CRC

RECOMMENDED MEASURES TO MAINTAIN AND PROTECT THE QUALITIES OF CHARLESTOWN'S SALT POND REGION

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RECOMMENDED MEASURES TO MAINTAIN AND PROTECT THE QUALITIES OF CHARLESTOWN'S SALT POND REGION

Prepared For

The Charlestown Planning Board

by

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I. INTRODUCTION AND SUMMARY RECOMMENDATIONS

This paper has been prepared at the request of Matthew Puchalski, Chairman of the Planning Board for the Town of Charlestown. It summarizes results produced by the URI Salt Pond project that help to understand the present and probable future conditions of Ninigret and Green Hill Ponds and their watersheds and outlines steps that could be taken by town government to solve a number of existing and potential problems. The four-year URI Salt Pond project was designed to investigate problems that are of great concern to local residents including declining water quality in the ponds, contamination of drinking water supplies, filling in of the pond with sand carried in through the breachway, overfishing and a steady decline in the famed beauty of these areas. A major purpose of the project is to develop findings and recommendations that can be put to practical use in addressing, and in some cases solving, these problems. Since the principal pathway of freshwater drainage to the salt ponds is through groundwater, the natural inland boundaries of the salt pond ecosystems are defined by the groundwatersheds. For Ninigret and Green Hill Ponds, these areas lie almost entirely within the town of Charlestown and are referred to in this paper as the salt pond region (see Figure 1).

We have concluded that Charlestown's salt pond region is on the verge of radical changes that we believe will not be welcomed by its residents. Unless major steps are taken now we foresee the following taking place:

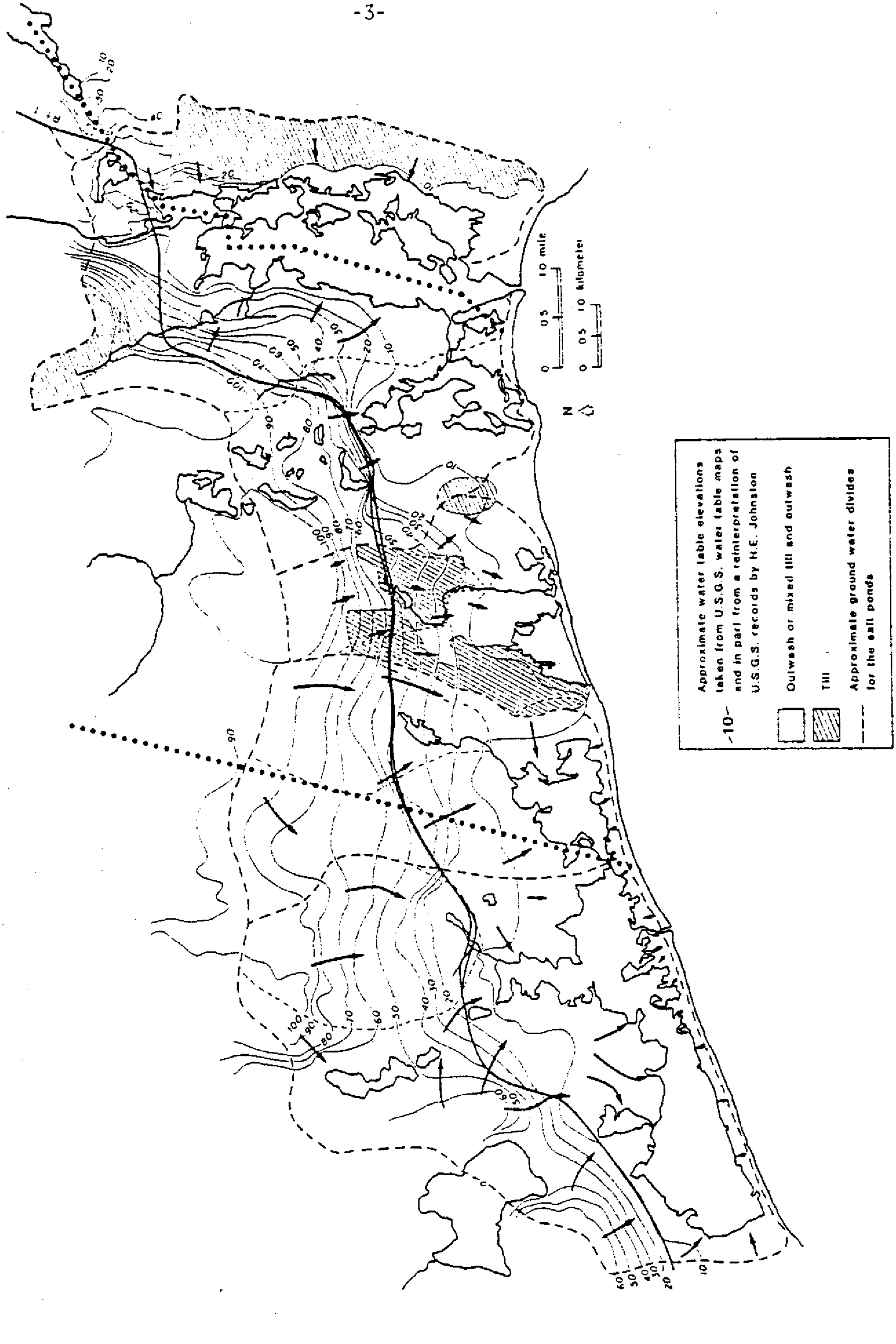
- the loss of the major reasons that residents give for living in Charlestown. According to two recent public opinion surveys these are the sense of living in a rural community and low property taxes[1]
- the salt ponds, the town's major natural features and a principal drawing card for tourism and new residents, will become increasingly polluted as present problems related to crowding and losses in the beauty of the ponds get worse
- the land will no longer be capable of providing residents with clean drinking water and domestic waste disposal; a public water system is likely to become a necessity

These forecasts are based on the assumption that further development within the watershed will proceed according to present zoning. This provides for a four-fold increase in the number of houses in the salt pond region. Such dense development will overtax the capacity of the area to provide the amenities that are presently enjoyed by all. Several of our recommendations are identical to, or parallel, those contained in the 208 Water Quality Management Program for Rhode Island[2] The research conducted through the URI Salt Pond Project has produced additional, site-specific information to support these recommendations and demonstrates, more clearly than before, why they are needed.

Figure 1. Approximate Groundwater Basins in the South Shore Region.

Source: John Grace and William E. Kelly, URI Department of Civil and Environmental Engineering, 1982.

Areas delineated by dashed lines are the recharge areas for groundwater in the salt pond region. The arrows indicate the general direction of groundwater flow within each groundwater basin. Dotted lines represent town boundaries.


-10-
Approximate water table elevations taken from U.S.G.S. water table maps and in part from a reinterpretation of U.S.G.S. records by H.E. Johnston
Outwash or mixed till and outwash
Till
Approximate ground water divides for the salt ponds
0 0.5 1.0 mile
0 0.5 1.0 kilometer
N

There is no doubt that many of the specific recommendations in this document will be hotly debated and will need refinement. All debate and evaluation, however, should be brought back to the objectives for the management of the salt pond region. We have based our selection of specific management initiatives on four principles.

1. To ensure that the resident population and physical alterations to the lands within the salt pond region do not overtax the area's ability to produce sufficient supplies of drinking water, assimilate wastes and maintain good water quality in the salt ponds.
2. To enhance and preserve an aesthetically pleasing landscape, high real estate values and a diversity of activities that make the salt pond region a desirable place to live and visit.
3. To provide for densities and types of development that maintain a resident population of diverse economic standings and will not overburden the town with demands for municipal services.
4. To encourage businesses and activities that produce long-term benefits for the region by maintaining renewable resources.

Our recommendations are focused on the first two objectives and fall into three categories. These recommendations will demand forceful action that can only be taken if the citizens of Charlestown decide that they wish to control their future. Determining how the land is used is a town prerogative and responsibility that is exercised through zoning powers by utilizing the many land management techniques that are available to town government. We recommend that the town adopt the following goals and work actively to achieve them:

1. Reduce the allowable number of housing units in the salt pond region by approximately 50 percent south of Rte. 1 and by approximately 60 percent north of Rte. 1. This can be achieved by zoning for two acre lots (R80) in areas currently zoned for one acre (R40) south of Rte. 1 and for five acre lots in what are at present largely undeveloped areas north of Rte. 1 that overlie the recharge area for groundwater that serves heavily developed residential areas around the salt ponds.
2. Conserve the rural character of the area by preserving remaining agricultural land and adopting a mandatory cluster ordinance for new subdivisions. The heritage of the south shore would be fostered by creating a historic district in the Cross Mills-King Tom Farm-Fort Ninigret area.
3. Several steps should be taken to minimize further contamination of groundwater drinking supplies and visual and water quality degradation in the salt ponds. Ordinances should be adopted that will maximize the efficiency of onsite sewage disposal systems, control runoff and provide visual buffers in developed areas.

Charlestown should coordinate its efforts to protect the quality and character of the salt pond region with those of neighboring towns and state agencies. The Coastal Resources Management Council is preparing a Special Area Management Plan for the salt ponds that will address use conflicts in the ponds, water pollution, public access, modifications to the shoreline and dredging. The Council is working with the Department of Environmental Management to address the rapid filling of Charlestown Pond with sand that flows in through the breachway. We urge the town to work with these agencies to forge a well-integrated, mutually supportive management initiative.

Part II of this paper summarizes our analysis of the Charlestown salt pond region and Part III sets forth the recommendations in greater detail. The appendices provide additional background information.

II. CHARACTERISTICS OF THE SALT POND REGION

Today Charlestown is the most rural of the south shore towns. Most of its 41 square miles are covered by hardwood forests which grew up in old fields and pastures left idle as a farming community turned to industry at the end of the last century. The past three decades have seen rapid residential growth as commuters and retirees settle in Charlestown to enjoy a rural setting, low property taxes and easy access to a beautiful ocean shore. The most rapidly developing area is the narrow plain that lies between the moraine and the salt ponds. This area has been the major focus of our study. However, since groundwater is the source of drinking water for all inhabitants and is the major source of the freshwater and nutrients that determine what species and abundance of plants and animals are present in the salt ponds, the groundwatersheds shown in Figure 1 provide the natural inland boundaries for a salt pond region management area. Charlestown's salt pond region is separated by Rte. 1 into two distinct districts (Figure 2).

Trends in Land Use

Only 12 percent of the land north of Rte. 1 was developed as of 1981. Three quarters of this area is presently zoned for 1 acre lots and a large proportion of the 22 percent zoned for 2 acres is within conservation areas (Figure 3). We estimate, that under current zoning, and removing state owned conservation areas and wetlands, the potential for further development is a tenfold increase, from just over 300 houses to over 3000.

