark RC&D Executive Committee, the team will undertake the review. At present, the ERT can undertake two reviews per month.

For additional information regarding the Environmental Review Team, please contact your local Soil Conservation District Office or Richard Lynn (868-7342), Environmental Review Team Coordinator, King's Mark RC&D Area, P.O. Box 30, Warren, Connecticut 06754.