Section 4 Environmental Assessment

4.0 Introduction

The Water Quality Management Plan (WQMP) will have a wide range of environmental and health impacts. These include surface water, groundwater, solid waste, land use and air impacts. The design of the Nassau-Suffolk 208 Program has allowed a detailed investigation of surface water and groundwater impacts, an overview of solid waste impacts, and a snapshot of land use and air impacts. Thus, surface and groundwater impacts, which are the most significant, have been emphasized in this assessment.

There are four major types of control available for preservation of surface and groundwater quality; these are structural and non-structural point source and non-point controls. There are uncertainties associated with the impacts of each control type. Structural point source controls have uncertainties of cost burden and of engineering feasibility for organics removal. Structural non-point controls have both cost uncertainties and engineering effectiveness uncertainties (new technologies). Non-structural point source controls have legal/institutional implementability uncertainties. Non-structural non-point controls have implementability uncertainties and also uncertainties as to abatement effectiveness. Non-structural controls are the environmentally preferred approach since they involve the least extensive secondary environmental impacts and are least irreversible. Structural point source controls constitute the least environmentally sound approach since they involve extensive commitment of resources and major rerouting and alterations of natural biogeochemical cycles.[1] This in turn means that structural point source controls impose extensive secondary impacts and are largely irreversible. Costly untested technologically intensive approaches are then required to mitigate secondary impacts.

There are several key water quality problems that have been addressed in this assessment; these are nutrient levels and ratios in bays, pathogens in bay waters and shellfish, salinity gradients in Great South Bay, water table levels, organic chemicals in groundwater, nitrogen in groundwater, hazardous waste loads and sludge loads. Careful control of some of these problems can only be achieved by sacrificing the level of control of some others. Thus, tradeoffs exist between various categories of environmental risks and controls. The tradeoffs have been presented in this assessment and must ultimately be resolved by government and/or citizen decisions.

This section discusses those environmental impacts which are likely to result from the various planning options as set forth in Section 3.5. The impacts are discussed in terms of several types of health-related and ecological effects. These categories of effects are set forth in Section 4.1. Types of effects which can be discussed on an areawide basis are presented in Section 4.2. This section has been organized to correspond to Section 3.5.1, "Areawide Alternatives", as closely as possible. Types of effects specific to the bays and groundwater zones are presented in Section 4.3, which corresponds to Section 3.5.2, "Area Specific Alternatives." Economic costs are discussed in Section 4.4. These four sections are then drawn together in a final section which presents a summary of the overall tradeoffs and recommendations (Section 4.5).

[1] Including H_2O, carbon, nitrogen, phosphorus, potassium and trace nutrient cycles.

4.0.1 Impact Categories. This assessment discusses environmental impacts in the four categories suggested by 40CFR6 (Subpart E):

1. *Short-Term Primary Impacts.* These effects, relevant only to structural options, are generally immediate results of construction that will be abated once the actual construction is completed. Such short-term impacts include those due to dredging, increased erosion, increased turbidity, altered topography, and leaks and spills from construction sites.

2. *Long-Term Primary Impacts.* Such effects are not transitory, but result from the permanent alteration of an environment by an action. Long-term nutrient, bacterial and BOD increases or decreases fall under this category, as does the loss or addition of wetlands and open spaces. Populations of organisms may increase or disappear as a result of such changes. If short-term impacts such as vegetation removal and erosion are not alleviated, they may become long-term impacts.

3. *Secondary Impacts.* Secondary impacts are not a direct result of an activity, but are induced as succeeding links in a chain of effects set off by the initial action. Secondary impacts as a result of water quality management include, for example, induced land use changes and development as a consequence of sewering programs, air quality impacts of sludge generation and disposal, and alterations in salinity gradients in Great South Bay resulting from groundwater table changes; whereas loss of potential public works jobs could be considered a secondary impact of not sewering.

Intermedia tradeoffs and transfers are an important class of secondary impacts that are usually overlooked in resource management and planning because of the technical difficulty in relating causes to effects or to the magnitude of the effects. Intermedia tradeoffs include surface water-groundwater, surface water-air and surface water-solid waste tradeoffs.

4. *Irreversible and Irretrievable Commitment of Resources.* The natural environment is composed of many links and feedbacks, which give the system flexibility to adapt to changes in the physical world. This flexibility is tested whenever natural disasters, such as storms or hurricanes, occur. Changes induced by humans, if done wisely and prudently, may be dealt with in a similar way by an ecosystem. However, as man continues to alter the environment, the ecosystem eventually fails to adapt, and permanent destruction of the previous habitats results. This category includes those actions, such as the extinction of a species or loss of a wetland, that will result in permanent loss of a resource. These actions are beyond the ability of the environment to alleviate, and therefore should be very carefully considered before implementation.

4.0.2 Uncertainties. The evaluation of environmental impacts is complicated by uncertainties as to the effectiveness of control measures. These uncertainties are due to the newness of many of the control technologies. There have been few previous applications of these controls and therefore performance data are largely lacking. Some of the main uncertainties that are encountered are summarized in Table 4–1.

Table 4–1

UNCERTAINTIES IN PROPOSED CONTROL MEASURES

	Type of Uncertainty				
Measure	Engineering (feasibility of the technology)	Performance (effectiveness of the technology)	Legal Institutional (implementability	Public Cost Burden (cost to taxpayer)	Private Cost Burden (cost to industry)
Best Management Practices, runoff controls		X	X		
Legal/institutional non-point controls		X	X		
Structural non-point controls		X		X	
Industrial pre-treatment	X		X		X
Sewering at 1 to 3 D.U./Gross Acre			X	X	
Stream Augmentation	X	X		X	
Recharge	X	X		X	

Source: ERCO

4.1 Assessment Criteria: Categories of Health and Ecological Effects

The effects of the proposed 208 Plan for Long Island have been evaluated with respect to several types of environmental risk. These include public health problems, natural resource problems, and other environmental problems. These types of problems are set forth below. The evaluations of some of them are straightforward. For example, health risks due to metals are evaluated in terms of drinking water standards. Others are more qualitative. For example, health risks due to viruses have no standards associated with them.

4.1.1 Health Risks. Health risks being considered in this assessment are of three types: first, the effects of toxic chemicals and pathogenic organisms in drinking water; second, the effects of pollutants in fish and shellfish used for human consumption; and third, the carcinogenic effects of organics in drinking water. These various effects have been considered according to pollutant type: metals, organics, nitrates, coliform bacteria and viruses.

4.1.1.1 Metals. Public health standards (NYS Health Standards) for various metals in drinking water are shown in Table 4–2. Standards for metals take into account an individual's overall intake of the metal. Such standards are also applicable to metals in food such as shellfish and fish. These standards can be used to evaluate the acceptability of plan alternatives with respect to trace metals health risks.

A sampling program has been carried out to measure metal concentrations in various water environments. It was carried out as part of a sampling program to measure levels of organic contaminants in groundwater. Thus,

Table 4–2

MAXIMUM CONTAMINANT LEVELS FOR METALS

	NYS[a] Drinking Water Regulations (mg/l)	NYS[b] Groundwater Regulations (mg/l)	Proposed Groundwater[c] Classifications, Quality Standards and Effluent Standards and or Limitations (mg/l)
Arsenic	0.05	0.2	0.05
Barium	1.0	2.0	1.0
Cadmium	0.01	0.02	0.01
Chromium (hexavalent)	0.05	0.1	0.05
Lead	0.05	0.1	0.05
Mercury	0.002	–	0.002
Selenium	0.01	0.02	0.01
Silver	0.05	0.1	0.05
Iron	–	0.6	0.3
Manganese	–	0.6	0.3
Zinc	–	0.6	5.0
Copper	0.1	0.4	–

[a]*Levels allowable in drinking water under the NYS Department of Health Drinking Water Standards. Source: Sanitary Code, Subpart S–1 Public Water Supply.*

[b]*Levels allowable in groundwater under New York State Regulations, Title Six, Section 703.4. Source: NYS, 1967.*

[c]*Title Six, 703.5 Proposed, NYS, May 1977.*

the sampling plan was designed to test water quality of areas likely to be organically contaminated. The set of samples does not necessarily represent the set that would have been selected if the major purpose was to identify metal contaminant problems. However, there are a variety of samples from areas near landfills, scavenger waste lagoons, and effluent discharges, as well as from typical residential areas. Thus the set of samples is reasonably representative of expected areas of contamination by metals. The metals for which the samples were tested (arsenic, barium, cadmium, chromium, lead, mercury and selenium) are those included in the 1976 EPA Interim Primary Drinking Water Regulations. A total of 124 samples were tested. Barium, selenium and silver were low in all samples. Arsenic, cadmium and chromium were low in most samples; however, they were high in certain types of effluent. Lead occurred at a significant level in various types of samples, and further diagnostic sampling would be prudent. Mercury occurred at concentrations in violation of standards in 38 samples with no apparent patterns of occurrence. A further sampling effort is needed to verify the extent of the problem and to identify possible sources. Table 4–3 summarizes the results.

4.1.1.2 Organics. Health risks from organic chemicals include (1) toxic effects, (2) carcinogenesis risk from low levels of organics in drinking water, (3) bioaccumulation in certain organs of shellfish and fish, and (4) tainting of shellfish and fish by hydrocarbons and other odor and taste-inducing organics. Monitoring results have indicated that the first and second of these four types of problems are of real concern (*e.g.*, ERCO; NCDH, 1977a). The third was of concern in the past when DDT and related pesticides were in common use (Porter *et al.*, 1977) and is now mainly of concern with respect to fish that spawn in such areas as the Hudson River where substances such as PCB's occur (ERCO). The fourth has not been shown to be a problem on Long Island.

Table 4–3

SUMMARY STATISTICS FOR COMPLETE SAMPLING PROGRAM
(mg/l unless otherwise noted)

Metal	EPA 1976 Drinking Water Standard	Observed Range	Observed Mean	Observed Median	Percent Violations of Standard	Percent Higher than 50 Percent of Standard Value
Arsenic	0.05	<0.0025–0.14	0.0004	<0.0025	0.8	0.8
Barium	1.0	<0.03–0.5	<0.03	<0.03	0.0	0.8
Cadmium	0.01	<0.00015–0.039	0.0013	<0.0005	2.4	3.2
Chromium	0.05	<0.0002–0.069	0.0015	<0.0002	0.8	1.6
Lead	0.05	<0.0007–0.24	0.01	0.002	6.4	6.4
Mercury (μg/l)	2	<0.13–5.2	1.8	0.44	18.7	37.0
Selenium	0.01	<0.004–0.011	<0.004	<0.004	0.8	2.4
Silver	0.05	<0.00025–0.14	0.002	<0.00025	1.6	2.4

Source: ERCO

SAMPLING PROGRAM

Included in the 208 was a sampling program initially designed to determine in a general way whether or not organic chemicals in domestic wastes or runoff would preclude treated sewage recharge. Early in the sampling effort it became clear that several organics were being identified in significant quantities. However, the techniques available for analysis of volatile organic compounds are still in a state of development (ERCO). Thus, it was difficult to quantify levels of volatile contaminants during the first part of the sampling program. Also, available toxicological literature is sketchy so that it is difficult to establish criterion levels. Since every groundwater sample analyzed showed some contamination, a pollutant hazard was indicated. This result, which did not answer the original question concerning recharge, is very significant from a public health standpoint. The last half of the sampling program was revised in order to address existing contamination from various sources rather than potential recharge effects. The final samples included some designed to help identify contaminant sources. The results for the second half of the sampling program were quantitatively accurate. For example, the final 24 samples were accurate to within twenty percent. The analytical results indicate that there is a significant public health risk. Further sampling programs are required to reduce present uncertainties concerning precision of the data, distribution of the contaminants, and identification of the sources. A summary of the ERCO results is given in Tables 4–4, 4–5 and 4–6. A summary of results of other surveys is given in Tables 4–7 through 4–10.

Table 4–4

SUMMARY STATISTICS–VOLATILE ORGANIC COMPOUNDS

Compound	# stations measured	# stations detected		# stations occurring @ > 10 μg/l		# stations occurring @ > 50 μg/l	
trichloroethylene	116	93	(80%)	35	(30%)	15	(13%)
chloroform	82	68	(77%)	20	(24%)	4	(5%)
1,1,1 trichloroethane	116	57	(49%)	25	(21%)	6	(5%)
carbon tetrachloride	78	28	(36%)	1	(1%)	0	
tetrachloroethylene	116	38	(33%)	10	(8%)	5	(4%)
dibromochloromethane	78	15	(19%)	0		0	
diethyl ether	38	6	(16%)	0		0	
1,1 dichloroethane	44	5	(11%)	3	(7%)	0	
bromodichloromethane	78	8	(10%)	3	(4%)	1	(1%)
freon–11	44	4	(9%)	0		0	
1,1 dichloroethylene	44	4	(9%)	0		0	
1,2 dichloroethane	44	3	(7%)	0		0	
bromoform	78	5	(6%)	1	(1%)	0	
1 chloropropane	44	1	(2%)	1	(2%)	0	

Source: ERCO

Table 4–5

SUMMARY STATISTICS–NONVOLATILE ORGANIC COMPOUNDS

Compounds detected at > 10 μg/l for at least one station	Number of Stations > 1 μg/l	Number of Stations > 10 μg/l	Number of Stations > 50 μg/l
methyl naphthalene	45	2	1
dimethyl naphthalene	37	3	0
dibutyl phthalate	34	20	8
octyl phenols	27	4	1
C_4 benzene	20	4	0
di-tert-butyl phthalate	20	6	2
phthalate (composition undetermined)	19	2	1
naphthalene	19	3	0
phthalate derivative (composition undetermined)	14	1	0
dibutoxy-ethoxy-ethyl methane	13	4	1
phthalate compound (composition undetermined	8	1	0
acenaphthene	6	1	0
C_{16} alkane	6	2	0
C_{28} alkane	6	1	1
tri-t-butyl orthoformate	6	1	0
diethyl benzene	5	2	0
2,3 dimethyl naphthalene	4	1	0
thymol	3	1	0
cyclohexane	3	2	1
o,m xylenes	2	1	1
isopropyl benzene	2	1	1
C_{20} alkane	2	1	0
trimethyl hexanoic acid	1	1	0

Source: ERCO

DISCUSSION OF RESULTS

The sampling results show the following:

a. *Water Media Characteristics*

Glacial Aquifer. Over one third of the sixty wells tested were significantly contaminated by volatiles and over one half by methylene chloride extractables. Of more serious concern, one fifth of the wells contained organic contaminants at the 50 parts per billion level, the level currently in use as the threshold for health risks from potentially carcinogenic organics. The sample size is sufficiently large for there to be little doubt that significant levels of organic contaminants occur in the Glacial aquifer.

Table 4–6

SUMMARY STATISTICS–ORGANIC CONTAMINANTS IN WATER, NASSAU AND SUFFOLK COUNTIES

	Volatiles				Methylene Chloride Extractables			
Medium	# stations	# stations w/at least 1 compound >10 μg/l	# stations w/at least 1 compound >50 μg/l	# stations w/at least 1 compound >100 μg/l	# stations	# stations w/at least 1 compound >10 μg/l	# stations w/at least 1 compound >50 μg/l	# stations w/at least 1 compound >100 μg/l
Effluent	12	6	3	0	12	4	1	1
Magothy	11	4	2	1	12	1	0	0
Glacial	66	31	14	7	69	32	12	3
Water Supply	14	8	3	2	11	4	1	1
Lloyd	1	1	0	0	1	1	0	0
Surface Water	1	1	0	0	1	1	0	0

Source: ERCO

Table 4–7

PESTICIDES IDENTIFIED IN USGS TEST OF WELLS LOCATED IN SUFFOLK COUNTY

Well No.	Pesticides and/or Herbicides (μg/l) identified in general screening process	Levels observed in subsequent resampling event (μg/l)
S43808	Dieldrin = .01	less than .01
S43815	PCB = trace	
S43819	Silvex = .01	less than .01
S45208	PCB = trace	
S46912	DDE = .01 DDT = .02 Dieldrin = .09	all less than .01
S46913	DDD = .04 DDE = .02 DDT = .08 Dieldrin = .11	all less than .01
S46914	Dieldrin = .02	less than .01
S46963	2,4–D = trace	less than .01
S47222	Silvex = trace	less than .01
S47230	Silvex = trace	less than .01
S47235	DDD = trace DDE = trace	both less than .01
S47977	2,4–D = .07	less than .01
S48425	2,4–D = trace	less than .01
S48946	PCB = trace	
S51575	DDD = 8.1	DDD = !.6
S51583	Dieldrin = .01	less than .01

Source: Baier, J.H., 1976.

Magothy Aquifer. Volatile organics appear to have penetrated to the Magothy aquifer. Methylene chloride extractables have not been measured at significant (>10 μg/l) levels. However, the sample size of Magothy wells tested is small; therefore, no firm statistical conclusions as to the extent of the contamination can be presented.

Effluent. Volatile and methylene chloride extractable organics are present in the effluents that have been sampled. Most of these are sewage treatment plant effluents, some of which are presently recharged. The halogenated volatile organics may be resulting from chlorination of effluents; however, comparative sampling of chlorinated and unchlorinated effluents is required to verify this.

Lloyd Aquifer. A single sample was taken from this formation. The sample showed no contamination. However, no conclusions are possible from this data.

b. *Chemical Species Characteristics*

Trichloroethylene, Chloroform, 1,1,1 Trichloroethane, Tetrachloroethylene. Three of these substances are occurring in at least fifty percent of the stations tested. Incidence of 50 parts per billion observations is over four percent. Many of the occurrences noted in this study are in Glacial aquifer wells. However, sampling of Nassau County water wells (NCDH, 1977a) shows a significant level of occurrence of these contaminants in water supply wells, many of which draw from the Magothy. As noted in Section Three, chloroform and trichloroethylene appear on the NAS (1977) list of known animal carcinogens. Thus, the presence of these chemicals in the Magothy aquifer presents a health risk. Identification and control of the sources of these contaminants should be of high priority.

Table 4–8

ORGANICS OBSERVED ON LONG ISLAND IN 1976

		Fractions from the Extraction Procedure				
	Volatile Organics	Neutral Fraction	Acidic Fraction	Acid Esterified Fraction	Basic Fraction	Particulate Extract
Untreated storm-water runoff	benzene toluene ethyl benzene p–xylene n–xylene	ethyl phthalate butyl phthalate isobutyl phthalate (T) ethyl hexyl phthalate dioctyl phthalate 2 additional phthalate compounds	methyl–18 methoxy-abiatata 2–isopropy–1,3-dioxolane ethyl benzaldehyde (T) diethyl phthalate methyl palmitate butyl phthalate dioctyl phthalate	methyl nonanoate phthyl eicosane (T) methyl xyristate methyl palmitate methyl stearate squalene (T)	diethyl phthalate dibutyl phthalate diotyl phthalate	ethyl phthalate ethyl hexyl phthalate dioctyl phthalate 2 additional phthalate compounds
Groundwater percolate of untreated storm-water runoff	methylene chloride benzene toluene 3 additional aromatic BC's	ethyl phthalate ethyl hexyl phthalate phthalate compound dioctyl phthalate	diethyl phthalate butyl phthalate 2–isopropyl–1,3–dioxolane dioctyl phthalate 1–decyne (T)	benzyl–2 (benzyl thio) propionate (T) methyl myristata (T) diethyl phthalate methyl palmitate methyl stearate butyl phthalate dioctyl phthalate squalene (T)	dioctyl phthalate	ethyl phthalate butyl phthalate ethyl hexyl phthalate dioctyl phthalate phthalate compound
Blank	methylene chloride (T)	butyl phthalate isobutyl phthalate butyl isobutyl phthalate	ND	ND	butyl phthalate octyl phthalate	ND
Medford effluent, tertiary treatment	ND	isobutyl phthalate butyl phthalate butyl isobutyl phthalate dibutoxyethane (T) iso-octyl phthalate	ND	ND	isobutyl phthalate	isobutyl phthalate butyl phthalate butyl isobutyl phthalate

Table 4—8 cont'd.

ORGANICS OBSERVED ON LONG ISLAND IN 1976

Groundwater percolate of Medford effluent tertiary treatment	chloroform	isobutyl phthalate butyl phthalate butyl isobutyl phthalate	methyl isoxanoate nor-octyl eicosane nor-decyl docosane b-butyl docosane 11—n decyl docosane n—pentyl beneicosane 10—n—10—n hexyleicosane n—octyl heptadecane methyl tricosane n—nonacosane n—datriaccotane n—octyl tetracosane	ND	ND	ND
Wantagh effluent, secondary treatment	perchloroethylene o—dichlorobenzene	ND	isobutyl phthalate butyl phthalate	butyl phthalate	butyl phthalate methyl undecane methyl decane	butyl phthalate isobutyl phthalate butyl isobutyl phthalate

Key: *(T) = tentative identification.*
ND = no compounds detected in sample
Source: Slimak and Harris, 1976

Carbon Tetrachloride, Dibromochloromethane. These contaminants have been observed in over 15 percent of the samples. Although they are widely present, they are only found at low levels. Thus, although their wide distribution is of concern, they cannot at present be considered to impose significant health risks.

Other Volatile Organic Contaminants. Eight other volatile compounds have been observed. They occur in only a small number of wells at generally small concentrations. However, in the final set of samples, (QA—1 to QA—24) which were analyzed under the best conditions, both 1,1 dichloroethane and bromodichloromethane occur at significant levels. More samples are needed to say anything about the occurrence of those two compounds. The other volatiles detected are not at present of major concern.

Phthalates. This general class of methylene chloride extractable organics occurs ubiquitously. Phthalate compounds were detected at very high levels in about eight percent of the samples. Phthalates occur as plasticizers. Thus, the presence of phthalates may be partially due to use of plastic tubing as part of the sampling devices. Nevertheless, since phthalates occur on the NAS (1977) list of chronic toxins, it is only prudent to consider the observed high phthalate levels as a health risk.

Other Methylene Chloride Extractable Organic Contaminants. A variety of these compounds were found. Some occurred at levels greater than 50 parts per billion. Eighteen substances occurred at levels greater than ten parts per billion. However, information on health risks imposed by these substances is scanty. Thus, the risk levels cannot presently be assessed. be assessed.

c. *Patterns of Occurrence*

The 124 samples taken represent 102 different sample stations. In most cases, only one sample was collected at each station. Thus, there is little statistical validity associated with looking at the contaminant levels of individual sites. Tables 4—11 through 4—13 present the data grouped according to suspected source categories. These data suggest a number of interesting patterns, which at present should be viewed as preliminary hypotheses. Further sampling is warranted with respect to all of the suspected source categories.

Table 4–9

SUMMARY OF VOLATILE ORGANIC SAMPLING OF NASSAU COUNTY MUNICIPAL WATER SUPPLIES[a][b]

Organic Compound	Number of Samples Observed at $\geq 10\ \mu g/l$[c]	Number of Samples Observed at $\geq 50\ \mu g/l$[c]	Number of Samples Observed at $\geq 100\ \mu g/l$[c]
1,1,2 trichloroethylene	25	7	2
1,1,1 trichloroethane	16	7	4
chloroform	11	1	0
tetrachloroethylene	7	5	4
1,2 dichloroethylene	6	0	0
benzene	3	1	0
toluene	2	0	0
bromodichloromethane	1	0	0
vinyl chloride	0	0	0
tri-fluorotrichloroethane	0	0	0
carbon tetrachloride	0	0	0
methylene chloride	0	0	0
ethyl ether	0	0	0

Source: NCDH, (1977a)

(a) All samples collected between June 1975 and May 1977.

(b) Samples analyzed by various labs using various methods.

(c) Total number of samples is 303; not all compounds analyzed for in all samples.

POTENTIAL HEALTH RISKS DUE TO ORGANIC COMPOUNDS IN WATER

Health risks from organic compounds include: (1) toxic effects; (2) carcinogenic effects from low levels in drinking water; (3) bio-accumulation in certain organs of shellfish, fish and other wildlife; and (4) tainting of shellfish and fish by hydrocarbons and other odor and taste inducing organics. Of these problems, the first and second are of major concern; the third was of concern in Long Island in the past when DDT and related pesticides were in common use (Porter *et al.*, 1977) and is now mainly of concern with respect to fish that spawn in areas such as the Hudson River, where substances such as PCB's occur. The fourth has not been shown to be a problem on Long Island. The organic chemicals study was limited to the first and second types of effects.

The National Academy of Sciences (1977) has recently reviewed the existing literature on environmental pollutants, and has divided the organic contaminants of water supplies into four categories: (1) known or suspected carcinogens (Table 4–14); (2) noncarcinogenic toxins (Table 4–15); (3) compounds which have been insufficiently studied with respect to chronic toxicity; and (4) compounds which have not been subjected to chronic toxicity tests.

Table 4–10

SUMMARY OF VOLATILE ORGANIC SAMPLING OF SUFFOLK COUNTY PUBLIC WATER SUPPLIES[a][b]

Organic Compounds	Number of Samples Observed at $\geq 10\ \mu g/l$	Number of Samples Observed at $\geq 50\ \mu g/l$	Number of Samples Observed at $\geq 100\ \mu g/l$	Total Number of Samples Analyzed
1,1,2 trichloroethylene	46	29	19	125
1,1,1 trichloroethane	41	16	7	121
tetrachloroethylene	18	3	1	122
chloroform	8	2	1	123
carbon tetrachloride	4	0	0	105
1,2 dichloroethylene	2	0	0	30
toluene	1	0	0	48
benzene	1	0	0	49
vinyl chloride	0	0	0	29
trichlorotrifluoroethane	0	0	0	45
bromodichloromethane	0	0	0	62
dichloromethane	0	0	0	7
chlorodibromomethane	0	0	0	1

Source: SCHD, 1978

(a) Samples collected between February 1976 and January 1978.

(b) Analyses by the following labs: NYSHD, Stony Brook; NYSHD, Albany; EPA, Ada, Oklahoma; New York Industrial Testing Lab; EPA, Edison, N.J.; H2M. Corp., Melville, N.Y.

"The potential for existing concentrations of organic pesticides and other organic comtaminants in drinking water to adversely affect health, cannot be answered with certainty at this time. The key issue is whether or not certain organic chemicals found in very low concentrations can cause or increase the rate of cancer development in man. Even though several of these chemicals have demonstrated carcinogenicity in laboratory animals, the extrapolation of such results to man remains difficult for a number of reasons" (NAS, 1977).

Phthalates were detected at concentrations equal to or greater than ten $\mu g/l$ in samples on Long Island (mainly from shallow aquifer wells), and in some cases were detected at concentrations greater than 50 $\mu g/l$. These levels were found by the NAS to constitute a toxicity risk, but not a cancer risk. The NAS (Table 4–15) reported that 38.5 $\mu g/l$ is the threshold level for the safe consumption of di-n-butyl phthalate. Therefore, the observed concentrations of di-n-butyl phthalate exceeds these levels in some Long Island shallow aquifer wells.

According to the NAS, many of the groundwater contaminants that are of concern on Long Island have not been sufficiently studied for their toxicity or carcinogenicity, including tetra-chloroethylene; 1, 2-dichloro-

Table 4–11

EFFLUENT AND GLACIAL CONTAMINATION LEVELS RANKED BY FREQUENCY OF OCCURRENCE OF CONTAMINANTS AT $\geq 10\ \mu g/l$. SAMPLE WAS BIASED TOWARD CONTAMINATED AREAS

	No. of Observations at $\geq 10\ \mu g/l$				No. of Observations at $\geq 50\ \mu g/l$				No. of Samples		
	Volatiles	Methylene Chloride Extractions	Volatiles or Methylene Chloride Extractions #	(% of all observ.)	Volatiles	Methylene Chloride Extractions	Volatiles or Methylene Chloride Extractions #	(% of all observ.)	Volatiles	Methylene Chloride Extractions	Volatiles or Methylene Chloride Extractions
Effluent											
Effluent Type:											
Leachate	1	1	2	(100%)	1	1	2	(100%)	2	1	2
Domestic chlorinated STP Effluent	4	2	5	(71%)	3	1	3	(43%)	4	7	7
Runoff Effluent	1	1	1	(50%)	1	0	1	(50%)	2	2	2
Glacial											
Overlying Land Use/ Aquifer Characteristics:											
Leachate Plumes	3	2	4	(100%)	3	0	3	(75%)	3	3	4
Commercial/Industrial Unsewered	2	2	3	(100%)	1	1	1	(33%)	2	3	3
Wooded	3	1	3	(100%)	1	0	1	(33%)	3	3	3
Agricultural	7	3	7	(88%)	3	0	3	(37%)	7	8	8
Runoff Recharge	6	3	6	(75%)	3	1	4	(50%)	8	8	8
Residential Sewered	1	7	8	(73%)	1	3	4	(36%)	1	10	11
Domestic STP Recharge	3	4	5	(63%)	0	0	0		7	8	8
Residential Unsewered	5	6	8	(50%)	4	5	7	(44%)	6	16	16
Mixed Unsewered	3	1	3	(43%)	1	1	2	(29%)	3	7	7

Source: ERCO

ethane; bromoform; bromodichloromethane; and propyl benzene. Others, such as 1, 1, 1-trichloroethane and dibromochloromethane were not included in the NAS study. Thus, despite the existence of information enabling the assessment of health risks for a few of the organic chemicals of concern on Long Island, major uncertainties about the health risks of many others have not been resolved.

4.1.1.3 Nitrates.[1] Nitrates become toxic to humans and other warm-blooded animals only under conditions in which they may be reduced to nitrite. This reduction takes place in the gastrointestinal tract, after which the nitrite may reach the bloodstream and react directly with the blood pigment, hemoglobin, to form methemoglobin. Once altered, the blood pigment can no longer efficiently transport oxygen from the lungs to the tissues and the physiological result is anoxia (lack of oxygen). The direct ingestion of nitrite nitrogen has a more immediate effect on the individual, but nitrite rarely occurs in Long Island drinking waters in sufficient concentrations to cause concern.

The reaction of nitrite with hemoglobin has been documented in approximately 2,000 cases in infants under three months of age in Europe and North America; seven to eight percent of those infants died as a result of the disease.[2] While many infants have not developed methemoglobinemia when fed with well waters having nitrate concentrations greater than ten milligrams per liter (NO_3–N), surveys have demonstrated that a minimal number of cases of infant poisoning were reported when water contained less than ten milligrams per liter (NO_3–N) (USEPA Drinking Water Regulations, 1976). Infants are apparently more susceptible than adults because their fluid

[1]Much of this section is adapted from Porter *et al.* (1978).
[2]This paragraph abstracted from EPA (1976b).

Table 4–12

NINETIETH PERCENTILE OF OBSERVED CONTAMINANT LEVELS ORDERED BY HIGHEST CONTAMINANT LEVEL PER SAMPLE

Sample Type	Sample #	Highest Contaminant Level
Glacial–residential–unsewered	QA 3	592 μg/l bromodichloromethane
Glacial–mixed–unsewered (WS)	QA 17	400 μg/l phthalate compound "a"
Magothy (WS)	QA 13	400 μg/l trichloroethylene
Glacial–agricultural	QA 21	290 μg/l 1,1,1 trichloroethane
Glacial–residential–unsewered	QA 19	285 μg/l trichloroethylene
Glacial–residential–unsewered	QA 2	275 μg/l 1,1,1 trichloroethane
Magothy (WS)	PWG 30	221 μg/l trichloroethylene
Glacial–residential unsewered	JDW 15	171 μg/l dibutyl phthalate
Glacial–Leachate Plume	QA 9	150 μg/l tetrachloroethylene
Glacial–mixed–unsewered (WS)	QA 12	150 μg/l tetrachloroethylene
Magothy (WS)	QA 6	145 μg/l chloroform
Scavenger Waste Lagoon	PWG 44	112 μg/l 1,1,1 trichloroethane
Glacial–residential–unsewered	JDW 14	109 μg/l octyl phenols
Magothy (WS)	QA 10	109 μg/l trichloroethylene

(WS) = water supply well

Source: ERCO

Table 4–13

NINETIETH PERCENTILE OF OBSERVED CONTAMINANT LEVELS ORDERED BY NUMBER OF CHEMICALS OBSERVED AT $\geq$10 μg/l PER SAMPLE

Sample Type	Sample #	Number of Organic Chemicals Observed at $\geq$10 μg/l
Glacial–mixed–unsewered (WS)	QA 17	8
Glacial–residential–unsewered	QA 19	5
Glacial–residential–unsewered	QA 2	5
Glacial–runoff recharge	PWG 1	5
Glacial–runoff recharge	PWG 2	5
Glacial–commercial/ industrial–unsewered	JDW 13	5
Glacial–residential–unsewered	QA 3	4
Magothy (WS)	QA 6	4
Glacial–residential–sewered	QA 8	4
Control (Passed through plastic tubing)	PWG 23	4
Runoff	PWG 49	4
Glacial–residential–unsewered	PWG 51	4

(WS) = water supply well

Source: ERCO

Table 4–14

CATEGORIES OF KNOWN OR SUSPECTED ORGANIC CHEMICAL CARCINOGENS FOUND IN DRINKING WATER

Compound	Highest observed concentrations in finished water in U.S. (μg/l)	Upper 95% Confidence estimate of lifetime cancer risk per μg/liter
Human Carcinogen		
Vinyl Chloride	10	5.1×10^{-7}
Suspected Human Carcinogens		
Benzene	10	ID
Benzo (a) pyrene	D	ID
Animal Carcinogens		
Dieldrin	8	2.6×10^{-4}
Kepone	ND	4.4×10^{-4}
Heptachlor	D	4.2×10^{-5}
Chlordane	0.1	1.8×10^{-5}
DDT	D	1.2×10^{-5}
Lindane (γ–BHC)	0.01	9.3×10^{-6}
α–BHC	D	6.5×10^{-6}
β–BHC	D	4.2×10^{-6}
PCB (Aroclor 1260)	3	3.1×10^{-6}
ETU	ND	2.2×10^{-6}
Chloroform	366	3.7×10^{-7}
Carbon tetrachloride	5	1.5×10^{-7}
PCNB	ND	1.4×10^{-7}
Trichloroethylene	0.5	1.3×10^{-7}
Diphenylhydrazine	1	ID
Aldrin	D	ID
Suspected Animal Carcinogens		
Bis (2–chloroethyl) ether	0.42	1.2×10^{-6}
Endrin	0.08	ID
Heptachlor epoxide	D	ID

Source: NAS, 1977
ID = Insufficient data to permit a statistical extrapolation of risk.
ND = Not detected.
D = Detected but not quantified.

