Industrial Wastes

James A. Mueller
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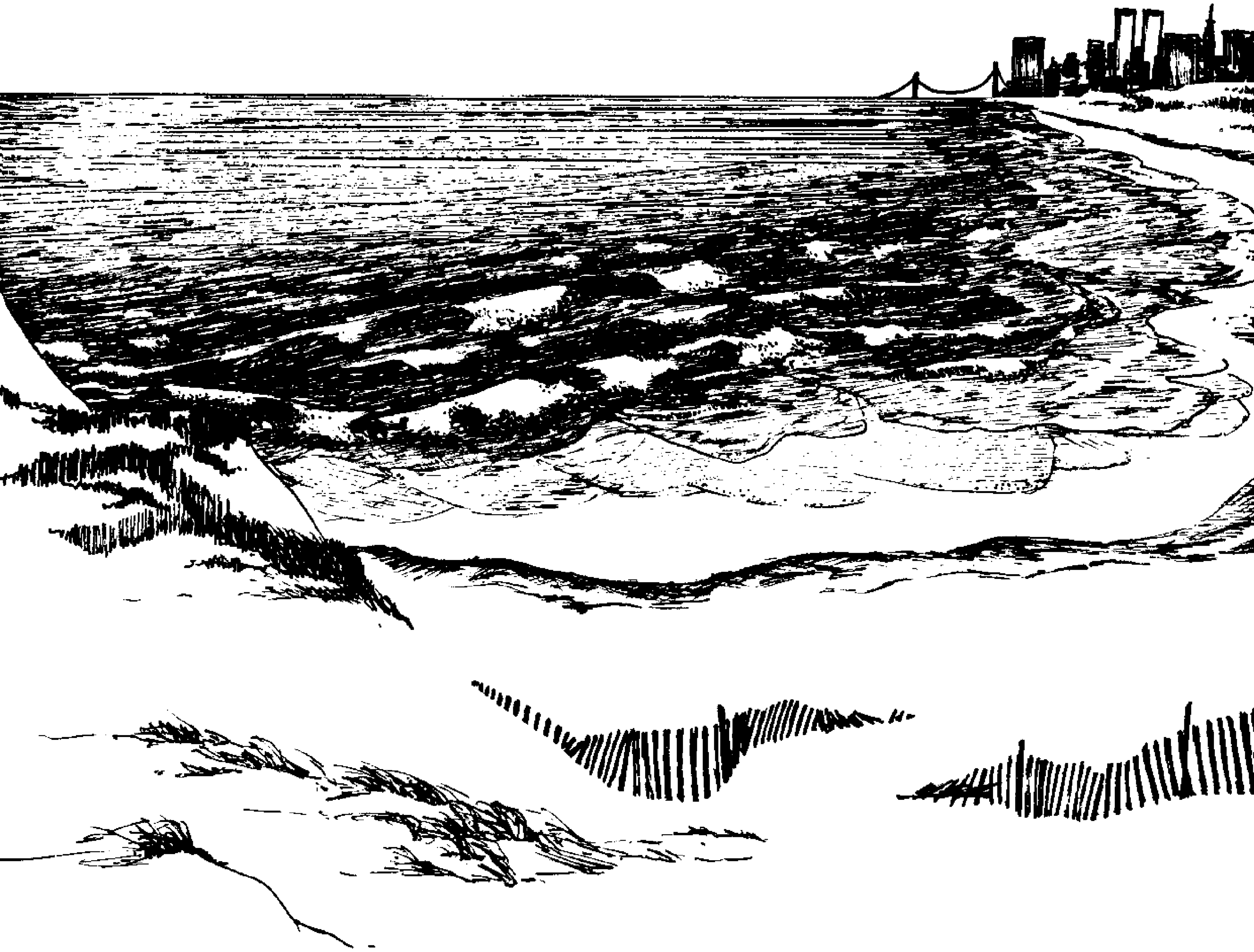

MESA NEW YORK BIGHT ATLAS MONOGRAPH 30

The offshore water in the bend of the Atlantic coastline from Long Island on one side to New Jersey on the other is known as New York Bight. This 15,000 square miles of the Atlantic coastal ocean reaches seaward to the edge of the continental shelf, 80 to 120 miles offshore. It's the front doorstep of New York City, one of the world's most intensively used coastal areas—for recreation, shipping, fishing and shellfishing, and for dumping sewage sludge, construction rubble, and industrial wastes. Its potential is being closely eyed for resources like sand and gravel—and oil and gas.

This is one of a series of technical monographs on the Bight, summarizing what is known and identifying what is unknown. Those making critical management decisions affecting the Bight region are acutely aware that they need more data than are now available on the complex interplay among processes in the Bight, and about the human impact on those processes. The monographs provide a jumping-off place for further research.

The series is a cooperative effort between the National Oceanic and Atmospheric Administration (NOAA) and the New York Sea Grant Institute. NOAA's Marine EcoSystems Analysis (MESA) program is responsible for identifying and measuring the impact of man on the marine environment and its resources. The Sea Grant Institute (of State University of New York and Cornell University, and an affiliate of NOAA's Sea Grant program) conducts a variety of research and educational activities on the sea and Great Lakes. Together, Sea Grant and MESA are preparing an atlas of New York Bight that will supply urgently needed environmental information to policy-makers, industries, educational institutions, and to interested people.

ATLAS MONOGRAPH 30 evaluates the character and importance of industrial waste discharges in the New York Bight region. Mueller and Anderson look at the magnitude of Bight area industrial wastes as compared to that of the nation; geographic distribution and input locations; mass loads from industrial waste discharges by source, by geographic location, and in comparison to waste inputs from other sources; industrial treatment methods; and official policies. They conclude that industrial discharges contribute significant portions of the contaminant input loads to New York Bight. Future decisions on waste management must consider interrelationships among all contaminant sources.

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MESA NEW YORK BIGHT ATLAS MONOGRAPH **30**

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Contents

Maps

Tables

Figures

Acknowledgments

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Abstract

The New York City metropolitan area, at the apex of New York Bight, supports vast industrial activity. In the past two decades the relative importance of manufacturing in the New York region has declined compared to the rest of the nation, but the area maintains its status as the largest center of manufacturing in the United States. Such industrial activity generates waste residuals that are discharged to the environment.

To evaluate the significance of these industrial wastes, the location and mass loads of industrial inputs are compared to those from nonindustrial sources. In the Bight area, much wastewater is now discharged through primary, as well as secondary, treatment plants. New federal regulations prescribing treatment levels and phasing out some ocean dumping are expected to bring about some improved water quality.

Industrial discharges contribute significant portions of the contaminant input loads to New York Bight. Future decisions on waste management must consider interrelationships among all contaminant sources.

Introduction

The economic history of the western world from the mid-eighteenth century to World War I is the story of the industrial revolution, characterized by the increasing application of technical knowledge to production problems. Inanimate power sources replaced animal and human power. Machines performed tasks formerly done by humans; new materials were synthesized; work was organized into large, centrally powered factories (Kemp 1974). Technological advances and industrial development brought economic growth, evident in increased productivity and higher standards of living. The economy of the United States in the nineteenth century progressively moved ahead and transformed with the technological changes.

As the nation was industrialized, New York City grew rapidly; its population expanded from 60,000 in 1800 to 814,000 in 1860 (Koebel and Krueckeberg 1975). This great urban growth intertwined with industrial development by providing jobs for people and workers for industry.

Such industrial production generates not only economic growth and higher standards of living, but also waste by-products. Raw materials are converted partly into goods and partly into waste residuals. The power that makes modern industry possible comes largely from the combustion of organic materials, which produces combustion waste products. The physical and chemical processes that transform matter into useful forms—metals, chemical products, plastics—leave residual by-products. Centralizing and concentrating production facilities to increase efficiency geographically concentrates waste sources, putting greater stress on the assimilative capacity of the environment than does dispersed distribution. Urbanization of population similarly centralizes sources of domestic wastes.

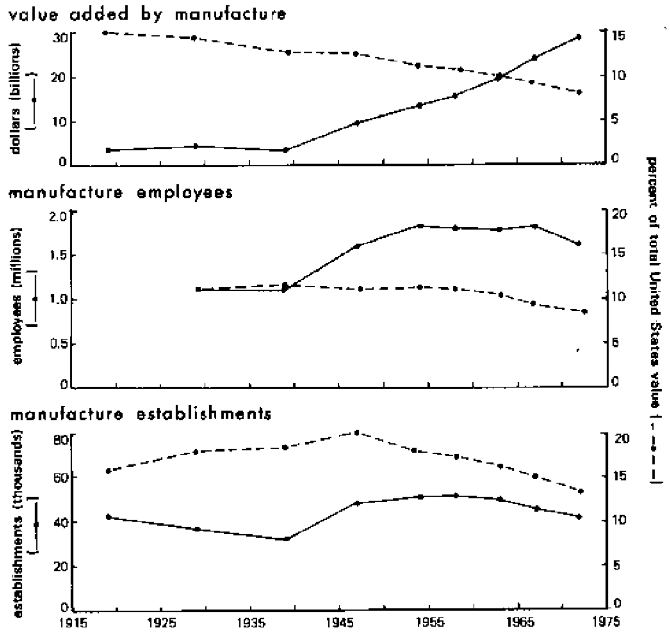
The objective of this monograph is to evaluate the character and importance of industrial waste discharges in the New York Bight area. To provide a broad perspective of Bight area industrial activity, we will look at: its magnitude compared to that of the nation; geographic distribution and input locations; mass loads from industrial waste discharges by source, by geographic location, and in comparison to waste inputs from other sources; industrial treatment methods; and official policies.

Industrial Activity

Kneese, Ayres, and d'Arge (1970) pointed out that technological external diseconomies, which occur when producers pass along part of their production costs in the form of environmental degradation, are inherent in all production. These externalized costs result from the disposal of consumption residuals, generally a function of population, and from the disposal of production residuals, a function of industry type and production process.

In the New York Bight region, manufacturing is the most important source of industrial waste. Mining is found on a small scale, and construction generates few point sources of waste, although it may contribute to urban runoff. Data on manufacturing are readily available and are used below as indicators of industrial activities likely to produce waste byproducts.

Figure 1 compares trends in manufacturing from 1919 to 1972 in the New York-Northeastern New Jersey Standard Consolidated Area (SCA)* to overall activity in the United States. The number of manufacturing employees and establishments, as well as percentages of total US values, have decreased since the mid-1950s. From 1960 to 1975, the average annual US employment growth was 2.7%, and that of the New York SCA was only 1.1% (Roniger 1975). Although the actual dollar value added by manufacturing in the New York SCA increased from 1940 to 1972, the percent of the total US value added by the New York region decreased during those years. The overall rate of economic and industrial growth of the New York region has been less than that of the nation for some time. This slower rate is associated with a leveling off of population and labor force and with a scarcity of space for expansion. Lack of room for development induces high rents and this, coupled with strong labor unions, high transportation costs, and generally high costs of living and doing business, has caused many manufacturing firms to seek quarters elsewhere when old plants require upgrading (New Jersey Department of Environmental Protection 1975*a*,*b*).



Source: US Bureau of the Census 1975*b*

Figure 1. Manufacturing trends in NY-NJ SCA

Although the New York region is developing at a slower rate than the nation, it still dominates US manufacturing—with a little over 8% of the total (Figure 2). The closest rivals are Chicago, with less than 6% of the nation's manufacturing, and Los Angeles, with less than 5%. The amount of industrial wastes generated in these areas, a function not only of the number but also of the age and type of industrial facility, is not known. However, it is evident from Figure 2 that the New York region probably produces as much or more industrial waste than any other area of the country. The effect of this concentrated industrial activity on New York Bight depends upon waste discharge location, waste treatment level used prior to discharge, and assimilative capacity of the receiving waters.

