Summary plan

208

Nassau·Suffolk Regional Planning Board

Dedication

THE HONORABLE H. LEE DENNISON, P.E.

First Suffolk County Executive, first in environmental planning, first in open space preservation, and first in the thoughts of his associates, constituents and friends.

SUMMARY PLAN

INTERIM REPORT SERIES: 7

May 1978

NASSAU-SUFFOLK REGIONAL PLANNING BOARD

Hauppauge, New York

This document was prepared by the Nassau-Suffolk Regional Planning Board pursuant to Section 208, Federal Water Pollution Control Act Amendments of 1972 (PL 92–500). This project has been financed in part with Federal funds from the United States Environmental Protection Agency under Grant Number P002103–01–0. The contents do not necessarily reflect the views and policies of the United States Environmental Protection Agency, nor any state, county, regional or local agency participating in the 208 program.

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Newsday Photo

Foreword

Water, life's ultimate indispensible mineral, is no match for its greatest enemy, man. But man's victory is hollow.

"Mommy, my toothbrush tastes funny." This scene could be early morning in Levittown, Lynbrook or Port Jefferson, as a typical Long Island family prepares to begin another day. The circumstances along with others similar in consequence could become reality in the absence of the comprehensive water quality management program contained in this multi-faceted work. Even with this document, they might come to pass. The program only shows the way. Unless implemented, toothbrushes may indeed begin to taste funny and surface waters, commercially and recreationally, may become endangered hydrological species. In this brief context–citing hazards but knowing they can be eliminated–I write this introductory segment with utmost pride. This work, in my opinion, represents excellence unusually distinctive in quality, a demonstration of a public agency's ability to create, produce and execute at the highest level of competency.

Long Island possesses rich and unusual natural bounty: white and pebbleless ocean sands, vast expanses of salt meadow, white-cedar swamps, inland pine barrens, flat plains, colorful downs, fiordlike harbors, bays, ponds, lakes and freshwater bogs. It offers something to suit the taste for nature in each of us. It is a remarkably varied, beautiful and fertile insular tract, lying at the threshold of the greatest urban center in the nation. For 250 years after its first settlement Long Island changed little. From 1812 to the turn of the century Suffolk County's total population increase amounted to only 42,582 souls. Even the railroad did little to alter the generally rural atmosphere. All this serenity came to an abrupt end following World War II when people, equal in number to the population of more than a dozen states, emigrated eastward across the city line. Vast public works were carried out, parkways and expressways laced the largest island on the Atlantic seaboard. But it was not until 1974, two years after passage of the Federal Water Pollution Control Act Amendments, that the fruits of environmental management became apparent and resulted in this far-reaching document. Chronologically it represents the Region's fourth most important plan–following the Nassau County Charter in 1938, the Suffolk County Charter in 1959 and the Bi-county Comprehensive Development Plan in 1970–affecting the lives of all its residents.

There is a valid question concerning the Region's success in developing comprehensive studies. Would they be possible without a regional planning agency? Possibly, yes; anything is. But as timely and of such professional calibre; probably not. Therefore, the underlying wisdom in establishing an areawide regional planning agency has been amply justified. The Nassau-Suffolk Regional Planning Board was created in 1965 by adoption of ordinances and resolutions by the Boards of Supervisors of Nassau and Suffolk, in accordance with provisions of the General Municipal Laws of New York State. As the solutions to economic and social problems become increasingly regionwide in nature, having this agency with a proven track record in performance already in place will serve as a source of assurance to Long Island citizens.

It would be extremely shortsighted to view this plan as just another study–its pages like leaves on trees, decidious and gone, once fallen to the ground. Its direct value is in its use as a working document, important to the life-styles of future generations and business growth. Indirectly, the applicability of its analyses and findings renders it of national importance and in turn assures national recognition of Long Island as a homogeneous entity with identity well beyond its false reputation as simply a bedroom community.

There is a legal expression, "The evidence speaks for itself." So do the following pages. In the main, Long Island's water supply, derived solely from its own groundwater sources (and not even partially from Connecticut–the erroneous impression lingers) is adequate in terms of quantity. Tunnels from upstate or other outside sources are not only unnecessary, they are equally foolish even to consider. But there is the point-blank question of preserving the quality of our water. This stern challenge must be met by the courage of government supported by an informed constituency, sensitive to parochial interests, yet willing to override them for the common good. Effective implementation will provide bread-and-butter benefits in preserving home values, protecting the quality of life and sustaining economic strength.

Elsewhere in this document the reader will find amply justified expressions of appreciation to the numerous private citizens who served on the technical and citizens advisory committees. Policy was always determined by Board members, past and present. Their cooperation along with that of elected officials was crucial to the completion of this work. In this regard our lasting gratitude is enthusiastically extended to the following: to former founding member and Chairman, Leonard W. Hall; former County Executives Ralph G. Caso and H. Lee Dennison; County Executives John V. N. Klein and Francis T. Purcell; former Board members, Thomas Halsey and Robert Flynn; and present Board members: Vice Chairman Seth Hubbard, Vincent Balletta, Robert Bell, Winfield Fromm and John Wickham. Finally, words are often weak and fruitless when attempting to describe the single most important contribution. For that I simply conclude with where it all began, was and will be, by use of proper noun: Dr. Lee E. Koppelman.

Harold V. Gleason
Chairman

ACKNOWLEDGEMENTS

This program has been a collective endeavor in the best sense of that term. Interdisciplinary skills, involving a wide array of scientific talents, and administrative inputs from all levels of government were required. The program could not have been satisfactorily completed without the enthusiastic participation and support of all persons involved in the development of the Nassau-Suffolk Areawide Waste Treatment Management Plan. The dedication and pride of involvement displayed by the members of the various county departments, consulting firms, and members of the public, were indeed a marvel, and credit for the products of this program must be shared with these people. We have tried to acknowledge their contributions by including their names on the Participation Page. We sincerely hope that we have not inadvertently omitted recognition of anyone. In particular, we owe a debt to our colleagues of the United States Environmental Protection Agency, Region II, who displayed as deep a committment to the interests of Long Island as any of the local representatives. Mr. Eckardt Beck, Regional Administrator, and his able colleagues, Mr. Conrad Simon, Mr. Charles Durfor, Mr. Anthony Conetta and others provided invaluable guidance and staff support. They were positive advocates for the program from its inception. Our requests were seriously considered and promptly acted upon—including bringing Federal scientific experts to our agency as specific problems unfolded. We enjoyed similar general support from the New York State Department of Environmental Conservation. Commissioner Peter Berle, Deputy Commissioner Theodore Hullar, Mr. Thomas Eichler, Mr. Michael O'Toole, Jr., Mr. Philip DeGaetano, Mr. Philip Barbato, Mr. Andrew Yerman, Mr. James Redman, and Mr. Wiacheslaw Fedoriw, ably represented the State's interests.

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Prefatory Comments

Introduction

The passage of the Federal Water Pollution Control Act Amendments of 1972 heralded a new era in environmental management. National interest and purpose was stated in the goal to achieve "water quality which provides for the protection and propagation of fish, shellfish and wildlife and provides for recreation in and on the water" by 1983, wherever attainable. It not only set forth a timetable for action but also provided some new approaches to solving the problems of our nation's polluted waters. For the first time there is a clear recognition that improved quality and the prevention of further pollution will also require changes in land use and management of growth in addition to the prevailing practice of building sewage treatment works. Non-point sources of contamination which result from construction and agricultural activities, highway runoff, widespread discarding of the residues of modern society, and the lack of control over animal wastes, etc. must now be considered. The Act is a landmark in three other instances. It provides for a comprehensive planned approach, requires strong citizen participation in the planning process and mandates a committment from state and local governments to implement the results of the planning effort.

Section 208 of the Act specifically creates a comprehensive water quality management program to deal explicitly with both the treatment and the prevention of water pollution. The plans prepared under this program must include a process for meeting established water quality goals and must show that management institutions exist with sufficient financial and legal authorities to implement the plan; or that new institutional arrangements will be created to achieve this purpose.

The Nassau-Suffolk Regional Planning Board (NSRPB) was designated by Governor Malcolm Wilson in December 1974 as the regional planning entity to carry out Section 208 planning for Nassau and Suffolk Counties. Realizing that a program of this magnitude had to have the support and input from those governmental agencies that either have an interest in, or a mandated role to play in water pollution control, the NSRPB immediately established a Technical Advisory Committee (TAC) to assist it in the preparation of the plan. The initial voting constituency of the TAC included representatives from the Nassau County Departments of Health, Public Works and Planning. The Suffolk County participants were from the Departments of Health and Environmental Control and the Suffolk County Water Authority. The seventh member was the Executive Director of the Nassau-Suffolk Regional Planning Board who served as Chairman of the Technical Advisory Committee and Project Director for the overall program.

In addition to the seven voting members, representatives from the Interstate Sanitation Commission, Region II of the Environmental Protection Agency (EPA), the New York State Department of Environmental Conservation (NYSDEC), the United States Geological Survey (USGS), the Suffolk County Soil and Water Conservation District and the Soil Conservation Service (SCS), the Cooperative Extension Service (CES) and the New York State Department of Health (NYSDH) were invited to participate as resource members.

In accordance with the guidelines for Section 208, and prior practices of the Board in conducting other regional planning studies, the Citizens Advisory Committee (CAC) was created to provide input to the TAC from the general public, and to act as a forum for distributing the findings of the study to the general public.

The Program received a $5.2 million grant from the EPA to carry out the detailed work program necessary to comply with the requirements of the Act.

Between January 1975 and December 1977 the TAC, which was formed prior to the grant award in June 1975, met at least one day a week, first for the design of the program and selection of consultants, and then for the general conduct of the Program. The CAC met bi-weekly during this period.

The consultants retained to carry out specific technical tasks were selected by national solicitation on the basis of merit. This single factor was one of the key elements in achieving the high level of competence displayed in the Plan.

Report Description

This report is a summary of the numerous working reports and studies prepared by the various consultants and member agencies of the project. It is also a reflection of the original workplan submitted to the EPA, with additional materials developed to meet amendments to the project which resulted from changes in the federal regulations, or work elements generated from requests made by the CAC. In addition to the working reports, six interim reports that summarize the technical documents have been prepared for public distribution. They are: (1) *Population Estimates and Projections 1975-1995,* (2) *Modeling Studies,* (3) *Surface Water Quality,* (4) *Groundwater Conditions,* (5) *Management Options* and (6) *Virus Study.*

This summary report constitutes the last in the general series. The TAC also published a study prepared by the SCS. This discusses the impact of animal wastes as a major non-point source of pollutants to the ground and surface waters. The interim reports and the summary report affords the serious reader a reasonably sufficient exposition of the 208 Plan.

This presentation is in seven sections with two appendices. *Section One—General Background*—contains a descriptive discussion of regional ground and surface water considerations. This portion has three segments. The first is a discussion of groundwater, including its major uses, existing quality and contamination sources. The second segment discusses the surface waters of the two counties in similar fashion. The third segment describes major options of structural and non-structural nature, and a description of the various evaluation and selection factors that are used in making choices.

Section Two—Assessment of Conditions—is devoted to an assessment of conditions, including population and land use, pollutant sources from point and non-point origin, and a discussion of transport mechanisms. Groundwater quality and quantity, and surface water quality are summarized to include the major findings of the study. The last segment of this chapter describes the marine, fresh water and terrestrial ecological conditions.

Section Three—Alternative Wastewater Management Programs—the major segment of this report, presents various wastewater management alternatives to control point and non-point source pollution. It includes structural and non-structural approaches ranging from sewer installations with varying degrees of treatment, to best management practices (BMP) for runoff control, fresh water conservation, watershed management and land use controls.

The first segment contains a listing and brief explanation of the objectives that the planning options should achieve in order to insure: public health protection, and the protection, enhancement and conservation of the natural resources—freshwater, marine, wetlands and terrestrial—of the two counties..

The next segment contains a series of structural and non-structural plan alternatives that meet in whole or in part a suitable solution to a defined problem or objective. The alternatives relate both to the hydrogeological nature of the two counties, as expressed by eight distinct zones, and to the marine surface waters. Strong efforts were made to include all reasonable alternatives. In this fashion the public has a general scenario of the many ways in which waste treatment can be addressed, with some explanation of the constraints attendant to each solution, and the consequences thereof.

Section Four—Environmental Assessment—relates the environmental impacts for each of the Plan alternatives discussed in Section Three.

Section Five—Citizen Participation—is a two-part discussion of citizen participation. The first portion (5.0—5.5), written by the Project Director, contains a history and critique of the creation, functions, activities and contributions of the CAC. The second portion (5.6—5.11), prepared by the CAC, discusses their critique of the process and planning options developed in the 208 Program.

Section Six—Preferred Plan Alternatives—presents the options deemed by the TAC to achieve the objectives of water quality planning for Long Island in the most desirable fashion. Explanations and reasons for the selections are discussed.

Section Seven—Implementation—contains the recommendations for management responsibilities—existing, modified or new—to carry out the financing, design, construction, maintenance, monitoring or regulation of the Plan elements. Recommendations for amendments to existing laws or the enactment of new ones at various governmental levels are also mentioned.

Appendix A—Modeling—contains a synopsis of the various models used in the 208 Study to simulate the natural groundwater and surface water systems, and to allow the technicians to test a wide range of options as though the environment was undergoing stress. Some of the models were specifically designed to furnish responses for geographically specific areas, (the South Fork study by Princeton) or for specific contaminants (the CES nitrate study).

Appendix B—Bibliographic Data Summary—identifies the range of data used to reach the plans' conclusions. It also contains a listing of the almost 175 reports and publications prepared by the TAC agencies and consultants in the conduct of the study.

Appendix C—Memoranda of Agreement—contains the two statements of agreement between the Suffolk County Departments of Health Services and Environmental Control.

Administrative Observations

The Section 208 effort discussed herein has proven to be challenging and rewarding. Since the Program is entirely new from a national point of view, it can serve as an example for other parts of the nation. An indication of the strengths and weaknesses, successes and failures resulting from this initial effort can assist in the formulation of continuing programs to be carried out in this Region and in other parts of the country.

Among the strengths, we would have to acknowledge the strong interest and support received from Region II of EPA. They have recognized that

Nassau and Suffolk have: a dependence on groundwater for potable water supply; a varied and complex marine environment surrounding the entire Region; areas of human settlement that represent the full triad of planning concerns, *i.e.*, urban, urban-suburban interface, suburban-rural interface, and the impact of all three on the natural environment. This recognition on the part of EPA yielded sufficient funds well beyond the normal allocation formula to carry out the Program.

Second was the full cooperation in the best professional sense, of the various members of the TAC who represented organizations with sometimes strong and differing institutional biases. Third, we also have to acknowledge at this point the very high caliber of talent that exists in public service at all levels of government which is evidenced in the results of this Study. A fourth factor was the impartial selection of consultants by the TAC without any external political or parochial controls to inhibit its national search for the most competent firms. The fifth aspect was the establishment of a strong CAC who were self-organized and not hand selected by the agency.

The weaknesses of the Program were primarily of an administrative and timing nature. Two major limitations were imposed by the insistence of EPA on plan completion, including approval by the Governor, within a two-year planning period. Although the Act requires Plan development within twenty-four months, provisions existed for project design prior to this phase for up to twelve months. EPA determined to dispense with the pre-planning opportunity. In a sense this fiat is the antithesis of the planning concept itself. The Agency was forced to "learn on the job," thus creating plans by work assignment amendments. The problem was further compounded by the changes in guidelines, regulations and reporting procedures imposed by EPA after the contract and original work program were agreed upon and approved. In essence, EPA was also "learning on the job."

The remedy for these time constraints was either to curtail some of the work efforts or to rigorously manage the productivity of staff and consultants. We chose the latter course, thus placing all of the participants under constant pressure. This in not an optimal administrative choice.

The second shortfall may develop at the end of the planning period. Implementation, in the full sense of the term, often can take as much time as the Plan development process itself. If the intent is to achieve the sincere acceptance and approval of the general public and various elected and appointed officials—and not be the result of default—then the planners and CAC members must have adequate opportunity to present the case. This was attempted in part during the two year period. The Project Director delivered nearly 50 presentations to various governmental, professional, civic, environmental and business groups in the two counties. Other members of the TAC, CAC, and consultants also made many presentations. However, the Plan options themselves could only be finalized at the end of the planning process. Thus, the public information phase has to extend beyond the first two years. This is particularly the case in a Region of almost three million people. One, or even several, "public hearings" are simply not adequate.

The Act also prohibited any work that might have been deemed research, thereby requiring agencies to use only existing techniques. Strict interpretation of this clause served to limit the comprehensiveness of the Study. A detailed example of this last point is discussed in *Section Five—Citizen Participation.*

Lest this litany of pitfalls, pratfalls and problems be deemed a dire prediction, let me stress that I do consider the 208 Program as a challenge and opportunity. Granted, the first generation of plans may show scars and evidence of misfit between expectation and achievement. Nevertheless, optimism should be the hallmark. The Nassau-Suffolk Comprehensive Water Quality Management Plan does address and satisfy the requirements of Section 208 of the Act.

This is the first national effort to cope with major environmental issues on a multi-disciplinary and interdisciplinary basis as part of comprehensive regional planning. Any successes from the first programs should strengthen future efforts and also provide the methodological base for solving other environmental problems.

February 7, 1978

Lee Koppelman
Project Director

Section I General Background

1.0 Introduction

This section sets the stage for the discussion of the options available to the Nassau-Suffolk Region in coping with the management of its waste treatment over the next two decades. The planning boundaries are described, followed by a brief description of the physical characteristics and the problems of growth resulting from three decades of rapid urbanization. One of the key problems readily apparent is the need to protect and properly manage the groundwater—the sole source of potable water for the two counties. In addition, the quality of fresh and marine surface waters must be protected for both commercial and recreational use. The response to these needs are the essence of this report.

A description of the institutional setting, and a capsule summary of the work elements designed to produce a workable plan follow. The last segment discusses the key water quality and quantity issues.

1.1 Planning Boundaries

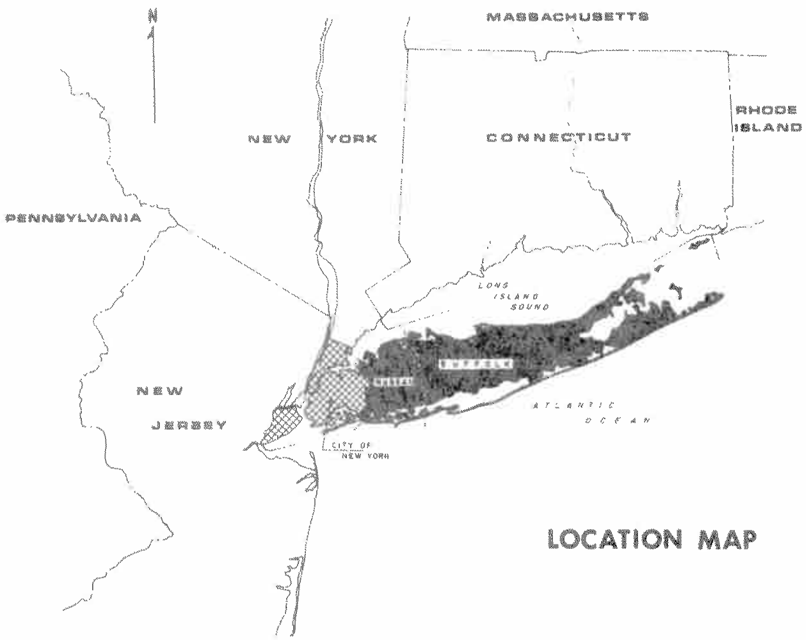
1.1.1 Location. Nassau and Suffolk Counties, occupying one-sixth of the land area of the New York Metropolitan Region, have been two of the fastest growing counties in the United States since the end of World War II. In 1960, the combined Nassau and Suffolk population of two million persons was one-eighth of the total Regional population of sixteen million. It is projected that 25 percent of the additional six million persons that will inhabit the Region by the year 1995 will be living in these two counties. The projected growth of the two counties indicates a potential increase in the impacts on the environment.

The counties, with their streams, lakes, rivers, ocean, bay and Sound frontages exceeding 1,000 linear miles in total, are familiar natural attributes to millions of persons interested in resort and recreation opportunities. Long Island Sound on the north and the Atlantic Ocean on the south and east afford a decidedly unique advantage for the proper development of marine resources. The south shore is paralleled by barrier beaches, which create bays between the south shore of the Island and the ocean from Long Beach on the west to the Hamptons in the Town of Southampton; Jones, Fire Island, Moriches and Shinnecock Inlets connect these bays to the ocean. This portion of the Long Island peninsula is over 100 miles long and 20 miles wide at its widest point, which is near the Nassau-Suffolk boundary. The major land area extends eastward from the Queens-Brooklyn and Nassau County border for approximately 60 miles to Riverhead. East of Riverhead two forks or peninsulas continue eastward, separated by the waters of Peconic and Gardiners Bays. The northern fork terminates at Orient Point and is approximately 27 miles in length. The southern fork terminates at Montauk and is about 44 miles long. The land areas of the two counties is approximately 1,200 square miles. Figure 1-1 depicts the municipal boundaries within the Region.

1.2 Geography

1.2.1 Physical Characteristics. A high ridge of glacial origin running approximately east and west from the northwesterly corner of Nassau County and then running in a southeasterly direction through Nassau from the North Shore reaches an elevation of about 300 feet above sea level. North of the ridge the topography is generally abrupt with an overall slope to Long Island Sound. South of the ridge is a long gentle slope terminating in the marsh and meadow land which borders the bays on the south. Four main river watersheds are located in Suffolk County. These are the Nissequogue in the Town of Smithtown, Connetquot in the Town of Islip, Carmans in the Town of Brookhaven and the Peconic in the Towns of Riverhead, Brookhaven and Southampton.

