TOWN OF DARTMOUTH
BUTTONWOOD BROOK WATERSHED
DRAFT MANAGEMENT PLAN

Prepared for:

THE TOWN OF DARTMOUTH
TOWN HALL
SLOCUM ROAD
DARTMOUTH, MASSACHUSETTS
02749

Prepared by:

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1.0 INTRODUCTION

Background

Historically, Buzzards Bay has been a productive source of shellfish such as quahogs, clams, scallops and oysters. The annual economic value of its landed catch is estimated at 6.6 million dollars.[1] Over the last twenty years, there has been a dramatic increase in the number of shellfish-harvesting areas closed due to pathogen contamination. In 1970, 4,358 acres were closed; by 1990, nearly 13,500 acres had been put off-limits to shellfishing.

The Town of Dartmouth Massachusetts, a coastal community on Buzzards Bay, has had over 1,700 acres of its shellfish beds closed during this period. Among those areas affected are 50 acres of shellfish beds located north of Mullins Wharf in upper Apponagansett Harbor (Figure 1). In 1989, The Town of Dartmouth received a Community Mini-Grant from the Buzzards Bay Project to develop a Water Quality Management Plan for the Buttonwood Brook Watershed, a drainage basin whose waters are popularly perceived as being substantially responsible for this shellfish bed closure. The goal of the watershed management plan is to develop management strategies that will:

- minimize bacteriologic pollution and,
- create conditions that might allow for the reopening of this shellfish area.

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[1]Boston University Marine Program. Shellfish in Buzzards Bay: A Resource Assessment, Woods Hole, Massachusetts, June 1987.

SITE LOCUS
BUTTONWOOD BROOK WATERSHED AND
NORTH APPONAGANSETT HARBOR
TOWN OF DARTMOUTH MINI GRANT
NEW BEDFORD NORTH AND SOUTH, MA TOPOGRAPHIC QUADRANGLES
APPROXIMATE SCALE 1" = 3200'

FIGURE 1

Watershed Description

The Buttonwood Brook Watershed (Figure 2), located on the eastern boundary of the Town of Dartmouth is comprised of approximately 2,300 acres, of which, about one third lie within the City of New Bedford. Generally, the watershed is bounded on the west by Slocum Road, on the south by Russells Mills Road and on the east by Rockdale Avenue. Buttonwood Brook (Branch A) originates in New Bedford near the water tower on Hathway Road and flows into the northern end of Apponagansett Harbor. Two tributaries (B) and (C) flow into the Brook north of Russells Mills Road.

With the exception of some areas of moderate slope on its periphery, the watershed's topography is relatively flat.

According to the U.S. Soil Conservation Service [2], four soil series predominate in the watershed: the Paxton Series, the Ridgebury Series, the Whitman Series and the Woodbridge Series. These soil series have similar characteristics; they are fine to extremely stoney sandy loams of little (0%) to moderate (8%) slope with seasonally perched water tables that limit their suitability for community development and septic tank absorption fields.

Of the watershed's 1,700 acres located in Dartmouth, 58% of the land use is urban (single family residential, institutional, commercial and retail/office) and 42% open space (regulated

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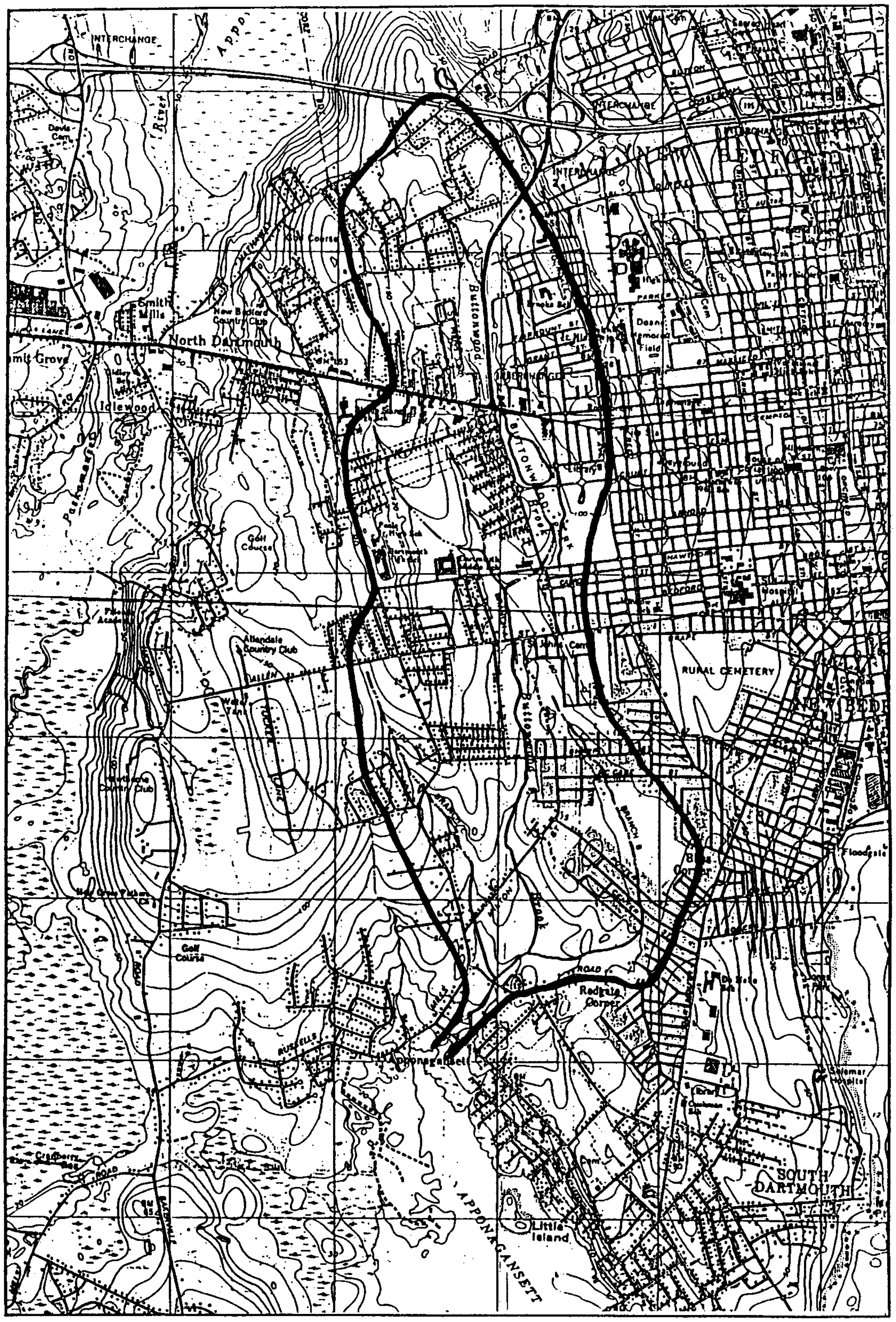
[2] Soil Survey of Bristol County Massachusetts, Southern Part



BUTTONWOOD BROOK WATERSHED

DARTMOUTH, MASSACHUSETTS

SANFORD ECOLOGICAL SERVICES, INC.
258 MAIN STREET
BOURNE, MASSACHUSETTS
JANUARY, 1990
SCALE 1 INCH = 800 FEET
SOURCE: USGS

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FIGURE 2

wetlands, conservation lands, and agriculture) (Figure 3). Deciduous wooded swamps, deciduous shrub swamps and wet meadows, all protected by local, state and federal regulations, flank significant portions of the brook and its branches.

Much of the watershed is presently serviced by both sanitary and stormwater sewer systems. However, stormwater is routinely discharged directly into the Buttonwood Brook system at numerous locations.

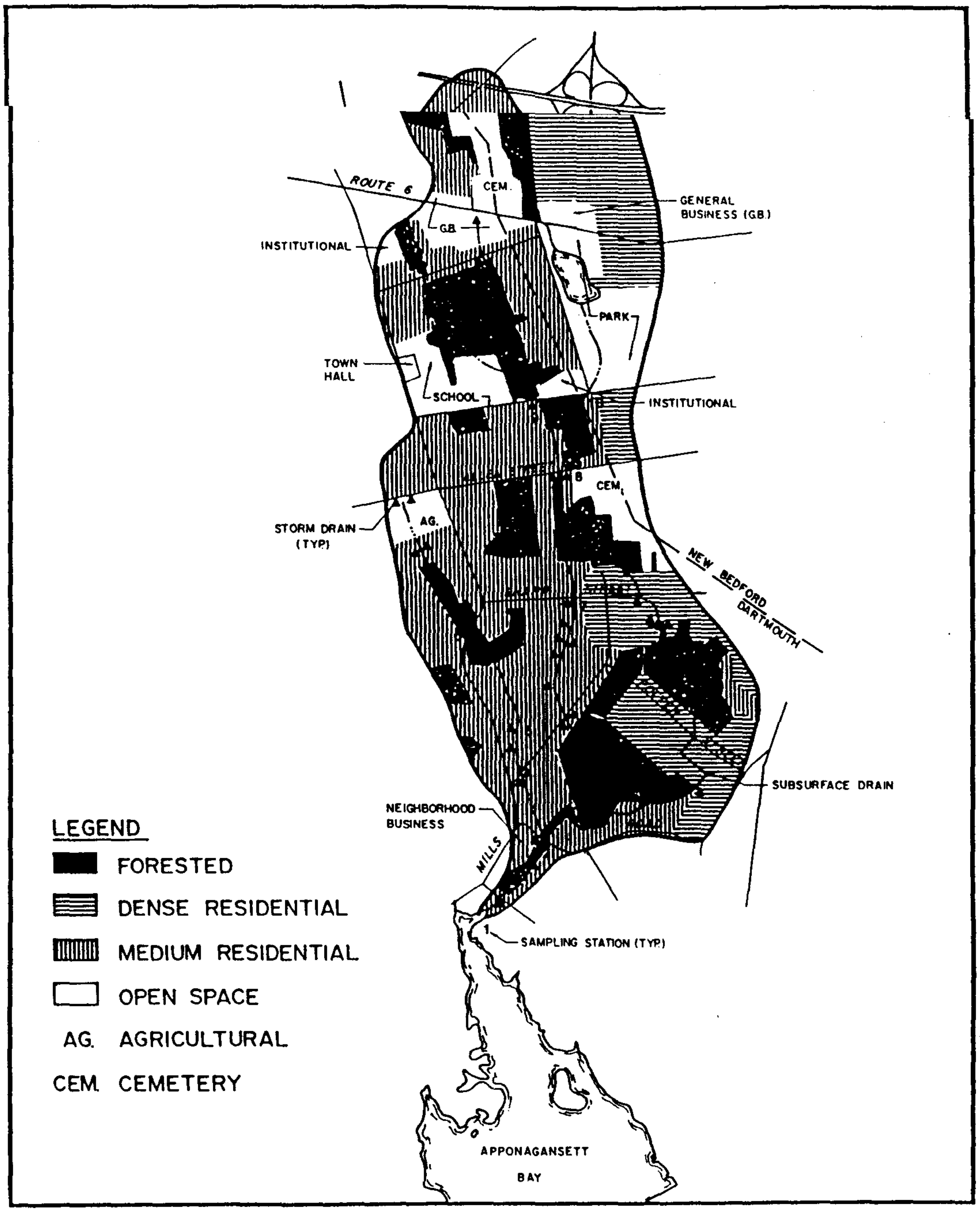
Project Scope

Preparatory to developing the Watershed Management Plan, the Town of Dartmouth, acting through its agent, Sanford Ecological Services, Inc. (SES) performed these tasks:

- Established a water quality monitoring program based on an assessment of the study area to target locations and general trends in seasonal nutrient and bacteriological pollution loads to the watershed (See Attachment 1),

- Inventoried shellfish populations in Apponagansett Harbor north of the line drawn from "Star of the Sea Villa" to "Mullin's Wharf", to determine the size, abundance, and species of shellfish present. The inventory provides a basis for the evaluation of the economic value of the Apponagansett Harbor resources. (See Attachment 2) and,

- Reviewed and evaluated all applicable existing land use and water quality regulations (See Attachment 3).