Table 4–15

SELECTED ORGANIC PESTICIDES AND OTHER ORGANIC CONTAMINANTS FOUND IN DRINKING WATER, WITH SUPPORTING DATA ON CHRONIC TOXICITY

Compound	Maximum Dose Producing No Observed Adverse Effect (mg/kg/day)	Suggested No-Adverse Effect Level from H_2O ($\mu g/l$) 1	2
2, 4-D	12.5	87.5	4.4
2, 4, 5-T	10.0	700	35.0
TCDD	10^{-5}	7×10^{-4}	3.5×10^{-5}
Aldicarb	0.1	7.0	0.35
Paraquat	8.5	59.5	2.98
Methoxychlor	10	700.0	35.0
Toxaphene	1.25	8.75	0.44
Diazinon	0.02	14.0	0.7
Parathion	0.043	30	1.5
Malathion	0.2	140	7.0
di-n-butyl phthalate	110	770	38.5
hexachlorophene	1	7	0.35

Source: ERCO

intake per unit of body weight is greater, and their gastrointestinal tract pH is often high enough to allow nitrate-reducing bacteria to survive. In addition, the predominant hemoglobin at birth (hemoglobin F) is more susceptible to methemoglobin formation, and there is a decrease in the activity of the methemoglobin reducing enzyme.

Recognition of this hazard led the United States Public Health Service in 1962 to adopt a standard for nitrate (measured as N) of ten milligrams per liter in drinking water.[1] The World Health Organization later followed the Public Health Service lead by recommending a similar standard. A survey undertaken by Walton (1951) provided justification for the standard. Subsequently, the standard has been subject to considerable debate. Some have suggested that the standard be relaxed since acute methemoglobinemia is rare in western societies today. For this rarity, however, general acceptance of the standard must be considered a major causative factor. It should also be noted that a large safety factor was not incorporated into the drinking water standard as is the rule with most other contaminants. For example, clinical cases of methemoglobinemia have been reported in areas where the water had less than ten milligrams per liter of nitrate. In addition, new findings have provoked fears that chronic effects also may justify a more stringent standard (U.S. Environmental Protection Agency, 1977). Furthermore, the ten milligram per liter standard should be interpreted in the context of an individual's overall nitrate consumption. The standard assumes that nitrates are being ingested in other forms. Thus, depending on foods eaten, effects may be noted at less than ten milligram per liter or may not be noted until a higher level is reached.

Compared to the acute effect of nitrate, much less is yet known about chronic effects. As in the case with acute toxicity, the actual cause of most chronic effects is due to nitrite produced by the reduction of nitrate. One of the first reports dealing with chronicity of nitrate attributable to drinking water was that of the Russians Petukhov and Ivanov (1970). Russian teenage children who consumed drinking water with a nitrate concentration greater than twenty milligrams per liter were found to have a decreased response to stimuli compared to children whose drinking water met the standard. In a later report (Petukhov *et al.,* 1972) it was claimed that children of various ages whose drinking water contained nitrate concentrations up to 45 milligrams per liter evinced a variety of symptoms, including cyanosis, lowered blood pressure and elevated levels of methemoglobin.

Shuval and Gruener (1975) completed extensive epidemiological studies encompassing nearly 3,000 infants up to two years of age. The study included a survey of babies in the Gaza Strip who consumed water with high levels of nitrate. A particular aim of the research was to determine whether or not cases of subclinical disease could be detected. The results showed that there was a relation between concentrations of nitrate in water used in a powdered milk formula and levels of methemoglobin. Even infants who consumed water containing nitrates only slightly above the standard had significant increases in the percentage of methemoglobin in their blood. In the subsequent U.S. EPA report (1977) it was concluded these results "provided direct epidemiological support for the current standard."

Nitrosamines are organic compounds (N-nitroso compounds) which are now known to be carcinogenic. Some of the compounds are also mutagenic or teratogenic.[2]

N-nitroso compounds are formed by the combination of amines with nitrites. This reaction, called nitrosation, may occur in the environment or in the animal stomach. Amines may originate in water from a wide variety of sources including industrial and domestic waste. Since nitrate is a potential precursor to nitrite, there is the possibility that the presence of amines and nitrates may, under some conditions, produce nitrosation. Much of the research on nitrosamines undertaken so far has investigated the development of cancer in laboratory animals given nitrosamines (for reviews see Crosby and Sawyer, 1976; and Shank, 1975).

Unfortunately, the degree to which amines or nitrosamines represent a public health hazard in drinking water is not presently known. The epidemiological studies so far attempted must be considered inconclusive (see, for example, Armijo and Coulson, 1975; Zaldivar and Wetterstand, 1975; and Hill *et al.,* 1972).

[1] For NO_3 measured as NO_3 rather than as N the standard translates to 44 milligrams per liter.

[2] See the Lancet, December 1. 1973, p. 1,243 for a general review.

4.1.1.4 Coliform and Other Bacteria. The presence of coliform bacteria in water has long been used as an indicator of fecal pollution. While coliforms themselves are generally harmless to man, their presence is used as a surrogate to indicate that pathogenic bacteria and viruses may also be present (EPA, 1976a).

In productive bay ecosystems, excessive contamination by pathogens can render clams, mussels and oysters unfit for consumption. Shellfish tend to concentrate particulate contaminants and associated coliforms when filter-feeding in polluted waters.

A significant portion of the Long Island bays are closed to shellfishing due to violations of the coliform standards. A list of the closed areas is presented in Table 4–16.

The total coliform standard for shellfish harvesting is a median not to exceed 70 MPN per 100 milliliters.[1] The standard for contact recreation is a logarithmic mean of 2,400 MPN per 100 milliliters.[2]

4.1.1.5 Viruses.[3] The major human virus groups known to occur in sewage include (1) Enteroviruses—transient inhabitants of the human alimentary tract consisting of over 100 species including Polioviruses, Coxsackieviruses and ECHO viruses; (2) Adenoviruses—upper respiratory viruses, which are able to withstand the acidity of the human gut and may be shed in feces; (3) Hepatitis virus; and (4) Reoviruses. While only Hepatitis virus and Poliovirus infections have been conclusively proven to have been transmitted by the water route (*i.e.,* sewage pollution of drinking water, shellfish beds, recreational waters, etc.), studies have indicated the likelihood of similar transmission of some or all of the species mentioned above. A listing of the viruses that may be waterborne, and diseases associated with them is presented in Table 4–17.

There is no historical information on viral levels in Long Island waters. Reports of human virus isolations from diverse aquatic systems in various

[1] The median MPN value in any series of samples representative of waters in the shellfish growing area shall not be in excess of seventy (70) per one hundred milliliters.

[2] The monthly median coliform value for one hundred milliliters of sample shall not exceed 2,400 from a minimum of five examinations and provided that not more than twenty percent of the samples shall exceed a coliform value of five thousand for one hundred milliliters of sample and the monthly geometric mean fecal coliform value for one hundred milliliters of sample shall not exceed two hundred (200) from a minimum of five examinations. This standard shall be met during all periods when disinfection is practiced.

[3] This section abstracted from Vaughn and Landry (1977).

Table 4–16

AREAS CLOSED TO SHELLFISHING DUE TO VIOLATIONS OF TOTAL COLIFORM STANDARDS

Area	Bay	Total Acreage	Acreage Closed to Shellfishing			
			Jan. 1, 1970	Jan. 1, 1976	Jan. 1, 1977	Dec. 1, 1977
1	Hempstead Bay	11,850	5,650	11,850	11,850	11,850
2	South Oyster Bay	6,190	700	4,020	4,020	4,620
3	Great South Bay	11,450	970	1,685	1,685	3,155
4	Great South Bay	18,980	705	1,010	1,010	1,110
5	Great South Bay	16,325	555	625	625	635
6	Great South Bay	11,525	285	550	550	550
3–6	Great South Bay	58,280	2,515	3,870	3,870	3,870
7	Bellport Bay	5,595	845	1,030	1,030	495
8	Moriches Bay	10,900	2,545	6,420	6,420	5,485
9	Quantuck Bay and Canal	730	165	165	165	165
10	Shinnecock Bay	9,170	220	220	220	220
1–10	South Shore Bays	102,715	12,640	26,675	26,675	26,675
11	Mecox Bay	1,045	435	320	320	320
12	Napeague Bay	9,135	0	0	0	0
13	Montauk Harbor	1,085	150	150	150	150
14	Acabonack	310	0	0	0	0
15	Three Mile Harbor	1,025	0	0	0	0
16	Gardiners Bay	48,950	0	0	0	0
17	Northwest Harbor	1,550	0	0	0	0

Table 4–16 . . . Cont'd.

Area	Bay	Total Acreage	Acreage Closed to Shellfishing			
			Jan. 1, 1970	Jan. 1, 1976	Jan. 1, 1977	Dec. 1, 1977
18	Shelter Island South	9,450	180	180	180	180
19	Sag Harbor and Cove	575	145	350	350	350
20	West Neck Harbor	625	0	0	0	0
21	Noyack Bay	3,540	0	0	0	0
22	Southold Bay	1,340	0	0	0	0
23	Hashamomuck Pond	170	0	5	5	5
24	Orient Harbor	3,560	0	0	0	0
25	Coecles Harbor	1,205	0	0	0	0
26	Little Peconic Bay	13,725	0	0	0	0
27	Cutchogue Harbor	585	2	2	2	2
28	Great Peconic Bay	19,060	0	0	0	0
29	Flanders Bay	3,090	470	780	780	780
30	Mattituck Creek	125	5	30	30	30
31	Wading River	50	0	50	50	50
32	Mt. Sinai Harbor	455	0	0	0	10
33	Port Jefferson Complex	1,550	815	815	815	900
34	Western Long Island Sound	88,300	20,915	37,150	37,150	37,150
35	Central Long Island Sound	188,000	2,500	0	0	0
36	Eastern Long Island Sound	121,000	300	300	300	300
37	Stony Brook Harbor	855	0	0	0	0
38	Nissequogue River	555	555	555	555	555
39	Smithtown Bay	22,300	500	900	900	900
40	Huntington Bay	2,420	0	0	0	0
41	Northport Bay	1,825	0	0	0	0
42	Northport Harbor	410	200	345	345	345
43	Centerport Harbor	490	125	185	185	185
44	Duck Island Harbor	185	0	0	0	0
45	Lloyd Harbor	600	0	0	0	0
46	Huntington Harbor	340	90	165	165	165
47	Oyster Bay Harbor	5,040	175	375	375	605
48	Cold Spring Harbor	1,325	95	215	215	215
49	Dosoris Pond	105	0	105	105	105
50	Hempstead Harbor	3,465	1,385	3,465	3,465	3,465
51	Fishers Island Sound	7,990	910	910	910	910
52	Stirling Basin	135	135	135	135	135
53	Pipes Cove	370	0	0	0	0
54	Napeague Harbor	885	0	0	0	0
56	Manhasset Bay	2,725	2,725	2,725	2,725	2,725
61	Cold Spring Harbor	220	0	0	0	0
62	Sebonac Creeks	430	0	0	0	0
63	North Sea Harbor	225	0	10	10	10
64	Wooley Pond	30	0	0	0	0

Source: NYSDEC (1977b).

Table 4–17

HUMAN VIRUSES COMMONLY FOUND IN SEWAGE AND DISEASES ASSOCIATED WITH THESE VIRUSES

Group	Subgroup	Number of Serotypes	Type Nucleic Acid	Diseases
Enterovirus	Poliovirus	3	RNA	Mild–Severe Gastroenteritis
				Abortive Poliomyelitis
				Aseptic Meningitis
				Paralytic Poliomyelitis
	Coxsackie-virus			
	A	24	RNA	Summer Minor Illness
				Herpangina
				Aseptic Meningitis
				Common Cold
				Hand, Foot and Mouth Disease
				Infant Diarrhea
	B	6	RNA	Aseptic Meningitis
				Common Cold
				Pleurodynia
				Neonatal Disease
				Sudden Infant Death Syndrome
				Myocarditis
				Pericarditis
	Echovirus	34	RNA	Aseptic Meningitis
				Mild Paralysis
				Febrile Illness
				Conjunctivitis
				Boston Exanthem Disease
				Infant Diarrhea
				Vaginitis and Cervicitis
				Pericarditis and Myocarditis
Hepatitis	A		RNA?	Infectious (viral) Hepatitis
	B		DNA?	Serum Hepatitis
Adenovirus		31	DNA	Acute Respiratory Disease
				Pharyngoconjunctival Fever
				Primary Atypical Pneumonia
				Epidemic Keratoconjunctivitis (shipyard eye)
				Intussusception
				Febrile catarrh
Reovirus		6	RNA	Unknown

Source: Vaughn and Landry (1977).

geographic regions (*e.g.,* rivers, bays, estuaries, treatment plant effluents) have appeared on occasion in the literature. As part of the 208 Program, a viral sampling program was carried out. Sample identifications were limited to enteroviruses. The results, which are summarized in Table 4–18, show that viral contamination is not of major concern in sampled waters.

Generalizing from the numbers in Table 4–18 was not done because of the small sample size and brief duration of the Program. In addition, no information was gathered on non–Enterovirus species, which may also be found in sewage pollution systems (*e.g.,* Adenovirus, Reovirus, Rotavirus (Reo-like), Norwalk-agents).

Viruses in Recharge. Recharge of sewage treatment plant effluent to the groundwater has been suspected of causing viral contamination. An important facet of the 208 Virus Study was the monitoring of several groundwater recharge sites in order to make a qualitative assessment of the effluent and the soil's ability to remove human viruses.[1] While being unable to define all the necessary conditions, it was hoped that the program of monthly viral analysis would be able to indicate the likelihood of returning virus-free effluent to groundwater aquifers.

Although not usually listed among recharge methods, the use of subsurface leaching fields will eventually result in the return of water to the aquifer. It is emphatically recommended that effluents of similarly low quality to those found at the Sunrise Sewage Treatment Plant not be used for such purposes.[2] However, the information gathered at this site may be useful as an index of the efficiency of such recharge systems under "worst possible conditions." Viruses were isolated from 80 percent of the sewage treament plant effluent samples taken, while only a 22.2 percent frequency was noted in the groundwater observation well. The data indicated that this type of disposal of low volume effluents in fairly isolated areas would be practical, providing the effluents were of adequate quality.

Among treatment plants discharging into recharge basins, the best results were obtained from the Stony Brook site where no viruses could be isolated from the eight samples taken and from Meadowbrook, where they showed an isolation frequency of 30.0 percent. Previously cited studies have demonstrated an inability of effluent borne viruses to penetrate appreciable distances through soil columns, depending on soil composition and effluent application rates. The apparent inability to recover significant numbers of viruses at the Stony Brook site was likely a result of the 80 foot soil depth from the bottom of the recharge basin to the aquifer.

The 34 foot soil layer from basin to aquifer at the Meadowbrook site seemed to be a less efficient virus remover. This conclusion does not account for differences in effluent qualities and soil characteristics. Studies of the

[1] Quantitative assessment would require more elaborate programs than those conducted for the 208 Program.

[2] The Sunrise Sewage Treatment Plant effluent quality problem is a well-known problem, and upgrading of the quality of the effluent has been ordered.

Table 4–18

RESULTS OF VIRAL STUDY

Sample	Percent of Samples Containing Virus	Number of Samples
Drinking Water	0	24
Lake Ronkonkoma	28	7
Penataquit Creek	18	11
Closed Shellfishing Areas—Islip	37	8
Water Column—Great South Bay		
Open Shellfishing Areas—Islip	37	8
Closed Shellfishing Areas—hard clams	28	7
Tissue—Great South Bay		
Open Shellfishing Areas—hard clams	40	5
Closed Shellfishing Areas	0	8
Water Column—Oyster Bay		
Open Shellfishing Areas	12	8
Closed Shellfishing Areas—oysters	37	8
Tissue—Oyster Bay		
Open Shellfishing Areas—oysters	12	8
Babylon Landfill—observation well	10	10
Storm Water Recharge—Massapequa observation well	8	12
Stony Brook STP—secondary chlorinated effluent	33	12
Stony Brook STP— groundwater observation well in recharge basin	0	9
Oyster Bay STP—secondary chlorinated effluent	36	11
Meadowbrook STP—secondary chlorinated effluent	25	12
Meadowbrook STP— groundwater observation well in recharge basin	30	10
Parkland III STP—tertiary chlorinated effluent	54	11
Parkland III STP— groundwater observation weill in recharge basin	30	10
Sunrise Garden Apartments STP— secondary chlorinated effluent	80	10
Sunrise Garden Apartments STP— groundwater observation well in leaching field	22	9
SCHD Experimental Septic System—influent	73	11
SCHD Experimental Septic System— effluent nonchlorinated	9	11

Summarized from Vaughn and Landry (1977).

latter may have indicated the presence of small fissures which would have allowed rapid virus infiltration by channeling. Had the observation well been located further down-flow, rather than within the dome of recharge water, some estimate of virus removal during horizontal flow would have been possible. In the absence of this information, it has been assumed (Vaughn and Landry, 1977) that removal rates through the aquifer would be similar to those encountered during percolation through the recharge basin. Based upon this, Vaughn estimated that viral penetration in the aquifer would not be significant after the first 100 to 200 feet of travel. Confirmation of this hypothesis would require an additional study of the site, including the installation of an additional observation well, 150 feet down the hydraulic gradient from the discharge basin.

The quality of effluents discharged from the Parkland III plant did not resemble those of a properly operated tertiary treatment system.[1] In spite of this, encouraging removal rates were noted in observation well waters. Based upon these data, it is conceivable that the recharge of properly treated effluents would contribute no significant viral contamination to the aquifer. The premise could be confirmed with a study similar to that just completed.

Viruses in Shellfish. There has been increasing concern over the likelihood of human virus carriage by shellfish. While there is little epidemiological evidence for the transmission of enteric disease from the consumption of sewage contaminated shellfish (with the notable exception of infectious hepatitis), the potential for infection cannot be ignored. Fugate, Cliver and Gatch (1975) outlined a number of reasons why a potential health hazard exists: (1) shellfish raising waters are continually being subjected to high levels of pollution from sewage sources; (2) shellfish, being filter-feeders, are able to efficiently concentrate viruses from the surrounding waters; (3) a majority of viruses are concentrated in the digestive organ of the mollusk, which is consumed along with all the other edible parts of the animal; and (4) shellfish are frequently consumed raw or with minimal cooking, which may not be sufficient to inactivate the viruses within them.

Oyster Bay was one case study considered by Vaughn and Landry (1977) for the Long Island 208. The "open" and "closed" areas studied in Oyster Bay were probably influenced by separate sources of pollutants. Results showed that 12.5 percent of all water and shellfish samples taken at the open site contained species of human viruses. Likely sources of viral contamination for this area included overland runoff, septic tank or cesspool leaching, and the discharge of treated sewage effluent from the Oyster Bay Sewage Treatment Plant located one to two miles away. While the major viral source could not be determined within the confines of this study, it should be noted that previous work by one of the authors (Vaughn and Metcalf, 1975; Metcalf, Vaughn and Stiles, 1972), conducted in a similar bay system receiving discharge from secondary treatment plants, indicated the presence of human viruses in shellfish beds that were located seven to eight miles from the nearest outfall.

The "closed" site was located several miles west of the "open" area discussed above. Microbial contamination at this site was probably influenced slightly by the sewage outfall, the more likely sources being overland runoff and septic tank seepage from the numerous older homes surrounding the

[1]*This problem has been known by the SCDEC and remedial action has been required.*

area. The results of sampling in this area yielded no virus isolates in the water column, yet 37.5 percent of the shellfish tested did contain viruses.[1]

Standards. There is as yet no established standard for permissible viral levels in aquatic systems. The reasons for this include the difficulty of sampling, the nonexistence of a single standard method for enumeration and identification, and the lack of concise epidemiological information concerning the waterborne transmission potentials of the virus groups involved. Despite uncertainty concerning an appropriate standard or threshold level, it appears prudent to minimize the occurrence of viruses in waters used for drinking, bathing or shellfish harvest.

4.1.2 Environmental Effects Directly Related to Bay and Groundwater Quality and Quantity

4.1.2.1 Quantity Effects

4.1.2.1.1 Aquifer Quantity. The availability of sufficient fresh water has long been of concern on Long Island. Long Island is surrounded by saltwater that has encroached upon the freshwater aquifer in some locales. Current information suggests that such saltwater intrusion is a localized phenomenon mainly related to local pumping practices and that the freshwater aquifer is not shrinking significantly (Miller and Sgambat, 1977a).

4.1.2.1.2 Water Level of Streams and Freshwater Wetlands.[2] Although the deep Magothy aquifer is not expected to change significantly, the shallow Glacial aquifer is expected to respond quickly to changes in freshwater recharge. Thus, sewering without local recharge can be expected to lower the water table. Significant lowering of the water table and of potentiometric surfaces has occurred over the last few decades in western and southwestern Nassau County. This appears to have resulted in decreased stream flow. The close dependence of streamflow on groundwater was underscored during the 1962–66 drought when record low flows were observed in fourteen of nineteen principal streams in Nassau and Suffolk Counties. The historical record of the combined annual average streamflow of the nineteen streams indicates a flow of 155 cubic feet per second (cfs) in 1966 as compared to the long-term average of 291 cfs.

Reductions in streamflow and declines in water table elevations can result in changes in the vegetation of certain freshwater wetlands. A total freshwater wetland area of over 1,500 acres has been inventoried within the nine major stream systems of southwestern Suffolk County and southern Nassau County. Water table ponds and lakes, such as Lake Ronkonkoma, Hempstead Lake and Southard's Pond (Carll's River) might experience some lowering of water levels. Marsh and meadow species of plants and trees dependent on a shallow water table environment may eventually occupy a greatly reduced area, closer to the remaining streams. A recent study on Long Island by Beitel (1976) suggests a possible sequence of vegetative succession similar to one that occurred at Artist Lake, Middle Island, New York during a lowering of the water table. In that case, nearshore lake habitats changed to marsh, and then to Red Maple swamp habitats. All waterbodies occurring in groundwater Zones VI, VII and VIII may be expected to be altered in the event of sewering with transport of effluent out of the zone. Streams in Zone VI are of particular concern with respect to secondary effects on Great South Bay salinity.

The tidal marshes on Long Island are marked by specific zones of vegetation. This zonation is a reflection of two basic parameters, (1) the degree to which the zones are inundated by the tides, and (2) the salinity gradients to which the vegetation is exposed. The lowest marsh zone, which is generally inundated with saline water twice a day, is dominated by cordgrass, *Spartina alterniflora. S. alterniflora* grows in almost mono-specific stands across extensive areas of low marsh in Long Island. At somewhat higher elevations, there is a high marsh or salt meadow zone, in which salt hay, *Spartina patens,* and spike grass, *Distichlis spicata,* predominate. Inundation is less frequent here, usually occurring only when tides exceed mean high level. Adams (1963), in a study of the North Carolina salt marshes, found that salt marsh species distribution was highly dependent upon elevation. In fact, Adams discovered that the vertical distribution of ten species of salt marsh plants spanned only one foot. Although there are individual differences between the species zonation in different geographical areas, species tend to be found within a well-defined elevation from the mean water level. Adams developed a mathematical relationship to determine the height of a species from mean sea level in a marsh as a function of the tidal range. This value was calculated for the three major species found in both Long Island and North Carolina (Table 4–19).

The sensitivity of marsh vegetation to the frequency and height of inundation has clear implications for any sort of development that affects the level of the water table. Although very little research exists on the effects of lowering the water table in marshes, much has been documented about the results of ditching upon tidal marshes (Bourn and Cottam, 1939, 1950; Cockran, 1938; Stearns, MacCreary and Dargh, 1939, 1940; Florschutz, 1959). Ditching, which effectively lowers the water table in a marsh, creates a higher, drier environment that the low and mud marsh species cannot tolerate. The delicate zonation patterns are altered, and the highly productive, low-marsh species give way to terrestrial and transition zone species such as the salt marsh aster, *Aster subulata,* the high tides bush, *Iva Fructescens,* and the groundsel bush, *Baccharis halimifolia,* (Cottam *et al.,* 1938). These plants are not as productive as low marsh vegetation, nor do they contribute and recycle nutrients in the estuary as effectively as low marsh vegetation, particularly cordgrass, *S. alterniflora.* Since the entire range of tidal marsh vegetation is only approximately one foot, net water level changes greater than an inch or two are expected to have drastic effects upon the species present.

[1] A likely reason for this negative finding was the heavy turbidity of the water.

[2] First two paragraphs abstracted from Miller and Sgambat (1977a).

Table 4–19

ELEVATION LEVELS FOR THREE TIDAL MARSH SPECIES*

	Elevation Above Mean Sea Level (ft)	
	Great South Bay	South Shore Bays
Spartina alterniflora	0.35–1.01	1.01–2.02
Spartina patens	0.51–1.46	1.46–2.92
Distichlis spicata	0.49–1.41	1.41–2.82

**Data is based upon indices calculated by Adams (1963), with tidal range of 1–2 ft for Great South Bay and 2–4 ft for the South Shore Bays*

In addition to impacts on vegetation, changes in the water level will affect the invertebrates that inhabit the marshes. When the water table drops, the soil dries and conditions become more acidic, causing a decline of molluscs and crustaceans, which are dependent upon alkaline conditions for construction and maintenance of their shells and exoskeletons (Nealy, 1962). These invertebrates are the main diet of many birds and animals, particularly waterfowl. As food sources for birds decrease, so eventually will bird populations. Permanent pools on the surface of the marsh may also diminish and dry up as a result of the lowered water table. These pools often support widgeon grass, *Ruppia maritima,* an excellent food for many ducks. The loss of these pools is yet another loss for the bird populations, removing both food and shelter.

The impacts of lowering the water table upon the wetlands in Great South Bay and the western South Shore bays are expected to be great, due to the sensitivity of marsh vegetation to both the height and frequency of inundation, and the water requirements of invertebrate and vertebrate populations. Any development, including sewering, that is expected to alter either the water table level or the height and frequency of inundation of the marsh must be thoroughly examined.

The minimum environmentally acceptable criterion is the maintenance of South Shore streams and wetlands at current flows and inundation levels.[1] The effectiveness of technological measures such as shallow recharge and stream augmentation in preventing ecological change is open to considerable uncertainty.

4.1.2.2 Quality Effects

4.1.2.2.1 Fish. Fish populations are highly mobile within the bay system. They also exhibit a diversity of survival strategies. Some species use the wetland areas of bays as breeding and nursery grounds. A few breed in the bay itself. Many species use the bays only occasionally or as feeding grounds. The various fish which use different parts of the bay system are then affected by changes in those aspects of the system they use. In particular, some may be affected by reduction in wetland areas and salinity changes (Gosselink and Beck, 1977). The accumulation of metals and organics by fish can be toxic to the fish themselves and may also affect their edibility (EPA, 1977).

Fish occupy different habitats during various life stages. Larval stages tend to be very sensitive to physical factors such as dissolved oxygen, turbidity, temperature and salinity (Tables 4–20, 4–21). Significant changes in salinity levels are likely to change the community composition of fish larvae that use the bays and their marsh edges as nursery grounds.

4.1.2.2.2 Shellfish. Shellfish populations have a low mobility and are affected by various types of changes in their habitat. Salinity changes can alter shellfish distributions and productivity (Maurer *et al.,* 1974). Table 4–22 summarizes the data used for determining the salinity ranges of major species of interest in eastern Great South Bay for which data exists. The observations from which the ranges were derived were made in Chesapeake Bay and the nearby estuarine communities that have prevailing conditions similar to those of Great South Bay. Where available, data from the larval stage of the molluscs was included as long-term salinity changes more severely impact the shellfish at this stage. The margins of the salinity ranges can be assumed to be sub-optimal, with some population decrease due to salinity-related mortality, and reductions in sizes of adult individuals. At the extremes of the range, the following sorts of effects could be expected: reductions in size of mature adults, decreased survival of juveniles and increased mortality due to predation and disease.

Severe dissolved oxygen deficits in near bottom water can cause shellfish mortality (Table 4–20). The various shellfish are selective with respect to substrate habitats (Kinner *et al.,* 1975). Substitution of muddy and silty sediments for sandy sediments may decrease the suitability of bottom areas for certain desirable benthic species. An important factor contributing to productivity of the benthic zones is the diversity of benthic micro-habitats. One of the most important effects of siltation may be the reduction in the diversity of rocky, sandy and muddy habitats present in bays. This may then reduce benthic productivity.

It is also possible that the runoff-derived solids, which appear to be responsible for much of the pollution by organic matter, can clog feeding mechanisms. This effect, however, is clearly dependent on the character of solids being discharged.

Coliform contamination affects the harvestability of shellfish. State standards[2] require that areas be closed when the median of a "representative" sample series is greater than 70 MPN per 100 milliliters.

[1] "Current" flows are definable by statistical measures such as twenty year means and variances or by steady-state or statistical hydrologic models.

[2] New York State Chapter X, Title 6, Section 701.5, SA waters.