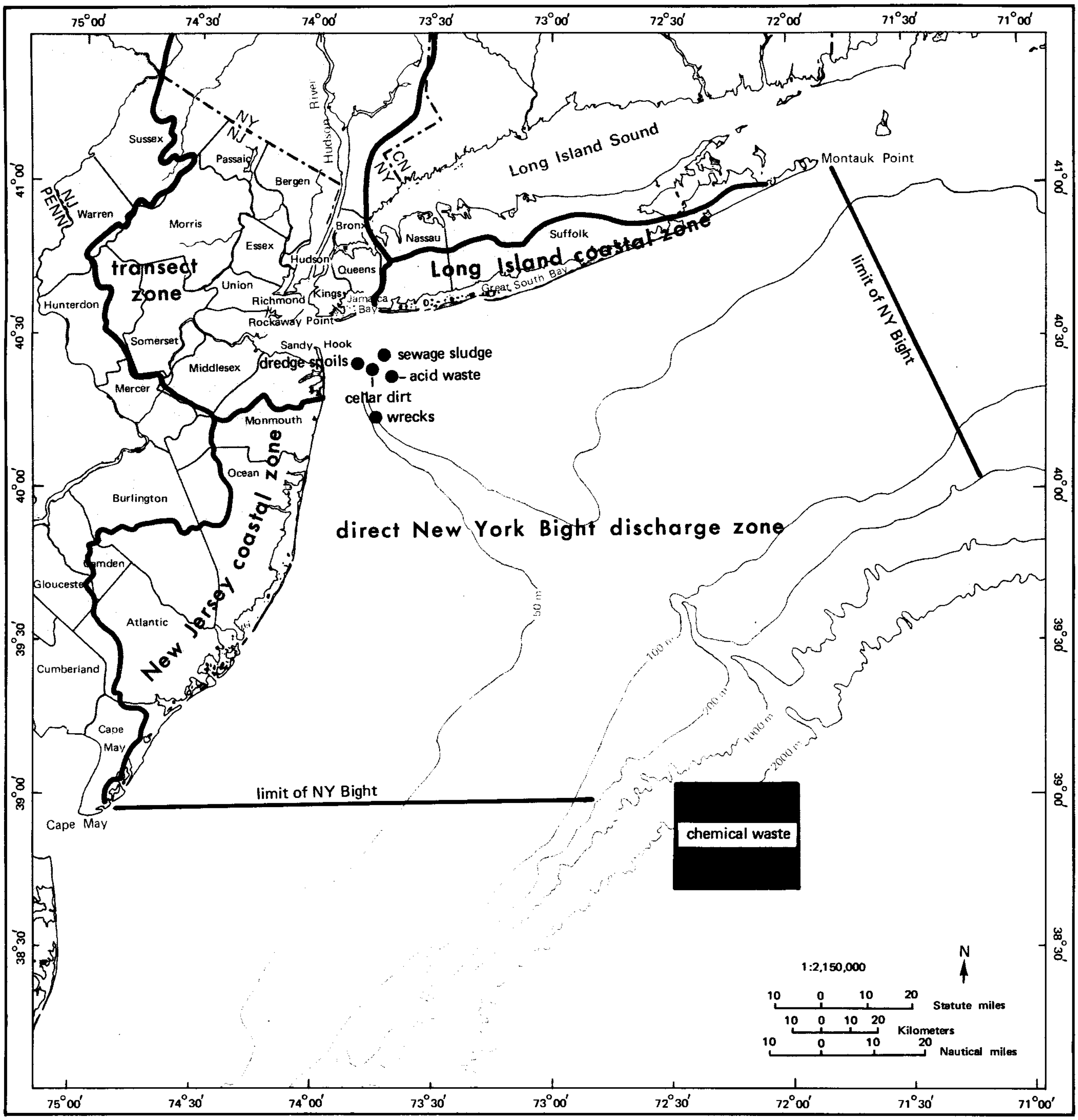
Geographical Distribution

To summarize the distribution of industrial activity and specific waste discharge in the New York Bight region, four geographical zones, three inland and one the Bight itself, were used (Map 1). A brief description of each zone is given below (also see Table 1).

The Transect Zone has the largest area, population, and number of industries and drains much of upper New York State as well as highly urbanized New York City. It is named for its outlet to the Bight, that is, the Sandy Hook-Rockaway Point

*This standard statistical area includes New York City; Putnam, Rockland, Westchester, Nassau and Suffolk counties in New York; Bergen, Essex, Morris, Somerset, Union, Hudson, Passaic, and Middlesex counties in New Jersey.

Map 1. General locator



Source: After Mueller et al 1976*b*

Lambert Conformal Conic Projection

transect at the southern limit of Lower Bay. The largest drainage basin contributing to the Transect Zone is the Hudson River-Mohawk River system, draining over 34,000 km^2 (13,000 mi^2), mainly in upper New York State. The remainder of the major streams in the Transect Zone is located in northern and central New Jersey and drain about 6,700 km^2 (2,600 mi^2). The principal streams here are the Hackensack, Passaic, and Raritan rivers. The waters of the lower Transect Zone are predominantly a complex of interconnected tidal estuaries.

The second inland zone, the **New Jersey Coastal Zone**, contains all the drainage basins discharging into New York Bight or its adjacent bays south of the Transect Zone to Cape May. The northern boundary is approximately 13 km (8 mi) south of Sandy Hook because this barrier spit diverts the flows of the Shrewsbury and Navesink rivers northward into Lower Bay. Most of the New Jersey coast is composed of barrier islands, with shallow bays between the islands and the coast. Except for the Shark and Manasquan rivers, all major streams discharge to these bays or estuaries and not directly to the Bight. The estuaries are heavily used for recreation and shellfishing. The New Jersey Coastal Zone has fewer people and industries than the Transect Zone and a land area of only about 5,000 km^2 (2,000 mi^2).

The **Long Island Coastal Zone** completes the land map. This zone includes southern Nassau and Suffolk counties, and extends eastward to Montauk Point. The western boundary is the New York City-Nassau County line, coinciding near its southern end with the eastern shore of Jamaica Bay. This zone is characterized by small streams draining to an extensive barrier estuary system. There is a large shellfish industry, and in the eastern portion a number of duck farms discharge wastewater into these bays or their tributaries. This zone contains less than 1,800 km^2 (700 mi^2) and it, too, is dwarfed by the size, population, and industrialization of the Transect Zone.

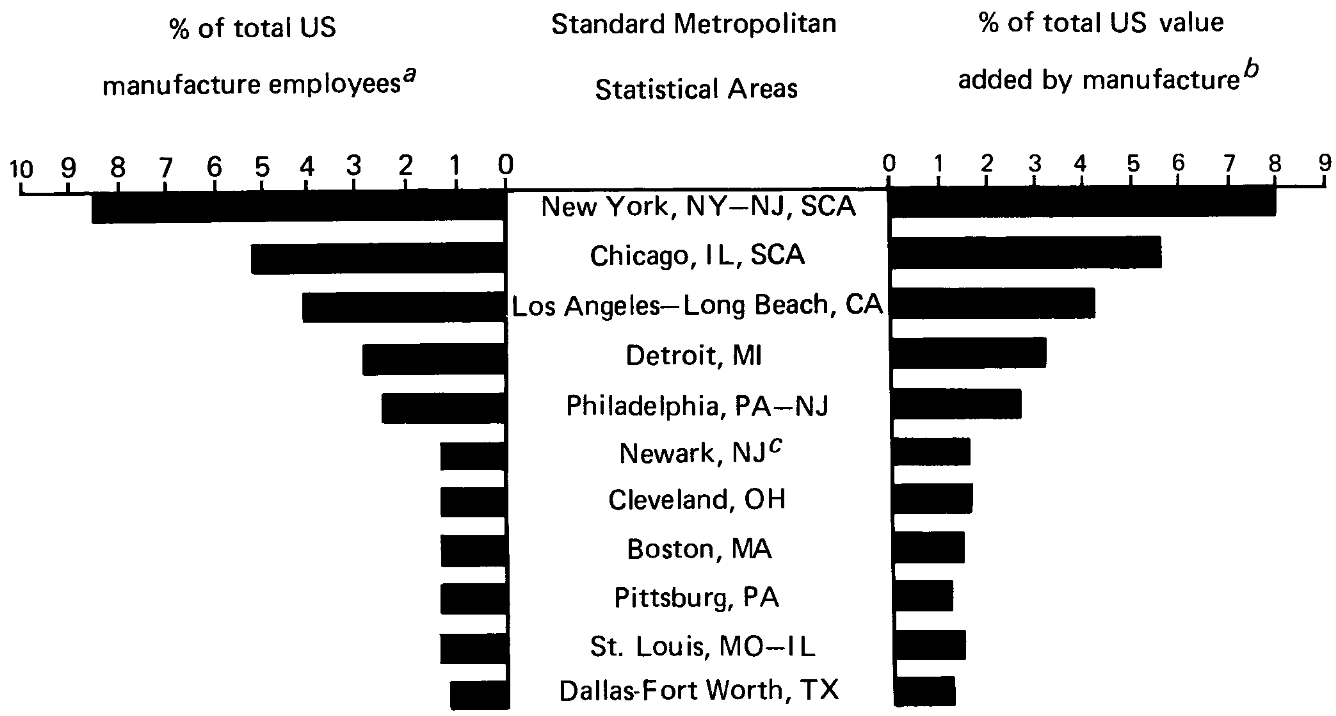
The fourth zone, **New York Bight**, receives direct waste discharges from barge dumping and from atmospheric fallout. Its 39,000 km^2 (15,000 mi^2) extend from Montauk Point, LI, to Cape May, NJ, and seaward to the 200 m (100 fm) bottom contour on the continental shelf edge.

Table 1. Zone characteristics

	Area (mi^2)	1970 Population	Average Population Density (cap/mi^2)
Transect Zone			
Upper Hudson	11,000	1,483,000	135
New York City-Lower Hudson	2,695	8,978,000	3,331
Northern New Jersey	2,595	5,026,000	1,937
New Jersey Coastal Zone	1,999	875,200	438
Long Island Coastal Zone	671	1,438,000	2,143

Source: Mueller et al 1976*b*

For analysis of industrial activity, counties in the land zones are used because of economic data available. The Transect Zone is subdivided into three areas (Upper Hudson Basin, New York City-Lower Hudson, and northern New Jersey) based on hydrologic, jurisdictional, and industrial considerations. Figure 3 illustrates the magnitude of industrial activity in the various zones. New York City is



a. 1972 total US manufacture employees = 1.622 million *b.* 1972 total US value added by manufacture = $354 billion

c. Also included in NY–NJ SCA

Source: US Bureau of the Census 1975*b*

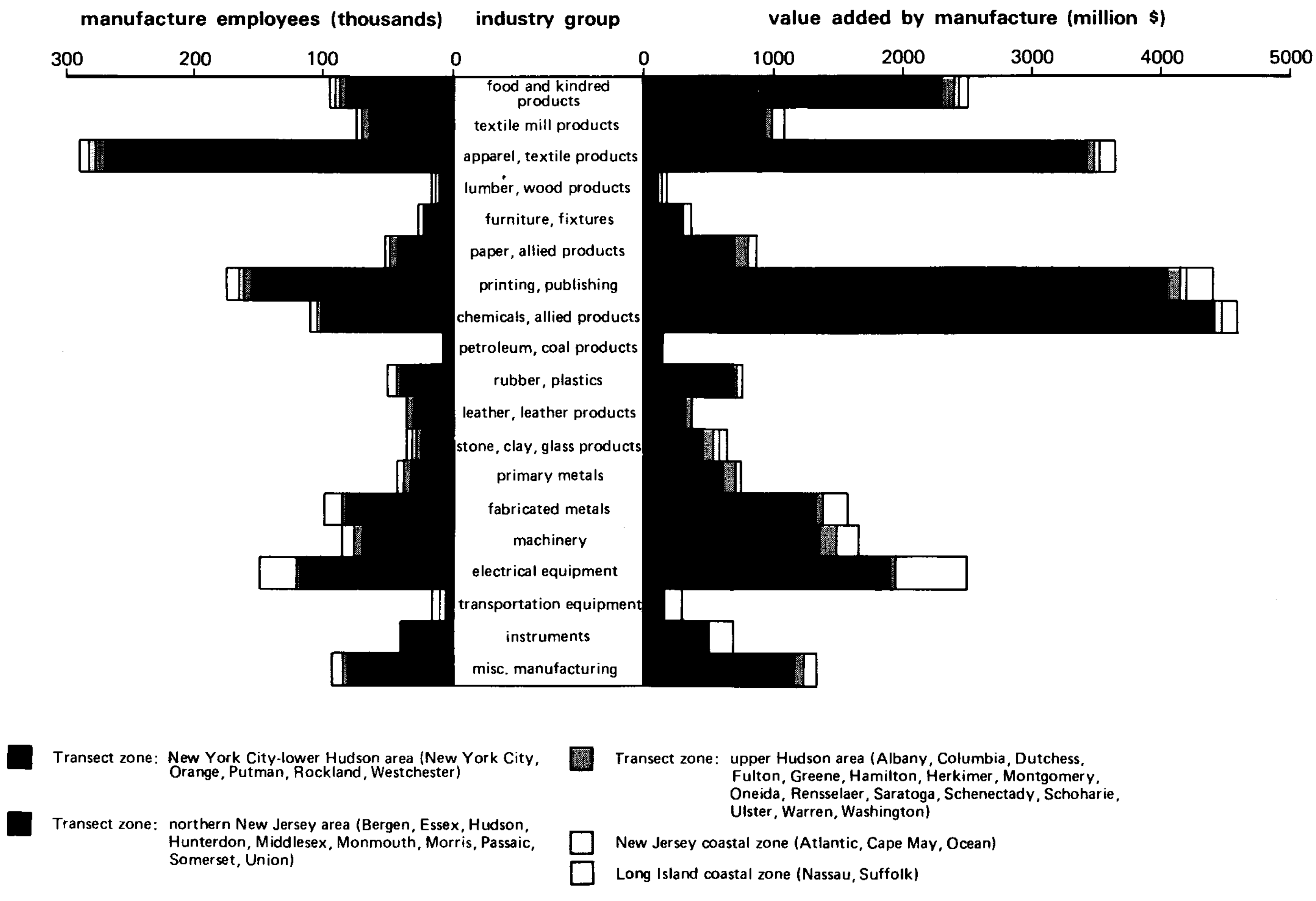
Figure 2. 1972 manufacture activity of US metropolitan areas

especially strong in apparel and printing and northern New Jersey in manufacture of chemicals. In New York City, printing and apparel manufacturing is done mainly by small, inconspicuous firms. By contrast, the chemical and electrical equipment industries in New Jersey are typically large, prominent establishments. Industrial activity in the Upper Hudson Basin and in the New Jersey Coastal Zone is comparatively small. The Long Island Coastal Zone supports a great deal of manufacturing, especially of electrical equipment.