BUTTONWOOD BROOK WATERSHED LAND USE MAP

SANFORD ECOLOGICAL SERVICES, INC.
258 MAIN STREET
BOURNE, MASSACHUSETTS
MARCH, 1991
SCALE: 1" = 800'

FIGURE 3

2.0 STATEMENT OF FINDINGS

Water Quality Summary

A summary of the Water Quality Evaluation found in Attachment 1, as well as a more detailed examination of fecal coliform pollution in the watershed is presented in this section of the report. In general, the chemical and physical parameters measured - nitrate-nitrogen, ammonia-nitrogen, total kjendahl nitrogen, ortho-phosphate, total suspended solids, and the metals cadmium, copper, lead, and zinc - occurred at levels below water quality standards and EPA toxicity thresholds for aquatic organisms. The biological parameter, fecal coliform, was found at levels which exceed standards used to regulate coastal shellfishing at many locations.

Fecal coliform is often used as an indicator for monitoring water quality for drinking and contact recreation and for managing coastal shellfishing; the latter being of greater importance in Buttonwood Brook due to the closure of shellfish beds in Upper Apponagansett Bay. For shellfish beds to remain open, the EPA recommends that the median fecal coliform bacteria concentration not exceed 14 MPN/100 ml and not more than 10% of the samples should exceed 43 MPN/100 ml. These levels are often surpassed in the Buttonwood Brook Watershed.

As further discussed in the Water Quality Evaluation (see Attachment 1), high levels of fecal coliform (110 to >2400 MPN/100 ml) were found at all ten sampling stations during the non-episodic summer sampling event. Specifically, in Buttonwood Brook (Branch A) for this non-episodic sampling event, coliform levels of 920, 1600, >2400, and 350 MPN/100 ml were measured at stations 10, 8, 7, and 2 (see Figure 4), which run from the headwaters to the mouth. These results indicate that high levels of fecal coliform enter the stream under normal flow

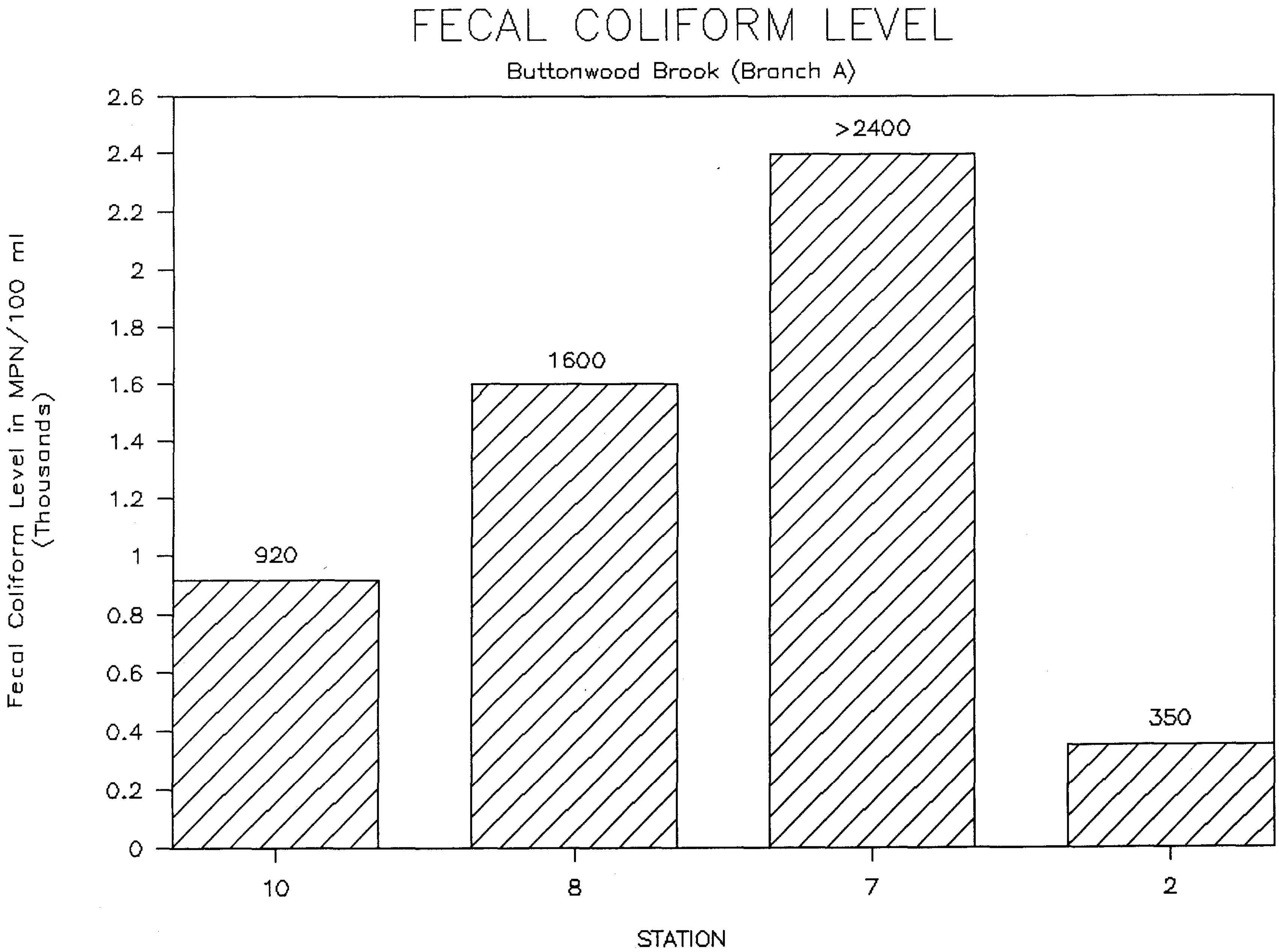

FECAL COLIFORM LEVEL
Buttonwood Brook (Branch A)
Fecal Coliform Level in MPN/100 ml
(Thousands)
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
920
1600
>2400
350
10
8
7
2
STATION

FIGURE 4

conditions upstream of station 10, between stations 10 and 8 and between stations 8 and 7. Improvement in water quality occurs by station 2, due in part to dilution by water from Branches B and C which converge with Buttonwood Brook (A) upstream of station 2. This data shows that subdrainage areas 7 and 8 appear to contain significant sources of fecal coliform pollution, even in the absence of significant precipitation events.

High levels of fecal coliform (240 to >2400 MPN/100 ml) were also observed at all ten sampling stations during the spring episodic (i.e., heavy rain) sampling event. These data are noteworthy for two reasons: (1) values as high as two orders of magnitude greater than those found during the non-episodic spring sampling event collected 20 days earlier were observed and (2) extremely high levels (>2400 MPN/100 ml) were observed in all three branches of the brook.

These data suggest that the source of fecal coliform is related to the land's surface (such as animal scat, etc.) and is washed into the brook via runoff rather than due to leaks in the sewerage system. This view is supported by the water chemistry as changes in the water chemistry indicative of sewage inputs (e.g., elevated nitrate nitrogen concentrations) are not observed.

In conclusion, subdrainage areas along all three branches of the brook contribute significant quanitities of fecal coliform to the system under episodic conditions. Subdrainage areas 7 and 8 appear to be the primary "hot spots" for fecal coliform pollution as high levels of fecal coliform occur at these locations even under non-episodic conditions.

It is important to point out that while nearly every urban and suburban land use exports sufficient coliform bacteria to violate health standards, older and more intensely developed areas are responsible for the greatest level of export[1]. In addition, elevated levels of coliform exceeding public health standards for contact recreation are commonly observed during storms in most urban streams. Thus, the situation in Buttonwood Brook is typical of waterways flowing through urban areas.

Shellfish Resource Summary

A summary of the Shellfish Resource Evaluation found in Attachment 2 is presented in this section of the reoprt. A 50 acre area located between Little Island and Lucy Street was sampled to evaluate the shellfish community structure and to allow an estimate of the empirical market value of the shellfish resources of upper Apponagansett Harbor to be made.

A total of 336 shellfish were collected during the sampling effort, all of which consisted of a single species: quahogs. According to established market designations, 74.5% of the collected quahogs were classified as chowder, 8.3% as cherrystone, and 12.9% as littleneck. A general trend based upon individual size was observed during the analysis of the data; in general, a higher proportion of smaller individuals was found in samples collected from the more southerly portion of the sampling area. Factors underlying this distribution pattern and the significance of this trend are not known, but could be related to season, salinity, tide, or other environmental conditions, including pollution.

Based upon information provided by the Massachusetts Division of Marine Fisheries and the sampling results, the

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[1]Schueler, Thomas R.,. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Washington Metropolitan Water Resources Planning Board.

empirical market value for the shellfish resources of the upper harbor was estimated to be approximately $166,000. As reopening of the shellfish beds of the upper harbor is an underlying factor in the development of a watershed management plan, the economic value of the shellfish resources should be considered in the design and implementation of the mitigation effort.

3.0 WATERSHED MANAGEMENT PLAN RECOMMENDATIONS

The recommended "Best Management Practices" for the mitigation of high levels of bacteria in urban runoff are infiltration systems (i.e., trenches and basins). These systems treat runoff prior to its discharge to ground water or to a receiving watercourse. The long-term pollutant removal rate for bacteria for these systems ranges from 75 to 90% for infiltration trenches and from 75 to 98% for infiltration basins depending upon the sizing methodology utilized. These systems are not practical for this watershed, however, because soil conditions found along Buttonwood Brook are characterized by seasonally perched water tables, a fatal design constraint for these infiltration devices. Besides soil, additional limiting factors include slope, depth to bedrock, and water table level.