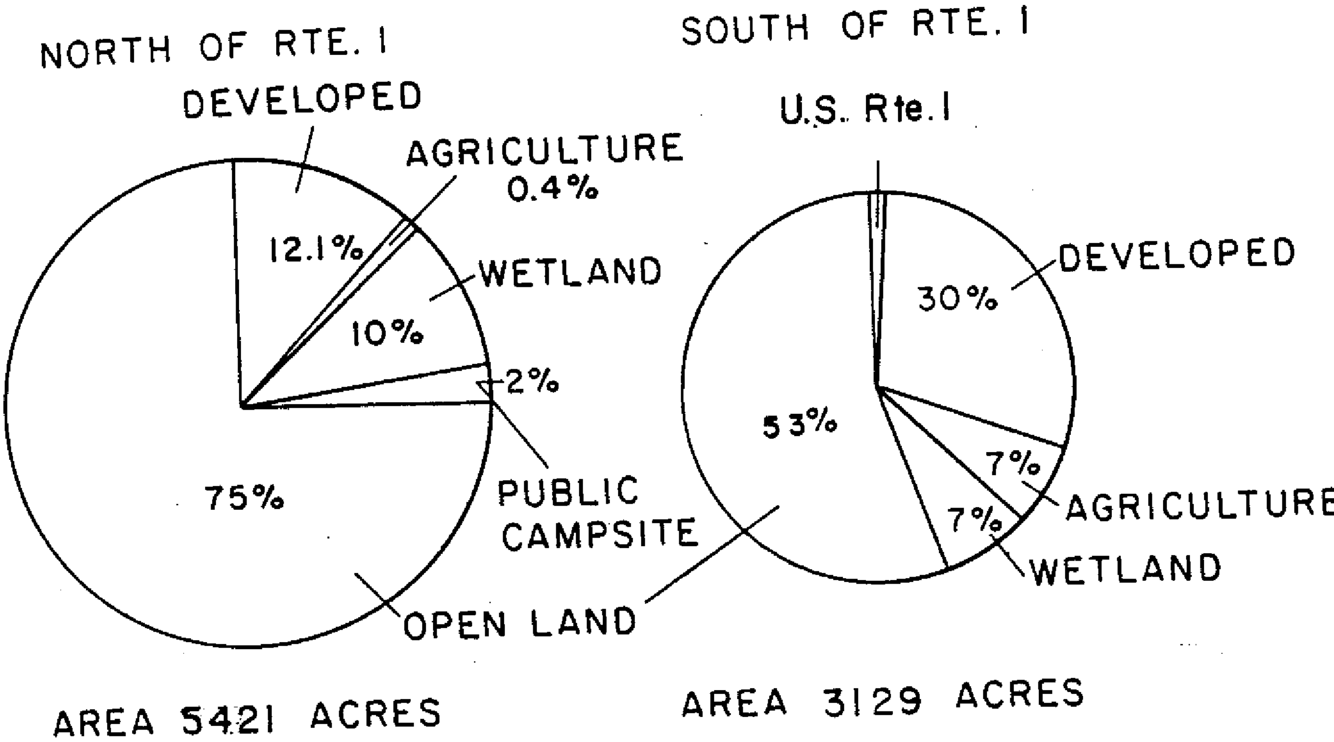
South of Rte. 1, 30 percent of the land is developed, but if we take out the 600 acre Air Base property and the state owned barrier beach, then approximately half of the land available for residential development has already been committed to this use. In several areas houses are on 1/8 to 1/2 acre lots. We estimate that current zoning will permit the total number of houses in this area to double from some 1200 to 2400. Such estimates for the potential number of houses are a "worst case" since every potential lot is provided for by zoning will not be developed. In urban areas such as Central Falls, Cranston, and Providence, developed areas are about 80 percent of the calculated zoning capacity. How quickly could full development be achieved in Charlestown? Figure 4 shows the increase in houses south of Rte. 1 between 1940 and 1980. If we project that rate of development, then saturation will be achieved within the next 20 years. If the slower national economy seen in this decade continues, the rate of growth will be slower. This should not inspire complacency! The trends are clear and Charlestown residents do not have to look far to see towns that were rural a few decades ago and are fully suburbanized today.

Figure 2. Land Use In Charlestown's Salt Pond Region, 1981.

Land use categories in the salt pond region were mapped on airphotos taken in April 1981 at a scale of 1:12,000. Land use categories are defined as follows:

- Open Land: forested and open lands not in active agricultural use, rural roads and miscellaneous uses not described below.
- Agriculture: fields in active production according to a U.S. Soil Conservation Service survey verified on-site in 1980.
- Wetlands: U.S. Department of Interior, National Wetlands Inventory 1980.
- Developed Lands: houses, lawns and sideyards, access roads, parking facilities, and undeveloped lots of less than 3 acres within otherwise developed areas; scattered dwellings in open areas were assigned 1 acre of developed land. No distinction was made between residential and commercial development.
- Public Campsites: established recreational campsites and facilities; state held conservation lands were classified as open lands.
- Highway: U.S. Rte. 1 including median and shoulder strip.

The size of the pies represent relative areas of land North and South of Rte. 1 in the Ninigret Pond watershed.


NORTH OF RTE. 1
DEVELOPED
12.1%
AGRICULTURE
0.4%
WETLAND
10%
2%
PUBLIC
CAMPSITE
75%
OPEN LAND
AREA 5421 ACRES
SOUTH OF RTE. 1
U.S. Rte. 1
DEVELOPED
30%
53%
7%
AGRICULTURE
7%
WETLAND
AREA 3129 ACRES

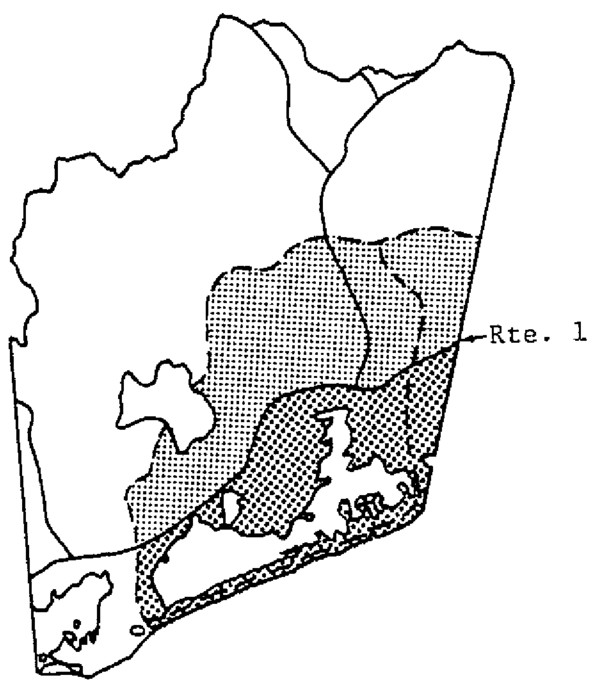

Rte. 1

Figure 3. Zoning in Charlestown's Salt Pond Region

Source: Charlestown zoning map and CRC air photo analysis.

Pies represent how the land in the Ninigret Pond watershed is zoned north and south of Rte. 1.

Bar graphs represent the amount of this land that has already been developed in each zoning category.

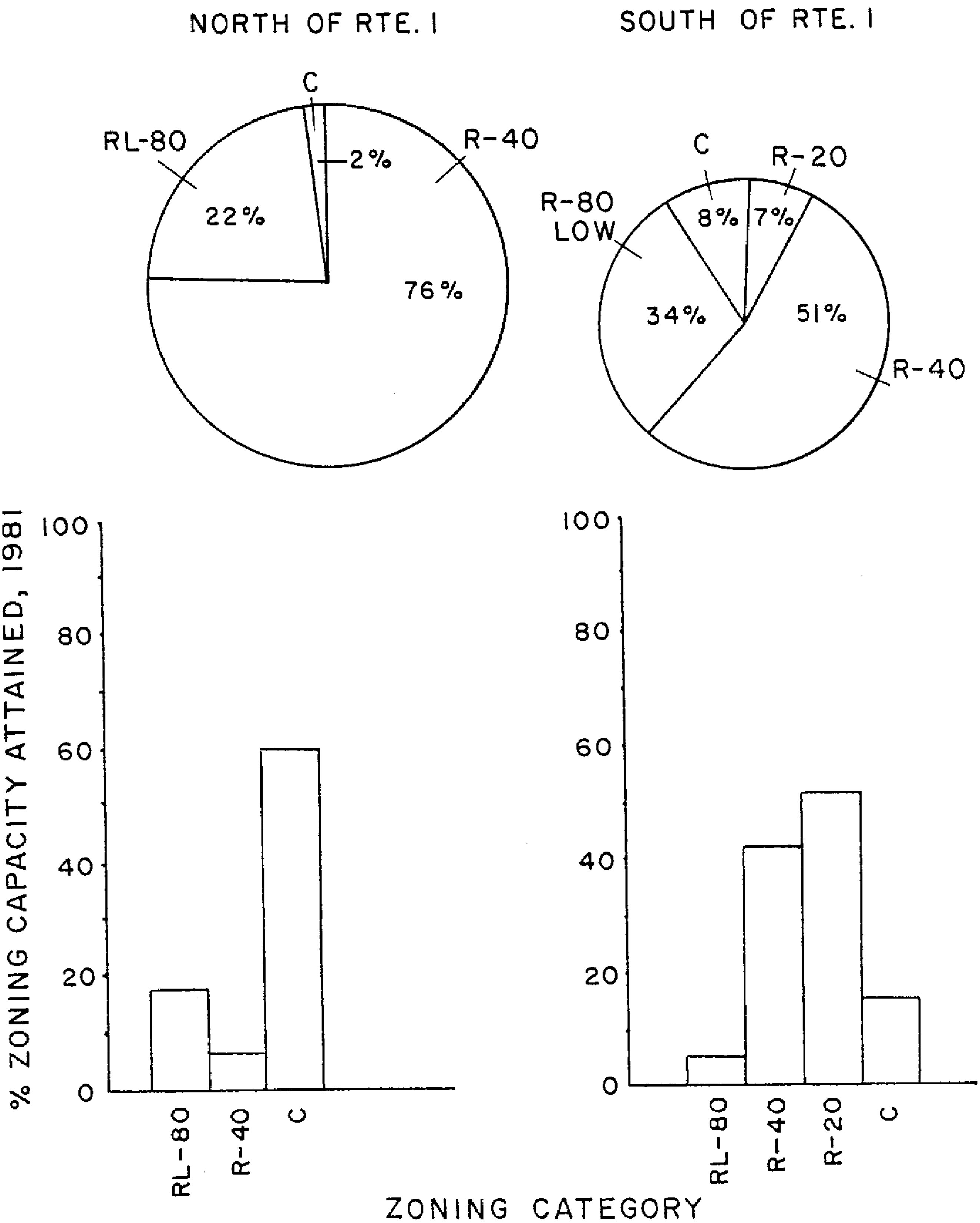

NORTH OF RTE. 1
SOUTH OF RTE. 1
C
RL-80
2%
R-40
22%
76%
C
R-20
R-80
LOW
8%
7%
34%
51%
R-40
% ZONING CAPACITY ATTAINED, 1981
100
80
60
40
20
0
RL-80
R-40
C
100
80
60
40
20
0
RL-80
R-40
R-20
C
ZONING CATEGORY

Figure 4. Numbers of Houses In the Salt Pond Region South of Rte. 1.