In Figure 4, the number of manufacture employees was chosen as the parameter because value added is influenced by inflation and because the range in the size of firms does not make number of establishments a good indicator. Manhattan dominates, followed by Brooklyn, Queens, and the northern New Jersey counties.

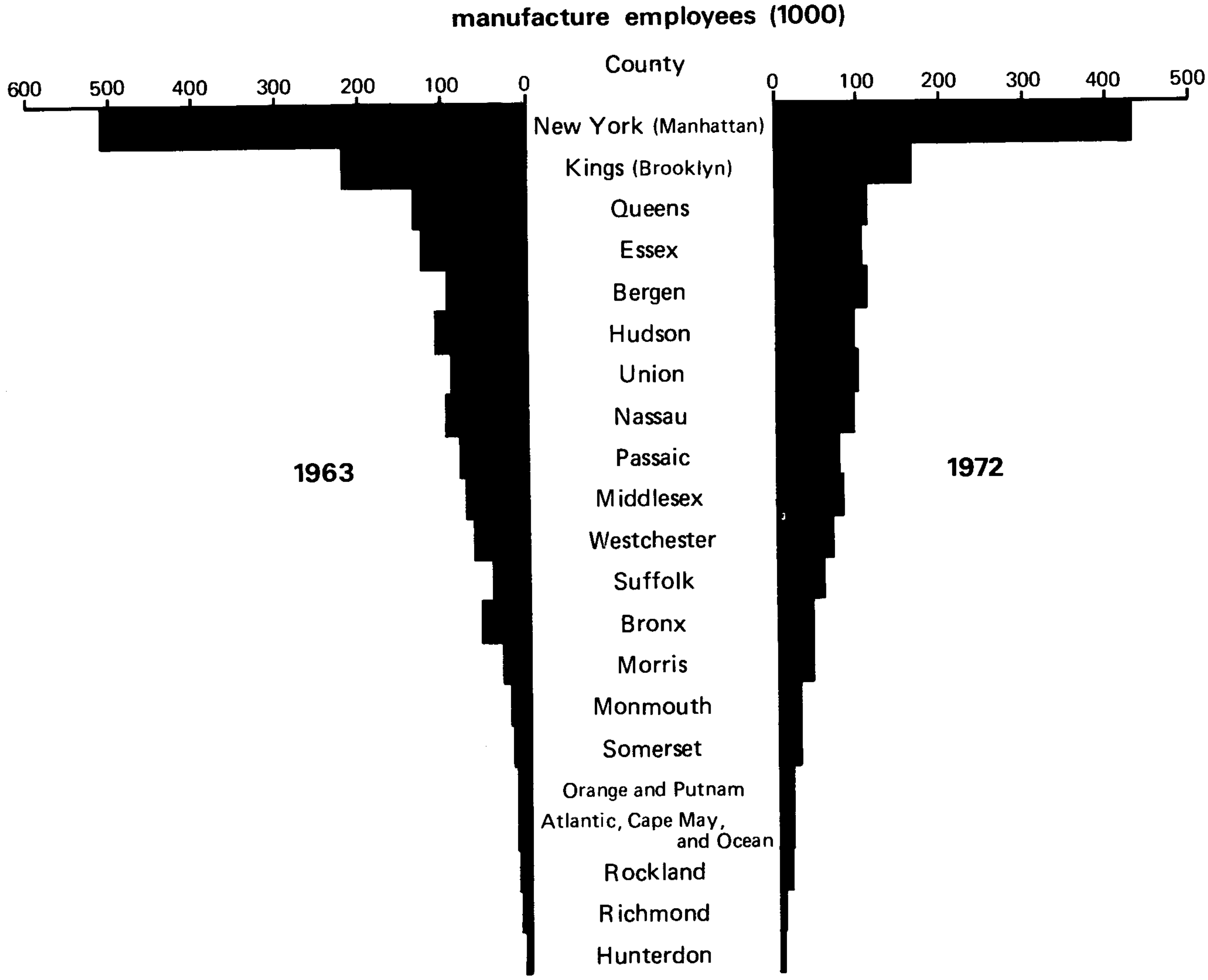
Although industrial activity is heavily concentrated in urban areas, manufacture has recently been growing in outlying counties at the expense of urban areas. Figure 5 shows that from 1963 to 1967, four of New York City's five boroughs lost manufacture employees; from 1967 to 1972, all five lost workers. Essex and Hudson, the most urbanized counties in New Jersey, experienced losses in both periods. Consistent gains were made by suburban Suffolk and Rockland counties in New York and by Morris, Bergen, and Monmouth counties in New Jersey. The largely rural New Jersey Coastal Zone, represented by Atlantic, Cape May, and Ocean counties, also grew through both periods, illustrating the movement away from cities.

Recent economic fluctuations have resulted in an increase in the number of new, larger plants and a decline in old, smaller plants in the New York urban area (New Jersey Department of Environmental Protection 1975*b*). Because manufacturing seems to be shifting from urban to suburban areas, outlying areas may have to deal with more industrial wastes in the future.



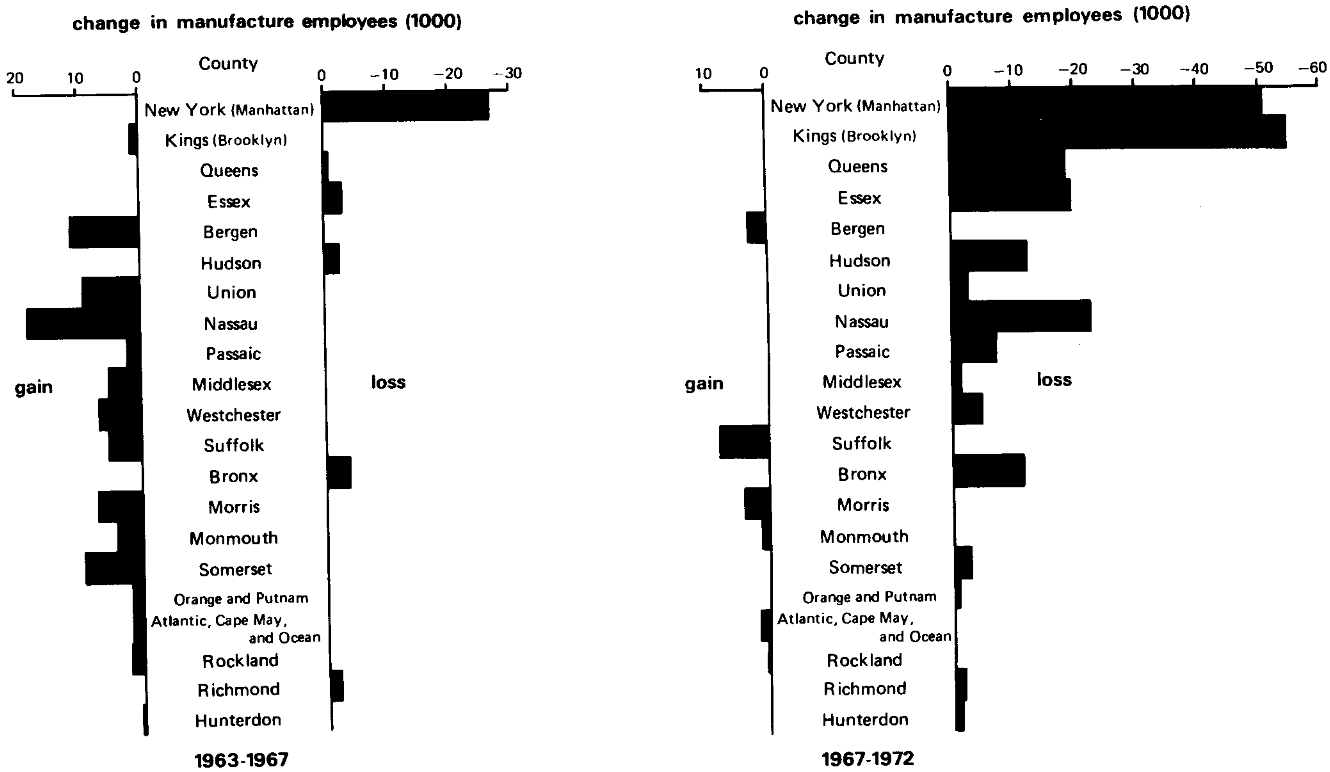
Source: US Bureau of the Census 1971, 1975*a*

Figure 3. Types of industrial activity within land zones



Source: US Bureau of the Census 1971, 1975*a*

Figure 4. Manufacture employees by county



Source: US Bureau of the Census 1971, 1975a

Figure 5. Change in manufacture employees by county

Industrial wastes are of interest principally when they contain contaminants that affect the environment adversely. A contaminant may be defined as a man-related substance with the potential for reducing the beneficial uses of a water body. Typical contaminants in industrial discharges, which may have deleterious effects on receiving waters, are: suspended and floatable solids, organic matter, plant nutrients, dissolved salts, heavy metals, toxic organics, oil, heat, and radioactive material.

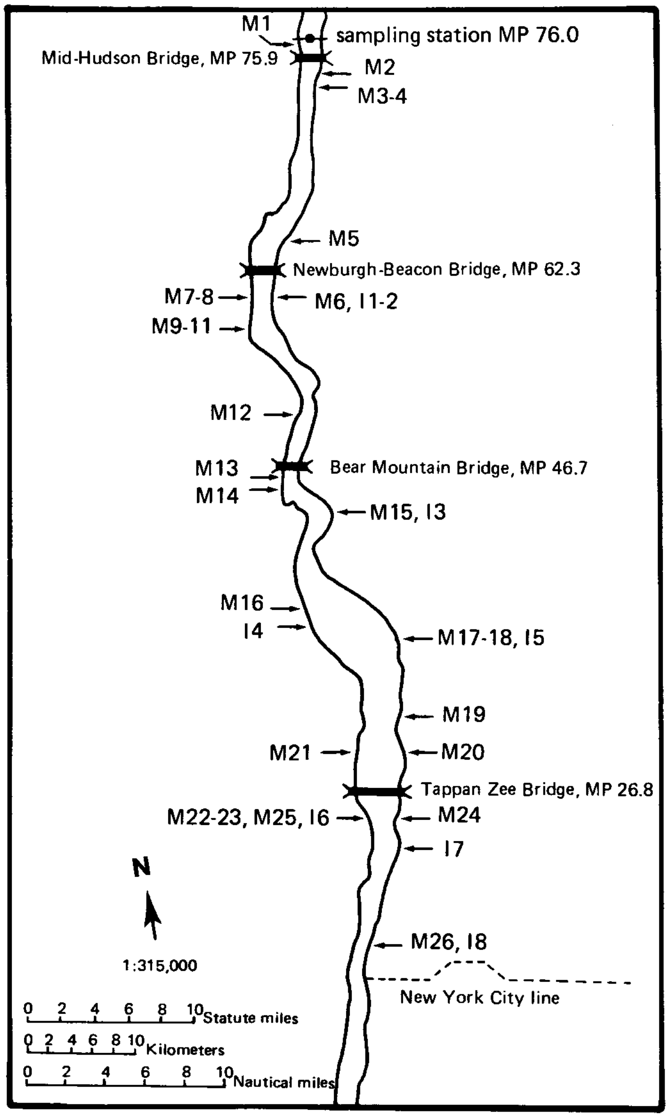
Wastewater

Maps 2-6 locate the significant industrial and municipal wastewater discharges in the land zones; their identities and flows are given in Tables 2 and 3. Inland wastewater inputs having metal or organic mass loading rates (lb/day) greater than those expected from a typical 1 million gallon/day (MGD) (4,000 m^3/day) secondary municipal treatment plant effluent are considered significant; discharges direct to the Bight are included whatever their loads. Except for industrial discharges into New Jersey rivers in the Transect Zone, wastewater discharges into fresh water are evaluated in a later section as gaged runoff.

Maps 2, 3, and 4 show the large number of both municipal and industrial discharges in the highly urbanized Transect Zone. Most wastewaters receive some treatment prior to discharge; a notable exception is the raw sewage input along portions of Manhattan, Staten Island, and Brooklyn. Most of the municipal wastewater discharges along the New Jersey coast (Map 5) are from small communities. Industrial inputs from the New Jersey coast are relatively small and, excluding cooling water, are mainly from two chemical companies in Ocean County. Few wastewater inputs occur on Long Island (Map 6) because wastewaters are generally discharged through septic systems to the ground. The major municipal discharges are from a few large treatment plants in Nassau County; the only direct industrial inputs are the treated effluents from duck farms on eastern Long Island.

These direct industrial discharges are only part of the total industrial wastewaters generated in the Bight area. The remainder is discharged to municipal sewer systems for combined treatment with municipal wastewaters prior to disposal to receiving waters (Table 3). Table 4 indicates that in the Transect Zone 34% of the municipal flows from northern New Jersey are contributed by industry, much greater than the 3% from the New York area. The large contribution from northern New Jersey is due to the industrial waste discharges from chemical, metals, and machinery industries there (Figure 3), compared to the low industrial discharges from the apparel and publishing industries in New York City. Also, New York City's high population density tends to increase the domestic flow fraction from this area.