The area is mainly composed of unconsolidated deposits of sand, gravel and clay laid down in more or less parallel beds on a hard bedrock surface. The rock floor is tilted downward in a southeasterly direction, so



KEY TO MUNICIPALITIES IN NASSAU AND SUFFOLK COUNTIES

VILLAGES IN NASSAU COUNTY

Town of Hempstead

1. Atlantic Beach
2. Bellerose
3. Cedarhurst
4. East Rockaway
*5. Floral Park (North Hempstead)
6. Freeport
7. Garden City
8. Hempstead
9. Hewlett Bay Park
10. Hewlett Harbor
11. Hewlett Neck
12. Island Park
13. Lawrence
14. Lynbrook
15. Malverne
16. Rockville Centre
17. South Floral Park
18. Stewart Manor
19. Valley Stream
20. Woodsburgh

Town of Oyster Bay

21. Bayville
22. Brookville
23. Centre Island
24. Cove Neck
25. Farmingdale
26. Lattingtown
27. Laurel Hollow
28. Massapequa Park
29. Matinecock
30. Mill Neck
31. Muttontown
32. Old Brookville
33. Oyster Bay Cove
34. Sea Cliff
35. Upper Brookville

Town of North Hempstead

36. Baxter Estates
*37. East Hills (Oyster Bay)
38. East Williston
39. Flower Hill
40. Great Neck
41. Great Neck Estates
42. Great Neck Plaza
43. Kensington
44. Kings Point
45. Lake Success
46. Manorhaven
47. Mineola
48. Munsey Park
*49. New Hyde Park (Hempstead)
50. North Hills
*51. Old Westbury (Oyster Bay)
52. Plandome
53. Plandome Heights
54. Plandome Manor
55. Port Washington North
56. Roslyn
57. Roslyn Estates
*58. Roslyn Harbor (Oyster Bay)
59. Russell Gardens
60. Saddle Rock
61. Sands Point
62. Thomaston
63. Westbury
64. Williston Park

CITIES IN NASSAU COUNTY

65. City of Glen Cove
66. City of Long Beach

VILLAGES IN SUFFOLK COUNTY

Town of Huntington

67. Asharoken
68. Huntington Bay
69. Lloyd Harbor
70. Northport

Town of Babylon

71. Amityville
72. Babylon
73. Lindenhurst

Town of Smithtown

74. Head of the Harbor
75. Nissequogue
76. Village of the Branch

Town of Islip

77. Brigthwaters
78. Ocean Beach
79. Saltaire

Town of Brookhaven

80. Belle Terre
81. Bellport
82. Lake Grove
83. Old Field
84. Patchogue
85. Poquott
86. Port Jefferson
87. Shoreham

Town of Southampton

88. North Haven
89. Quogue
*90. Sag Harbor (East Hampton)
91. Southampton
92. Westhampton Beach

Town of Southold

93. Greenport

Town of Shelter Island

94. Dering Harbor

Town of East Hampton

95. East Hampton

**Incorporated Villages situated within two towns*

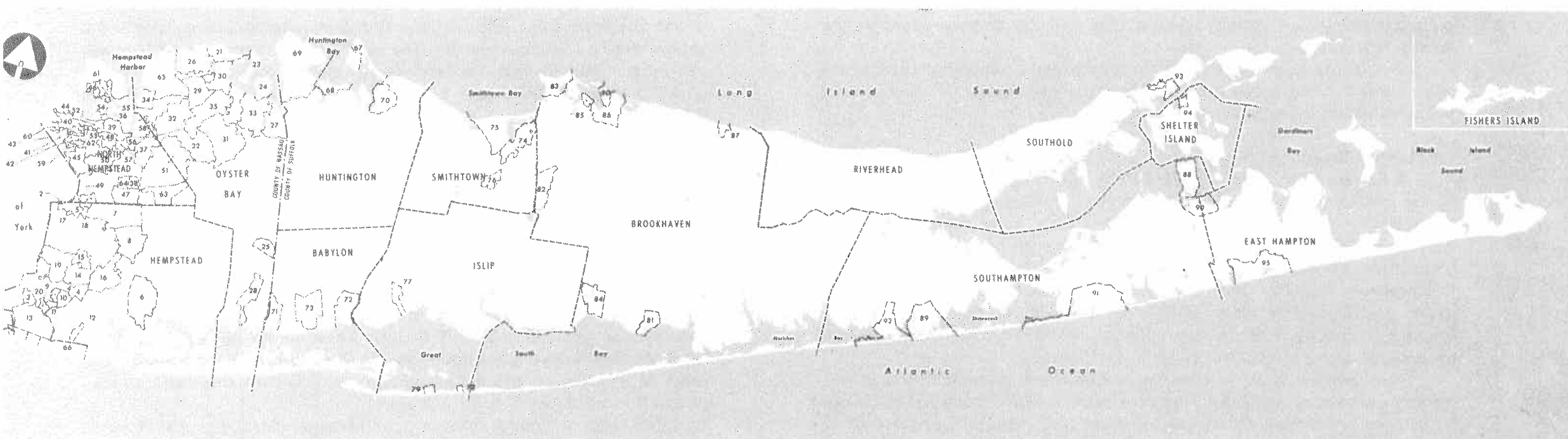


FIGURE 1–1 *Nassau and Suffolk Counties—Municipal Boundaries*

that from a position of surface outcroppings in the northwest end of Long Island (Queens County) it reaches a depth of 2,100 feet below sea level beneath Fire Island. The subsoil is generally sandy and yellow colored except on the ocean side of the south shore dunes, which are of light gray sea sand. The topsoil is particularly suited for agricultural uses in various parts of the Region. Elsewhere the ground is generally covered with scrub growth, mostly oaks and pine. North of the glacial ridge there is an abundance of flora including many of the hardwoods as well as evergreen cover.

Estuarine marshes and the off-shore waters abound in a variety of shell- and finfish. The inland fresh waters, particularly in Suffolk County, have an abundance of trout and other important sport fish.

The water supply for the Nassau-Suffolk Region is obtained entirely from groundwater. Natural replenishment of this supply is derived solely from precipitation (*i.e.*, rain, snow and sleet) which averages 44 inches per year. It has been estimated that approximately 50 percent of the precipitation is lost due to evapotranspiration and other factors, so that only about half of the precipitation reaches water-bearing strata.

1.2.2 Problems of Growth. Obviously, Long Island is an area where the quality of life and large segments of the economy are related to and dependent on the quality of its environment. Tourism, agriculture, seasonal homes and residential communities, thrive in areas of healthy and aesthetically attractive natural settings. There are a number of major surface and groundwater pollution problems. Marine water problems include excessive nutrient enrichment and the closing of beaches and shellfishing areas due to bacterial contamination, which is attributed to both point and non-point sources of pollution. Some portions of the fresh water streams have dried up and others are threatened because of lowered groundwater levels due to sewering and excessive well pumpage. Groundwater quality has been degraded by nitrates, chlorides and other contaminants from fertilizers, recharge of domestic and industrial wastewater, landfill leachate, and stormwater recharge. Water quality—both potable and marine—is the key to Long Island's future. Planning for the orderly growth of these communities and the management of their wastes is the linchpin that will determine the quality of the future.

In response to earlier perceived growth problems, *e.g.*, residential sprawl, transportation deficiencies, rapidly changing community characteristics, increased deterioration of older downtowns and housing, and shortages of community facilities, the Boards of Supervisors of Nassau and Suffolk Counties created the Nassau-Suffolk Regional Planning Board in 1965. This agency's prime task was the preparation of a comprehensive plan that would serve as a guide for all units of government in the two counties for coping with future growth and for reversing the negative aspects of past development.

The Comprehensive Land Use Plan was completed in July, 1970. In essence, it recommended controls on the ultimate size of growth, location and form of development, and institutional changes necessary to achieve implementation. Based on environmental data extant at the time, it was apparent that the most obvious limit to growth was the availability of potable water. It was also apparent that some degradation of these waters had already occurred. However, the projected total population of 3.3 million people by 1995, was less than 60 percent of the estimated population that could be sustained, and it was assumed that the Plan was environmentally prudent.

The Nassau-Suffolk Regional Planning Board also recommended that additional funds be sought to conduct water quality studies in order to insure that the two counties' sole source of potable water not be jeopardized. The advent of the 1972 Amendments to the Water Pollution Control Act (PL 92-500), and particularly the Section 208 planning provision, furnished the answer to this quest. In the next section, a brief discussion of the planning program will indicate the nature of the designation process and the organization of the technical staff and will identify the major substantive elements in the Program.

1.3 Institutional Setting

1.3.1 Designation. The 1972 Amendments to the Act provide that the Governor may designate regional planning agencies to engage in 208 planning. Where such agencies are not designated, the State is required to assume the planning responsibility. Several of the operating agencies in Nassau and Suffolk Counties, and the Nassau-Suffolk Regional Planning Board expressed interest in this designation. The two County Executives agreed that the Board should be the applicant.

All agencies that wished to be eligible for 100 percent funding had to receive designation before January 1, 1975 and receive contractual approval from EPA prior to July 1, 1975. In late November 1974, a preliminary work program was quickly assembled and a designation request was made to the Governor. On December 28th, Governor Malcolm Wilson gave the first designation in the State of New York to the Board.

1.3.2 Technical Staffing. The Program represents a joint effort of the Board and various regulatory, operating and planning agencies in Nassau and Suffolk Counties. A Technical Advisory Committee (TAC), with seven voting members, was formed. The Nassau Departments of Health, Public Works, and Planning were matched by representatives from the Suffolk County Water Authority and the Departments of Health Services and Environmental Control. The Executive Director of the Board, who is Project Director for the Program, serves as the Chairman of the TAC.

In addition, the New York State Department of Environmental Conservation, Region II of EPA, and the Interstate Sanitation Commission also provide representatives to serve as non-voting resource persons. The TAC is composed totally of professionals. It was organized in this fashion with the recognition that the agencies with the responsibilities for carrying out portions of the Plan should have the opportunity to participate in its formulation. Also these participants represented the cumulative local expertise and knowledge base at the onset of the Program.

Preparation of a detailed work program was the initial work conducted by the TAC. At first, a list was compiled of each agency's recommended projects. Much culling, additions, deletions and alterations occurred as the items were compared with the requirements and/or limitations of the Act. The document finally submitted to EPA and the State for contract approval was reduced from $17 million to $5.2 million during this iterative design stage, and quite faithfully adhered to the requirements in the Act.

A secondary concern during this pre-planning period was expressed in regard to the work to be conducted by consultants where specialized talents and equipment were needed. The TAC followed the procedure mandated by the Board, and sole source contracts were awarded only to those governmental and/or academic institutions that had a unique talent. In all other cases, the TAC prepared "Requests for Proposals," which were advertised nationally. This procedure was followed in order to secure the best talents in the country. Although this technique was time-consuming and often onerous, it has proven meritorious. The consultants were selected by the voting members of the TAC based on the technical merit of their proposals. Budget information was kept sealed until each selection was made.

1.3.3 Work Elements. The general goals of the Program to achieve water quality criteria established by Federal and State laws require an extensive knowledge of: the existing and proposed land uses and demography of the Region; the quantity, quality and hydrology of the ground and surface waters, including inter-relationships between both; the types, sources, amounts and impacts of contaminants entering the waters; the alternative technologies best suited to address any specific problems; the legal, fiscal and institutional arrangements, and the laws, agencies and regulations needed to implement the completed Plan. This aspect will be discussed in the implementation section of this report.

The Comprehensive Land Use Plan released by the Nassau-Suffolk Regional Planning Board in 1970 still serves as the basic guideline for growth in the two counties until 1985–1990. The Plan has been updated over the past three years as a result of a United States Department of Housing and Urban Development assisted project that involved the development and testing of a methodology for the integration of coastal zone science with the planning process. Fortuitously, only minor modifications were indicated to enable the Plan to meet specific environmental needs. This affords a strong advantage to the two counties' likelihood of producing a workable waste management plan—the land use plan already exists. Thus it is much easier to develop and test two major management approaches. If we assume that the land use plan will be realized, then it becomes a task of estimating the contamination loadings that will result from the various land uses and recommending treatment facilities, *e.g.,* sewers, treatment plants, etc. Conversely, the land use plan can be modified and population densities altered to avoid the need for structural solutions. Both approaches are examined in this Program.

Comprehensive water supply studies were conducted in each county during the 1960's and early 1970's. These studies evaluated the possible changes in groundwater quantity that might result from the implementation of various wastewater treatment proposals. The United States Geological Survey, which was chosen as one of the public agency consultants by the Board because of their extensive knowledge of Long Island's groundwater, has conducted studies in the bi-county area for many decades. During recent years, the Survey developed an electric analog model, which simulates the physical characteristics of the groundwater system. This model was used in the 208 Study to simulate water level responses to a number of hypothetical water-management options.

Water quality problems are usually of significantly greater complexity than questions of water levels or of water quantity. Investigations and monitoring programs are generally conducted for the purpose of providing information on ambient groundwater conditions, as well as of examining the adverse effects of known or suspected sources of pollution, and to assess water quality improvements attributable to correction measures (*e.g.,* sewers). For example, in the past, studies have been conducted addressing the impacts of individual on-lot sewage disposal systems, landfill leachate, detergents, sewage treatment effluent recharge, stormwater recharge, meteorological conditions, fertilizers and pesticides. The pollutants monitored were limited to those considered relevant to public health and natural resources, for which reliable monitoring procedures were available.

During the past few years, the increasing awareness of the presence of additional hazards to public health and natural resources, as well as the continuing development of sampling and analysis techniques, have resulted in the monitoring of additonal substances, *e.g.,* viruses and organic chemicals. The 208 Program included a study of organic chemicals, heavy metals and viruses in wastewater and groundwater in the bi-county area. Water sample locations were carefully selected to reflect the influence of various types of land use and wastewater activities. Samples were analyzed for heavy metals, organics in trace amounts and viruses.

In order to provide simulation capabilities for water quality evaluations, the Department of Civil Engineering of Princeton University was retained to adapt and apply existing digital models (one, two and three-dimensional) to simulate the impacts of various groundwater levels on saltwater intrusion, and further groundwater pollution. The modeling runs are paralleled with quality evaluations based on empirical data and related literature. The work also included a digitization of the Geological Survey's analog model to facilitate the testing of management alternatives.

Similar emphasis was placed on questions of surface water quality. Various estuarine steady-state and time-variable models were applied to specific bodies of water to estimate the effects of various waste treatment schemes on receiving water quality.

The reliability of model results bears a direct relationship to the accuracy of pollutant loadings input into them. Point sources of contamination have been routinely identified and tested. In the past this was sufficient because wastewater studies were directed towards engineering solutions to these sources of contamination. Much of the current planning effort is also concerned with non-point sources of pollution—stormwater runoff, sedimentation, uncontrolled deposits of animal wastes, etc. Several responses to these more pervasive and usually unquantified sources were included in the Work Program. The Cooperative Extension Service conducted field studies and literature searches to identify and evaluate the volumes of pesticides, fertilizers and other home and agricultural chemicals used in the two counties. The impact of nitrogenous fertilizers, relative to other sources, was evaluated in part by means or a preliminary regional nitrogen balance. The Suffolk County Soil and Water Conservation District identified other non-point pollution problems associated with various animal populations, runoff and sedimentation. In addition, the two County Health Departments, the Suffolk County Department of Environmental Control (which was already engaged in a study of fertilizers), the Suffolk County Water Authority, and the Town of Islip Department of Environmental Control, all contributed substantially to the sampling and analysis of non-point sources.

The information gathered from the sampling and analysis programs served as inputs for the determination of engineering and non-structural alternatives for the achievement of water quality objectives. This approach afforded the broadest possible array of policy choices as to method, location, timing and cost of solutions.

The alternatives and their consequences have been considered by the TAC for the purpose of selecting the most viable combinations of solutions—structural and non-structural—that in the aggregate form the Comprehensive Areawide Waste Treatment Management Plan for Nassau and Suffolk Counties. The Citizens Advisory Commitee (CAC) has also reviewed and contributed to the final product. In some instances where more than one solution is viable, or where a consensus was not achieved, this report mentions the array of choices.

1.4 Regional Ground and Surface Water Considerations

Within the overall framework of the 208 Program, major technical issues have arisen which have had to be addressed as part of the Study. This segment of Section One includes a discussion of the major considerations. It relies upon the previous segments to describe the regional setting and then discusses ground and surface water uses, and quantity and quality problems. The segment is concluded by generalized descriptions of management options, which may be applicable to the Bi-county Region. It is presented to effect a transition between the planning issues and the scientific/engineering considerations.

1.4.1 Groundwater

1.4.1.1 Major Uses. Groundwater beneath Nassau and Suffolk Counties is the only source of potable water for almost three million people. Pumpage and use characteristics within the Region are complex and fragmented. The user of groundwater can be a single facility operating its own domestic well on a small parcel of land, a large water district with a dozen individual high capacity wells located miles apart in several different communities, a private water company with a single well field serving one subdivision, or an industry partially supplied by its own well system and partially dependent on a local utility. Thus, pumpage for different well owners can range from a few hundred gallons to many millions of gallons per day.

The use of water withdrawn is equally varied. Groundwater pumpage satisfies not only domestic requirements, such as drinking water, but also must meet the needs of industry, commerce, agriculture and recreation.

Water supplies are developed principally from two major water-bearing units: the Upper Glacial and Magothy aquifers. A relatively unexploited third aquifer, the Lloyd, lies beneath the upper two formations, and is separated from them by a thick, confining bed of clay. Total withdrawal from all aquifers now approaches 400 MGD (million gallons per day).

The pattern of pumpage is not uniform. The development of multiple sources of supply, even when not necessitated by fragmented supplies, was deliberate in order to more uniformly withdraw from the system and then minimize the disruption of equilibrium conditions. Major concentrations of pumpage have been developed near areas of dense population, leaving other portions of the subsurface reservoirs underutilized. This has resulted in a pronounced east-west imbalance in pumpage distribution. Also, degradation of water quality in the Upper Glacial aquifer beneath urbanized areas has led to the abandonment of shallow wells, in favor of withdrawing water from progressively deeper aquifer zones. Thus, the principal water supply aquifer in Nassau County and western Suffolk is the Magothy, whereas the principal water supply aquifer in eastern Suffolk County is the Upper Glacial.

Groundwater discharge supports streamflow for most of each year. The volume of groundwater underflow discharged to surrounding saltwater bodies can affect surface water salinity. Relatively small fluctuations in water table elevations, on the order of a few feet, can cause pronounced changes in stream discharge. On the other hand, underflow to saltwater bodies is not very sensitive to such fluctuations. It has been estimated that substantial changes in consumptive use of groundwater in the Region would be required to significantly affect underflow.

A certain amount of underflow is also needed to maintain the fresh-salt water interface at an equilibrium position. The position of the boundary between fresh and saline groundwater is dependent upon changes in water levels in the various aquifers. However, the fresh-salt water interface is generally some distance offshore in the confined aquifers of Long Island. Therefore, changes in head at the interface, resulting from reductions in natural recharge or increases in pumpage and consumptive water use, are generally small and localized. Inland movement of saline groundwater is very slow, even in areas where the interface is already on shore and in close proximity to centers of pumpage.

1.4.1.2 Existing Quality. The quality of groundwater in the aquifers of Long Island is dependent upon a number of factors. In undeveloped areas, recharge from relatively good quality rainfall, together with whatever natural treatment and pollutant retention is provided by the vegetation, soils and geologic sediments have resulted in the availability of very high quality groundwater in the underlying aquifers. Where the land has been subjected to heavy use or modification by man, groundwater quality has been degraded. The degree of degradation is dependent upon the type of land use; the location of individual sources of contamination, such as cesspools and landfills; the characteristics of the contaminants; and the length of time that the waste disposal practice has been in existence.

Groundwater quality is also extremely dependent upon hydrogeologic factors. Recharge to the Magothy from the water table or Upper Glacial aquifer occurs over a large area along the central east-west corridor of the Island. This region, where groundwater movement is generally vertically downward and unimpeded by intervening clays, is commonly referred to as the Magothy recharge area. Therefore, sources of contamination discharging to the water table can migrate downward to the underlying Magothy.

Deep flow also occurs in portions of the Upper Glacial deposits to the north of the limits of the Magothy recharge area in Nassau and western Suffolk.

Along the South Shore and parts of the North Shore groundwater movement is generally horizontal or upward, and intervening clays inhibit downward movement of groundwater, even where heavy pumping is taking place. This region is referred to as the Magothy discharge area. Groundwater quality is considerably more vulnerable to land use changes and sources of contamination in recharge areas than in discharge areas.

Another factor affecting groundwater quality over the long term is the slow movement of groundwater, especially in the vertical component. Under natural conditions, it takes about 100 years for water from the surface to reach the lower portion of the Magothy in the center of the Island. Heavy pumpage in the Magothy can reduce this time period to about twenty years. Thus, sources of contamination can be eliminated (for example septic tanks and cesspools replaced by sewers) but the effects on deeper aquifers may not be noticeable for many decades. In the Upper Glacial aquifer the effects of pollutants and of remedial measures are realized much faster.

Actual groundwater quality problems in the 208 Region have been characterized by a significant rise in nitrate concentrations in portions of the recharge area of the Magothy aquifer. Also of importance is the discovery of organic chemicals in sections of the two counties in both shallow and deep aquifers. Several independent analyses of nitrate trends in shallow groundwater and in the Upper Glacial aquifer were completed during the period in which the 208 Program was conducted. From this work, it is difficult to make clear-cut generalizations regarding statistically calculated trends, especially with respect to making distinctions between sewered and non-sewered areas. However, there is general agreement that nitrate concentrations are decreasing in many shallow wells in southwestern Nassau County where sewering took place in the 1950's and early 1960's. In unsewered eastern Nassau, one of the analyses also found generally decreasing nitrate trends, while another failed to find a trend. Water in shallow wells in southwestern Suffolk has generally increasing concentrations of nitrate. On the basis of limited data, it appears that the quality of the underlying Magothy has not improved. In Nassau County, the Magothy has apparently sustained an overall decline in water quality.

Individual sources of contamination, such as landfills and industrial waste recharge basins, have developed discrete bodies of contaminated groundwater. These plumes of contaminated water are isolated, but are of extreme importance locally. Analysis of organic chemicals is a new effort, and, thus far, no trends can be developed from the very limited data collected.

1.4.1.3 Contamination Sources and Identification of Control Needs. There are many sources and causes of contamination in the 208 area. Basically, these can be divided into four categores (Table 1—1). The first two categories include discharges of contaminants that are derived from solid and liquid wastes. The third category concerns discharges of contaminants that are not related to wastes, and the fourth category consists of those causes of groundwater contamination that are not discharges at all.

The variety and type of controls available for each category differ. For example, some Category I causes may require a discharge permit, whereas others may be controlled by restrictions on land use. Sources under Category II may require satisfaction of specified construction standards, such as the lining of landfills and the installation of leachate collection systems. Guidelines and manuals (*e.g.,* tons/lane-mile limits on highway deicing salts) may be the only tools available for dealing with Category III. Special types of regulatory controls are available for the causes of groundwater contamination listed under Category IV. An example is the current system of groundwater diversion applications and hearings employed to minimize saltwater encroachment. Another is the continued licensing of drilling contractors in order to upgrade waterwell construction practices.

The protection of groundwater quality involves both the elimination or mitigation of existing problems, and the prevention of new ones. Control needs will vary depending upon the nature and location of the source of pollutants, and upon the prevailing background or baseline conditions.

In the case of an established industrial source, the imposition of effluent controls and monitoring to assure compliance may be the best approach. Where the pollutant generating activity is a necessary one that is not readily controlled by traditional permitting systems, as in the case of landfills,

TABLE 1–1
CLASSIFICATION OF SOURCES AND CAUSES OF GROUNDWATER CONTAMINATION USED IN DETERMINING LEVEL AND TYPE OF CONTROL

Category I	Category II	Category III	Category IV
Systems, facilities or sources designed to discharge waste or wastewaters to the land and groundwaters.	Systems, facilities or sources not specifically designed to discharge wastes or wastewaters to the land and groundwaters.	Systems, facilities or sources that may discharge or cause a discharge of contaminants that are not wastes to the land and groundwaters.	Causes of groundwater contamination that are not discharges.
Domestic on-site waste dispoal systems	Sanitary sewers	Highway deicing and salt storage	Airborne pollution
Sewage treatment plant effluent	Landfills	Fertilizers and pesticides	Water well contruction and abandonment
Industrial waste discharges	Animal wastes	Product storage tanks and pipelines	Saltwater intrusion
Stormwater basin recharge	Cemeteries	Spills and incidental discharges	
Incinerator Quench water		Sand and gravel mining	
Diffusion wells (heat)			
Scavenger waste disposal			

relocation to an area where the aquifer is already degraded, and no longer used for water supply, may be appropriate. The prevention of degradation in relatively pristine areas may require a management program that employs a combination of land use and other non-point source controls to prohibit or severely restrict the development of potential pollutant sources.

1.4.2 Surface Water

1.4.2.1 Major Uses. Surface waters on Long Island provide a variety of beneficial uses. Fresh waters, including streams and lakes, are used for aesthetic enjoyment, swimming, fishing and boating. Marine waters, including bays and estuaries, are used for both commercial and recreational purposes. Shellfishing and finfishing are major commercial enterprises in bays and estuaries. Recreational use includes shellfishing, sportfishing, swimming and boating. In addition, the assimilation capacities of surface waters may allow their use as a major receiving system for waste disposal.