As a result of these limitations, SES recommends that the following actions be taken to mitigate contaminant impacts to Buttonwood Brook and Apponagansett Harbor. Numbers indicate a suggested priority:

1. The Dartmouth Department of Public Works should initiate a program to regularly clean catch basins. Properly maintained catch basins are most effective at removing particulates, especially larger-sized sediments, and particulate-associated contaminants. To maximize contaminant removal efficiency from storm water runoff, catch basins should be cleaned four to six times per year.

2. The Dartmouth Board of Health should conduct a survey of animal populations within the watershed, with special emphasis on those areas of the watershed suspected of being coliform "hot spots". As indicated in the Water Quality Evaluation and the Water Quality Summary, fecal coliform inputs under normal flow conditions were greatest in subdrainage areas 7 and 8.

3. The Dartmouth Department of Public Works should initiate a street sweeping program in the watershed, particularly in the "hot spots". The quantity of contaminants available to be picked up by storm water runoff will be reduced by frequent sweepings of roadways in problem areas. A twice monthly sweeping program is expected to be effective in reducing levels of particulate and particulate-associated contaminants (including toxicants and trace metals) from storm water runoff.

4. The Dartmouth Board of Health, in conjunction with other local, state and federal agencies, should initiate public education/outreach programs in the Buttonwood Brook Watershed to increase public awareness of how day-to-day activities impact coastal resources. A successful program of this kind has been established in the Chesapeake Bay Area.

5. The Dartmouth Board of Health should examine the water quality in Buttonwood Brook on a regular basis to monitor the effectiveness of this program in reducing fecal coliform levels, as well as those of other contaminants sampled in this study.

6. Additional contaminant impacts on Apponagansett Harbor should be investigated. While Buttonwood Brook does contribute contaminants to the bay, other potential sources of contaminants, including coliform, exist and

should be examined. These include: a) the approximately 1700 boats moored in the harbor, b) the six storm water outfalls which originate outside of the Buttonwood Brook Watershed and discharge directly into the eastern side of the harbor, c) the runoff from agricultural fields to the west of the harbor (a significant population of Canada geese forage here), and d) the three other streams (including Salt Creek) which discharge directly into the bay.

7. The flushing characteristics of Apponagansett Harbor should be investigated. The causeway could restrict water flow and negatively impact normal flushing patterns resulting in stagnation of the water in the bay. If this occurs to any significant extent, cleaning up the discharges to the bay may not have the desired effect.

ATTACHMENT 1

WATER QUALITY EVALUATION

ATTACHMENT 1

WATER QUALITY EVALUATION

This section of the report presents the methodology and results of a year long water quality evaluation of the Buttonwood Brook Watershed which was conducted by Sanford Ecological Services in conjuction with volunteers from the Dartmouth Fisherman's Association between 14 February and 10 November 1990.

Methodology

Samples for water quality analysis were collected seasonally from ten stations throughout the watershed (Figure 1) under both non-episodic and episodic conditions. Non-episodic sampling allowed evaluation of water quality under normal flow conditions; episodic sampling measures the contributions of road and land runoff during major precipitation events.

All water samples were analyzed in state certified laboratories for nitrate-nitrogen, ammonia-nitrogen, total kjendahl nitrogen, ortho-phosphate, total suspended solids, and fecal coliform. Sampling for the metals cadmium, copper, lead, and zinc occurred only during the summer episodic sampling event. The results of water quality analyses are presented in Appendix A.

Results

The discussion of the results is presented in two sections. In the first section, the water quality characteristics of the watershed are discussed for each parameter with emphasis placed on the levels observed, seasonal variation, non-episodic versus episodic results,

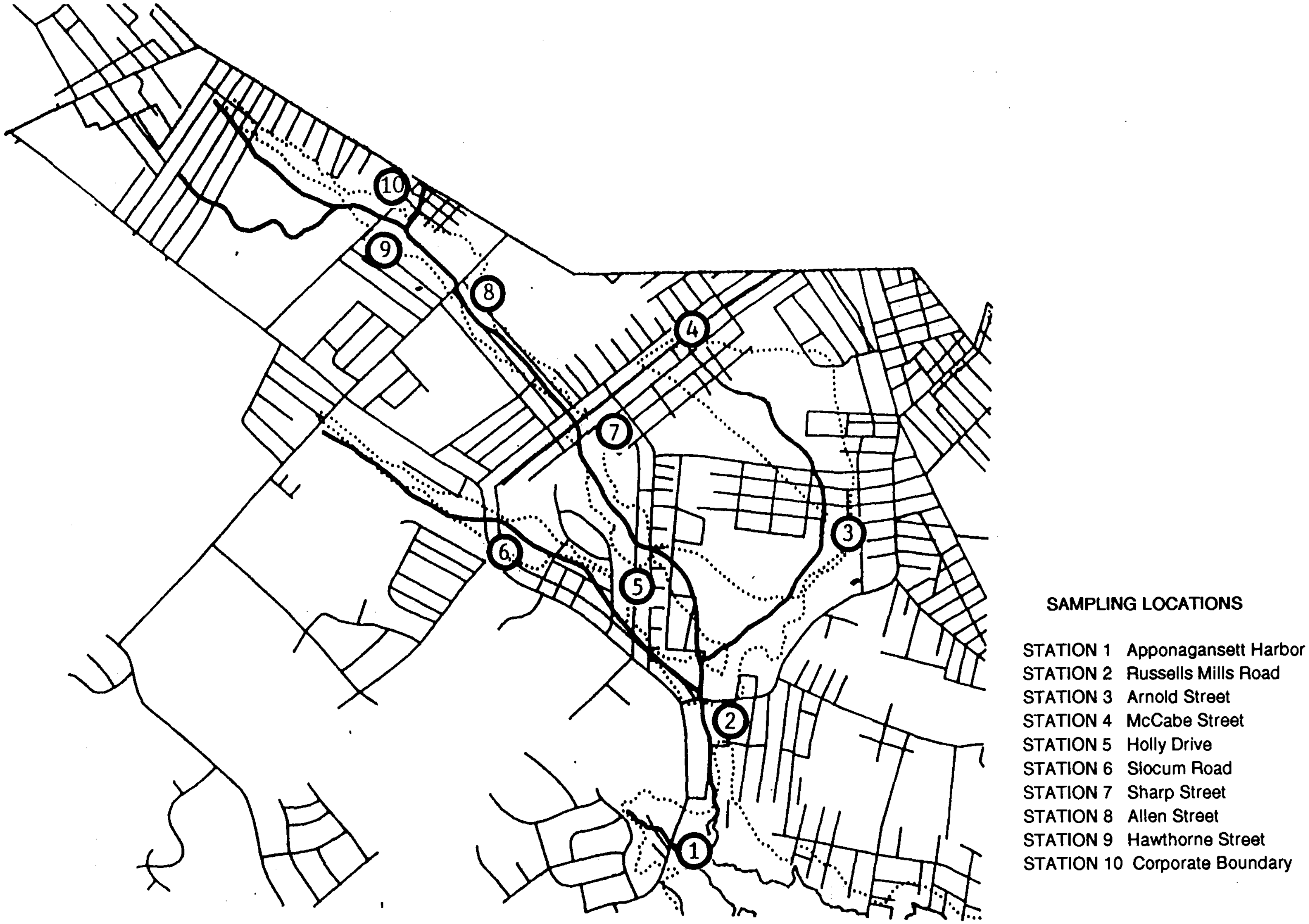

FIGURE 1
SAMPLING STATION LOCATIONS
BUTTONWOOD BROOK WATERSHED
DARTMOUTH, MASSACHUSETTS
APPROPROXIMATE SCALE 1" = 2000'

and comparisions to available toxicity thresholds. The second section presents a more general discussion comparing the relative contaminant contributions with corresponding land use patterns for ten subdrainage basins within the watershed.

Water Quality Analysis Results

Nitrate-nitrogen, the first of the parameters evaluated to examine nitrogen loading, is indicative of wastewater releases and is generally accepted as the limiting nutrient .01 mg/L and averaged roughly 5 mg/L. The EPA water quality criterion for nitrate-nitrogen indicates that levels of 5 mg/L should be protective of most warmwater fisheries. Thus, nitrate-nitrogen is not a significant contaminant in the Buttonwood Brook Watershed.

The two remaining nitrogen parameters examined in this study, ammonia-nitrogen and total kjendahl nitrogen (TKN), are indicative of sanitary pollution and nutrient loading. Ammonia-nitrogen levels under non-episodic conditions ranged from <0..01 mg/L and averaged roughly 5 mg/L. The EPA water quality criterion for nitrate-nitrogen indicates that levels of 5 mg/L should be protective of most warmwater fisheries. Thus, nitrate-nitrogen is not a significant contaminant in the Buttonwood Brook Watershed.

The two remaining nitrogen parameters examined in this study, ammonia-nitrogen and total kjendahl nitrogen (TKN), are indicative of sanitary pollution and nutrient loading. Ammonia-nitrogen levels under non-episodic conditions ranged from <0.05 to 0.45 mg/L, with the highest values typically observed during the summer. In contrast, under episodic conditions the ammonia-nitrogen levels were usually lowest in the summer with values for all seasons within the range of <0.05 to 0.25 mg/L. TKN concentrations for non-episodic and episodic conditions were similar, and both were seasonally dependent with the highest values found during the summer and autumn. The non-episodic and episodic values ranged from < 0.05 to 1.17 mg/L and 0.07 to 1.83 mg/L, respectively. In general, these values are not of concern.

Phosphorus is generally accepted as the limiting nutrient controlling the eutrophication of freshwater systems. Under non-episodic and episodic conditions, concentrations of ortho-phosphate ranged from <0.05 to 0.08 mg/L and <0.05 to 0.38 mg/L, respectively. In the majority of the samples analyzed for this study, ortho-phosphate levels were below the detection limit of 0.05 mg/L. The elevated levels found in the summer episodic sample at station 8 (Allen Street; 0.38 mg/L) and during the autumn episodic event at station 6 (Slocum Street; 0.16 mg/L) are of some concern. These values probably result from runoff from nearby agricultural areas.

Under non-episodic conditions, total suspended solids ranged from <4.0 to 142 mg/L. These were seasonally dependent with the highest values at most stations observed in the summer. The levels found under episodic conditions were also seasonally dependent with the highest values typically observed in the winter and spring. In this case, the levels ranged from <4.0 to 44 mg/L. While no specific numerical standard is provided in the literature, in general, the values reported are not of concern, with the exception of the summer non-episodic sample from station 1 (Apponagansett Bay; 142 mg/L) located at the mouth of Buttonwood Brook.