Map 2. Transect Zone wastewater discharge locations—Hudson River, 1972



Source: Hetling 1974

Table 2. Direct industrial discharge locations and wastewater flows, 1972

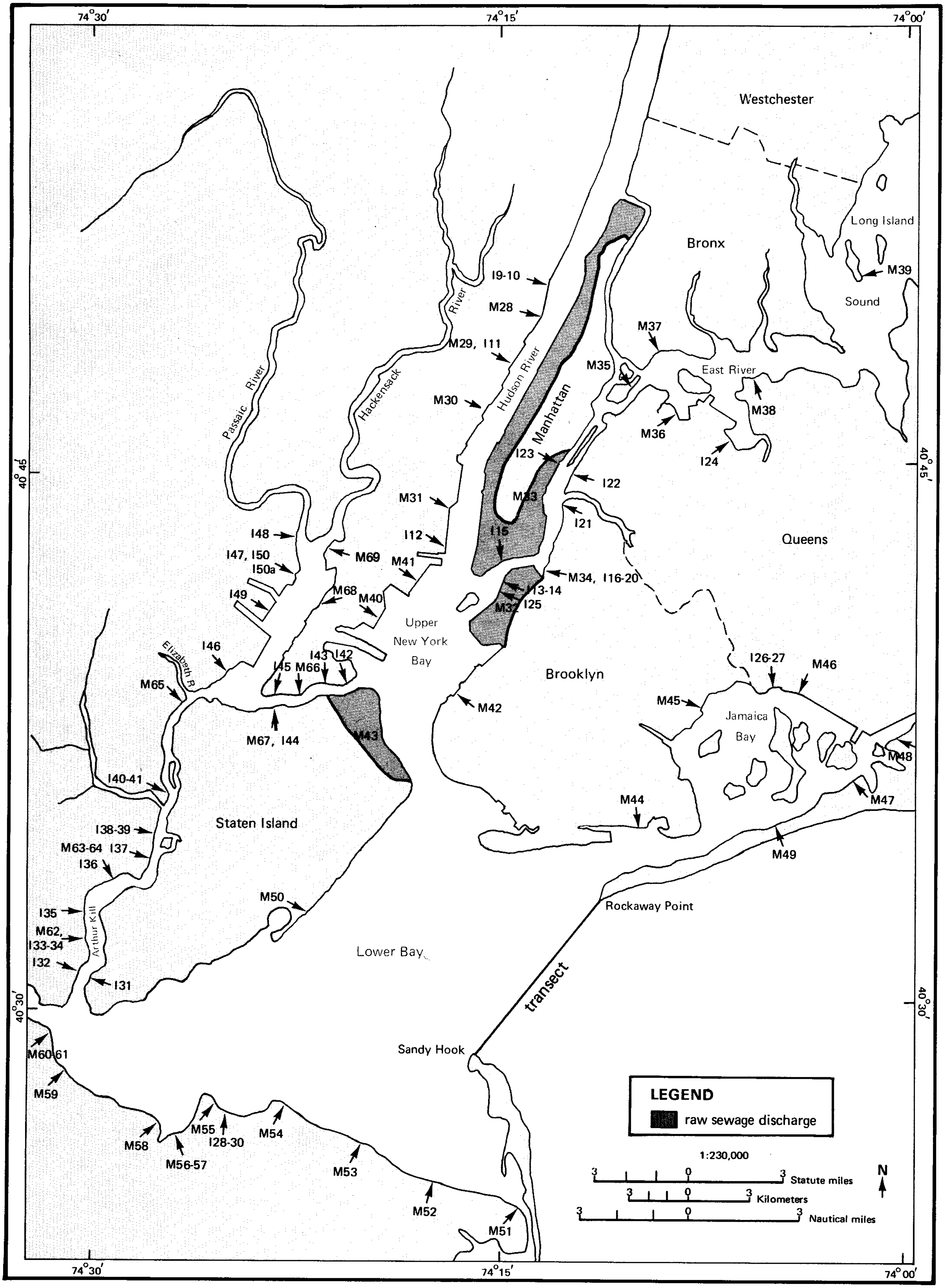
ID No.[a]	Waste Source	County	Flow (MGD)
TRANSECT ZONE			
Hudson River			
I1	Little Falls Paper	Orange	0.5000
I2	Cornwall Paper	Orange	1.6000
I3	Standard Brands	Westchester	19.3000
I4	Kay Fries Chemical	Rockland	1.2000
I5	Penn Central	Westchester	0.2000
I6	Continental Can	Rockland	2.6000
I7	Anaconda Wire	Westchester	0.7000
I8	CPC International	Westchester	8.6000
I9	Spencer Kellog	Bergen	1.1600
I10	Lever Bros.	Bergen	7.7000
I11	Wilson-Martin Div.	Hudson	0.5700
I12	Colgate Palmolive	Hudson	11.3000
East River			
I13	Consolidated Edison Co.[b]	Kings	1,100.0000
I14	Amstar Corporation	Kings	9.3000
I15	Consolidated Edison Co.[b]	New York	202.0000
I16	Phelps-Dodge Ref. Co.	Queens	0.5200
I17	Sun Oil Co.	Queens	0.0010
I18	Rendering Co. of America	Kings	0.5600
I19	Pinkas Fischer Co.	Kings	0.1200
I20	Van Iderstine Co.	Queens	3.1000
I21	Pepsico Inc.	Queens	5.0000
I22	Consolidated Edison Co.[b]	Queens	1,390.0000
I23	Consolidated Edison Co.[b]	New York	490.0000
I24	Port of NY Authority-LaGuardia	Queens	0.4700
Upper Bay			
I25	Bush Terminal Assoc.	Kings	0.9600
Jamaica Bay			
I26	Port of NY Authority	Queens	0.7700
I27	Port of NY Authority	Queens	1.0300
Lower, Raritan, and Sandy Hook bays			
I28	Lanvin Charles of the Ritz	Monmouth	0.1000
I29	IFF Inc.	Monmouth	0.2100
I30	Owens-Illinois Inc.	Monmouth	0.2800
Arthur Kill and tributaries			
I31	Nassau Smelting & Ref.	Richmond	0.5900
I32	AM Smelting & Ref.	Middlesex	7.3000
I33	Chevron Oil Co.[b]	Middlesex	63.4000
I34	American Cyanamid Co.	Middlesex	0.0700
I35	Amerada Hess Corp.	Middlesex	1.0100
I36	US Metals Ref. Co.	Middlesex	31.9000
I37	FMC Corp.	Middlesex	4.8900
I38	GAF Corp.	Union	20.0000
I39	El DuPont De Nemours Co.	Union	18.4000
I40	Humble Oil & Ref. Co.[b]	Union	202.0000
I41	Phelps Dodge Copper Products	Union	2.2000
IF1	Scherring Corp.	Union	0.8000
Kill Van Kull			
I42	Exxon Co.	Hudson	2.8300
I43	Humble Oil & Ref. Co.	Hudson	3.5600
I44	United States Gypsum Co.	Richmond	0.9600
I45	General Cable Corp.	Hudson	0.1800
Newark Bay			
I46	Singer Co.	Union	1.1500
I47	Allied Chemical Corp.	Union	0.5700
I48	A. Gross Co.	Essex	2.5900
I49	Anheuser-Busch Co.	Essex	0.0020
I50	Vulcan Materials Co.	Essex	15.1000
I50a	El DuPont De Nemours Co.	Essex	0.9000
Raritan River and tributaries			
I51	Jersey Central P&L Co.[b]	Middlesex	198.0000
I52	Anaconda Co.	Middlesex	2.2500
I53	Panacon Corp.	Middlesex	0.5100
I54	Tenneco Chemicals Inc.	Middlesex	1.5600
I55	Jersey Central P&L Co.[b]	Middlesex	302.0000
I56	Tenneco Chemicals Inc.	Middlesex	0.3900
I57	Anheuser-Busch Inc.	Middlesex	0.7800
I58	Triangle Conduit & Cable Co.	Middlesex	0.0400
I59	Johnson & Johnson	Middlesex	0.0250
I59a	Ford Motor Co.	Middlesex	0.3300
IF2	American Cyanamid	Somerset	23.8000
IF3	General American Transport. Corp.	Middlesex	0.0250
IF4	Johns Manville	Somerset	13.1000
IF5	Ortho Diagnostics	Somerset	0.4800
IF6	Hercules Inc.	Morris	2.1200
Rahway River			
I60	American Cyanamid Co.	Union	2.5000
I61	Middlesex Water Co.	Union	23.2000
I62	Rheem Manufacturing Co.	Union	0.0001
I63	Merck & Co. Inc.	Union	0.3500
Passaic River and tributaries			
I64	Western Electric Co.	Hudson	8.2500
I65	Essex Chemical Corp.	Essex	5.7600
I66	Diamond Shamrock Corp.	Hudson	0.7100
IF7	Marcal Paper Mills Inc.	Bergen	1.1800
IF8	Curtiss-Wright Corp.	Essex	0.3200
IF9	Whippany Paper Board	Morris	7.8500
IF10	SB Penick	Morris	0.3700
IF11	Ford Motor Co.	Bergen	1.3800
IF12	Tenneco Chemical Co.	Bergen	5.4800
IF13	Curtiss-Wright Corp.	Bergen	1.3500
Hackensack River			
I69	Union Textile Printers Inc.	Hudson	0.6000
I70	Koppers Company Inc.	Hudson	0.7900
I71	Tanatex Chemical Co.	Bergen	0.5300
I72	Diamond Shamrock Corp.	Bergen	4.1000
I73	Spinnerin Yarn Co., Inc.	Bergen	0.4300
I74	Universal Oil Products Inc.	Bergen	0.8600
I75	Aeroil Products Co., Inc.	Bergen	1.7500
NEW JERSEY COASTAL ZONE			
Toms River			
I1	Toms River Chemical Corp.	Ocean	11.2000
Direct Bight			
I2	Toms River Chemical Corp., Dover Township	Ocean	5.2000
Manasquan River			
I3	Borden, Inc., Pt. Pleasant	Ocean	0.0025
IF1	Nestle	Monmouth	0.8900
Southern bays			
I4	Atlantic City Electrical Co.[b]	Atlantic	831.0000
I5	Atlantic City Electrical Co.[b]	Cape May	14.3000
LONG ISLAND COASTAL ZONE			
I1	Gallo Duck Farm	Suffolk	0.3000
I2	Carmans River Duck Farm	Suffolk	0.1400
I3	3 duck farms	Suffolk	0.6700
I4	7 duck farms	Suffolk	0.4300
I5	6 duck farms	Suffolk	0.5500
I6	2 duck farms	Suffolk	0.1900

[a]I—industrial discharges in tidal (nongaged) areas
IF—industrial discharges in freshwater (gaged) areas
see Maps 2-6 for locations

[b]cooling water discharge

Sources: New Jersey Department of Environmental Protection 1975*a,b;* Mueller et al 1976*b;* EPA and NPDES permits