Table 4–20

SENSITIVITY OF SELECTED FISH AND SHELLFISH TO DISSOLVED OXYGEN BY LIFESTAGE[a][b]

Species	Lifestage[c]	Sensitivity to Dissolved Oxygen
Blueback herring *(Alosa aestivalis)*	A	Susceptible to low dissolved oxygen
Alewife *(Alosa pseudoharengus)*	A	Susceptible to low dissolved oxygen
Bay anchovy *(Anchoa mitchilli)*	A	Intolerant of low dissolved oxygen
Bunker menhaden *(Brevoortia tyrannus)*	J & A	Susceptible to low dissolved oxygen
Weakfish *(Cynosion regalis)*	S & E	Requires $>$5 ml/l
	L, J, E	Moderate tolerance to low dissolved oxygen
Mummichog *(Fundulus heteroclitus)*	J & A	High tolerance to low dissolved oxygen to 1 ml/l
Striped killifish *(Fundulus majalis)*	E	High O_2 consumption rate
	J & A	High tolerance to low dissolved oxygen to 1 ml/l
Brown bullhead *(Ictalurus nebulosus)*	E	Need high concentrations of dissolved oxygen
	A	Extremely tolerant
Atlantic silverside *(Menidia menidia)*	J & A	High susceptibility to low dissolved oxygen
Hard clam *(Mercenaria mercenaria)*	E	Normal development at .5 mg/l; 100% mortality at 0.2 mg/l
	L	Growth stops below 2–4 mg/l
White perch *(Morone americana)*	A	Moderate tolerance to dissolved oxygen
Striped bass *(Morone saxatilis)*	E	4–5 mg/l reduces hatching success
	L	4–5 mg/l and lower, larval effects
	A	3 mg/l at 16–19° C is probable minimal permissible level
Striped mullet *(Mugel cephalus)*	E	Below 5 ppm decreases survival
	L	Below 4–5 ppm decreases survival
	J & A	Moderate tolerance to low dissolved oxygen
Summer flounder *(Paralichthys dentatus)*	A	High tolerance to low dissolved oxygen
Bluefish *(Pomatomus saltatrix)*	J & A	Highly susceptible to low dissolved oxygen
Winter flounder *(Pseudopleuronectes americanus)*	A	High tolerance to low dissolved oxygen

[a] *ERCO*
[b] *Summarized from Daiber and Thornton, 1976.*
[c] *A = Adult*
J = Juvenile
L = Larval
E = Eggs
S = Spawning Adult

Table 4–21

SENSITIVITY OF SELECTED FISH AND SHELLFISH TO TURBIDITY BY LIFESTATE[a][b]

Species	Lifestage[c]	Sensitivity to Turbidity
Blueback herring *(Alosa aestivalis)*	E	Can take up to 1000 mg/l without apparent effect on hatching
Alewife *(Alosa pseudoharengus)*	E	500 mg/l affected hatching success ($p < .025$)
Anchovy *(Anchoa mitchilli)*	A	Sensitive to turbidity
Bunker menhaden *(Brevoortia tyrannus)*	J	No effect on survival at 1000 mg/l
American oyster *(Crassostrea virginica)*	E	Significant effect on survival and growth at 125 mg/l
	L	Severe mortality at 100 mg/l
	A	Reduction in pumping rates at 100 mg/l
Weakfish *(Cynosion regalis)*	A	Sensitive
Mummichog (Fundulus heteroclitus)	A	Tolerant to high concentrations C_{10} = 23,000 mg/l
Striped killifish *(Fundulus majalis)*	A	High tolerance C_{10} = 23,000
Atlantic silverside *(Menidia menidia)*	A	Highly sensitive LC_{10} = 580 mg/l
White perch *(Morone americana)*	E	1000 mg/l affects hatching success ($p < .005$)
	J	500 to 1000 mg/l has adverse effect on survival ($p < .05$)
	A	Sensitive
Striped bass *(Morone saxitilis)*	E	1000 mg/l affected hatching success; LD_{50} is 3411 ppm
	L	500 to 1000 mg/l affected survival ($p < .005$)
	A	Sensitive
Yellow perch *(Perca flavescens)*	E	Can take up to 1000 mg/l with no effect
	L	500 to 1000 mg/l affected survival adversely ($p < .005$)
Bluefish *(Pomatomus saltatrix)*	J	Sensitive

[a] *ERCO*
[b] *Summarized from Daiber and Thornton, 1976.*
[c] *A = Adult*
J = Juvenile
L = Larval
E = Eggs
S = Spawning Adult

4.1.2.2.3 Contact Recreation. The suitability of waters for contact recreation is evaluated in this report by using the 30-day median 2,400 MPN/100 milliliters total coliform standard.[1]

[1] New York State Chapter X, Title 6, Section 701.5, SB waters.

Table 4–22

SALINITY RANGES OBSERVED FOR VARIOUS MOLLUSCS
(Parts Per Thousand)

Common Name	Scientific Name	Maurer[1]	Others[2]	Thornton[3]
Soft Clam	Mya arenaria	5–20	5–25	
Hard Clam	Mercenaria mercenaria	15–30	10–35	Juvenile 20–32,5
Surf Clam	Spisula solidissima	27–35	10–35	
Razor Clam	Ensis directus	13–28	7–32	
Blue Mussel	Mytilus edulis	20–35	15–35	
Oyster	Crassostrea virginica	Optimum 14–28[4]		Adult 7–30
		5–38		Juvenile 15–30
Scallop	Pectin	20–35	17–35	

[1] *Maurer and Watling, "The Distribution and Ecology of Common Marine and Estuarine Pelecypods in the Delaware Bay Area," The Nautilus, (April 1974), 88 (2): pp. 39–45.*
[2] *Reported by Maurer.*
[3] *Thornton, Delaware Coastal Atlas (1976).*
[4] *Maurer and Watling, Studies on the Oyster Community in Delaware, College of Marine Studies, University of Delaware, Newark, Delware (1973).*

4.1.2.2.4 Aesthetics. The effects of the 208 options on aesthetics are evaluated mainly in terms of the aesthetics of three zones: shorelines, marine waters and open space. Of these three, generally the 208 Plan will have little effect on aesthetic quality of shorelines. Rather, shoreline improvements can be expected to result from Coastal Zone Management (CZM) programs. Reductions in pollutant loadings to bays will improve the public perception of the quality of those water bodies. Lowering of the water table as a result of sewering with marine surface discharge will reduce wetland acreage, and the associated aesthetic value that relates to the wetlands' role as a habitat for diverse bird, fish and insect communities, and as nurseries for desirable aquatic species. Reduction of wetland acreage may also degrade existing views and vistas. Table 4–23 summarizes the relationships between recreational uses, aesthetics and water quality. Open space related aesthetic benefits can derive from watershed management approaches in Zones III and IV and stream buffer zone measures in Zones VI and VII.

4.1.2.2.5 Bay Nutrient Cycling. The quantity and composition of nutrient loads are of primary importance in assessing the environmental effects likely to result from wastewater management alternatives in Long Island bays. Nitrogen and phosphorus concentrations in particular are known to regulate the growth of phytoplankton in coastal waters.

In many waters subjected to waste loadings, oxygen-demanding substances depress dissolved oxygen concentrations below saturation. This is generally not a problem in Long Island bay waters where phytoplankton respiration and photosynthesis regulate dissolved oxygen concentrations.

Table 4–23

OVERVIEW OF RELATIONSHIP OF WATER QUALITY AND AESTHETIC QUALITY

Aesthetic Variables	Constituents Causing Aesthetic Degradation	Activity Affected by Aesthetic Degradation
Color	Metals, organics	Contact, noncontact recreation
Turbidity, nuisance algae	Suspended sediment, nutrients	Contact, noncontact recreation
Community diversity	Nutrients, dissolved oxygen	Noncontact recreation

Source: ERCO

The bay ecosystems also depend upon phytoplankton as primary producers. Thus, changes in nitrogen and phosphorus concentrations due to waste disposal can have a profound influence on bay ecosystems. This consideration is especially important in the shallow Long Island bays where relatively small quantities of effluent can cause substantial increases in ambient concentrations of nutrients.

There are two major types of effects—increases in gross levels and changes in atomic ratios among nutrients. Increases in nitrogen concentrations induce increases in phytoplankton productivity and algal blooms. This causes an increased oxygen consumption. Changes in the molar ratio of nitrogen to phosphorus are more critical than the absolute concentrations in determining the dominant species in phytoplankton communities.

Based upon an evaluation of available data from Long Island bays, Tetra Tech has indicated that 0.4 milligrams per liter total nitrogen is the level above which dissolved oxygen deficits violating the state standard of five milligrams per liter can be expected to occur. The actual maximum nitrogen level may vary from bay to bay and should be evaluated specifically for each bay.

Nitrogen (N), phosphate (P) and organic carbon (C) levels are significant indicators of water quality. Their ratio is a reliable indicator of the quality and quantity of flora and fauna supportable by the water. Optimally, the molar P:N:C ratio should be near 1:16:106. Generally C is very much higher than 106; and N is a limiting factor, with steady state N/P ratios in the neighborhood of ten to fifteen for most marine waters. N/P ratios less than ten occur at times in healthy Long Island bays. Persistence of N/P ratios below ten, apt to result from the disposal of some wastes, are generally a sign of an unhealthy ecosystem with a tendency to support phytoplankton populations of a limited number of species. Often the resulting species are not suitable food sources for prey-size selected filter-feeders. These alterations in phytoplankton communities tend to have subsequent effects on the marine food web, such as decreased fish and shellfish production. Interestingly enough, there seems to be no evidence indicating that N/P

ratios higher than sixteen have any adverse effects on an ecosystem (McCarthy, 1977). While N/P steady state ratios control the diversity of species and health of an ecosystem, absolute concentrations of these elements determine the total productivity of that ecosystem. Thus, the N/P ratio should be maintained at a proper level to ensure species diversity, while the absolute concentrations of N and P should also be maintained at some level (possibly 0.4 milligrams Nitrogen per liter) such that phytoplankton production does not cause severe algal blooms and D.O. deficits.

4.1.3 Other Environmental Concerns. Management of ground and surface water quality is best done in concert with several environmental concerns relating to the ecosystem's natural processes, which protect water quality. These concerns, relating to the safeguarding of certain naturally significant areas, are an important aspect of meeting water quality objectives.

4.1.3.1 Open-Space Watershed Management. Much of Long Island Island's precipitation is recharged. The original vegetation-based ecosystems, such as pine and scrub oak barrens, acted as recharge agents; that is, they (1) held water and nutrients in the vegetation and detritus for slow release to the aquifer, (2) contributed a chemical and bacterial setting which gave aquifer waters a particular chemistry, and (3) provided pervious zones that minimized runoff. Thus preservation of or establishment of similar areas relate to management of groundwater quality and of runoff. On Long Island, there are specific areas that are important to the groundwater and others that are important to the surface water environment. There are a range of approaches that can work. Three of these are as follows:

1a. *Acquisition of areas and preservation as open spaces.* Areas such as wetlands, safe zones surrounding pumped areas and selected recharge areas are best protected in such a fashion.

1b. *Acquisition of areas and regulation of use.* This differs from (1a) in that acquired lands are maintained in a multiple-use status. Regions such as watersheds, regional recharge zones and highly transmissive aquifer zones can be partially protected by institution of such measures for selected parcels of land.

2. *Protective regulation of land uses and activities.* Many of the recharge areas, watershed areas and intensively pumped areas are currently developed to a medium or high density. Control of further development of such areas can protect water resources.

4.1.3.2 Estuarine and Bay Wetland Ecosystems. Wetlands border Long Island bays and estuaries. They play an important role in nutrient cycles, organic matter cycles and marine population life cycles. In addition, wetlands act as buffers, filtering the runoff and siltation inputs to bays. Thus, maintenance of these areas is an important aspect of marine water quality management.

Vegetated tidal wetlands[1] cover some 23,000 acres of Nassau and Suffolk Counties. The largest area of wetlands is found on the South Shore, with the western South Shore bays containing some 8,800 acres within South Oyster Bay, East Bay, Middle Bay and Hempstead Bay. Most of this wetland acreage is on small marsh-islands that do not afford access from the mainland except by boat. To the east, Great South Bay is the next largest wetland bay, containing more than 5,500 acres along its shores and rivers and on Fire Island. In terms of total acreage, Peconic and Flanders Bays are ranked next, containing some 1,400 acres. Most of these habitats are small tracts along creeks that feed into the bays, but there are several tracts encompassing more than 100 acres. Oyster Bay is the site of a National Wildlife Refuge covering more than 3,000 acres, about one-tenth of which are vegetated tidal wetlands. Other North Shore bays have scattered wetland tracts along creeks but much of the bay shoreline has been filled and bulkheaded. The Huntington-Northport complex contains some 300 acres, much of it in Caumsett State Park and Lloyd Harbor. Around Port Jefferson Harbor there are approximately 150 acres of wetlands remaining, while Manhasset Bay and Hempstead Harbor together contain some 170 acres.[2]

Between 1964 and 1972, seventeen percent of the wetlands on Long Island were lost due to dredging and filling activities (O'Connor and Terry, 1972). During a 1973–1977 moratorium period, considerably less marsh was lost. The Tidal Wetlands Act (Article 25 of the Environmental Conservation Law of New York) calls for the preservation and protection of tidal wetlands, preventing their despoilation and destruction, giving due consideration to the reasonable economic and social development of the state" (NYSDEC Tidal Wetlands Land Use Regulations, 6 NYCRR, Part 661, 1977). Most activities, including all types of construction and dredging, are regulated by the State, and require a permit. However, for many of the activities associated with residential, commercial and industrial development, as well as sewering, treatment plant expansion, and runoff control, permits continue to be issued, although a significant time delay may be involved. The State of New York (Haje, 1976) calculated that only twenty acres of wetland were legally filled from 1973 to 1976. However, since permits continue to be obtainable, enforcement efforts may not adequately control all types of construction activities which, as discussed below, impact upon wetlands. Although no ecological methodology presently exists to analyze minimum wetland requirements for a bay, the current acreage appears to be critically low for most bays and is probably well below the minimum for a functioning marsh system in Manhasset Bay and Hempstead Harbor. For that reason, special protection of wetlands in those bays with sufficient wetlands, namely Great South Bay, South Shore bays, Peocnic Bay and Oyster Bay, is an essential part of an areawide water quality plan. The level of protection afforded by permit activities should be increased in those areas. Water pollution control facilities should be sited to avoid wetlands, wherever feasible.

[1] Defined as intertidal marsh (IM), high marsh or salt meadow (HM), coastal fresh marsh (FM), and formerly connected tidal (FC) vegetated wetlands.

[2] With the exception of the numbers for Peconic/Flanders Bay, numbers presented in this section were provided as preliminary calculations based on 1976 data by the NYSDEC.

4.2 Impacts of Areawide Alternatives

All control measures proposed for the Water Quality Management Plan that can be discussed on a bi-county basis are included in this section. This includes measures specifically designed to be Island-wide in scope (Section 3.5.1) and aspects on zone-specific measure that are common to all zones (general effects associated with parts of Section 3.5.2).

Table 4—24 is a guide to the organization of this section.

Table 4—24

CORRESPONDENCE OF WQMP OPTIONS WITH IMPACTS DISCUSSIONS

WQMP Option		Impacts Discussion	
Section:	3.5.1	Section:	4.2.1
	3.5.1.1		4.2.2
	3.5.1.2		4.2.3
	3.5.1.3		4.2.4
	3.5.1.4		4.2.5
	3.5.1.5		4.2.6
	3.5.1.6		4.2.14
	3.5.1.7		4.2.7
	3.5.1.8		4.2.15
	3.5.1.9		4.2.8
	3.5.1.10		4.2.9
	3.5.1.11		4.2.10
	3.5.1.12		4.2.15
	3.5.1.13		4.2.11
	3.5.1.14		4.2.12
Sewering Options			4.2.13
Treatment Plants			4.2.15
Outfalls			4.2.16

4.2.1 Effects Associated with Miscellaneous Individual Source Control Measures. The non-point source pollutants that the controls identified in Section 3.5.1 seek to abate, constitute a significant portion of the total load to water bodies. In particular, non-point sources contribute up to 99 percent of the coliform load and about 40 percent of the nitrogen load to the bays that were studied. They contribute to nitrogen, metal and organics groundwater contamination. Despite the significance of these measures with respect to abating health risks, there are major uncertainties associated with a few of them. These uncertainties are of two sorts: questions concerning effectiveness and questions of implementability. If these measures are proven to be effective and if the implementation is commensurate with the need, the net result of various recommended controls will definitely be environmentally beneficial. The measures are discussed individually in Sections 4.2.2 to 4.2.12.

4.2.1.1 Short-Term Primary Impacts. Many of the control options for non-point sources will involve a considerable delay before regulatory programs can be drafted and accepted and before enforcement programs can be organized. Thus, the major short-term impacts will be due to continued pollutant loads until measures are implemented. The short-term impacts can be minimized by giving priority to implementing those measures which control those sources imposing the greatest health and environmental effects.

4.2.1.2 Long-Term Primary Impacts

Metals. None of the proposed controls cause additional metal contamination. Controls of diffusion wells, landfills and discharge and storage of industrial materials and wastes will reduce levels of metals discharged to the environment. Generally, metals in marine, fresh and groundwater are rapidly adsorbed onto sediments. This is suggested by low levels of metals, well below standards, in groundwater sampled in this program. It is also indicated by previous research (*NAS,* 1976). Major metal pollutant problems have tended to arise from accumulation of metals in the food chain where there is a high metal level concentrated in sediment or water column. Such a situation may occur when sediment metal levels are high and members of the food chain are detritus feeders. Sediment metal levels should be monitored since metals data is lacking for the Long Island bays.

Organics. None of the proposed controls causes additional organic chemical contamination. Controls on product storage tanks and pipelines, landfills, groundwater development, discharge and storage of industrial materials and wastes, diffusion wells, fertilizer use and pesticides will all significantly reduce organic chemical discharges. It is difficult to determine which controls would be most effective in reducing organic levels, since all the various sources have not been inventoried or monitored.

However, monitoring of the groundwater has shown organic chemical contamination to be a significant health problem (Section 4.1.1.2). Thus, employment of all available controls would be the most prudent strategy. Also, as noted, there is a major data gap that needs to be eliminated, namely the lack of data on all sources of organic chemical pollution.

Nitrates. None of the proposed controls cause additional nitrates contamination. Control of leakage from sewers, effluent recharge, domestic on-site systems, animal wastes and fertilizer use will all help abate nitrate loads. Modeling work done for this program suggests that animal wastes controls and fertilizer use controls will both help abate nitrate loads. The modeling work also suggests that on-site systems and fertilizers are the major sources. However, the model used did not account for non-conservative transport of nitrates in the groundwater below the root zone. Also, comparison of modeling results showed that some areas display particularly high levels relative to model loading numbers. Variation in monitoring well data may be attributable to local groundwater hydrology and surficial geology. Thus, although control of on-site systems performance and of fertilizer use are of most importance, the effectiveness of controls will vary geograph-

ically. In some locales, a wide range of controls need to be implemented to meet the ten milligrams per liter standard (I and II) or to obtain lower levels (III and VI). Hydrogeological zones can only be specified in a general way at this time. They have been set forth in Chapter Three (see Table 3–3).

Coliforms and Viruses. None of the proposed controls cause additional coliform contamination. Since pathogen transport through soil and aquifer usually is very limited, none of the controls is likely to affect groundwater quality. Control of animal waste could possibly reduce coliform levels in bays. Although it is difficult to link coliform levels in bays to sources, evidence put forth during this project suggests that dog and duck wastes are significant animal waste contributors to bay coliform levels. However, the best management control measures put forth in Section 3.4.1.12 are unlikely to reduce dog and semi-wild duck waste contributions.

Water Quality, Water Level—Streams and Ponds. Control of groundwater pumping patterns will help maintain the water level of streams and ponds. Work done for this study has shown that, regionally, groundwater supply is not a problem, but that water table levels are a problem where recharge is at reduced levels. Locally, both water table and water supply can be depleted in areas that are overpumped. Thus, such controls are highly beneficial.

Fish, Shellfish. The controls being considered in this section mainly affect fish and shellfish in terms of metals, organic chemicals, oils and coliform bacteria. Metals, organics and coliforms have been considered previously in this section. The major impacts of oils on fish and shellfish are likely to be caused by spills and accidental discharges. Control measures are not likely to be of great value in reducing impacts of spills. However, they may slightly reduce the probability of spill occurrence. As of 1977, no major spills have occurred in Long Island bays. However, study of the recent Huntington spill may prove instructive.

Aesthetics, Wetlands, Unique Habitats, Open Space. Land use controls (3.5.1.13) will have a significant benefit in preserving habitats and open space. All of the areawide measures applied to hydrogeologic zones with surface water impacts (Zones IV, V, VI, VII and VIII) will have a positive aesthetic impact due to water quality improvements (see Section 4.1.2.2.4).

4.2.1.3 Secondary Impacts. Most of the proposed controls involve regulation of the use of products, the use of land, or waste disposal. Some proposed regulations will have an impact on consumer practices (for example, pet purchases may be affected). Others will have impacts on industry and agriculture (for example, fertilizer use). All regulations will affect staffing requirements for regulatory agencies. Generally, the trade-offs between positive environmental benefits and negative secondary impacts cannot be analytically resolved. There is no way to optimize between two measures which cannot be expressed in common units. The trade-off must then be resolved politically. Below a list is presented of the key trade-offs related to non-point controls:

1. Control of effectiveness of on-site systems *vs.* cost to homeowners for maintenance.
2. Agricultural fertilizer controls *vs.* requirement for trained personnel to properly carry out scientific application.
3. Residential fertilizer controls *vs.* lawn appearance.
4. Efficient organic controls *vs.* cost to industry and to homeowners.
5. Animal waste controls *vs.* inconvenience to owners.

4.2.1.4 Adverse Environmental Impacts. None.

4.2.1.5 Irreversible and Irretrievable Commitment of Resources. No substantial commitments since most of the measures are legal/institutional in nature.

4.2.2 Provide for Routine Maintenance of On-Site Septic Tank and Leaching Pool Systems. The routine maintenance of septic systems will help them to operate with pollutant removal at or near design efficiency. Such a measure will be environmentally beneficial with respect to groundwater and surface water quality and public health. One result of such a control will be the generation of additional loads of scavenger wastes. However, the additional scavenger wastes would have to be handled at existing or future treatment plants. Any increases in treatment plant design sizes due to scavenger waste flows would induce effects such as those discussed in 4.12.15.

4.2.3 Prohibit the Use of Certain Chemical Cleaners in On-Lot Systems. This measure is intended to control one of the sources of organic chemical contaminants. Due to the lack of a study on relationships of organics sources to groundwater quality, it is difficult to evaluate the impact of the proposed control. From a conservative standpoint, the measure is environmentally beneficial from a public health standpoint since it will have a positive effect on groundwater organic chemical levels.

From an areawide planning standpoint, the benefits of this measure are not clear at the present. A comprehensive plan for organic chemicals control is strongly recommended as an extension of the 208 planning process. This is an interim measure that should be followed by development of an overall organics control plan.

4.2.4 Expand Regulations and Enforcement Regarding the Disposal of Industrial Wastes. The strict enforcement of pretreatment regulations is highly beneficial from the standpoint of operation of waste water treatment plants. Expansion of regulations to cover organic chemicals discharges to the ground will probably result in decreased groundwater organics levels. However, the lack of a study of the relationship between organic chemical sources and groundwater quality leaves considerable uncertainty as to the beneficial impact of implementing controls on industrial sources. An effect of the proposed controls will be increased quantities of hazardous treatment wastes to be disposed of. On an areawide basis, the proposed measures would have environmental benefits.

4.2.5 Regulate the Storage and Transportation of Chemical Products. Measures to minimize spills and other accidental mishaps of hazardous mater-

ials are clearly environmentally beneficial.

4.2.6 Reduce the Use of Fertilizers. Porter *et al.* (1978) showed that fertilizers constitute a major source of nitrates to groundwater on Long Island. Two major sectors to which restrictions can be applied are agricultural use and residential (lawn) use. Figure 4–1 summarizes a Long Island study which shows that scientific fertilizer application in the agricultural sector results in lowered groundwater nitrates. Similar results may be expected for lawn fertilizers, which are largely applied in excess and leach rapidly below the root zone. Other studies have shown that sewage sludge compost, a slow release nitrogen source, results in low nitrate leaching. It is recommended that use of fertilizer be regulated, that low maintenance lawns be planted, and that education relative to scientific fertilizer application be carefully carried out. Such fertilizer controls are environmentally beneficial.

4.2.7 Reduce Animal Wastes. The characteristics of dog, fowl and human wastes are presented in Tables 4–25 and 4–26. The dog population of Long Island is indicated in Table 4–27. These data demonstrate that animal

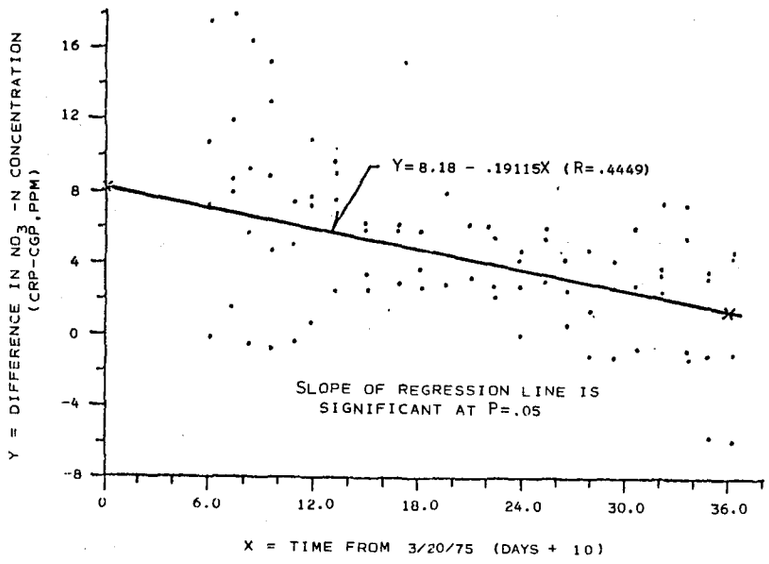


FIGURE 4–1 *Summary of Experimental Data Showing Reductions in Groundwater Nitrates Obtained by Scientific Fertilizer Application (Potato Farm)*

Source: Baier, J. and K. Rykbost, 1976, "The Contribution of Fertilizer to the Groundwater on Long Island," presented at the Third National Groundwater Quality Symposium.

Table 4–25

ANALYSIS OF DOG DROPPINGS: CHICAGO[a]

Constituent	Three Sample Collections		
	1	2	3
Water Soluble, mg/100 ml	16.5	20.2	178.3
Volatile Water Soluble, mg/100 ml	10.3	15.9	145.8
BOD_5, mg/g	78	377.3	300
COD, mg/g	200.7	552	720
Coliform, MPN/g	16,090	16,090	1,400,000

[a]*Source: American Public Works Association (1969).*

wastes contribute both nitrogen and coliform bacteria to surface waters. These contaminants end up in runoff, which enters bays and recharge basins. Thus, animal waste controls that reduce these loads would be clearly beneficial. Effective controls may lessen the need for sewering and may reduce coliform levels in bays sufficiently to permit the reopening of shellfish beds.

4.2.8 Reduce Reliance on Landfills. The proposed measures are clearly of environmental benefit. Organic sampling (1978) demonstrated the hazards to groundwater quality associated with landfills.

4.2.9 Provide for the Treatment of Hazardous Wastes. The collection and treatment of hazardous wastes, discussed in 3.5.1.10 and in Plan Section K "Residual Waste Control Needs" has clear environmental benefits. However, the treatment processes result in hazardous residues and sludges still requiring ultimate disposal. The WQMP recommends (a) removing wastes from the bi-county area or, if that is not feasible, (b) building a bi-county treatment facility, or two county ones. Alternative (a) simply transfers the disposal problem to other areas and does not provide for ultimate disposal of wastes. It is an unacceptable strategy from a Metropolitan Regional standpoint, although it may appear to be adequate from a bi-county perspective. Alternative (b) is the more acceptable option, it being understood that special precautions must still be taken when landfilling treatment residues and sludges. Chemical landfilling may result in accidental discharges to groundwater, with the resulting contamination of the Magothy aquifer if the landfill is in the recharge zone, or of the bays if it is located in a shallow flow zone.

4.2.10 Provide Alternatives to Ocean Disposal of Municipal Treatment Plant Sludge. The alternatives presented in Section 3.5.1.11 as being equally acceptable are not equal in terms of environmental impact. Incineration is the least desirable because of associated air emissions and high energy expenditures. Co-incineration generates the same emissions but provides some energy savings. Pyrolysis produces significantly less harmful air emissions and provides a high energy return. Landfilling and land application probably are not feasible from land use and pathogen contamination standpoints. Thermal

Table 4—26

SUGGESTED HUMAN AND ANIMAL WASTE PRODUCTION VALUES
FOR BIOCHEMICAL OXYGEN DEMAND (BOD) AND BACTERIOLOGICAL CONTENT

		Daily Solid Waste Production			Solid Waste Only			Solid Waste Bacteria Content (Million MPN/g)			
								Coliform			
Biotype	Nassau-Suffolk Population (Numbers)	Single Animal (Grams)	Total Population (Pounds)	BOD per Animal Per Day (Pounds)	Human BOD Equivalent	Daily Total Human BOD Equivalent	Total Animal BOD Load (% Human)	Total	Fecal	Fecal Strepto-Cocci	FC/FS*
Human	2,735,637	150	903,000	0.17	1.00	2,735,637	100.0	NA	13.30	3.0	4.43
Dog	425,000	227	212,500	0.13	0.76	323,000	11.81	18.0	18.00	7,300.	0.002
Horse	30,000	16,100	1,063,875	1.40	8.24	247,200	9.04	NA	NA	NA	NA
Duck	750,000	336	400,000**	0.02	0.12	90,000	3.29	NA	32.70	53.6	0.61
Cattle	1,825	26,300	105,721	1.89	11.12	20,294	0.74	NA	0.23	1.3	0.18
Chicken	121,200	182	48,587	0.02	0.12	14,544	0.53	NA	1.30	3.4	0.38
Swine	635	2,700	3,776	0.34	0.20	1,270	0.05	NA	3.30	84.0	0.04

**Fecal coliform-Fecal streptococci ratio*
***Total volume of waste from market ducks adjusted for probable age distribution and does not include wild or semi-wild population.*
Source: NSRPB, 1977, "Animal Waste: Non-point Source Pollution" 208 Program Report Series.

drying produces a usable product but requires a significant energy expenditure. Composting provides a stable product with few negative effects. Thus, any or all of three alternatives—pyrolysis, composting and thermal drying—would be environmentally acceptable.

4.2.11 Minimize Population Density. Land use controls would have several important environmental benefits including: (a) avoidance of high density conditions that appear to be associated with significant degradation of groundwater quality, (b) provision for substantial dilution of on-lot residual discharges, (c) preservation of vegetative cover and habitat areas, which provide the setting for natural cycling of micronutrients, and (d) minimization of human impacts on the hydrologic cycle.

4.2.12 Promote Water Conservation. Water conservation can decrease sewage flows requiring treatment. Conservation practices could assume particular importance under sewering approaches. Sewering, when coupled with marine surface discharges, makes most domestic water uses consumptive. Thus, water conservation is environmentally beneficial.

4.2.13 Effects Associated with Sewering Activities. Comprehensive (1 D.U.) and less extensive Island-wide (2 D.U./gross acre and 3 D.U./gross acre) sewering are options for each of the 208 water management zones of Long Island. As a result of these options, substantial construction of both sewer lines and treatment plants will be required. Such activities will tend to (1) safeguard groundwater from nitrate, organic chemicals, and pathogen contamination (with secondary improvements in surface waters); (2) cause a lower water table if there is no recharge; (3) increase loads of treated effluent to some combination of bays, ocean, and recharge; and (4) increase the sludge load. Effects (2), (3), and (4) are important intermedia impacts that must be considered. Sewering is often judged environmentally beneficial without sufficient consideration of intermedia tradeoffs of groundwater nitrogen and surface water pathogens against surface water quality, air quality, and sludge loads, many of which involve significant health impacts. The major tradeoffs can be summarized as follows:

(a) *Sewering with Surface Outfall.* Limits domestic contributions to groundwater nitrogen; limits public health risks to surface waters resulting from septic tank failures; increases marine/bay nitrogen levels; increases marine/bay coliform levels; decreases streamflows and wetland inundation; involves high costs with high cost uncertainties.

(b) *Sewering with Surface Outfall and Stream Augmentation.* Same as above, although streamflow decreases may (possibly) be mitigated.

(c) *Sewering with Recharge.* Limits domestic contributions to groundwater nitrogen; limits public health risks to surface waters resulting from septic tank failures; may cause groundwater contamination depending on reliability of recharge/treatment technology; may possibly mitigate streamflow and wetland inundation impacts. High cost uncertainties, (engineering uncertainties concerning recharge).

(d) *Sewering only in Selected Areas (high water table, 5 D.U./gross acre densities) with Non-structural Measures.* Limits (with uncertainty) non-point contributions to groundwater nitrogen; limits public health risks to surface waters resulting from septic tank failures; maintains low marine/bay nitrogen levels (with nitrate contributions from groundwater underflow); protects streamflows and wetland inundation levels.

Although, in some areas there may be no presently available alternative for the reduction of groundwater nitrogen, on an areawide basis, sewering should only be used as one of a set of measures to deal with the range of environmental problems.

4.2.13.1 Short-Term Primary Impacts. *Metals, organic chemicals, nitrates, coliforms, virus, water quality, water level, fish, shellfish, contact*

Table 4—27

DOGS ENUMERATED AND LICENSED: NASSAU AND SUFFOLK TOWNS, CITIES AND SELECTED VILLAGES IN 1976

The following municipalities were enumerated and licensed in 1976.