In recognition of the variety of, and sometimes competing, beneficial uses, Long Island marine waters have been classified by the New York State Department of Environmental Conservation as to their potential best usage in the public interest.

The New York State Department of Environmental Conservation classification of best usages for marine waters, in decreasing order of water quality requirements, comprises the following four classes:

SA Waters suitable for shellfishing for market purposes and primary[1] and secondary[2] contact recreation.

SB Waters suitable for primary and secondary contact recreation and any other use except shellfishing for market purposes.

SC Waters suitable for fishing and all other uses, except for primary contact recreation and shellfishing for market purposes.

SD Waters not primarily suitable for recreational purposes, shellfish culture, or development of fishlife and which cannot meet the requirements of these uses.

Notes 1. Primary contact recreation means activities where the body may come in direct contact with raw waters to the point of complete submergence (*e.g.,* swimming, diving, water skiing, skin diving and surfing).

2. Secondary contact recreation means activities where contact with the water is minimal and ingestion of water is not probable (*e.g.,* fishing and boating).

These specific uses are dependent upon naturally functioning marine ecosystems which are commonly characterized by a number of water quality parameters. Two major parameters are dissolved oxygen and coliform bacteria concentrations. Adequate dissolved oxygen is essential to the growth and reproduction of finfish and shellfish. Dissolved oxygen is also required in the natural decomposition of organic wastes. Current public health standards call for low coliform bacteria concentrations since the presence of such bacteria is regarded as an indication of potentially pathogenic contamination due to human or animal wastes.

1.4.2.2 Existing Quality. The tidal flushing of Long Island's North Shore bays is substantially greater than in the South Shore bays or the Peconic Estuary. Because of the greater tidal range in Long Island Sound, a parcel of fresh water or waste discharged to a North Shore bay will be flushed out within one to three days, whereas from one to three months may be required in eastern Great South Bay.

The dispersion and flushing of pollutants within any bay is generally maximum for discharges near the inlet and decreases with distance away from the inlet. Localized pollution problems generally exist where streams or municipal waste discharges enter a bay at a point well away from the inlet.

Within each bay, constituent concentrations are modified by biochemical processes. The parameters of primary concern, which reflect the net result of complex processes, are coliform bacteria and dissolved oxygen concentrations. Levels of these constituents have been established for each bay system by the New York State Department of Environmental Conservation. In addition to these parameters, salinity levels, and the concentrations of non-point sources, are a major source of contaminants to the surrounding marine waters. The degree of contamination derived from a particular stream will depend upon the volume of streamflow, the rate and degree of pollutant input, and the degree of mixing of stream and bay waters. Other sources of marine surface water contamination include pointsource discharges from sewage treatment plants, subsurface inflow from groundwater, discharges from boats, and inputs from adjacent marine waters. In any particular bay, the degree of contamination attributable to those sources depends upon the rate of input of the pollutant and its rate of removal from the system by physical and biological processes.

1.4.3 Management Options

1.4.3.1 Introduction. There are many approaches that can be utilized to manage the ground and surface water quality problems of the Bi-county Region. The more traditional type of program has reacted to existing water quality problems by constructing facilities to ameliorate them. Less traditional approaches are to guide growth and to develop various types of programs which prevent water quantity or quality problems from occurring or to develop solutions which do not include facilities. The former approach can be defined as a structural set of solutions while the latter approach is non-structural in nature. The recommendations of the 208 include implementation of both types of programs.

The 208 has identified and evaluated numerous options and approaches. In some cases, only general evaluations could be performed while at other times, detailed studies were possible. However, the intent throughout has been to identify a viable set of options, both structural and non-structural, which should be studied in detail in more localized studies. This is the key to the relationship between 208 and the more detailed studies (*e.g.,* 201 Facilities Plans) in the Nassau-Suffolk area. The 208 must identify the structural and non-structural alternative approaches which are viable on a regional level. The more detailed local studies must start with the regionally satisfactory options and screen them as to their applicability at the local level.

1.4.3.2 Structural Approaches. The structural approach to wastewater management begins with collection of the waste. Water carriage has been and will continue to be the method of waste transportation in the Nassau-Suffolk Region for all wastes except certain special hazardous wastes. Sewers will be used whether the wastes are conveyed to large regional facilities or to smaller local or sub-regional plants. Modifications such as pressure or vacuum systems may be used in local situations.

The 208 Program has analyzed alternative collection concepts and has determined that vacuum and pressure collection systems should be evaluated in local studies. The comparison to traditional gravity collection should be made on the basis of construction cost, operation and maintenance costs and on operational reliability. A concern of the 208 is the energy consumption, on a continual basis, of pressure or vacuum systems. As energy costs continue to increase, and as energy resources become increasingly limited, vacuum or pressure collection systems become increasingly less attractive.

Structural treatment options are generally grouped according to the types of wastes that they process. Domestic sewage, for example, is one type of waste, industrial waste, another. A number of processes, both biological and physical/chemical, are available for the treatment of domestic sewage (activated sludge, activated carbon filtration, etc.) and other systems have been proposed or tried on an experimental basis (*e.g.,* spray irrigation, marsh-pond system, etc.). It is worth noting that all biological systems, including conventional biological treatment as well as spray irrigation and marsh-pond, are variations on a single theme, differing in design details such as scale, layout and treatment efficiency.

Industrial liquid wastes can be divided into two categories: toxic and non-toxic. The non-toxic wastes can be handled in the same manner as domestic sewage. The toxic wastes are almost exclusively handled by physical/chemical treatment processes.

Stormwater runoff is difficult to treat by structural approaches because of high and variable flow rates. Sedimentation and disinfection may be feasible options.

The 208 Program has investigated various treatment options and has determined that two of the newer concepts should be tested in a situation where the processes would receive no more than normal operating attention. The marsh-pond treatment process will be tested by Suffolk County at the Village of Greenport sewage treatment plant site (1978 funds approved). Although design procedures and criteria will be obtained during this test, normal operation by plant personnel rather than control by an engineering staff will be used. Similarly, improved septic tank systems, which de-nitrify the waste, should be tested in a small development. Once these systems have operated satisfactorily through all seasonal conditions, and procedures for design and implementation are obtained, their use as potential alternatives to conventional systems can be considered.

The treated effluent and sludge, which includes domestic industrial and hazardous wastes, must be disposed. The normal disposal methods for treated effluent are sea or bay disposal, recharge to the ground, stream augmentation or land surface application. The options available for sludge disposal include barging, various types of incineration and land disposal either on Long Island or outside the area. EPA regulations, however, call for the cessation of ocean dumping of sludge by 1981. The selection of any of these disposal techniques depends upon the toxicity of the waste, cost-effectiveness and the degree of desired protection of ground and surface water quality.

1.4.3.3 Non-Structural Management Options. Non-structural management options identified in this Program relate to the control of potential sources of pollution. They may be categorized as follows:

a. Options to prevent the establishment of sources
b. Options to better manage existing sources
c. Options to eliminate existing sources.

Land use controls can be used to prevent new sources of pollution from arising. An activity may be prohibited, or it may be permitted to develop in a controlled manner consistent with environmental objectives.

Good management practices can minimize pollution discharges. For example, in areas of low soil permeability, septic systems may malfunction as a result of septage not being periodically pumped from the tank. Hence an appropriate management policy may be to require pumping according to a formally required procedure. Likewise, wastes from domestic animals on streets and highways may constitute a major source of contamination in storm drainage water. A non-structural option may be to prohibit littering or to require owners of dogs not to allow their dogs to defecate where water pollution might result. Regular sweeping of streets would also limit the amount of pollutants transported in stormwater.

Another management practice that may be particularly relevant to Long Island is to encourage the use of fertilizers and pesticides at levels not exceeding the requirements of cultivation. Thus householders could be encouraged to adopt "low maintenance" methods of cultivating lawns as opposed to growing species of grasses that demand high levels of water and chemicals for their maintenance.

If use of inorganic fertilizers by householders were to be banned outright, the ban would constitute an example of the total elimination of a potential source of contamination. Such bans are difficult to implement. However, Suffolk County's recent prohibition of the sale of non-biodegradable synthetic detergents is an example of a successful management attempt to eliminate an existing pollution source. Likewise the prohibition of chronically toxic and persistent pesticides such as DDT has begun to reduce the levels of these chemicals in the environment. Similarly, certain organic materials should also be controlled. The substitution of less harmful materials in place of such organic chemicals may provide a partial, non-structural solution.

1.4.3.4 Legal/Institutional. Another set of possible management options deals with the formulation of legal and institutional programs. These types of approaches might include:

—strengthening of existing laws or regulations
—enacting new laws or regulations
—restructuring of existing county and town level agencies
—establishment of new agencies
—elimination of existing agencies
—redefinition of responsibilties.

The thrust in these types of management options is to ensure that proper regulatory power exists, that regulation and operation of facilities do not conflict, and an adequate system of monitoring and control is available.

An institutional approach recognizes that improvements can be made in the administration and implementation of water quality management programs. It recognizes the need for improved communication between operating agencies and for a clear definition of responsibilties.

1.5 Summary

Nassau and Suffolk Counties together form a region of about 1,200 square miles, having a total of more than 1,000 miles of ocean and bay shoreline, lakefront and river edge. The area's subsoil is mostly sandy, and groundwater is the sole source of potable water. Precipitation averages 44 inches per year, of which approximately one-half is lost to the atmosphere and to the surface waters by evapo-transpiration and runoff.

Long Island's environment possesses a particular importance, because the area is an important place of resort for vacationers and sportsmen of all kinds. Its waters and marshes abound in shellfish and finfish of many varieties, and its coastline offers esthetic pleasure to many.

The quality of this environment, however, is beginning to suffer from problems due to growth. In areas of more intense development, marine water quality is deteriorating from the discharge of excessive quantities of nutrients. Beaches and shellfishing areas have been closed to the public because of bacterial contamination. In certain locations, heavy pumping of groundwater and the installation of sewers with disposal to marine surface waters have caused a permanent drop in the water table, with the resulting drying up of parts of streams. Groundwater quality, in parts of the Region, has been degraded by pollutants from excessive fertilizer application, the recharge of domestic and industrial wastes, landfill leachate and stormwater recharge.

The dangers of uncontrolled development have been recognized for a long time, and the Nassau-Suffolk Regional Planning Board issued a Comprehensive Land Use Plan in 1970. Since then, Congress has recognized the need for more detailed studies of water pollution problems in many areas, and, in 1972, passed the Federal Water Pollution Control Act Amendments. Under Section 208 of this act, funds have been made available to study the Region's waste disposal and water supply problems, and to devise a plan for their solution.

The plan will include a combination of many management options, which can be categorized under the following three headings:

a. Structural, *e.g.,* the installation of collection and treatment systems, etc.
b. Non-structural, *e.g.,* passing ordinances for the control of animal wastes, instituting special practices for minimizing runoff at construction sites, carrying out public education programs concerning the correct use of certain materials in agriculture and in the home, and so on.

c. Legal/Institutional, designed to improve the administration and implementation of water quality management programs.

Some of these options will have areawide applicability, others will be determined by the specific needs of each locality. In combination, they will protect the Bi-county Region's esthetic and recreational values, and ensure a healthy and adequate water supply for the foreseeable future.

Section 2 Assessment of Conditions

2.0 Introduction

Current land use patterns in the nearly 1,200 square mile Nassau-Suffolk Region have been influenced by the counties' geographic location within the New York Metropolitan Area and by the historic trends that that have affected the development of Long Island during the more than three centuries since the first colonial settlements were established in the east end towns of Southampton and Southold.

The earliest settlements clustered around the harbors since Long Islanders were dependent upon the sea for food and for the transport of farm products and wood to the New York City market. The construction of the railroad during the second quarter of the nineteenth century provided impetus for the expansion of farming and for the establishment of new settlements along its route. Decades later, vacationers, increasingly aware of the recreation resources of the Atlantic and Long Island Sound shores, began to come by train or boat to the older villages and to the new resort developments that preempted attractive and accessible shoreline sites in such places as Long Beach, Massapequa, Sea Cliff, Glen Cove, Cold Spring Harbor and Huntington. Soon suburban enclaves appeared in still semi-rural western Nassau County as hardy commuters took up residence in proximity to the railroad stations. Completion of an East River tunnel in the early twentieth century speeded rail travel between Manhattan and Long Island and further spurred development of the communities along the North Shore, main line and South Shore branches of the railroad throughout Nassau and into western Suffolk. Before World War I, and especially during the 1920's, wealthy people purchased large tracts of land and built the mansions, gardens and private clubs that gave rise to the characterization of the North Shore area from Great Neck to Huntington as the "Gold Coast." Others established similarly luxurious weekend or vacation retreats in scattered locations along the South Shore or built summer "cottages" in the seasonal "Gold Coast" colonies in the Hamptons. The less affluent acquired small parcels and built cabins or tiny cottages in the presumably healthful wooded areas around Lake Ronkonkoma and along the moraine or in such shorefront communities as Bayville, San Remo, Babylon, Lindenhurst and Mastic Beach.

As early as the mid 1920's, increased mobility provided by the automobile permitted the expansion of older settlements. However, the Great Depression and, shortly thereafter, World War II brought new construction to a virtual standstill and set the stage for the explosive growth that was to follow the end of hostilities.

Commencing in the late 1940's, new household formations and a backlog of unsatisfied housing needs generated previously unknown levels of construction activity, first in central and eastern Nassau, then in western Suffolk. Increased population brought a need for vastly expanded services and provided a skilled labor force for Long Island's growing defense and high technology industries. Farms and woodlands, older homes and estates gave way to the schools and universities, the offices, stores and shopping centers that accompanied the eastward spread of residential development.

By 1975 growth had just about halted in Nassau and had slowed markedly in western Suffolk. According to the most recent estimates, less than two percent of the land area of Nassau and about 30% of the land area of Suffolk remains vacant. Approximately 95 percent of the vacant land in Suffolk is in Brookhaven and the five eastern towns. The Census Bureau's line indicating the eastern limit of the urbanized area was located in central Brookhaven in 1970, but has now been redrawn to include Long Island's most rapidly developing areas in central and eastern Brookhaven.

2.1 Land Use in the 208 Planning Region

2.1.1 Summary of Existing Land Use Patterns

2.1.1.1 General. The information on existing land use, which has been furnished to the 208 consultants in considerable area-specific detail, was obtained by updating older land use maps through the use of aerial photography, office records and, where necessary, field checks. Computerized tabulations of land use on a 1440 acre grid cell basis are available at the Planning Board. Table 2–1 presents a summary of the land use data, as of 1975.

More than three-fourths of the land area in the 208 Planning Region is built up or otherwise committed, with 44.5 percent in residential and 31.7 percent in non-residential uses. The latter category includes agricultural uses, which occupy about 5.8 percent of the bi-county acreage. Virtually all of the agricultural lands are located in Suffolk County, which has undertaken a multi-million dollar program to preserve at least two-thirds of the existing farmland through the purchase of development rights.

There is little, if any, opportunity to affect water quality or the need for sewer construction through changes in proposed land uses in Nassau

Table 2–1

THE NASSAU-SUFFOLK 208 AREA: PERCENTAGE OF LAND AREA IN VARIOUS USES, BY TOWN AND COUNTY, 1975

	RESIDENTIAL					NON-RESIDENTIAL							
Locality	High Density	5–10/D.U. per acre	2–4/D.U. per acre	0–1/D.U. per acre & Low Density	Total Residential	Industry	Commerce	Utility and Landfill	Agricul-ture	Institutional & Open Space	Total Non-Residential	Vacant	Total Land Area
Nassau													
N. Hempstead	4.6	20.5	19.5	25.5	70.1	2.6	6.3	0.3	–	17.8	27.0	2.9	32,828
Hempstead	4.1	56.1	1.0	1.0	62.2	0.9	6.7	0.4	–	28.4	36.4	1.4	77,413
Oyster Bay	1.4	19.5	14.4	30.4	65.7	2.8	3.9	0.4	–	25.4	32.5	1.8	69,275
County Total	**3.1**	**35.5**	**9.6**	**16.8**	**65.0**	**1.9**	**5.6**	**0.4**	**–**	**25.3**	**33.2**	**1.8**	**179,516**
Suffolk													
Huntington	0.3	7.0	21.8	42.5	71.6	1.2	3.3	0.7	–	17.7	22.9	5.5	59,227
Babylon	3.2	38.4	9.1	–	50.7	5.8	3.6	2.3	–	33.5	45.2	4.1	32,886
Smithtown	0.6	3.6	37.8	22.3	64.3	3.3	3.4	0.3	–	23.3	30.3	5.4	34,160
Islip	1.6	17.9	33.9	6.3	59.7	2.4	2.7	2.9	–	28.6	36.6	3.7	63,909
Brookhaven	0.8	2.7	26.6	11.4	41.5	0.9	1.4	2.1	1.8	18.3	24.5	34.0	163,366
Riverhead	0.3	0.5	4.2	5.6	10.6	0.3	1.0	12.4	45.7	12.8	72.2	17.2	41,462
Southampton	0.2	1.1	6.0	7.7	15.0	0.1	0.9	2.1	12.6	9.0	24.7	60.2	87,100
Southold	0.1	0.8	7.0	6.1	14.0	0.2	0.8	0.1	30.0	9.1	40.1	45.8	30,191
Shelter Island	–	0.9	3.5	5.7	10.1	–	0.8	0.3	0.4	4.3	5.7	84.1	7,603
East Hampton	–	0.3	8.0	4.7	13.0	0.2	0.5	1.8	3.4	17.0	22.9	64.1	46,416
County Total	**0.7**	**6.3**	**18.9**	**12.2**	**38.1**	**1.3**	**1.8**	**2.5**	**7.7**	**18.0**	**31.2**	**30.7**	**566,320**
The Nassau-Suffolk 208 Area	**1.3**	**13.3**	**16.6**	**13.3**	**44.5**	**1.4**	**2.7**	**2.0**	**5.8**	**19.7**	**31.7**	**23.8**	**745,836**

(Percentages may not total 100.0 due to rounding)

Source: Section C of the Areawide Waste Treatment Management Plan.

County. The townwide figures suggest a similar lack of opportunity in the western Suffolk towns of Huntington, Babylon, Smithtown and Islip. The remaining Suffolk towns, sensitive to real or assumed water supply problems and to other "quality of life" issues, have already moved to impose limits on growth through changes in zoning.

2.1.1.2 Residential Land Use. Gross residential densities generally decrease from west to east, with the highest densities in the Town of Hempstead and particularly in older Nassau communities such as the City of Long Beach and the Village of Hempstead. The next highest densities are found in portions of North Hempstead, southern Oyster Bay and southwestern Suffolk. Lower densities are found in much of northern Oyster Bay, Huntington, Smithtown and most of Brookhaven. The lowest densities are found in the remaining estate areas in northern Oyster Bay, in the extreme eastern part of Brookhaven and in the five east end towns of Riverhead, Southampton, East Hampton, Shelter Island and Southold. Residential densities vary greatly within relatively short distances, tending to be higher in the older harbor-related or rail-related communities, even in eastern Suffolk. According to the 1970 census, densities ranged from a high of 22.8 persons per acre in the City of Long Beach to 0.2 persons per acre in the Town of Shelter Island.

Most of the bi-county population resides in single family detached structures on plots of from 1/10 of an acre to several acres or more. The 1970 census revealed that 84.0 percent of the Region's inhabitants lived in single family dwellings, 15.7 percent in multi-family units and 0.3 percent in mobile homes. The percentage of the population residing in single family units was somewhat higher in Suffolk, while the percentage in multi-family units was somewhat higher in Nassau. Mobile home dwellers were virtually non-existent in Nassau and were of local rather than county-wide significance in Suffolk.

Land use studies distinguish five categories of residential use. The first or most intensive category, high density, includes all development at more than ten housing units per acre. In Nassau, the typical high density development averages about 25 housing units to the acre; in Suffolk, about fifteen. Highest densities were found in high rise apartment areas in Long Beach and Hempstead Village, where they reach 200 and 100 housing units per acre, respectively.

The second category, five to ten housing units per acre, is essentially a single family detached or two family category although it occasionally includes apartments in some of the Nassau communities and a few recreation-related or senior citizen condominiums. Areas in the five to ten housing units per acre category account for well over half of the residential acreage in Nassau, and slightly less than one-sixth of that in Suffolk.

The third category, two to four housing units per acre, like the zero to one and the low density (estate or rural) categories, is a single family dwelling category. It is a predominant category in Suffolk where it accounts for almost half of the residential acreage. Much of the newer housing in this category has been built at two units to the acre. In many areas, sewers have already been provided through connections to existing systems or through the construction of a small collection system and treatment plant to serve a single large development or group of developments. In other areas sewers are needed at present or may eventually be required. There appear to be some locations where individual systems are functioning and may continue to function well enough to meet relevant public health criteria. In areas of low density, individual systems can be constructed so that regional groundwater quality will meet drinking water standards.

The zero to one housing unit per acre category and the low density category account for slightly more than one-fourth of all residential acreage in Nassau and slightly less than one-third of all residential acreage in Suffolk.

2.1.1.3 Non-Residential Land Use. The original tabulations, which were furnished to the consultants, listed eight non-residential land use categories: industrial, commercial, institutional, utility, open space, landfill, agriculture and duck farm. For purposes of the summary table, the acreage reported for landfills has been combined with that reported for utilities. The utilities category includes power plants, waste treatment and water supply facilities, radio and TV transmission sites and transportation facilities. The acreage reported for duck farms has been combined with that for all other agricultural uses; the acreage reported for institutional uses has been combined with that for open space uses. The latter category includes acreage for parks, conservation areas, private clubs or other recreation facilities, and cemeteries.

Industrial uses occupy only 1.4 percent of the land area in the Region; 1.9 percent of the land area in Nassau and 1.3 percent of the land area in Suffolk. Although some manufacturing operations are located in older mixed use areas, increasing numbers of them are concentrated in industrial parks or strip developments, close to the Long Island Expressway, or along several of the major north-south highways.

Commercial uses, among them retail and service establishments, offices, restaurants, marinas and warehouses, occupy nearly twice the area occupied by industrial uses in the Region as a whole; three and one-half times the area occupied by industrial uses in Suffolk. Commercial uses are found in a variety of locations—in older downtowns, in strip and mixed use roadside developments, and in neighborhood, community and regional shopping centers. The Garden City—Hempstead Village—Roosevelt Field area encompasses the greatest single concentration of commercial activity in Nassau County. Smaller concentrations are located along Northern Boulevard from Manhasset to Roslyn; along Sunrise Highway, east to Patchogue; and along Route 110 from the Walt Whitman Shopping Center south to the Long Island Expressway.

Utilities and landfills account for 2.0 percent of the acreage in the 208 area; 0.4 percent of the acreage in Nassau and 2.5 percent of that in Suffolk. Nearly all of the power plants and major sewage treatment facilities are located on shorefront sites in both counties, while water supply, communication and transportation facilities, and landfills are usually located on inland parcels. Although most uses in this category are unevenly distributed throughout the Bi-county Region, there is at least one landfill in each of the thirteen towns. The larger land users in the utilities category, the communications transmission sites and the airports, are all located in Suffolk, which listed more than twenty times the Nassau acreage in this category.

Agricultural land use represents a shrinking, but nonetheless important, category in Suffolk County and in the Region. It accounts for 5.8 percent of the land area in the Region and 7.7 percent in Suffolk County. The few remaining agricultural enterprises in northeastern Nassau County are generally small scattered operations specializing in nursery crops or produce for local sale and consumption. Estimation techniques preclude separate identification of such uses.