Source: Charlestown Tax Assessor's Files and CRC air photo analysis

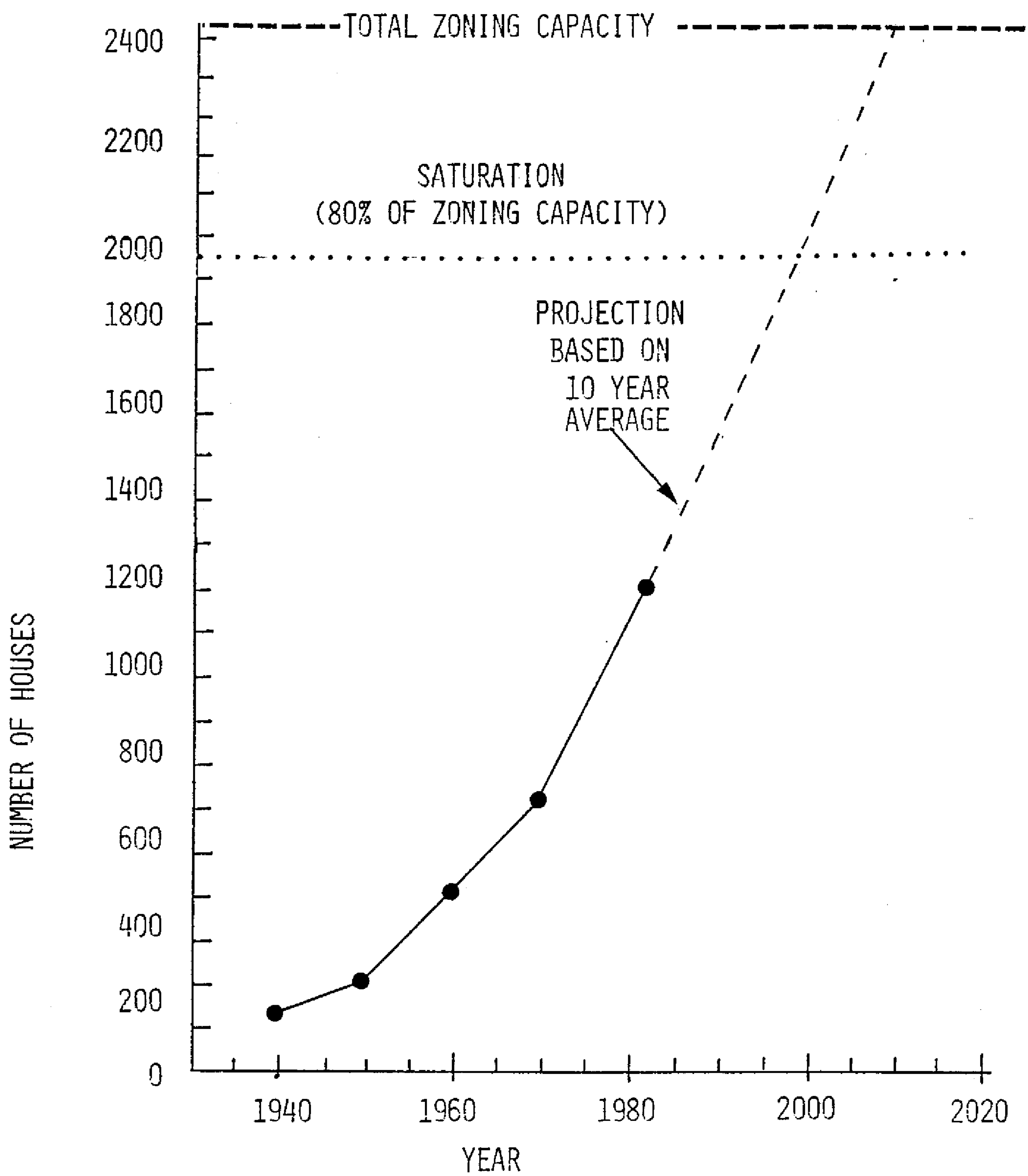

TOTAL ZONING CAPACITY
SATURATION
(80% OF ZONING CAPACITY)
PROJECTION
BASED ON
10 YEAR
AVERAGE
NUMBER OF HOUSES
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1940
1960
1980
2000
2020
YEAR

TABLE 1.
NUMBER OF HOUSES IN THE CHARLESTOWN SALT POND REGION IN 1981 AND PROJECTED AT SATURATION DEVELOPMENT IN ACCORDANCE WITH PRESENT ZONING.

	1981	Zoning Capacity
North of Rte 1	328	3158
South of Rte 1	1215	2411
Total	1543	6269

Development potentials were calculated by two methods:

North of Route 1 the potential number of houses in non-wetland areas was calculated by measuring the size of areas within current zoning categories assuming that minimum lot sizes will be adjusted upward to compensate for roads and rights-of-way according to the following table taken from the Town of South Kingstown Subdivision Ordinance:

Zoning category	minimum lot size	road correction
R-80	1.84	.95
R-40	.92	.90
R-30	.69	.90
R-20	.46	.80
R-15	.34	.80

South of Route 1 the development potential was determined on a lot-by-lot basis due to the more complex land ownership patterns and the large number of recorded lots that do not meet minimum lot sizes. For each lot, information on size, location, owner, state of development, and age of buildings were gathered from tax assessment files as of December 31, 1980. Lots large enough to be subdivided were divided by the minimum applicable zoning lot size in the manner described above for the area north of Route 1. In densely platted areas it was assumed that separate undeveloped lots are legally developable. Adjoining substandard lots under single ownership were combined to conform as much as possible to the minimum zoned lot size. Government held conservation lands were excluded from this analysis since residential or commercial uses of these areas are not considered likely.

House counts north of Route 1 are based on airphotos (scale 1:12,000) taken April 11, 1981. House counts south of Route 1 are based on Tax Assessor's files as of December 31, 1980.

Population Growth and Property Taxes

Charlestown's 4800 residents today enjoy the lowest property taxes of any community along the south shore (Figure 5) and one of the lowest in the state. If the town's residential population were not growing, residents might hope to see low taxes continue in the future. Unfortunately, more people require more services and the resident population is growing more rapidly in Charlestown than in neighboring south shore towns. If the growth rate of the past decade is projected into the future, the population in the salt pond region will have quadrupled by the year 2000. Charlestown obtains 80 percent of its tax revenues from residential property (Figure 6) and present trends do not suggest that this share will get any smaller. Unfortunately, moderately priced single family homes, which are the form of residential development encouraged by present zoning, commonly do not pay their way in town services. Community planners consider that a good rule of thumb is to assume that the average household costs the town some $2000 year year in services but that only half that amount is recovered in taxes from each household. The balance must be made up by businesses, large property owners and subsidies to the town from state and federal government. A much larger population will demand more and better services and these can only be supported by higher taxes. If the town is forced to build a public water system as well as new or bigger schools and provide other services, and if federal subsidies continue to be less generous than in the past, then Charlestown's tax rate will increase substantially.

Rising property taxes are only one undesirable consequence of a larger resident population. Dense development changes the character of the landscape. Few people would argue that all recent housing developments south of Rte. 1 have enhanced the beauty of that area. A larger resident population around the ponds will bring greater crowding on the water in the summer, a more urbanized shoreline, greater competition for already heavily pressed populations of fish and shellfish and increasing threats to both the purity of drinking water and water quality in the salt ponds. A major focus of the URI salt pond project has been to understand the linkages between water quality and a growing human population.

Freshwater Supply

Within the groundwatersheds rainwater seeps through porous soils to the water-table and flows slowly southward toward the ponds (Figure 1). South of the moraine some groundwater flows out at the surface to form small streams, but most of it continues underground and emerges through springs and seeps close to the landward shore of the salt ponds. The excellent data on groundwater flow along the south shore provide a level of detail that is superior to that for almost any other area of New England. The estimated nine million gallons of freshwater that enter Ninigret Pond each day provide residents in the groundwatershed with an abundant supply of freshwater.[3] At present, houses in the groundwatershed pump only 2 percent of the total supply and much of it is returned to groundwater through leaching fields. An adequate supply of freshwater does not appear to be a problem as residential development proceeds in the Ninigret Pond watershed, but unfortunately the quality of this water is already a concern.(see Appendix B, Table 1).

Figure 5. Equalized Property Tax Rates and Town Expenditures in South Shore Towns, 1980.

Source: R.I. Department of Community Affairs, Division of Tax Equalization.

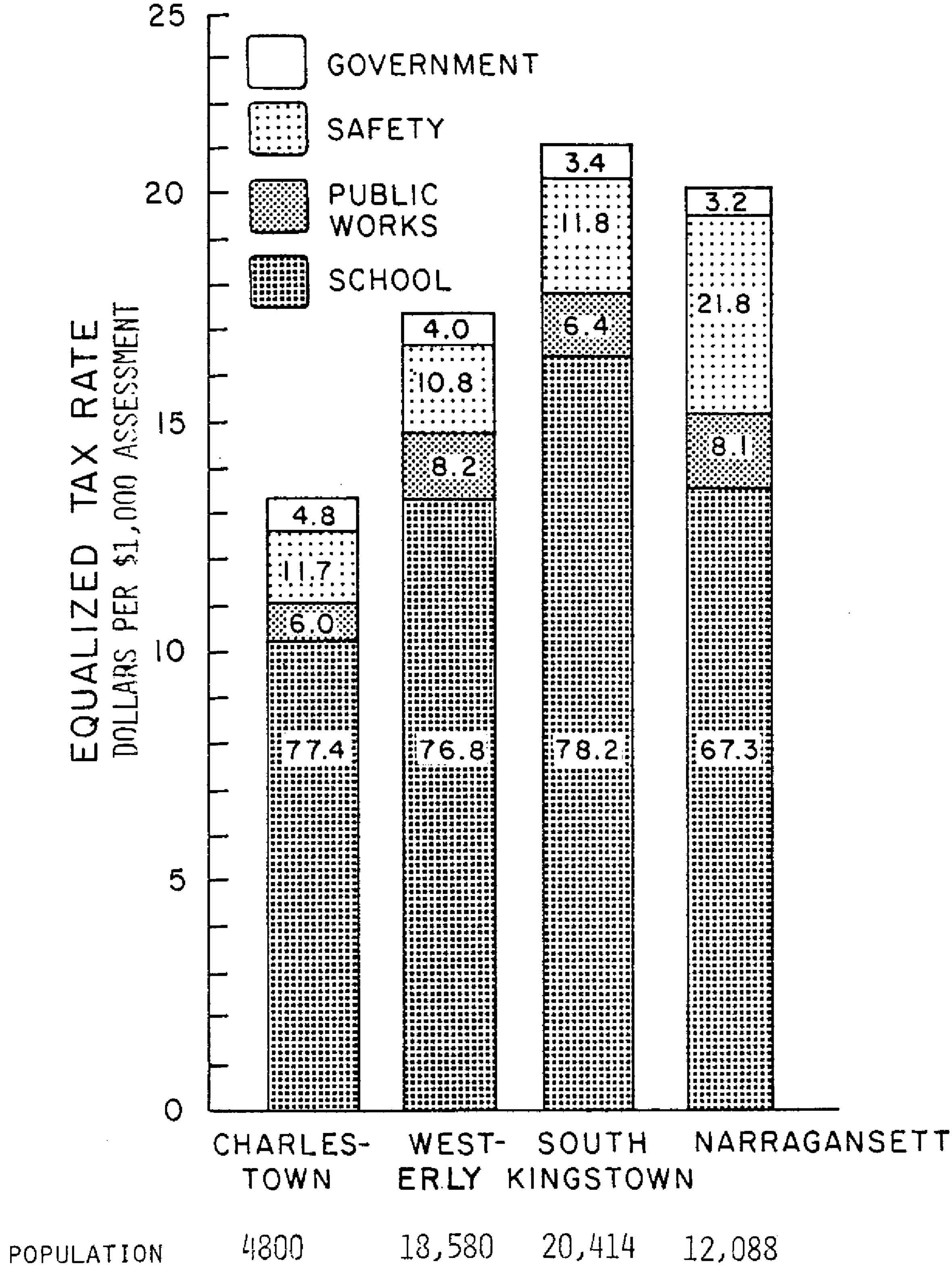

GOVERNMENT
SAFETY
PUBLIC WORKS
SCHOOL
EQUALIZED TAX RATE
DOLLARS PER $1,000 ASSESSMENT
25
20
15
10
5
0
4.8
11.7
6.0
77.4
4.0
10.8
8.2
76.8
3.4
11.8
6.4
78.2
3.2
21.8
8.1
67.3
CHARLES-TOWN
WEST-ERLY
SOUTH KINGSTOWN
NARRAGANSETT
POPULATION
4800
18,580
20,414
12,088

Figure 6. Sources of Tax Revenues in South Shore Towns in 1981.

Source: R.I. Department of Community Affairs, Division of Tax Equalization.