Town	Enumerated	Licensed
Hempstead	59,995	50,682
North Hempstead	21,957	22,573
Oyster Bay	30,525	29,048
Cities		
Glen Cove	2,418	2,064
Long Beach	1,953	1,874
Town		
Babylon	27,515	21,564
Brookhaven	35,324	26,372
East Hampton	1,683	2,302
Huntington	18,175	24,687
Islip	39,811	23,206
Riverhead	2,674	2,824
Shelter Island	378	1,597
Smithtown	12,633	11,894
Southold	2,747	3,066
Southampton	6,500	4,283

Total Enumerations = 287,886

Village	Enumerated	Licensed
Atlantic Beach	482	222
Bayville	613	613
Bellerose	128	130
Cedarhurst	553	535
Centre Island	113	117
Floral Park	1,629	1,522
Laurel Hollow	320	325
Freeport	3,916	3,336
Garden City	2,002	2,332
Hempstead	3,250	2,593
Hewlett Bay Park	84	79
Hewlett Neck	71	64
Lynbrook	2,258	1,926
Malverne	1,021	1,005
Massapequa Park	3,075	2,727
Mill Neck	291	269
Old Brookville	336	300
Oyster Bay Cove	436	439
Rockville Centre	2,124	2,238
Sea Cliff	896	807

Total Licensed = 249,615

Village	Enumerated (1974)	Licensed (1975)
East Rockaway	1,535	1,153
Farmingdale	640	621
Hewlett Harbor	208	197
Island Park	526	524

Total Enumerations = 7,973

Village	Enumerated (1974)	Licensed (1975)
Lawrence	798	693
South Floral Park	131	140
Stewart Manor	267	309
Valley Stream	3,763	3,598
Woodsburgh	105	88

Total Licensed = 7,323

Source: Esser et al., (1977).

recreation: Dewatering activities in sewer excavations may generate a contaminated waste. This pump water must be carefully monitored and disposed of.

Aesthetics. Construction of sewer lines, interceptors, and associated structures will cause some aesthetic degradation. Such problems can be minimized, if desired, by the use of optimal construction schedules and practices. Short-term aesthetic problems are probably outweighed by other long-term environmental benefits.

Wetlands. Expansion or upgrading of present treatment plants located around the Long Island bays may result in temporary disruption to the flora and fauna of the surrounding wetlands and to fish and shellfish populations. As a site is developed and prepared, the clearing of vegetation

increases land erosion and alters runoff drainage patterns. The hydrocarbons and other chemicals used in construction tend to spill on the ground and are washed into the soil or into the surrounding bays. Although many of the treatment plants are already located on sites that allow expansion, some will need more land for construction and thus may impinge upon neighboring wetlands.

Comprehensive sewering requires pipeline construction, and in some areas this will involve laying pipes through wetlands. Such an activity involves dredging, which, at least temporarily, alters the vegetation and drainage patterns of the area. If dredged material is subsequently replaced and the area is revegetated, these impacts will be minimized.

Although more than 50 percent of Nassau County is presently sewered, including some of the North and most of the South Shore area, less than ten percent of Suffolk County is currently sewered. Most of the areas surrounding Great South Bay remain unsewered, and if plans for sewering are implemented in those areas, great care must be taken to preserve the wetlands and to locate treatment plants away from valuable areas such as the Connetquot River and Bellport Bay. Any construction of pipelines that run through wetlands must be carefully supervised to ensure minimal damage and proper restoration.

Unique habitats. Effects due to sewer and sewage treatment plant construction can be negligible if all structures are built outside habitat areas.

Open spaces. No significant effect.

4.2.13.2 Long-Term Primary Impacts

Metals, organic chemicals. There is a positive effect associated with the hookup of industries to sewers, although pretreatment waste then have to be disposed of.

Nitrates. In most sewered areas, the level of nitrate in the Magothy aquifer is expected to be significantly less than it would have been had those areas not been sewered. This decrease is most likely to be noted in Zones I, II and III. However, it must be noted that the relationship between sewering, fertilizers, aquifer hydrology and nitrogen has not been firmly established. This decrease in groundwater nitrates is a positive effect, both from a groundwater supply standpoint and with respect to underflow to bays.

Coliform and viruses. Coliform and viruses do not appear to travel long distances in the groundwater (Vaughn and Landry, 1977). Thus, the benefits of sewering in this respect may be limited to (1) reductions of pathogen levels in the vicinity of septic systems and (2) reductions in individual discharges of untreated wastes to bays and streams, including discharges due to system failures.

Water quantity and water table. The comprehensive sewering option tends to reduce the quantity of water being recharged unless sewage treatment plant effluent is recharged. Work done during the 208 Study suggests that the effect on the overall water supply reservoir will be insignificant, but that streams and wetlands will have lowered water levels and the salinity of Great South Bay may be altered. This will be a significant negative environmental impact.

Fish, shellfish, contact recreation, aesthetics. See Table 4–28.

Wetlands. Failure to reclaim areas used in construction of treatment plants and pipelines will result in permanent loss of valuable wetlands. Increased erosion and runoff, and a loss of vegetation and resulting increase in detritus, may upset the ecological balance of the wetlands, reducing their value as nutrient sinks and productive habitats for fish, shellfish and wildlife.

Sewering in areas adjacent to wetlands may prove beneficial in terms

Table 4–28

MATRIX DISPLAY OF LONG TERM PRIMARY EFFECTS OF SEWERING

	Sectors Affected						
Changes Due to Sewering	**Freshwater Fish Diversity**	**Marine Fish Community Diversity**	**Shellfish Community Diversity**	**Contact Recreation**	**Shoreline Aesthetics**	**Water Quality Aesthetics**	**Open Space Aesthetics**
Water Table	NE	O	O	O	O	NE*	NE*
Stream Flow	NE	O	O	O	O	NE*	O
Great South Bay Salinity	O	NE	NE*	O	O	NE	O
Groundwater Nutrients	PE	PE	PE	O	O	PE*	O

PE = Significant Positive Effect
NE = Significant Negative Effect
O = No Effect
** = Key Effect*

Source: ERCO

of limiting the sewage that flows into these areas and thence into the bay. The soil in such locations is generally unsuitable for on-site disposal systems because of its vulnerability to high storm tides and its saturation. By installing sewers, one may cause some reduction in the amount of nutrients and bacteria which flow into the wetlands, since on-site systems are reduced in number.

Lower water table elevations due to sewering with marine discharge will reduce freshwater wetland area extent, especially along the South Shore. This is a significant negative effect.

Unique habitats. No significant effect if structures are properly sited.

Open space. A potential threat is posed to terrestrial habitats. Construction agencies must use available municipal land for the treatment plants, and in many communities on Long Island the most available municipal sites are open spaces, potential park sites and forests. Any structural option may represent a tradeoff of water quality against the preservation of terrestrial habitats and the vegetation and wildlife harbored there.

4.2.13.3 Secondary Impacts. There are a number of indirect consequences of sewering activities that are too broad in scope to consider in detail in this study. These can be divided into several categories as follows: (1) effects on other environmental media, (2) social and economic effects, (3) public health effects and (4) natural resource effects.

Those aspects of sewering activities likely to induce secondary effects are changes in water levels, interruptions in natural chemical cycles, changes in development patterns and improved surface and groundwater quality.

Effects induced by changes in water level are discussed in this section as part of direct effects and include changes in wetland vegetation and stream ecology. Induced water level changes are the subject of an in-depth study to be conducted by USEPA and SCDEC. Impacts on natural chemical cycles cannot be determined in this water quality management program because of the lack of data and time-resource constraints. Induced changes in development as a consequence of sewering have been studied at the national level by CEQ (Urban Systems, Inc., 1974). This study concluded that sewering activities will generally induce land development and growth. NSRPB studies indicate that this induced effect has not occurred in the SMSA, and cannot be linked to sewering activities on Long Island. The Urban Systems study contends that sewering provides the vehicle for land subdivision and high rise construction in a fashion similar to the well-known strip development of highways. The NSRPB contends that Long Island sewering activities lag rather than lead development. Suffolk County contends that costs to homeowners of sewering discourages growth. No usable analysis of the Long Island situation is available. Thus, the Urban Systems viewpoint cannot be completely discarded.

4.2.13.4 Adverse Environmental Impacts. All those enumerated under Short-Term Primary Impacts and Secondary Impacts, and those adverse under Long-Term Primary Impacts.

4.2.13.5 Minimize Adverse Impacts. In order to mitigate the effects of construction upon wetlands and aesthetics, certain steps can be taken. These include minimizing the construction area, preventing erosion during construction, and restoring the sites following completion of the activity. Particular care should be taken to restore natural drainage patterns and to maintain buffer strips between the construction area and watercourses. Structures should be sited to avoid important wildlife habitats and valuable open space.

4.2.13.6 Irreversible and Irretrievable Commitment of Resoureces. The permanent loss of some wetlands and the degradation of wetland environments by vegetation loss and erosion are two aspects of comprehensive sewering that result in irreversible and irretrievable commitments of resources. If construction activities are handled so as to minimize adverse effects, this permanent loss will be minimal.

The decline in streamflow and change in water level of wetlands is a very significant environmental effect. The selection of comprehensive sewering options dictates that one be prepared to trade off improvements in groundwater nitrate level against the loss of freshwater wetlands or be prepared to augment streamflow and freshwater wetland levels. Nassau and Suffolk Counties have recently proposed to the EPA that a comprehensive study of the effects of Sewage Disposal Districts Two and Three (Nassau) and the Southwest Sewer District (Suffolk) on stream flow and Great South Bay salinity be performed. Thus, a better judgment of the impact and extent of stream flow changes can be made when that study is complete.

4.2.14 Effects Associated with Stormwater Runoff Controls. Most of the coliform contamination outside of western Long Island Sound, and much of the nutrients, solids, organics and metals in the surface waters, originate in non-point stormwater runoff. Thus, control of this runoff is a key management alternative for the bays, particularly those where shellfish beds have been closed because of high coliform bacteria levels and those which exhibit elevated nitrogen levels. These include Great South Bay, Moriches Bay, Oyster Bay, Port Jefferson Harbor and Huntington/Northport. The nature of runoff contaminants tends to be different for the different areas (Weston, 1977d). For example, in Oyster Bay, coliform bacteria from semi-wild duck and other animal populations frequenting tributary ponds is a key contaminant. However, not enough is known about the runoff to each bay to be able to demonstrate the major differences. In general, nutrients and total coliform bacteria dominate pollutant loadings in runoff in eastern bays, and metals and organics attain a greater significance in western bays.

The control of storm runoff can be accomplished by employing two types of alternatives for pollution abatement, namely structural and nonstructural Best Management Practices. Structural alternatives include the following:

1. Sedimentation in storage reservoirs followed by chlorination of the effluent.

2. Sedimentation in storage reservoirs followed by ozonation of the effluent.

3. Primary treatment using swirl regulator/concentrators followed by chlorination of the effluent.

4. Marsh-pond treatment with sedimentation.

5. Natural pond retention and disinfection.

Control by non-structural methodologies involves the following alternatives:

1. Employment of Best Management Practices (BMP) to reduce the volume of runoff reaching surface waters by means of on-site recharge, detention (storage in permanent basins or ponds; temporary ponding on dual-purpose paved areas) and retention (use of natural drainage system; creation of broad channels; employment of flow-retarding devices).

2. Use of Best Management Practices designed to limit availability of pollutants in transport by controlling sediments, and by fertilizer and animal waste controls.

3. Interception and disposal of accumulated pollutants before they reach surface waters by street cleaning and catch basin maintenance.

Non-structural controls have been proposed for Long Island bays. The effectiveness of such controls is not known. Thus, a pilot program has been proposed to evaluate the non-structural approach.

If such a pilot program produces poor results, structural measures will be required. On an areawide basis, extensive runoff controls are environmentally beneficial.

4.2.14.1 Short-Term Primary Impacts. Short-term primary impacts will result primarily from the construction of detention or retention structures, and specialized treatment plants built specifically to treat stormwater runoff.

Metals, organic chemicals. Various contaminants are freed to runoff during construction, including exposed materials (debris, trash), stagnant water, fuel and chemical spillage, vehicle drippings and others. The impacts of runoff and leachate from these materials entering the aquatic ecosystems are varied and relatively unexplored. Synergistic effects of hydrocarbons and heavy metals contamination in shellfish have not been studied, for instance. These effects can be controlled by analysis of soil samples prior to site selection so as to avoid construction in contaminated soils, and by construction of runoff contaminant-control structures.

Nitrates, coliform, virus, water quality, water level. No effect.

Fish, shellfish. The impacts to watercourses and bays associated with construction include the following:

1. Increased volume of water to watercourses from surface runoff.
2. Increased turbidity from loss of natural cover and topsoil.
3. Increased sedimentation and possible shoaling.
4. Peripherally, loss of wetland habitat.

Fish and shellfish are sensitive to increased turbidity and sedimentation, especially in egg, larval and juvenile stages (see assessment of change in outfall location). Benthic shellfish, once covered, are smothered. It may take up to two years before the area is recolonized. These effects can be minimized by prudent construction practices.

Contact recreation, aesthetics. A significant benefit for contact recreation will be due to reductions in coliform levels. Aesthetic benefits will derive from general water quality improvements. (See Section 4.2.1.6.)

Wetlands. Construction of ponds or basins, as well as the building of facilities to treat the runoff, may result in temporary destruction of wetlands through removal of vegetation and soil erosion. The potential dangers due to site preparation and access, and the storage of machinery and supplies, are similar to those for any other type of construction. In this case, however, large areas of land must be altered in order to meet the size requirements of settling basins (on the order of 400 feet by 200 feet by fifteen feet). Thus, the impact on wetlands is potentially greater, possibly including the destruction of extensive tracts of land that may shelter large populations of wildlife.

Unique habitats, open space. No significant effects when properly sited.

4.2.14.2 Long-Term Primary Impacts

Metals. Structural or non-structural controls may significantly reduce metal pollution due to runoff. This is due to adsorption of metals onto settleable material.

Organics. Some reductions may be noted.

Nitrates, coliforms, viruses. The major purpose of these measures is to provide an environmental/health benefit by reduction of these constituents.

Water quantity, water level. No effect.

Fish, shellfish. Long-term impacts of improving structural and non-structural stormwater runoff controls will result in an improvement in general water quality depending on the control alternatives implemented. Sedimentation in storage reservoirs and/or the use of a swirl/concentrator will remove suspended soilds. At peak design flow, the swirl/concentrator system will remove 60 percent of the suspended solids. Disinfection units can also be linked to these systems to eliminate coliform contamination. However, during a typical five year period, thirteen percent of the storms would result in overflows without treatment.

In the long term, storage with sedimentation followed by disinfection will adequately address the suspended sediments and coliform components of stormwater runoff. Thus, impacts on fish and shellfish associated with turbidity, such as gill clogging and smothering, will be decreased. Additionally, lower coliform levels will render shellfish beds harvestable and may also improve bay quality with respect to bathing.

The non-structural alternatives of detention and retention of more diffuse sources of stormwater runoff will also improve water quality in the long run, by reducing turbidity. Peak flows will be modified, reducing suspended sediment concentrations in watercourses. Retention of water will also enhance the settling of suspended sediments.

Non-structural alternatives may not adequately control such sources of pollution from storm runoff as coliform bacteria, pesticides, metals and hydrocarbons, since they deal only (at least directly) with flows and suspended sediments. It is true, for instance, that some phosphorus and heavy metals adsorb onto soil particles, which settle and are thereby removed. However, nitrates are extremely soluble in water and are not removed by alternatives that merely detain or retard flows. Additions of nitrate as oxidized forms of ammonia and nitrite will fertilize plant communities and lead to overproduction and imbalanced food webs, *i.e.,* ecosystem deterioration. A non-structural alternative that is an exception to this is street cleaning, which has been shown to reduce contaminant concentrations. A pilot study of the impact of street cleaning on runoff quality has been proposed for a South Shore locale. The results of that study will show whether or not structural non-point controls will be required.

Contact recreation. Certain areas of the bays that are valuable for both primary and secondary contact recreation are subject to violations of the coliform standards. The implementation of stormwater runoff control measures should result in significant water quality improvements relative to contact recreation potential, since the major coliform source for most bays is runoff.

Aesthetics. Aesthetics can be affected positively if attention is paid to landscaping of runoff detention structures.

Wetlands. The large area requirements of storage ponds will often motivate the developer to use less expensive land, such as wetlands. In addition, the natural drainage patterns may facilitate siting ponds on relatively low land to avoid the need for pumping water. Yet the importance of wetlands in the coastal ecosystem is so great that all attempts should be made to avoid permanent loss of these habitats. This is particularly true of storage reservoirs with or without treatment, since they require very large areas. Other control measures, such as the use of already paved areas and recharge areas with vegetation, put much less demand upon the wetlands. Such alternative measures should be utilized wherever possible in the sensitive areas of Oyster Bay and Great South Bay.

Wetland areas themselves can be used as runoff filters and, in some cases, may be constructed specifically for that purpose. Such construction would be a strong positive benefit. It is suggested that a pilot effort be designed to test the practicability of such a runoff-treatment marsh system.

Unique habitats, open space. Care must be taken to avoid the use of environmentally valuable lands for runoff control structures.

4.2.14.3 Secondary Impacts. Management practices that involve street cleaning, or treatment of water, produce addtional residue that must be disposed of in an environmentally acceptable manner.

4.2.14.4 Adverse Environmental Impacts. Control measures involving the construction of ponds or basins exert adverse effects, as discussed above. Pre-emption of open space areas or wetlands introduces tradeoffs between terrestrial, wetland and marine quality.

4.2.14.5 Minimizing Adverse Effects. Site selection on the basis of the environmental value of land and careful supervision of construction practices will help reduce unnecessary impacts. Specific controls for erosion are a necessity. These should include minimal land clearing, covering of stripped areas with mulch, and then replanting when construction is completed.

To avoid encroachment on valuable terrestrial habitat or wetland areas, all efforts should be expended to find alternate sites for retention ponds. Detention ponds may be located within residential or commercial areas and suitably landscaped to serve an aesthetic and recreational purpose in addition to runoff control. Avoidance of wetland sites and location of the ponds closer to the sources of urban runoff, will permit removal of the sediments at an early point and will prevent siltation of marshlands.

4.2.14.6 Irreversible and Irretrievable Commitment of Resources. The loss of wetland areas and open space through construction of settling basins and ponds threatens the healthy functioning of the coastal ecosystem. Commitment of such land is usually irreversible, and thus all other control measures and sites should be considered before wetlands or valuable habitats are chosen.

4.2.15 Effects Associated with the Upgrading of Treatment Plants. Upgrading the facilities and capabilities of treatment plants to remove contaminants from wastewater deals directly with the point source aspect of the bay and groundwater quality problems in the bi-county area. With respect to fish and shellfish, preserving the natural conditions of the bay ecosystems is the only way to maintain and enhance the productivity and diversity of the indigenous populations; however, mariculture, a special case, is an exception to that rule. Removing excess nitrogen, a critical limiting nutrient in estuarine ecosystems, and maintaining suitable N/P ratios, will help maintain the natural associations of species and the stability of the trophic structure. It should be noted that nitrogen removal would be unnecessary except for a few bays if the non-sewering options were selected, but would be essential under the one dwelling unit per gross acre and three dwelling units per gross acre sewering options. For many bays, upgrading treatment plants is only effective in concert with non-point controls. Upgrading of plants in Manhasset Bay and Hempstead Harbor will be only partially effective for local harbor improvements if Long Island Sound conditions do not improve.

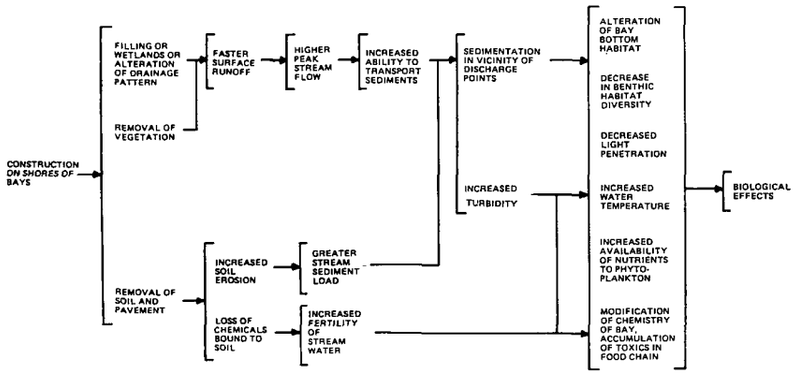
Upgrading of the existing treatment plant facilities with effluent discharge at the present outfall or construction of a mid-bay outfall have been recommended for Manhasset Bay, Hempstead Harbor, Oyster Bay, Huntington Bay, Port Jefferson Harbor, Peconic/Flanders and Patchogue (in Great South Bay). Specific judgments are made in Section 4.3. Some areawide considerations are discussed here.

4.2.15.1 Short-Term Primary Impacts. Short-term primary impacts on aquatic ecosystems due to construction should be minimal, provided treatment plants are not located in proximity to bay shores or wetlands.

Nor should treatment plants be located on watercourses that feed directly into large streams, rivers or wetlands that either empty into, or fringe, the bay ecosystems. Aquatic ecosystems are impacted by construction in the following ways. (See Figure 4–2.)

1. Increased erosion and loss of topsoil leading to:
   - Increased downstream flooding.
   - Increased bottom sedimentation.
   - Increased turbidity.
   - Increased sediment load
2. Construction-related dissolved or suspended leachate contamination such as:
   - Additions of hydrocarbons.
   - Additions of soil minerals.
   - Additions of heavy metals.
   - Additions of fertilizers or pesticides.
   - Additions of stagnant water.
3. Other changes in aquatic water quality:
   - Changed water temperature.
   - Changed pH (estuarine systems are well buffered).
   - Increased BOD.

Measures to mitigate aquatic impact from upland construction will be site-specific. Thus, specific impacts need to be assessed once sites are selected.



Source: ERCO

FIGURE 4–2 *Effects of Construction on Bay Conditions*

4.2.15.2 Long-Term Primary Impacts. In general, the long-term effects are beneficial. Improving the quality of effluent discharged in the bay, Sound, and near shore coastal waters can only improve fish and shellfish productivity and diversity, and bathing water quality. In cases where tertiary treated wastes are recharged, effluents to bays are eliminated. Noxious species will decline, diversity on all trophic levels will increase, and, as a result, ecosystem stability will be enhanced. Algal blooms associated with nutirent overloading will decrease. Coliform counts will be reduced in some bays, opening shellfish areas to production, and consequently increasing water usage. However, there are some tradeoffs involved. First, augmented treatment generates additional sludge, which requires disposal. Sludge disposal then imposes air pollution loads (in the cases of co-incineration, incineration or pyrolysis) or land requirements (in the cases of composting and land application). Also, advanced nitrogen removal may impose lowered N/P ratios, which may affect the phytoplankton community diversity. Another tradeoff relates to increased residual chlorine caused by increased effluent loads. This chlorine is toxic to marine organisms in some cases and may inhibit growth in the vicinity of outfalls. Table 4–29 illustrates present levels of residual chlorine. Future levels are not expected to be significantly higher. At least some dilution will occur in the receiving water. Present EPA criteria levels for toxicity are three micrograms per liter of chlorine for salmonid fish and ten micrograms per liter for other freshwater and marine organisms. Thus, chlorine from treatment plants does not appear to pose a significant threat. Similarly, ammonia levels are expected to remain well below the toxicity threshold. When waste effluent is to be recharged, chlorinated effluent will contain unacceptable levels of chlorinated organics and other disinfectant techniques may be required.

Metals and organics. No significant effect.

Nitrates. No health-related effects for surface discharges. Nitrogen concentrations in groundwater will be lowered by sewering and recharge. The net effect of reduction in nitrogen inputs due to sewering with or without recharge is beneficial.

Coliform and viruses. In cases where shoreline areas are sewered and diverted to treatment plants, some of the non-point pathogen loading may be reduced.

Water quality, stream water levels. Beneficial for nitrogen levels.

Fish, shellfish. See Section 4.3 for a bay-by-bay discussion.

Contact recreation. As a public health measure, bathing is generally prohibited in the vicinity of outfalls.

Aesthetics. All effects are highly dependent on treatment plant design and siting. Effects include the following:

- Visual effect of structures.
- Water quality improvements (color, turbidity).
- Ecological improvements (increased species diversity).

Table 4–29

1976 STP CHLORINE RESIDUAL AVERAGES NASSAU COUNTY

Treatment Plant	Average Cl_2 Residual in PPM	Number of Data Points
Cedar Creek STP	3.2	64
Bay Park STP	1.7	60
Lawrence STP	2.1	30
Long Beach STP	2.9	36
West Long Beach STP	1.3	18
Freeport STP	2.7	24
Jones Beach STP	2.3	8
Cedarhurst STP	1.6	13
Inwood STP	1.7	7
Belgrave STP	2.7	8
Great Neck Sewer District STP	2.2	22
Great Neck Village STP	2.3	17
Port Washington STP	2.6	11
Glen Cove STP	2.3	51
Roslyn STP	1.7	20
Oyster Bay STP	1.9	7
Seawanhaka Yacht Club STP	4.0	7
Cold Spring Harbor STP	3.7	11
C.W. Post STP	2.5	6
Farmingdale STP	3.6	5
Meadowbrook STP	1.6	4
Roslyn Duck Pond Chlorinated Discharge	0.5	7

Source: Nassau County Department of Health, 1978.

4.2.15.3 Secondary Effects. A bay discharge is generally less expensive than an ocean outfall which often requires a long conduit (outfall). Recharge which implies the most stringent treatment requirements is generally the most expensive disposal technique. However, the costs of ocean discharge are more favorable when several plants can be routed to one outfall. With respect to sludge generation, treatment plants impose tradeoffs between bay quality and air quality, land use and groundwater quality.

4.2.15.4 Short-Term Versus Long-Term Environmental Benefits. The long-term environmental benefits of improved effluent quality are clear. However, in the long term, and as technology advances, alternatives to effluent disposal in the bays should be considered. These include flow reduction and land reclamation. As the demand for fresh water from diminishing conventional sources has increased, the interest in land reclamation of industrial and municipal wastewater effluents has expanded concomitantly. In many areas of the country, wastewater effluents are being utilized to supplement freshwater supplies. Wastewater reclamation technologies employing additions from municipal effluent have been used for irrigation (principally agriculture), groundwater recharge, stream augmentation, overland flows (migration and renovation) and for non-potable domestic use.

4.2.16 Effects Associated with Point Source Outfall Relocations. Relocation of the outfalls to mid-bay sites is advanced as an option for Huntington Bay, Hempstead Harbor, Manhasset Bay, Port Jefferson Harbor and Peconic/Flanders Bay; to an offshore site for Peconic-Flanders and South Shore Bays; and/or out of the area for eastern Great South Bay, Manhasset Bay and Oyster Bay. The movement of sewage effluent outfalls does not remove the excess nutrient (N and P) nor the BOD from the ecosystem, but rather ameliorates ecological stress conditions through pollution dilution. In many cases, this is a critical first step towards improving the water quality in the estuarine bays since several of the bays, particularly Great South Bay, have poor flushing rates and consequently tend to accumulate pollutants. When minimum sewering options are selected, such measures are not required. As described in Section 4.20, non-point controls are required in concert with point source controls to achieve water quality improvement. Specific bay situations are discussed in Section 4.3.

4.2.16.1 Short-Term Primary Impacts. Relocation of outfalls to mid-bay or offshore locations requires construction activity through the estuarine and marine benthos (Great South Bay) and possibly through barrier islands (Fire Island, Long Beach) and fringing wetlands. In general, line construction across the bay bottoms requires dredging by mechanical or, more likely, hydraulic means. The short-term impacts associated with dredging include the following (Darnell, 1976):

- Modification of bottom topography
  - Trenching and backfilling involve the removal of some benthic deposits and the smothering of others.
- Modification of water circulation patterns
- Increased turbidity of water
  - Increased oxygen demand
  - Reduced light penetration
  - Reduced photosynthetic oxygen production
  - Release of toxic organic compounds
  - Release of pesticides, heavy metals and hydrogen sulfide
  - Increased temperature
- Bottom siltation with very fine sediments
- Destruction of benthic flora and fauna
- Disturbance of nesting areas in wetlands

If construction of effluent outfall pipelines is managed correctly, the modification of bottom topography can be minimized by replacing extracted sediments over the pipeline and by contouring and grading the benthos. Such procedures can also eliminate modification of circulation patterns. Potentially, the most damaging aspect of construction activity in bays involves the

turbidity generated by dredging. Turbidity (or suspended sediments) impacts fish and shellfish in the following ways:

1. Suspended sediments increase the oxygen demand in the water column due to increased microbial action (consequently community respiration) on detrital particles. This causes dissolved oxygen to decrease, imposing potential hazards on organisms highly susceptible to oxygen deprivation, particularly active, migratory fishes, which have high dissolved oxygen requirements and low tolerance to oxygen deprivation (Thornton, 1975).

2. Suspended sediments inhibit transmission of light through the water column, thus decreasing the standing crop of phytoplankton. Phytoplankton helps form the base of the estuarine food web and is the chief component of the diet of most shellfish. This effect has been documented in the South Shore bays (NCHD, 1977b).

3. Suspended sediments can introduce toxic materials, such as pesticides (chlorinated hydrocarbons), heavy metals and radionuclides, to the water column. These materials are selectively incorporated into fish and shellfish by biological magnification, and cause lethal and sub-lethal effects.

4. Suspended sediments clog the gills of fishes, inhibiting carbon dioxide-oxygen exchange and causing asphyxiation.

5. Suspended sediments clog the mucous membranes of many suspension and filter feeder molluscs by mimicking the size of the host organisms' food particles. This causes inefficient feeding, choking, clogging and in many cases, death.

6. The settling of suspended sediments can physically cover and smother whole benthic organisms.

Turbidity affects juvenile forms of many of the ecologically and commercially important fishes, shellfishes and crustaceans in the South Shore, Manhasset Bay, Hempstead Harbor and Port Jefferson Harbor areas. Monitoring of this effect is already required by the EPA. Some of the more important fish species in these locations include the striped bass *(Morone saxatilis)*, the bluefish *(Pomatomas saltatrix)*, the white perch *(Morone americana)*, menhaden *(Brevoortia tyrannus)* and other herrings, and the silverside *(Menidia menidia)*. Important shellfish are the hard clam *(Mercenaria mercenaria)*, the blue mussel *(Mytilus edulis)*, bay scallops *(Aequipecten sp.)*, and softshell clams *(Mya arenaria)*, and in some cases, the American oyster *(Crassostrea virginica)*. Crustacea of interest include the blue crab *(Callinectes sapidus)*. Offshore, the surf clam *(Spisula solidissima)* and the American lobster *(Homarus americanus)* are a commercially important shellfish and crustacean, respectively.

The specific effect of suspended sediments on the macroscopic biological community has been well studied. In general, the older the life stage, the more tolerant the species. Adult oysters *(Crassostrea virginica)* are extremely tolerant of high silt loads as are other epi- and infauna of the estuary, which must contend with naturally high silt loads at various times of the year. The egg, larval and juvenile stages of estuarine species can be heavily impacted by artificially high concentrations of suspended sediments (Auld and Schubel, 1974; Schubel *et al.*, 1974; Sherk, 1972). The growth and survival of hard clam and oyster eggs and larvae are disrupted at suspended sediment concentrations as low as 125 milligrams per liter (Davis, 1958). Sherk (1972) tested the effects of suspended sediments on various estuarine fishes. Atlantic silversides *(M. menidia)*, juvenile bluefish *(P. saltatrix)*, juvenile menhaden *(B. tyrannus)* and young of the year white perch *(M. americana)* are highly sensitive to suspended sediment loads. At the other end of the spectrum, striped killifish *(Fundulus majalis)* and the mummichog *(F. heteroclitus)* were most tolerant. Deposition of suspended sediment as a result of water disposal of dredge material covers and smothers clams, oysters, crabs, shrimp and other benthic organisms. Benthic communities that are completely covered require two years to re-establish.

Decreases in dissolved oxygen are commonplace with suspended sediments, the oxygen demand in the water column increasing by a factor of as much as eight (Issac, 1965). Decreases in dissolved oxygen impact the more migratory species of fish, such as herrings *(Alosa sp.* and *B. tyrannus)*, silversides *(M. menidia)*, bluefish *(P. saltatrix)*, anchovy *(Anchoa sp.)* and mackerel *(Scomber scombrus)* (Thornton, 1975).

There is evidence to support the claim that suspended dredge material fertilizes the water through nutrient release, although the effect is not an immediate one (Sherk, 1972).

The following is a list of recommendations concerning the deposition of spoil (Clark, 1974; Daiber *et al.*, 1972, 1974, 1976; Marcellus, *et al.*, 1973; Metzgar, 1973; Maurer *et al.*, 1974; Sherk, 1972) as presented in Daiber and Thornton (1976).