The trace metals examined in this study - cadmium, copper, lead, and zinc - are common roadway and parking lot runoff constituents. Concentrations of these metals were measured only once during the summer episodic event. Cadmium and lead levels were below their respective detection limits of 0.010 and 0.070 mg/L at all ten stations. Copper concentrations ranged from <0.004 to 0.029 mg/L and zinc levels ranged from 0.05 to 0.131 mg/L. The elevated levels of copper at stations 7, 8, and 9 (Sharp Street, Allen Street, and Hawthorne Street), and the elevated zinc concentrations at stations 6, 8, and 9 (Slocum Road, Allen Street, and Hawthorne Street) are of concern from an aquatic toxicological viewpoint. The copper concentrations exceed both chronic and acute EPA toxicity levels for freshwater organisms of 0.018 mg/L and 0.012 mg/L, respectively. Zinc levels at stations 6 and 9 exceed the chronic EPA toxicity threshold of 0.110 mg/L and the level at station 8 exceeds the acute EPA toxicity threshold of 0.120 mg/L. These levels may be due to automobile emissions and deposition in the above mentioned areas.

Fecal coliform is used as an indicator organism for monitoring water quality and for managing coastal shellfishing. Non-episodic fecal coliform levels ranged from <2 to >2400 MPN/100 mL and were seasonally dependent with the highest values typically found during the spring, summer, and autumn. Episodic values ranged from <1 to 6200 (>2400) MPN/100 mL. These were also seasonally dependent with the highest values occurring during the spring (summer levels were not measured). This seasonal dependence is not unusual because bacteria multiply more rapidly at higher temperatures. Excessively high levels were found at all ten stations for the spring episodic samples (240 to >2400 MPN/100 ml) and for the summer non-episodic event (110 to >2400 MPN/100 ml). Elevated levels were also observed at all ten stations for the non-episodic spring and autumn sampling events. Thus, fecal coliform pollution is a widespread problem in the Buttonwood Brook Watershed.

Patterns of fecal coliform pollution in the watershed are discussed in greater detail in the Water Quality Summary section of this document.

Water Quality and Land Use Practices

The Buttonwood Brook Watershed was divided into ten subdrainage areas based on the location of the sampling stations (Figure 2). These subdrainage areas range from 80.95 to 1783 acres in size. In six out of the ten subdrainage areas, over 50% of the land use is urban. Storm drains discharge road runoff to the brook in all but one of the subdrainage areas (area 10). A summary of land use practices for the various subdrainage areas of the Buttonwood Brook Watershed are presented in Appendix C.

Subdrainage area 10

The subdrainage area located at the headwaters of the basin is the main contributing area to sampling station 10 (Corporate Boundary). This subdrainage area consists of 553.83 acres and comprises 31.1% of the total watershed area. The land use is primarily urban consisting generally of residential neighborhoods and highways. Branch A of Buttonwood Brook flows through Buttonwood Park and Buttonwood Zoo approximately one-quarter mile upstream of sampling station 10. Concentrations of tested parameters for subdrainage area 10 were generally below the calculated mean values for the watershed except for ammonia-nitrogen, which was consistently elevated.

Subdrainage area 9

The subdrainage area contributing to sampling station 9 (Hawthorne Street) is 260.86 acres in size and comprises

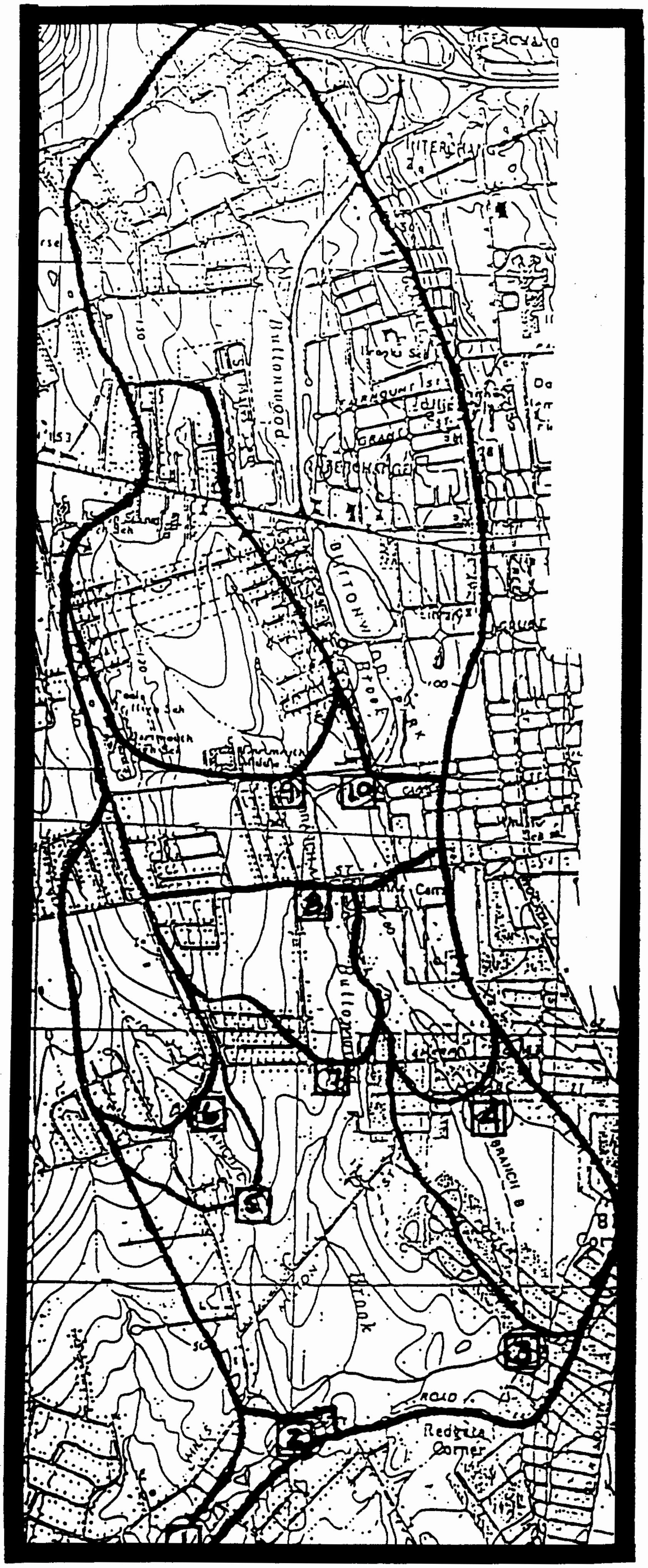

FIGURE 2 BUTTONWOOD BROOK SUBDRAINAGE AREAS

SCALE: 1" = 2,000'

14.6% of the total watershed. Land use is primarily urban consisting generally of residential areas and schools. This subdrainage area is located at the headwaters of Branch A of Buttonwood Brook. Episodic water quality analyses indicate that the drainage from this area contains elevated levels of copper and zinc. These metals are probably derived from road runoff.

Subdrainage area 8

The contributing subdrainage area to sample station 8 (Allen Street) is 964.26 acres in size and comprises 54.1% of the total watershed. This subdrainage area includes subdrainage areas 9 and 10 and is located on Branch A of the brook directly south of subdrainage area 9. The land use in this area is approximately 71% urban consisting of residential neighborhoods, schools, cemeteries, and other urban structures. Analyses indicate that the Buttonwood Brook discharge at this station is generally elevated in copper and zinc. The elevated copper and zinc levels are probably derived from road runoff.

Subdrainage area 7

The subdrainage area contributing to sample station 7 (Sharp Street) is 1057.63 acres is size and comprises 59.3% of the total watershed area. It includes subdrainage areas 8, 9, and 10 and is located south of subdrainage area 8 along Branch A of Buttonwood Brook. The land use in this subdrainage area is approximately 64% urban. In general, metal concentrations are lower at station 7 than at upgradient station 8. This probably results from the large area of open space between these two sample collection stations.

Subdrainage area 6

Subdrainage area 6 is 100.94 acres in size and comprises 5.7% of the total watershed area. This subdrainage area is located at the headwaters of Branch C of Buttonwood Brook. Approximately 66% of this subdrainage area is open space with the remaining area covered by residential neighborhoods. Water quality analyses indicate elevated levels of nitrate-nitrogen from this drainage area. This is probably a consequence of the agricultural activity in this subdrainage area. In addition, the level of zinc, probably derived from road runoff, is higher than average.

Subdrainage area 5

The subdrainage area contributing to sample station 5 (Holly Drive) is 146.41 acres in size and comprises 8.2% of the total watershed area. This area includes subdrainage area 6 and is located on Branch C of Buttonwood Brook just downstream of that area. The land use in this subdrainage area is approximately 61% open space and 39% urban. Water quality analyses indicate that nitrate-nitrogen is elevated at the station, however, this elevated level probably originates from subdrainage area 6. The level of zinc is much lower than that measured at station 6.

Subdrainage area 4

Subdrainage area 4 measures 80.95 acres in size and comprises 4.5% of the total watershed area. This area is located at the headwaters of Branch B of Buttonwood Brook and is approximately 65% open space. The remaining 35% is primarily residential neighborhoods. Water quality analyses indicate that no significant levels of contaminants are derived from this portion of the watershed.

Subdrainage area 3

The subdrainage area contributing to sample station 3 is 212.37 acres in size and comprises 11.9% of the total watershed area. This area includes subdrainage area 4 and is located directly south of subdrainage area 4 along Branch B. Land use in the area is approximately 49% urban. Water quality analyses indicate that no significant levels of contaminants are derived from this portion of the watershed.

Subdrainage area 2

Subdrainage area 2 is 1756.99 acres in size and comprises 98.5% of the total watershed area. Branch B, Branch C, and Branch A of Buttonwood Brook converge within this subdrainage area which includes subdrainage areas 3 through 10. Approximately 52% of the land use is urban. Water quality analyses indicate that contaminants present at this portion of the watershed are probably derived from upgradient areas.

Subdrainage area 1

Sample station 1 is located at the mouth of Buttonwood Brook where it empties into Apponagansett Bay. Subdrainage area 1 is 1783 acres in size and represents 100% of the total watershed area. Approximately 58% of the watershed land use is urban. No significant changes in water quality occur between sampling station 2 and sampling station 1.

Conclusion

Water quality analyses indicate that no specific location contributes significant quantities of chemical contaminants to Buttonwood Brook. In general, the contaminants that were observed (i.e., nitrate-nitrogen and metals such as copper and zinc) are derived primarily from road and agricultural runoff throughout the basin. One area, subdrainage area 6, which is located in the eastern portion of the watershed, does contribute elevated levels of nitrate-nitrogen. This probably results from agricultural runoff of fertilizers.

Levels of fecal coliform were, in general, elevated throughout the watershed with extremely high levels observed at station 7 and 8 during non-episodic summer sampling and at virtually all of the stations during episodic spring sampling. It should be noted that nearly all suburban and urban land uses export coliform at levels that exceed health standards. Furthermore, older and more intensely developed areas generally export the highest levels, and coliform levels exceeding standards are common occurances during storms in most urban streams[1]. Thus, the situation in the Buttonwood Brook Watershed is not unusual, but is of particular concern because this parameter is utilized by the Massachusetts Division of Marine Fisheries to regulate shellfishing.