Map 3. Transect Zone wastewater discharge locations—New York area, 1972



Source: Mueller et al 1976*b*

Mercator Projection

Table 3. Municipal discharge locations and wastewater flows, 1972

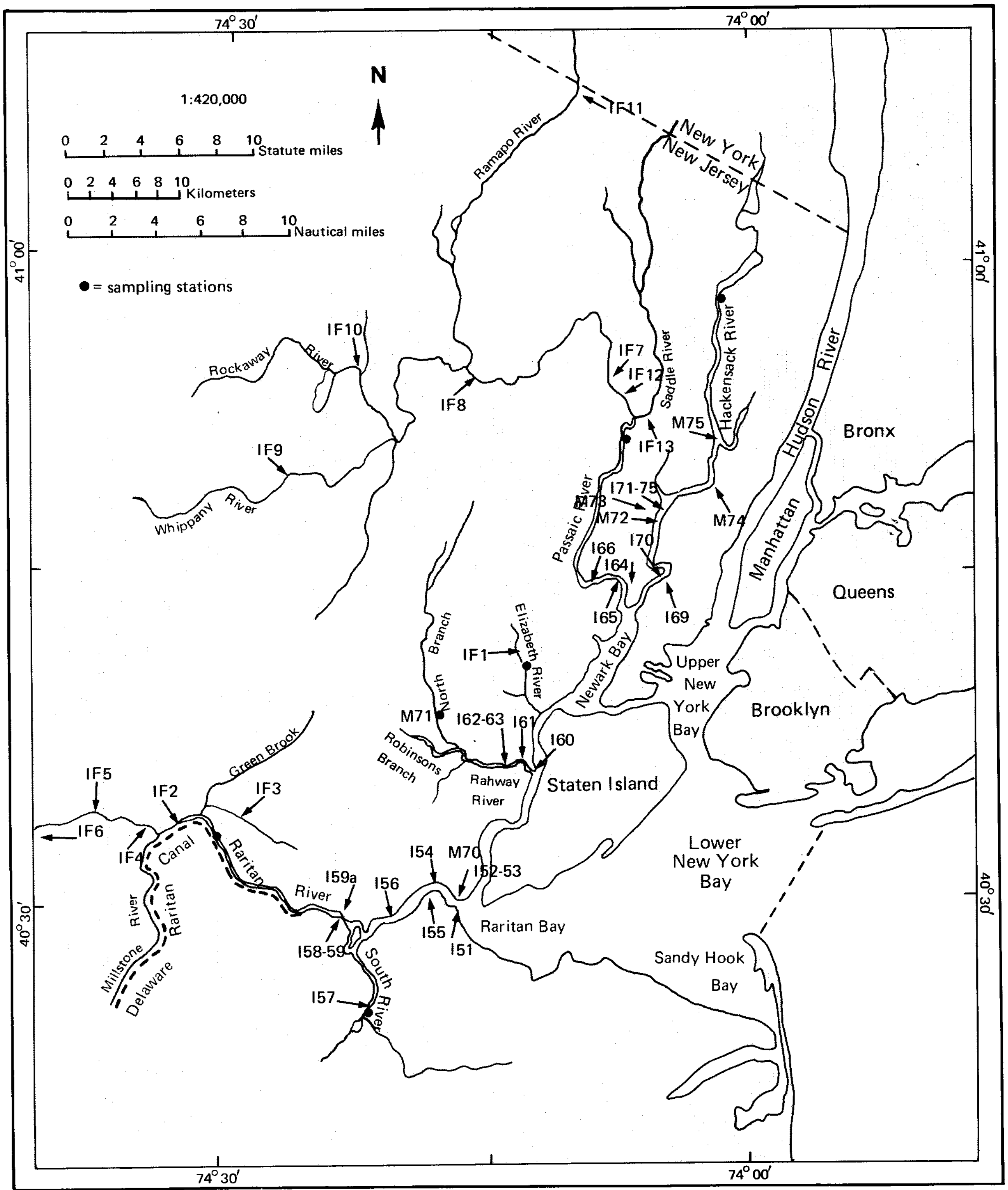
ID No.[a]	Waste Source	County	Type Treatment	Flow MGD	Flow % Industrial
TRANSECT ZONE					
Hudson River					
M1	Highland SD	Ulster	Pri	0.300	
M2	Hudson River	Dutchess	Pri	0.600	
M3	Poughkeepsie	Dutchess	Pri	6.000	
M4	Arlington SD	Dutchess	Sec	4.000	
M5	Wappinger Falls	Dutchess	Pri	0.750	
M6	Beacon	Dutchess	Sec	3.100	32.00
M7	Newburg	Orange	Sec	3.500	25.00
M8	New Windsor SD #2	Orange	Sec	1.820	
M9	Cornwall SD #1	Orange	Sec	1.500	0
M10	Middleton	Orange	Sec	4.250	10.00
M11	Goshen	Orange	Sec	1.500	
M12	Cornwall (joint)	Orange	Sec	0.750	
M13	USMA-West Point	Orange	Sec	1.050	
M14	Highland Falls, North	Orange	Pri	0.600	
M15	Peekskill	Westchester	Pri	3.900	4.00
M16	Haverstraw joint (+village)	Rockland	Sec (+Pri)	2.060 (+1.0)	
M17	40 communities	Westchester & Putnam	Pri	0.300	
M18	Ossining-Correctional & 2 STPs	Westchester	Pri	2.800	
M19	North Tarrytown	Westchester	Pri	1.600	35.00
M20	Tarrytown	Westchester	Pri	2.600	0.00
M21	Nyack & S. Nyack	Rockland	Pri	1.500	
M22	Orangetown SD #2	Rockland	Sec	15.200	
M23	Suffern	Rockland	Sec	1.500	
M24	Irvington	Westchester	Pri	1.400	
M25	Rockland County SD #1	Rockland	Sec	21.600	0.70
M26	Yonkers joint mtg. seasonal	Westchester	Pri	88.200	6.60
M27	Manhattan-Hudson & Upper Harlem River	New York	Raw	200.000	
M28	Edgewater	Bergen	Pri	2.500	
M29	N. Bergen (Woodcliff)	Hudson	Pri	1.600	0
M30	W. New York	Hudson	Pri	9.600	
M31	Hoboken	Hudson	Pri	17.300	40.00
East River					
M32	Red Hook	Kings	Raw	70.000	1.40
M33	East Side	New York	Raw	150.000	
M34	Newtown Creek	Kings	Sec	173.000	6.80
M35	Wards Island	New York	Sec	242.000	1.00
M36	Bowery Bay	Queens	Sec	107.000	6.80
M37	Hunts Point	Bronx	Sec	156.000	0.90
M38	Tallmans Island	Queens	Sec	61.000	2.60
M39	City-Hart Island	Bronx	Pri	1.000	
Upper Bay					
M40	Passaic Valley SC	Essex	Pri	258.000	39.00
M41	Jersey City-East	Hudson	Pri	36.700	
M42	Owls Head	Kings	Sec	96.000	1.30
M43	Staten Island	Richmond	Raw	60.000	
Jamaica Bay					
M44	Coney Island	Kings	Sec	99.000	0.30
M45	26th ward	Kings	Sec	66.000	1.60
M46	Jamaica	Queens	Sec	93.000	2.10
M47	Inwood STP	Nassau	Sec	1.500	10.00
M48	Cedarhurst	Nassau	Sec	0.910	0.50
M49	Rockaway	Queens	Sec	19.200	0.10
Lower, Raritan, and Sandy Hook bays					
M50	Oakwood Beach	Richmond	Sec	19.200	0.01
M51	Highlands	Monmouth	Pri	1.700	0
M52	Atlantic Highlands	Monmouth	Pri	0.180	
M53	Middletown-Belford	Monmouth	Pri	4.900	0
M54	Keansburg	Monmouth	Pri	2.100	
M55	Bay Shore Sewerage Co.	Monmouth	Sec	1.700	7.00
M56	Keyport	Monmouth	Pri	1.000	0
M57	Matawan Borough	Monmouth	Pri	1.500	0
M58	Clifford Beach	Monmouth	Pri	0.600	
M59	Laurence Harbor	Middlesex	Pri	1.500	
M60	South Amboy	Middlesex	Pri	1.000	0
M61	Middlesex County SA	Middlesex	Pri	80.400	50.00
Arthur Kill					
M62	Woodbridge	Middlesex	Pri	5.600	
M63	Carteret	Middlesex	Pri	3.200	
M64	Linden-Roselle JM	Union	Pri	14.900	30.00
M65	Essex-Union JM	Union	Pri	50.000	17.00
Kill Van Kull					
M66	Bayonne	Hudson	Pri	7.200	22.00
M67	Port Richmond	Richmond	Pri	16.400	7.60
Newark Bay					
M68	Jersey City-West	Hudson	Pri	17.000	
M69	Kearny	Hudson	Pri	4.400	100.00

ID No.[a]	Waste Source	County	Type Treatment	Flow MGD	% Industrial
Raritan River					
M70	Perth Amboy	Middlesex	Pri	7.200	46.00
Rahway River					
M71	Rahway Valley SA	Union	Sec	35.100	26.00
Hackensack River					
M72	N. Arlington-Lyndhurst JM	Bergen	Pri	2.400	24.00
M73	Ruth/E-Ruth/Carls JM	Bergen	Sec	3.670	
M74	N. Bergen (n. plant)	Bergen	Pri	1.000	7.00
M75	Bergen County SA	Bergen	Sec	64.100	20.00
NEW JERSEY COASTAL ZONE					
Direct Bight					
M1	Highlands	Monmouth	Pri	0.500	
M2	Fort Hancock, US Army	Monmouth	Pri	—	
M3	Sea Bright	Monmouth	Pri	0.117	
M4	NE Monmouth SA	Monmouth	Sec	2.500	0
M5	Long Branch SA	Monmouth	Pri	4.500	0
M6	Ocean Township SA	Monmouth	Sec	2.200	
M7	Deal	Monmouth	Pri	0.371	
M8	Asbury Park	Monmouth	Pri	3.600	0
M9	Camp Meeting Assoc.	Monmouth	Pri	1.020	0
M10	Bradley Beach-Evergreen Ave	Monmouth	Pri	0.218	
M11	Bradley Beach-Ocean Park Ave	Monmouth	Pri	0.640	
M12	Avon-by-the-Sea	Monmouth	Pri	0.407	
M13	Neptune Township #2	Monmouth	Sec	0.657	0
M14	Neptune Township #1	Monmouth	Pri	1.700	0
M15	Neptune City	Monmouth	Pri	0.504	
M16	Belmar	Monmouth	Pri	1.800	0
M17	Manasquan	Monmouth	Pri	0.686	
M18	NJ State Dept. of Defense	Monmouth	Sec	0.185	
M19	Seagirt	Monmouth	Pri	0.378	
M20	Spring Lake-Pitney Ave	Monmouth	Pri	0.300	
M21	Spring Lake-Penn. Ave	Monmouth	Pri	0.786	
M22	Spring Lake Heights	Monmouth	Pri	0.450	
M22a	Camp Evans, US Army	Monmouth	Pri	0.035	
M23	Bayhead	Ocean	Pri	0.488	
M24	Pt. Pleasant Beach	Ocean	Pri	1.180	
M26	Lavalette	Ocean	Pri	0.870	
M27	Dover Township SA	Ocean	Pri	3.500	0
M28	Seaside Park	Ocean	Pri	1.200	0
M29	Seaside Heights	Ocean	Pri	1.500	0
M29a	Berkley Township SA	Ocean	Sec	0.040	
M30	Beach Haven SA	Ocean	Pri	1.200	0
M31	Long Beach Township SA	Ocean	Pri	1.500	
M32	Ship Bottom SA	Ocean	Pri	0.500	
M33	Surf City Borough	Ocean	Pri	0.780	
Metedeconk River					
M25	NJ Water Co., Lakewood	Ocean	Sec	1.600	0
Great Egg Harbor River					
M43	Belcoville, Weymouth Twp	Atlantic	Pri	0.300	
Southern bays					
M34	Atlantic City Sewer Co., City Island	Atlantic	Pri	15.800	1.20
M34a	Atlantic-City Sewer Co., Texas Ave	Atlantic	Pri	0.188	
M35	Brigantine	Atlantic	Sec	1.040	
M36	Pleasantville City	Atlantic	Sec	1.520	0
M37	Ventnor Margate	Atlantic	Pri	4.860	0
M38	Ocean City-46th St	Cape May	Sec	1.160	
M39	North Wildwood	Cape May	Pri	1.020	
M40	Wildwood	Cape May	Pri	2.850	
M41	Wildwood Crest	Cape May	Pri	1.920	0
M42	Longport	Atlantic	Pri	0.419	
M44	Ocean City Sewer Service Co.	Cape May	Pri	3.700	
M45	Middle Twp Sewer District 1	Cape May	Pri	0.175	
M46	Sea Isle City	Cape May	Pri	0.280	
M47	Stone Harbor	Cape May	Pri	0.732	
LONG ISLAND COASTAL ZONE					
M1	Bay Park	Nassau	Sec	68.000	9.80
M2	Long Beach	Nassau	Sec	6.600	0.20
M3	Freeport	Nassau	Sec	3.400	30.00
M4	Wantagh (1974 flow)	Nassau	Sec	7.000	10.00
M5	US Air Force	Suffolk	Sec	0.230	
M6	Patchogue	Suffolk	Pri	0.270	20.00

[a]see Maps 2-6 for locations

Sources: Mueller et al 1976*b*; EPA and NPDES permits

Map 4. Transect Zone wastewater discharge locations—New Jersey rivers, 1972



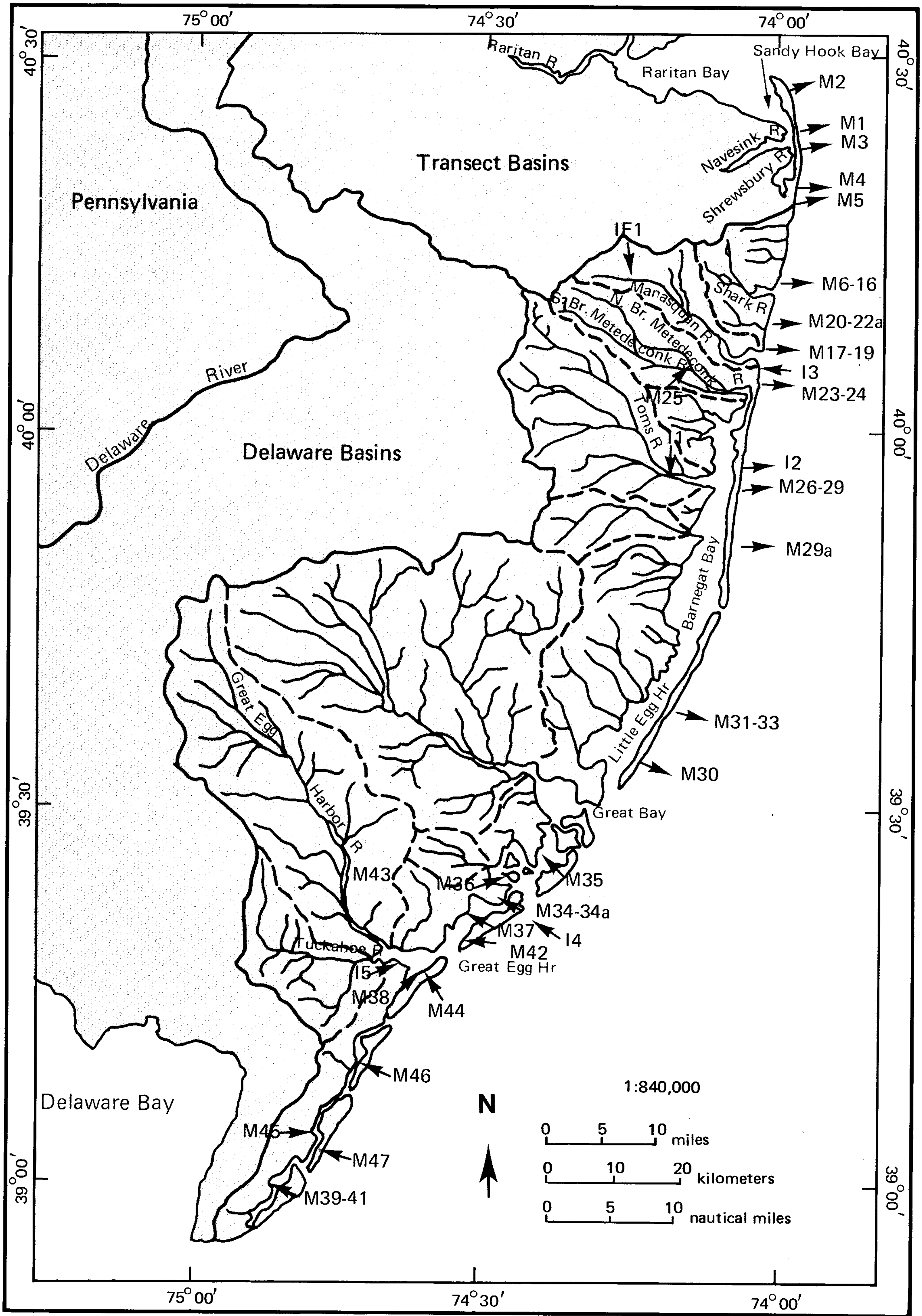
Source: Mueller et al 1976*b*

Mercator Projection

In the Transect Zone, the volume of indirect industrial wastes discharged through municipal plants is about equal to the volume of industrial wastes directly discharged to receiving waters. Along the New Jersey coast, an insignificant quantity of industrial wastes is discharged to municipal systems; on Long Island the major industrial flow to receiving waters is indirectly discharged from municipal treatment plants. The total quantity of industrial wastewater flow generated in the New York Bight area is approximately doubled when the indirect industrial contribution is included.