1.Prior to full-scale dredging, there should be a determination of the physical and chemical characteristics of the spoil, in order to decide the most appropriate means of dredge spoil disposal.

2. Spoil should not be placed on high value natural habitats that serve as nursery areas for marine species. These include: marshes, beds of submerged vegetation, protected shallows, oyster reefs, tidal flats.

3. Spoil should not be placed back in the water, if possible, but rather on the uplands. Constraints should be placed on types of materials that can be disposed of in open water. However, effects of upland disposal on groundwater must be monitored.

4. Spoil suitable as "fill" for residential, commercial and industrial development should be used for such purposes. This use is subject to groundwater effects. Constructive alternative uses for spoil should be researched.

5. Abandoned sand and gravel pits in proximity to the water should be used as spoil receptacles provided spoil can be restrained from running off or polluting freshwater supplies.

6. Under certain conditions, spoil can be used to enhance existing marsh or to create new marsh.

7. Spoil deposition sites should be planned to allow future mainten-

ance, as in the creation and development of spoil islands, which have been found to be beneficial for terrestrial habitat and migratory waterfowl.

8. Natural channels should not be blocked with spoil.

9. Beach nourishment and spoil are related problems that should be approached jointly.

10. Temporal aspects of spoil deposition should include consideration of biological factors like spawning seasons and schooling patterns, and factors such as the bathing season.

There is a possible impact on wetlands on the South Shore, where the proposed relocation of the Bay Park outfall to permit ocean discharge may disturb wetlands and bay benthos due to dredging, removal of vegetation, and increased turbidity in the area. Caution must be exercised when planning routes and construction methods and times.

Construction activities for an ocean outfall for Bay Park would probably involve a route passing through Long Beach. This would have various effects on the environs of the City of Long Beach.

4.2.16.2 Long-Term Primary Impacts. The long-term impacts of outfall relocation will greatly improve the water quality in the areas from which the outfalls were moved. The BOD, COD, refractory organics, suspended soilds, total nitrogen, total phosphorus, dissolved minerals, and coliform levels should all decrease.

Moving the outfalls offshore will lower the input of nutrients and BOD to the wetland areas, thus increasing the available oxygen in an oxygen-limited environment. This will be beneficial for many fish and will help reverse the eutrophic tendencies of the wetland areas attributable to pollution.

From a dissolved oxygen standpoint, a reduction in BOD would encourage susceptible species as snapper blues *(P. saltatrix),* Atlantic silversides *(M. menidia)* and herrings *(Clupeidae)* to use the formerly impacted areas (Thornton, 1975).

Shellfish such as the hard clam *(Mercenaria mercenaria)* and the oyster *(Crassostrea virginica)* are remarkably tolerant to high concentrations of various nutrients, particularly such nitrogenous compounds as ammonia, nitrite ion, nitrate ion and ortho-phosphate (Epifaunio and Srna, 1976). Effluents of secondarily treated domestic sewage rarely contain levels of these chemicals as high as the 96-hour mean lethal tolerance limits reported in that study. However, sub-lethal toxic concentrations of ammonia (7.2 milligrams per liter) will be encountered around sewage outfalls and will restrict the distribution of molluscs. Consequently, the movement of outfalls to areas of increased flushing will induce a corresponding improvement in shellfish density and diversity in present outfall locales.

Although it is true that wetland areas can serve as nutrient sinks for coastal ecosystems, their capacity is not unlimited and should not be overburdened by anthropogenic wastes. Thus, moving sewage outfalls offshore is a positive step in wetland preservation.

4.2.16.3 Secondary Impacts. Negative secondary impacts include problems associated with spoil disposal, costs associated with monitoring outfall construction and operation, and possible saltwater intrusion into wells hydraulically linked with dredge sites.

Patrick (1949) proposed that moderate pollution would tend to eliminate susceptible species from a community, causing the few that survived to flourish due to reduced competition and greater chance of multiplication. A reduction in pollution should encourage a more healthy, diverse community to evolve.

4.2.16.4 Adverse Environmental Impacts. The risk of leakage from pipelines is always a possibility. If pipes are not properly lined or connected, waste materials may seep into the surrounding soil and alter the vegetation. In the event of violent storms, shifting sands may expose previously buried pipes and perhaps rupture joints. Such an accident would result in great volumes of effluent being discharged directly into the bay and wetland areas, adversely affecting both the vegetation and the wildlife of those areas. Such an event might cause eutrophication and a resulting anoxic area. The leaching of the sewage contaminants to other areas of the bays would then affect water quality and thereby the finfish and shellfish.

4.2.16.5 Minimizing Adverse Impacts. Careful design of pipeline construction is one of the best ways to preclude unnecessary leakage. Siting pipes to avoid wetland areas as well as unstable beaches is vital to safe planning. Geologic conditions should be considered when choosing a route for the line. As mentioned above, proper restoration of the wetland sites affected by pipeline construction is a necessity. Soil must be replaced over the lines, covered with mulch, and planted with marsh vegetation. Precautions must be taken to prevent significant alteration of the drainage patterns due to the soil displacement.

4.2.16.6 Irreversible and Irretrievable Commitment of Resources. None.

4.2.16.7 Relationship Between Short-Term Uses of Environment and Long-Term Environmental Productivity. Moving outfalls to mid-bay or ocean locations, may cause local, temporary perturbations to wetlands and the benthos, but it is beneficial in the long run because of the improvement of water quality and the resulting health of the bay and surrounding wetlands. As long as construction activities are managed in order to minimize habitat destruction, such a project will increase productivity and maintain the healthy ecological functioning of the system.

As was mentioned earlier, relocation of outfalls merely postpones the ultimate resolution of the problem of effluent disposal by physically displacing the outfall to areas of greater water volume and flushing. This is a reasonable temporary measure to immediately improve the water quality in the bays of Nassau and Suffolk Counties, assuming the short-term impacts are kept at a minimum (*i.e.,* restoration of impacted areas is a must). It appears that properly engineered relocation of the outfalls will cause no irreversible or irretrievable commitment of resources. Planners must realize, however, that

the disposal of the effluent in the nearshore Atlantic Ocean, Long Island Sound, or in the middle of the bays may eventually become unacceptable if effluent quality is not improved. Long Island Sound and the New York Bight, although large expanses of water, are already showing some signs of degradation, and increased loads will only exacerbate the situation.

4.3 Area Specific Impacts

The discussions presented below correspond to the subsections of 3.5.2, "Area Specific Alternatives."

Hydrogeologic Zone Alternatives

(Correspond to Subsections of 3.5.2.1.)

4.3.1 Zone I: Deep Flow System (Magothy Recharge Area). Zone I encompasses much of the residential, transport and commercial, and industrial activity areas of Nassau and Suffolk Counties. About ten percent of the area is presently sewered. Other characteristics of Zone I are given in Tables 4–30 to 4–32. The major environmental characteristic of Zone I is that materials released at the surface move downward into the Magothy aquifer. Thus levels of discharge need to be controlled. Zone I is presently well-developed and current land use plans call for continued residential and nonresidential use of the Island's center. Thus, the volume of wastes to be treated and disposed of will grow. Also, pressure to develop existing open spaces will grow. The environmentally favored approach is Alternative IA with possible selective sewering in areas characterized by septic system failures and densities of five or more dwelling units per gross acre, and in other areas indicated by monitoring results. Selection of IA represents a judgement that takes into account the uncertainties concerning implementability and effectiveness of IA and the uncertainties concerning cost-effectiveness and side effects of IB, IC and ID. Both best and worst case situations were considered with respect to the resolution of the various uncertainties.

There are four alternative plans for waste management. These plans represent distinctive approaches; namely, the structural, traditional sewering approach; the non-structural, monitoring, regulatory and non-point source control approach; and intermediate approaches. These approaches have significantly different environmental impacts. One difference relates to the uncertainty of impact. The other relates to secondary problems such as water level and sludge disposal. The sewering approaches (Plans IB, IC and ID) have been in use for years (although the non-point source control aspects of these plans are a new approach). Thus, the impacts are fairly well known. Generally, nitrates, organic chemicals and metals are redistributed from groundwater to waste streams and sludge residues. Water table levels become lower when marine outfalls are employed for ultimate disposal. The effects of Plan ID will be more pronounced than for IB and IC. The non-structural and non-point source control approach (Plan IA) is a fairly untested strategy. Thus, there is a high uncertainty associated with the impacts. Sewage nitrogen is altered by on-site systems to ammonia or nitrates and is diluted in leaching fields. Organic chemicals and metals are controlled at the source and collected as concentrated hazardous wastes. Coliform bacteria in runoff are reduced by management practices or treatment.

There are environmental advantages to each approach. Plans ID and IC, and to a lesser extent, IB, have as their main advantage the predictability of impacts. One can be reasonably confident that the plan will significantly reduce nitrate levels in groundwater and that with a combination of industrial

Table 4–30

DOMESTIC TREATMENT SYSTEMS BY ZONE*,**

Zone***	No. of Systems	Avg. Total Flow (MGD)	BOD Effluent lbs/day	SS Effluent lbs/day	F. Coli N/100 ml	TN lb/day	TP lb/day
I	32	15.978	4,087.1	3,596.2	3,712	3,084	498
II	4	.377	247.2	270.3	217	103	–
III	19	2.285	520	344	1,072	302	74
IV	5	0.455	76.7	176	521	182	9
V	1	0.025	1	1	41	2	–
VI	25	2.557	1,277	397	4,190	558	58
VII	24	90.460	15,255	23,189	2,393	22,619	2,671
VIII	12	7.495	3,966	2,031	3,738	2,179	211

Source: Weston, 1976.

***Note: These figures are all based upon the discharge site of the sewer district rather than the areas sewered. For this reason, the coastal zones are particularly high while inland zones may be underestimated. This is especially true of Bay Park STP which has a flow of 63.9 MGD. Although much of the sewer district may be located in Zone I, the outfall flows in Zone VII.*

****See Figure 3–2 for a map of the Zone boundaries.*

Table 4–31

INDUSTRIAL POINT SOURCES BY ZONE*

Zone	Process Flow Rate (gal/day)**
I	675,376,600
II	639,860
III	18,033
IV	87,000
V	35,000
VI	398,600
VII	297,068,000
VIII	396,838,900

Summarized from Weston, 1976
***Includes thermal discharges.*

Table 4–32

MISCELLANEOUS SOURCES BY AREA*

Zone	Landfills Active & Abandoned	Domestic STP's Discharging to Groundwater	Incinerator Effluent To Ground	Duck Farms	Semi-Wild Duck Concentrations
I	12	34	2	0	0
II	2	3	0	0	0
III	0	17	0	0	0
IV	8	2	0	6	2
V	3	0	0	0	1
VI	5	20	1	17	1
VII	5	5	1	0	3
VIII	4	5	0	0	1

Summarized from Miller and Sgambat, 1977.

hook-ups to sewers, and non-point controls, groundwater metal and organic chemical levels will be reduced. Their major disadvantage is the set of environmental side effects. These include lowered water table elevations, if there are surface discharges of effluent (*i.e.,* lowered surface water body levels and flows), increased sludge loads, and a possible catalyst for further development in some areas. (For a discussion of this effect, see Section 4.2.13.3.) Plan IA has as its major advantage the comprehensive minimizing of waste loads with a minimum of side effects and lower cost. Nitrate, metal, organic chemical, pesticide, salt, oil and coliform bacteria levels might all be significantly reduced if controls were to be properly implemented. Its disadvantage is the presently high uncertainty concerning the impact level that will occur. All four plans, if properly implemented, have environmental benefits. The tradeoffs are (a) between a more costly but more certain approach and a less costly approach with higher environmental benefits but higher uncertainty; (b) greater effort to protect surface water quality, air quality and groundwater quantity, versus greater effort to protect groundwater quality (nitrate levels). With respect to sewage, nitrate levels in the Magothy aquifer underlying parts of Area I are high and variable. This can be seen in Table 4–33. Concerning industrial wastes, organics are a problem in the groundwater as mentioned in Section 4.1.1.2. Table 4–34 summarizes data from Zone I. Studies of recharge basins suggest that runoff contributes both organic chemicals and nitrates.

Table 4–33

SELECTED TEST WELL DATA REPRESENTATIVE OF THE HIGH RANGE OF NITRATE LEVELS IN GROUNDWATER UNDERLYING ZONE I*

Well	Date	NO_3–N(mg/l)	Well Depth (feet)	Aquifer
Jericho Turnpike at LIE, Hicksville	9-7-76	2.5	100	Glacial
Round Swamp Road, Huntington	9-1-76	21	168	Magothy
Miller Place, Syosset	9-7-76	9.3	111	Glacial
Garden City Country Club, Garden City	6-2-76	2.4	63	Glacial
	6-23-76	2.4		
	10-6-76	3.6		
Miller Place, Syosset	9-13-76	14	490	Magothy
	10-23-76	15		
Syosset Circle, Jericho	3-3-76	1.6	400	Magothy
	10-27-76	2.6		

Source: Suffolk County Department of Health, 1977.

Plan IA: No Sewering; Emphasis on Individualized Point and Non-point Controls.

Plan IA is considered here in terms of some selective sewering in most areas with population densities of five or more dwelling units per gross acre. Plan IA will reduce nitrate levels somewhat. In general, Zone I is an area of recharge. However, hydrologic characteristics vary locally. Thus there will be locales where higher loads of nitrate will have little effect on ambient levels in the Magothy aquifer. This may be due to direction of aquifer flow, geologic barriers or aquifer chemistry. Proper use of Plan IA should obviate sewering in such areas. Plan IA will maximize the use of the natural nitrogen cycle in the disposal of man-generated nitrates by minimizing structural solutions. Thus, artificial side effects will be minimized.

Land use controls, an important aspect of Plan IA, will be of great benefit in preventing occurence of the conditions of high density residential

Table 4–34

SUMMARY STATISTICS–VOLATILE ORGANIC COMPOUNDS
(Principally Zone 1)

Compound	# stations measured	# stations detected*		# stations occurring @ > 10 μg/l*		# stations occurring @ > 50 μg/l*	
trichloroethylene	116	93	(80%)	35	(30%)	15	(13%)
chloroform	82	68	(77%)	20	(24%)	4	(5%)
1,1,1 trichloroethane	116	57	(49%)	25	(21%)	6	(5%)
carbon tetrachloride	78	28	(36%)	1	(1%)	0	
tetra chloroethlene	116	38	(33%)	10		5	(4%)
dibromochloromethane	78	15	(19%)	0		0	
diethyl ether	38	6	(16%)	0		0	
1,1 dichloroethane	44	5	(11%)	3	(7%)	0	
bromodichloromethane	78	8	(10%)	3	(4%)	1	(1%)
freon–11	44	4	(9%)	0		0	
1,1 dichloroethylene	44	4	(9%)	0		0	
1,2 dichloroethane	44	3	(7%)	0		0	
bromoform	78	5	(6%)	1	(1%)	0	
1 chloropropane	44	1	(2%)	1	(2%)	0	

**percentages given in parenthese.* *Source: ERCO*

and commercial land use that lead to extensive non-point pollution of the Upper Glacial aquifer. In addition, land use controls will act to preserve small undeveloped parcels that constitute the remaining natural habitat. The magnitude of organic chemical loads to be controlled in Plan IA is high, since many industrial wastes will not be diverted to sewers. The loads need to be considerably reduced to keep groundwater organic levels safe from a health standpoint. Each element of the set of non-point and non-structural measures proposed in Plan IA needs to be strictly applied to accomplish that. There is a fairly high uncertainty as to whether the various measures can be applied at a high level of control. Thus, the uncertainty of Plan IA with respect to organic chemicals is high.

Control of metals, nitrogen, organic chemicals and coliform bacteria in runoff is an important aspect of Plan IA. The de-emphasis of sewering must be accompanied by improvement in the quality of runoff to surface waters and to recharge basins. There is a lack of previous experience with implementation of the runoff controls. Thus, there is a high uncertainty as to how effective runoff controls will be in reducing metal, organic chemical, nitrate and coliform bacteria loads. Environmental effects that can be expected from the non-point, non-structural and runoff measures are discussed in Section 4.2.

In summary, Plan IA depends, for a large portion of its effectiveness, on measures such as animal waste control ordinances, fertilizer use ordinances and street cleaning practices, which have a large uncertainty associated with their workability.

Plans IB, IC and ID: Three Dwelling Units Per Gross Acre, with Selective Two Dwelling Units Per Gross Acre and One Dwelling Unit Gross Acre Sewering.

Plan ID, and to a lesser extent, Plans IB and IC, will maintain nitrate levels in groundwater below ten milligrams per liter in locales where nitrates travel downward through the aquifer. However, such locales cannot be mapped in detail. These alternatives may be expected to result in locally high nitrate levels as was suggested by the analysis done for this project, which showed that, in some modeled grid cells, sewering had little correlation with groundwater nitrate (Porter *et al.*, 1978). This approach, however, will result in high nitrogen loading at sewage treatment plants (STPs). Plans IB, IC and ID are designed to avoid violations of groundwater nitrogen standards. They are based on considerable data analysis done during the last two years (Weston, 1977a, 1977b; Porter *et al.*, 1978; Miller and Sgambat, 1977b). Generally, the analyses indicated a large amount of uncertainty as to groundwater nitrogen sources and transport. The data showed that if ten percent violations of standards are an allowable level of nitrate contamination, then sewering at densities of between one dwelling unit per gross acre and three dwelling units per gross acre would result in acceptable nitrate levels with a limited level of enforcement of other controls. Thus, Plan ID is a conservative sewering approach, Plans IC and IB are standard sewering approaches, and Plan IA requires successful implementation and enforcement of other controls for success with respect to nitrogen.

Organic chemicals in industrial effluents will be pretreated and dis-

charged to sewers in Plans IB, IC and ID. Also, the volume of domestically used organics, such as cesspool cleaners, that are introduced to groundwater via on-site systems will be reduced. Thus, a significant fraction of the organics will be controlled by sewering. This leaves a smaller organic load (spills, storage tanks, runoff) subject to the uncertainties associated with non-point measures, which were noted above in the discussion of Plan IA. However, it will be necessary to provide for the disposal of increased quantities of sludges and sewage treatment plant efluents rich in organic chemicals. Effects of sewering, sewerage treatment plants, and outfalls are covered in Section 4.2.

Runoff controls for Plans IB, IC and ID are the same as those proposed for Plan IA. Thus, the same uncertainties discussed with reference to Plan IA apply. However, with respect to nitrates and organic chemicals, the non-point contribution to the total load is less in Plans IB and IC, and least in Plan ID. Thus, the uncertainties are of less consequence.

4.3.2 Zone II: Impaired Water Quality Area. Zone II encompasses a locality of mixed commercial/industrial and residential land, shown in Figure 2–1. Groundwater quality underlying this area is locally unusable and regionally poor, especially with respect to organic chemicals. This zone has displayed the worst groundwater quality in the region. This can be illustrated by groundwater monitoring data from local wells (Table 4–35). The hydrology of this area is similar to that of Zone I; that is, it is a Magothy recharge area. The plume of already contaminated groundwater can be expected to move down into the deeper portions of the Magothy aquifer, then south and up in the South Shore zones.

Zone II is currently being sewered. Thus, there do not appear to be options available with respect to sewering. For non-point source controls, Plan II calls for strict implementation of the whole range of available controls. In addition, industries would connect to sewers and pretreat their waste streams. Such controls would halt significant degradation of the aquifer. Water tables and stream flows will also be reduced as a result of sewering (assuming marine discharge). Implementation of Plan II would generate a sizable quantity of hazardous wastes to be disposed of at the proposed regional facility. Two water supply alternatives, which do not present comparative environmental issues, are also proposed.

In the short term, say a period of up to 50 years, the environmental benefits to be obtained from Plan II would be minimal. No matter how strict the adherence to the plan, the plume of contaminated groundwater would only slowly disperse. Over the long term, environmental benefits could be expected.

4.3.3 Zone III: Highest Grade Reservoir. Zone III encompasses the eastern portion of the Magothy recharge zone, which is generally very high in water quality. The hydrology of this area is similar to that of Zone I; that is, it is a recharge area. It is different from Zone I in that more options for waste management are open. First, less development has occurred. Thus, waste management considerations may have more of a role in determining rational

Table 4–35

RESULTS OF TESTING FOR VOLATILE ORGANICS IN SELECTED WELLS IN ZONE II

NCDH Well #	Date	Compound	Concentration
8941	07-12-76	Chloroform	7.8 μg/l
3876	11-29-76	Trichloroethylene	2.8 μg/l
		Trichloroethane	1.9 μg/l
		Carbon Tetrachloride	2.3 μg/l
3876	12-06-76	Vinyl Chlorides	< 10 μg/l
		Trichloroethylene	60 μg/l
		Tetrachloroethylene	17 μg/l
		Trichlorethane	15 μg/l
		Chloroform	< 1 μg/l
		Benzene	< 2 μg/l
6078	12-06-76	Vinyl Chlorides	< 10 μg/l
		Trichloroethylene	< 1 μg/l
		Tetrachloroethylene	100 μg/l
		Trichloroethane	< 5 μg/l
		Chloroform	< 1 μg/l
		Benzene	< 2 μg/l

Source: Nassau County Department of Health (1977a).

patterns of development. Second, less sewering has occurred. Thus, the option of not sewering is more of a real alternative to be considered.

The plans suggested for protection of the Magothy aquifer in Zone III differ mainly in the extent of the protection that will be provided. Plan IIIB is a "watershed management" plan calling for land acquisition, land use controls and other non-point source controls. Plans IIIA, IIIC, IIID and IIIE are more modest in level of control, calling for a combination of sewering and non-point source controls. Among the environmental advantages of Plan IIIB are (1) control of density of on-site dischargers, thus limiting nitrate loads to groundwater; (2) maintenance of natural recharge sites, thus maintaining water levels and natural treatment of recharge water; and (3) preservation of terrestrial habitats, thus protecting terrestrial populations. However, Plan IIIA with selective sewering is a sound control strategy presenting the same tradeoffs mentioned in Plan IA and is also environmentally acceptable. Plan IIIA has less uncertainty associated with it than IA, since Zone III is further from the New York City industrial center and supports fewer large scale industrial dischargers. Plans IIIC, D and E present many environmental side effects avoided by the other two plans, and previously discussed in connection with Plans IB, C and D. However, recharge of effluent is planned for IIIC, D and E, which would minimize water-table effects and introduce a range of possible groundwater contaminants, such as organic chemical contaminants generated by chlorination.

Long Island's groundwater derives from precipitation, which falls on the ground and percolates through the soil to the aquifers. Since the aquifers are used as the only source of drinking water for the area, the quality of the recharge becomes critical. Urban development, through the clearing of land and the paving of many surfaces, has tended to decrease the amount of recharge to groundwater and to increase the amount of runoff to surface waters. The groundwater recharge basin program, begun in Nassau County in 1935, succeeded in partially alleviating the effects of runoff by providing large unlined basins, where water could seep down to the aquifer. Yet these basins occasionally fail to provide adequate percolation because of poor design, high water table elevation, or inadequate maintenance. The quality of the recharged water also tends to be poor, contributing to the degradation of water supply. The constituents of this poor quality water are many, deriving mainly from urban and industrial development: metals, fertilizers, de-icing compounds, roadway hydrocarbons, air pollutants, pesticides, animal wastes and concrete leachates. Thus, the maintenance of terrestrial open spaces, free of the influences of development, is of prime concern to Zone III. Furthermore, a good deal of open land exists in this zone at the present time, and it would be of great ecological value to preserve some of that land undisturbed. Thus, the watershed management option for Zone III is beneficial from an ecological point of view.

Plan IIIA is similar to IIIB in its approach; however, it is less comprehensive in its level of control. Thus, Plan IIIA presents most of the benefits enumerated above, but does not allow the full range of benefits obtained by implementation of Plan IIIB.

Plans IIIC–E call for sewering developed sections of Zone III. The environmental implications of sewering are discussed in Section 4.2.13. Sewering can be expected to help preserve the water quality of the aquifer at a high level. However, strict fertilizer and animal waste controls are required if the present excellent water quality is to be maintained. Although present data is not detailed enough for analysis to indicate the relative contributions of different sources of nitrate and organic chemicals in various areas, the data shows clearly that each contaminant is contributed by several categories of sources. Thus, the approach of Plan IIIC, which includes a variety of control measures, is an environmentally prudent one. However, side effects such as changes in the water table (alleviated if wastewater is recharged) and sludge generation are introduced.

4.3.4 Zone IV: North Fork and Eastern South Fork. The aquifer underlying the North Fork is of locally marginal water quality, mainly in areas underlying farms (see Table 4–36). Also, there is the potential for saltwater intrusion if pumping patterns are not carefully managed. This is due to adjacent saltwater bodies in the north and south. Modeling done for the South Fork for this project showed that if pumping patterns were carefully controlled, water quantity and salinity would not be a problem. However,

Table 4–36

EXAMPLES OF HIGH NITRATE-N CONCENTRATIONS IN SELECTED GROUNDWATER TEST WELLS UNDERLYING ZONE IV

Well Location	Date Sampled	NO_3–N (mg/l)
Mattituck	10-22-75	16.3
Greenport	10-19-75	8.2
Southold	11-03-75	12.0
East Mattituck	09-16-75	13.1
Test Plot (North Fork Potato Farm)	03-26-75	23.0
Test Plot	03-26-75	21.0
Test Plot (South Fork Potato Farm)	03-26-75	20.0
Test Plot	03-26-75	17.0

Source: Miller and Sgambat (1977b)

existing data suggests that water quality will be a major problem in Zone IV if strict control measures are not implemented.

The alternative plans present several approaches to the problem of water supply on the Forks. Plans IVC to IVE, water quality preservation plans, require sewering in residential areas and/or non-point source controls. Agricultural fertilizers are an important source of nitrates to the groundwater in the North Fork and eastern South Fork. Control of that nitrate source is the central aspect of Plan IVB. Plan IVA, water importation, calls for importation of water for domestic use from areas to the west. Thus, North Fork and eastern South Fork aquifers' water quality would be allowed to degrade despite state and national policies opposing degradation. Sewering would be minimized, allowing water table levels to be maintained. Plans IVC, D and E are sewering approaches which correspond in their impacts to IB, C and D. Plans IVB to E are superior options with respect to public health, since Plan IVA allows irretrievable contamination of the aquifer. Plans IVA and IVB are superior with respect to stream flow and wetland preservation since water table levels can be more easily maintained. Plan IVB is the overall environmentally favored approach involving, again, the same tradeoffs discussed for Zone I.

The environmental impact of Plan IVA would involve writing off a segment of the aquifer as a resource. According to today's knowledge of groundwater, this would be a permanent and irretrievable action, at least on a scale of 100 to 200 years. If Plan IVA were implemented, agricultural fertilzation could proceed at any level and landfills serving a large region could be sited in Zone IV. In addition, sewering could be avoided except in localities with septic tank failures.

The environmental effects of Plan IVB would resemble those of Plan IA. The success of Plan IVB is to a large measure dependent on non-point and non-structural controls. Due to the importance of farm-related sources, fertilizer controls would constitute a key aspect of the plan. The effectiveness of such measures is subject to uncertainty. Thus, although the level of environmental benefits expected to be obtained from Plan IVB are high, the uncertainty associated with that expectation is also high. Since fertilizer nitrogen is the major contributor of nitrates in Zone IV, Plan IVB with selective sewering is clearly the environmentally dominant option.

The effects of Plans IVC to IVE would be similar to those of Plans IB to ID. However, since fertilizer nitrogen is the dominant groundwater pollutant in Zone IV, the benefits of sewering are not proportionately as great as for other zones. If Plans IVC, IVD or IVE are implemented, any sewage treatment plant outfalls should be excluded from the creeks of Peconic/Flanders Bays. Rather, they should be located in the open bay or in the ocean. Recharge or stream augmentation with tertiary treatment would be the most environmentally favorable wastewater treatment plan option because of its positive effect on preserving the present water level of streams and wetlands. Currently existing wetlands in Zone IV are critical to the maintenance of acceptable water quality in the Peconic estuary and in the Peconic/Flanders Bay creeks.

4.3.5 Zone V: Western South Fork. The western South Fork area is very similar to Area IV except that agricultural land use is much reduced and is replaced by residential use. Plans VA to VE correspond with Plans IVA to E and the environmental impacts also correspond. The major difference is that the reduced importance of agriculture reduces the difficulties in implementation that were presented when discussing Plan IVB. Zone V also is presently the site of numerous supply wells. Attention to the regulations of pumping patterns is of environmental importance, since modeling of the South Fork showed that poorly managed pumping could result in local saltwater intrusion problems.

4.3.6 Zone VI: Surface Water Impact Area. See Section 4.3.15.

4.3.7 Zone VII: South Shore Shallow Flow Discharge System. Zone VII is located south of the Magothy recharge zone. Thus, contamination from activities in Zone VII will mainly affect the Glacial aquifer. Zones VII and VIII are alike in being shallow flow zones. Hence, the discussion of the options for Zone VII is also relevant to the Zone VIII options (Section 4.3.8). The significant difference between Zones VII and VIII is that the former contains a number of streams that feed the South Shore bays. These streams are important recreationally, ecologically, and as a freshwater source to South Shore bays (Section 4.1.2.2). Streamflow will diminish if sewering occurs without recharge or streamflow augmentation. The effectiveness of a shallow recharge program to maintain water table levels is untested and uncertain. Thus, a minimum sewering alternative (sewering only in areas of septic tank failure) is the environmentally preferable option unless VIIA to VIIC are accompanied by effective measures for streamflow protection. Plans VIIA to VIIC are likely to be detrimental to the South Shore bays ecosystem due to alterations of the water budget unless water table preservation measures work. Thus, Plan VIIA to C are environmentally less acceptable without stream augmentation (possibly including shallow recharge). The effectiveness of recharge measures is still uncertain. All of the proposed non-point controls will have significant environmental benefit.

4.3.8 Zone VIII: North Shore Shallow Flow System. The land constituting Zone VIII occupies a band of varying width along the North Shore of Long Island. Zone VIII has been restricted to those locales for which extant hydrologic data shows a horizontal or upward movement of groundwater. Zone VIII may be expanded to include more of the North Shore when monitoring activities are extended to other locales. A significant proportion of the precipitation in Zone VIII runs off to bays and to bay tributaries. The fraction of precipitation entering groundwater has not been accurately established but appears to vary locally from zero to 50 percent. A significant portion of the shoreline area is also characterized by a high water table. A saturated zone means that septic system failures are likely.

The three plans for Zone VIII are similar to the three for Zone VII. Plans VIIIB and C are sewering options and Plan VIIIA is a minimum sewering option. The environmental tradeoffs are similar to those for Zone I. Plan VIIIA, if implemented properly, would be environmentally superior, while Plans VIIIB and C may be environmentally acceptable but involve secondary environmental impacts. For Zone VIII, the uncertainties associated with Plan VIIIA and the secondary impacts of Plans VIIIB and C are less important, since the water is not moving into the Magothy aquifer. All three plans call for sewering of areas of septic tank failure. With present technology, that is the only satisfactory option for the saturated zone. Thus, all plans are acceptable from that standpoint.

All three plans call for siting of landfills within Zone VIII. From a groundwater quality standpoint, this is clearly an acceptable strategy. Siting of landfills on sites underlain by horizontally or upward moving groundwater will protect the Magothy aquifer. However, care must be taken to protect the natural resources of the bays. Metals and organics may be transported to the bays from landfills via groundwater underflow. Thus, the siting of landfills involves a tradeoff of groundwater quality versus impacts on natural resources. On the other hand, if landfills are not sited, then there remains a significant waste disposal problem with the likelihood that the wastes would be exported from the region. If disposal sites for hazardous wastes are not allowed, ocean dumping is likely. From a marine resource standpoint, it appears environmentally sounder to site hazardous waste disposal areas and obtain substantial, if not complete, filtering of leachates before they reach bays rather than to deposit hazardous wastes at ocean dumping sites. With

respect to solid wastes, reuse is the environmentally favored alternative.

The control of surface runoff is a key requirement in Zone VIII (see Section 4.2.14). Provisions for substantial removal of coliform bacteria and nitrate from surface runoff is a requirement for an acceptable plan for Zone VIII. Surface runoff control has been discussed for each North Shore bay in Sections 4.3.9, 4.3.10, 4.3.11, 4.3.12 and 4.3.13. Surface runoff is a pollutant source that falls somewhere between the alternatives for land area and alternatives for bays. It is important that the topic be clearly integrated into the final plan.