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[1]Schuler, Thomas R.,. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Washington Metropolitan Water Resources Planning Board.

ATTACHMENT 2

SHELLFISH RESOURCE EVALUATION

ATTACHMENT 2

SHELLFISH RESOURCE EVALUATION

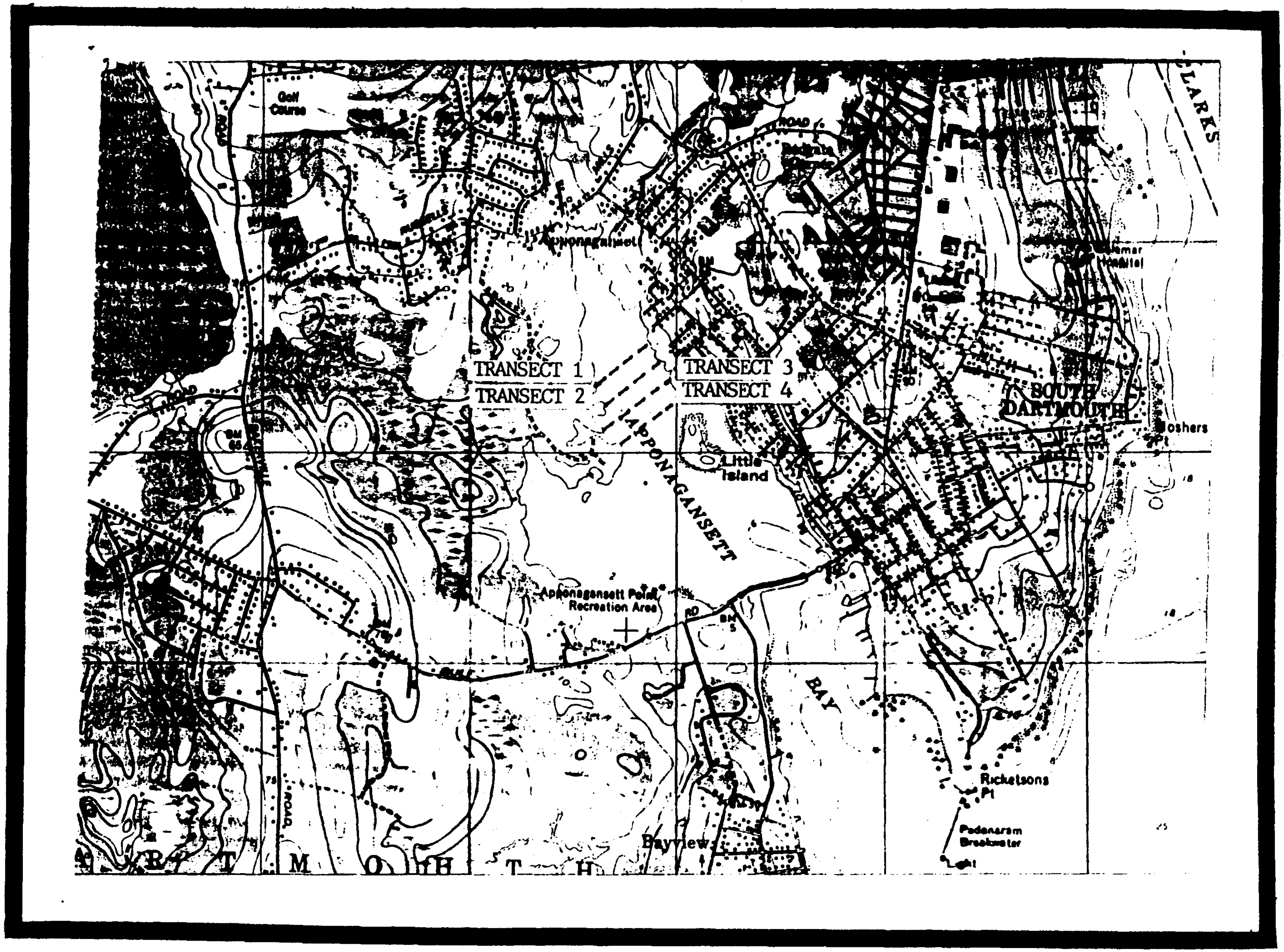
This section of the report presents the methodology and results of a shellfish resource evaluation conducted on 10 November 1990 in the subtidal and intertidal regions of upper Apponagansett Bay. This study was conducted by Sanford Ecological Services, Inc. (SES) in conjunction with Mr. Michael Hickey of the Massachusetts Division of Marine Fisheries and volunteers from the Dartmouth Fisherman's Association. The shellfish resource area examined in this study is fifty acres in size and is situated between Little Island to the south and Lucy Street to the north (Figure 1).

Methodology

Four transects were established across upper Apponagansett Bay at 275 foot intervals. Sampling stations were located at 50 foot intervals along each transect. At each sampling station, three grab samples (2 square feet each, 6 square feet total sampling area per station) were taken from a boat using a bullrake. The shellfish from the three grab samples at each station were combined into a single sample and were classified by species, individual size (shell length), and market designation. The harvested shellfish were turned over to John Sherman for disposition.

Results

All 396 of the shellfish collected in this survey were quahogs. Thus, the shellfish resources of upper Apponagansett Bay at the time of this sampling consisted of only a single species. The collected quahogs ranged in size from 1.6 to 4.6 inches. The sampling data collected during this survey is presented in Appendix B.



APPROXIMATE LOCATION OF SHELLFISH SAMPLING TRANSECTS

SCALE: 1" = 2,000'

FIGURE 1

The market designations for quahogs, which are based on shell length, are: littleneck, 2.0 to 2.25 inches; cherrystone, 2.25 to 2.5 inches; and chowder, 2.5 inches and larger (pers. comm., M. Hickey). According to these designations, 74.5% of the collected quahogs were classified as chowder, 8.3% as cherrystone, and 12.9% as littleneck. The remaining 4.3% of the collected quahogs had a shell length of less than 2 inches; consequently, these had no market designation and were not included in the economic analysis.

Based on the November sampling, the overall population density for quahogs of all sizes in the upper bay was approximately 0.76 individuals per square foot of substrate. The estimated densities for the various market designations in individuals per square foot were approximately: chowder, 0.57; cherrystone, 0.06; littleneck, 0.10; and no market designation, 0.03.

Some trends were noted regarding the distribution of the various market designations among the four transects (see Figure 1). At transect 1, the uppermost in the bay, 95.4% of the 65 quahogs collected were chowder and 4.6% were classified as littleneck. At transect 2, 87.4% of 119 organisms were classified as chowder, 5.9% each as cherrystone and littleneck, and 0.8% had no market designation. At transect 3, 56.1% of 57 quahogs were chowder, 21.1% were cherrystone, 17.5% were littleneck, and 5.3% had no market designation. At the most southerly transect, transect 4, 62.6% of 155 organisms were classified as chowder, 9.0% as cherrystone, 20.0% as littleneck, and 8.4% had no market designation. In general, the proportion of the collected quahogs consisting of smaller sized individuals tended to increase in samples collected at transects located lower (more southerly) in the bay. The significance of and factors underlying this distribution pattern are not known, but could possibly be related to season, salinity, tide, and/or other environmental conditions, including pollution.

The number of quahogs per market designation is based upon samples collected from 522 square feet of the upper bay. The shellfish resource area examined in this survey covers 50 acres (2,178,000 square feet); therefore, the total number of quahogs per market designation for the entire resource area can be estimated by multiplying those collected in the sampling effort by a factor of 4172. Based on the estimated number of quahogs present in the resource area, the number of quahogs per pound, and the price per pound for each market designation, the empirical market value for the shellfish resources of upper Apponagansett Bay was estimated to be approximately $166,000. Due to the systematic sampling methodology employed in this study, no estimate of variability associated with this value can be determined. The complete economic analysis is presented in tabular form in Appendix C.

In conclusion, the shellfish resources of upper Apponagansett Bay, based on sampling on 10 November 1990, consist of a single species of shellfish (quahog). Using information provided by Mr. Hickey of the Division of Marine Fisheries, the empirical market value for the shellfish resources was estimated to be approximately $166,000.

ATTACHMENT 3

REVIEW OF MUNICIPAL REGULATIONS

A REVIEW OF DARTMOUTH MUNICIPAL REGULATIONS AFFECTING WATER QUALITY WITHIN THE BUTTONWOOD BROOK WATERSHED

Towns within the Commonwealth of Massachusetts may exercise significant authority over land use, development, and public health issues as a result of the Commonwealth's home rule tradition. This section of the report will review the Town of Dartmouth's regulations and bylaws as they affect water quality protection within the Buttonwood Brook Watershed. The following categories of regulations will be assessed: zoning, subdivision, wetland protection, agriculture, and earth removal.

Zoning

Zoning is the principal form of land use control authorized by M.G.L. Ch. 40A. Zoning ordinances allow local governments to control development according to land use suitability and compatibility of uses. Zoning regulations specify lot size, shape and dimensions, the density of structures, frontage, parking and height requirements and most significantly, the land usage. In addition to defining land usage, zoning regulations allowable percentage of lot coverages by structures. The density of development affects water quality through its impact on aquifer recharge, flooding, contamination of stormwater runoff, and, in unsewered areas, through septic system discharges.

In the Buttonwood Brook Watershed, the following zoning districts have been established:(see Figure A)