The organic load discharged from the major wastewater sources to receiving waters ultimately draining to New York Bight is summarized in Table 5. The loads are expressed as five-day biochemical

Map 5. New Jersey Coastal Zone wastewater discharge locations, 1972



Source: Mueller et al 1976*b*

Mercator Projection

oxygen demand (BOD_5), a test determining the amount of oxygen required during five days of bacterial degradation of organic wastes under standard conditions. The values represent the stress imposed on the oxygenation capacity of the waterbody receiving the waste load. The two largest point sources, the Passaic Valley Sewerage Commission (PVSC) treatment plant and the Middlesex County Sewerage Authority (MCSA) plant, receive approximately one-half their wastewater from industrial inputs (S.A. Lubetkin, personal communication; S. Seid, personal communication). Although the flow from the PVSC treatment plant is approximately one-half that from raw sewage discharges in New York City, the organic load is greater because organic matter is more concentrated in industrial wastes than in domestic sewage.

Barged Wastes

Six sites presently exist in New York Bight for dumping wastes (Table 6, Map 1). Dredge spoil comes from dredging of navigable waterways in Bight ports (Figure 6). Fly ash from steam-powered electricity generation has also been disposed of in the dredge spoil dumpsite (Gross 1970). Dredged material from Long Island coastal inlets, Great South Bay, and Shark River in New Jersey are dumped a short distance off the coast for beach nourishment.

Rubble, a relatively inert material, comes from excavation, demolition, and construction. The wreck dumpsite is intermittently used for disposal of unwanted ships. The municipal sewage sludge site receives solid wastes from wastewater treatment plants (Figure 7). The site was chosen in 1924 to avoid interference with navigation and offensive discoloration and washup of solids on beaches. Use of the waste acid disposal site, established in 1948, has been permitted since 1975 only to Allied Chemical, E.I. duPont De Nemours, and NL industries (EPA 1975). Acid wastes consist of by-product hydrochloric acid, spent sulfate solution, and inert ore slurry. Chemical wastes from 33 firms are transported to a site off the continental shelf. This site is actually just outside the defined New York Bight borders but is included here because of its proximity and because data are available.

In the past, garbage and solid wastes were also dumped in the Bight, but this practice was discontinued in the early 1930s. Containerized radioactive wastes have been disposed of in the Bight; six explosive and chemical ammunition dumps are also located in the Bight (Westinghouse Electric Corporation 1972). Since 1972, no significant quantities of radioactive wastes from US sources have been dumped in the sea, and since 1970 all ocean disposal of unserviceable munitions has ceased (NOAA 1974).

A comparison of barged waste volumes from 1960 to 1974 (Figure 8) indicates that dredge spoils comprise the principal barge input to the Bight. Dredge volumes vary from year to year according to the rate of sediment deposition and intermittent dredging schedules in the navigable channels throughout the Bight. The large quantity of dredge spoils taken from New York Harbor (Map 7) is significantly more contaminated than that taken from Long Island and New Jersey coastal inlets. The degraded quality in the harbor is due to settling of contaminated solids from industrial and nonindustrial sources, including raw sewage and partially treated wastewater dis-

Table 4. Distribution of industrial wastewater flows, 1972

	Municipal Wastewater: Total Discharges (MGD)	Municipal Wastewater: Percent Industrial	Indirect Industrial Discharges (MGD)	Direct Industrial Discharges (MGD)	Total Industrial Discharges (MGD)
Transect Zone					
New York	1,788	3	54	58	112
New Jersey	654	34	222	248	470
New Jersey Coastal Zone	74	<1	∿0	17	17
Long Island Coastal Zone	86	10	9	2	11
TOTAL	2,602	11	285	325	610

Source: Mueller et al 1976*b*

charges, contaminated stormwater or urban runoff, as well as gaged runoff from rivers and streams emptying into estuaries. A quantitative estimate of interactions between inland contaminant sources and estuarine sediments that become dredge spoil is not presently available.

Sewage sludge shows a generally increasing trend with time because greater levels of wastewater treatment generate more sludge for disposal. The decline in sludge volume during 1971 and 1972 (Figure 8) was due to construction upgrading New York area treatment facilities, resulting in temporarily lower wastewater treatment efficiency and sludge production. Sludge quality depends on the quantity of contaminants removed during wastewater treatment and on the level of sludge treatment used prior to ultimate disposal. Although a significant quantity of raw sludge is discharged to the Bight, the trend (Figure 9) is to provide anaerobic digestion prior to disposal. This process stabilizes the sludge by destroying about 50% of the organic solids as well as most pathogenic bacteria.

Municipal treatment plants dumping sludge in the Bight had a weighted average of 13% of their flows coming from industries in 1972. The actual industrial fraction of the sludge generated by these plants is higher than the flow fraction because industrial wastes are more concentrated than domestic sewage. The remaining barge dumps are all considered industrial; acid wastes comprise the major volume (Figure 8).

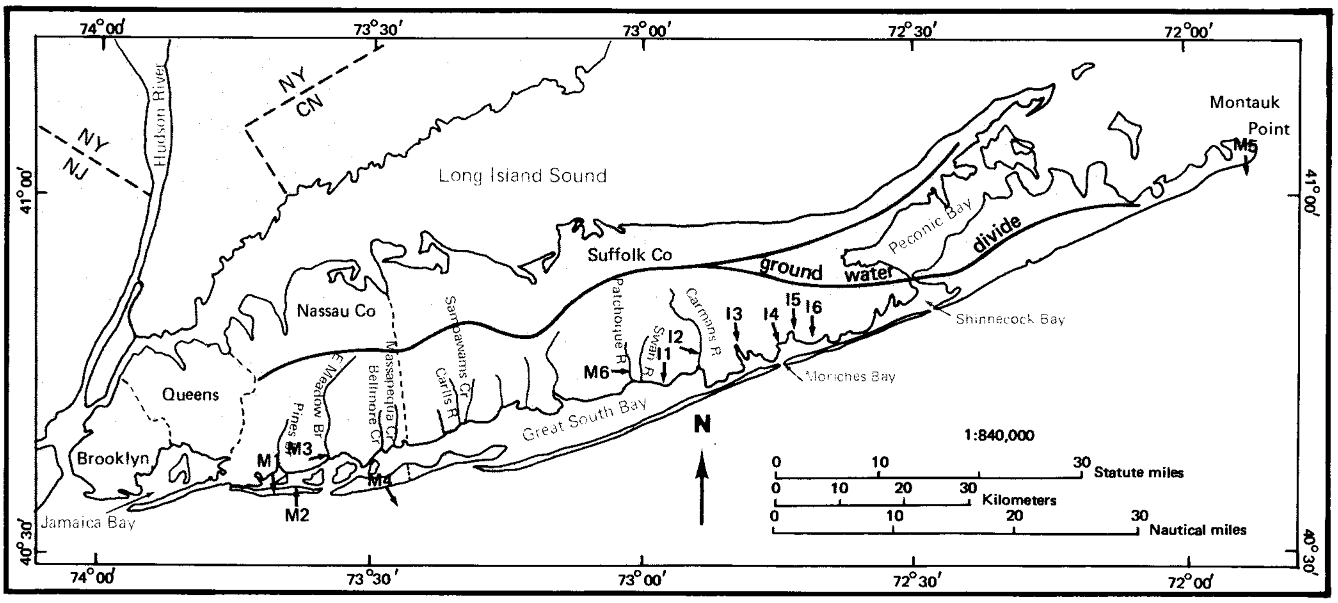
Table 5. Transect Zone: major wastewater sources, 1972

ID No.[a]	Source	Flow (MGD)	BOD_5 Load lb/day	BOD_5 Load metric ton/day
M40	Passaic Valley SC	258.00	603,000	273.0
	Raw sewage-NYC total	480.00	524,000	238.0
M27	Manhattan-West Side	200.00	219,000	99.0
M33	Manhattan-East Side	150.00	164,000	74.0
M32	Brooklyn-Red Hook	70.00	76,500	35.0
M43	Staten Island	60.00	65,600	30.0
M61	Middlesex County SA	72.80	167,000	76.0
M26	Yonkers JM	88.20	78,700	36.0
M64	Linden-Roselle JM	14.90	66,600	30.0
M65	Essex-Union (Elizabeth) JM	50.00	58,100	26.0
M36	Bowery Bay	107.00	53,500	24.0
M34	Newtown Creek	173.00	50,500	23.0
M35	Wards Island	242.00	46,400	21.0
M71	Rahway Valley SA	35.10	43,900	20.0
M42	Owls Head	96.00	42,400	19.0
M41	Jersey City-East Side	36.70	38,300	17.0
M44	Coney Island	99.00	37,200	17.0
M37	Hunts Point	156.00	35,100	16.0
M67	Port Richmond	16.40	23,800	11.0
M75	Bergen County SA	64.10	23,000	10.0
M45	26th ward	66.00	22,000	10.0
M68	Jersey City-West	17.00	18,200	8.3
M30	West New York JM	9.60	17,500	7.9
I38	GAF Corp.-Linden	20.00	17,200	7.8
M31	Hoboken	17.30	16,600	7.5
M66	Bayonne	7.20	15,100	6.8
M63	Carteret	3.20	14,200	6.4
M70	Perth Amboy	7.20	12,000	5.4
M38	Tallmans Island	6.10	11,700	5.3
M46	Jamaica	93.00	11,600	5.3
I54	Tenneco Chemicals-Ford	1.56	11,100	5.0

[a]see Maps 2-6 for locations

Source: Mueller et al 1976*b*

Map 6. Long Island Coastal Zone wastewater discharge locations, 1972



Source: Mueller et al 1976*b*

Mercator Projection

Atmospheric Fallout and Runoff

Atmospheric fallout is the direct input of gaseous and particulate contaminants into the Bight during periods of both dry weather and precipitation. Sources of atmospheric contaminants include motor vehicles, power plants, space heating, and industries. The mass emission rates of air contaminants in Table 7 show emissions to be about equally divided between New York and New Jersey. The industrial fraction of the air contaminants that ultimately reaches Bight waters is unknown.

Runoff from land surfaces into Bight waters comes from three sources: streamflow or gaged surface runoff, urban runoff, and groundwater outflow. The industrial fractions of these inputs are not quantitatively known; however, a rough estimate of the fraction of industrial input in gaged runoff (Table 8) was made for New Jersey rivers containing freshwater industrial wastewater discharges. Table 8 does not quantitatively account for biological decay and deposition in the rivers from the points of waste discharge to the sampling stations, and therefore the data represent maximum possible contributions. The freshwater industrial discharges to the Elizabeth and Raritan rivers are significant. Lead and chromium industrial discharges into the Raritan River are actually greater than the measured values at the sampling stations. For the Passaic River, however, the upstream industrial discharges are not as significant compared to total loads measured in the river. The fraction of industrial contribution to the largest gaged runoff source, the Hudson River, may be relatively small due to lower industrial activity and a larger drainage basin compared to the rivers in northern New Jersey (Figure 3). The industrial fraction of urban runoff is also low since this input is more a function of population density, municipal street cleaning, and construction than industrial waste discharges.

Figure 6. Hopper dredge *Essayons:* dredges channels in New York Harbor by hydraulic suction and transports material to dumpsite; 525 ft long, 12 hoppers with capacity of 8,270 yd^3 of dredge spoil, displaces 22,410 long tons when loaded (Courtesy of US Army Corps of Engineers, New York District)

Mass Loads

Industrial waste inputs to the Bight from the quantitatively definable wastewater and barged waste sources are presented in Figure 10. The water quality parameters include suspended solids because of their effect on light penetration and deposition, BOD_5 as a measure of oxygen-demanding substances, nitrogen and phosphorous as typical nutrients for plant growth, and heavy metals because of toxicity.