Ninety percent of the farm acreage in Suffolk is located in three towns: Riverhead, Southold and Southampton. The major upland crops are potatoes, cauliflower, sod and nursery stock. Ducks are raised at waterfront locations in Brookhaven, Riverhead and Southampton.

The last non-residential category comprises two major groups of land uses: institutional uses and open space. The institutional uses include churches, schools, hospitals, governmental buildings and other public or quasi-public establishments. The open space uses include parks, parkways, preserves, private recreational facilties, and cemeteries. The combined institutional-open space category accounts for almost one-fifth of the land area in the Region as a whole; a somewhat higher proportion of that in Nassau and a somewhat lower proportion of that in Suffolk. Institutional uses occupy about one-fourth of the acreage in this category. Small institutional uses are dispersed throughout the two county area. Major educational facilities, many of them located on former estates, occupy large sites in northern Oyster Bay and northwest Brookhaven, while a research facility, the Brookhaven National Laboratory, and a nuclear generating plant, now under construction, occupy some areas in northeastern Brookhaven. New York State is gradually phasing out operations at three sizeable Department of Mental Hygiene hospitals in Suffolk: Kings Park, in Smithtown; and Pilgrim and Central Islip, in Islip. Some land has already been sold off or transferred to local government for other uses, and it is expected that eventually New York State will part with most or all of the remaining acreage.

Open space uses occupy about three-fourths of the acreage in the combined institutional-open space category. Although the greater part of the open space acreage is in Suffolk County, the more intensively used recreation areas are in Nassau County. For the most part, the larger Nassau sites are at inland locations; the larger Suffolk sites are on the shore or in stream corridors. In both counties public and private efforts to preserve wetlands and stream valleys have resulted in the commitment of extensive acreage to conservation and other open space use. (See Figure 2–1 in the Map Section.)

2.1.2 Projected Land Use Patterns. The Nassau-Suffolk Comprehensive Plan sets forth priorities for rational social and economic development of Long Island that are compatible with the existing natural environment. The Plan, which was originally completed in 1970, was amended, in part, during 1976 and 1977. The revisions reflect new environmental knowledge and concern. The 1976 and 1977 amendments affected the watershed of the Peconic River, eastern Great South Bay, and Moriches Bay. These are indicated in the 1995 Revised Land Use Plan. It is anticipated that further revisions will be made as increased knowledge and changed conditions dictate. The Plan is a regional one that relates the amount of land that is zoned for categories such as industry, housing and commerce to the amount of land that will be needed for these purposes. The primary goal of the Nassau-Suffolk Comprehensive Plan is to develop a series of corridors, clusters and centers throughout the Bi-county Region. The most valuable recreation land is at the waterfront, and the best location for housing is adjacent to this recreation land. The most logical location for industry and other development is along the central spine of the Island, which would put it in proximity to the major transportation facilities. The use of the corridor concept means that the highest intensity uses would be equidistant from the North and South Shores. The development of high intensity uses in this central corridor would minimize the need for such uses in coastal areas, thus affording some protection to the sensitive shore edge in Nassau and Suffolk Counties. The recommendations for industry include a stipulation that the use of accessible sites along major highways and railroads be reserved to meet the needs of both counties. The corridors along the shorefront would be primarily reserved for water related recreation and low density residential development and, on the eastern forks, for agriculture and fishing. The Plan makes a number of recommendations relating to residential densities. It provides for the lowest density along the shore, with an increase towards the central transportation corridor.

Land for parks and conservation has been accorded a first priority in the Regional Plan. There are many sites that must be preserved in order to provide adequate recreational opportunities for existing and future residents, or to protect the environmental resources from the degradation that could result from improper development.

The Plan recommends the use of clustering techniques, a most effective tool for open space preservation at minimal cost to the community. Clustering allows for the construction of a mix of town houses, apartments and single family detached houses, while maintaining the permitted density for the development as a whole. Through the use of clustering adjoining developments, extensive open space systems can be developed, thus retaining land that is best left in an undeveloped state. This land is valuable for watershed protection and preservation of sites of particular scenic beauty or ecological significance. It also provides sites for certain recreational uses. The clustering technique also allows a reduction in utility costs such as those for water lines and sewers, and a reduction in other public expenditures for road construction and maintenance.

The Plan recommendation for centers is a combination of preservation and more intelligent use of developable land. There are proposals for new centers to be located only in the portions of the Island that are presently undeveloped and where it is not possible to expand existing small concentrations of non-residential uses. A significant part of the new economic activity should be concentrated in older central business districts that have extensive community facilities but are losing population and importance in their section of the Region. Other locations should be extensions of small business districts that have a nucleus of community services.

The Plan accords a high priority to land for apartments, since changing age patterns and family structure indicate a demand for this type of housing. It is recommended that many of the new apartments be located in older business districts where rebuilding and increased densities would stimulate revitalization, encourage greater use of mass transit and utilize existing services.

The Plan proposes to locate as much new commercial and office space as possible in the existing central business districts. Location of new business activity in the older downtowns would permit the use of existing infrastructure and would reduce some of the pressure on the remaining vacant land.

The 1995 Plan envisions a Region in which more than three-fifths of the acreage is used for residential purposes and less than two-fifths for non-residential purposes, including farming. It is assumed that, by 1995, all of Nassau-Suffolk will have been committed to one or another land use, and that there will be no vacant land. Such an assumption does not preclude further development, which may occur through the sub-division of large estates or non-residential holdings, through in-filling in established residential and commercial areas, and through clearing and redevelopment of older areas. Table 2–2 presents a summary of the proposed 1995 land uses.

Implementation of the Plan as revised will result in an increase in residential land use of slightly more than two percent in Nassau and of more than 59 percent in Suffolk, and an increase in non-residential land use of just over one percent in Nassau and of 26 percent in Suffolk.

In Nassau, almost all of the increase in residential acreage will be in the ten dwelling units or more per acre category, while in Suffolk, approximately two-thirds of the increase will be in the less than one housing unit per acre category and the low density category, and over one-fourth will be in the two to four housing units per acre category.

Of the very small increase in acreage devoted to non-residential uses in Nassau, about three-fifths will be in industrial, one-fifth in institutional and open space, and one-fifth in commercial uses. Of the much larger increase in non-residential acreage in Suffolk, just over four-fifths will be in institutional and open space, about three-twentieths in commercial, and less than one-twentieth in industrial uses. The number of acres in agricultural use will decline, but will still account for more than six percent of the total in Suffolk County and somewhat more than 37 percent and 25 percent of the total in Towns of Riverhead and Southampton respectively. (See Figure 2–2 in the Map Section.)

2.2 Pollutant Sources

2.2.1 Point Sources. Point sources include all discharges from domestic wastewater treatment plants and from those industries which do not discharge to a municipal system but operate their own treatment facility. The land, the ocean, and the intervening bays all receive waste discharges directly from point sources. Table 2–3 indicates the quantities of industrial and domestic wastes being discharged in Nassau and Suffolk Counties. Although the numbers of industrial and domestic plants are similar, domestic flows exceed industrial by a factor of 40.[1]

The major pattern of discharge differs markedly between Nassau and Suffolk. Nassau, being the more heavily sewered, and having all major treatment plants located near the shore, discharges 98 percent of its treated wastewaters to the surface water. Suffolk, however, discharges approximately the same amount to the land as to the bays. The quantity of wastes being treated also differs significantly, with Nassau treating a total of about 107 MGD compared to Suffolk's 16 MGD. It should be noted that operations of the Southwest District Sewage Treatment Plant are scheduled to commence in 1978. It is anticipated that flow from this plant will add 30 MGD to the Suffolk County surface water discharges by 1986.

Although greatly outweighed by domestic volumes, industrial wastes have created significant localized degradation, especially to the groundwater resource. Recent well pumping cutbacks in both Nassau and Suffolk have been related to organic industrial discharges (*e.g.*, halogenated hydrocarbons). Leachate from landfills, septic system cleaners and other home products have also been cited as possible sources of contamination. The lack of historical data on trace organic chemicals makes quantification of this problem extremely difficult.

Pollutants from point sources include oxygen-demanding substances (BOD, COD), micro-organisms, heavy metals, organics, suspended solids and nutrients. For discharges to groundwater, nitrogen compounds and organic chemicals receive the most attention, although localized problems may exist with any of the contaminants listed. Modeling and other studies of the reaction of the ground and surface water to these pollutants have indicated that, for discharges to bays, nitrogen and bacteriological parameters are of primary importance. Analysis of marine water quality has shown that contravention of the dissolved oxygen standard is generally caused by the respiration of excess algae. The most feasible means of reducing dissolved oxygen standards contravention is to limit algal production through limitation of the nutrient element, nitrogen. Nitrogen is thus a key water quality parameter which is common to both groundwater and surface water and therefore is selected as a pollutant indicator.

The designation of nitrogen as the prime water quality indicator under consideration in this study is based upon the following:

1. The presence of nitrogen in all its forms, but particularly as nitrate, in both ground and marine waters correlates directly with the level of man's activities within the affected areas.

Table 2–2

THE NASSAU-SUFFOLK 208 AREA: PERCENTAGE OF LAND AREA IN VARIOUS USES, BY TOWN AND COUNTY, 1995

	RESIDENTIAL					NON-RESIDENTIAL							
Locality	High Density	5–10/D.U. per acre	2–4/D.U. per acre	0–1/D.U. per acre & Low Density	Total Residential	Industry	Commerce	Utility and Landfill	Agricul-ture	Institutional & Open Space	Total Non-Residential	Vacant	Total Land Area
Nassau													
N. Hempstead	6.0	20.9	19.5	25.5	71.9	2.7	6.9	0.1	—	18.4	28.1	—	32,828
Hempstead	5.5	55.9	1.0	1.1	63.5	1.1	6.8	0.3	—	28.3	36.5	—	77,413
Oyster Bay	2.6	19.7	14.4	30.4	67.1	3.1	4.0	0.3	—	25.5	32.9	—	69,275
County Total	**4.4**	**35.6**	**9.6**	**16.8**	**66.4**	**2.2**	**5.7**	**0.3**	—	**25.4**	**33.6**	—	**179,516**
Suffolk													
Huntington	1.6	7.1	21.8	43.4	73.9	3.9	3.6	0.5	—	18.1	26.1	—	59,227
Babylon	5.3	38.0	9.0	—	52.3	6.9	3.6	2.1	—	35.1	47.7	—	32,886
Smithtown	1.3	4.3	39.1	22.3	67.0	5.3	3.4	—	—	24.3	33.0	—	34,160
Islip	2.3	18.4	34.2	6.6	61.5	3.5	2.8	3.0	—	29.2	38.5	—	63,909
Brookhaven	1.8	5.1	36.7	23.4	67.0	3.1	1.9	1.5	0.5	26.0	33.0	—	163,367
Riverhead	0.7	1.0	9.3	13.0	24.0	1.5	1.5	12.3	37.3	23.4	76.0	—	41,462
Southampton	0.4	2.0	14.0	44.1	60.5	0.8	1.7	2.5	12.1	22.4	39.5	—	87,100
Southold	0.6	1.0	20.0	27.8	48.4	0.4	1.6	2.0	24.6	22.0	50.6	—	30,191
Shelter Island	—	1.2	8.1	52.0	61.3	—	1.5	0.1	0.4	36.7	38.7	—	7,603
East Hampton	0.1	0.3	15.0	46.3	61.7	0.6	1.4	1.6	3.4	31.3	38.3	—	46,416
County Total	**1.5**	**7.2**	**24.9**	**27.1**	**60.7**	**2.7**	**2.2**	**2.5**	**6.3**	**25.6**	**39.3**	—	**566,321**
The Nassau-Suffolk 208 Area	**2.2**	**14.0**	**21.2**	**24.6**	**62.0**	**2.6**	**3.1**	**2.0**	**4.8**	**25.5**	**38.0**	—	**745,837**

Source: Section C of the Areawide Waste Treatment Management Plan

2. A numerical standard not to exceed ten milligrams per liter as nitrate nitrogen must be met for all drinking waters supplied to the consumer.
3. As noted above, the presence of excess nitrogen in the marine receiving waters is a cause of eutrophication and attendant contraventions of the dissolved oxygen standard.
4. The determination of nitrogen is an accurate and fairly rapid and straightforward analytical procedure.
5. A great deal of historical data exists relative to nitrogen concentrations in both ground and surface waters which can be used to assess trends.

The choice of this parameter, however, does not preclude the consideration of other contaminants, such as organic chemicals and bacteria, in the selection of wastewater management alternatives. This is more clearly exhibited in the following sections.

The distribution of point discharges is illustrated in Table 2–4. The bays of Nassau County currently receive the greatest amount of treated waste discharge, the highest being Hempstead Bay (Reynolds Channel). Suffolk County bays receive relatively little discharge, the highest quantities currently being discharged to Port Jefferson Harbor and Huntington Bay.

Waste treatment plants generate sludge. Currently, Nassau County disposes of approximately 90 million gallons of sludge per year, predominantly

Table 2–3

TOTAL POINT SOURCES–FLOW SUMMARY (JANUARY, 1976)

	No. of Plants	Discharge in MGD To Groundwater	To Surface Water	Total
Nassau	Domestic 23	1.21	104.42	105.63
	Industrial 20	0.79	0.41	1.20
Suffolk	Domestic 101	7.39	6.87	14.26
	Industrial 86	1.20	0.87	2.07

Source: Section C of the Areawide Waste Treatment Management Plan

Table 2–4

DOMESTIC WASTEWATER TREATMENT PLANT DISCHARGES TO BAYS*, 1976

Water Body	County	Flows (MGD)	Total Nitrogen Lbs/day	Total Coliform 10^{10} Organisms/day
Manhasset Bay	Nassau	7.18	1,600	93
Hempstead Harbor	Nassau	6.41	3,000	140
Oyster Bay	Nassau	1.90	390	9.1
Huntington Bay	Suffolk	2.03	360	16
Port Jefferson Harbor	Suffolk	1.44	160	6
Flanders Bay	Suffolk	1.82	840	2.8
East Great South Bay	Suffolk	0.47	130	10
West Great South Bay	Suffolk	0.06	10	<0.001
South Oyster Bay	Nassau	0.0	0	0
East Bay	Nassau	0.18	40	33
Middle Bay	Nassau	4.2	860	130
Hempstead Bay	Nassau	72.45	16,000	4,300
Little Neck Bay	Nassau	1.59	240	3
Total		99.73		

*These loadings do not include BOD or suspended solids, since these parameters are not a major concern of the 208 Program. They do not, in general, cause significant water quality problems. Nitrogen and coliforms, on the other hand, impact substantially on water quality in all the bays.

Source: Section C of the Areawide Waste Treatment Mangement Plan.

by barging to the Atlantic Ocean. Suffolk County treatment plants produce approximately twenty million gallons of sludge per year, disposed of almost entirely in landfills.

In the context of 208, landfills can be considered as either point sources or non-point sources. In the Bi-county Region, there are a total of 40 major operating and abandoned land disposal sites. The liquid waste generated at landfills is termed "leachate" and is formed by the interaction of rainfall with the buried wastes. Leachate constituents may include organics, heavy metals, nitrogen, chloride, iron and microorganisms. The volume of waste can be significant. Theoretically, given average Long Island rainfall and typical geologic conditions, 100 acres of landfill could generate 40 million gallons of leachate per year.

2.2.2 Non-Point Sources. Non-point sources of pollution are a major water quality management problem in the Nassau-Suffolk area. The sources are both wet-weather related as well as continuous. The pollutant loads are discharged to surface water bodies and to the ground. Non-point discharges have been found to contain a variety of pollutant parameters, ranging from relatively innocuous grit to complex organic compounds in trace (microgram/liter) concentrations, with organics of different formulations contained in the sources listed below.

The pollutant parameters of major concern in non-point sources of pollution are basically the same as those found in point sources: various forms of nitrogen, organic chemicals, coliform bacteria and heavy metals. There is, however, a basic difference in the patterns of occurrence for the two types of sources—pollutant loadings from non-point sources show greater variation over time than those from point sources. This makes accurate quantification difficult and control approaches most costly.

The 208 Program has identified the following non-point sources of pollution as contributing major pollutant loadings to the ground and surface waters of the study area:

1. Stormwater runoff from highways, medium and high density residential areas and commercial/industrial areas. The major contaminants in the runoff from these areas are coliform bacteria, organic chemicals, sediment, heavy metals and nitrogen. The loadings are discharged to surface waters and to the ground.[2]
2. Cesspools and septic systems. Contaminants from properly functioning systems include nitrogen and, to a lesser degree, organic chemicals. The loadings are almost entirely to the groundwater.[3]
3. Fertilizers and pesticides applied to crops, lawns and landscaping. Over-fertilization appears to occur in residential and recreational areas. The major contaminants from agricultural chemicals are nitrogen and organic compounds. The loadings are both to groundwater and to surface water.[4]
4. Groundwater underflow to marine waters. This can be a major source of nitrogen. (See Table 2–7.)

The literature or departmental experiences have also identified a number of other non-point sources of pollution, which may cause local or temporary water quality problems, but are not as pervasive as the sources described in the previous paragraph. These sources include runoff from construction sites, discharges from boats, runoff from oil storage depots, and sand and gravel mining sites, exfiltration from sewers, and leakage from product pipelines. Although these sources are not as regionally important as the four major sources listed in the previous paragraph, they can cause significant local water quality problems.[5]

Sub-surface oil and gasoline storage tanks constitute an additional non-point source that has an impact on groundwater quality. The 208 Program has not been able to quantify the potential contamination from this source but has recognized that it could be substantial. Detailed studies and monitoring/regulatory programs for this non-point source should be continued and expanded.

Table 2–5 summarizes non-point source loadings of key parameters discharged to surface water bodies and Table 2–6 presents corresponding information for discharges to groundwater. The magnitude of the numbers, when compared to the point source loadings of the previous section, testifies to the severity of the non-point source problem. Areas contributing surface runoff directly to streams and salt water bodies are displayed in Figure 2–3.

Because of the magnitude of the loadings and the potential serious impacts on bay water quality, major efforts were made in the 208 Program to define the wet-weather loads to the bays. Studies of pollutant generation were conducted in a limited number of areas selected as representative of land uses or combinations of land uses found on Long Island. Data from these studies was then extrapolated to obtain estimates for the entire SMSA. In Nassau County, which is characterized by extensive urbanization and sewering, point sources contribute the major portion of the pollutant loads of BOD, total nitrogen and total phosphorus. Wet-weather non-point sources contribute the major loadings of suspended solids and fecal and total coliform bacteria, except in Hempstead Bay. In Suffolk County, pollutant loadings are dominated by non-point sources. This is true of all parameters studied for all major surface water bodies except Flanders Bay, which receives an estimated 76 percent of its total nitrogen loading from point sources.

Tables 2–7, 2–8 and 2–9 summarize the total loadings of nitrogen and total and fecal coliforms to the various bays from point and non-point sources.

Along the North Shore of the Bi-county Region, surface runoff patterns conform approximately to the natural contours. Much of the precipitation which falls on developed areas runs off directly to the bays and follows the natural drainage divides. The precipitation which falls on undeveloped land generally infiltrates directly to the groundwater.

Surface runoff patterns along the South Shore are more complex. In general, Sunrise Highway defines the approximate northern limit of direct runoff to the bays. Most of the area north of Sunrise Highway and south of

Table 2–5

ESTIMATED STORMWATER RUNOFF LOADINGS TO LONG ISLAND BAYS, 1976

Receiving Water Body	County	Total Nitrogen (Lbs/day)	Total Coliform 10^{12} Organisms/day
Manhasset Bay	Nassau	170	58
Hempstead Harbor	Nassau	220	74
Oyster Bay	Nassau	290	130
Huntington Bay	Suffolk	370	150
Port Jefferson Harbor	Suffolk	200	58
Flanders Bay	Suffolk	30	5
East Great South Bay	Suffolk	670	190
West Great South Bay	Suffolk	440	120
South Oyster Bay	Nassau	270	69
East Bay	Nassau	220	57
Middle Bay	Nassau	330	88
Hempstead Bay	Nassau	90	25

Source: Section L of the Areawide Waste Treatment Management Plan.

Table 2–6

ESTIMATED STORMWATER RUNOFF LOADINGS TO RECHARGE FACILITIES
(Based on 1975 land use data and sampling data)

County	Drainage Basin	Total Nitrogen (Pounds/day)	Lead (Pounds/day)	Total Chromium (Pounds/day)
Nassau	N–1	720	75	14
	N–2	710	71	93
	Subtotal	**1430**	**146**	**107**
Suffolk	S–1	840	79	110
	S–2	790	81	81
	S–3A	610	58	43
	S–3B	30	3	6
	S–11B	170	19	118
	S–12C	10	1	1
	S–13B	20	1	1
	Subtotal	**2470**	**242**	**360**
	Bi-county Total	**3900**	**388**	**467**

Source: Section L of the Areawide Waste Treatment Management Plan.

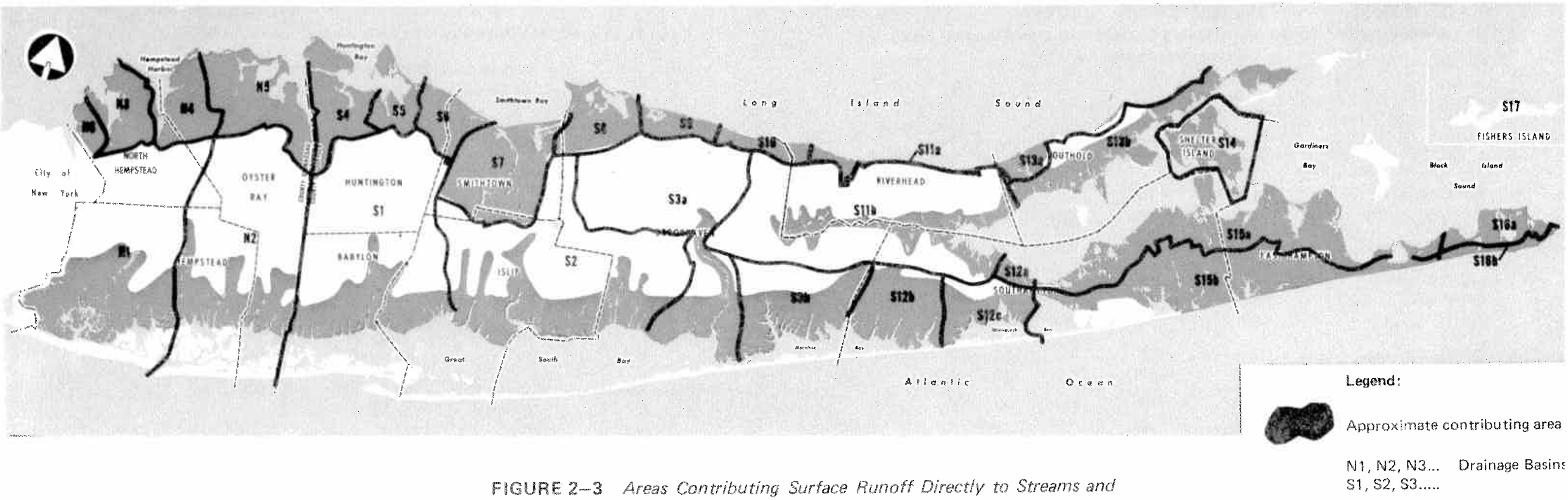


FIGURE 2–3 *Areas Contributing Surface Runoff Directly to Streams and Saltwater Bodies*

the moraine along the Long Island Expressway does not contribute surface runoff directly to the bays except for the drainage basins of certain streams. However, the storm related waste load contributed from these areas may be significant. The extent of these drainage basins was estimated in the course of the 208 Program.