DISTRICT	MINIMUM LOT SIZE	PERCENT COVER ALLOWED
SRA	40,000 sf	40%
GB	40,000 sf	65%
GR	15-20,000 sf	40%
NB	20,000 sf	65%

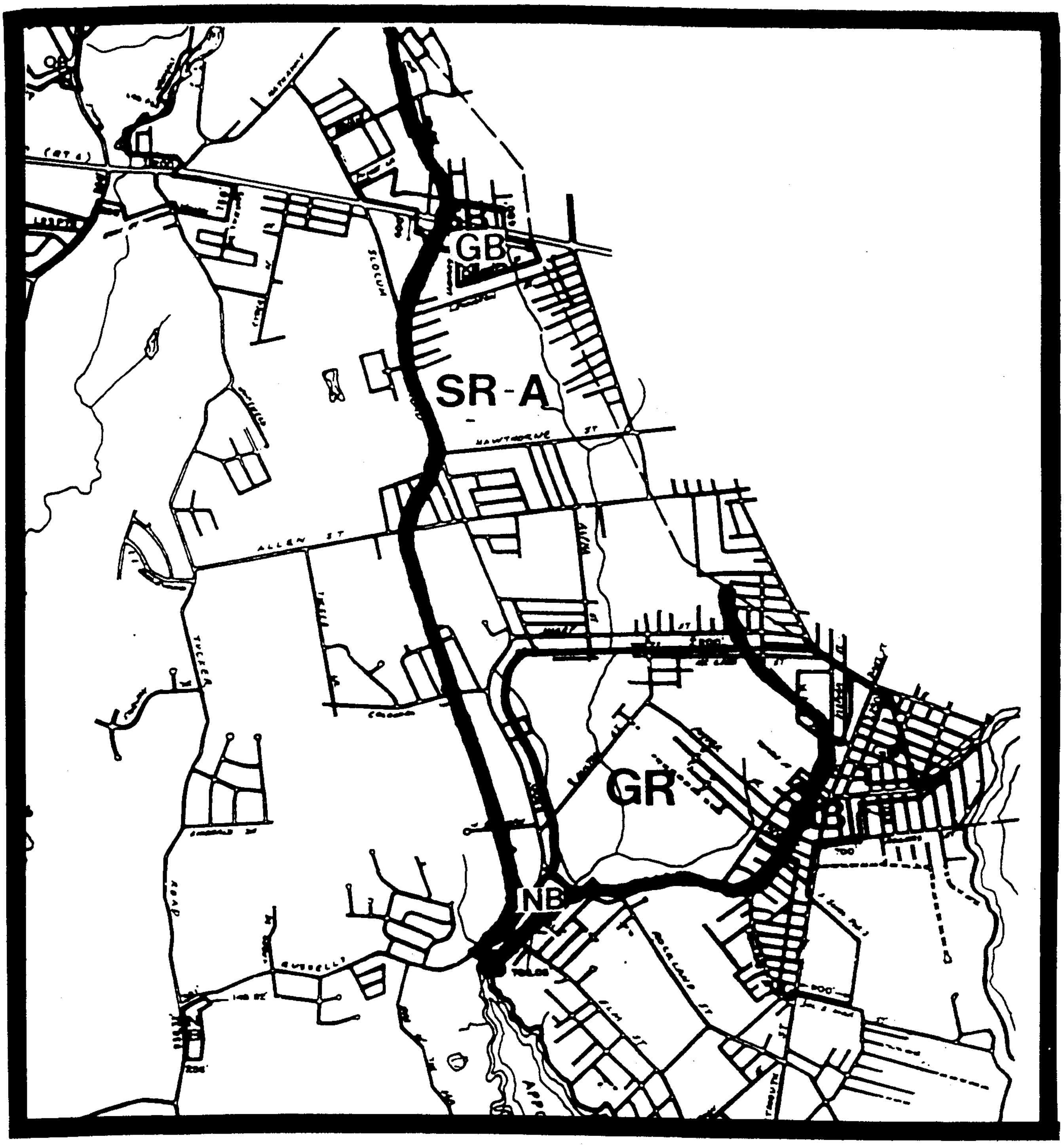


FIGURE A

ZONING DISTRICTS WITHIN THE BUTTONWOOD BROOK WATERSHED

Source: Dartmouth Planning Board
(Not to Scale)

By Special Permit, Cluster Development and Planned Residential Development are also allowed to promote more efficient use of land and to provide for open space and resource protection.

In addition to these districts, three overlay districts provide protection to inland and coastal wetlands:

- o Superimposed Inland Wetlands,
- o Flood Prone Land District, and
- o Coastal Wetlands District.

Subdivision Rules and Regulations

The initial stages of urbanization within a watershed are well documented.[1]

1) Site clearing leads to the loss of native vegetation.

2) Site grading leads to the loss of natural depressions that temporarily store water, and the loss of the original humus-rich soil through construction activity and erosion.

As a result, the land loses much of its natural water storage capacity and its ability to prevent rainfall from being rapidly converted to runoff.

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[1]Schueler, Thomas R.,. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Washington Metropolitan Water Resources Planning Board.

Once construction is completed, rooftops, roads, parking lots, sidewalks, and driveways make most of the site impervious to rainfall. Runoff overloads the existing drainage system necessitating "improvements" to redirect runoff from the site. These drainage improvements dramatically affect stream hydrology:

- o increased peak discharges rise 2 to 5 times higher than the pre-development levels,
- o runoff increases by as much as 50% from forested conditions,
- o the cumulative impacts of sedimentation, increased flooding, higher water temperatures, and pollution degrade the aquatic ecosystem, and,
- o pollutants, which have accumulated on impervious surfaces, run off into adjacent and downstream receiving waters.

To regulate land on which such alterations occur, local planning boards are empowered by the Subdivision Control Law, M.G.L., Chapter 41, Section 81K - 81GG to promulgate rules and regulations governing the standards for the design and construction of proposed developments. These regulations stipulate criteria for managing drainage discharges from development to moderate its effect on flooding, subsurface hydrology, and water quality. Subdivision Rules and Regulations specify standards for roadway construction, utilities, curbs, sidewalks, and drainage.

Subdivision rules and regulations can influence, for better or worse, the impacts of urbanization on a watershed. Requirements for wide streets, piped drainage, double sidewalks, paved driveways and direct stormwater discharge to surface water channels can result in degradation of the quality of downstream water. On the other hand, good subdivision rules and regulations that require stormwater detention, on-site direct discharge, oil and gas traps, protection of existing vegetation, dry wells for roof drains, and reduced road size can offset the negative drainage impacts of development.

The Rules and Regulations Governing the Subdivision of Land in the Town of Dartmouth (June 1990) contain the following drainage requirements:

- Stormwater is to be recharged to the ground on site,"to the maximum extent feasible".

- To encourage on-site groundwater recharge of surface stormwater, open leaching type catch basins are allowable.

- Peak runoff and stream flows at the boundaries of a development shall be no greater than 80% of the rate prior to development. In any case, the discharge shall not exceed one (1) cubic foot per second (CFS) per acre.

- Water collected by the drainage system shall be detained on-site and filtered through man-made detention and filtration systems before discharging into any waterbody, wetland area or the general environment. Drainage water, detained on-site, must flow a minimum of 100' from the drainage system outfall through detention/retention facilities before discharge.

- All detention and filtration systems should be designed to retain the "first flush" of drainage water entering such facilities.

- Stormwater drainage systems shall be designed to handle all water generated in the tributary watershed.

- All drainage calculations and designs are reviewed by a consultant employed by the Town.

Wetlands Protection By-Law and Regulations

Much like the Massachusetts Wetlands Protection Act, the Dartmouth Wetlands Bylaw (April 1990), identifies wetland interests or values that are likely to be affected by activities carried out in areas subject to protection under the Act. The purpose, areas of jurisdiction, and definition of key words and phrases of the Dartmouth Wetlands Bylaw and its Regulations, though similar to the WPA, go beyond the State statute to promote the protection of ground and surface water quality.

The Massachusetts Wetlands Protection Act lists eight wetland functions it is charged to protect: 1) public and private water supply, (2) 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. The Dartmouth Bylaw supplements these with three additional functions or values, one of which is water quality related: erosion and sedimentation control.

The Wetlands Protection Act lists four protectable freshwater wetland resources: (1) Bank, (2) Bordering Vegetated Wetlands, (3) Land Under Water Bodies and Waterways, and (4) Land Subject to Flooding. The Dartmouth Wetlands Protection Bylaw extends its jurisdiction to land in or within a 100' buffer zone of any freshwater wetland, marsh, wet meadow, bog, swamp, or vernal pool; any lake, river, pond, stream, estuary or any land under said waters. The definitions of activities allowed by the Act have been amplified to encompass issues of drainage and water quality. For example, the Dartmouth Bylaw extends the definition of "alter" to encompass:

- any activities, changes, or work which may cause or tend to contribute to pollution of any body of water or groundwater.

The Bylaw Regulations serve as a guide to enforce and implement the Bylaw. Of particular interest in the Regulations is the section on <u>Stormwater Management Guidelines and Requirements</u>. Realizing the likelihood of stormwater discharges causing permanent or cumulative damage to the functions of wetlands and the quality of receiving waters, the Regulations provide detailed requirements for roadways and parking places that:

- specify "zero increase" as the goal of stormwater attenuation,

- require that hydrologic analysis must include all parts of the project which may be modified by construction activity as well as any up-gradient areas on or off-site, and
- allow the Conservation Commission to require that the design of attenuation facilities take into account the potential development of the entire tributary watershed, including off-site areas

Board of Health

In 1977, the Department of Environmental Protection (DEP) adopted the current regulations under Title V of the State Environmental Code. Title V regulations were designed as a minimum health standard to protect water supplies from bacterial contamination, and to ensure adequate siting and design of sewage disposal systems. Regulations specify requirements for the type and capacity of systems, location, installation, and maintenance. According to Title V, each sewage disposal system shall be located so that it "will not create a nuisance or discharge into any watercourse." Title V sets forth the minimum distance of sewage disposal facilities from wells, surface water supplies and watercourses. Septic tanks must be at least fifty (50) feet from wells or surface water supplies and twenty five (25') from watercourses. Leaching facilities are required to be at least one hundred (100') from wells or surface water supplies and fifty feet (50') from watercourses.

Local Boards of Health, under M.G.L. Chapter 111, Section 31, may adopt regulations to supplement Title V. The Dartmouth Board of Health has increased the setback distances for septic systems and leaching facilities. Its regulations stipulate a fifty (50') setback for septic systems from watercourses and a one hundred foot (100') setback for leaching fields from water courses.

Agriculture

MGL Chapter III, Section 31 authorizes Boards of Health to make reasonable health regulations and to publish and enforce these regulations. With regard to agriculturally induced water quality issues, the Board of Health can regulate the proximity of animal husbandry activities to waterbodies. The Dartmouth Board of Health requires a 100' setback of manure storage from any waterbody.

Earth Removal

The Town of Dartmouth Soil Conservation By-laws (1979) established a Soil Conservation Board to regulate earth removal activities. While the existing By-laws impose certain conditions for securing earth removal permits, they do not contain adequate provisions to protect water quality. For example, the Dartmouth By-law fails to specify:

- permissible depths of excavation to the water table,
- sedimentation and erosion control guidelines,
- grading and slope requirements following earth removal,
- replanting and revegetation requirements, and
- any additional requirements that will ensure that the site is left in such a condition that it will be suitable for the land use for which it is zoned.

Summary

The Town of Dartmouth's existing zoning by-laws, subdivision rules and regulations, and wetlands bylaws and regulations are demanding with regard to their design and drainage requirements. But, for the most part, the Buttonwood Brook watershed is an urbanized watershed. Regulatory controls for new development will not substantially mitigate existing water quality conditions in much of the watershed. What is needed are public policy initiatives to implement the "Best Management Practices" set forth in Section 3.0 of this report.

REFERENCES

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Town of Dartmouth, MA. Soil Conservation By-Laws. January 1, 1979.