The volume of barged wastes is insignificant compared to the industrial wastewater flow, which is equally split between direct discharges and indirect discharges through municipal systems. The principal suspended solid input is rubble from construction in the New York area. The BOD_5, nitrogen, and phosphorus industrial loads are mainly from wastewater discharges, as are a major portion of the heavy metals. Barged industrial wastes from acid and sludge discharges contain a significant fraction of most heavy metals dumped into the Bight.

Analysis of the industrial fractions of municipal wastewaters and sludge for suspended solids, BOD_5, nitrogen, and phosphorus are based on New Jersey treatment plant data. The MCSA 1973 annual report indicates known industrial load components of 47% for BOD_5 and 45% for suspended solids. These are conservatively low values because only nine industrial plants are included, while industries that discharge to municipal systems tributary to MCSA are not included. A realistic estimate of industrial contribution for these parameters in the northern New Jersey area is 60%. This is somewhat higher than estimated

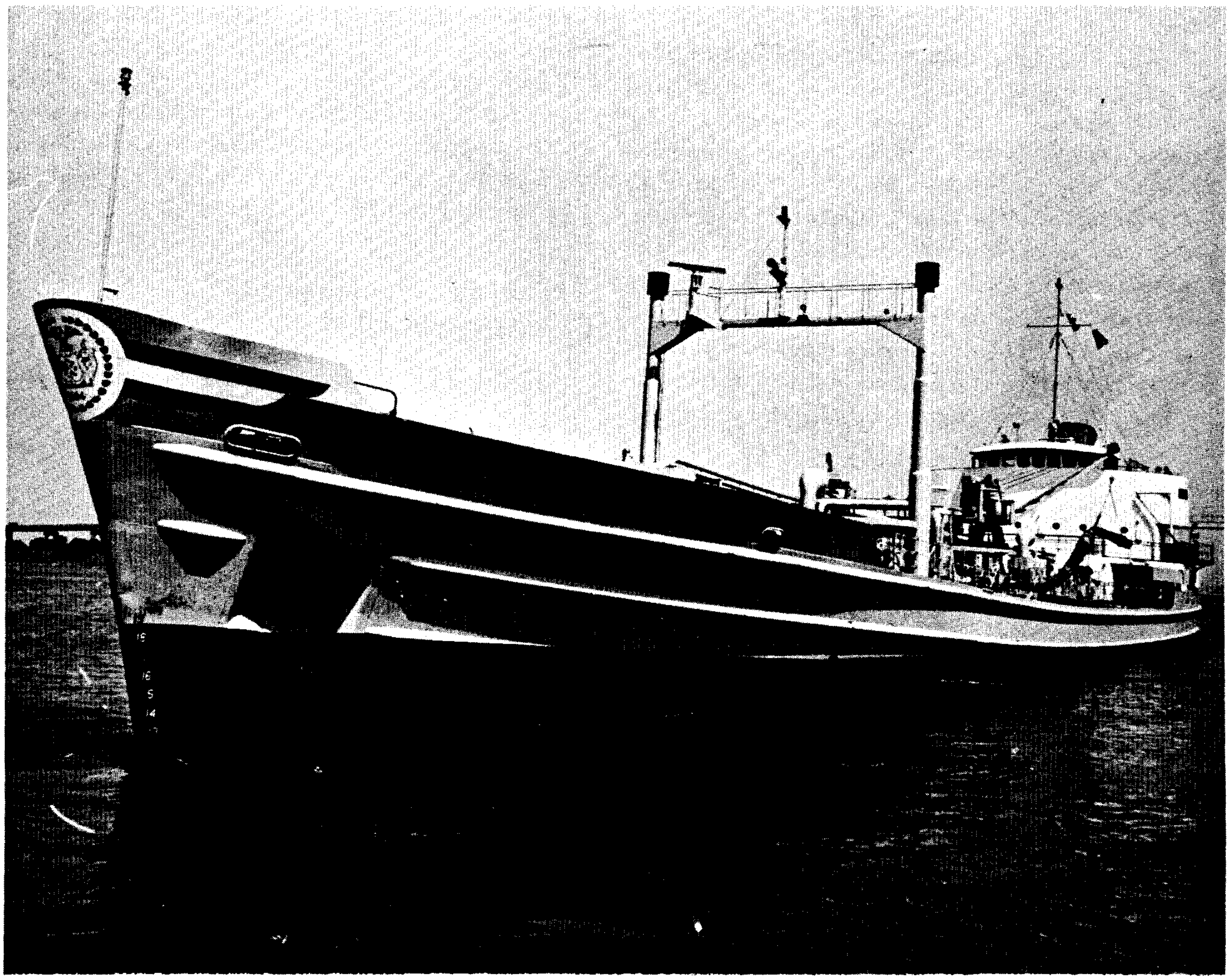


Figure 7. *Newtown Creek,* operated by NYC Environmental Protection Administration; cargo capacity—3,960 yd^3, makes trips to sewage sludge dumpsites where sludge is discharged by gravity through underwater valves (Courtesy of NYC Environmental Protection Administration)

MCSA values and lower than estimated PVSC values; typical per capita loads and population served were used to obtain the domestic fraction. For the New York area of the Transect Zone and the Long Island Coastal Zone, a load fraction of 5% was calculated by scaling up the New York percent industrial flow (3%) by the New Jersey load–flow ratio, 60%:34%. Industrial contribution in the New Jersey Coastal Zone was considered negligible.

Estimates for heavy metals in the New Jersey area of the Transect Zone were made using an average value of 80% industrial contribution to municipal wastewaters for all metals, as extrapolated from Rowe (1971) (Table 9). For New York, values of industrial contribution for individual metals from Klein et al (1974) were used (Table 10). As the latter study has no data on lead, an average of the other metals (33%) was used in estimating industrial contributors for lead in the New York area of the Transect Zone and for all metals in the Long Island Coastal Zone.

The higher fractions of industrial contribution for northern New Jersey, compared to New York City, are due to the magnitude and type of industrial activity (Figure 5) and to differences in population density (Table 1). Northern New Jersey supports the manufacture of chemicals, electrical equipment, machinery, and fabricated metals, all industries with the potential for discharging heavy metals. Although New York City has a large electroplating industry, the higher overall population density tends to reduce the relative percentage of industrial metals contribution by increasing water supply, runoff, and residential inputs.

Although quantitative estimates of chlorinated hydrocarbon inputs in the New York region are not readily available, their presence in the environment is established. High doses of these man-made toxic organics are known to have harmful effects on aquatic organisms and under laboratory conditions have been shown to be mutagens. These substances are used as herbicides, pesticides, and in the manufacture of other goods, and may enter the environment in a number of ways. They are stable compounds with long residual lives because they resist biological and chemical degradation. They are also soluble in fatty tissues of organisms; they accumulate to progressively high levels along food chains (bio-accumulation). Since 1975, high levels of polychlorinated biphenyls (PCBs), exceeding the acceptable level for human consumption set by the US Food and Drug Administration, have been found in Hudson River fishes. PCBs are now used primarily in the manufacture of electrical equipment. Two General Electrical Company plants on the upper Hudson River have been named as PCB dischargers (Beil 1976). The US Environmental Protection Agency (EPA) recently proposed regulations that would prohibit discharge of PCBs from plants manufacturing electrical equipment and strictly limit amounts discharged by other types of operations (EPA proposes regulations . . . 1976).

Industrial v. Nonindustrial Contaminant Inputs

An estimate of the significance of the industrial waste inputs to New York Bight can be obtained by comparing them to the relatively nonindustrial inputs

Table 6. Bight dumpsites

	Location (Lat)	Location (Long)	Area (nmi^2)	Radius (nmi)	Distance from Nearest Shore (nmi)
Dredge spoil (mud)	40°23′48″N to 40°21′48″N	73°51′28″W to 73°50′00″W	–	0.6	5
Rubble (cellar dirt)	40°23′N	73°49′W	–	0.6	7
Municipal sewage sludge	40°22′30″N to 40°25′00″N	73°41′30″W to 73°45′00″W	6.25	–	10
Acid wastes	40°16′N to 40°20′N	73°36′W to 73°40′W	12.00	–	13
Chemical wastes	38°40′N to 39°00′N	72°00′W to 72°30′W	450.00	–	92
Wrecks	40°10′N	73°42′W	–	0.5	10

Source: Mueller et al 1976*b*

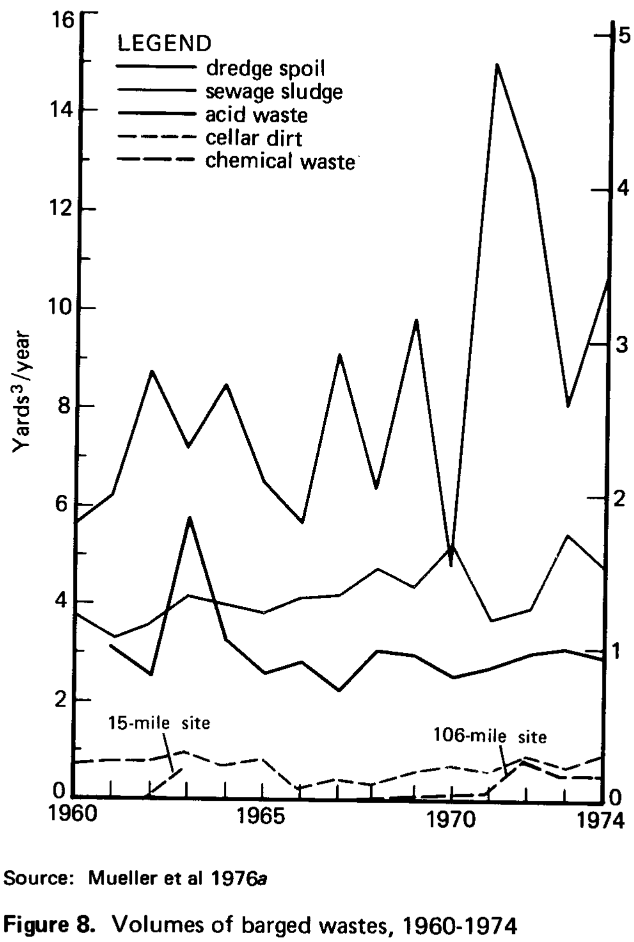
from municipalities and runoff. Although dredge spoils and atmospheric fallout contain industrial components, their magnitudes cannot be determined. Pie charts of the distribution of flow and nine water quality parameters illustrate the relative import of industrial waste inputs.

Figure 11 indicates that industrial inputs contribute little of the flow to Bight waters: most comes from precipitation and runoff. The amount of flow to the Bight—in fact, each water quality parameter considered—from the New Jersey and Long Island Coastal Zones is small compared to that from the Transect Zone and Direct Bight. Contaminant inputs from the less densely populated New Jersey and Long Island coasts are generally less than 6% of the total input. Groundwater flow and groundwater contaminant loads from Long Island are also considerably less.

The suspended solids load from industrial inputs is about 9% of the total; most of this industrial load consists of rubble (Figure 12). Dredge spoils and runoff are the chief sources of suspended solids. The actual solids load entering the Bight is not known since the river sediment is not included because it is probably uncontaminated; also, a fraction of inland runoff, industrial, and municipal loads are deposited in estuarine waters and are included in dredge spoils. Since most of Upper Bay and the rivers draining to it are dredged by the US Army Corps of Engineers, the contaminants deposited there will generally be included in dredge spoils. Only a small portion of Lower and Raritan bays are dredged (Map 7). A quantitative estimate of the interactions between inland contaminant sources and dredge spoils is not presently available.

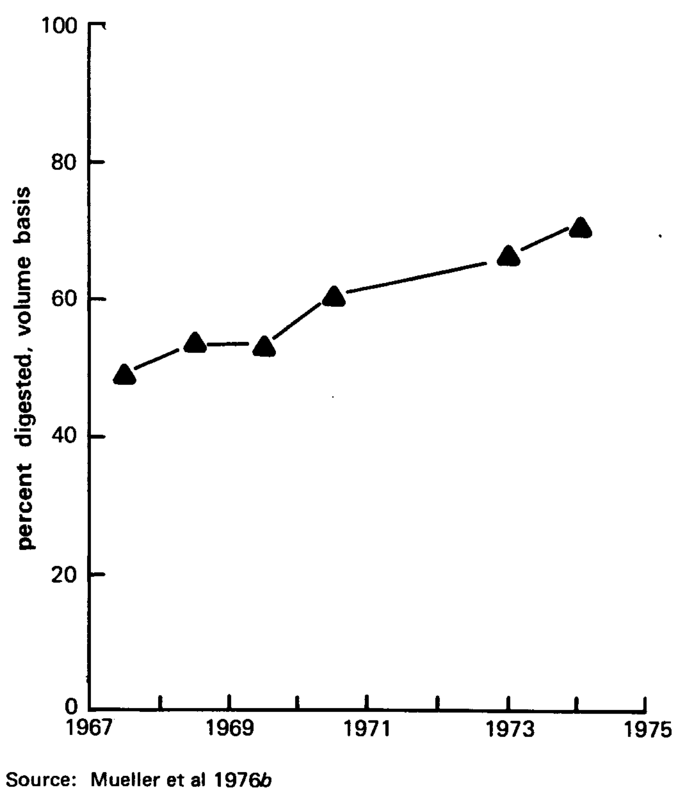
Industrial inputs of BOD_5 (the biodegradable organic matter) account for 22% of the total, slightly more than runoff and more than half the municipal inputs (Figure 12). Of all the contaminants evaluated, BOD_5 and chromium contain the largest industrial fractions. The industrial fractions evaluated in the pie charts must be considered minimum since they do not incorporate undefined dredge spoil, gaged runoff, or atmospheric industrial inputs.