The contribution to the groundwater regime occurs through precipitation infiltrating directly or being collected and recharged through recharge basins. Thus, a very large geographic area contributes substantial pollutant loads directly to the groundwater regime.

2.3 Transport Mechanisms of Potential Pollutants

The hydrologic cycle (precipitation, evapotranspiration, recharge to groundwater and runoff) provides a means of transporting contaminants on Long Island by flowing water. As fresh water flows through and over soil, it dissolves soluble materials. Overland flow suspends particulate matter.

Precipitation is the sole source of fresh water on Long Island. Generally, rainfall is distributed uniformly throughout the year and averages about 44 inches per year. Approximately eighteen inches, or about 40 percent of this annual amount, is returned to the atmosphere. Approximately 22 inches, or 50 percent, recharges to the groundwater by percolating down through the soil, and the remaining five to ten percent runs off. In addition, nearly 400 million gallons are pumped daily from the groundwater aquifer, and much of this also becomes a vehicle for contaminant transport.[6]

The major components of the hydrologic cycle may be represented in a highly simplified mass balance equation:

Recharge (fresh water restored to aquifers) = Precipitation – Runoff – Evapotranspiration – Change in Soil Storage

For the purpose of the 208 Program, the elements of this mass balance were computed for the whole Bi-county Region. The unit of time adopted for the calculations was one month, and the spatial units were defined by the 762 grid cells into which the Region was divided. These cells, each having an area of 2.25 square miles, were specified by a system defined by the Nassau-Suffolk Regional Planning Board (NSRPB) for land use planning purposes.

A brief description of the role of these components in transporting potential contaminants is presented in the following sections.

2.3.1 Precipitation. It can be seen in Figure 2–4 that precipitation averages just under four inches per month, and is quite evenly distributed throughout the year. Furthermore, the spatial distribution is also uniform. Precipitation is important, not only because it generates the flows of water that occur on the Island, but also because it is a direct contributor of pollutants. Residual materials that have become airborne over the northeastern

Table 2–7

COMPARISON OF TOTAL NITROGEN LOADINGS TO LONG ISLAND BAYS, BY SOURCE, 1976*

pounds/day
(percentage of total)

	Groundwater	Dry Weather Streams	Rainfall	Storm Runoff	Point Sources	Total
Manhasset Bay	280 (12)	140 (6)	110 (5)	170 (7)	1,600 (70)	2,300
Hempstead Harbor	500 (12)	340 (8)	120 (3)	220 (5)	3,000 (72)	4,180
Oyster Bay	790 (46)	70 (4)	170 (10)	290 (17)	390 (23)	1,710
Huntington Bay	760 (42)	130 (7)	200 (11)	370 (21)	360 (20)	1,820
Port Jefferson Harbor	250 (32)	70 (9)	110 (14)	200 (25)	160 (20)	790
Flanders Bay	—	120 (11)	120 (11)	30 (2)	840 (76)	1,110
Mecox Bay	150 (49)	70 (21)	30 (9)	60 (21)	—	310
Shinnecock Bay	180 (33)	40 (7)	250 (48)	60 (12)	—	530
Moriches Bay	700 (33)	640 (30)	290 (14)	190 (9)	300 (14)	2,120
Eastern Great South Bay	330 (11)	830 (27)	1,100 (36)	670 (22)	130 (4)	3,060
Western Great South Bay	720 (20)	1,800 (50)	640 (18)	440 (12)	10 —	3,610
South Oyster Bay	430 (24)	840 (48)	230 (13)	270 (15)	0 —	1,770
East Bay	270 (21)	630 (52)	90 (7)	220 (17)	40 (3)	1,250
Middle Bay	380 (16)	680 (29)	90 (4)	330 (14)	860 (37)	2,340
Hempstead Bay	590 (3)	80 (1)	80 (1)	90 (1)	16,000 (94)	16,840

**Loadings do not include nitrogen contributed by Long Island Sound or the Atlantic Ocean. See parts "B" and "D" of the Plan for discussion of estimated loadings.*

Table 2–8

TOTAL COLIFORM LOADINGS TO LONG ISLAND BAYS, 1976*

Organisms (MPN)/day
(percentage of total)

	Dry Weather Streamflow	Storm Runoff	Point Sources	Total
Manhasset Bay	2.4×10^{12} (4)	5.8×10^{13} (95)	9.3×10^{11} (1)	6.1×10^{13}
Hempstead Harbor	6.4×10^{12} (8)	7.4×10^{13} (90)	1.4×10^{12} (2)	8.2×10^{13}
Oyster Bay	5.6×10^{11} —	1.3×10^{14} (99)	9.1×10^{10} —	1.3×10^{14}
Huntington Bay	2.7×10^{12} (2)	1.5×10^{14} (98)	1.6×10^{11} —	1.5×10^{14}
Port Jefferson Harbor	1.7×10^{12} (93)	5.8×10^{13} (97)	6.0×10^{10} —	6.0×10^{13}
Flanders Bay	1.0×10^{12} (13)	5.1×10^{12} (64)	1.9×10^{12} (24)	8.0×10^{12}
Eastern Great South Bay	9.4×10^{12} (5)	1.9×10^{14} (95)	1.0×10^{11} —	2.0×10^{14}
Western Great South Bay	2.6×10^{13} (18)	1.2×10^{14} (82)	8.6×10^{6} —	1.4×10^{14}
South Oyster Bay	6.0×10^{11} (1)	6.9×10^{13} (99)	0 —	7.0×10^{13}
East Bay	6.7×10^{11} (1)	5.7×10^{13} (98)	3.3×10^{11} (1)	5.8×10^{13}
Middle Bay	9.7×10^{11} (1)	8.8×10^{13} (97)	1.3×10^{12} (2)	9.0×10^{13}
Hempstead Bay	1.5×10^{12} (2)	2.5×10^{13} (36)	4.3×10^{13} (62)	6.9×10^{13}

**Loadings do not include coliform organisms transported to the bay from Long Island Sound or the Atlantic Ocean. See parts "B" and "D" of the Plan for discussion of estimated loadings. Total coliform loading estimates have not been made for Moriches, Shinnecock and Mecox Bays.*

portion of the United States are returned to earth in the precipitation. For example, the average concentrations of nitrogen in rainfall vary from about 1.0 milligrams per liter in Nassau County to 0.5 milligrams per liter in eastern Suffolk.[7] Thus precipitation deposits over 3000 tons of nitrogen on the two counties every year. This deposition is a significant source of the nutrient.

Table 2–9

FECAL COLIFORM LOADINGS TO LONG ISLAND BAYS, 1976*

Organisms (MPN)/day
(percentage of total)

	Dry Weather Streamflow	Storm Runoff	Point Sources	Total
Manhasset Bay	1.1×10^{11} (0.5)	2.1×10^{13} (99.5)	2.5×10^{9} (–)	2.1×10^{13}
Hempstead Harbor	3.3×10^{11} (1)	2.6×10^{13} (99)	4.1×10^{9} (–)	2.6×10^{13}
Oyster Bay	9.2×10^{10} (–)	6.6×10^{13} (99)	2.9×10^{8} (–)	6.6×10^{13}
Huntington Bay	2.5×10^{12} (4)	6.2×10^{13} (96)	0.3×10^{9} (–)	6.5×10^{13}
Port Jefferson Harbor	5.7×10^{11} (3)	1.6×10^{13} (97)	2×10^{10} (–)	1.7×10^{13}
Flanders Bay	1.0×10^{12} (14)	4.4×10^{12} (63)	1.6×10^{12} (23)	7.0×10^{12}
Eastern Great South Bay	2.9×10^{12} (5)	5.7×10^{13} (95)	1.6×10^{10} (–)	6.0×10^{13}
Western Great South Bay	8.2×10^{12} (27)	2.2×10^{13} (73)	8.6×10^{6} (–)	3.0×10^{13}
South Oyster Bay	5.7×10^{10} (1)	1.1×10^{13} (99)	0 (–)	1.1×10^{13}
East Bay	2.7×10^{11} (19)	0.9×10^{12} (63)	2.6×10^{11} (18)	1.4×10^{12}
Middle Bay	2.0×10^{11} (1)	1.6×10^{13} (97)	2.5×10^{11} (2)	1.6×10^{13}
Hempstead Bay	8.7×10^{9} (–)	4.5×10^{12} (85)	7.6×10^{11} (14)	5.3×10^{12}

**Loadings do not include coliform organisms transported to the bay from Long Island Sound or the Atlantic Ocean. See parts "B" and "D" of the Plan for discussion of estimated loadings. Total coliform loading estimates have not been made for Moriches, Shinnecock and Mecox Bays.*

2.3.2 Evapotranspiration. Figure 2–4 shows that evapotranspiration is markedly seasonal, being close to zero during winter months and almost equal to total precipitation during the summer. Evapotranspiration therefore indirectly affects the transport of contaminants, since it can reduce runoff and groundwater recharge to insignificant levels during much of the summer period. It can also affect contaminant transport directly because co-evaporation distillation of contaminants may occur in conjunction with evapotranspiration. For example, a class of pesticides, which includes DDT, is very immobile in soil. Yet quantities of these pesticides have been found in marine environments. It is believed that the primary mode of transport is co-distillation of the pesticides with water from the soil.[8]

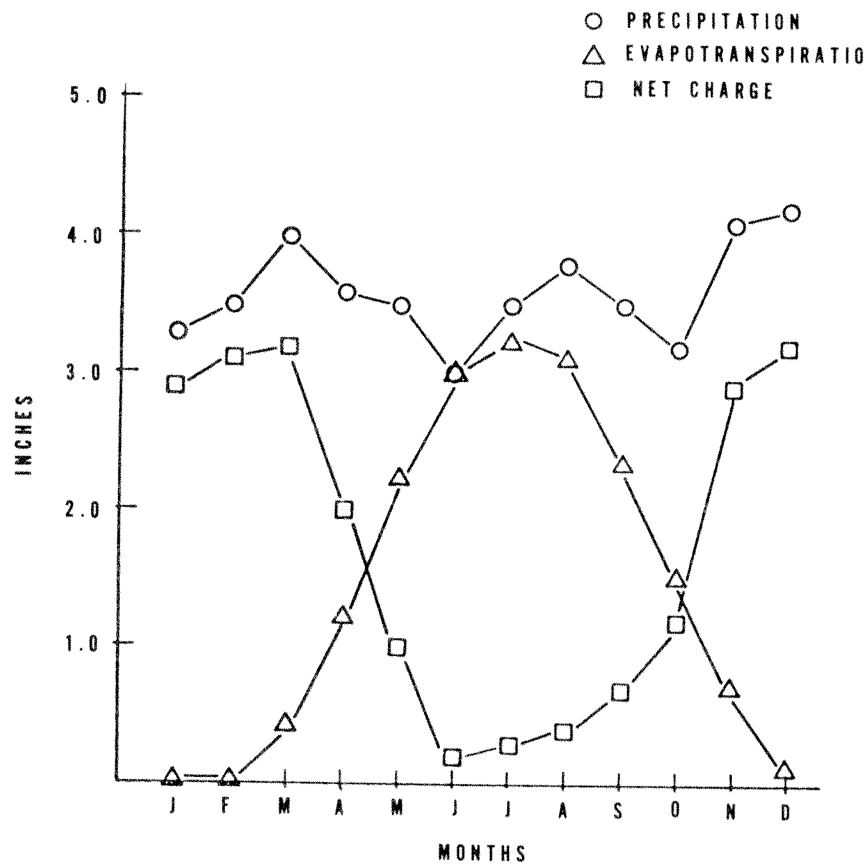


FIGURE 2–4 *Average Values for Hydrologic Components*

It may also be noted that urbanization, with its associated impervious areas (highways, rooftops and parking areas) effectively decreases evapotranspiration and augments runoff. On Long Island, much of this runoff is collected and allowed to percolate through the soil in excavated basins. Localities containing highly developed areas and recharge basins can thus provide greater quantities of groundwater recharge than rural and agricultural areas. However, the quality of water recharged in urban areas is substantially lower than rural recharge areas.

2.3.3 Recharge. Recharge water, prior to its passage through the soil, may be contaminated in many ways. Contaminants in the original precipitation and materials on the land surface, such as animal wastes or organic chemicals on highways, may affect the quality of the water before it begins to percolate through the soil. There is, in addition, a major source of contamination within the soil: cesspools and leaching fields are used for human waste disposal by 40 percent of the population of Nassau and 80 percent of the population of Suffolk.

Soil can, to a limited extent, remove organic pollutants, heavy metals and microorganisms, such as bacteria and viruses, from the groundwater by processes such as filtration, adsorption, precipitation and ion exchange. However, highly soluble salts, such as chlorides and nitrates, will generally not be removed. Potential for desorption is an additional complication.

Thus groundwaters underlying Long Island's soils have acquired increasing amounts of inorganic materials as the Region has become urbanized. As shown in Table 2–10A, the estimated annual load of nitrogen carried down to groundwater by regional recharge is over 16,000 tons. This nitrogen is primarily in the nitrate form, and about 30 percent of it originates from human waste being discharged to groundwater. The 16,000 tons which appears in the groundwater is only about 50 percent of the original load. Runoff accounts for very little of the difference and it is believed that denitrification in the soil is a major factor. A very large portion of the nitrogen input to the Long Island system is believed to escape to the atmosphere in the gaseous form.[8]

The figures given in Table 2–10A represent gross averages for the entire Bi-county Region. It must be recognized that a great deal of variability will be encountered under specific conditions. Also, the relative average magnitudes of the various components will change from locality to locality within the Region. For example, Table 2–10B shows gross estimates of nitrogen produced in a residential area with medium density housing. As can be seen, the relative magnitudes of the loads differ from those for the whole Region.

The original total load of nitrogen for the acre, would produce a concentration of inorganic nitrogen of about 30 milligrams per liter, if it all leached. It is estimated however, based on work done during the 208 Program, that reductions in nitrogen levels during, or prior to, leaching to groundwater, would produce an actual concentration closer to fifteen milligrams per liter. This compares with ten milligrams per liter that would be

Table 2–10A

GROSS SUMMARY OF ESTIMATED SOURCES AND FATE OF NITROGEN IN THE BI-COUNTY REGION.
(Based on 1975 and 1976 data.)

Source	Nitrogen Initial Load	(tons/yr.) Load to Groundwater	Comment on Sink
Wastewater			
On-site systems	8500	4300	(Denitrification, etc.)
Sewers & sewage treatment			
Sewer leakage	500	200	(Denitrification, etc.)
Effluent discharge to ground	200	100	(Denitrification, etc.)
Effluent discharge to marine bays	4200	—	(Discharge to sea)
	13400	4100	
Fertilizers			
Farm (Inc. Sod farms)	4000	1000	(Crop removal)
Turf (Inc. households, golf courses, etc.)	9300	5600	(Volatilization & Denit.)
Animals (primarily dogs & cats)	1600	800	(Volatilization & Denit.)
Ducks	600	300	(Volatilization & Denit.)
	15500	7700	
Precipitation	4000	3700	(By difference from totals)
Totals	32900	16000*	(Totals estimated by water/nitrogen model)

**Assuming an annual recharge of about 500 billion gallons, the resulting concentrations in the leachate equals about 6.8 mg/l.*

Table 2–10B

ESTIMATED ANNUAL LOADS ORIGINATING ON AN ACRE OF RESIDENTIAL LAND, WITH THREE HOUSES.

Source	Lbs. of Nitrogen Initial Load	Approx. load to Groundwater	Assumption
10 Persons	100	50	(10 lbs. N/person)
15,000 sq. ft. of turf	45	25	(average household income $16,000)
Pets	10	5	(0.82 lbs/person approx.)
Precipitation	10	6	(1 mg/l)

predicted by empirical relations based on groundwater data presented in Porter (1978).

As discussed by Porter, the estimate of ten milligrams per liter is probably an underestimate of the true level of nitrogen in the groundwater due to bias in the data.

2.3.4 Groundwater Flow. Once the recharge water enters the saturated zone, movement is controlled by the natural and artificial flow regimes operating in the system. Although groundwater moves very slowly, it can travel long distances. As a result, sources of contamination of human or natural origin, which are apparently remote, may have prolonged and wide-reaching groundwater impact at some time in the future.

Based on estimated flow rates in the Upper Glacial aquifer, many shallow wells in that aquifer now reflect the quality of water that entered the groundwater system since the late 1940's.[10] The exact age of water at these wells is probably quite variable, depending on depth, location, permeability of the sediments at the particular site, and the influence of pumping.

In the central portion of Long Island, recharge to the Magothy from the water table aquifer occurs over a large area. The definition of this region is critical in trying to assess how chemical contaminants, introduced to the water table from the land surface, will tend to move in the groundwater system. Groundwater in the water-table aquifer near the groundwater divide is subject to hydraulic gradients which tend to carry some of the water vertically downward to the deepest part of the Magothy. To the south and north of this zone, water from the shallow deposit flows with vertical and horizontal components that result in some water moving in the middle portion of the Magothy. Farther toward the coastlines, circulation becomes shallower until, at some point, flow is essentially horizontal in both the water-table and the Magothy aquifers. Beyond this area, water in the Magothy has a vertically upward component, while the water in the shallow deposits flows essentially horizontally until it discharges to streams or saltwater bodies. Under predevelopment conditions, it takes about 100 years for water from the surface to reach the lower portion of the Magothy in the center of the Island. The travel time to the barrier beach is about 800 years and, to the North Shore, about 400 years.[11] However, the travel time may be greatly reduced by pumping. Partial cross sections of Long Island, depicting typical patterns of groundwater flow, are shown in Figures 2–6 and 2–7. The location of these cross-sections is shown in Figure 2–5.

In general, the distribution of known contaminants follows the typical flow patterns shown above. It should be noted, however, that the flow patterns in reality are complicated by layers of different types of materials in the ground, such as clay lenses in otherwise sandy layers. However, groundwater flow into the bays constitutes a significant source of nitrogen to the surface waters. In some cases the nitrogen loads from groundwater inflow are more than one-third of the total input.[12]

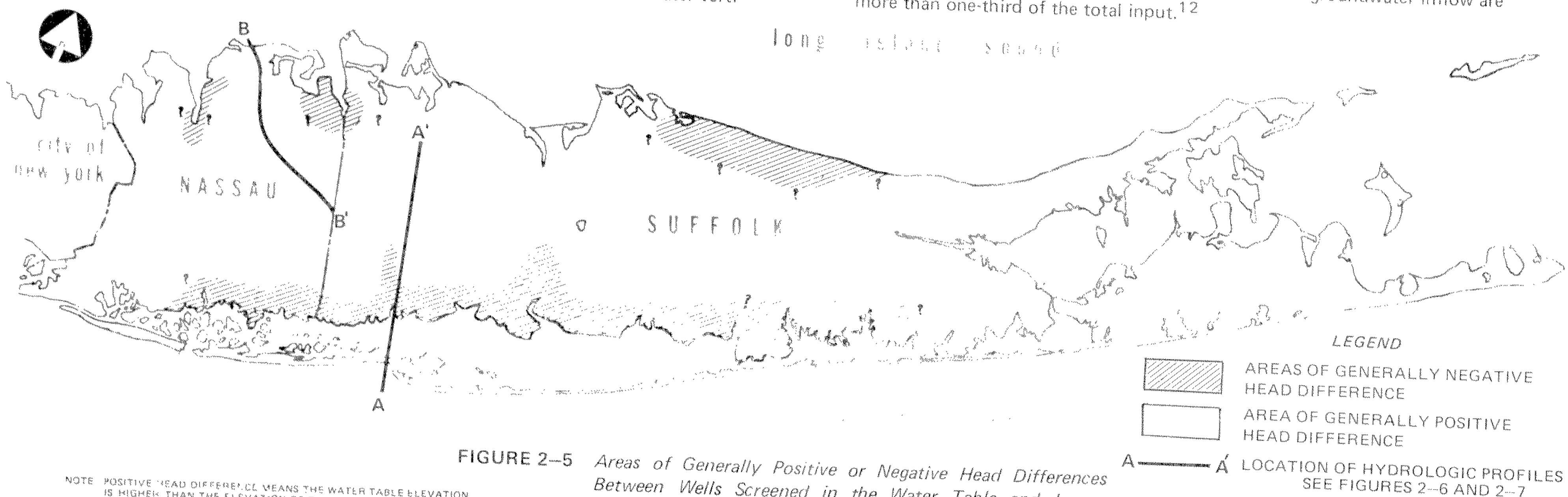
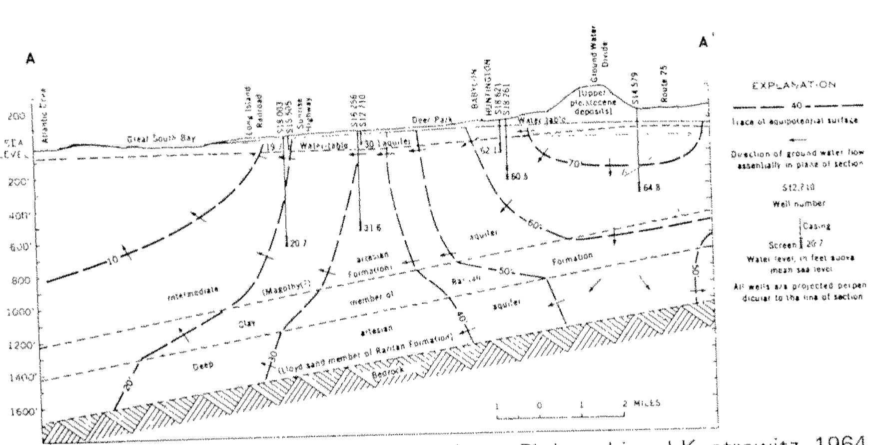


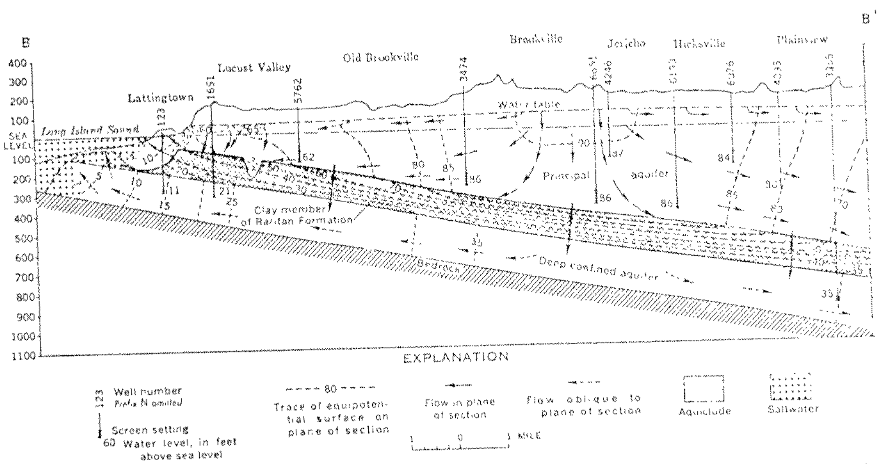
FIGURE 2–5 *Areas of Generally Positive or Negative Head Differences Between Wells Screened in the Water Table and Lower Magothy Aquifers, Based on USGS Maps for 1966, 1972, 1974 and 1975*

NOTE POSITIVE HEAD DIFFERENCE MEANS THE WATER TABLE ELEVATION IS HIGHER THAN THE ELEVATION OF THE BASAL MAGOTHY POTENTIOMETRIC SURFACE AT A GIVEN POINT



(from Pluhowski and Kantrowitz, 1964)

FIGURE 2–6 *Approximate Hydraulic Profile of the Groundwater Reservoirs Underlying the Babylon–Islip Area, October 1960*



(from Franke and Cohen, 1972)

FIGURE 2–7 *Hydraulic Section Through the Groundwater Reservoir from Lattingtown to Plainview, in March, 1961*

2.3.5 Surface Runoff. As already indicated, the volume of surface runoff from undeveloped land represents probably no more than five to ten percent of the original precipitation.