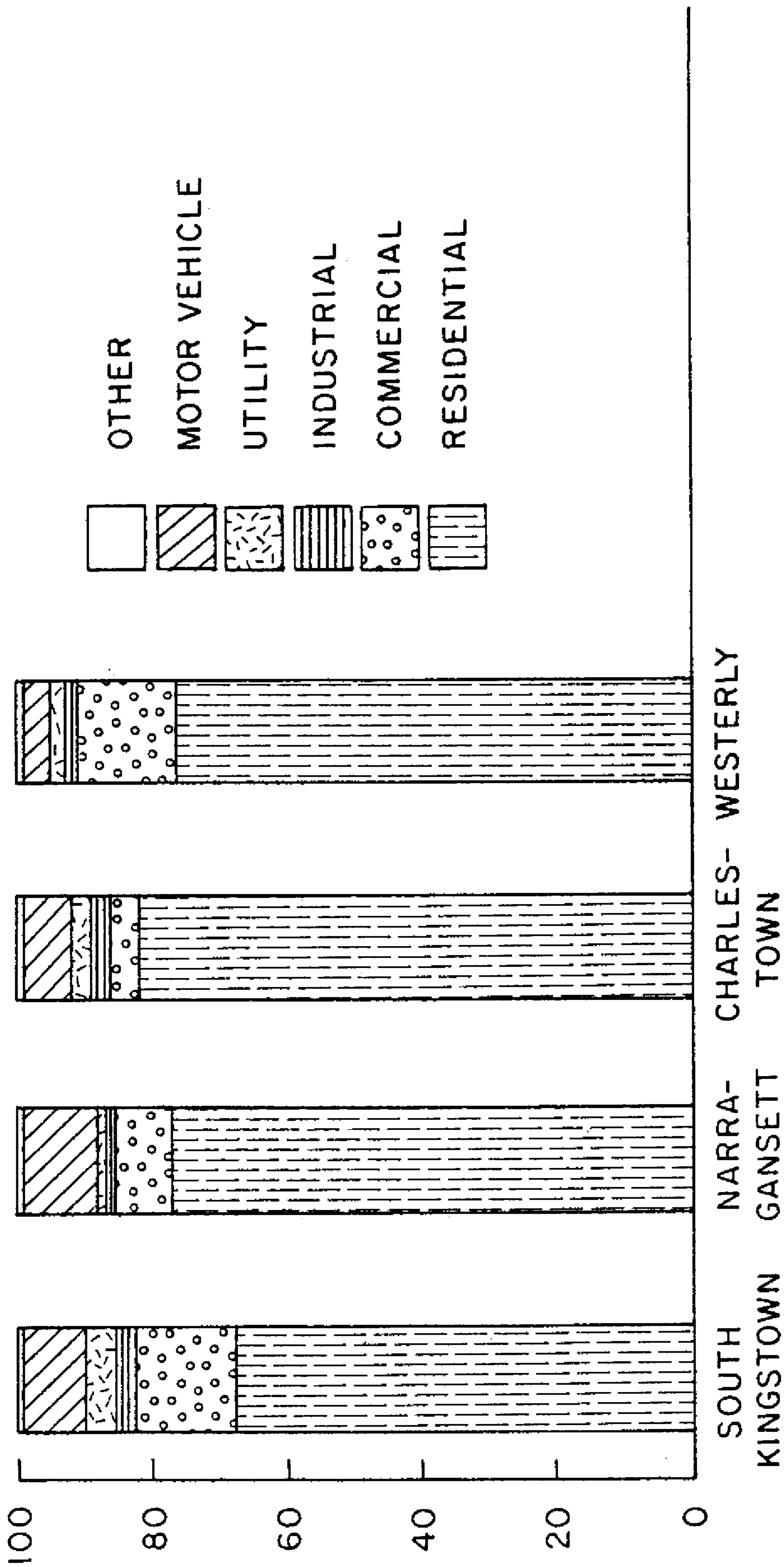
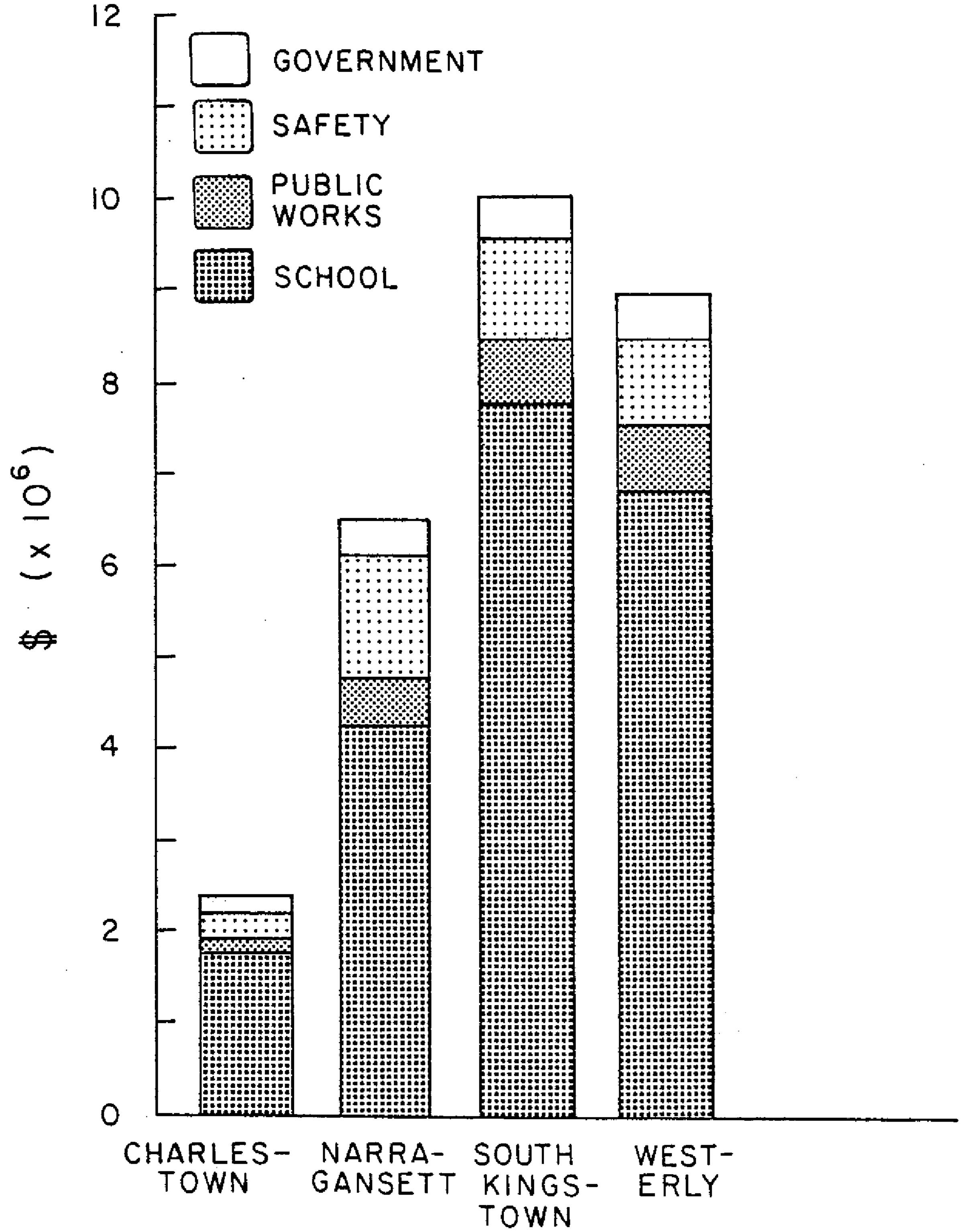

OTHER
MOTOR VEHICLE
UTILITY
INDUSTRIAL
COMMERCIAL
RESIDENTIAL
SOUTH KINGSTOWN
NARRA-GANSETT
CHARLES-TOWN
WESTERLY
100
80
60
40
20
0

Figure 7. Expenditures by South Shore Towns In Fiscal Year 1980.

Source: R.I. Department of Community Affairs


12
10
8
6
4
2
0
$ (x 10^6)
GOVERNMENT
SAFETY
PUBLIC WORKS
SCHOOL
CHARLES-TOWN
NARRA-GANSETT
SOUTH KINGS-TOWN
WEST-ERLY

Drinking Water Quality

The principal pollutant that threatens the quality of drinking water supplies and conditions in the salt ponds is nitrate. Appendix B gives estimates for the sources of nitrate to groundwater in the salt pond region. These estimates show that suburban development is the primary source of nitrate and that inputs from onsite sewage disposal and lawn fertilizer, which account for most of the nitrate loadings, will increase in importance as the population increases. Groundwater contamination from dense suburban development is causing severe problems for coastal communities on Long Island and in Connecticut, Delaware and North Carolina where soil conditions are similar to those of the Rhode Island south shore.[4] Extensive sampling for nitrate concentrations in the water drawn from 100 wells throughout the salt pond region (Figure 8) shows that the highest nitrate concentrations are found in the older densely developed areas.[5] The water in several wells contains nitrate concentrations close to, or above the federal health standard-10 milligrams per liter of nitrate nitrogen (mg/l NO_3^--N). The amount of nitrate that reaches groundwater from an average house depends on a number of factors that include the volume of sewage produced, the rate and type of microbial decomposition that takes place in the disposal system, depth to groundwater, the types of soils through which the leachate must flow and other factors. Despite all the variables, it is possible to extrapolate from present conditions and literature values to predict how much nitrate concentrations in the groundwater will increase as the human population increases. Such calculations for the Charlestown salt pond region suggest that the volume of groundwater is sufficiently large to keep nitrate concentrations diluted below the 10 mg/l NO_3^-N limit if there is no more than the one house for every two acres. In several areas south of Rte. 1 housing is already four to six times more dense than this and further development appears to be inevitable. It is therefore essential to keep nitrate levels as low as possible in groundwater before it reaches these areas; this suggests that one house for every 5 acres north of Rte. 1 is a sensible goal.

Impacts of Nitrate Enriched Groundwater on the Salt Ponds

High nitrate concentrations in the groundwater are likely to have adverse impacts on water quality in the salt ponds. Nitrate is a limiting nutrient, a primary determinant of the amount of plant growth in the ponds, and as it becomes available in greater amounts plant growth is stimulated. More vegetation, particularly in the form of floating mats and stringy green algae, is in itself undesirable, and the problem becomes more serious when the bacteria that break down decaying plant matter consume the available oxygen in the water. Thus, overfertilized (eutrophic) waters are characterized by high concentrations of nutrients, low oxygen, turbidity, and if sufficiently severe are toxic to fish or shellfish. In the summer, poorly flushed areas such as Foster's Cove periodically show the symptoms of severe eutrophication and turbid waters thick with algae predominate in large areas of both ponds. Field experiments in Ninigret Pond have demonstrated that additions to salt pond waters of very low levels of nitrate do indeed cause dramatic blooms of nuisance algae.[6] Many long time observers of Charlestown and Green Hill Ponds are convinced that the signs of eutrophication are becoming steadily more evident. Unfortunately the research suggests that the worst may be yet to come. Groundwater flows slowly toward the ponds at speeds ranging from 300 to over 1000 feet each year. Many of the houses in the watershed were built recently and we may assume that the nitrate they are adding to groundwater is not yet reaching the salt ponds. If no new houses are built in the watershed, we may expect that the amount of nitrate in the ponds will continue to increase for many years to come. Further development can only make the problem worse.