In addition to the points covered above, Sections 4.2.13, 4.2.15 and 4.2.16 discuss some general issues relevant to minimum sewering Plan VIIIA and 4.2.2 discusses some issues relevant to VIIIA to C. In summary, the three plans are environmentally acceptable. From an environmental standpoint, VIIIB and C may be unnecessarily cautious, resulting mainly in local surface water improvements. Land use controls under a minimum sewering plan would have significant ecological benefits, as was discussed with respect to Plan IIIB.

Surface Water Alternatives. (Corresponds to Section 3.5.2.2.)

4.3.9 Manhasset Bay. Manhasset Bay is located in northwestern Nassau County, adjacent to Long Island Sound. The shore of the bay is lined with commercial facilities. Most of the shoreline has been filled and bulkheaded, leaving just 87 acres of vegetated wetland remaining (NYSDEC, 1977a). This lack of coastal wetlands by itself represents a significant change in the bay ecosystem. This change has probably caused a significant decrease in vertebrate communities in the bay. The shoreline developments contribute a wide range of pollutants to the bay. The bay is reputed to be one of the best pleasure boat areas on the Sound. There are numerous marinas and yacht clubs. In addition to effects that can be linked to extensive development, the quality of the tidally flushed bay is dominated by conditions in Long Island Sound. These two factors, as well as the treatment plant loadings from three sources, contribute to very high nutrient levels and the contamination of shellfish beds by total coliform bacteria. Although the entire bay is rich in hard clams, it has been closed to shellfishing due to high coliform concentrations. In general, barring improvements in Long Island Sound quality, pollution abatement measures [(B) (a) (i)], [(B) (a) (ii)], [(B) (a) (iii)] will have only local effect. The flushing of the southern end of the harbor is poor and upgrading of sewage treatment or relocation of the outfalls could achieve locally significant improvements in water quality. However, even if Sound and bay water quality were to be improved, the lack of wetlands would continue to severely constrain the bay's ecological viability.

Modeling has demonstrated that the boundary conditions from the Sound may sometimes overshadow any effects from pollutant sources within the bay (Johanson *et al.,* 1977a). The Management Plan therefore calls for New York City and southwestern Connecticut to institute effective controls on the many sources contributing loads to the Sound. But since such measures are outside the direct scope of the Nassau-Suffolk 208, specific actions have not been detailed in this Plan. Several specific measures are proposed that may have some local beneficial effect on the bay. However, if Sound conditions are not improved, the benefits of extensive local measures such as centralized collection of domestic wastes or treatment plant upgrading will probably not be significant enough to outweigh the costs. Since benefits are not expressible in dollar units, an absolute judgment cannot be made.

Local measures recommended for the bay include upgrading the treatment plants [(B) (a) (i)], moving the outfalls to mid-bay locations [(B) (a) (ii)] diverting flows out of the area [(B) (a) (iii)], and instituting non-point controls. The negative environmental effects from upgrading the Port Washington and Great Neck plants will be minimal in terms of wetland loss, since the surrounding areas are already developed. If steps are taken to control runoff from any needed construction, then the short-term negative impact upon the bay waters will also be minimal. If advanced treatment is implemented without both phosphorous and nitrogen removal, the N/P ratio may be lowered with detrimental effects upon the phytoplankton. However, due to the tidal exchange in the bay and the dominance of the Sound conditions, changes in the N/P ratio will not be great. The beneficial results of this treatment will be local in nature. Some improvements in the nutrient levels and oxygen demand will be noted in the vicinity of the present outfalls. Model predicted buildups in the southern portion of the bay will be mitigated. General nutrient and coliform bacteria levels in the bay will not be much improved due to Sound conditions. No reduction in the closed shellfish zone is anticipated. Benefits from additional treatment measures will be minimal if non-sewering options for surrounding land areas are selected, since the volume of treated flows will remain near present levels.

Moving the outfall to a mid-bay location will probably do more than advanced treatment to relieve high nutrient buildups in the southern and eastern portions of the bay, as shown in the modeled scenarios. However, such an action requires trenching the bottom and backfilling in order to lay a pipeline, and results in short-term adverse effects upon fish and shellfish from the increased turbidity, as noted in Section 4.2.16. There is also the problem of spoil deposition, and in Manhasset Bay, with its developed shoreline, there may be a tendency to use the last remaining wetlands as dump sites. Such wetland use should be avoided. As with the AWT option, benefits of treatment measures will be small if minimum sewering options are selected.

For one dwelling unit per gross acre to three dwelling units per gross acre sewering scenarios, diversion of the effluent out of the area will go further than [(B) (a) (i)] or [(B) (a) (ii)] to improve local water quality and to benefit the organisms of the bay. Planning must be done carefully to assure that the areas to which the flow is diverted can handle the increased flow. In that regard, it should be kept in mind that the ocean and Long Island Sound are not infinite sinks (see Section 4.2.16). The danger of pipeline leakage or deterioration exists, but can be minimized with proper design and

construction. Even complete removal of point sources by diversion of all wastes out of the bay cannot improve either the baywide nutrient balance or the water quality with respect to bacterial levels because of the overriding influence of Long Island Sound.

Non-point and storm runoff loads constitute a significant problem in Manhasset Bay due to extensive shoreline development and lack of wetland to buffer non-point inputs. For example, they account for 30 percent of local nitrogen inputs to the bay. Thus, a control program that does not effectively control non-point inputs will not be an acceptable strategy. The proposed Best Management Practices approach to storm runoff controls [(B) (b) (i)] has some likelihood of reducing the coliform bacteria, nutrient metal and organic chemical loads to Manhasset Bay. However, it is not known how effective such an approach will be. Hence, it is strongly recommended that a pilot study be implemented to test the effectiveness of Best Managment Practices in reducing non-point runoff.

In summary, a combination of structural measures to control point sources, alternative [(B) (a) (i)] through [(B) (a) (iv)], non-structural measures to control non-point sources, and minimization of sewage flows in surrounding land areas could produce local water quality improvements. The dominating influence of Long Island Sound water on bay water quality makes it impossible for Nassau and Suffolk Counties alone to control the quality of the bay water. However, AWT or mid-bay discharge could have significant local benefits. No action, option [(B) (a) (v)], is another alternative that could be followed at present. If [(B) (a) (v)] were to be selected it would represent a judgment that the local water quality benefits obtainable for other options could not be justified on a cost/benefit basis when compared on an areawide basis with investments in other water quality controls. The onus is clearly on the City of New York to control the large pollutant flows which degrade western Long Island Sound water quality.

4.3.10 Hempstead Harbor. Hempstead Harbor has been highly developed for both industrial and residential use. It has many similarities to Manhasset Bay in terms of loss of wetlands, significance of non-point inputs, and importance of the Sound influence. This harbor handles the largest amount of water-borne commerce on Long Island (Gross *et al.,* 1972) and also shelters many pleasure boats. In general, it is well flushed and subject to substantial influences from Long Island Sound. Although the bay has high potential for production of hard clams, the entire bay has been closed to shellfishing due to coliform contamination. There are also some areas of shoreline and natural woodland, which support beach and upland species, but the wetlands, so vital to nutrient cycling, have all but disappeared. The most recent survey estimates that a total of only about 83 acres of vegetated wetland remains in Hempstead Harbor (NYSDEC, 1977a). Landfill from shoreline development has also changed the character of the bottom sediments and has reduced the harbor area by a small amount. As in the case for Manhasset Bay, local control measures [(C) (a) (i)], [(C) (a) (ii)], [(C) (a) (iii)] or [(C) (b)] will result in only limited, locally observable improvements in water quality. For example, controls on Glen Cove Creek discharges will mainly improve conditions only within that creek, because of the dominance of Sound influence in the open bay. For that reason, the structural measures discussed below are only marginally justifiable from a cost/benefit standpoint, and [(C) (a) (iv)] is an attractive alternative.

Structural controls have been proposed to mitigate pollutants in Glen Cove Creek and the inner harbor. Glen Cove Creek is subject to both municipal and industrial loads. These loads probably contribute significant quantities of nutrients, metals and organic chemicals; however, detailed source inventories are not available. The loads combine to severely degrade local water quality; the industrial loads of metals and organic chemicals constitute the bulk of the problem. Industrial discharges to Hempstead Harbor are specifically considered in alternative [(C) (b)] and it appears that it would be beneficial if such discharges in Glen Cove Creek, which are meeting present standards, were to be pretreated beyond presently required pretreatment or that outfalls be routed out of the area (possibly to the centralized hazardous waste facility). Until treatment measures for the full suite of contaminants are instituted and toxic conditions in the creek abate, implementation of nitrogen controls will have little or no effect on the ecology of Glen Cove Creek.

Currently, the Glen Cove Sewage Treatment Plant is upgrading to include nitrification of wastes and the Powers Chemco plant is ugrading to remove ammonia. However, according to the Tetra Tech model (Johanson *et al.,* 1977b), nitrogen removal is required to alleviate water quality stress. In order to mitigate the localized nutrient concentration in Glen Cove Creek, the Management Plan calls for either nitrogen removal at both the Glen Cove Sewage Treatment Plant and Powers Chemco ammonia removal plant, [(C) (a) (i)], or relocation of both outfalls to mid-bay, [(C) (a) (ii)], the impacts of which are discussed in Sections 4.2.15 and 4.2.16. Either of these actions would substantially improve the nitrogen water quality in Glen Cove Creek, although the harbor as a whole would be only slightly improved because of the overriding influence of Long Island Sound. Upgrading the plants would pose very little threat environmentally, since there are no endangered wetlands or habitats in the vicinity of the plants. Since much of the bottom sediments in the creek have been altered already, and none of the bay is open to shellfishing, the impact of dredging and laying an outfall pipeline is not expected to be adverse if timed to avoid peak periods for spawning and for recreational use.

Similar impacts in Hempstead Harbor can be expected from the various courses of action. The same set of choices as outlined for Glen Cove (upgrade treatment or locate outfall in mid-bay) are applicable to the Roslyn Treatment Plant flows, if one dwelling unit per gross acre or two dwelling units per gross acre sewering is implemented. In particular, the flushing of the southern end of the harbor is poor and upgrading treatment or relocating the

outfall would improve the water quality greatly. Instituting nitrogen removal without phosphorus removal, however, could result in changes in dominant phytoplankton and a consequent perturbation of the marine food web within the southern portion of the harbor. Thus, phosphorus removal with accompanying nitrogen removal should be considered. An estimated nineteen percent of nitrogen loads to the bay are contributed by non-point sources. Metals, organics, coliform bacteria and sediment are also components of the non-point sources. As with Manhasset Bay, wetland edges have largely been filled and runoff directly impacts the bay without the benefit of a buffer. The implementation of non-point controls should accompany point source measures. Non-point controls, for example, could result in lowered coliform levels in water adjoining beaches. However, for this bay, non-point controls alone are clearly not adequate.

In summary, industrial effluent controls [(C) (b)], non-point controls [(C) (c)], and point source controls [(C) (a)] can all produce local improvements in water quality. As with Manhasset Bay, improvement of Long Island Sound conditions is a necessary precursor to the restoration of a healthy nutrient balance and reduction of coliform bacteria in the harbor. Until this can be done, no great improvements in the nutrients, BOD, and finfish and shellfish populations can be expected for Hempstead Harbor as a whole, and local measures will be only marginally cost-effective. As with Manhasset, the onus is on New York City and southwestern Connecticut to implement the measures that will contribute to improvement in western Long Island Sound and Hempstead Harbor. However, AWT or mid-bay discharge could have significant local benefits. No action, option [(C) (a)(iv)], is another alternative that could be followed at present. If [(C)(a) (iv)] were to be selected, it would represent a judgement that the local water quality benefits obtainable for other options could not be justified on a cost/benefit basis when compared on an areawide basis with investments in other water quality controls. Best Management Practices [(C)(b)] should be implemented no matter which of the point source control alternatives is selected.

4.3.11 Oyster Bay. Oyster Bay supports distinctive commercial and recreational resources. These include a major National Wildlife Refuge Area and a significant mariculture industry. The presence of the refuge area dictates that particular caution be exhibited in order to safeguard the protected wildlife habitats. With respect to 208 alternatives, this mainly suggests that (1) trace contaminants (organic chemicals and metals) that may enter the food web be controlled and (2) overall pollutant loads be controlled to maintain the diversity of planktonic and benthic food organisms near the bottom of the food chain pyramid. The presence of the mariculture industry suggests that the bay system should be protected from pollutants that impose shellfish health risks, such as coliform bacteria and trace contaminants (organic chemicals and metals). In addition to their role as an economic resource, these oyster populations may play a significant role in maintaining nutrient and phytoplankton equilibria. It is likely that these populations, in addition to the extensive wetlands, are partly responsible for keeping the nutrient levels low by acting as sinks.

To safeguard the commercial and recreational resources of the bay and its embayments, several potential pollutants need to be controlled. These include metals, organic chemicals, coliform bacteria and suspended solids. There is a paucity of monitoring data for trace contaminant levels in the water columns, sediments or organisms of the bay system. At present, however, point source inputs of trace pollutants to the bay system are limited. The only industrial sources of significance are oil transport facilities, which are the sites of occasional small spills. Suspended solids are also contributed mainly by non-point sources. Thus, the major concern regards future industrial sources and non-point sources, and, therefore, alternative [(D) (a) (i)] is acceptable.

The plan for waste management in Oyster Bay calls for the application of stormwater runoff controls to reduce coliform levels, [(D) (b)]. Non-point sources are estimated to contribute 77 percent of the bay's nitrogen loads. The use of non-structural measures alone may well be insufficient in reducing contamination due to total coliforms and trace contaminants (*i.e.,* metals, organic chemicals) in a situation where pollutants from non-point sources constitute the bulk of the load. The reductions that will be achieved are not predictable prior to a pilot effort. Both total coliform and metal levels directly affect the harvestability of the shellfish in the bay. Thus, structural runoff controls are desirable for maximum protection of bay resources.

A substantial portion of the existing wetlands in and around Oyster Bay are under the purview of the Oyster Bay National Wildlife Refuge. The existence of the refuge protects the wetlands of Oyster Bay, which are an important stopover on the Atlantic Flyway. Thus, the recommended long-term policy position *vis-a-vis* Oyster Bay is to keep the bay system in a relatively pristine state. Several measures are needed: (1) structural non-point control options are important since the effectiveness of non-structural approaches is uncertain; (2) nitrogen and phosphorus removal for any discharges, [(D) (a) (iii)], should be considered even though modeling runs found that secondary treatment would result in "acceptable" ambient levels; removal of discharges from the bay in favor of recharge or Sound discharge could also be considered, [(D) (a) (ii)] or [(D) (a) (iv)]; (3) strict preservation of all wetlands and terrestrial buffer zones is required.

4.3.12 Huntington Bay. Although the waters of this bay complex are relatively well mixed, two of the four harbors, Northport and Huntington, show low dissolved oxygen and high nutrient levels. These two harbors are also the locations of two treatment plant outfalls, and have relatively few wetland areas on their perimeters. Many of the shellfish beds in these harbors, while showing potential for production, have been closed due to coliform contamination.

One of the recommendations for Huntington Bay is nitrogen removal at both sewage treatment plants, alternative [(E) (a) (i)]. This would control

the nutrient level and thus avoid algal blooms; however, the phosphorus would remain high and the steady state N/P ratio in these harbors could decrease. Such an effect can alter the dominant phytoplankton species in the water and thus perturb the feeding shellfish, which depend upon phytoplankton for most of their food. If phosphorus is also removed, the alternative becomes environmentally superior.

A second option for controlling nutrients in these harbors is moving the outfalls to mid-bay locations [(E) (a) (ii)]. This would reduce the nutrient levels within the bay without significantly altering the N/P ratio, and thus would be beneficial to the phytoplankton and shellfish in the waters. The three other options involve routing sewage out of the area, [(E) (a) (iii), (iv) and (v)]. From the standpoint of Huntington Bay quality, these last three options are the best, although no option adding to effluent loads to Oyster Bay should be considered.

In evaluating these structural options, additional environmental impacts must be addressed. First, it must be noted that, if minimum sewering options for surrounding land areas are selected, flows will remain near present levels. Upgrading of treatment is essential even if non-structural non-point measures are implemented. In order to upgrade the treatment plants under option [(E) (a) (i)], construction of new facilities will be required (see Section 4.2.15). Caution must be exercised to avoid erosion and degradation of surrounding areas. Because there is very little wetland in the area surrounding these plants, wetland loss is unlikely in this case. Of more concern is the second option, which requires trenching the bottom and back-filling to lay a pipeline out to the middle of the bay (see Section 4.2.16). This action may impact upon the benthic organisms, particularly the valuable shellfish. Such effects tend to be transitory in nature. Time of year of construction activities becomes critical. Very high rates of sedimentation may result in habitat loss, clogged shellfish feeding mechanisms, and smothering. Other problems include altered bottom topography and circulation patterns. These effects can be minimized by replacing extracted sediments over the pipeline, grading, contouring the substrate and relocating shellfish following construction. The increase in turbidity can be minimized by careful deposition of spoil, but some effects will inevitably remain. The recharge alternatives [(E) (a) (iii) and (v)] have possible health and feasibility drawbacks associated with them and, in Zones I and VIII, present no particular benefits (Miller and Sgambat, 1977a).

Non-point inputs constitute an estimated 80 percent of nitrogen loading and 99 percent of total coliform bacteria loading to Huntington Bay. Thus, control of non-point inputs [(E) (b)] is in some respects more important than point source controls. The non-structural controls that have been proposed are untested. Thus, the results of a pilot effort such as that suggested in Section 4.2.14, above, are needed to determine whether structural non-point controls will be required.

Wetland acreage has been greatly reduced in the Huntington Bay area over the past fifteen years. There are two interpretations of the effect of this reduction. One is that the fewer the remaining wetlands, the more essential is their preservation to the ecology of the area. The other is that once wetlands have been reduced below a critical size, they no longer represent a viable functioning habitat unit in a given system. The authors adhere to the second viewpoint and suggest that strict preservation of wetlands in other bays (Oyster Bay, Peconic Bay) is likely to be much more worthwhile than institution of such measures in Huntington. However, the remaining wetlands in Huntington Bay are clearly a valuable aesthetic resource.

In summary, structural point source controls [(E) (a)] appear to be dominant under maximum sewering (one dwelling unit per acre) schemes for reduction of locally high nitrogen and low dissolved oxygen (D.O.) in Huntington and Northport Harbors. Non-point controls [(E) (b)] are dominant under minimum sewering for nitrogen and D.O. and under all sewering schemes for total coliform bacteria.

4.3.13 Port Jefferson. Port Jefferson Harbor contains valuable shellfish resources, but only some 150 acres of wetland remain. The central harbor, which is a port for commercial shipping, is also the site of the Port Jefferson primary sewage plant treatment outfall. It is this central harbor that is subject to high nutrient levels and contains closed shellfish beds. The embayments, Conscience Bay and Setauket Harbor, are rich in marine and bird resources. Those areas are relatively unaffected by STP outfalls but would benefit from non-point controls. In fact, existing non-point inputs to the embayments contribute to conditions in the open bay.

The structural control plan [(F) (a)] for Port Jefferson does not call for nutrient removal at the treatment plant unless the flow increases dramatically. Since the the sewage treatment plant presently provides only primary treatment, upgrading to secondary treatment, alternative [(F) (a) (i)], is expected to mitigate the impacts of increased flow. The Tetra Tech model predicts that a fifteen million gallon per day (the actual flow increase under one dwelling unit per acre sewering is expected to be only some eight million gallons per day) secondary effluent will only slightly degrade nitrate levels and is actually a positive step for phytoplankton growth with respect to nutrient ratios. The anticipated N/P ratios would be higher than those observed at present and thus there is no cause for concern over dominant phytoplankton species. However, if the plant should be upgraded to advanced treatment alternative [(F) (a) (ii)] then a problem may arise unless phosphorus is removed with the nitrogen. Under minimum sewering, no AWT would be required.

Another proposed structural measure is a mid-bay outfall alternative [(F) (a) (iii)]. This alternative is environmentally acceptable in that steady state nutrient ratios will not be affected and nitrate levels will change minimally. The dredging that will be necessary to lay the pipe will occur in sediments that are silty and may be somewhat polluted. If care is exercised in recontouring the benthos and in disposing of the spoil, the short-term effects

associated with increased turbidity will be minimal. The most productive shellfish areas are located in Conscience Bay and Little Bay-Setauket Harbor, which are removed from the proposed construction area in the main harbor. Thus, effects upon the shellfish may be minimized as well. Again, under minimum sewering options, this measure would not be required.

Another structural solution calls for the recharge of any effluent flows in excess of present levels, alternative [(F) (a) (iv)]. This would require advanced treatment of effluent to minimize nitrogen discharges to groundwater. A health risk of contributing chlorinated organic chemicals to groundwater would exist if the effluent were to be chlorinated, however, further study of this problem is needed and other disinfection procedures may be required. If health risks associated with disinfection procedures can be eliminated, recharge would be acceptable. Organic chemicals contributed to groundwater by recharge would be much less than non-point and industrial inputs. Metal contributions would probably be negligible due to pretreatment of industrial effluent.

The second portion of the Management Plan calls for stormwater runoff controls to reduce coliform and nutrient levels [(F) (b)]. As discussed above, this is a positive measure for the shellfish populations within the embayments, although the nature of Port Jefferson Harbor's sediments suggest that the main harbor may remain an unproductive habitat despite water quality improvements, because of prior pollution and/or the natural state of the sediment.

In summary, the requirements for structural point source measures are moderate under maximum sewering and minimal under minimum sewering strategies. Non-point source controls are needed to maintain and improve the quality of the western embayments. There are no clearly dominant alternatives, although recharge seems to be an attractive choice. In contrast to the western North Shore bays, for which flow diversion to South Shore facilities is feasible, for Port Jefferson recharge is the only presently available option for routing sewage flows away from the North Shore.

4.3.14 Peconic Estuary, Flanders Bay. The Peconic-Flanders system is a particularly sensitive system, since the site is a shallow estuary, with low tidal flushing in the western portion. There are more than 1,400 acres of wetlands, although many areas have been dredged or filled, and wetland destruction continues at a slow rate. Unless such infringement is completely halted and some wetlands reconstructed, the nutrient levels in the estuary will continue to rise, possibly leading to disruption of the ecosystem at some future time. The creeks and Peconic estuary are particularly sensitive, exhibiting high nitrate and low dissolved oxygen.

The wastewater management for Peconic-Flanders requires treatment of the duck farm effluents to remove nitrogen. Some of the farms have already stopped discharging into the river or tributaries; when the three remaining significant dischargers also cease discharging, the nutrient levels will fall to an acceptable level. This will have a beneficial effect upon finfish and shellfish, avoiding algal blooms and maintaining a higher dissolved oxygen concentration. Such an action may, however, have a negative effect on the duck farm industry. Although some local farms have recently closed, a connection between regulatory enforcement and the facility demise has not been established. Such losses may be unavoidable if a healthy bay ecosystem with a balanced nutrient cycle is to be maintained.

The upgrading of the Riverhead Treatment Plant will be necessary even if the effluent load does not increase under the sewering strategies selected. Moving the outfall out of the Peconic estuary to a bay or Sound location, [(G) (a) (ii)], [(G) (a) (iii)], [(G) (a) (iv)], would prove far superior environmentally than maintaining the present outfall [(G) (a) (i)], because of high nitrate and low dissolved oxygen (D.O.) in the estuary. In fact, maintaining the outfall at its present site, [(G) (a) (i)] is environmentally unacceptable. There is more flushing in the bay than in the estuary, so that nutrient buildups are mitigated. As long as the precautions for dredging and construction discussed in Section 4.2.16 are followed, moving the outfall to a Sound location will tend to improve the environmental quality of the estuary and bay. Immediate establishment of a monitoring program [(G) (c)] to measure effects of the present outfall in the Peconic estuary is required under any option, in order to provide information on the nature of D.O. patterns in the estuary.

It is strongly recommended that the D.O. standard for Peconic-Flanders be modified. Historical data show that: (1) the Peconic-Flanders system presently supports productive marine populations, and (2) 23 percent of historical samples are below the present NYSDEC standard. Thus, no matter which options or measures for the Peconic-Flanders system are selected, violations of the present New York State D.O. standard are likely to continue.

It is clear that, due to problems involved in discharging to the Peconic-Flanders system, minimum sewering in Zone IV is a desirable strategy and option [(G) (a) (i)] is unacceptable. Non-point measures [(G) (b)] are needed as well to minimize D.O. and nutrient degradation. Non-point sources contribute 24 percent of nitrogen loadings to Flanders Bay but will contribute a higher percentage when duck farm discharges cease.

4.3.15 South Shore Bays. The South Shore bays, especially Mecox, Moriches and eastern Great South Bay, tend to be sensitive to pollutant inputs. Large portions are shallow, tend to be poorly flushed, and concentrations of nutrients and coliforms readily build up. Such areas support large populations of phytoplankton, which can easily induce dissolved oxygen deficits when nutrient levels rise. They support significant fish and shellfish populations, which are sensitive to salinity changes and which easily accumulate trace levels of metals and organics.

The measures proposed for the South Shore bays are designed to minimize nutrient inputs into the bay. According to Tetra Tech's model, inputs into eastern Great South Bay and the most western of the South Shore bays are already too high and need to be reduced. A similar situation probably

exists for Moriches and Mecox Bays; however, modeling studies and extensive sampling of these bays was not included in the 208 Program. The proposed measures present the most stringent set of controls on nitrogen that could be implemented and are environmentally optimal from nitrogen, phytoplankton and dissolved oxygen standpoints. However, full implementation of the Plan element calling for the reduction of groundwater underflow nitrate-nitrogen concentration to two milligrams per liter will be difficult to achieve.

The strategy of sewering (one, two or three dwelling units per gross acre) gives treatment plant effluent a significant role in the South Shore bays' freshwater budget. The Tetra Tech model suggests that the combination of stream flow reduction and discharge of effluent to the ocean would change the salinity gradients in the bays, especially in eastern Great South Bay. Also, groundwater investigations (Miller and Sgambat, 1977c) show that water table levels and stream flows are reduced along the South Shore in sewered areas. Any change in average bay salinities is likely to impact the distribution of fish and shellfish in the bay. This impact would not necessarily be negative, but in the absence of a good predictive tool with which to assess the probable change, the prudent environmental approach is to assume a negative impact. Reduction in stream flows and wetland levels will adversely impact the area of wetland habitat available to birds and fish populations. Thus, from an environmental standpoint, minimizing sewering is desirable, depending upon the level of nitrogen loadings that must also be controlled. For the Zone VII—western South Shore bays system, minimum sewering (only in areas of septic system failures) is judged preferable, based on measures required for water table maintenance and the ability of the bays to flush nutrients entering in the groundwater flow. There is an appreciable decrease in the effectiveness of tidal flushing, as a means of nitrate dispersal, at the eastern end of Zone VII. For the Zone VI—eastern South Shore bays system, a judgment is based on a tradeoff of wetland levels and bay salinities versus bay nutrient levels. It is a difficult choice, and strict land use controls together with a variety of nutrient contols would be the best option, with sewering avoided when possible. Stream augmentation (with shallow recharge, if feasible) of all effluents in Zones VI and VII is the only acceptable option if sewering occurs. Any effluents recharged or discharged to streams require extensive tertiary treatment beyond nitrogen removal.

Non-point runoff contributes significant amounts of nitrates and coliform bacteria to South Shore bays. It is strongly recommended that a pilot effort at implementation of both the non-structural and structural approaches be instituted for the South Shore. Only after analysis of data from such pilot efforts can it be determined whether non-structural non-point source controls are effective. From an environmental standpoint, structural controls are the currently prudent strategy, due to the uncertainties associated with the Best Management Practices approach.

Specific considerations for each South Shore bay are as follows:

Mecox Bay. Mecox Bay is characterized by violations of dissolved oxygen and coliform bacteria standards (Bigham and Lorenzen, 1977). The bay exhibits poor flushing through an inlet that requires frequent dredging if it is to be kept open. The naturally poor exchange characteristics of the bay suggest that the bay's poor water quality may be at least partially a natural condition. Nevertheless, the surrounding land areas are somewhat developed and the associated human activities have contributed to the violation of standards. Most notably, residuals from duck farming have been historically discharged to the bay. This practice has left a sizeable deposit of organically rich sludge in Hayground Cove. This deposit contributes to nutrient loading and to oxygen consumption.

Mecox Bay exhibits "threshold" levels of various water quality variables; that is, violations of standards occur, but the biological community that can be observed is not one of chronically low diversity. Augmented loadings can be expected to push the bay ecosystem into a polluted state, whereas decreased loadings can be expected to reduce violations of criteria. Thus, the stringent controls recommended as alternatives [(H) (a)] and [(H) (c)] are environmentally prudent and likely to result in easily measurable ecological benefits. From an ecological standpoint, construction of a new inlet [(H) (b)] is likely to significantly alter the bay's ecology. It is as likely to be detrimental as beneficial.

Sewering in the vicinity of Mecox Bay (parts of Zone V) will affect water levels of wetlands and streams connected to Mecox Bay. Such changes are likely to be detrimental to bay ecology. Thus, sewering alternatives imposed without recharge or flow augmentation are not ecologically prudent.

Shinnecock Bay. Shinnecock Bay is connected to Peconic Bay, Moriches Bay and the Atlantic Ocean. All of these connections are by way of narrow inlets and canals. The exchange of bay water with Atlantic Ocean water is via the Shinnecock Inlet and is considerable, as indicated by Shinnecock Bay salinity (Pagenkopf and Bigham, 1976). Shinnecock Bay tends to display lower nitrogen, coliform bacteria and solids levels than Mecox or Moriches Bays. Thus, the need for a full array of strict controls for Shinnecock Bay is less pronounced than for adjoining bay waters. The measures suggested for Shinnecock Bay [(I) (a)], [(I) (b)] will all be ecologically beneficial. However, the present good condition of the bay and the extensive tidal exchange suggest that strict application of the measures, especially of [(I) (b)] are of lower priority than are similar efforts affecting other sections of the South Shore.

In particular, sewering in the vicinity of Shinnecock Bay is not justifiable on surface water nitrogen grounds and is likely to be detrimental to local wetlands and streams.

Moriches Bay. Moriches Bay is similar to Shinnecock Bay in geologic origin and tidal exchange (Pagenkopf and Bigham, 1976). The bay is large in area and contains valuable wildlife, fish and shellfish habitats. High nutrient and coliform bacteria levels have been noted in Moriches Bay. Further additions of nitrogen would pose the threat of serious environmental degradation.

Changes in ambient nutrient levels and in hydrodynamics have historically caused problems in Moriches Bay. In the late 1950's, closing of the Moriches Inlet resulted in significant algal blooms and loss of shellfish productivity. These historical events have demonstrated the ecological necessity of all of the measures [(J) (a)] and [(J) (b)]. Two further considerations, not specifically noted in Section Three, are worth mentioning here. First, an historical study of Moriches Bay nutrient relationships has emphasized the importance of the N/P ratio as an indicator and as a possible controlling factor. Thus, careful monitoring of the ratio is required, if this plan is to be environmentally acceptable. Specific control actions will have to be formulated from time to time, as the ratio shifts. Second, sewering in the area surrounding Moriches Bay (parts of Zones V and VI) will probably be detrimental to the bay ecosystem and will, at a minimum, impose a difficult set of environmental tradeoffs. A benefit of sewering would be decreased nitrogen input to the bay from groundwater underflow; a serious detriment would be lowered wetland water levels and stream flows, unless stream augmentation (with shallow recharge, if feasible) could successfully maintain the water table. Lowered water levels and stream flow would be likely to change the character of the bay's contiguous wetlands and might alter the bay's salinity regimes. The wetland areas are of great importance to the bay's nutrient cycle and marine food web. The specific material flow and ecological community changes cannot be predicted.

Eastern Great South Bay. Eastern Great South Bay is a highly productive system. The ecological community yields large populations of commercially and recreationally important fish and shellfish. Among the most significant resources are hard clams and winter flounder. The area exhibits great sensitivity to long-term changes in freshwater inflows, rainfalls and wind patterns. The system appears to be delicately balanced and quite vulnerable to many sorts of changes. The system has a natural variability, which can be expected to increase or decrease depending on pollutant inputs. Major increases in system variability can be expected to be negative in impact. Among the changes that could seriously alter or destabilize the ecosystem are natural climatic and predator-prey cycles, and alterations in inlet configuration, stream-flow, patterns of nutrient inflow, and sediment makeup.

To minimize changes in inlet configuration, monitoring of the hydrodynamics and periodic dredging are required. Implementation of such a program is an acknowledgement that maintenance of the current ecological community is more desirable than allowing natural evolution of the bay ecosystem to occur. Construction of a new inlet as suggested in [(K) (b)] is undesirable from an ecological standpoint because it is impossible to predict what community shifts would be imposed. The community shifts thus imposed might even include establishment of new, undesirable predator-prey links.