Measurements at twelve sites during the 208 Study produced an estimated average rate of infiltration of over seven inches per hour. This suggests that the soil is capable of infiltrating the precipitation of a 100 year storm, which delivers as much as four inches of precipitaion in one hour, or eight inches in 24 hours. It should be noted that extremely heavy precipitation may impact the soil in a way that reduces natural infiltration.

Most runoff occurs as a result of precipitation falling on an impermeable area. It follows that the volume of runoff has been increased by urbanization. The proliferation of residential areas, shopping malls, highways and parking lots has required the provision of drainage system. Drains, and storm sewers all greatly augment the transfer of contaminants. Nitrogen, sediments, coliform bacteria and other pollutants may all be dissolved or suspended and conveyed to surface water. (See Table 2–11.)

Table 2–11

APPROXIMATE YEARLY LOADS TO SURFACE WATERS FROM WET-WEATHER RUNOFF, 1975

Drainage Basin	BOD lbs/yr	Suspended Solids lbs/yr	Total Nitrogen lbs/yr	Total Phosphorus lbs/yr	F. Coli organisms/yr	T. Coli organisms/yr
Nassau Subtotal	1,185,000	8,942,000	597,000	195,000	5.4×10^{16}	1.9×10^{17}
Suffolk Subtotal	2,307,000	16,911,000	1,137,000	368,000	1.1×10^{17}	3.5×10^{17}
Total	3,492,000	25,853,000	1,734,000	563,000	1.6×10^{17}	5.4×10^{17}

Source: Weston, R. F., 1977, "Wet-Weather, Non-Point Source Pollutant Loads in Nassau and Suffolk Counties," Prepared under contract to the 208 Program Study.

2.4 Groundwater Availability and Quality

A basic understanding of present groundwater conditions and trends is essential in evaluating various 208 plans for waste management. The following sections describe current knowledge of the overall availability of groundwater to meet water supply requirements. In addition, the status of water quality in the various aquifers underlying the 208 Region is discussed.

2.4.1 Groundwater Availability. The limit on the amount of groundwater available for development is termed the "safe" or "permissive" yield of the system. The concept of safe or permissive yield is normally defined as: "the amount of groundwater which can be withdrawn from the system and used consumptively on an annual basis without producing undesired results."[14] Over the years, several values have been proposed for this limiting yield on Long Island. The term "deficiency" refers to exceeding the permissive yield. For the Long Island 208 Region, water used "consumptively" simply means that it is not returned to the groundwater system.

Domestic and industrial pumpage, that is eventually lost to the system following collection, treatment and bay or ocean discharge, constitutes the principal year-round consumptive use of fresh water on Long Island. Irrigation practices constitute the principal seasonal consumptive use. As consumptive use increases, groundwater is taken from storage, and underflow to streams and the sea is reduced. These stresses on the groundwater system result in water-level declines and saltwater encroachment.

Greeley and Hansen in 1971 estimated a mean permissive yield of 151 MGD for Nassau County. Holzmacher, McLendon and Murrell in 1970 computed a permissive yield of 466 MGD for Suffolk County. The Nassau County Department of Health computed the average consumptive loss in Nassau during the period of 1969 to 1973 to be 133 MGD. Average consumptive loss for Suffolk County was on the order of 40 to 50 MGD for the same period.

Both of the engineering studies estimated that large water-table declines would result from withdrawal at permissive yield rates if most areas were sewered and effluents were discharged by ocean outfall. Greeley and Hansen predicted maximum declines of 30 feet, and Holzmacher, McLendon and Murrell estimated reductions up to 75 percent of present elevations above sea level before equilibrium occurs. The authors of both county investigations felt that, at the permissive yield, the saltwater interface off the South Shore would move landward to a new equilibrium position, perhaps a mile from its present position. The water-level declines predicted for Nassau are significantly greater than those predicted in recent runs of the U.S. Geological Survey (USGS) analog model. A report[15] of the USGS for the 208 Study analyzed groundwater response to proposed sewerage programs and projected populations increases in Nassau and Suffolk Counties by 1995. The total modeled increase in withdrawal by 1995 was 9.54 MGD in Nassau County and 46.42 MGD in Suffolk County. The total modeled decrease in recharge by 1995 was 39.9 MGD and 42.67 MGD in Nassau and Suffolk Counties, respectively. It was concluded that by 1995, these stresses would result in a stabilized water table after declines of as much as sixteen feet in east-central Nassau County, and as much as six feet in central Suffolk County. Slightly smaller declines in the potentiometric head may occur in the Magothy aquifer.

Declining water levels will significantly reduce streamflow and will also affect the amount of freshwater underflow to the bays. For instance, a run of the USGS analog model predicted reductions of streamflow of about 55 percent by 1995 in southeast Nassau County, based on present population and sewering projections. Reductions in streamflow may cause changes in the vegetation of certain freshwater wetlands. In addition, significant long-term reductions in groundwater outflow and streamflow to the various saltwater bodies surrounding Long Island may alter salinities. The environmental consequences of these changes are unknown at the present time. A decrease in freshwater discharge to the bays could be offset in part by shifting centers of pumping, stream augmentation or recharge with sewage effluent, importation or transfer of groundwater from surplus areas, or through planned water conservation programs.

A factor that adds some uncertainty to predictions of impacts in Nassau County is the future of the Jamaica Water Company in Queens. This supplier is pumping about 60 MGD, creating significant underflow from western Nassau to Queens. It is understood that, upon completion of New York City's third water tunnel, distribution of surface water to this area will be made possible. However, the lack of additional supply sources upstate, or elsewhere, precludes complete replacement of the present Queens groundwater supply, especially during drought periods. If Jamaica Water Company pumpage is eliminated or reduced in the future, underflow will be reduced and significant recovery of water levels in western Nassau will occur.

The Queens/Nassau common water-level decline illustrates the insignificance of political boundaries when dealing with the management of resources common to the entire Island. The present sub-surface flow from Nassau to Queens is estimated to be between ten and fifteen MGD. While some of this flow is due to natural conditions, a significant portion is undoubtedly due to heavy pumping in Queens. There have been a number of plans proposed for future groundwater development in the 208 area, that call for installing a regional well field in Suffolk County and pumping the water to Nassau County. At the present time, there is little natural exchange of groundwater between these two counties. However, if water levels are allowed to decline substantially in Nassau County, natural underflow of groundwater from Suffolk will occur.

If present patterns of use continue, groundwater outflow within the Magothy will be reduced along both the north and south shores of Nassau and Suffolk Counties. However, on the basis of past and present studies of saline groundwater on Long Island, including those on the North and South Forks, it is expected that the regional impact of saltwater intrusion will be small. The saltwater wedges in the upper and lower Magothy in the south-western and southern parts of Nassau, an area of historical saltwater contamination, will probably not advance much more than a mile locally, and less than a mile regionally, by the year 2000.[16] This would put the interface of the deep wedge in the vicinity of Sunrise Highway in Valley Stream and Lynbrook. Those few supply wells screened in the lower Magothy would be affected.

From the standpoint of water supply and wastewater management, it is essential that the potential threat of saltwater encroachment be viewed in its proper perspective and be fully understood. The loss of usable groundwater resources as a result of saltwater intrusion has been minor in comparison to the extensive fresh groundwater supplies that still remain in storage and untapped within the 208 Study area. Water-level declines due to increased pumpage, sewering, or temporary deficiencies in rainfall do not bring about massive encroachment of saltwater bodies within the various aquifers. In only one area of the Bi-county Region (southwestern Nassau), has there been documented evidence that saltwater is actively intruding. Even here, the average rate of movement has been less than twenty feet per year, notwithstanding the fact that water levels in nearby areas have been below sea level for decades.

Many of the past studies infer that a critical shortage of water may be expected within the next few decades. Increased consumptive use and declining water levels have frequently been equated with running out of water. The fact is, that on a bi-county basis, there is sufficient available groundwater to supply Long Island for many years beyond the current 1995 population projection, provided that action is taken to solve problems in specific areas and proper management techniques are adopted.[17] In evaluating wastewater management options, *i.e.,* recharge and stream augmentation, under 208, emphasis must be placed on determining the impact of proposed plans on groundwater quality and the effects on other segments of the environment, such as streamflow and freshwater discharge to the surrounding saltwater bodies.

2.4.2 Groundwater Quality. A further constraint to water supply self-sufficiency is water quality. Past and present waste disposal practices modify the purity of a significant portion of the available groundwater resource. The presence of nitrate, trace organic chemicals and heavy metals in some portions of the aquifer system may be much more important to long-term availability of usable water supply than short-term droughts and saltwater encroachment. In the following discussion, nitrate occurrence and trends are used to illustrate present conditions in the various aquifers. This constituent has been of great concern historically in the 208 Region, and data are available to reach some preliminary conclusions on how changes in land use and the presence of contamination sources have impacted groundwater quality on a regional basis. Other contaminants, such as heavy metals, organics in trace amounts and detergents have been of local importance. Chlorides, related to saltwater intrusion, have been discussed in the previous section on groundwater availability.

2.4.2.1 Water-Table Aquifer. The water-table or uppermost aquifer on Long Island receives most of the contaminants originating at the land surface. This aquifer consists primarily of Upper Glacial deposits and includes some sediments of the Magothy formation, the Manetto gravel and recent deposits. The aquifer has become contaminated to various degrees and is, in some places, unsuitable for use as a source of potable water supply. The groundwater found in these sediments is of special importance because in many areas it supplies water to the deeper Magothy formation. In addition, streams in Nassau and Suffolk Counties are largely dependent on flow from shallow groundwater and closely reflect its quality. Significant input to the bays and most freshwater lakes is also derived from the water-table aquifer by underflow.

The normal background quality of groundwater in the shallow sediments of Nassau and Suffolk Counties is very good. In general, the water can be characterized as soft, mildly corrosive and, in some cases, somewhat high in iron and manganese.

Over the past few decades, widespread effects of urbanization have considerably altered the quality of groundwater in the water-table aquifer. Many studies have detailed the extent and magnitude of these effects, with particular attention paid to nitrate, detergent, chloride and, to a lesser extent, sulfate. These constituents are usually good indicators of contamination. Median concentrations of these parameters in Nassau and Suffolk for the period 1972–76 with the exception of detergents are given in Table 2–12.

Statistical analyses of nitrate concentrations in selected wells throughout Nassau and Suffolk Counties were performed as part of the 208 Program. Trends in nitrate are important not only in themselves, but also because associated contaminants may follow similar trends.

A recent study[18] found that, of 21 wells in Sewage Disposal District No. 2 in Nassau, thirteen show valid decreasing trends of nitrate. Four had increasing trends. The median change in nitrate per year for all of the seventeen wells that showed trends is –0.34 milligrams per liter. Eight of the wells

Table 2–12

CONCENTRATIONS OF SELECTED CONSTITUENTS
IN THE UPPER GLACIAL AQUIFER, 1972–76

	Median		Mean	Range
Southwestern Nassau				
Nitrate	4.9	(159)	4.8	0.04 – 14
Chloride	28	(164)	43	6.6 – 950
Sulfate	44	(128)	47	5.0 – 120
Northern and Eastern Nassau				
Nitrate	3.0	(259)	4.3	0.00 – 36
Chloride*	19	(309)	83	1.3 – 14,000
Sulfate	30	(259)	30	0.00 – 450
Suffolk				
Nitrate	1.4	(1,273)	2.3	0.00 – 23
Chloride*	12	(2,047)	20	0.10 – 2,600
Sulfate	9.2		19	0.00 – 470

Note: The number in parenthesis indicates the number of analyses. Concentrations are in mg/l.

**High concentrations of chloride (i.e., 14,000 and 2,600) are due to contamination by salt water and are not representative of typical concentrations in fresh water.*

Source: Section B of the Areawide Waste Treatment Management Plan.

indicate a pattern of increasing and then decreasing concentrations. The time of inflection, or change from positive to negative slope, occurred during the late 1950's or early 1960's in most of these wells, and does not appear to be a drought-related phenomenon. The change corresponds to large scale sewer construction which started in the early 1950's and was completed in 1964.

In addition to the decreasing trends of nitrate in most of the water-table wells in Sewage Disposal District No. 2, the median nitrate concentration in streams sampled during the period 1972–1975 shows substantially lower levels in southwestern Nassau as compared with those in southeastern Nassau. The median values are shown in Table 2–13. Although it is not possible to identify trends on the basis of the limited data, it appears that sewering may have been responsible for reducing nitrate levels in the stream discharges, which generally represent the most recently recharged water in Sewage Disposal District No. 2.

Despite generally decreasing trends of nitrate in wells in Sewage Disposal District No. 2, the actual concentrations in some wells are still quite high. Possible explanations for this are (1) the sewers are leaking, (2) the use of home fertilizers is such an important input that removal of on-lot sewage disposal systems alone results in only a slow decrease in nitrate levels, or (3) insufficient time has elapsed for even shallow wells to be flushed of high nitrate water.

Applying the criteria used in the study, the number of wells in the unsewered portion of Nassau County (Sewage Disposal District No. 3) is found to be insufficient to permit any conclusions. Three wells show increasing trends in nitrogen concentration, while two show decreasing trends. Wells in northern Nassau County generally show either small increases or small decreases in nitrate concentration.

Twenty-one water-table wells in Suffolk that have nitrate-nitrogen concentrations above background levels show significant nitrate trends. Of eighteen wells in southwestern Suffolk (Babylon and Islip), sixteen show increasing trends, an indication of deteriorating water quality. The period of record for most of these wells started in the 1960's. Southwestern Suffolk is of interest because it is hydrologically similar to Nassau Sewage Disposal District No. 2. Recent land use is also similar, although development took place some years later. The median change per year in nitrate in the eighteen wells in this part of Suffolk is +0.13 milligrams per liter.

An indication of the effects of sewering on groundwater quality is provided by ongoing studies of the U.S. Geological Survey.[19] Preliminary findings of continued evaluation of the information obtained during the preparation of a U.S. Geological Survey report for the 208 Program[20] reveals significantly lower median concentrations of ammonia in shallow groundwater underlying Sewage Disposal District No.2 compared to shallow groundwater in Sewage Disposal District No. 3 in Nassau County. Again, sewering was undertaken in District No. 2 during the 1950's, whereas the installation of sewers in District No. 3 is still underway. In addition, an evaluation of water quality trends in only the very shallow glacial deposits in District No. 2 and District No. 3 indicates stronger decreasing trends of nitrate in the former. These preliminary findings are indications of the results of a reduction in nitrate loading, apparently due to sewering.

Table 2–13

QUALITY OF NASSAU AND SUFFOLK STREAMS

Stream	Median Nitrate-Nitrogen (mg/l) 1972–75		Median Specific Conductance (μmhos) 1972–75	
North Shore (Nassau and Suffolk)				
Glen Cove Creek	3.39	(11)	228	(14)
Mill Neck Creek	0.77	(26)	164	(35)
Cold Spring Brook	0.50	(12)	76	(13)
Nissequogue River	1.13	(8)	100	(12)
Southwestern Nassau				
Valley Stream	0.88	(6)	150	(9)
Pines Brook	2.03	(9)	340	(11)
Southeastern Nassau				
East Meadow Brook (tributary)	3.61	(28)	449	(38)
Bellmore Creek (tributary)	8.58	(10)	353	(14)
Bellmore Creek	5.87	(12)	340	(14)
Massapequa Creek	7.00	(31)	320	(36)
Southwestern Suffolk				
Santapogue Creek	2.26	(13)	290	(15)
Carlls River	2.93	(14)	215	(16)
Sampawams Creek	3.16	(15)	215	(17)
Penataquit Creek	3.61	(14)	313	(17)
Champlin Creek (Oakdale)	1.85	(14)	151	(16)
Connetquot River	0.93	(12)	80	(15)
Connetquot River (North Great River)	0.88	(12)	84	(14)
Southeastern and Eastern Suffolk				
Patchogue River	1.11	(10)	114	(4)
Swan River	1.20	(10)	90	(12)
Carmans River	0.74	(29)	101	(36)
Peconic River	0.25	(12)	92	(24)

Note: The number in parenthesis indicates the number of analyses.

Source: Section B of the Areawide Waste Treatment Management Plan.

2.4.2.2 Magothy Aquifer. The natural chemical quality of water within the Magothy is generally excellent and characterized by a very low dissolved solids content. Contamination of the Magothy is of great concern, since many public supply wells are screened in this formation. Past water-quality investigations have dealt primarily with the distribution and trends of nitrate. From these studies, it is well established that many wells within the Magothy are pumping chemically altered or contaminated water.

The 1972–76 median concentrations of nitrate, chloride and sulfate in the various portions of the study area illustrate the relative degree of alteration (Table 2–14). Differences in concentrations of these constituents between the two specified areas of Nassau are probably not due to sewering, except possibly at the shallower depths. Other factors, such as location of wells with respect to past land uses, are probably more important. Those water-quality trends now occurring in the water-table aquifer, as discussed in the previous section, will undoubtedly be reflected in some way in the Magothy in future years. In general, the levels of contaminants decrease with depth, until near-background concentrations are found in most wells greater than 600 feet deep. The apparent smaller value of nitrate for wells of the sewered area less than 200 feet deep may be due to insufficient sampling.

Table 2–14

MEDIAN WATER-QUALITY DATA IN THE MAGOTHY AQUIFER 1972-1976

Depth (feet)	Southwest Nassau		East and North Nassau		Suffolk	
Nitrate as N						
Less than 200	0.88	(18)	2.8	(104)	2.6	(4)
200 to 399	2.5	(130)	2.8	(443)	0.10	(263)
400 to 599	0.2	(526)	1.1	(515)	0.10	(391)
Greater than 600	0.01	(42)	0.13	(177)	0.01	(322)
Chloride						
Less than 200	18	(18)	13	(108)	14	(13)
200 to 399	12	(136)	10	(45)	5.0	(270)
400 to 599	6.4	(542)	5.8	(532)	4.5	(400)
Greater than 600	4.6	(42)	4.4	(179)	4.0	(355)
Sulfate						
Less than 200	32	(14)	22	(93)	2.6	(11)
200 to 399	13	(122)	7.0	(392)	3.2	(264)
400 to 599	5.0	(500)	2.0	(403)	3.2	(388)
Greater than 600	3.0	(39)	1.0	(159)	3.4	(399)

Note: Numbers in parentheses are the number of analyses. All concentrations in mg/l.
Source: Section B of the Areawide Waste Treatment Management Plan.

A recent U.S. Geological Survey study in southeast Nassau County provides an analysis of vertical and horizontal distributions of nitrate, chloride and dissolved solids.[22] The conclusions reached illustrate the typical history of heavily urbanized areas served by heavy pumpage from local, deep aquifer zones:

1. Downward movement of nitrate in the Magothy between the early 1950's and 1973 ranged from no significant movement in the area south of North Merrick and South Farmingdale to a maximum movement of a few hundred feet in the areas of Westbury, Hicksville and Plainview. There also seems to be a definite horizontal movement of equal nitrate concentration lines through the aquifer.
2. There has been a more rapid downward movement of nitrate in the eastern part of the study area than in the central and western parts. The rapid movement in the eastern part may be partly due to a large increase in pumpage in the Plainview area.
3. There is a zone of high-nitrate water in the Magothy aquifer in the area of Westbury, Hicksville and Plainview. Some of these increases may be attributable to past large-scale farming, and the associated use of fertilizers in the Hicksville and Levittown areas, and to subsurface domestic discharges and pumpage.
4. The downward movement of chloride covers a broader area than does that of nitrate.
5. There has been significant downward movement of higher than normal total solids concentrations between the 1950's and 1973. Overall downward movement ranges from a few feet to approximately 300 feet. A zone of high total solids concentrations of more than 200 milligrams per liter is found in the Hicksville and Plainview areas. The total solids concentration in groundwater in the Plainview area approximately doubled in twenty years.

It is also likely that reduction of pumpage from the Glacial formation and preferential or exclusive development of the Magothy formation has accelerated the downward movement of contaminated waters. A study completed in 1969 reviews the trends of nitrate in 373 public suppy wells in Nassau County.[23] Most of the wells analyzed were deep wells, screened in the Magothy. Eighty wells showed statistically significant increasing trends and nine were decreasing. A general upward trend of nitrate in most Magothy wells is also confirmed by a study presently under way by the U.S. Geological Survey.[24] In this investigation, trends of nitrate in most Magothy wells in Nassau County showed statistically significant increases. Studies in Suffolk County have not been as extensive as in Nassau, but the data indicates no significant change in water quality in the Magothy aquifer.

2.4.2.3 **Lloyd Aquifer.** The Lloyd aquifer is the least altered by human activities. This is due primarily to the thick confining bed of Raritan clay which overlies the Lloyd in most places and impedes the exchange of water with the Magothy. On the North Shore, however, the Raritan clay is discontinuous in places, and the aquifer is in lateral, and possibly vertical, hydraulic connection with Pleistocene deposits which have replaced the Magothy deposits. Regionally, the Lloyd is recharged through the clay over a broad area covering most of Nassau and Suffolk Counties. Discharge in the western part of the study area is primarily through wells, while in the eastern part discharge is mostly to the bays and to the ocean. (See Table 2–15 for Nassau water quality data.)

Table 2–15

THE MEDIAN CONCENTRATIONS OF SELECTED CONSTITUENTS IN THE LLOYD AQUIFER IN NASSAU COUNTY (1972–76)

	Southwest Nassau		North and East Nassau	
Nitrate as N	0.07	(13)	0.21	(100)
Chloride	5.1	(12)	5.2	(106)
Sulfate	6.0	(13)	3.0	(94)

Note: Concentrations in mg/l; numbers in parentheses are numbers of analyses.
Source: Section B of the Areawide Waste Treatment Management Plan.

Many of the wells in the north and east area are located in Manhasset, Great Neck and in the northern part of the Town of Oyster Bay. Some of the wells in these areas show elevated levels of nitrate, indicating contamination from the surface. This suggests some degree of hydraulic connection with overlying sediments, probably in areas where the Raritan clay has been eroded and replaced by more permeable deposits.

Uncontaminated water in the Lloyd is characterized by low dissolved solids (less than 50 milligrams per liter). Iron, however, commonly occurs at levels considerably above the recommended limit of 0.3 milligrams per liter.

2.4.2.4 **Organic Chemicals.** Several years ago, an incident of groundwater contamination was reported near an industrial complex in Nassau County. Subsequent sampling and analysis of water from wells within the complex indicated significant concentrations of vinyl chloride and industrial degreasers such as tri- and tetrachloroethylene. The wells yielding water containing these contaminants were removed from service as sources of potable water. An intensive survey of all public drinking water supply wells in both Nassau and Suffolk Counties has been underway for the past two years. As of October 1977, almost 650 analyses have been performed on samples collected from 475 public water supply wells in both counties. Fifteen wells have been removed from service because of the presence of volatile organic compounds.

The formation of chlorinated hydrocarbons in "finished" waters, as the result of chlorination practices, requires the presence of the precursor compounds. This is very rarely the case in Long Island groundwaters, especially Magothy waters, even though it has been the case in some surface waters.