Other Threats to Water Quality From Continuing Development

Modern individual sewage treatment systems (ISDS) are usually very effective in preventing bacteria in sewage from entering groundwater or escaping onto the surface. An ISDS system, however, has an average life expectancy of 20 years. Houses with old ISDS's or systems that pre-date the adoption in 1969 of state regulations for individual sewage disposal systems may be disposing of sewage improperly. As the houses in developed areas close to the ponds become older we can therefore expect that bacterial contamination from malfunctioning systems to become an increasing problem. The lands around Green Hill Pond are densely developed and the pond is poorly flushed. It exchanges approximately 1 percent of its volume with the sound on each tide.[7] It is thus not surprising that the summer concentrations of coliform bacteria (the legal indicator of bacterial contamination) were amongst the highest in a year long survey of six salt ponds during 1980.[5] During the summer, fecal and total coliform concentrations exceeded the upper limit permitted in waters that are open to shellfishing (Figure 9). It is reasonable to assume that levels will increase as development of the remaining open lands around the ponds proceeds. Coliform bacteria are also used as an indicator of pollution in drinking water supplies. Analysis by the R.I. Department of Health from 163 wells in the Charlestown Beach and Sea Lea Colony areas during 1966 through 1972 showed that waters in 32 percent of the wells tested were considered unsafe for human consumption and an additional 18 percent showed signs of bacterial contamination.[8]

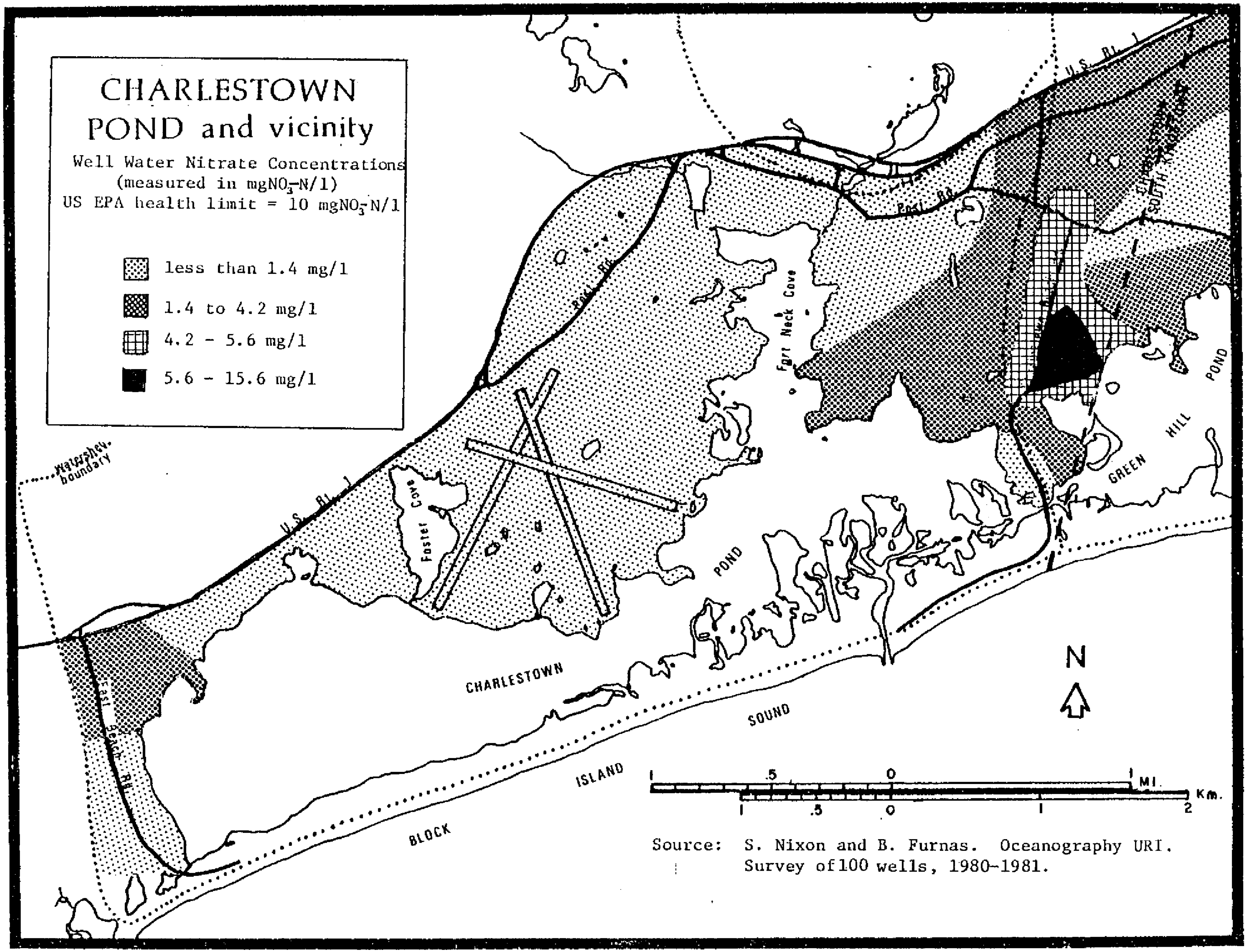
A sewer system would effectively prevent both bacteria and nitrates in domestic sewage from reaching the salt ponds. Unfortunately, sewers encourage dense development, and change the patterns of freshwater flow in the watershed. In the densely developed areas usually associated with sewers, contaminated surface runoff is likely to become a significant problem; this is the reason why salt ponds adjacent to sewered high density developed areas on Long Island and in North Carolina are contaminated and closed to shellfishing.

At present, surface runoff from developed areas does not appear to be a major source of pollution to the ponds. However, as development proceeds the increase in impermeable surfaces created by asphalt roads, roofs, etc. will increase the amount of surface runoff to streams and ponds after rainstorms and during spring thaws. This will carry a variety of potential pollutants including bacteria, petroleum, and metals that, along with the stresses caused by sudden large inflows of freshwater, can have an adverse effect on organisms in the salt ponds. Runoff from Rte. 1 has already deposited large amounts of silt in some areas of the salt ponds and their tributaries.

Figure 8. Nitrate Nitrogen Concentrations in Well Water in the Charlestown Salt Pond Region.

Source: Scott Nixon and Barbara Nowicki, URI Oceanography.

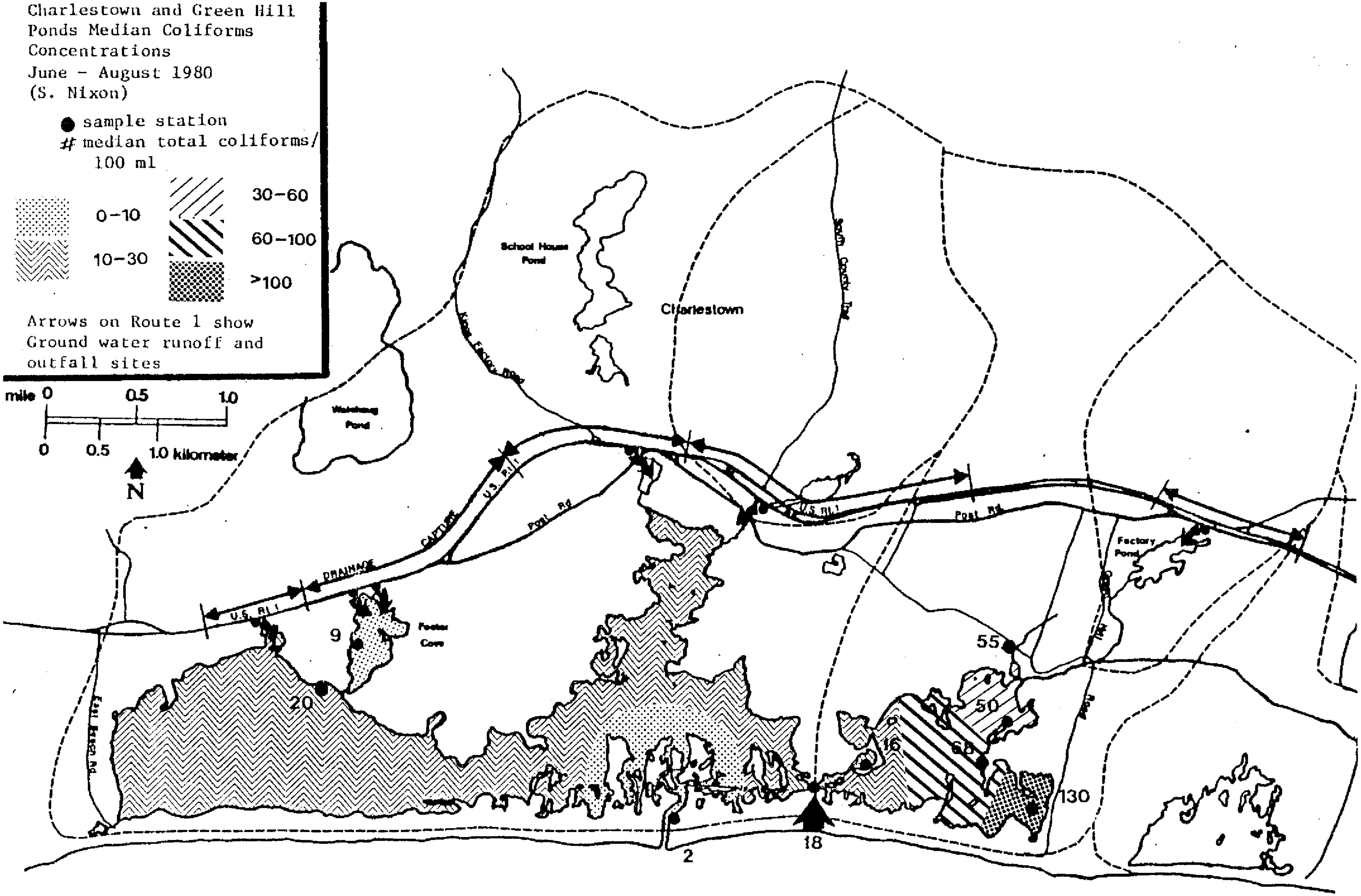
These data are compiled from 100 samples collected from private wells during 1981-1982.



Source: S. Nixon and B. Furnas. Oceanography URI.
Survey of 100 wells, 1980-1981.

Figure 9. Concentrations of Total Coliform Bacteria In Ninigret and Green Hill Ponds, June-August, 1980.

Source: Scott Nixon and Barbara Nowicki, URI Oceanography


Charlestown and Green Hill
Ponds Median Coliforms
Concentrations
June - August 1980
(S. Nixon)
● sample station
median total coliforms/
100 ml
0-10
10-30
30-60
60-100
>100
Arrows on Route 1 show
Ground water runoff and
outfall sites
mile 0 0.5 1.0
0 0.5 1.0 kilometer
N
School House Pond
Charlestown
South County Trail
Kings Factory River
Watchaug Pond
U.S. Rt. 1
Post Rd
CAPTURE
DRAINAGE
Foster Cove
Factory Pond
Post Rd
East Beach Rd
9
20
2
18
16
65
50
55
130

A Public Water Supply?

If drinking water supplies become polluted the town will be forced to build a public water system. This has already occurred in South Kingstown where older communities in Matunuck and Green Hill can no longer rely on individual wells for potable water and a waterline had to be built from town-owned wells in the Factory Brook area to provide a new supply. In 1972 Keyes Associates, a Providence engineering firm, examined the possibility of building a public water system for the area of Charlestown south of Rte. 1 that would draw its water from wells on the Naval Air Base. The cost estimate was in excess of \$3 million.[9] An updated estimate for a similar system is being prepared by Rhode Island Projects for the Environment, Inc. (RIPE). It is highly probable that a water system for the area south of Rte. 1 will become necessary as development proceeds. It will be very expensive and will have a large impact on the tax rate. Unless carefully managed, it may also divert groundwater flow out of the Ninigret Pond watershed with consequent impacts on the pond environment.

A Sewer System?