To minimize excess nutrient inputs, measures [(K) (a)] and [(K) (c)] have been proposed. [(K) (a) (iii)] and [(K) (c)] are both needed. [(K) (a) (ii)] is probably preferable to [(K) (a) (i)] because of water table considerations. However, the level of sewering is a critical factor in choosing between the two alternatives. The strict limiting of the extent of sewering with marine surface discharge in Zone VI is ecologically necessary because of the risks imposed if the water table is lowered, although tradeoffs are involved. It is uncertain whether the combination of inundation requirements for wetland plant growth and freshwater inputs for maintenance of Great South Bay salinity regimes will be met by any recharge or flow augmentation scheme. Thus, the marine ecosystem is likely to degrade under comprehensive sewering of Zone VI. However, even with sewering some nitrates will be contributed by groundwater underflow, unless there are strict controls on non-point sources. Thus, careful and extensive land use controls rather than comprehensive sewering are the measures that are environmentally preferable. The studies currently being proposed by Nassau and Suffolk Counties concerning South Shore stream flows are likely to cover these environmental matters in considerably finer detail. Such studies should carefully weigh the uncertainty imposed by water table lowering before any further sewering in Zones V, VI or VII is approved.

Western Great South Bay. These waters are transitional in nature and may require some combination of measures presented under options (K) and (L). Sewering this portion of Zone VII imposes the same risks described for Zone VI and should be avoided for those areas not already sewered.

Western South Shore Bays. These waters are characterized by considerably higher tidal exchange than the bays to the east. They lie directly south of a densely developed region of Long Island. At present, the ability of the western bays to disperse pollutant loads is offset by the excessively high loads currently entering those waters. The major nutrient loading is contributed by effluent from the Bay Park facility. Thus, implementation of measure [(L) (a) (i)] alone will have very significant environmental benefits. Implementation of measures [(L) (a)] and [(L) (b)] will act to protect the valuable resources of these bays and are recommended. If measures [(L) (a)] and [(L) (b)] are fully implemented, groundwater nitrogen inflow will not be of major concern, since the bays will be able to maintain stable nutrient levels by flushing.

4.4 Aggregate Economic Costs

It is impossible to accurately quantify all of the real costs—monetary, indirect and opportunity— of liquid waste disposal systems for the Nassau-Suffolk Region, or for any area. There are costs that can be directly or accurately quantified. Among those are the costs for equipment for water quality monitoring, treatment plants, disposal facilities, pumps, lines, etc. However, accurate comparison of the true economic effect of alternatives for wastewater treatment requires the incorporation of estimates for opportunity costs as well as for any unquantifiable externalities that are imposed upon the area involved. It is very difficult to predict what might have happened in the future had not a particular regulation been imposed or a certain

treatment plant built. Perhaps a flourishing business with employment benefits, profits to the owner, tax revenue, and an increased "quality of life" accruing to the community is prevented from opening. It is extremely difficult to predict the expected return on the aforesaid business opportunity, just as it is extremely difficult to assign a dollar value to the "increased quality of life." However, these effects are all real benefits (or disbenefits) to the community and affect the actual desirability of the option that would cause such changes. Many other examples of opportunity costs being imposed by a particular liquid waste treatment strategy can be constructed. The important point is that while an economically and socially efficient choice of treatment strategies must take opportunity costs and externalities into account, there is no accepted, iron-clad method to reduce such costs to a form where they can be directly compared with other costs.

4.4.1 Discussion of Cost Uncertainties. Costs for various components of the Nassau-Suffolk wastewater quality management program have been estimated (NSRPB, 1978).[1] However, assembling those component costs into aggregate costs is difficult, because many of the cost estimates represent rough order approximations and many options simply defy quantification. Inability to cost out all available options has a tendency to focus attention on those elements for which cost data is known. This often results in decisions weighted toward the known costs while other, equally significant options, may be ignored or dismissed out of hand. It is the purpose of this section to explain the difficulties of specifying certain aspects of cost and to give the reader an understanding of the potential magnitude of unknown costs.

4.4.1.1 Plan Options by Hydrogeologic Zones. Table 4–37 presents a matrix of the various cost elements associated with the options considered by the NSRPB. The cost elements are displayed according to the relative accuracy that can be expected from estimates of the element's cost. The "hardest" estimates can be developed for those cost elements listed as "straight engineering" type costs. Estimates become increasingly "soft" as the reader moves to the right on this matrix and are "softest" for those elements for which the estimation involves specifiying opportunity costs.

The "hardness" of the cost estimates is dependent on the procedure used to estimate them. The procedures for estimating each element are discussed below, by cost type.

Straight Engineering Costs. Straight engineering costs are cost estimates for equipment and operations and maintenance for which the equipment required can be fully specified. Equipment for water quality monitoring at the specific locations; for pumping volume monitoring of irrigation wells required for IV B, C, D and E, as well as the equipment required for additional treatment and disposal facilities can all be completely specified, and cost estimates can be generated using standard cost estimating techniques. These techniques generally yield estimates accurate to within ± 25 percent.

Engineering with Speculation. Costs in this category are similar to those in the first category; cost estimates are based on full specifications of the equipment needed. However, the amount and size of equipment required is only estimated, because it is subject to change over the lengthy planning period involved. The cost for sewering a region once it attains a certain population density (X dwelling units per gross acre) is dependent on (1) how much of the region becomes populated with X dwelling units per gross acre; (2) in what years each of the sewered areas attains such densities; and (3) water consumption rates. Because of the potential for error in forecasting population growth and water consumption rates, sewering costs are subject to larger tolerances than harder "straight engineering" costs.

Similarly, the other element in this category—relocating water supply wells— is subject to the localized growth in water supply demand. This will determine the number of wells required and their locations.

Speculative Cost. Costs in this category are incurred only if certain conditions occur. Therefore, costs for these elements may be as low as zero, but in certain cases they may also be very high. All of the cost elements in this category are contingent on environmental degradation below threshold levels that the other elements seek to preclude. Careful planning should include contingencies such as the proposed additional monitoring if water quality problems arise, contingency water treatment if water supply sources fall below acceptable quality, and contingency pumping plans (that may increase water supply units) should water demand and quality jeopardize water supply.

Difficult to Estimate. Cost elements that fall into this category relate to untested, presently not clearly detailed programs. This would include, for example, educational programs to encourage animal waste control, or possibly other measures in the event that educational programs fail to achieve desired results.

Opportunity Cost. The most difficult elements to estimate are those relating to opportunity costs. For these elements, costs are not dollars spent for equipment and operation, but rather are reflected as savings or revenue foregone because of the loss of opportunity to accrue them. For example, land use controls (*e.g.,* buffer zones or stricter controls forbidding certain forms of development) may prevent an entrepreneur from opening up a certain business in an area. The municipality loses the revenue as well as the employment potential that might have been gained from this business. The entrepreneur may also lose the profits he might have earned by opening in the area. It is extremely difficult to predict the expected return on the foregone business opportunities because the value of the business opportunity is not clear. The problem is further aggravated by the fact that opportunity costs are borne by various groups, not just the municipality. In the example above, the entrepreneurs incur opportunity costs, as do workers who may have prospective jobs foreclosed to them.

[1] Nasau-Suffolk Regional Planning Board, 1. Section H: Municipal Waste Treatment Systems Needs, 2. Section L: Urban and Industrial Stormwater System Needs.

Table 4–37

NATURE OF COST UNCERTAINTIES FOR HYDROGEOLOGIC ZONE ALTERNATIVES

Areawide Alternatives		Straight Engineering	Engineering with Speculation	Difficult to Estimate	Speculative
		Expanded Industrial Waste Disposal Regulations Structural Runoff Controls Provide for Treatment of Hazardous Wastes Provide Sludge Disposal Alternatives Require Nitrogen Removal for Inland Treatment Plants	Promote Water Conservation Storage and Transport of Chemical Products Regulations Minimize Pollution from Site Preparation Reduce Reliance on Landfills	Septic Tank Maintenance Prohibit Use of Chemical Cleaners	Restrict the Use of Fertilizers Nonstructural Runoff Controls Reduce Animal Wastes Minimize Population Density
Hydrogeologic Zone – Specfic Alternatives					
Zone	**Alternative**				
I	A	Permit no Additional Sewering	Strictly Control On-site Systems	Strictly Regulate Site Management Practices	Specify Acceptable Lot Size
	B	Sewering			
	C	Sewering			
	D	Sewering			
II	A	Route Wastes to Cedar Creek Require Wellhead Treatment		Water Importation	
III	A	Permit No Additional Sewering	Strictly Control On-site Systems	Strictly Regulate Site Management Practices	Specify Acceptable Lot Size
	B		Monitoring Program		Land Use Controls
	C	Sewering			
IV,	A	Sewering			Water Importating
V	B	Permit no Additional Sewering	Strictly Control On-site Systems	Strictly Regulate Site Management Practices	Specify Acceptable Lot Size
	C	Sewering			
	D	Sewering			
	E	Sewering			
VI	A	Permit no Additional Sewering	Strictly Control On-site Systems	Strictly Regulate Site Management Practices	Specify Acceptable Lot Size
	B	Sewering			
	C	Sewering			
	D			Construct and Maintain New Inlet	
VII,	A	Sewering			
VIII	B	Sewering			
	C	Sewering			

Source: ERCO

Excluding landfills from various areas will create costs reflected in the higher costs for landfilled waste disposal. Additional transportation to landfills located outside a zone from which landfills are excluded will increase labor (hours for driving) as well as vehicle O & M costs (gas, oil, tune-ups, replacements). It may also preclude local control of landfills by towns within zones excluding landfills.

Excluding the development of water supply wells similarly increases water supply costs. Wells will have to be developed outside of certain zones, thus requiring additional piping and pumping costs.

A fertilizer management program may reduce a farmer's output or raise his costs by forcing him to use more expensive alternative fertilizers. Reduced profit will also reduce income tax revenues.

4.4.1.2 Plan Options by Surface Water Bodies. Table 4—38 presents the elements of the NSRPB plan options for surface water bodies. Here again, the elements are displayed according to the accuracy with which their costs can be estimated. The problems of estimating costs for these elements are subsumed in the previous discussion.

4.4.2 Estimates of "Hard" Cost Components for Representative Alternative Plans. In costing alternatives, it is necessary to quantify as many of the cost components as can be accurately and objectively derived, and to then rely on human value judgements in assigning a relative value to those costs that cannot be quantified. One still remains on shaky ground. This section will present representative calculations on the quantifiable costs for three different wastewater treatment alternatives for Nassau and Suffolk Counties. In addition, those aspects that are basically unquantifiable will be identified and discussed briefly, while the task of placing a value judgement on their relative costs will be left to the 201 level studies.

The present worth cost data has been taken by ERCO from estimates by Roy F. Weston in *Nassau County Wastewater Management*, October 1977. The average (levelized) annual cost for the three alternatives was obtained by dividing the present worth by 11.129, which is the appropriate conversion factor for calculations using a twenty year planning period and a discount rate of 6.375 percent.

Of the annual costs to be incurred, capital costs are subsidized by both the Federal Government and the State of New York, and operating and maintenance (O & M) costs are subsidized by the State. Because the available data did not specify the projected net cost to the counties, it was necessary to select a subsidy rate that would reflect both the capital and O & M subsidies as well as the fact that O & M costs are incurred throughout the period and are thus subject to the discount rate of 6.375 percent. A subsidy rate of 75 percent was estimated for purposes of analysis.

To obtain the average annual cost to the county as a percentage of the tax structure, the estimate of the average annual cost is divided by an estimate of the tax revenues for Nassau and Suffolk Counties. Ideally, this

Table 4—38

NATURE OF COST UNCERTAINTIES FOR SURFACE WATER ALTERNATIVES

Water Body	Alternative	Straight Engineering	Engineering with Speculation	Difficult to Estimate	Speculative
Manhasset Bay	(a) (i)	Nitrogen Removal			
	(a) (ii)	Move Outfall			
	(a) (iii)	Divert to Cedar Creek			
	(a) (iv)	Divert to Port Washington			
	(a) (v)				No Action
Hempstead Harbor	(a) (i)	Nitrogen Removal			
	(a) (ii)	Move Outfall			
	(a) (iii)	Divert to Glen Cove, Port Washington, or Cedar Creek			
	(a) (iv)				No Action
	(b)		Maintain and Abate Industrial Discharges to Glen Cove Creek		
Oyster Bay	(a) (i)	Retain Present Treatment			
	(a) (ii)	Divert to Cedar Creek			
	(a) (iii)	Nitrogen Removal			
	(a) (iv)	Divert to Glen Cove			

Table 4–38 . . . Cont'd

Water Body	Alternative	Straight Engineering	Engineering with Speculation	Difficult to Estimate	Speculative
Huntington Bay	(a) (i)	Nitrogen Removal			
	(a) (ii)	Move Outfall			
	(a) (iii)		Tertiary Treatment and Recharge		
	(a) (iv)	Divert to Regional Site			
Port Jefferson Harbor	(a) (i)	Secondary Treatment			
	(a) (ii)	Nitrogen Removal			
	(a) (iii)	Move Outfall			
Flanders Bay—Peconic Estuary	(a) (i)	Nitrogen Removal			
	(a) (ii)	Move Outfall			
	(a) (iii)	Nitrogen Removal			
		Move Outfall			
	(a) (iv)	Move Outfall			
	(c)		Monitoring		
Mecox Bay	(a) (i)				Prohibit New Discharges
	(a) (ii)	Nitrogen Removal			
	(b)			Stabilize Inlet	
	(c) (i)				Severely Restrict Development
Shinnecock Bay	(a) (i)				Prohibit New Discharges
	(a) (ii)			Maintain Inlet	
	(b) (i)				Severely Restrict Development
Moriches Bay	(a) (i)				Prohibit New Discharges
	(a) (ii)	Nitrogen Removal			
Great South Bay	(a) (i)	Ocean Outfall			Prohibit New Discharges
	(a) (ii)		Tertiary Treatment and Recharge		Prohibit New Discharges
	(a) (iii)	Nitrogen removal			
	(b)			Construct New Inlet	
	(c) (v)				Prohibit New Development
Western South Shore Bays	(a) (i)	Ocean Outfalls			
	(a) (ii)	Divert Outfall			
	(a) (iii)		Upgrade Lawrence Treatment Facility		
Nearshore Atlantic Ocean					Strict Enforcement of Ocean Dumping Regulations
Fresh Water Bodies	(a)	Nitrogen Removal			

estimate of the tax revenue should be an estimate of the forecasted average annualized tax revenues through the twenty year planning period. However, no such estimates have been obtained. Therefore, it was necessary to use historic data for each county. For Nassau County, the tax revenue estimates were obtained from a prospectus for a recent county bond issue that included the average revenue for the period 1970–1974. This figure has been used as a measure of estimated future tax revenue, and is likely to understate tax revenues, which are presumed to grow over time. For Suffolk County, the value used for future estimated tax revenue is the 1976 tax revenue figure given by a prospectus for 1977 Southwest Sewer District Refunding Bonds.

A. *Alternative 1.*[1] One Dwelling Unit (D.U.) Per Gross Acre Sewering for All Groundwater Zones; Non-structural Non-point Controls; All Bay Discharges to Ocean or Sound.

The cost figures developed by Roy F. Weston are formulated for different scenarios. By selecting the costs that correspond to the specifications in Alternative One, a total for the quantifiable costs can be obtained. Table 4–39 presents the total quantifiable costs in both Nassau and Suffolk Counties, assuming a control strategy corresponding to Alternative One. The costs are broken down into costs for sewering and treatment, for non-structural non-point source pollution controls and for hazardous industrial waste treatment. Each of those categories is in turn expressed in terms of average (annualized) cost *to the county* as a percentage of tax revenues based on the estimates discussed earlier. A similar procedure is followed for Alternatives Eight and Twenty-one, which are presented in Tables 4–40 and 4–41 and are as follows:

B. *Alternative 8.* One Dwelling Unit Per Gross Acre Sewering for All Groundwater Zones; Structural Non-point Controls; South Shore Bay Discharges to Ocean; North Shore Bay Discharges to be Secondary Treated Mid-Bay Outfalls.

C. *Alternative 21.* Strict Fertilizer Controls, Five Dwelling Units Per Gross Acre Sewering for All Groundwater Zones; Structural Non-point Controls; South Shore Bay Discharges to Ocean; North Shore Bay Discharges to be AWT Outfalls at Inner Harbor Sites.

For all four categories in each of the three alternatives, the least expensive regional option was selected. Where no regional options were given in the sources, the least expensive existing option was chosen. Therefore, it is quite possible that the costs could be higher if different strategies were adopted for some reason other than cost. Keep in mind also that the costs presented are only those costs borne by the respective counties. The remainder of the burden is covered by Federal and State Government subsidies at a rate of 75 percent of the total cost.

The calculated cost estimates exclude the costs of laterals, which may be on the order of 100 percent of other collection and treatment costs. As can be seen from Tables 4–39 to 4–41, the relative quantifiable costs for all three alternatives are fairly similar, but are more expensive for Suffolk

Table 4–39

WASTEWATER DISPOSAL FINANCIAL BURDEN[1]

Alternative One: One D.U./Gross Acre Sewering for all Groundwater Zones, Non-structural Non-point Controls; All Bay Discharges to Ocean or Sound

Costs To County	Millions of Dollars			
	Nassau		Suffolk	
	Average Annual	% Tax Revenue	Average Annual	% Tax Revenue
Sewering & Treatment*	7.8	3.1	31.525	27.2
Sludge Disposal (Regional Composting)**	1.8	.7	4.2	3.6
Nonstructural Non-point Control Costs†	.2	.07	.38	.33
Hazardous Industrial Waste Treatment Costs†	.1	.04	.16	.14
	9.9	3.9	36.3	31.3

**Source: Roy F. Weston and SUNY at Stony Brook, Nassau County Wastewater Management, October 1977. "Final Output of Recommended Treatment Levels and Sensitivity Runs."*

***Source: Nassau Suffolk Regional Planning Board, 208 Areawide Waste Treatment Management. Section K, "Residual Waste Control Needs," November 1977.*

†Source: Same as above except Section L, "Urban and Industrial Stormwater Systems Needs, November 1977.

[1]Costs exclude costs of laterals which may equal the total of all other collection and treatment costs.

County than for Nassau County, where a considerable portion of the area is already sewered. The magnitude of the costs for Alternatives One, Eight and Twenty-one may range from about 3.9 to 4.3 percent of Nassau's single year tax revenues, while the relevant magnitude of costs in Suffolk may range from about 30.8 to 33.6 percent of the county's single year tax revenues. In other words, if the costs implied in one of the three selected alternatives were incurred in a single year, the cost could total about four percent and 30 percent of Nassau and Suffolk's tax revenues, respectively, for that year. In fact, however, it must be realized that capital costs for water treatment purposes are typically borne through time, and in staged amounts, by means of bonding. Moreover, the gestation period of such investments requires that the construction and the cost of such projects be phased through time.

[1]Alternatives discussed in Section H of the Areawide Waste Treatment Management Plan.

Table 4–40

WASTEWATER DISPOSAL FINANCIAL BURDEN[1]

Alternative Eight: One D.U./Gross Sewering for all Groundwater Zones; Structural Non-point Controls; South Shore Bay Discharges to Ocean; North Shore Bay Discharges to be Secondary Treated Mid-Bay Outfalls

Millions of Dollars

Costs To County	Nassau Average Annual	Nassau % Tax Revenue	Suffolk Average Annual	Suffolk % Tax Revenue
Sewering & Treatment*	6.4	2.5	31.5	27.2
Sludge Disposal (Regional Composting)**	1.8	.7	4.2	3.6
Non-structural Non-point Controls†	1.7	.7	3.1	2.7
Hazardous Industrial Waste Disposal Costs†	.1	.04	.16	.14
	10.0	3.9	38.95	33.64

**Source: Roy F. Weston and SUNY at Stony Brook, Nassau County Wastewater Management, October 1977. "Final Output of Recommended Treatment Levels and Sensitivity Runs."*

***Source: Nassau Suffolk Regional Planning Board, 208 Areawide Waste Treatment Management. Section K, "Residual Waste Control Needs," November 1977.*

†Source: Same as above except Section L, "Urban and Industrial Stormwater Systems Needs, November 1977.

[1]Costs exclude costs of laterals which may equal the total of all other collection and treatment costs.

4.4.2.1 Uncertainties in the Costs. The costs given here should be taken as order of magnitude costs only. A number of factors contribute to this, including the following:

1. The costs are estimates and involve basic uncertainties in their formulation, as do all estimates of future costs.

2. The capital costs have been amortized over a twenty year life span and with a 6.375 percent discount rate. Changing the period of time or the discount rate will change the average annual cost as well.

3. The tax revenues are estimated from actual historic revenue data. Thus, they most likely understate the tax revenues that are expected to increase with time as the area grows.

4. The costs used are for the least expensive of the regional plan estimates. If other waste treatment options are adopted, the cost would increase correspondingly.

Table 4–41

WASTEWATER DISPOSAL FINANCIAL BURDEN[1]

Alternative Twenty-one: Strict Fertilizer Controls; 5 D.U./Acre Sewering for all Groundwater Zones; Structural Non-point Controls, South Shore Bay Discharges to Ocean; North Shore Bay Discharges to be AWT Outfalls at Inner Harbor Sites

Millions of Dollars

Costs To County	Nassau Average Annual	Nassau % Tax Revenue	Suffolk Average Annual	Suffolk % Tax Revenue
Sewering & Treatment*	7.2	2.9	28.3	24.4
Sludge Disposal (Regional Composting)**	1.8	.7	4.2	3.6
Non-structural Non-point Controls†	1.7	.7	3.1	2.7
Hazardous Industrial Waste Disposal Costs†	.1	.04	.16	.14
	10.8	4.3	35.76	30.84

**Source: Roy F. Weston and SUNY at Stony Brook, Nassau County Wastewater Management, October 1977. "Final Output of Recommended Treatment Levels and Sensitivity Runs."*

***Source: Nassau Suffolk Regional Planning Board, 208 Areawide Waste Treatment Management. Section K, "Residual Waste Control Needs," November 1977.*

†Source: Same as above except Section L, "Urban and Industrial Stormwater Systems Needs," November 1977.

[1]Costs exclude costs of laterals which may equal the total of all other collection and treatment costs.

It should be evident, then, that care must be taken when utilizing any of these figures for comparison of the alternatives. It should also be clear that other factors play a part in any decision involving any choice of waste treatment alternatives.

4.4.2.2 Unquantifiable Costs. Some of the other important factors to consider come under the rubric of opportunity costs. For these elements, costs are not dollars spent for equipment and operation, but rather savings or revenues foregone because of the loss of opportunity to accrue them. For example, land use controls (*e.g.*, buffer zones or stricter controls forbidding certain forms of development) may cause the loss of business opportunities

or other alternatives that would have resulted in benefits for the community. Thus, the cost of that land use control is the direct cost of implementing the control *plus* the foregone benefits that would have resulted had the control not been implemented. It is clear that foregone future benefits are virtually impossible to predict, and that it is even more difficult to place a dollar figure on their social and dollar value. However, they embody a cost to society and must not be dismissed out of hand as trivial or inconsequential. Opportunity costs can neither be accurately quantified nor ignored. Therefore, intelligent estimates must be made about the magnitude of the opportunity cost involved and some measure of a subjective judgment must occur as to which alternatives will be chosen. The scope of this report does not extend to such a task; it will be left to the policymakers.

4.4.3 Secondary Impacts of Pretreatment. Pretreatment requirements can be expected to induce secondary economic effects. Adequate pretreatment will be very costly for some industrial dischargers who generate residuals for which simple removal technologies have not been developed. The economic burdens to industrial dischargers will be very unevenly distributed depending on the match of the state-of-the-art of wastewater engineering to particular waste streams. Small industries can be expected to suffer a high burden, percentage-wise. Detailed economic analyses will be required as part of the special studies.

4.5 Overall Impacts and Discussion

4.5.1 Aggregate Bi-County Impacts. This section takes an Island-wide view of the various measures that were discussed in Sections 4.2 to 4.16 on a bay-by-bay and zone-by-zone basis. This Island-wide view lends itself to consideration of intermedia pollutant tradeoffs. Such tradeoffs include the following: groundwater/surface water, surface water/solid waste, and groundwater/wetland quality. These tradeoffs are presented in terms of net residual loadings to the various media for seven alternatives in Tables 4–42 to 4–48.

The residuals loadings have been calculated by use of a residuals allocation procedure developed by ERCO (Beck and Post, 1978). Values of eight variables are calculated for eight bays, eight groundwater zones, Long Island Sound and the Atlantic Ocean. In many cases the values are only order-of-magnitude estimates. However, these estimates are useful for the study of Island-wide patterns and intermedia tradeoffs. This residuals allocation procedure provides a summary and overview of the detailed studies, models and analyses that have constituted the Nassau-Suffolk 208. The values of variables have been specified using data from many of the 208 technical reports.[1]

Twenty-two Island-wide control strategies were considered using this procedure. These twenty-two alternatives cover a wide range of approaches including sewering (one dwelling unit per acre sewering Island-wide), nonstructural groundwater nitrogen control with selective sewering (five dwelling units per gross acre sewering Island-wide), recharge of effluent, ocean disposal of all effluents, and no action. The complete list of alternatives is given in Table 4–49.

The tradeoffs fall into several groups. First, choice of sewering at low densities is expected to lower groundwater nitrogen; add more surface nitrogen; decrease streamflow, unless recharge completely mitigates the effect; and generate additional solid waste. Choice of ocean outfalls preserves bay conditions at the expense of Long Island Sound or ocean nitrogen loading. Choice of recharge may introduce various contaminants into the groundwater, but mitigates streamflow decreases and improves bay nitrogen conditions.

Organic chemicals are not included in the residuals allocation because there is no basis for formulating estimates. Inventories of sources of organic chemical contaminants are still being assembled. Thus any load estimates would be pure guesswork. An assessment of relative contribution of domestic versus industrial loads does not exist. If organic chemicals follow the pattern of other contaminants, non-point and domestic disposal sources can be expected to be proportionately important. Chlorinated effluents may be a dominant load. Due to the uncertainty concerning all sources, the plan elements presented in Section Three can only be assumed to provide control of several specific sources of organic contaminants. Other important sources, such as runoff recharge basins, are not yet included in the plan. Thus, due to the nature of the health risks imposed by the organic chemicals, further work including source inventories and analyses, ambient monitoring, and technology research, is of high priority from an environmental viewpoint.

Air pollutants are also not included in the residual allocation summaries. The major potential for air pollution is in the disposal of treatment plant sludges. The sludge loading numbers give a general picture of air pollution potential if incineration is the selected disposal method. However, there are many alternatives for sludge disposal. Composting and land application involve a minimum of air pollution. Pyrolysis contributes a smaller suite of air residuals than incineration, although the fine particulates contributed by pyrolysis are particularly troublesome. Thus, from an air pollution standpoint, composting and land application are favored approaches.

As can be seen from the residuals loading allocation tables comparing the 22 options, there is no clearly environmentally preferable strategy. Certain classes of risks will have to be tolerated in order to minimize others that are deemed more critical. Among the water quality problems least reversible, and therefore of greatest concern, are high organic chemical

[1] Major sources:
Nitrogen and Coliform: Point source loads for 1995 at one dwelling unit per acre by Weston (1977a). Non-point source loads to bays by Tetra Tech. Non-point source loads to groundwater by Porter *et al.* (1978).
Sludge: 1995 loads for one dwelling unit per acre by Weston (1977b).
Streamflows: ERCO judgements based on Miller and Sgambat (1977a).
Metals: Point Sources, Weston (1977c); *Non-point Sources,* Weston (1977d).

Table 4–42

ALTERNATIVE 1: 1 D.U./GROSS ACRE SEWERING FOR ALL GROUNDWATER ZONES; NON-STRUCTURAL NON-POINT CONTROLS; ALL BAY DISCHARGES TO OCEAN OR SOUND

	Surface Bays								Groundwater Zones							
	Manhasset	Hempstead Harbor	Oyster Bay	Huntington/Northport	Port Jefferson	Peconic/Flanders	Suffolk South Shore	Nassau South Shore	Zone I	Zone II	Zone III	Zone IV	Zone V	Zone VI	Zone VII	Zone VIII
Nitrogen:																
—surface (lbs/day)	671	1,150	1,290	1,420	612	264	6,350	4,540								
—groundwater (lbs/acre yr)									165	165	175	200	125	165	165	200
Total Coliform (Organisms/day)	$5x10^{13}$	$7x10^{13}$	$1x10^{14}$	$1x10^{14}$	$5x10^{13}$	$6x10^{12}$	$2x10^{14}$	$4x10^{14}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$
Water Table (Change (Δ feet)	0	0	0	0	0	0	0	0	0	0	0	–1	–2.5	–2.5	–2.5	–2.5
Sludge (dry lbs/yr)	0	0	0	0	0	0	0	0	0	0	99,000	35,000	0	140,000	373,000	453,000

	Total Surface Water	Total Groundwater
Cu (lbs/yr)	52,000	42,000
Cr (lbs/yr)	110,000	97,000
Pb (lbs/yr)	290,000	81,000
Ni (lbs/yr)	100,000	75,000

contaminant levels in groundwater, nitrate contamination of groundwater, changes in stream and wetland water levels, and changes in bay salinity patterns. The final choices will rest with the policymakers.

4.5.2 Discussion of Sewering Density and Groundwater Nitrates. This section addresses the relationship between groundwater nitrate levels and sewering practices. In the following subsections analyses of nitrate data are reviewed, observations on interpretation of the data are given, control measure implications are discussed, and the position of nitrate concerns in the general context of intermedia environmental tradeoffs is presented. There is no optimal solution. The environmental tradeoffs are many and each tradeoff is complex. This section seeks to point out the positive and negative impacts of sewering. It is hoped that the planner, armed with this knowledge, will use sewering properly—as only one of many tools to be employed in the complex task of balancing the numerous environmental demands.

There are many public health and ecological objectives that must be weighed against the nitrate standard. In such a complex Water Quality Management Plan, it would be dangerous to base large portions of the Plan on one variable—dangerous in the sense that other variables may not be addressed. The real environmental objective function has many dimensions. Hence, it is environmentally unsound to proceed with comprehensive sewering (one dwelling unit per gross acre), or indeed even less extensive sewering plans (two dwelling units per gross acre or three dwelling units per gross acre

Table 4–43

ALTERNATIVE 8: ONE D.U./ACRE SEWERING FOR ALL GROUNDWATER ZONES; STRUCTURAL NON-POINT CONTROLS; SOUTH SHORE BAY DISCHARGES TO OCEAN; NORTH SHORE BAY DISCHARGES TO BE SECONDARY TREATED MID-BAY OUTFALLS

	Surface Bays								Groundwater Zones							
	Manhasset	Hempstead Harbor	Oyster Bay	Huntington/Northport	Port Jefferson	Peconic/Flanders	Suffolk South Shore	Nassau South Shore	Zone I	Zone II	Zone III	Zone IV	Zone V	Zone VI	Zone VII	Zone VIII
Nitrogen: —surface (lbs/day)	5,730	4,110	2,360	9,650	2,660	7,250	5,910	4,180								
—groundwater (lbs/acre/yr)									165	165	175	200	125	165	165	200
Total Coliform (organisms/day)	$3x10^{13}$	$5x10^{13}$	$7x10^{13}$	$8x10^{13}$	$3x10^{13}$	$4x10^{12}$	$1x10^{14}$	$2x10^{14}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$
Water Table Change (Δ feet)	0	0	0	0	0	0	0	0	0	0	0	−1	−2.5	−2.5	−2.5	−2.5
Sludge (dry lbs/yr)	0	0	0	0	0	0	0	0	99,000	35,000	0	140,000	373,000	453,000	0	0

	Total Surface Water	Total Groundwater
Cu (lbs/yr)	29,400	24,000
Cr (lbs/yr)	63,800	54,800
Pb (lbs/yr)	164,000	44,500
Ni (lbs/yr)	56,900	42,400

Island-wide sewering), which are mainly justifiable only with respect to groundwater nitrogen. Selective sewering is certainly justified. Certain areas with high groundwater elevations, areas with very high population densities (over five dwelling units per gross acre, above which it becomes clear that non-point controls will in very few cases be sufficient) (Weston, 1977a; 1976) and certain other areas that may be identified by monitoring will require sewering; further collection of monitoring data is needed.