The 208 Program responded to requests from its TAC and CAC, and initiated a program to analyze samples from groundwaters, stormwater, domestic waste discharges and landfill leachates for the presence of volatile and non-volatile organic compounds. The survey of non-volatile compounds resulted in the detection of substituted benzene compounds, napthalenes and various butylphthalates. Some of these compounds are common constituents of plasticizers, and some are on the list of those suspected of being carcinogenic to animals. Volatile organic compounds were also detected at parts per billion concentrations, with their sources yet to be determined or evaluated. Studies are continuing, and a full report will be forthcoming.[25]

2.5 Surface Water Quality

2.5.1 **Introduction.** As part of the 208 planning process, an extensive review of historical water quality data was made for selected bays. The bays were chosen for detailed investigation because of current water quality problems or the presence of existing or proposed major discharges. The data, which were collected between 1970 and 1975, were obtained from various sources. These programs were designed for a variety of purposes, not necessarily to characterize the water quality throughout the bay. To supplement this data base and to provide data for mathematical model calibration and verification, an additional data collection program was undertaken during 1976. All of these data, in conjunction with mathematical model results, provide a means to characterize the water quality of each bay. Presentation of data and detailed analysis is contained in a large number of technical reports. This section provides a summary water quality assessment for each bay for eight selected bay systems. A non-modeling water quality assessment was prepared for Moriches, Shinnecock and Mecox Bays, western Long Island Sound and the nearshore Atlantic Ocean.

It is important to note that, on the north shore of Long Island, water quality conditions within the bays are largely influenced by the quality of Long Island Sound water, which provides the boundary values for the bay models. Long Island Sound shows a definite gradient of improving quality from west to east. For example, total coliform bacteria concentrations ranged from approximately 2400 MPN per 100 milliliters near Manhasset Bay to less than twenty MPN per 100 milliliters near Huntington Harbor. Nitrogen shows a similar trend, with concentrations decreasing from approximately 0.8 milligrams nitrogen per liter at Manhasset Bay to approximately 0.3 milligrams nitrogen per liter at Port Jefferson Harbor.[26]

Conversely, if boundary conditions are low, waste loads can be relatively high, due to the rapid mixing and high flushing rates in the North Shore bays. The importance of these boundary values cannot be overemphasized, because no waste management plan for an individual bay would be able to reduce concentrations significantly below the boundary values.

The Peconic Estuary-Flanders Bay system, as well as the Great South Bay, have relatively long residence times and, although changes are slow to manifest, dilution and flushing are much less than in the North Shore bays. This characteristic causes water quality in these two systems to be highly sensitive to internal waste loads, and boundary effects to become minimal.

Unlike Long Island Sound's effect on water quality of the North Shore bays, the nearshore Atlantic Ocean water quality does not appear to significantly influence water quality of the South Shore bays. Available water quality data indicate that total nitrogen concentrations are consistently between 0.1 and 0.4 milligrams nitrogen per liter in nearshore Atlantic waters that represent the boundary conditions for the South Shore bays. Furthermore, bacterial water quality local to the Long Island South Shore is determined primarily by contaminant loads emitted by the bays themselves. A review of historical physical and water quality data in the New York Bight Apex indicates that the great majority of wastes emitted from New York Harbor travel south along the New Jersey coast, except during sustained periods of southerly winds. In addition, the sludge dumping practices in the Bight Apex do not, at present, appear to significantly affect water quality along the South Shore of Long Island. For these reasons, waste management plans for reducing waste loads within the South Shore bays should be effective in controlling water quality in these bays.[27]

The following subsections provide a description of observed water quality conditions in all of the bays, and attempt to indicate the amount of pollutants that result from different sources, based on data taken from Sections B and D of the Areawide Waste Treatment Management Plan. The last section provides a summary for all bays. Most of the discussion centers around coliform bacteria and nitrogen concentrations because they have been found to be key indicators of water quality conditions.

2.5.2 Manhasset Bay. Manhasset Bay, the most westerly of the North Shore bays that were studied, is largely influenced by Long Island Sound. Seventy percent of the total nitrogen contributed to the bay from internal loading is from point sources. The remainder (700 pounds per day) comes from non-point sources including groundwater inflow, stream base flow, stormwater runoff and direct rainfall. Storm-related nitrogen inputs are approximately twelve percent of the internal nitrogen loading to Manhasset Bay. Depending on location in the bay nine to 80 percent of the observed nitrogen is a result of internal sources. Concentrations of total nitrogen within the bay range from 0.1 to 3.4 milligrams nitrogen per liter. The high concentrations are found in the vicinity of discharges located in relatively poorly-flushed areas.

The nitrogen concentrations are sufficient to allow large phytoplankton blooms. The field data for 1976 showed chlorophyll a values to exceed 300 micrograms per liter on occasion.

Large masses of phytoplankton generally produce very high dissolved oxygen concentrations during the day through photosynthesis, and very low dissolved oxygen levels during the night due to respiration. While a normal value for dissolved oxygen would be between 7.5 and 9.0 milligrams per liter, the field data for 1976 showed values to reach nearly 20.0 milligrams per liter during the day. While nighttime measurements of dissolved oxygen were not made, some early morning measurements as low as 3.6 milligrams per liter suggest considerable dissolved oxygen depression at night.

Ninety-five percent of the total coliform bacteria contributed by sources within Manhasset Bay is from stormwater runoff. An additional four percent is contributed by stream base flow, while point sources generally contribute only one percent. These total coliform loadings, in conjunction with high boundary concentrations (2400 MPN per 100 milliliters), have resulted in the classification of Manhasset Bay as unfit for shellfishing and occasionally, after storm events, have resulted in the temporary contravention of the standards for swimming.

2.5.3 Hempstead Harbor. Hempstead Harbor, located just east of Manhasset Bay, is also largely influenced by Long Island Sound water quality. Approximately 72 percent of the internal nitrogen loading is from point sources.

The remainder (approximately 1200 pounds per day) comes from non-point sources, including groundwater inflow, stream base flow, stormwater runoff and direct rainfall. Storm-related nitrogen inputs are approximately five percent of the internal nitrogen loading. Concentrations of total nitrogen within the harbor ranged from 0.3 to 16.8 milligrams nitrogen per liter. Depending on location in the harbor, thirteen to 80 percent of the observed nitrogen is a result of internal sources. The high values are found in the vicinity of discharges that are located in relatively poorly flushed areas.

These nitrogen concentrations are sufficiently high to allow large phytoplankton blooms. The field data for 1976 showed chlorophyll a values up to 200 micrograms per liter on occasion. Such large chlorophyll a concentrations generally produce large amounts of oxygen by photosynthesis during the day, and consume larger amounts by respiration at night. Field data showed oxygen concentrations to range from two to seventeen milligrams per liter.

Ninety percent of the total coliform bacteria contributed by sources within the harbor is from storm runoff. An additional eight percent is contributed by stream base flow and two percent by point sources. These total coliform loadings, along with high boundary concentrations, have resulted in the closing of shellfishing areas in Hempstead Harbor.

2.5.4 Oyster Bay. Oyster Bay receives a total nitrogen loading of approximately 1,700 pounds per day from all non-point sources within the bay. About 46 percent of the loading is from groundwater underflow and 23 percent from point sources. The nitrogen contribution of Long Island Sound to Oyster Bay is substantially less than to Manhasset Bay and Hempstead Harbor. Concentrations range from a "worst case" boundary condition of 0.45 milligrams nitrogen per liter to an average of about 0.30 observed in August 1976.

Nitrogen concentrations in Oyster Bay observed in August 1976 ranged from 0.1 milligrams nitrogen per liter to 0.53 milligrams nitrogen per liter. The highest concentrations were observed in Mill Neck Creek and the south end of Cold Spring Harbor. In Mill Neck Creek, point sources account for about 34 percent of observed nitrogen concentration. In Cold Spring Harbor, 31 percent of the observed nitrogen concentration is due to point sources. In these areas the additional nitrogen was contributed by Long Island Sound.

Virtually one hundred percent of the total coliform loading to Oyster Bay is from stormwater runoff. Median coliform counts in Long Island Sound at the entrance to Oyster Bay/Cold Spring Harbor are below the maximum 70 MPN per 100 milliliters standard for shellfishing areas. Areas in the vicinity of the Cold Spring Harbor Treatment Plant outfall, the Oyster Bay Treatment Plant outfall, Mill Neck Creek and adjacent to Mill Pond are closed to shellfishing.

2.5.5 Huntington Bay. Approximately 42 percent of the total internal nitrogen loading (1800 pounds per day) to Huntington Bay is estimated to derive from groundwater inflow. An additional twenty percent comes from point sources, twenty-one percent from runoff, eleven percent from direct rainfall and seven percent from stream base flow. Concentrations of total nitrogen within the bay range from 0.1 to 1.4 milligrams nitrogen per liter. Depending on location in the bay, with a boundary nitrogen concentration of 0.32 milligrams nitrogen per liter, three to 50 percent of the observed nitrogen is a result of internal sources. The high values are in Centerport Harbor and Northport Harbor, where point sources discharge to poorly mixed areas. Huntington Harbor receives the Huntington Sewage Treatment Plant discharge.

The generally high nitrogen concentrations result in substantial algal production in those area that are poorly flushed. Chlorophyll a values up to 50 micrograms per liter have been found in Centerport Harbor and in Huntington Harbor. Dissolved oxygen concentrations ranged from 4.2 to 12.6 milligrams per liter.

Ninety-eight percent of total coliform bacteria loading contributed by sources within the bay are computed to derive from storm runoff. Stream base flow contributes most of the remaining two percent. Treatment plant discharges are minor sources. Total coliform bacteria concentrations within the Bay range from less than three to 1100 MPN per 100 milliliters. Typical coliform concentrations in Long Island Sound, near the entrance to Huntington Bay, are less than 70 MPN per 100 milliliters. As expected, the poorly flushed areas receiving treatment effluent and stream discharges (Northport Harbor, Centerport Harbor and Huntington Harbor) are closed to shellfishing.

2.5.6 Port Jefferson Harbor. Port Jefferson Harbor exhibits the best water quality of all the North Shore bays studied under the 208 Program. The total nitrogen loading from internal sources is approximately 800 pounds per day. Twenty percent of this total is contributed by point sources (Port Jefferson Treatment Plant). Total loads (wet and dry weather) indicate that groundwater inflow contributes 32 percent, stream base flow nine percent, direct rainfall fourteen percent and stormwater runoff 25 percent of the total nitrogen loading to the harbor.

The contribution of Long Island Sound to nitrogen concentrations in the harbor is relatively low. Four observations in the Sound during June and July 1976 ranged from 0.20 milligrams nitrogen per liter to 0.41 milligrams nitrogen per liter with a mean of 0.30 milligrams nitrogen per liter.

Total nitrogen values ovserved in the harbor during June and July of 1976 ranged from 0.10 to 0.73 milligrams nitrogen per liter. Highest concentrations were observed at the south end of Port Jefferson Harbor, in Little Bay, and in Conscience Bay. In July 1976, point sources and stream base flow accounted for 21 percent of the nitrogen at the south end of Port Jefferson Harbor. Non-point sources alone accounted for over twenty percent of the nitrogen in Little Bay and Conscience Bay. The remaining nitrogen in all areas was contributed at the boundary.

It is estimated that stormwater runoff is responsible for 97 percent of the total coliform input to Port Jefferson Harbor. The remaining three percent is contributed mostly by stream base flow. The treatment plant discharge is only a minor source. This has resulted in the closing to shellfishing of areas near the mouths of the three streams discharging to the Port Jefferson Harbor system. Total coliform concentrations at the Long Island Sound boundary are below the maximum of 70 MPN per 100 milliliters allowable for shellfishing waters.

2.5.7 Peconic-Flanders. The Peconic Estuary-Flanders Bay system, located on the eastern end of Long Island, is characterized by long residence times. The total internal nitrogen loading was approximately 1100 pounds per day in 1976. Approximately 76 percent of this nitrogen loading was from point sources, which included duck farms and the Riverhead Sewage Treatment Plant. Stream flow and direct rainfall each account for an additional eleven percent of nitrogen loads. Bay water quality, under dry weather conditions, is impacted by sewage treatment effluent.

Concentrations of total nitrogen in the system range from 0.1 milligrams per liter to over 9.0 milligrams per liter. The higher concentrations are generally found in the Peconic Estuary and near Meetinghouse Creek. Very high chlorophyll a concentrations were observed in areas with high nitrogen levels. Chlorophyll a concentrations ranged from less than five micrograms per liter to over 370 micrograms per liter. Dissolved oxygen ranged from near zero to over fourteen milligrams per liter.

It was determined that 64 percent of total coliform loadings result from storm runoff. Approximately thirteen percent is from stream base flow.

Total coliform bacteria concentrations in the Peconic/Flanders system ranged from five to 13,000 MPN per 100 milliliters. The Peconic Estuary is closed to shellfishing because of high bacterial concentrations.

2.5.8 Great South Bay. The Great South Bay is a large open estuary about 25 miles long and one to two miles wide. The average depth is near six feet. Water quality in the bay is largely affected by stream discharges, groundwater flow, two sewage treatment plants and tidal flushing.

Residence time in portions of Great South Bay is two to three months. This means that a parcel of wastewater requires about two or three months to be flushed out of the bay. It also means that, at any time, the bay contains nearly all the wastes and freshwater discharged to it over the last two or three months.

Total nitrogen loading to the Great South Bay is approximately 6,600 pounds per day. Of this total, approximately 39 percent is from base streamflow, sixteen percent from groundwater inflow, 26 percent from direct rainfall, seventeen percent from storm runoff and only two percent from point sources. Total nitrogen concentrations observed in November 1976 range from 0.12 to 1.72 milligrams nitrogen per liter. The values generally increase from west to east, with highest concentrations found near Bellport Bay (Carmans River).

Chlorophyll a concentrations ranged from one to 90 micrograms per liter. Dissolved oxygen concentrations ranged from 0.2 to fourteen milligrams per liter. The lower values of dissolved oxygen are generally toward the western end of the bay and are not found in conjunction with the higher chlorophyll a levels.

The shallow nature of the Great South Bay, the abundance of macrophytes, and the benthic oxygen demand all contribute to the oxygen balance of the Great South Bay. As a result of the long residence time in the bay, phytoplankton abundance is often limited by nitrogen depletion.

Approximately 90 percent of the total coliform bacteria loadings to Great South Bay are from stormwater runoff. The remainder is primarily from base streamflow. Total coliform concentrations in Great South Bay ranged from less than two to greater than 35,000 MPN per 100 milliliters in the vicinity of Bayshore Cove. Portions of the Great South Bay near stream discharges are closed to shellfishing as a result of high bacterial concentrations.

2.5.9 Western South Shore Bays. The western South Shore bays include Hempstead, East, Middle and South Oyster Bay. These bays comprise a series of interconnecting channels, marshes, tidal flats and islands. Hydraulic residence times are relatively small compared to Great South Bay, and flushing is good. However, there are a number of large pollutant sources.

Total nitrogen loading is approximately 22,400 pounds per day, 75 percent of which is from point sources. Groundwater inflow and stream base flow contribute an additional seven and ten percent, respectively. Storm runoff contributes only four percent, and direct rainfall two percent of total nitrogen loading. Total nitrogen concentrations within the bays ranged from 0.03 to 2.4 milligrams nitrogen per liter. Areas in the vicintiy of discharges, particularly the Bay Park Sewage Treatment Plant, showed the highest concentrations.

Chlorophyll a concentrations ranged from less than one to 130 micrograms per liter, illustrating the potential for large phytoplankton production. Dissolved oxygen concentrations ranged from 0.04 to fourteen milligrams per liter. The oxygen concentrations are primarily a result of organic matter oxidation, algal respiration and benthic oxygen demand.

Approximately 83 percent of total coliform loadings to the western South Shore bays result from storm runoff. Point sources account for approximately fifteen percent. Specifically, in Hempstead Bay, point sources contribute approximately 62 percent of total coliform; 36 percent comes from nonpoint sources. Total coliform bacteria concentrations in the bays ranged from less than two to greater than 24,000 MPN per 100 milliliters. Virtually all of the western South Shore bays are closed to shellfishing because total coliform concentrations exceed the standard. It should be noted, however, that the contribution of fecal coliform loadings is less evenly distributed between runoff and point sources with the former accounting for roughly 96 percent, and the latter for four percent.

2.5.10 Moriches Bay. Moriches Bay lies to the east of Great South Bay on Long Island's South Shore. An estimated 2100 pounds per day of nitrogen are discharged to the bay, mainly from groundwater underflow (33 percent) and stream base flow (30 percent). Point sources of discharges from duck farms account for fourteen percent of the nitrogen loading, while direct rainfall and runoff together contribute 23 percent. There are no known measurements of nitrogen input from duck sludge deposits, and it is therefore nearly impossible to estimate any present day nutrient loadings.

Virtually 100 percent of total and fecal coliform loadings to Moriches Bay are from stormwater runoff. Total coliform concentrations commonly exceed 70 MPN per 100 milliliters in tributaries of Moriches Bay, with an observed range from less than three to greater than 2,400 MPN per 100 milliliters. Several tributaries and their mouths are closed to shellfishing due to total coliform concentrations in excess of the standard.

The status of Moriches Inlet is a major influence on water quality. The inlet is at present open, providing more tidal flushing than at any other time in the past 40 years. Total nitrogen concentrations in Moriches Bay average around 0.6 milligrams nitrogen per liter. Water quality in the bay has been steadily improving due to stabilization and natural enlargement of the inlet and recent reductions of point source loadings.

2.5.11 Shinnecock Bay. Shinnecock Bay lies to the east of Moriches Bay and receives a relatively small nitrogen loading (500 pounds per day). The largest single source of nitrogen to the bay (48 percent) is direct rainfall. There are no point sources. Coliform loadings to Shinnecock Bay are due solely to stormwater runoff. Observed coliform concentrations throughout

Shinnecock Bay are typically below ten MPN per 100 milliliters. As a result, there are presently no areas closed to shellfishing in Shinnecock Bay. Also, as a result of the small nitrogen loading, Shinnecock exhibits excellent water quality. The average total nitrogen concentration in the bay is approximately 0.32 milligrams nitrogen per liter.

2.5.12 Mecox Bay. Mecox Bay is a shallow coastal embayment located east of Shinnecock Bay on Long Island's South Shore. Mecox Bay receives an estimated 310 pounds per day of nitrogen of which groundwater underflow contributes 49 percent, stream base flow 21 percent, stormwater runoff 21 percent and rainfall nine percent. There are presently no point sources to Mecox Bay. In addition, there is no clear evidence to suggest that duck sludge deposits created by the past operation of the Mecox Bay Duck Farm do or do not contribute nitrogen to the bay. Coliform contamination in excess of the State standard occurs in Mecox Bay due mainly to stormwater runoff. As a result, most of Mecox Bay is closed to shellfishing.

Despite this small loading to the system, Mecox Bay has exhibited water quality problems, especially in its side embayments. Total dissolved inorganic nitrogen concentrations have average 0.77 milligrams per liter in Hayground Cove. Coliform concentrations frequently contravene standards in Hayground Cove and Mill Creek, probably as a result of stormwater runoff loads. The only outlet for the bay is an ephemeral channel connecting it to the Atlantic Ocean. This inlet provides limited flushing and drainage to Mecox Bay approximately 50 percent of the time.

2.5.13 Comparison of Bay Water Quality. Any evaluation of surface water quality necessarily requires a consideration of physical, chemical and biological processes. Unfortunately, existing governmental regulations set standards for only two parameters normally considered in marine water quality assessments. Dissolved oxygen and coliform bacteria levels have traditionally been measured for most of the waters on Long Island, and are used by the State as the basis for the classification of areas as to their "best use." Table 2–16 presents data on both dissolved oxygen and total coliforms for each bay system, and the frequency with which State standards for these parameters have been contravened. In addition, data on total nitrogen and chlorophyll a levels are presented. These parameters have been shown to be highly useful in determining the general biological state of the marine waters of Long Island. Analyses of historical and newly acquired 208 data have indicated that total nitrogen values of approximately 0.4 milligrams nitrogen per liter and chlorophyll a levels of about twenty micrograms per liter can be used as guidelines for evaluating the overall biological state of each system.[28]

Table 2–16

SUMMARY OF WATER QUALITY DATA AND FREQUENCY OF STANDARDS CONTRAVENTION FOR LONG ISLAND MARINE WATERS

	Manhasset Bay	Hempstead Harbor	Oyster Bay	Huntington-Northport Complex	Port Jefferson Harbor	Peconic-Flanders Complex	Hempstead Bay	Middle Bay	East Bay	S. Oyster Bay	W. Great South Bay	C. Great South Bay	E. Great South Bay	Moriches Bay	Shinnecock Bay
Diss. O_2^+ (ppm)	2–19	2–17	3–18	4–15	4–10	0.2–12	1.2–14.1	0.4–14.0	3.8–15	1–15	0.2–15	2–15	3.6–10	–	–
T. Coli.$^+$ (MPN/100 ml)	4–11000	3–11000	2–11000	2–11000	2–1600	2–15000	3–24000	3–11000	2–24000	2–11000	2–35000	2–1600	2–24000	<3–2400	<3–1100
T. Nit.$^+$ (mgN/l)	0.1–3.4	0.3–16.8	0.1–0.5	0.1–1.4	01.–0.7	0.1–11.8	0.03–2.38	0.08–1.62	0.09–0.63	0.12–0.76	0.13–1.24	0.12–1.65	0.51–1.72	0.1–1.6	0.1–0.6
Chl a$^+$ (mg/l)	2–308	4–220	10–35	1–49	1–18	1–372	<1–130	<1–40	3–50	3–14	1–50	1–90	1–46	–	–
T. Col. % exceed 70 MPN/100 ml	11*	11*	24	26	33	55	16	8	6	33	46	38	40	27	10
Diss. O_2 % below 5.0 ppm	17	46	5	36	4†	60	20	24	3	6	45	16	8	–	–
Chl a % above 20 mg/l	59†	60†	57†	21†	<1†	15	14	10	8	<1	61	42	62	–	–

$^+$ *range includes historical and newly acquired 208 data.*
† *indicates frequency of contravention calculated based on average of 208 data only—all other frequencies based on historical data.*
* *criteria is based on 2400 MPN/100 ml—therefore % contravention of 70 MPN/100 ml would be significantly higher.*

Source: Tetra Tech Inc. 1977, "Water Quality Evaluation—Western Long Island Sound," Prepared under contract to the Nassau-Suffolk 208 Program Study.

Several general conclusions can be drawn from the data presented in Table 2–15.

1. All bays exhibit ranges of dissolved oxygen concentrations that periodically contravene the five milligrams per liter standard. Hempstead Harbor and western Great South Bay show the highest frequency of depressed oxygen values, whereas Oyster Bay and Port Jefferson Harbor on the North Shore, and East Bay and South Oyster Bay on the South Shore, exhibit the lowest frequency of low oxygen levels. (Moriches and Shinnecock Bays were not evaluated for this parameter.)
2. All areas studied show total coliform concentrations above the 70 MPN per 100 milliliters standard set for shellfish areas. Historically, sampling locations are not uniformly distributed, but rather concentrated in areas where contravention of the standard is expected to occur, in order to determine the necessity for closing shellfishing areas. Consequently, the record is biased toward high bacterial values. The percent frequency of contravention seems to indicate that the Peconic-Flanders and Great South Bay systems exhibit the most persistently elevated coliform values. Unfortunately, the only historical data available for Manhasset Bay and Hempstead Harbor were analyzed with respect to the swimming water standard of 2400 MPN per 100 milliliters. Had available data for these areas been based on the 70 MPN per 100 milliliters criterion, both areas would have shown significantly higher frequencies of coliform contamination. The majority of the open water areas of Great South Bay are free of coliform contamination, and indeed, almost all open water areas are certified for commercial shellfishing. Areas closed to shellfishing in August 1977 are shown in Figure 2–8.
3. There are large regional variations in total nitrogen concentrattions. North Shore bays generally exhibit slightly lower values than the South Shore bay systems. The influence of treatment plant locations can be seen in Manhasset Bay, Hempstead Harbor, Peconic-Flanders and the Hempstead Bay system.