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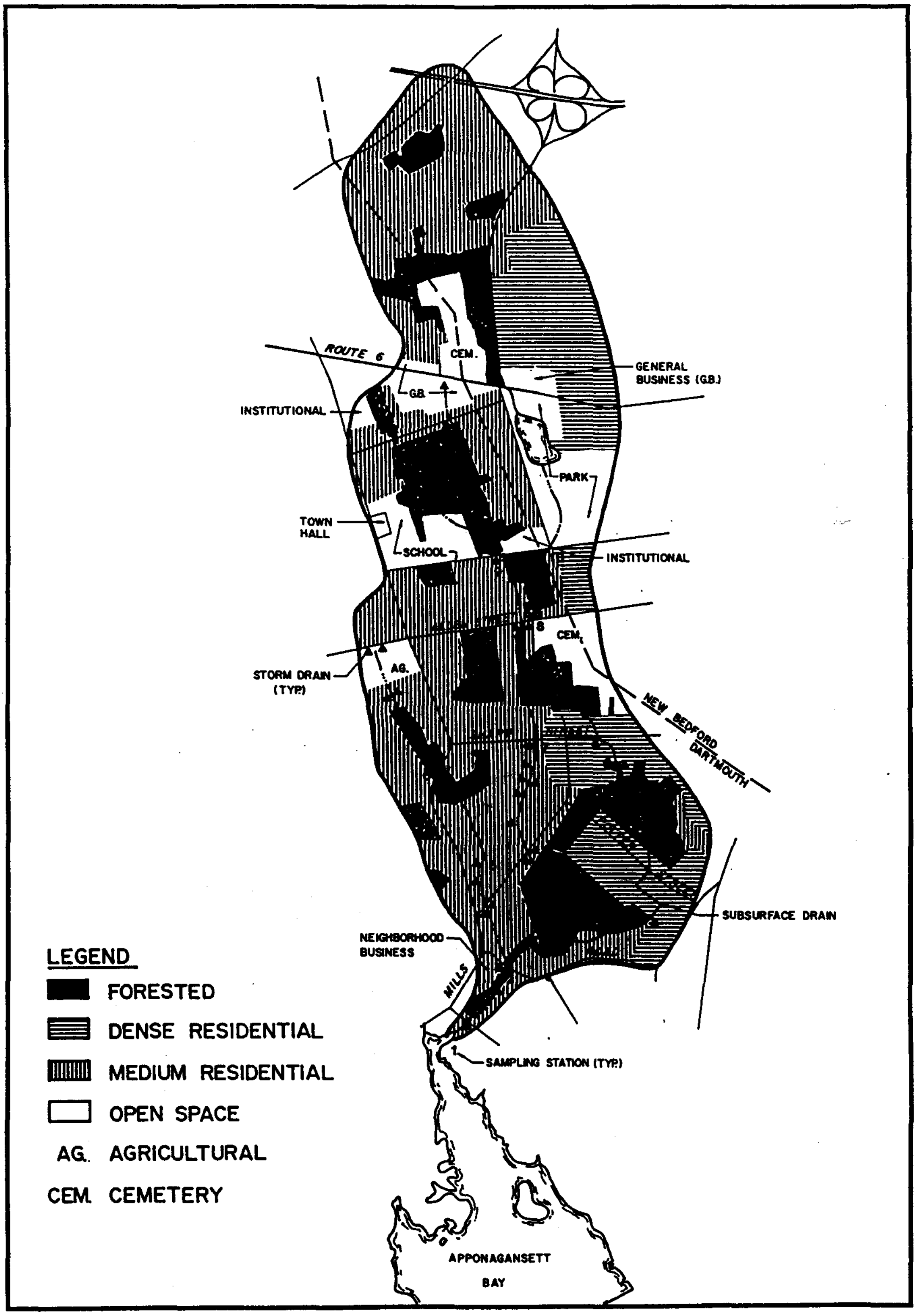
ATTACHMENT 4

WATERSHED LAND USE MAP



BUTTONWOOD BROOK WATERSHED LAND USE MAP

SANFORD ECOLOGICAL SERVICES, INC.
258 MAIN STREET
BOURNE, MASSACHUSETTS
MARCH, 1991
SCALE: 1" = 800'

APPENDIX A

BUTTONWOOD BROOK WATER QUALITY DATA

TABLE 1. BUTTONWOOD BROOK WATER QUALITY DATA (NON-EPISODIC)

SEASON DATE PARAMETER	STATION	LOCATION	WINTER 2-14-90	SPRING 5-9-90	SUMMER 7-30-90	AUTUMN 10-10-90
NITRATE NITROGEN (mg/L)	1	APPON.HRBR.	1.98	1.03	0.43	0.07
	2	RUSS.MILLS	2.49	1.45	1.91	2.1
	3	ARNOLD	1.93	1.34	1.8	2.16
	4	McCABE	2.09	1.14	1.83	0.94
	5	HOLLY	6.03	6.00	7.01	5.66
	6	SLOCUM	6.50	4.86	5.52	5.2
	7	SHARP	1.91	1.08	2.91	1.33
	8	ALLEN	1.09	0.79	1.57	1.27
	9	HAWTHORNE	1.35	0.93	1.4	0.99
	10	BOUNDARY	0.67	0.11	0.81	0.80
		MEAN	2.60	1.87	2.52	2.05
		SD	2.00	1.93	2.11	1.88
		HIGH	6.50	6.00	7.01	5.66
		LOW	0.67	0.11	0.43	0.07
AMMONIA NITROGEN (mg/L)	1	APPON.HRBR.	<0.05	0.07	0.38	0.11
	2	RUSS.MILLS	<0.05	<0.05	0.06	<0.05
	3	ARNOLD	<0.05	0.06	0.12	<0.05
	4	McCABE	<0.05	0.06	0.15	0.06
	5	HOLLY	<0.05	0.13	<0.05	<0.05
	6	SLOCUM	<0.05	<0.05	<0.05	<0.05
	7	SHARP	0.06	0.07	0.21	0.08
	8	ALLEN	<0.05	0.08	0.18	<0.05
	9	HAWTHORNE	<0.05	<0.05	0.14	<0.05
	10	BOUNDARY	0.07	0.14	0.45	<0.05
		MEAN	0.05	0.08	0.18	0.06
		SD	0.01	0.03	0.14	0.02
		HIGH	0.07	0.14	0.45	0.11
		LOW	<0.05	<0.05	<0.05	<0.05
TOTAL KJELDAHL NITROGEN (mg/L)	1	APPON.HRBR.	0.06	0.21	1.17	0.46
	2	RUSS.MILLS	<0.05	0.17	0.61	0.81
	3	ARNOLD	<0.05	0.12	0.52	0.36
	4	McCABE	<0.05	0.17	0.43	0.36
	5	HOLLY	<0.05	0.31	0.3	0.46
	6	SLOCUM	<0.05	<0.05	0.13	0.51
	7	SHARP	0.06	0.15	0.35	0.36
	8	ALLEN	<0.05	0.19	0.43	0.41
	9	HAWTHORNE	<0.05	0.08	0.48	0.36
	10	BOUNDARY	0.07	0.20	0.48	0.41
		MEAN	0.05	0.17	0.49	0.45
		SD	0.01	0.07	0.27	0.14
		HIGH	0.07	0.31	1.17	0.81
		LOW	<0.05	<0.05	0.13	0.36

TABLE 1 (CONTINUED)

SEASON DATE PARAMETER	STATION	LOCATION	WINTER 2-14-90	SPRING 5-9-90	SUMMER 7-30-90	AUTUMN 10-10-90
ORTHO-	1	APPON.HRBR.	<0.05	<0.05	0.08	<0.05
PHOSPHATE	2	RUSS.MILLS	<0.05	<0.05	<0.05	0.06
(mg/L)	3	ARNOLD	<0.05	<0.05	<0.05	<0.05
	4	McCABE	<0.05	<0.05	<0.05	0.06
	5	HOLLY	<0.05	<0.05	<0.05	<0.05
	6	SLOCUM	0.06	<0.05	<0.05	<0.05
	7	SHARP	<0.05	<0.05	<0.05	<0.05
	8	ALLEN	<0.05	<0.05	<0.05	<0.05
	9	HAWTHORNE	<0.05	<0.05	<0.05	<0.05
	10	BOUNDARY	<0.05	<0.05	0.08	0.05
		MEAN	0.05	0.05	0.06	0.05
		SD	0.00	0.00	0.01	0.00
		HIGH	0.06	<0.05	0.08	0.06
		LOW	<0.05	<0.05	<0.05	<0.05
TOTAL	1	APPON.HRBR.	7.0	24	142	4
SUSPENDED	2	RUSS.MILLS	<4.0	<4.0	<4.0	36
SOLIDS	3	ARNOLD	<4.0	<4.0	4	<4.0
(mg/L)	4	McCABE	<4.0	<4.0	14	6
	5	HOLLY	<4.0	4.0	18	<4.0
	6	SLOCUM	<4.0	<4.0	12	14
	7	SHARP	<4.0	<4.0	14	<4.0
	8	ALLEN	<4.0	<4.0	14	4
	9	HAWTHORNE	5.0	<4.0	12	<4.0
	10	BOUNDARY	5.0	8.0	16	4
		MEAN	4.5	6.4	25	8.4
		SD	1.0	6.3	41	10.2
		HIGH	7.0	24	142	36
		LOW	<4.0	<4.0	<4.0	<4.0
FECAL	1	APPON.HRBR.	63	>64	920	>246
COLIFORM	2	RUSS.MILLS	63	30	350	>246
(MPN/100mL)	3	ARNOLD	46	41	920	71
	4	McCABE	23	>64	920	246
	5	HOLLY	5	64	350	>246
	6	SLOCUM	4	14	110	143
	7	SHARP	17	>64	>2400	>246
	8	ALLEN	<2	64	1600	>246
	9	HAWTHORNE	<2	>64	240	90
	10	BOUNDARY	17	>64	920	>246
		HIGH	63	>64	>2400	>246
		LOW	<2	14	110	71

TABLE 2. BUTTONWOOD BROOK WATER QUALITY DATA (EPISODIC)