A major objective of bi-county 201's or further areawide planning should be collection and analysis of groundwater data for various contaminants. Sewering of large areas, especially along the South Shore, is environmentally unsound with respect to the interruption of hydrological and chemical cycles. Controls of other nitrogen sources and non-structural controls of septic tank performance should be preferentially implemented. One aspect of the water quality management program should be implementation of a permanent mapping and analysis program to lay out and update nitrate and organic chemicals susceptibility zones.

Finally it should be noted that a major cause of nitrate buildups in groundwater is the alteration of natural nutrient cycling by removal of natural forest and marsh ecosystems. The best control strategy is an approach that minimizes such alterations, and includes land use controls, fertilizer controls and runoff controls, such as marsh-pond systems in runoff recharge basins. With this approach, emphasis must be placed on implementation and

Table 4—44

ALTERNATIVE 10: RECHARGE OF SOUTH SHORE TREATMENT PLANT EFFLUENTS (SECONDARY TREATMENT); MAXIMUM LAND USE CONTROLS AND NON-STRUCTURAL CONTROLS IN GROUNDWATER ZONE III; NORTH SHORE BAY DISCHARGES TO BE SECONDARY TREATED MID-BAY OUTFALLS; 1 D.U./GROSS ACRE SEWERING

	Surface Bays								Groundwater Zones							
	Manhasset	Hempstead Harbor	Oyster Bay	Huntington/Northport	Port Jefferson	Peconic/Flanders	Suffolk South Shore	Nassau South Shore	Zone I	Zone II	Zone III	Zone IV	Zone V	Zone VI	Zone VII	Zone VIII
Nitrogen:																
—surface (lbs/day)	5,800	4,200	2,470	9,800	2,740	7,260	6,350	4,540								
—groundwater (lbs/acre/yr)									12,100	165	175	200	125	263	1,170	200
Total Coliform (organisms/day)	$6x10^{13}$	$8x10^{13}$	$1x10^{14}$	$1x10^{14}$	$5x10^{13}$	$6x10^{12}$	$2x10^{14}$	$4x10^{14}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$
Water Table Change (Δ feet)	0	0	0	0	0	0	0	0	0	0	0	−1	−2.5	−.5	−.5	−2.5
Sludge (dry lbs/yr)	0	0	0	0	0	0	0	0	0	0	99,000	35,000	0	140,000	373,000	453,000

	Total Surface Water	Total Groundwater
Cu (lbs/yr)	9,620	84,800
Cr (lbs/yr)	16,000	195,000
Pb (lbs/yr)	212,000	160,000
Ni (lbs/yr)	25,700	151,000

enforcement of these controls, since their operability is less straightforward than that of sewering.

4.5.2.1 Review of the Data Analyses Done as Part of Water Quality Management Program Planning. Two analyses of observation well data have been done as part of the Nassau-Suffolk 208 Program.[1] One analysis is based on data from 127 samples. The samples selected conform to the following selection criteria: (a) Samples were restricted to wells from unsewered locales with population densities relatively stable over a twenty year period; (b) Samples were from depths less than 100 feet; (c) Samples were restricted to 1970 to the present. These conditions attempted to avoid the time of travel problems between population density input and well measurements. Weston arranged the data into five groups based on school districts. The results of their analysis are presented in Table 4—50.

A separate analysis was done using a larger sample of well measurements (Porter *et al.,* 1978). Porter's analysis proceeded by grouping the data according to uniform sized grid cells, which were smaller in size than the school districts used by Weston. The grid cells used, covered a larger geographic extent than Weston's school districts. Only grid cells covering areas

[1] A third analysis, by the USGS, has not yet been published or released, and is therefore not covered in detail in this discussion.

Table 4–45

ALTERNATIVE 12: 5 D.U./GROSS ACRE SEWERING FOR ALL GROUNDWATER ZONES; NON-STRUCTURAL NON-POINT CONTROLS; SOUTH SHORE BAY DISCHARGES TO OCEAN; NORTH SHORE BAY DISCHARGES TO BE SECONDARY TREATED MID-BAY OUTFALLS

	Surface Bays								Groundwater Zones							
	Manhasset	Hempstead Harbor	Oyster Bay	Huntington/Northport	Port Jefferson	Peconic/Flanders	Suffolk South Shore	Nassau South Shore	Zone I	Zone II	Zone III	Zone IV	Zone V	Zone VI	Zone VII	Zone VIII
Nitrogen:																
—surface (lbs/day)	3,240	2,680	1,880	5,610	1,670	3,760	6,350	4,540								
—groundwater (lbs/acre/yr)									290	290	300	325	250	290	290	325
Total Coliform (organisms/day)	5×10^{13}	7×10^{13}	1×10^{14}	1×10^{14}	5×10^{14}	5×10^{13}	2×10^{12}	4×10^{14}	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$
Water Table Change (Δ feet)	0	0	0	0	0	0	0	0	0	0	0	0	–.5	–.5	–.5	–.5
Sludge (dry lbs/yr)	0	0	0	0	0	0	0	0	0	0	49,500	17,500	0	70,000	187,000	227,000

	Total Surface Water	Total Groundwater
Cu (lbs/yr)	9,620	84,800
Cr (lbs/yr)	16,000	195,000
Pb (lbs/yr)	212,000	160,000
Ni (lbs/yr)	25,700	151,000

completely sewered or completely unsewered were analyzed. Results of Porter's analysis are given in Tables 4–51 and 4–52.

Both Weston and Porter analyzed their data sets by linear regression. Figure 4–3 presents the derived regression lines. (Table 3–11 presented in Section 3.5.2 is not a data table, but is, rather, a tabular presentation of the linear regression analysis performed by Porter.)

The USGS reports the following provisional findings based on their data:

"When the upper glacial aquifer is treated as a single unit over the entire period of record (1952–76), median nitrate concentrations show no difference over time or between the sewered and unsewered parts of the study area. Care must be exercised when comparing medians from one time interval to another because of bias introduced by the abandonment of wells, changes in samples (analyses) size, changes in sampling frequency, and changes due to hydrologic events (drought, wet periods).

Median ammonium concentrations (as N) of 0.01 milligrams per liter for the sewered area and 1.1 milligrams per liter for the unsewered area for the most recent time interval (1972–76) reflect an improvement in water quality in the sewered area. Of thirteen wells having long-term water quality records (fifteen years or more) in the sewered part of the study area, eight had significant decreasing trends in nitrate concentration with a median value of 0.21 milligrams per liter per year. Two wells had significant increasing

Table 4–46

ALTERNATIVE 14: NO ACTION

	Surface Bays								Groundwater Zones							
	Manhasset	Hempstead Harbor	Oyster Bay	Huntington/Northport	Port Jefferson	Peconic/Flanders	Suffolk South Shore	Nassau South Shore	Zone I	Zone II	Zone III	Zone IV	Zone V	Zone VI	Zone VII	Zone VIII
Nitrogen: —surface (lbs/day)	5,870	4,290	2,580	9,950	2,810	7,280	6,800	4,900								
—groundwater (lbs/acre/yr)									290	290	300	325	250	290	290	325
Total Coliform (organisms/day)	$8x10^{13}$	$1x10^{14}$	$2x10^{14}$	$2x10^{14}$	$8x10^{13}$	$8x10^{12}$	$3x10^{14}$	$4x10^{14}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$
Water Table Change (Δ feet)	0	0	0	0	0	0	0	0	0	0	0	0	<.5	<.5	<.5	<.5
Sludge (dry lbs/yr)	0	0	0	0	0	0	0	0	0	0	34,700	12,200	0	49,000	131,000	159,000

	Total Surface Water	Total Groundwater
Cu (lbs/yr)	10,700	94,000
Cr (lbs/yr)	17,800	217,000
Pb (lbs/yr)	235,000	178,000
Ni (lbs/yr)	28,500	167,000

trends and three wells showed no trends. In the unsewered area there was only one well with a long record of nitrate analyses, and this well had a significant increasing trend in nitrate concentrations.

4.5.2.2 Interpretation of Data Analysis. As pointed out in reports by Miller and Sgambat (1977a) and others, the movements and fates of nitrates introduced to the groundwater are very complex. Thus, a conclusive analysis of groundwater nitrate data is very difficult and wholly beyond the scope of the water quality management program. Review of individual well measurements as well as consideration of summarized data indicate the complexity of the nitrate distribution trends.

Some wells have been sampled many times. Hence, some consideration of individual sites and grids is justified. Individual grid cell data from Porter's analysis shows high and low nitrate levels occurring at the full range of population levels. In some grids, high population densities seem to be accompanied by high nitrate levels; but in other grids, such a relationship cannot be discerned.

Summary statistics of Porter's data set show a net lower nitrate level in Upper Glacial groundwater in sewered grids as opposed to unsewered grids. However, the information provided does not fully eliminate the possible effects of sewering from other density-related factors. Some of the other factors contributing to the lower nitrate levels may be (a) less fertilizer use in higher density areas; (b) changed runoff-recharge patterns due to impervious

Table 4–47

ALTERNATIVE 21: STRICT FERTILIZER CONTROLS, 5 D.U./GROSS ACRE SEWERING FOR ALL GROUNDWATER ZONES; STRUCTURAL NON-POINT CONTROLS; SOUTH SHORE BAY DISCHARGES TO OCEAN; NORTH SHORE BAY DISCHARGES TO BE AWT OUTFALLS AT INNER HARBOR SITES

	Surface Bays								Groundwater Zones							
	Manhasset	Hempstead Harbor	Oyster Bay	Huntington/Northport	Port Jefferson	Peconic/Flanders	Suffolk South Shore	Nassau South Shore	Zone I	Zone II	Zone III	Zone IV	Zone V	Zone VI	Zone VII	Zone VIII
Nitrogen: —surface (lbs/day)	862	1,210	1,230	1,690	640	604	5,910	4,180								
—groundwater (lbs/acre/yr)									275	275	225	225	225	275	275	275
Total Coliform (organisms/day)	$3x10^{13}$	$5x10^{14}$	$7x10^{13}$	$8x10^{13}$	$3x10^{13}$	$4x10^{12}$	$1x10^{14}$	$2x10^{14}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$
Water Table Change (Δ feet)	0	0	0	0	0	0	0	0	0	0	0	0	–.5	–.5	–.5	–.5
Sludge (dry lbs/yr)	0	0	0	0	0	0	0	0	0	0	49,500	17,500	0	70,000	187,000	227,000

	Total Surface Water	Total Groundwater
Cu (lbs/yr)	5,430	48,000
Cr (lbs/yr)	9,050	110,000
Pb (lbs/yr)	119,000	89,000
Ni (lbs/yr)	14,500	84,800

surfaces in densely populated areas; (c) less vegetation, with associated organic cycles and root zone activity; (d) changing land uses and, (e) geologic characteristics. The apparent mean difference in groundwater nitrate levels between sewered and unsewered areas is 1.3 milligrams per liter for a 6.8 persons per acre difference in population density.

Porter attempts to take into account variability of nitrate concentrations over time and by locale. His analysis of such variability led to selection of a mean of six milligrams per liter NO_3 as N as a guideline number for achieving 90 percent compliance with the ten milligrams per liter standard.

Porter's regression analysis indicates a statistically significant correlation of a high order. However, Porter has eliminated two data points on the basis of a plausibility screen before running his analysis and these observations may reduce the statistical significance of his result.

Weston's regression analysis is statistically significant at the 95 percent level. The zero population point used in the Weston analysis was taken from a different set of data and does not conform to the screening criteria previously discussed. It is possible that Weston's data base did not cover a wide enough range of population densities and their zero population point did not actually represent "natural" conditions. The sensitivity of groundwater nitrate concentrations to sewering density numbers in populated areas from a zero population data point may not be a wholly relevant

Table 4–48

ALTERNATIVE 22: 5 D.U./GROSS ACRE SEWERING FOR ZONES III, IV, V, VIII;
1 D.U./GROSS ACRE SEWERING FOR ZONES I, II, VI, VII, SECONDARY MID-BAY DISCHARGES ON THE NORTH SHORE;
OCEAN OUTFALL ON THE SOUTH SHORE; NON-STRUCTURAL NON-POINT CONTROLS

	Surface Bays								Groundwater Zones							
	Manhasset	Hempstead Harbor	Oyster Bay	Huntington/Northport	Port Jefferson	Peconic/Flanders	Suffolk South Shore	Nassau South Shore	Zone I	Zone II	Zone III	Zone IV	Zone V	Zone VI	Zone VII	Zone VIII
Nitrogen: —surface (lbs/day)	3,240	2,680	1,880	5,610	1,670	3,760	6,350	4,540								
—groundwater (lbs/acre/yr)									290	290	100	200	125	290	290	200
Total Coliform (organisms/day)	7×10^{13}	1×10^{14}	1×10^{14}	5×10^{14}	6×10^{12}	2×10^{14}	4×10^{14}	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$	$<10^{10}$
Water Table Change (Δ feet)	0	0	0	0	0	0	0	0	0	0	0	−1	−2.5	−2.5	−2.5	−.5
Sludge (dry lbs/yr)	0	0	0	0	0	0	0	0	0	0	49,500	17,500	0	140,000	373,000	227,000

	Total Surface Water	Total Groundwater
Cu (lbs/yr)	9,620	84,800
Cr (lbs/yr)	16,000	195,000
Pb (lbs/yr)	212,000	160,000
Ni (lbs/yr)	25,700	151,000

analysis.

Since the purpose of the analysis is to compare sewered versus unsewered areas, the arguments in favor of including "natural" conditions or a "wide" range of population densities may not be particularly relevant. The unsewered areas of concern may also have high population densities. At least two interpretations of the Weston and Porter data are possible: (A) there may, in fact, be a rough cause-effect relationship between population density and groundwater nitrates, or (B) there may be a hyberbolic relationship between the two variables, such that at low populations densities groundwater nitrogen is low, and at densities greater than one half to one dwelling unit per gross acre, nitrate levels are high; they do not increase linearly, and may not be closely related to on-lot systems density. (See Figure 4–4.)

All data is from Upper Glacial wells. Thus, the data analysis does not present conditions of Magothy water supplies. The time horizon for travel of sampled waters to waters tapped for supply may be five to 200 years. Thus, the efficacy of acting on the basis of an Upper Glacial pollution threshold is somewhat uncertain. On the basis of nondegradation arguments, one would take non-point control measures with or without sewering. On the basis of expected net dollar returns on investment through time, expensive control measures may not be called for due to future technological advances in the state of the art,which may make nitrate removal a less costly technique,

Table 4–49

SUMMARY OF ALTERNATIVES CONSIDERED

Alternative	Description
(1)	1 D.U./Gross acre sewering for all grounwater zones; non-structural non-point controls; all bay discharges to ocean and Sound.
(2)	1 D.U./Gross acre sewering for all groundwater zones; non-structural non-point controls; south shore discharges to ocean; north shore bay discharges to be secondary treated, mid-bay outfalls.
(3)	1 D.U./Gross acre sewering for all groundwater zones; non-structural non-point controls; south shore bay discharges to ocean; north shore bay discharges to be AWT, outfalls at the present inner harbor locations.
(4)–(6)	2 D.U./Gross acre sewering for all groundwater zones; the same set of alternatives as (1)–(3) in all other respects.
(7)–(9)	Structural non-point controls; the same set of alternatives as (1)–(3) in all other respects.
(10)	Recharge for south shore treatmnet plants; maximum land use and non-structural controls in Groundwater Zone III; secondary treatment and mid-bay outfalls for north shore bays.
(11)–(13)	5 D.U./Gross acre sewering for all groundwater zones; the same set of alternatives as (7)–(9) in all other respects.
(14)	No action.
(15)–(17)	5 D.U./Gross acre sewering for all groundwater zones; the same set of alternatives as (7)–(9) in all other respects.
(18)	Maximum land use and non-structural controls for Groundwater Zone III; otherwise the same alternatives as (22).
(19)–(21)	Strict fertilizer controls; otherwise the same alternatives as (15)–(18).
(22)	5 D.U./Gross acre sewering for Zones III, VIII, IV, V; 1 D.U./Gross acre sewering for Zones I, II, VI, VII; secondary treatment and mid-bay discharge on the north shore and ocean outfalls on the south shore.

as well as possible economic changes.

USGS analysis of streams suggests that unsewered areas at a given density contribute more nitrogen to surface waters than sewered areas. However, lack of stream ecology surveys limits the usefulness of that result.

USGS aggregate analyses of Upper Glacial groundwater data gave no conclusive indication of differences in nitrogen levels between sewered and

Table 4–50

FINAL DATA SET INDICATING THE RELATIONSHIP BETWEEN POPULATION DENSITY AND RESULTING NITRATE CONTAMINATION BY SCHOOL DISTRICT

School District	Average Population Density Per Acre	Average NO_3–N Concentration 1970–Present
Westbury	8.0	11.3
Hicksville	11.2	9.4
Island Trees	12.4	13.9
East Meadow	10.5	10.2
Levittown	14.5	8.9
Initial Boundary Condition[1]	0.0	1.0

[1]An initial boundary condition representing no population was chosen as 1.0 mg NO_3–N/1 for the following reasons:
a. The concentrations of nitrogen in precipitation is approximately 1.0 mg/l.
b. Streams draining undeveloped areas have concentrations of nitrogen close to 1.0 mg/l.
c. Data from wells in rural Suffolk have concentrations less than 1.0 mg/l.
d. The CES regression analysis shown in Figure 4–3 has an intercept of 1.99 mg/l.
Source: Weston (1977a) and Section H of the Areawide Waste Treatment Management Plan.

Table 4–51

POPULATION DENSITIES AND AVERAGE MEDIAN NITRATE-NITROGEN CONCENTRATIONS IN WATER FROM WELLS SCREENED IN THE UPPER GLACIAL AQUIFER 1972–76 IN GRID CELLS WHICH ARE ENTIRELY UNSEWERED

Grid Cell No.	Persons/Acre	Average Median (mg/l)
2	1.5	2.5
55	3.3	6.6
66	0.9	1.9
71	1.5	1.5
81	9.5	19.0
82	4.2	3.1
84	0.7	1.5
104	4.4	2.3
105	10.9	9.6
119	1.6	5.0
120	6.3	9.8
123	11.9	2.3
133	1.3	1.2
140	12.8	13.0
154	2.1	3.2
157	16.6	8.4
174	8.5	7.5
Overall average	5.8	5.8

Source: Porter et al. (1978).

Table 4–52

POPULATION DENSITIES AND AVERAGE MEDIAN NITRATE-NITROGEN CONCENTRATIONS IN WATER FROM WELLS SCREENED IN THE UPPER GLACIAL AQUIFER 1972-76 IN GRID CELLS WHICH ARE ENTIRELY SEWERED

Grid Cell No.	Persons/Acre	Average Median (Mg/l)
18	6.4	5.6
19	12.2	5.9
29	9.1	4.4
30	13.7	1.4
31	11.8	7.2
33	14.1	3.9
34	12.2	5.8
43	10.2	6.8
44	11.0	4.2
46	13.0	4.8
48	14.5	2.6
59	10.7	3.6
60	16.8	2.7
61	9.6	2.0
63	12.4	1.6
75	27.2	7.0
76	12.5	6.7
93	16.5	3.2
94	13.2	1.4
143	9.0	4.9
159	11.2	9.4
Overall Average	12.7	4.5

Source: Porter et al., (1978).

unsewered areas.

Mean nitrate concentrations near the water table are significantly lower in the sewered area than in the unsewered area for both recent time periods (1967–71 and 1972–76). Lower concentrations of total nitrogen were also observed in stream water from the sewered area than in streams draining the unsewered area.

4.5.2.3 Control Measures Implications. Public Health standards (Section 4.1.1.3) dictate that nitrate-nitrogen levels remain below ten milligrams per liter in water supplies. For the 208 Program, this translates to maintenance of the Magothy aquifer NO_3 concentrations below ten milligrams per liter or treatment at the wellhead. The bi-county 208 Program has interpreted the standard level as a tenth percentile rather than an absolute standard. This interpretation appears reasonable. Based on that standard, and assuming treatment at the wellhead is ruled out as the primary basis of control, the analysis of well data suggests a need for widespread controls of nitrate levels. Significant violations of the standards over a twenty year period can be predicted.

The Porter well data show that sewering reduces nitrate levels. The data also shows that in many locales the relationship of population density to nitrate levels is tenuous or nonexistent. Hence, only other controls such as fertilizer regulations, animal waste ordinances, and marsh-pond systems in recharge basins can be expected to reduce nitrate levels in those locales.

A nitrogen budget of the bi-county area by Porter *et al.* (1978) showed the major role of non-point nitrogen sources (see Table 4–53). Detailed nutrient studies of natural ecosystems have shown the important role of vegetation in recycling nitrates from rainfall and some runoff. The lack of

Table 4–53

GROSS SUMMARY OF ESTIMATED SOURCES AND FATE OF NITROGEN IN THE BI-COUNTY REGION (BASED ON 1975 AND 1976 DATA) [1]

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)
Sub-total	13400	4600	
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.)
Sub-total	15500	7700	
Precipitation	4000	3700	(By difference from totals)
Totals	32900	16000*	(Totals estimated by water/nitrogen model)

[1] *When using this table it should be noted that the numbers represent regional averages and do not refer to specific sites.*

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

Source: Porter et al. (1978).

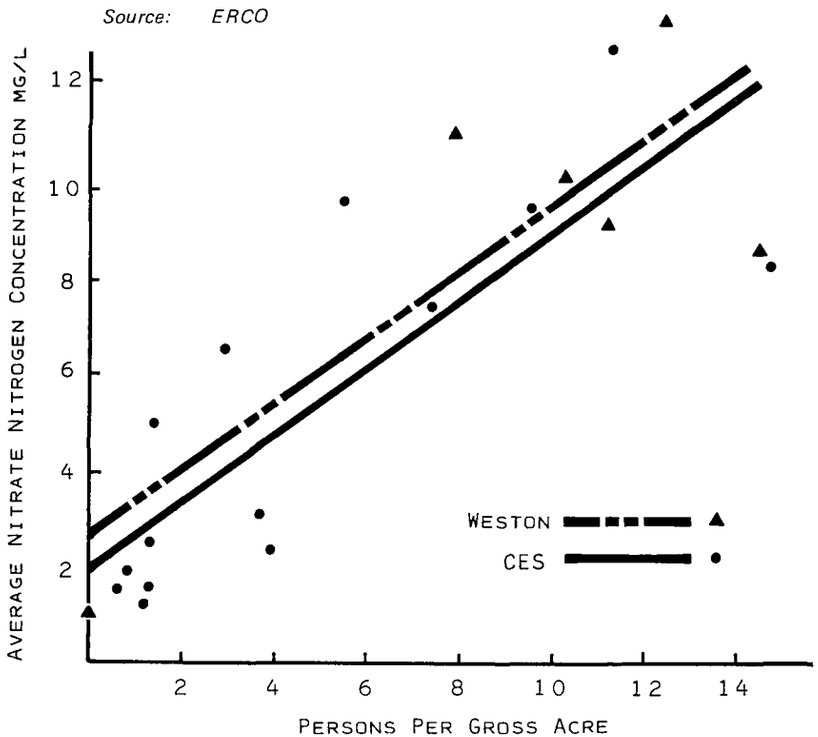


FIGURE 4–3 *Analyses of Two Independent Studies Relating Groundwater Quality to Population Density*

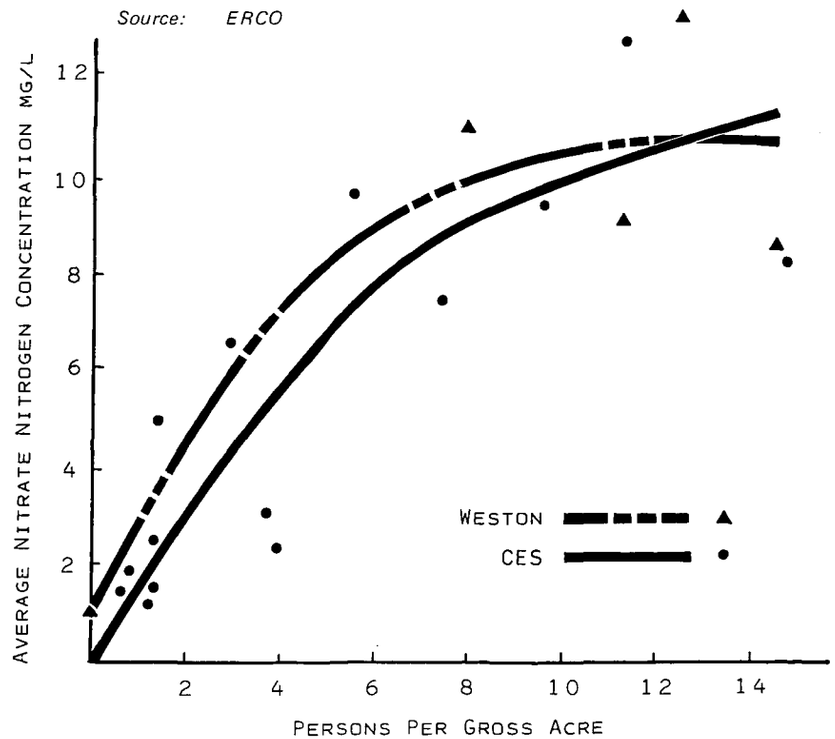


FIGURE 4–4 *Alternative Interpretation of Two Independent Studies Relating Groundwater Quality to Population Density*

natural vegetaion in the residential and urban areas of the Bi-county Region coupled with augmentation of nitrogen loads to groundwater has altered the dynamics of the natural cycles. Measures such as fertilizer controls, which reduce the nitrate loads to be cycled by grasses and crops; land use controls that preserve natural ecosystems; runoff holding ponds and marsh-ponds in recharge basins, which simulate natural ecosystem functions; and animal waste controls and street cleaning, which remove waste from artifical ecologically inactive areas can partially compensate for reduction of natural treatment of runoff and rainwater. Such measures can be expected to significantly reduce nitrate loads to groundwater.

4.5.2.4 Intermedia Tradeoffs. Acceptable groundwater nitrate levels (with associated secondary benefits) is only one of the numerous objectives enumerated in Section 4.1. The following are among the negative impacts of sewering with marine discharges: (1) reduction of streamflows and wetland inundation levels as already observed in southwestern Nassau County; (2) increase in sewage flows that must then be disposed of to bays, oceans or groundwater (Since nitrates also impose a threat to ocean waters, the net result of ocean outfalls is the transfer of a problem from bay to oceans rather than its elimination.) (3) increase in sludge quantities. (Increased sludge quantities may cause negative air quality impact if the sludge is incinerated, co-incinerated or pyrolyzed. The net effect may be positive if sludge is composted.) and (4) induced growth may occur in those areas not already fully developed. (Urban Systems, Inc. (1974) performed a detailed study that demonstrated this impact.)

4.5.2.5 Environmental Judgment with Respect to Sewering Strategy. The many tradeoffs associated with choices for groundwater protection have been carefully and critically studied. These have been considered quantitatively and analytically when possible. This has included use of statistical, graphical and cost-benefit tools. Such investigations have been summarized in this chapter in the various data tables and graphical presentations. In many cases, important aspects of the evaluation have only admitted to qualitative analysis. This has been due to lack of monitoring data or of understanding of environmental functions. Qualitative evaluation has been in the form of expert judgment based on the literature and on ecological, chemical and

hydraulic principals. Those have been presented in this chapter by way of textual explanations and argument.

Based on both quantitative and qualitative evaluation, an environmentally preferred course of action has emerged. This course involves the following:

1. Selection of nonsewering options as a general guideline.

2. Emphasis on providing the regulatory, monitoring and enforcement tools required to implement nonsewering options.

3. Selected sewering in areas where (a) on-site system failures will occur and development is allowed, (b) locally high population densities (over five dwelling units per gross acre) occur, and (c) other areas as indicated by monitoring results. The need for such selected sewering must be clearly demonstrated by 201 studies.

4. Allocate sufficient funds and develop a detailed management plan to adequately implement the watershed management approach in Zone III.

5. Strictly enforce all nonsewering controls, sewer in areas of on-lot system failures, and avoid other sewering to minimize disruption of the water balance. Closely monitor bay N levels in Zones VI and VII. Emphasize land use controls and preservation of buffer zones around water bodies and strictly preserve wetlands to minimize disruption of nitrogen cycling.

6. Only sewer in cases of on-lot system failures or if groundwater flow to bays is clearly demonstrated to present local surface water problems in Zone VIII. Given the range of tradeoffs available, this is ecologically the most sound approach in those zones.

4.5.3 The Major Tradeoffs Involved in Selection of This Course of Action.

1. The choice not to sewer at one dwelling unit per acre, two dwelling units per acre or three dwelling units per acre will allow continuation of nitrate leaching to glacial groundwater in some areas due to on-lot systems. Depending on how the data is interpreted, it appears that domestic nitrate sources will affect mean groundwater nitrate concentrations unfavorably by one to five milligrams per liter. This will involve secondary impacts on bay nitrate levels for Zone VI.

2. Strictly enforced fertilizer controls, on-lot systems maintenance, animal waste controls and land use controls will reduce nitrate leaching to glacial groundwater in some areas. If these controls work, nitrogen balances suggest this will lower mean groundwater nitrate concentrations by three to four milligrams per liter.

3. There is some uncertainty as to how effectively the nonsewering controls can be implemented. This uncertainty gives an error bracket to the figures given in point two above such that the controls may result in as low as only one milligram per liter reduction if they are poorly regulated and enforced, and may result in up to a five milligram per liter reduction if the plan is implemented in a first-class fashion.

4. Selection of nonsewering options will greatly reduce the needs for stream augmentation and recharge. Stream augmentation (with shallow recharge, if feasible), would be a critical part of an acceptable sewering strategy. At present, there is great uncertainty associated with whether or not stream augmentation would work. Changes in inundation levels of wetlands of only a few inches will probably significantly degrade the quality of wetland habitats (see Section 4.1.2.2); changes in stream flows can be expected to change salinity conditions in Great South Bay.

5. Selection of nonsewering strategies would greatly reduce needs for treatment plant expansion and sludge handling facilities. It would eliminate the need for AWT/mid-bay outfalls in bays presently surrounded by unsewered areas and in Port Jefferson Harbor and in Oyster Bay. Based on the above tradeoffs and uncertainties, it is judged that properly implemented nonsewering plan elements, with selective sewering, can be reasonably expected to have results ranging from significant lowering to slight decreases in groundwater nitrates. Comparing this with expected stream flow and marsh inundation declines and increased sewage and sludge loads, the nonsewering options are generally judged environmentally preferable. If sewering options were selected, no further sewering of Zones VI, VII and VIII (except for small treatment facilities involving local recharge of advanced treated effluent) should be undertaken until stream augmentation/shallow recharge is implemented in the Southwest Sewer District and its effectiveness is studied.

4.5.4 Concluding Remarks. Several of the key findings of this environmental assessment are repeated here. They serve as a summary of the environmental portion of the Water Quality Management Plan:

1. *Organic Chemical Contamination* of the aquifer is a critical concern. An acceptable control plan could not be drawn up for the Water Quality Management Plan due to lack of an inventory of sources. Immediate study of organics distribution and formulation of such a plan is required.

2. *Hazardous Wastes* cannot be considered an exportable residual. The proposed measures in the Water Quality Management Plan are adequate with respect to the 208 but not with respect to ultimate disposal of hazardous wastes. However, this is mentioned more as a comment on EPA policy rather than as a conclusion relating to the water quality management program.

3. *Non-point Controls* are implementable and could control a large segment of the residuals of concern. The proposed measures are adequate. Of particular importance are preservation of buffer zones, fertilizer controls, structural measures to treat runoff to bays, marsh-pond type recharge basins, and controls of industrial disposal practices.

4. *Sewering* has numerous environmental drawbacks, as noted in Sections 4.2.12 and 4.5.2.4, and should only be selectively implemented.

5. *Great South Bay's Marine Resources* will be rapidly degraded if the strict control measures proposed are not implemented.

6. *Manhasset Bay and Hempstead Harbor* cannot be expected to improve in quality except for local harbor areas until western Long Island

Sound problems are corrected.

7. *Nutrient Nitrogen/Phosphorus Ratios* will be impacted if nitrogen removal wastewater treatment plants are installed without complementary phosphorus removal. This may cause adverse changes in the marine food web.

8. *The Ocean is Not an Infinite Sink.* Reliance on ocean disposal of sewage and pretreated hazardous wastes may have long-term deleterious effects. This a comment on EPA policy and not a criticism of the water quality management program.

9. *Sludge Disposal* alternatives vary widely in their impacts. Composting, land application, and thermal drying are environmentally beneficial while pyrolysis has significant energy benefits. All other alternatives should be avoided.

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