   In the Nassau County South Shore systems, values decrease from west to east, reflecting increased flushing and the distance from the Bay Park Sewage Treatment Plant outfall. Values in Great South Bay generally increase from west to east, reflecting the inputs from Carmans River and the decrease in flushing with increasing distance from Fire Island Inlet. All bays periodically exceed 0.4 milligrams nitrogen per liter. This has been suggested as the concentration below which abnormally high fluctuations in dissolved oxygen levels would not be expected. Indeed, all bays exhibit phytoplankton "bloom" conditions from time to time, with concommitant fluctuations in dissolved oxygen levels.
4. Chlorophyll _a_ concentrations are used as an indicator of the standing crop of phytoplankton.[29] Larger fluctuations in this parameter often indicate the probability of associated fluctuations in nitrogen and dissolved oxygen. This is readily apparent in Manhasset Bay, Hempstead Harbor, Peconic-Flanders and the Great South Bay systems. Oyster Bay and Port Jefferson Harbor on the North Shore, and South Oyster Bay on the South Shore, exhibit the narrowest range of chlorophyll _a_ values.

2.6 The Long Island Ecosystem

The following discussion on the Long Island ecosystem is based on information taken from a report prepared by Energy Resources Company Inc.,[30] and contained in Section P of the Areawide Waste Treatment Mangement Plan.

2.6.1 Ecological Processes on Long Island. The functioning of the Long Island ecosystem is governed by several processes that integrate the biological elements and cycle and transport material. The major processes affecting the food web include nitrogen cycles, phosphorus cycles, organic matter cycling, land-water interactions and surface-groundwater interactions. The nature of one of these processes on Long Island is indicated in Figure 2–9. Present stresses on the Long Island ecosystem include accumulations of trace contaminants, modification of wetland habitats by point and non-point source inputs, and various chemical discharges. The reduction in shoreline wetlands has eliminated much of the capability of the bays to easily assimilate sediment, and organic and nutrient material loadings. Groundwater-surface water relationships have also been alterd by development, that is, the substitution of impermeable surfaces for natural vegetation, and sewering.

2.6.2 Existing Ecological Communitites. The Nassau-Suffolk Region is characterized by complex ecological systems, of which the chief components are offshore water, bays and estuaries, streams and lakes, wetlands, land, and groundwater. A number of significant types of interactions tie together the six subsystems with respect to the environmental processes affected by waste treatment (nutrient cycles, organic cycles, food web). Most treated and untreated wastes are discharged to offshore areas, bays and land; some are discharged to streams and lakes.

The present conditions and areal extent of the various subsystems can be assessed. In the following discussion, offshore water, bay and estuary, stream and lake, wetland and land systems are discussed in order. Finally, the processes occurring in these systems are considered. A discussion of groundwater has been provided in Section 2.4.

Each of the subsystems presented below can be further divided into smaller systems, which are termed "habitats." Diverse habitats generally permit a variety of life forms to flourish, and provide many predator-prey relationships, which promote system resiliency. Easy access to food sources often allows the development of productive fisheries. The edges of bays

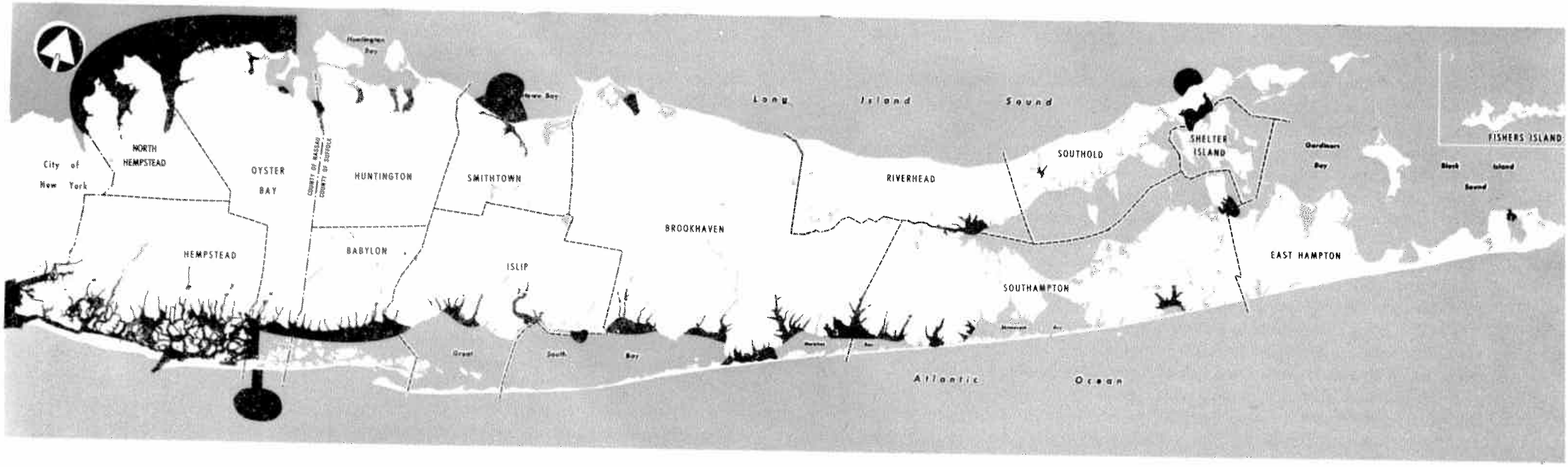


FIGURE 2–8 *Areas Closed to Shellfishing in August 1977*

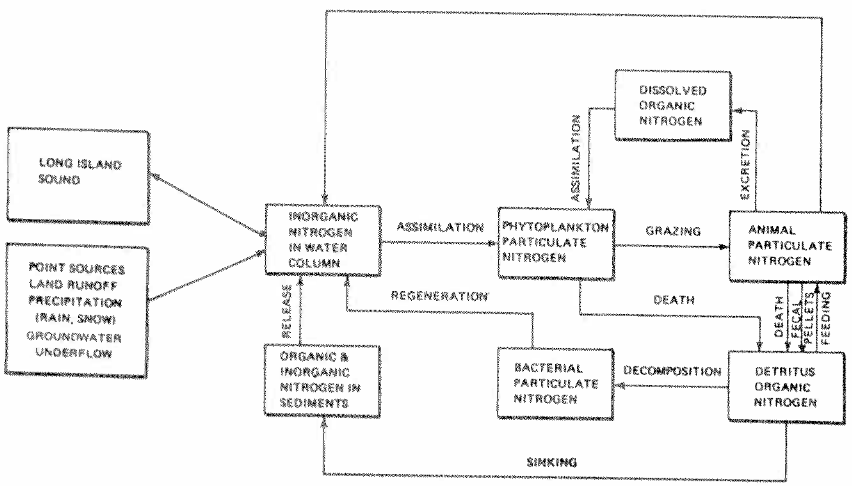


FIGURE 2–9 *Typical Nitrogen Cycle for a Bay Ecosystem*

Source: Energy Resources, Inc., 1977, "Environmental Tradeoffs on Long Island with Respect to Areawide Waste Management," Prepared under Contract to the Nassau-Suffolk 208 Program Study.

provide a simple example of the importance of habitat diversity. The various natural "edge" habitats include *Spartina alterniflora* marshes, *Spartina patens* marshes, sandy beaches, gravel and boulder beaches, bluffs, mudflats, and stream mouths. In many bays, large areas of such habitats have been replaced with uniform, bulkheaded shoreline. These altered areas are generally less ecologically productive except, perhaps, for phytoplankton blooms. Oyster Bay, with a diversity of shoreline habitats, supports a productive community of shoreline uses: waterfowl, sea birds and mammals; Manhasset Bay and Hempstead Harbor, with less diversity of habitat and a great proportion of altered shoreline, mainly support bottom and water column users such as shellfish and finfish.

2.6.2.1 Offshore Subsystems. The offshore ecosystem is composed of several ecological habitats, commonly termed marine zones. These are: the surface film, where ultraviolet radiation inhibits productivity; the near-surface layer, which is highly productive; the water column, which is sparsely inhabited; the near-bottom layer, which is productive; and the benthic zone, which is organized around processing of detritus. The offshore waters of Long Island include Block Island Sound, Long Island Sound and New York Bight.

Open waters are characterized by significant local and regional horizontal and vertical circulation patterns. Thus, materials introduced in a dissolved or suspended state tend to be rapidly dispersed. Despite rapid dispersion, western Long Island Sound has high pollutant concentrations that are attributable to East River discharges.

2.6.2.2 Bay and Estuarine Subsystems. Bay subsystems include a variety of habitats. Each of the six bays studied in detail has its own particular ecological characteristics.

Manhasset Bay and Hempstead Harbor are the closest to New York City. Hence, they have a relatively developed shoreline, and adjoining Long Island Sound waters tend to be of low quality. The two bays are long and narrow, and are well flushed by tidal action. They are generally characterized by few wetlands, high levels of water pollutants, shellfish populations contaminated by coliform bacteria, and minor fish kills.

Farther east, Oyster Bay has a well protected shoreline, large areas of wetlands, and low pollutant levels, except in a few highly localized problem areas. The bottom substrate is generally suitable for oyster production, and an active oyster mariculture program is carried out. The wetland, creek and pond habitats are suitable for invertebrate and fish spawning.

Huntington Bay is a complicated bay system containing well-flushed bay areas and less well-flushed harbors and creeks. The northeast sections contain shallows and mudflats. The harbors are presently subjected to significant pollutant loads, while the open bay areas exhibit generally low pollutant levels. Wetlands are limited.

Port Jefferson Harbor is the cleanest of the six North Shore bays. This may be attributable to its easterly position on the North Shore. It is a small harbor with limited diversity of habitats. However, the adjoining Conscience and Little Bays are relatively undeveloped, with extensive wetland areas.

Peconic-Flanders is a large bay-estuarine system, which grades from deep and well-flushed in Little Peconic Bay to shallow and poorly-flushed in the Peconic estuary. Many of the creeks tributary to Flanders Bay have been dredged and display eutrophic conditions. Some of these creeks support extensive wetlands. The shallows and wetlands are key fish spawning areas.

The eastern part of the South Shore bay system tends to be very shallow and poorly flushed. The western bays are better flushed. Essentially all of the Nassau County South Shore bays have been closed to shellfishing due to elevated coliform concentrations. On the other hand, in Great South Bay, in Suffolk, the only areas closed to shellfishing are located along the northern shore, at the river mouths. Both systems support a great diversity of estuarine forms and are prime spawning areas for shellfish. Great South Bay provides a suitable habitat for bottom dwellers such as hard clams and flounder.

Phytoplankton are a major primary producer in bay systems. They can be sensitive to changes in water quality, particularly with respect to nitrogen levels, nitrogen/phosphorus ratios and turbidity. It is generally agreed that nitrogen/phosphorus ratios of 10:1 or higher are usually correlated with high phytoplankton species diversity, whereas values below 10:1 are generally found in areas associated with elevated algal biomass and low species diversity. Water quality can give an indication of what flora and fauna may be present in a body of water, and conversely, phytoplankton biomass and diversity can give an indication of water quality. Highly turbid waters have a reduced phytoplankton mass. Polluted waters generally have very small diversity. Excess nitrogen can stimulate algal production with the attendant problems associated with eutrophication. Algal blooms shift productivity and species distribution at the lowest level of production. Phytoplankton blooms have been observed in most Long Island bays.

The bays, estuaries and Long Island Sound support large fish populations, many of which have great commercial value. These populations are sensitive to changes in salinity, phytoplankton, and zooplankton levels, and also to the abundance of shellfish and other finfish upon which they feed. The life cycles of some species are dependent upon both the bay and wetland habitats, while some species depend on wetlands mainly as spawning or nursery areas. The important finfish species of Long Island can be conveniently divided into two categories: resident and migratory populations.

Among commercially valuable finfish inhabiting the bays are the winter flounder, menhaden and blackfish; the latter two species, however, move offshore to spawn. Northern pipefish, mummichug and Atlantic silversides are the most important resident forage species in several bay systems, especially Great South Bay.

Bluefish and striped bass are the most abundant of the migratory species that spend a portion of their life cycle in Long Island waters. Northern porgy and weakfish, somewhat less abundant migratory species, spawn in shallow bays and estuaries where the larvae remain for one season.

Shellfish and invertebrates are plentiful; however, the shellfish industry is affected by sewage disposal and non-point runoff since shellfish are generally found in shallow waters close to the shore or in bays. In 1975, 214,000 acres or eighteen percent of the Long Island shellfish beds were closed because of coliform bacteria contamination.

Commercially significant shellfish species include lobster, oyster, many species of clams, blue mussel, bay scallop and, in some years, blue claw crab. Hard clams are particularly abundant in Great South Bay, while oysters are found in large quantities in Oyster Bay.

The bays adjoining wetlands on Long Island serve as wintering grounds for some birds, breeding grounds for others, resting stops for many birds migrating on the Atlantic flyway, and permanent homes for other species. Scoters, black ducks, scaup, mergansers, goldeneye and brant overwinter in many wetlands on Long Island. Black ducks, Canada geese, mallards, gadwalls and wood ducks also breed there. Other species commonly seen in the wetlands of the region include old-squaws, canvasbacks, ringedneck ducks, buffleheads, pintail ducks, baldpates, teal, ruddy ducks and coots. These populations are affected by bay water quality, by changes in wetland areas, and by alterations of beaches and other bird habitats.

2.6.2.3 Streams, Lake and Freshwater Wetlands. Although streams, lakes and freshwater wetlands are of minor areal importance in the Long Island system, these water bodies are significant. Detailed information concerning the ecology of many Long Island freshwater bodies is minimal. The streams are generally edged with a narrow band of wetlands. These wetlands, together with epibenthic plants, are nutrient cyclers. In those areas where the streams have been channeled or the wetlands have been filled, nutrient and organic cycles are curtailed and pollutants are transported downstream.

The scattered lakes are generally small and shallow. Many are impoundments, formed by damming of streams. Whereas stream water usually exhibits a significant flow, water in impoundments has a high residence time and thus is susceptible to nutrient and coliform inputs. Residence time is related to the rate of stream inflow and outflow. Past sewering and pumping, particularly in Nassau County, have lowered the water table, and hence streamflow in a number areas, and have thus increased residence time in some impoundments. Many Long Island lakes and streams display eutrophic conditions and high coliform counts as a result of wild and semi-wild waterfowl pollution and runoff. In addition, coliform die-off rates are extended due to the warmer water temperatures, thus maintaining high levels for longer periods. Swimming is only allowed where an average value of total coliform is below a specified standard, and adequate sanitary and safety facilities are provided.

2.6.2.4 Marine Wetland Subsystem. Wetlands serve as nurseries and spawning grounds for many commercially important fishes and shellfishes. They also protect the shoreline from the intensive erosion that might otherwise occur during storms, and they serve to attenuate many harmful effects of such pollutants as human and animal wastes and wet-weather runoff by assimilating nutrients into a diverse food web. Wetlands and tidal marshes cover 545 square kilometers of Long Island, and their continued viability is a major environmental concern in regional wastewater management.

Immediately above the mean high water line in wetlands, there is a low marshy area characterized by infrequent inundation and soft, peaty, often saline soils. This zone is usually dominanted by either of two plants, salt marsh hay *(Spartina patens)*, or spike grass *(Distichlis spicata)*, or by a combination of the two. The saltworts are less abundant but still common. A variety of marsh plants that are less tolerant of saltwater inundation grow at somewhat greater elevations above the high tide level. One of the most notable among these is the marsh reed, *Phragmites communis.* Phragmites thrive in a wide range of soil types, including very saline soils. As a result, it frequently dominantes spoil banks created during dredging operations or landfilling. Other marsh species include the cattails, black grass, groundsel bush and marsh elder.

The greater part of Long Island's tidal marshes and wetlands, 314 square kilometers, are in Suffolk County. The remaining 231 square kilometers are in Nassau County, where large areas of salt marsh are located in the sheltered South Shore bays in the Towns of Hempstead and Oyster Bay.

2.6.2.5 The Inland Environment. Five major types of plant cover existed on Long Island prior to development: (1) the red oak forest; (2) pine-oak and pine-dune forest; (3) scarlet oak/black oak forest; (4) Hempstead Plains (grasslands); and (5) downs grassland and dune heath. The extensive red oak forest of the western third of the Island has virtually disappeared and very little remains, even in Suffolk County. The Hempstead Plains have been almost totally destroyed, splinter fragments remain only in the vicinity of Mitchel Field. The pine-oak and pine-dune forest and the scarlet oak/black oak forest still survive in large tracts. Small areas of the downs grasslands and dune heath remain.

Although many other tree and plant species are found scattered, or even in local abundance, at various sites, and although many areas have been cleared and the indigenous vegetation removed, the historically dominant communities still exist in certain areas.

The major types of altered habitats that exist on Long Island include (1) urban or suburban residential and commercial areas, (2) agricultural lands, (3) old fields, and (4) recharge basins. Each of these plays a role in the terrestrial subsystem.

The terrestrial subsystem includes both natural and man-induced habitats. Generally, Long Island vegetation is a product of the Island's geologic setting. The sandy, glacial soil supports such scrub growth as pitch pine, black pine and black oak. Long Island's chief agricultural activity is the growing of potatoes, which do well in sandy areas. The sandy soil column allows rapid assimilation of precipitation. The leaching of fertilizer tends to be rapid, although vegetative cover slows the process.

There are specific settings in which maintenance of vegetation is of particular ecological importance. As discussed in 2.6.1, a diversity of habitats is generally desirable. This is particularly true of the land/water interface, since aquatic species need the protection of the upland vegetation. The preservation of forested or shrub buffers at the edge of wetlands and ponds, and along streams, is critical.

2.7 Summary

Pollution enters the ground and surface waters of Long Island from both point and non-point sources. Point sources include such discharges as municipal waste treatment plant effluents and industrial wastes, both treated and untreated. Nassau County treats about 107 MGD of domestic and industrial wastes, and discharges all except two MGD to surface waters. The two MGD is recharged and, of this, 40 percent is of industrial origin. In contrast, only 0.4 percent of the flow discharged to surface waters is of industrial origin. Suffolk County currently treats sixteen MGD, although, by 1986, when the Southwest Sewer District plant is operating at capacity, this quantity will rise to 46 MGD. At the present, Suffolk's treated effluent, of which ten to fifteen percent is of industrial origin, is discharged to ground and surface waters in roughly equal amounts. Nassau also generates 90 million gallons per year of waste treatment sludge, mostly disposed of in the Atlantic Ocean. Suffolk generates twenty million, mostly disposed of in landfills.

Non-point sources of pollution comprise stormwater runoff from impervious surfaces, cesspools and septic systems, fertilizers and pesticides and groundwater underflow to streams and bays. Stormwater finds its way into both ground and surface waters. Effluents from domestic on-site waste disposal systems enter the groundwater. Fertilizers and pesticides are applied to the ground surface, and rainfall washes them down into the groundwater. In certain areas, contaminated groundwater carries pollutants into streams and marine waters by underflow.

The concept of "safe" or "permissive" yield is defined as the volume of groundwater that can be withdrawn from the aquifer and used consumptively on an annual basis without producing undesirable results. The safe yield for Nassau County has been estimated at 151 MGD, and that for Suffolk County at 466 MGD. In contrast, although current withdrawal rates are considerably higher, consumptive losses are estimated at 133 MGD for Nassau and 30 MGD in Suffolk. Daily pumpages in Suffolk are well over 110 MGD, and peak days pumpages over 300 MGD, but a substantial portion is returned to the system and not consumed, or is discharged to the ocean.

Chlorophyll a is an indicator of the standing crop of phytoplankton, and if large fluctuations of chlorophyll a occur, then large fluctuations occur in total nitrogen and dissolved oxygen levels. Such changes are observed frequently in Manhasset Bay, Hempstead Harbor, Peconic Bay and Great South Bay.

Because of pollution in western Long Island Sound, the water quality and marine environment in the North Shore bays show steady improvement with distance from New York City. Superimposed on this pattern are local variations due to runoff and poor flushing in certain creeks and harbors. The amount of development falls off from west to east, so that the easterly bays have better water quality and more extensive wetlands. Most of the South Shore bays in Nassau County are closed to shellfishing. However, in the Great South Bay, in Suffolk County, such closures are confined to river mouths. In the Peconic Estuary-Flanders Bay system, tidal flushing diminishes going from the bay into the estuary. There are extensive wetlands on the tributary creeks, and eutrophication is frequently observed.

All bays support large and valuable fish populations, which are sensitive to changes in salinity and plankton levels. Shellfish and invertebrates are also plentiful. Shellfish are particularly sensitive to sewage disposal and non-point pollution runoff. Marine wetlands and tidal marshes cover 545 square kilometers, and provide habitats and wintering areas for many bird species.

The total surface area of streams and lakes, and their associated wetlands is small. The lakes are generally shallow, and suffer from eutrophication due to waterfowl pollution and surface runoff.

Long Island's sandy glacial soil supports scrub growth, such as pitch pine, black pine and black oak. Much of the original tree cover has been lost to development. The sandy soil allows the rapid seepage of rainfall, which, in turn, carries contaminants rapidly into the groundwater. Vegetative cover helps to slow this process.

In sum, Nassau and Suffolk Counties present a picture of rapid growth and development, in the course of which the area's great natural resources have been seriously impacted. Those that remain are still of the highest quality. Section 3.0 addresses the alternatives for the protection of these resources.

Long Island's geologic system is characterized by three geologic formations, stratified and generally hydraulically connected. The uppermost aquifer usually contains the water table surface, and is most susceptible to contamintion as a result of activities on the land surface. Water quality in the uppermost aquifer is somewhat variable, at times containing objectionable concentrations of iron and manganese, and at times, evidence of the leaching of domestic wastes. Water quality variability in shallower wells is more related to population density and land use. Concentrations of most contaminants are somewhat lower in Suffolk than in Nassau. For example, Nassau County wells show an average nitrate level of 4.5 milligrams per liter compared to 2.3 milligrams per liter in Suffolk. Similarly, Nassau County shallow wells range in chloride concentration from nineteen to 83 milligrams per liter, whereas Suffolk County averages twelve milligrams per liter.

The next deeper aquifer is the Magothy formation. Its background water quality is excellent, having very low dissolved solids. In the deep recharge area, the Magothy formation is affected by seepage of contaminants from the water table aquifer, as evidenced by nitrates detected deep in the Magothy in the center of Nassau County.

The deepest aquifer is the Lloyd, and this too has excellent background quality, with low dissolved solids. In some locations, the iron content can exceed the drinking water standard. The Lloyd aquifer has not yet been greatly developed for water supply.

Organic chemicals have been appearing in the groundwater in recent years. Their concentrations have been very low, but their presence is a cause for public concern. Fifteen wells have been removed from service because of trace amounts, mostly in industrial areas.

In the marine waters of Long Island, all bays have shown dissolved oxygen concentrations which periodically fall below the standard of five milligrams per liter. Hempstead Bay and western Great South Bay show this periodic drop most frequently. Similarly, all bays show high total coliform counts periodically, at least in some locations. North Shore bay waters generally contain lower total nitrogen concentrations than South Shore bays. Nassau County South Shore bays show a decrease in total nitrogen level from west to east, attributable to the improved tidal flushing as one moves east. In contrast, Great South Bay waters show a decrease in total nitrogen from east to west. Again, this is probably due to improved tidal flushing, in this case as one approaches Fire Island Inlet.

NOTES

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