SEASON DATE PARAMETER	STATION	LOCATION	WINTER 3-18-90	SPRING 5-29-90	SUMMER 9-22-90	AUTUMN 11-10-90
NITRATE NITROGEN (mg/L)	1	APPON.HRBR.	2.00	1.45	2.03	1.71
	2	RUSS.MILLS	1.49	2.25	2.12	1.69
	3	ARNOLD	1.92	2.12	2.48	1.21
	4	McCABE	1.64	1.86	1.79	0.85
	5	HOLLY	4.59	2.62	2.96	5.3
	6	SLOCUM	6.1	3.95	4.84	3.5
	7	SHARP	1.94	1.67	2.48	1.58
	8	ALLEN	4.73	0.98	2.77	1.32
	9	HAWTHORNE	1.22	1.00	0.61	0.52
	10	BOUNDARY	0.63	0.35	1.29	0.34
		MEAN	2.63	1.83	2.34	1.80
		SD	1.82	1.01	1.13	1.51
		HIGH	6.1	3.95	4.84	5.3
		LOW	0.63	0.35	0.61	0.34
AMMONIA NITROGEN (mg/L)	1	APPON.HRBR.	0.08	0.11	<0.05	<0.05
	2	RUSS.MILLS	0.10	0.08	<0.05	0.06
	3	ARNOLD	0.15	0.21	<0.05	0.14
	4	McCABE	0.12	0.25	<0.05	0.11
	5	HOLLY	0.12	0.10	<0.05	0.06
	6	SLOCUM	<0.05	0.22	<0.05	0.13
	7	SHARP	0.13	0.16	<0.05	0.10
	8	ALLEN	0.17	0.07	0.18	0.19
	9	HAWTHORNE	0.08	<0.05	<0.05	0.12
	10	BOUNDARY	0.15	0.19	<0.05	0.20
		MEAN	0.12	0.14	0.06	0.12
		SD	0.04	0.07	0.04	0.05
		HIGH	0.17	0.25	0.18	0.19
		LOW	<0.05	<0.05	<0.05	<0.05
TOTAL KJENDAHL NITROGEN (mg/L)	1	APPON.HRBR.	0.13	0.11	0.24	0.17
	2	RUSS.MILLS	0.18	0.08	0.52	0.12
	3	ARNOLD	0.23	0.28	0.92	0.36
	4	McCABE	0.18	0.25	1.00	0.17
	5	HOLLY	0.76	0.10	0.82	0.15
	6	SLOCUM	0.29	0.22	0.34	0.34
	7	SHARP	0.22	0.16	0.24	1.83
	8	ALLEN	0.25	0.07	0.34	0.19
	9	HAWTHORNE	0.12	0.07	0.34	0.12
	10	BOUNDARY	0.19	0.19	0.14	0.29
		MEAN	0.26	0.15	0.49	0.37
		SD	0.18	0.08	0.31	0.52
		HIGH	0.76	0.28	1.00	1.83
		LOW	0.12	0.07	0.14	0.12

TABLE 2 (CONTINUED)

SEASON DATE PARAMETER	STATION	LOCATION	WINTER 3-18-90	SPRING 5-29-90	SUMMER 9-22-90	AUTUMN 11-10-90
ORTHO-	1	APPON.HRBR.	<0.05	<0.05	<0.05	<0.05
PHOSPHATE	2	RUSS.MILLS	<0.05	<0.05	<0.05	<0.05
(mg/L)	3	ARNOLD	<0.05	<0.05	<0.05	<0.05
	4	McCABE	<0.05	<0.05	<0.05	<0.05
	5	HOLLY	<0.05	<0.05	<0.05	<0.05
	6	SLOCUM	<0.05	<0.05	<0.05	0.16
	7	SHARP	<0.05	<0.05	<0.05	<0.05
	8	ALLEN	<0.05	<0.05	0.38	0.09
	9	HAWTHORNE	<0.05	<0.05	<0.05	<0.05
	10	BOUNDARY	<0.05	0.05	<0.05	<0.05
		MEAN	0.05	0.05	0.08	0.06
		SD	0.00	0.00	0.10	0.04
		HIGH	<0.05	0.05	0.38	0.16
		LOW	<0.05	<0.05	<0.05	<0.05
TOTAL	1	APPON.HRBR.	22	26	<4.0	4.0
SUSPENDED	2	RUSS.MILLS	13	44	<4.0	<4.0
SOLIDS	3	ARNOLD	12	14	<4.0	<4.0
(mg/L)	4	McCABE	13	22	<4.0	6.0
	5	HOLLY	5.0	15	4.0	<4.0
	6	SLOCUM	8.0	22	<4.0	<4.0
	7	SHARP	8.0	30	<4.0	<4.0
	8	ALLEN	<4.0	28	<4.0	<4.0
	9	HAWTHORNE	5.0	24	<4.0	<4.0
	10	BOUNDARY	<4.0	20	<4.0	<4.0
		MEAN	9.4	24.5	4.0	4.2
		SD	5.7	8.6	0.0	0.6
		HIGH	22	44	4.0	6.0
		LOW	<4.0	14	<4.0	<4.0
FECAL	1	APPON.HRBR.	23	920	*	<1**
COLIFORM	2	RUSS.MILLS	14	>2400		6200
(MPN/100mL)	3	ARNOLD	130	1600		<1
	4	McCABE	170	>2400		<1
	5	HOLLY	49	>2400		<1
	6	SLOCUM	14	>2400		<1
	7	SHARP	30	>2400		<1
	8	ALLEN	14	1600		<1
	9	HAWTHORNE	41	920		<1
	10	BOUNDARY	350	240		<1
		HIGH	350	>2400		6200
		LOW	14	240		<1

* Samples for this date were not analysed within recommended holding period.
** Counts for this date in cfu/100ml as determined by membrane filtration method.

TABLE 3. BUTTONWOOD BROOK WATER QUALITY DATA (EPISODIC, 9-22-90)

STATION	LOCATION	CADMIUM	COPPER	LEAD	ZINC
1	APPON.HRBR.	<0.010	0.004	<0.070	0.051
2	RUSS.MILLS	<0.010	<0.004	<0.070	0.074
3	ARNOLD	<0.010	<0.004	<0.070	0.079
4	McCABE	<0.010	0.009	<0.070	0.101
5	HOLLY	<0.010	<0.004	<0.070	0.050
6	SLOCUM	<0.010	0.011	<0.070	0.113
7	SHARP	<0.010	0.026	<0.070	0.085
8	ALLEN	<0.010	0.029	<0.070	0.131
9	HAWTHORNE	<0.010	0.019	<0.070	0.111
10	BOUNDARY	<0.010	0.008	<0.070	0.059
	MEAN	0.010	0.012	0.070	0.085
	SD	0.000	0.010	0.000	0.028
	HIGH	<0.010	0.029	<0.070	0.131
	LOW	<0.010	<0.004	<0.070	0.050

Note: Total metal concentrations in mg/L

APPENDIX B

SHELLFISH SAMPLING DATA, 10 NOVEMBER 1990
APPONGANSETT HARBOR, DARTMOUTH, MASSACHUSETTS

Transect 1

Station	Shell Length of Individual Quahogs in Inches
1	-
2	-
3	-
4	-
5	-
6	-
7	3.7 3.0 3.2 3.2
8	3.6 2.9 2.7
9	3.3 3.0 3.3 4.6 2.2
10	3.8 3.2 3.3 3.1 3.0 3.8 3.3
11	3.6 3.4 3.1 3.5 3.5 3.8 2.9
12	3.4 3.0 3.2 3.8 3.6 3.4 2.5 2.9 2.9 3.9
13	2.5 3.7 3.4 3.7 3.4 2.9 3.1
14	3.3 2.8
15	3.2 3.4
16	2.7 4.1 3.6 3.0 2.8 2.6 3.0 2.8 2.1 2.2 3.2
17	2.7 3.2 3.2 2.6 2.7 3.9 3.2
18	-
19	-
20	-

Transect 2

Station	Shell Length of Individual Quahogs in Inches
1	-
2	3.5 2.6 2.8 2.5 2.4 3.9 2.9 3.0
3	2.7 2.9 3.4 3.6 2.8 2.2 3.7 3.5 3.2
4	2.1 3.4 2.9 3.4 3.8 2.1
5	4.0 2.8 3.5 2.8 2.8
6	2.6 2.6 2.4 3.3 2.6
7	3.4 3.9 2.1 2.9 3.4
8	4.1 3.4 3.2 2.5 2.3
9	4.2 4.0 3.3 3.3 3.7 3.7 3.4 3.4
10	3.4 3.4 2.9 3.6 2.6 1.9 2.6 3.0 3.3 3.4 3.3 2.6
11	3.2 3.3 2.1 3.8 3.2 3.4 3.1 3.7 3.2 3.3
12	3.7 3.3 4.0 3.5 3.5 3.2 2.6
13	3.1 3.7 3.3 3.0 2.7
14	3.7 2.7 3.2 2.4 3.1 2.9 3.3
15	3.6 2.8 3.0 2.4 3.2 3.0
16	3.8 2.8 2.2 3.1 2.4 2.6
17	2.7 3.1 3.1 3.6 3.1
18	3.3 2.9 2.7 2.4 2.9
19	3.3 2.2 2.9 3.3 2.6
20	-

Transect 3

Station	Shell Length of Individual Quahogs in Inches
1	2.2 2.1
2	2.6 2.8
3	2.1 2.1 2.3
4	2.3 2.6
5	2.4 1.8 3.3
6	2.4 2.4
7	3.3
8	2.4
9	2.2 2.1
10	2.3
11	2.4
12	3.2 2.2
13	2.1 1.9
14	2.8 2.7 2.3 2.4
15	2.3 2.7 2.2
16	3.3 2.9
17	2.9 2.8 2.5
18	3.1 2.6 3.1 3.6 2.7
19	2.8 3.0 2.5 2.9
20	3.0 2.9 3.1 3.0 2.5 2.7 2.0 2.3 1.9 2.5 3.2 2.6

Transect 4

Station	Shell Length of Individual Quahogs in Inches
1	3.6 2.8 3.2 3.9 2.7 2.7 2.3 2.3 2.5
2	3.3 3.3 2.1
3	-
4	2.8 3.4 2.5 3.0 2.1
5	2.7
6	2.2 3.7
7	2.9 3.1 1.6 2.6
8	3.2 3.4 2.9 2.5 2.5 2.5 2.5 2.9 2.5 2.5 3.4 2.5 3.5 2.8 2.7 2.2 2.2 2.2 1.9
9	3.1 2.0 2.5 3.4 2.6 2.4 2.3 3.3 2.5 1.8 1.9
10	3.2 3.1 3.4 2.6 2.7 2.5 2.5 2.2 2.1 2.1 2.1 2.0 1.9
11	4.2 4.0 2.7 2.2 2.3 2.2 1.9 2.2 1.7 2.0
12	3.7 2.8 2.6 1.9 1.8 2.2
13	3.0 2.6 2.1 2.9 1.7
14	2.0 2.3 2.1 2.0
15	2.5 2.6
16	1.9 2.4 2.1 2.3 2.2
17	2.4 1.9 2.5 2.9 2.5 2.3 2.9 2.2
18	2.7 2.6 2.4 2.6 2.3 2.3 1.9
19	3.0 2.6 2.1
20	4.0 2.8 2.6 2.5
21	4.0 3.5 3.5 2.9 3.4 2.8 2.1
22	3.1 2.9 2.3
23	3.6 2.9 2.5 2.2 2.5
24	2.9 2.5
25	2.6 3.0 3.0 2.1
26	2.9 2.5 3.3 2.7 2.2
27	2.9 2.8 3.0 2.5 2.5 2.6 2.1 2.1

APPENDIX C

EMPIRICAL MARKET VALUE OF SHELLFISH RESOURCES
APPONGANSETT BAY, DARTMOUTH, MASSACHUSETTS

Market Designation	Estimated Number in Resource Area	Number of Quahogs per Pound *	Price per Pound *	Estimated Market Value
littleneck	212,772	6	$0.925	$ 32,802
cherrystone	137,676	3.5	$0.25	$ 9,834
chowder	1,230,740	1	$0.10	$123,074
			TOTAL	$165,710

* pers. comm., Mr. Michael Hickey, Division of Marine Fisheries, 14 March 1991