A public sewer system is an effective way to prevent nitrates from domestic sewage from entering groundwater and the salt ponds. A sewer system for Charlestown, however, may not be a realistic possibility. The costs dwarf those of a public water system and federal funds are no longer as readily available as in the past. The sewage treatment plant just completed in South Kingstown cost \$7.4 million and operating and maintenance costs are high. Public sewers around Charlestown and Green Hill Ponds could ultimately result in increased pollution from runoff and also disrupt the balance between the fresh and salt water in the pond. With sewers the water that passes through houses would no longer recharge the groundwater as septic leachate, but would be shunted off to a treatment plant and disposed of at one location, which in Charlestown's case would probably be an ocean outfall. This diversion would rob the salt ponds of vital groundwater flow.

III. RECOMMENDATIONS

Measures to Reduce the Ultimate Density of Houses

If the quality of drinking water supplies, the quality of salt pond waters and the beauty of the Charlestown salt pond region is to be maintained, the town must change zoning to allow the number of houses to at most double, rather than quadruple, as the present zoning ordinance will allow. Reducing the ultimate density of housing should also have a beneficial effect on the tax rate.

Figure 10 shows, in generalized terms, areas where minimum lot sizes could be increased substantially.

- areas south of Rte. 1 currently zoned for 1 acre that could be rezoned for 2 acres or more
- areas north of Rte. 1 that overlie the recharge area for groundwater that serve heavily developed residential areas around the salt ponds; here zoning could be upgraded from 2 acres to not less than 5 acres
- cluster zoning should be imposed on all developments in remaining agricultural and open space lands south of Rte. 1 (Figure 11).

Measures to Maintain the Character and Beauty of the Landscape

The salt pond region will be a desirable place in which to live and visit as long as it retains its beauty and character. These characteristics are directly linked to property values.

- the town should consider establishing an historic district in the Cross Mills-King Tom Farm-Fort Ninigret area shown on Figure 10. Modifications to existing buildings and new construction in this area should conform to the 18th and 19th century style of building
- the town should pursue a variety of options such as those discussed at Coastal Resources Center workshops in the winter of 1981-82 to preserve the fast disappearing farmlands, viewsites and open space south of Rte. 1 that are identified in Figure 11. The priority parcels and definition of specifically what need to be preserved should be identified by the town
- subdividions that border on the salt ponds or their tributaries should provide for a buffer zone of undisturbed naturally occurring vegetation at least 100 feet wide
- the maximum height of single-family dwellings south of Rte. 1 should be reduced from 40 feet to 25 feet
- the town should retain a landscape architect to develop standards for development that will enhance and maintain the beauty and character of the salt pond region

Additional Measures to Prevent the Pollution of Drinking Water Supplies and Salt Ponds

The principal threat to groundwater quality is at present the nitrate produced primarily by properly functioning on-site sewage disposal systems and lawn fertilizers. As the salt pond region becomes more densely developed, surface runoff will become an increasingly significant source of a variety of pollutants including organic matter and bacteria.

In areas where development is already too dense for groundwater to dilute nitrate loadings, new houses should be required to meet low nitrate discharge standards. Methods for achieving low-nitrate discharges are described in Appendix A and include:

- composting or incinerating toilets
- on-site denitrification of domestic sewage
- collection and treatment of sewage at a municipal or small-scale "package" treatment plant
- a requirements that the lawn areas of each new dwelling unit does not exceed 2000 square feet

A large-scale municipal sewage system is not recommended but small-scale "package" treatment facilities may be the best option for sewage disposal in some neighborhoods. Septic systems are much more likely to operate successfully if they are properly maintained. A septic tank management program is also outlined in Appendix A.

Figure 10. Recommended Changes in Current Zoning To Reduce the Ultimate Number of Housing Units in the Salt Pond Region.

SALT POND REGION HOUSING
DENSITY RECOMMENDATIONS

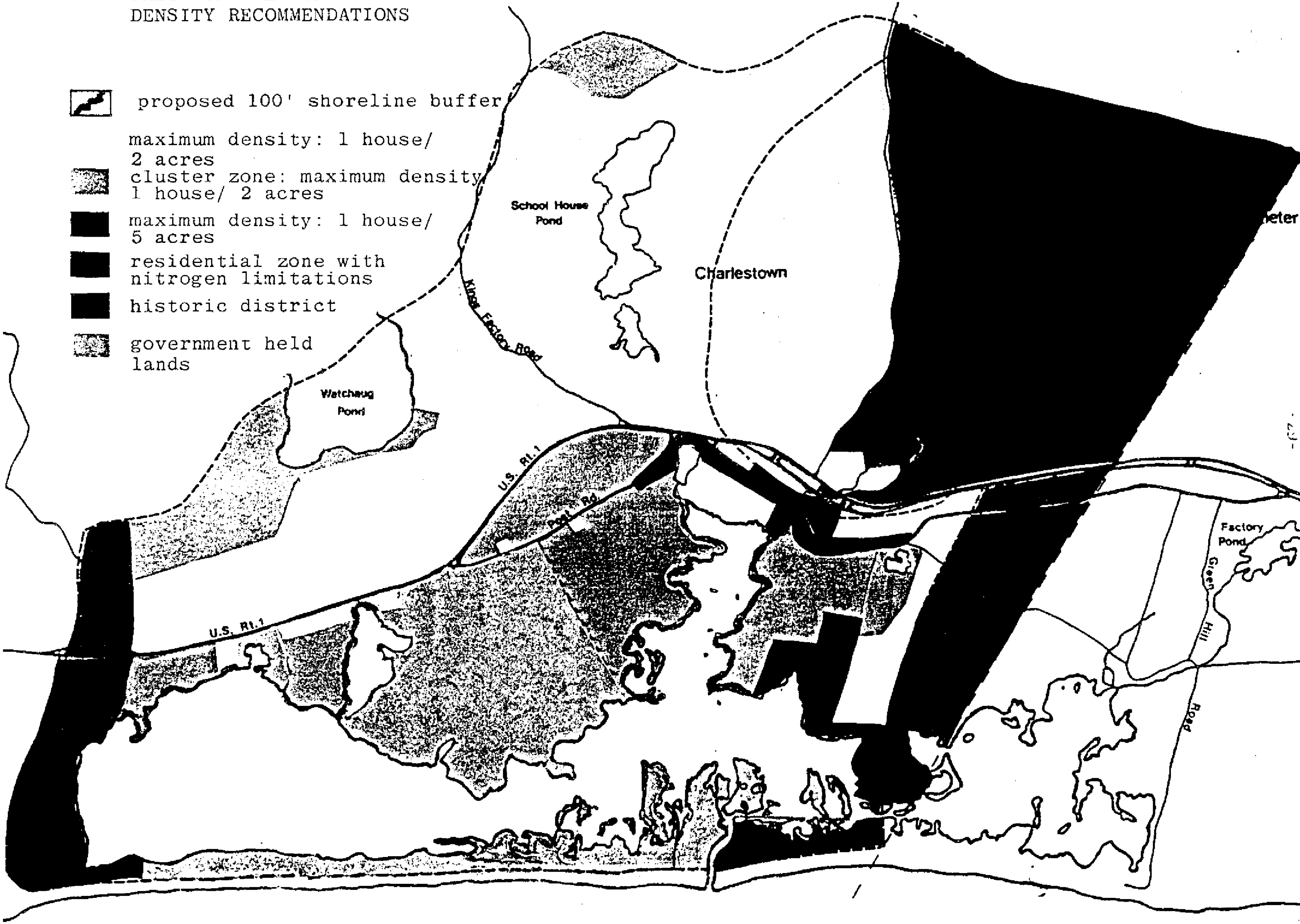
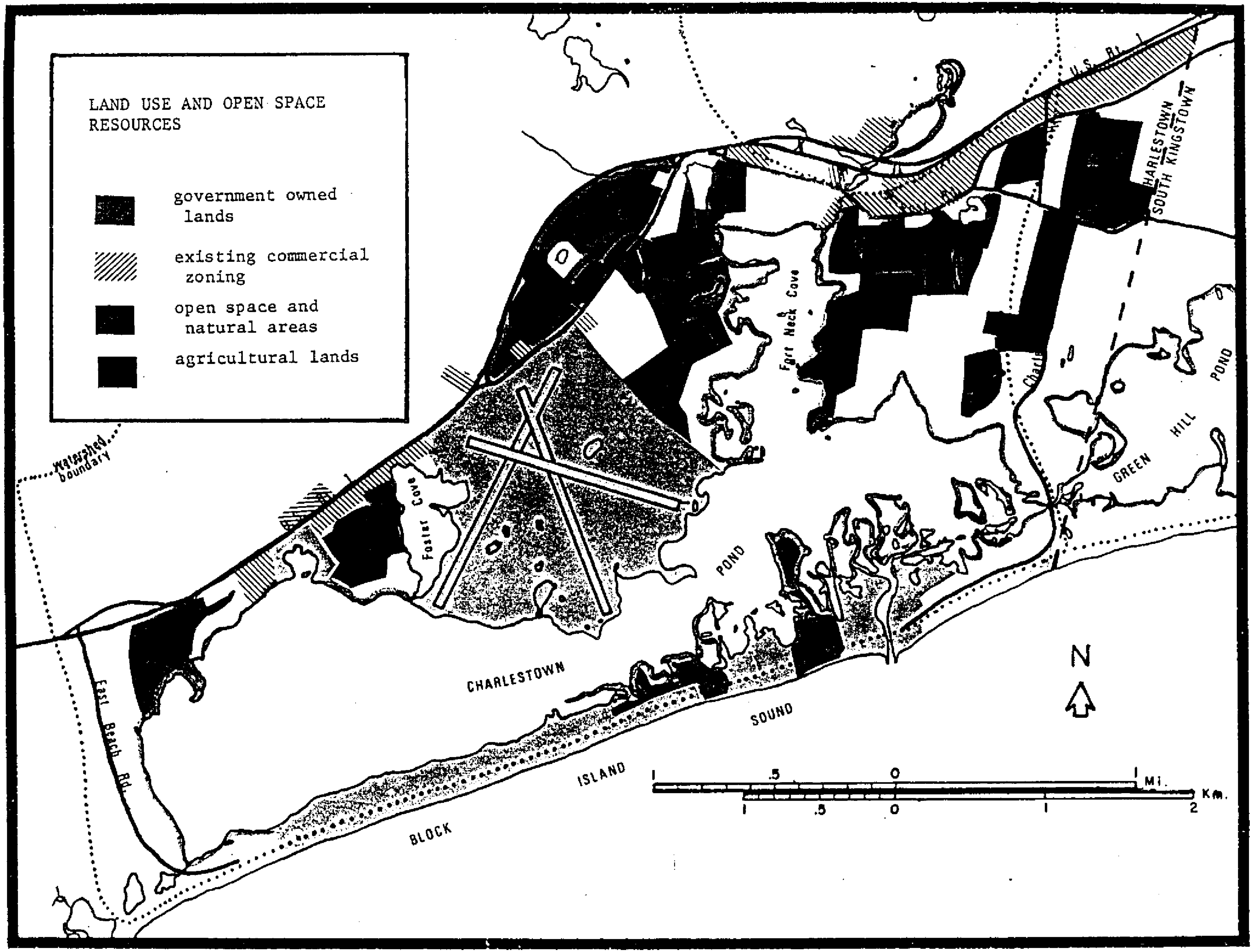


Figure 11. Existing land uses and important open space and agricultural resources south of Rte. 1.

Agricultural land in dark green and open space areas in light green should be preserved in order to maintain the character of the salt pond region and mitigate adverse effects of future development.


LAND USE AND OPEN SPACE RESOURCES
government owned lands
existing commercial zoning
open space and natural areas
agricultural lands
Watershed boundary
U.S. Rt. 1
CHARLESTOWN
SOUTH KINGSTOWN
Fort Neck Cove
Foster Cove
GREEN HILL POND
POND
CHARLESTOWN
East Beach Rd.
BLOCK ISLAND SOUND
N
Mi.
Km.

The pollutants carried by runoff are best handled through measures that minimize direct discharges to waterbodies and encourage infiltration of runoff into the ground. Techniques described in Appendix A that should be incorporated where appropriate into zoning ordinances include:

- elimination of existing point discharges to the ponds from Rte. 1 by using vegetated swales and catchment basins
- buffer strips of natural vegetation around all waterbodies and wetlands
- adoption of a stormwater runoff control ordinance for subdivisions
- use of permeable pavements and other structural measures that encourage the dispersion of runoff
- cover and contain road salt storage piles to minimize infiltration to groundwater and streams

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APPENDIX A

MEASURES TO PROTECT GROUNDWATER AND SALT POND WATER QUALITY

Techniques for Achieving a Low Nitrate Discharge

To protect the quality of groundwater, a low-nitrogen effluent should be required of all new houses built in areas dependent on private wells where lot sizes are too small (less than 2 acres) to assure that the septic effluent will be sufficiently diluted to keep the nitrogen concentration below 10 mg/l NO_3^--N. Low nitrogen discharge standards may also be applied to areas abutting poorly flushed portions of the salt ponds that already show signs of eutrophication. On-site sewage disposal alternatives which do not remove nitrogen (such as mounds, aerobic tanks and electro-osmosis) only expand the areas which may be developed and therefore increase the total nitrate loadings to the drainage basin. Techniques of disposal that may achieve a low nitrate discharge include:

Compost Toilet or Incinerating Toilet: Properly operating systems present no public health dangers. They produce ash or a soil-like compost free of pathogens and nearly all the nitrogen is vented to the atmosphere as a gas. Maintenance of compost systems involves checking liquid levels, adding bulking agents and removing approximately half a bushel of compost each year. These systems are approved by DEM where soil and groundwater heights meet the criteria for a subsurface sewage disposal system that could be built if the composting systems were to fail. Composting systems are used in conjunction with a reduced leachfield which handles the "gray water" produced by sinks, washing machines and baths.

On-site Denitrification: Waste treatment and water recycling systems are currently available on a scale suitable for multi-unit housing, shopping centers, office buildings, and manufacturing plants. Systems suitable for individual homes are being developed. A denitrification unit converts nitrate to nitrogen gas which is released to the atmosphere. A residential unit is being tested which removes approximately 70 percent of the nitrate from household effluent using a buried 1,300 gallon concrete treatment unit, a sump pump and absorption field. The system is designed to treat 300 gallons per day. Production units will be available in 1982 and are estimated at $8,000 per unit and would cost some $400 per year in electricity to operate.[11]

Traditional septic tanks with an added denitrification process are being tested on Long Island and at the University of Connecticut. The Long Island unit consists of a standard septic tank and leachfield with an impermeable pan beneath it. Methanol is pumped into the pan to stimulate denitrification. The Connecticut unit uses "gray water" to denitrify "black water" and requires three tanks, a sand filter and a leachfield. Both systems are being designed for minimum upkeep and cost. Denitrification systems have not been approved by the R.I. Department of Environmental Management.

Collect and Treat: Construction of a traditional sewage collection system and treatment plant would effectively remove nitrogen and effluent from the watershed. This option, however, is extremely expensive and is potentially destructive to pond ecology and is not recommended. If Charlestown decides that it must sewer, the system should be carefully planned to minimize loss of groundwater to an ocean outfall. Two options are available which remove nitrogen and do not divert groundwater supplies. Forest land application of wastewater following primary treatment can effectively reduce nitrogen and also produce a harvestable crop. Land for this type of treatment is available north of Rte. 1. Another alternative is traditional sewage treatment with tertiary treatment to remove nitrogen followed by subsurface infiltration of the treated waters to recharge groundwater.

A third option for collection and treatment are package sewage treatment plants. Plants are prefabricated and available in a range of sizes suitable for subdivisions and small towns. Tertiary treatment modules are available to remove nitrate. To avoid diversion of groundwater flows to an offshore outfall, effluent should be discharged through subsurface infiltration to groundwater.

Lawns: The size and distribution of lawns can be influenced by town ordinances. Subdivision and zoning regulations should encourage small lawns and the preservation of trees and natural vegetation. Use of lawn fertilizer should be discouraged in all areas south of Rte. 1, and a guideline of no more than 2000 square feet of lawn per house should be applied to new developments in areas designated for low-nitrate discharge.

A Septic Tank Management Program

The town should establish septic tank management programs with the goal of upgrading substandard systems and improving maintenance. While minimum standards for the installation of on-site disposal units are enforced by the state, the towns can do much to safeguard public health by ensuring that septic systems function properly and that backups, clogging and bacterial contamination are avoided. Septic tank maintenance and upgrading will not solve the nitrate problem, but will help check the flow of other contaminants into groundwater and the salt ponds. A management program would ideally consist of several components. Some could be incorporated into existing town programs, while others would require state enabling legislation and/or a system of user fees. The elements of a program could be as follows:

a. Establish an education and information program on the importance of a properly maintained system. The town could offer a septic tank cleaning rebate, and publicize the program to encourage pumping.
b. Require homeowners to eliminate known violations such as effluent pipes that are connected to storm sewers. Investigate areas with high coliform concentrations such as Green Hill Pond for direct sewage flows and old cesspool systems.
c. Issue permits for on-site disposal systems with the requirement that the owner show proof of inspection or pumping every three years.
d. Require septage haulers to maintain records of pumpouts, septic tank failures and their probable cause. Such records could be used to pinpoint areas of chronic failure.
e. Ensure upgrading and continued maintenance of all systems by a pre-sale inspection for all houses. Failed or substandard systems should become an encumbrance on the deed of the property. Require repair or replacement within one year of purchase.

Measures to Control Pollution from Runoff

Surface runoff from areas of dense residential development and roads contains pathogens, nitrates, heavy metals, hydrocarbons, sediments and other pollutants that can have a major impact on such small, poorly flushed waterbodies as the salt ponds. The volume of runoff that flows from an area is proportional to the percentage of impermeable surface. The most effective way to minimize the effects of the contaminants contained in runoff on the salt ponds and tributaries is to forestall continuing development in as yet undeveloped areas and to eliminate existing direct flows.

Direct Flows: The major existing source of direct flows from storm drains to the salt ponds is Route 1. There are also several storm drains that flow from town roads directly into the Foster's Cove, Mud Cove, and Cross Mills Stream. The towns should urge the Department of Transportation to redesign culverts and storm sewers as they renovate and upgrade Rte. 1. The towns should incorporate sections into subdivision regulations prohibiting direct drainage into surface waterbodies.

Natural Vegetation Buffer Strips: Buffer strips of natural vegetation can be effective in reducing runoff and removing contaminants. This measure requires no construction or additional expenditures on the part of the homeowner or developer. A 100-foot buffer zone of natural vegetation around the perimeter of the salt ponds, tributary streams and wetlands should be incorporated into subdivision regulations. The towns should consider granting conservation easements on such buffer strips.

Stormwater Runoff Control Ordinance: The towns should adopt special regulations that would apply to subdivisions and commercial developments in the salt pond region. This would ideally require that runoff from developments will not exceed predevelopment levels, thus preventing downstream flooding, limiting contamination from pollutants in runoff and maintaining groundwater supplies. In addition, the ordinance should require practices which minimize erosion and sedimentation during construction.

Permeable Pavement: The towns should encourage the use of structural devices which aid infiltration and slow runoff and amend the building code to promote such devices. Porous pavements allow for infiltration and groundwater recharge and reduce the need for storm sewers. Porous asphalt laid over a base of crushed stone is suitable for roads and parking lots but requires regular cleaning if it is to function properly. Modular paving is available in a variety of lattice, block and brick designs. Concrete grid pavements are used extensively in Europe. With a properly designed subbase, they can support heavy vehicle traffic and are suitable for parking lots, driveways, and emergency vehicle roads. Concrete grid pavements can virtually eliminate runoff. Studies of pollutants in runoff from grid pavements indicated they were reduced to less than 2 percent of the quantity carried by runoff from a concrete slab. Filtration through the grid pavement and underlying soils removed significant amounts of the pollutants tested, with the exception of nitrate.

Permeable gravel or porous pavement should be required for all driveways and parking lots within 200 ft. of the salt ponds and tributaries. Paved roads should not slope directly down to the shoreline. Permeable pavement should be encouraged elsewhere in the pond's drainage basins.

Other Structural Techniques: Other structural techniques which should be encouraged include:

a. Dutch drains consist of gravel filled ditches with an optional drainage pipe in base. They can be used to collect runoff from roofs without gutters and as dividing strips to collect sheet flow from areas of impermeable pavements. Runoff from small storms can be retained entirely within the drain. In large storms, the drain can reduce peak flow rates. Infiltration to groundwater is increased in either case.
b. Terraces and runoff spreaders are earth formations which intercept runoff and decrease erosion. A terrace is an embankment constructed across the slope which directs runoff around the slope rather than down it. A level spreader is a channel which disperses runoff over an undisturbed, vegetated area. These techniques are most effective on rolling topography with well-drained soils.
c. Seepage pits consist of shallow holes backfilled with stone or gravel. They receive runoff and aid infiltration and are effective in well-drained soils.
d. Recharge basins are pits designed to receive runoff and maintain natural recharge by infiltration through the bottom and sides of the basin. They are particularly effective in aquifer recharge areas. Experience on Long Island has shown that little maintenance is necessary in porous glacial soils.
e. Tile fields and seepage ditches or perforated corrugated steel pipe can be used to distribute runoff through the subsoil. Sediment removal is necessary to avoid clogging of the system.
f. Seepage beds are large areas of unpaved open space or porous pavement which allow stormwater to spread out and soak in after a storm. They can be used as parking lots or recreational areas.

Minimize the Risks of Groundwater Contamination from Road Salt

A salt storage pile is operated by the state at Cross Mills. The pile is covered by six inches of sand. Research by Dr. Kelly on the migration of salt from the pile to groundwater suggests that the pile should be covered with a roof.

The town controls the salting of secondary roads. They should minimize the salt to sand ratio in the mixture and application rates.

APPENDIX B

SOURCES OF NITROGEN IN THE NINIGRET AND GREEN HILL POND REGION

GROUNDWATER QUANTITY AND QUALITY IN THE CHARLESTOWN SALT POND REGION

	Ninigret Pond Watershed	Green Hill Pond Watershed in Charlestown	Total
Groundwater Quantity:			
Watershed area[1]	7,039 ac	1,511 ac	8,550 ac.
Groundwater flow[1]	8.582×10^6 gal/day	1.788×10^6 gal/day	10.370×10^6 gal/day
Cross Mills Stream[1]	$.084 \times 10^6$ gal/day		
Groundwater use:			
# houses, 1980[2]	1228	315	1543
Groundwater use, 1980[3]	$.1783 \times 10^6$ gal/day	$.0457 \times 10^6$ gal/day	$.2240 \times 10^6$ gal/day
% of flow	2%	3.0%	2%
# houses, 2000[6]	4816	1276	6092
Groundwater use, 2000	$.6993 \times 10^6$ gal/day	$.1853 \times 10^6$ gal/day	$.8846 \times 10^6$ gal/day
% of flow	8%	10%	8.5%
Groundwater Quality:			
# wells sampled[7]	50	50	100
av. depth[7]	45.5 ft.	44.2 ft.	45 ft.
av. NO_3 conc., 1980[7]	1.67 mgN/l	3.9 mgN/l	
av. NO_3 conc., 2000	6 mgN/l	8 mgN/l	
health limit (NO_3)	10 mg/l	10 mg/l	

NITROGEN LOADINGS (lbs/yr)

SALT POND WATERSHEDS IN THE TOWN OF CHARLESTOWN

Source	Ninigret Pond 1980	Ninigret Pond 2000	Green Hill Pond in Charlestown 1980	Green Hill Pond in Charlestown 2000
Groundwater				
Residential				
Septic[8]	20,262	79,464	5,196	21,054
Lawns[9]	18,260	49,375	7,482	13,080
Pets[10]	1,661	6,516	426	1,726
Roads[11]	1,397	5,588	466	1,864
Total (residential)	41,580	140,943	13,570	37,724
Agriculture[12]	3,225	?	0	0
Precipitation[13]	7,946	7,946	1,654	1,654
Total groundwater loading	52,751	148,889	15,224	39,378
Direct Loading to Salt Ponds				
Runoff from Rte. 1 culverts[13]	169	676	--	--
Precipitation on Pond surface[14]	7,400	7,400	1,860	1,860
Grand Total	60,320	156,965	17,084	41,238

FOOTNOTES TO GROUNDWATER QUANTITY AND QUALITY IN THE CHARLESTOWN SALT POND REGION

1. J. Grace, 1981, report to CRC. Green Hill Pond watershed flow recalculated as (1.31 ft/yr recharge) x ($ft.^2$ of watershed in Charlestown).

2. C. Collins, 1981 aerial photo count.

3. Groundwater use discharged as sewage. (# houses, 1980) x (44 gal/cap/day)[5] x (3.3 people per house)[4]

4. South Kingstown mean, 1980 census data. A. Prager.

5. L.I. Planning Board, 1978. Average of seven studies.

6. C. Collins, 1982. Projected saturation at current zoning including grandfather lots. Projected from Charlestown growth trends of last 40 years.

7. S. Nixon, et al. URI Pond Project nutrient budget. Groundwater quality survey.

8. Average nitrate concentration in groundwater from residential development:

   Septics:

   (# houses, 1980)[a] x (10 lb. N/cap/day septage)[b] x (3.3 people/house)[c] - (50% loss via DNF)[d]
   ____
   (groundwater flow)[e]

   a. C. Collins counts. 1981 aerial photos by groundwater basin excluding sewered houses.

   b. Per capita sewage nitrogen. Based on 10 lb. N/person per year. L.I. 1978 p. 193.

   c. South Kingstown mean, 1980 census data.

   d. Loss due to denitrification. Andreoli, 1979. 50% loss of N occurs in ISDS and only 50% of nitrogen waste from a household reaches groundwater.

   e. Volume of groundwater flow per watershed. J. Grace. 1981. Report to CRC.

9. Lawn Fertilizer:

   (area of watershed)[a] x (% residential)[b] x (35% lawn)[c] x (1.7 lb N/1000 x ft^2/yr applied)[d] x (60% DNF)

   a. J. Grace, 1981, report to CRC.

   b. C. Collins planimetry 1981 aerial photos.

   c. Proportion of residential land in lawn from L.I. Planning 208 (1978) p. 196.

d. Rate of fertilizer application from L.I. Planning 208 (1978) p. 195 (this is the lowest application rate, can be as high as 3.75 lb N).

e. 60% loss due to denitrification and volitilization. From L.I. 208 (1978) p. 215.

10. Pets

$$(\#\ \text{houses}) \times \frac{3.3\ \text{people}}{\text{house}}) \times (0.41\ \text{lb. N/person/yr})^{a}.$$

a. From L.I. 208 (1978) p. 206

11. Roads

$(2.04\ \text{lb N/curb mile})^{a} \times (\#\ \text{curb miles})^{b} \times (\#\ \text{storms/yr})^{c} \times (.5)^{d}$

a. Sartor and Boyd. 1972. p. 62. (for residential area)

b. Calculations by J. Gallagher. 1977. Using 1975 USGS Topographic maps and linear distance meter.

c. 50 (rough estimate of number of storms per year, Deason 1981)

d. Denitrification factor in glacial soils, from L.I. 1978 p. 215. Assume houses quadruple by 2000, with comparable increases in road traffic and N loading

12. Agriculture

$(38\ \text{ac. corn})^{a} \times (\text{available N})^{b} + (53\ \text{ac potatoes})^{a} \times (\text{available N})^{b}$

a. acres from Rural Runoff Task Force, Statewide Planning, 1978.

b. 25% of added fertilizer gets to g.w. (L.I. 1978). The rest is lost via denitrification and plant uptake.

1 ton of 10-10-10/ac corn = 200 lb N)
1 ton 5-10-10/ac potatoes = 100 lb N) typical fertilization application in S. County

From: H. Browning, Jr., local farmer

13. Precipitation on watershed area

$(4.33\ \text{lbs N/ac})^{a} \times (\text{area of watershed}) \times (.25\ \text{reaches groundwater})^{b}$

a. Conc. from S. Nixon et al. 1982. Final report to R.I. Statewide Planning.

b. Assume similar pattern to fertilizer where 25 percent of N input gets to groundwater and 75 percent is lost via denitrification (DNF) and plant uptake. From L. I. 208 (1978) p. 215.

14. Precipitation directly on pond surface

(4.33 lbs N/ac) x (surface area of Ninigret and Green Hill Ponds)

15. <u>Runoff from Rte. 1 culverts</u>

(2.04 lb N/curb mile) x (# curb miles draining into each culvert) x (# storms/yr) x (.5)

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APPENDIX C

LAND USE IN SALT POND REGION, 1981

LAND USE IN THE COASTAL PONDS' WATERSHEDS (ACRES), 1981

		Developed	Agriculture	Wet	Borrow Pit	Developed Park	Open	Other	US Rte. 1	Total
Ninigret Pond Watershed										
	N*	491	11	557	0	109	3191	11		4370
	S*	681	170	229	54	0	1417	0	118	2669
	T*	1172	181	786	54	109	4608	11	118	7039
Green Hill Pond Watershed in Charlestown										
	N	173	11	--	0	0	867			1051
	S	361	58	--	7	0	24		10	460
	T	534	69	--	7	0	891		10	1511
Total Charlestown Water-shed Area										
	N	664	22	557	0	109	4058	11		5421
	S	1042	228	229	61	0	1441	0	128	3129
	T	1706	250	786	61	109	5499	11	128	8550
Green Hill Pond Water-shed in South Kingstown										
	N	140	0	--	0	0	917			1057
	S	470	125	216	7	0	561		40	1419
	T	610	125	216	7	0	1478		40	2476
Total Green Hill Water-shed										
	N	313	11	0	0	0	1784		0	2108
	S	843	183	216	7	0	580		50	1879
	T	1156	194	216	7	0	2364		50	3987
Trustom Pond Watershed										
	N	--	--	--	--	--	41		0	41
	S	104	221	49	0	0	516		2	892
	T	104	221	49	0	0	557		2	933
Cards Pond Watershed										
	N	40	62	0	0	--	521		0	623
	S	197	342	27	9	--	245		20	840
	T	237	404	27	9	--	766		20	1463

* N: watershed area north of Route 1.
S: Route 1 and the watershed area south of Route 1.
T: total pond watershed area.

LAND USE IN THE COASTAL PONDS' WATERSHEDS (ACRES), 1981

		Developed	Agriculture	Wet	Borrow Pit	Developed Park	Open	Other	US Rte. 1	Total
Potters Pond Watershed										
	N	60	8	5	0	0	998		0	1071
	S	491	259	126	0	0	454		48	1378
	T	551	267	131	0	0	1452		48	2449
Pt. Judith Pond Watershed in South Kingstown										
	N	463	93	0	0	0	838		0	1394
	S	353	106	63	14	0	1069		66	1671
	T	816	199	63	14	0	1907		66	3065
Pt. Judith Pond Watershed in Narragansett										
	N	0	0	0	0	0	31			31
	S	978	20	270	0	92	871		15	2246
	T	978	20	270	0	92	902		15	2277
Pt. Judith Pond Watershed										
	N	463	93	0	0	0	869			1425
	S	1331	126	333	14	92	1940		81	3917
	T	1794	219	333	14	92	2809		81	5342
South Kingstown Total										
	N	703	163	5	0	0	3315		0	4186
	S	1615	1053	481	30	0	2845		176	6200
	T	2318	1216	486	30	0	6160		176	10386

Source: CRC 1981 air photo analysis

LAND USE IN THE COASTAL PONDS'WATERSHEDS (PERCENTAGES), 1981

		Developed	Agriculture	Wet	Borrow Pit	Developed Park	Open	Other	Rte 1
Ninigret Watershed	T	16.6	2.6	11.2	0.8	1.5	65.4	0.2	1.7
	N	11.2	0.3	12.7	0	2.5	73.0	0.3	-
	S	25.5	6.4	8.6	2.0	0	53.1	0	4.4
Green Hill Watershed in Charlestown	T	35.3	4.6	0	0.5	0	59.0	0	0.7
	N	16.5	1.0	0	0	0	82.5	0	-
	S	78.5	12.6	0	1.5	0	5.2	0	2.2
Total Charlestown Watershed	T	20.0	2.9	9.2	0.7	1.3	64.3	0.1	1.5
	N	12.2	0.4	10.3	-	2.0	74.9	0.2	-
	S	33.3	7.3	7.3	1.9	0	46.1	0	4.1
Green Hill Watershed in South Kingstown	T	26.6	5.0	8.7	0.3	0	59.3	-	1.6
	N	13.2	-	-	-	-	86.8	-	-
	S	33.1	8.8	15.2	0.5	0	39.5	-	2.8
Total Green Hill Watershed	T	29.0	4.9	5.4	0.2	-	59.3	-	1.3
	N	14.8	0.5	0	0	0	84.6	-	-
	S	44.9	9.7	11.5	0.4	0	30.9	-	2.7

LAND USE IN THE COASTAL PONDS' WATERSHEDS (PERCENTAGES), 1981

	Developed	Agriculture	Wet-lands	Borrow Pit	State Developed Park	Open	Other	Rte 1
Trustom Pond Watershed	11.1	23.7	5.3	0	0	59.7	-	0.2
N	-	-	-	-	-	100	-	-
S	11.7	24.8	5.5	0	0	57.8	-	0.2
Cards Pond Watershed	16.2	27.6	1.8	0.6	-	52.4	-	1.4
N	6.4	10.0	-	-	-	83.6	-	-
S	23.5	40.7	3.2	1.1	-	29.2	-	2.4
Potters Pond Watershed	22.5	10.9	5.3	0	0	59.3	-	2.0
N	5.6	0.7	0.5	0	0	93.2	-	-
S	35.6	18.8	9.1	0	0	32.9	-	3.5
Pt. Judith Pond Watershed in S. Kingstown	26.6	6.5	2.1	0.5	0	62.2	-	2.2
N	33.2	6.7	-	-	0	60.1	-	-
S	21.1	6.3	3.8	0.8	0	64.0	-	3.9
Total Ponds' Watersheds in S. Kingstown	22.3	11.7	4.7	0.3	-	59.3	-	1.7
N	16.8	3.9	0.1	-	-	79.2	-	-
S	26.0	17.0	7.8	0.5	-	45.9	-	2.8
Pt. Judith Pond Watershed in Narragansett	43.0	0.9	11.9	-	4.0	39.6	-	0.7
N	0	-	0	-	-	100	-	-
S	43.5	0.9	12.0	-	4.1	38.8	-	0.7
Pt. Judith Watershed T	33.6	4.1	6.2	0.3	1.7	52.6	-	1.5
N	32.5	6.5	-	-	-	61.0	-	-
S	34.0	3.2	8.5	0.4	2.3	49.5	-	2.1