The industrial fractions of nitrogen and phosphorus loads (Figure 13) are 14% and 12% respectively. The load distribution for other sources differs significantly. Whereas municipal wastewater is a



Source: Mueller et al 1976*a*

Figure 8. Volumes of barged wastes, 1960-1974



Source: Mueller et al 1976*b*

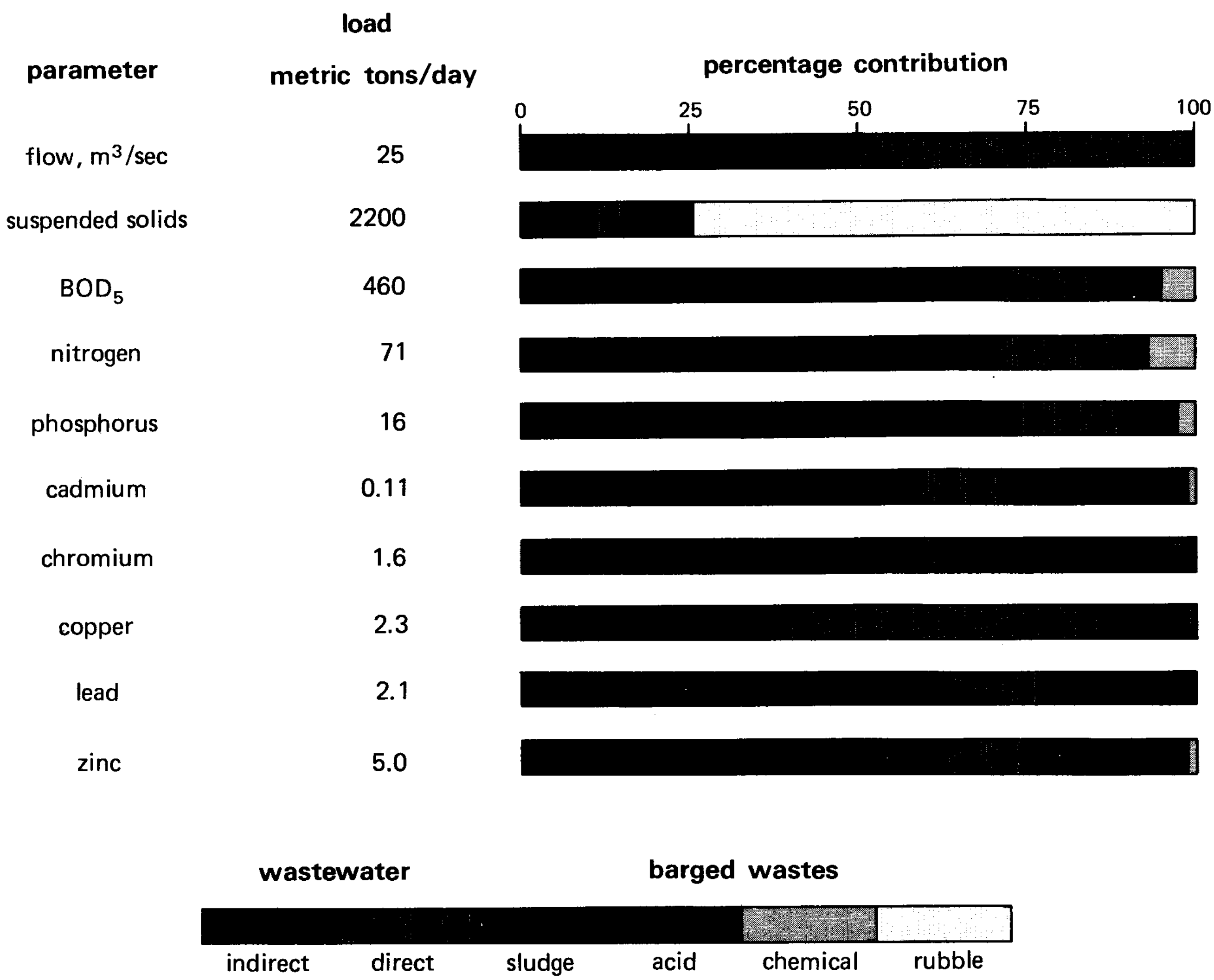
Figure 9. Digested sludge fraction of sewage sludge dumped into Bight

major contributor of both nitrogen and phosphorus, dredge spoils contribute the largest phosphorus input but only a small fraction of the nitrogen. Atmospheric input is significant for nitrogen but negligible for phosphorus, and the gaged runoff nutrient load is also greater for nitrogen than for phosphorus.

For heavy metals (Figure 14), dredge spoils contribute the largest fraction except for zinc, where runoff is greatest. The industrial components are: cadmium 5%, chromium 26%, copper 16%, lead 16%, and zinc 14%. Urban runoff is an important source of all metals, especially zinc and lead (perhaps due to rapidly settling particulate lead emissions from vehicles).

A study conducted in New York City by Klein and his associates (1974) indicated that three additional sources of metals are significant in New York City discharges: water supply, residential wastewater, and urban runoff (Table 10). The copper and zinc concentrations in the water supply system accounted for, respectively, 20% and 7% of the concentrations at the wastewater treatment plant influents; residential wastewater accounted for 25% to 50% of the heavy metals concentration.

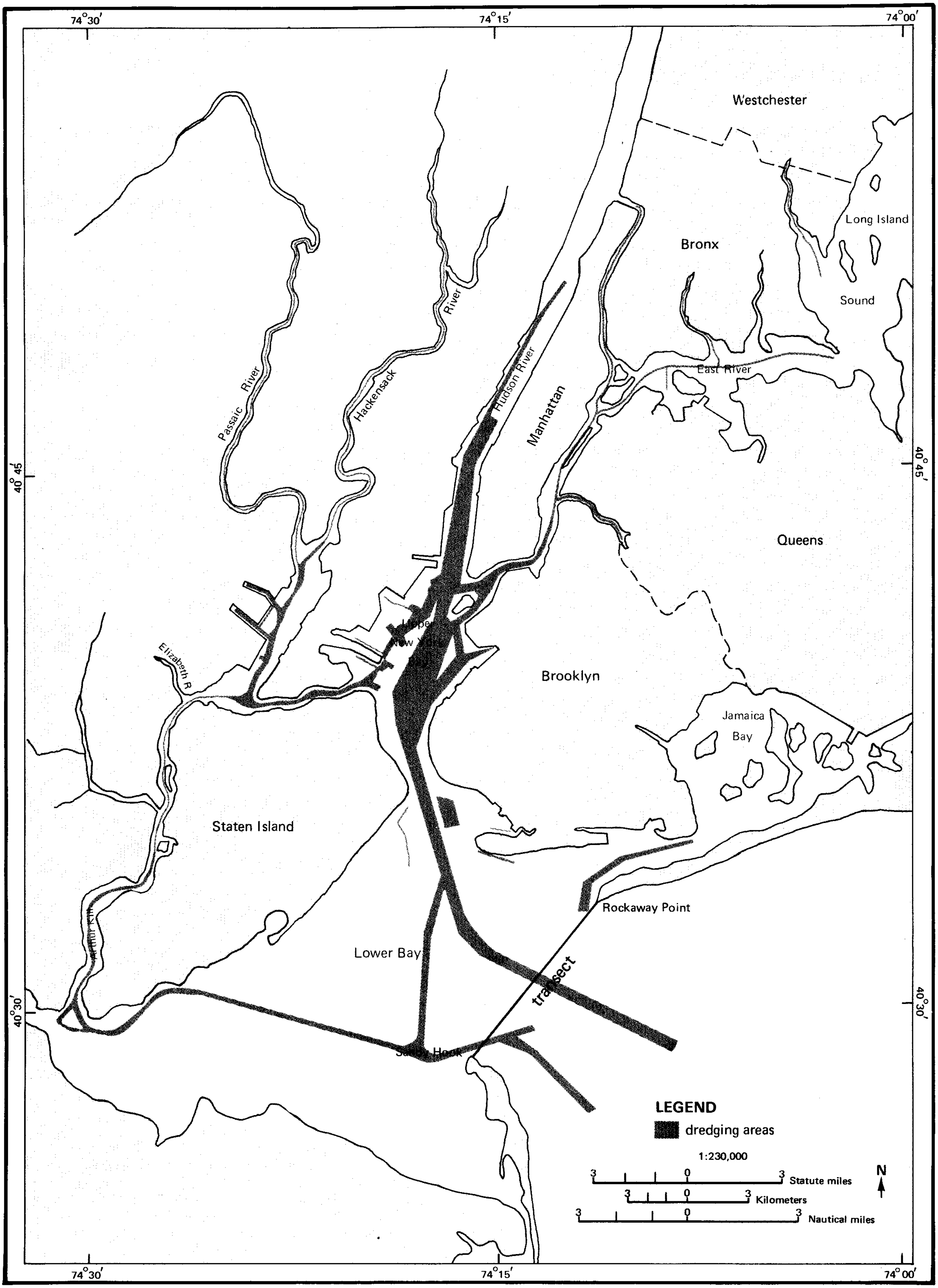
In Table 11, industrial loads are compared to loads calculated from background seawater concentrations and estimated flow rates moving across the Bight. Chromium (63%) and lead (140%) are being added at comparatively high rates. Though the accuracy of the background flow is unknown, the resulting load estimates should be indicative of the relative significance of the various parameters.



Sources: Anderson and Mueller 1976; Mueller et al 1976*a*

Figure 10. Sources of industrial loads

Map 7. Dredging areas, New York Harbor area



Source: US Army Corps of Engineers

Mercator Projection

Wastewater Treatment

Characteristics of industrial wastewaters vary significantly with the type and age of a facility. Wastewater treatment must therefore be tailored to each type of industry and to particular plant sites. The degree of contaminant removal necessary depends on various factors, including the assimilative capacity of the receiving waters with respect to water usage designation, and economic analysis of the benefits and costs of treatment. The typical wastewater treatment processes (Figure 15) given below may be utilized in combinations for treatment of various wastewaters.

Primary treatment employing gravity settling removes gross pollutants such as floatable and suspended solids. Only the fraction of organic matter, nutrients, and heavy metals associated with settleable solids is removed in this process, generally less than 30%. Used alone, primary treatment affords some protection to the receiving waters by reducing esthetic impacts as well as sludge deposits. Oxygen-demanding substances still remain and will exert an oxygen demand on the receiving waters, its significance depending on the size and condition of the waterbody. In the New York Bight area, most wastewater mass loads are now discharged through primary treatment plants.

Plans are to phase out numerous local primary treatment plants by the early to mid-1980s; large, existing primary plants will be converted to secondary treatment.

Much of the colloidal and dissolved organic matter remaining after primary treatment of municipal wastewaters and most industrial wastewaters is biodegradable. Secondary treatment employs biological processes occurring naturally in receiving waters but utilizes much higher microbial populations and shorter reaction times. The numerous types of biological processes make use of either attached or suspended microbial growths. The biological oxidation process typical in large municipal treatment plants (Figure 16) recirculates flocculent biomass to oxidize the organic matter in the primary effluent. In the presence of high biomass populations (1,500 to 5,000 mg/l suspended solids), relatively high oxygen uptake rates result, requiring continual injection of air into the oxidation tank to maintain aerobic conditions in the system.

Secondary treatment of wastewaters removes most suspended solids and organic matter; some nutrients are removed by incorporation into biological growth. Metals removal for secondary treatment is within the range obtained by Klein and his associates (1974) in their study of New York City plants; lowest was for nickel, highest for chromium. The major oxygen-demanding load of secondary effluents on receiving streams is generally ammonia

Table 7. Mass emissions of air contaminants from Bight region

	Emission Rate (metric tons/day)		
	New York[a]	New Jersey[b]	Total
Particulates	281	256	537
Sulphur oxides	660	789	1,450
Nitrogen oxides	839	850	1,690
Hydrocarbons	1,990	1,390	3,380
Carbon monoxide	7,190	5,570	12,800

[a]Suffolk, Nassau, Rockland, Westchester counties, and New York City

[b]Hudson, Bergen, Passaic, Essex, Union, Somerset, Morris, Monmouth, and Middlesex counties

Source: Mueller et al 1976*b*

Table 8. Freshwater direct industrial mass loads as percent of gaged runoff loads for northern New Jersey rivers

	Raritan River[a]	Passaic River[b]	Elizabeth River[c]
Flow	5.1%	2.4%	5%
Suspended solids	10.0%	1.6%	
BOD_5	41.0%	19.0%	52%
Total nitrogen	29.0%	0.8%	
Total phosphorus	21.0%	3.4%	
Metals			
Chromium	370.0%	33.0%	
Copper	38.0%	3.3%	
Lead	330.0%	0.5%	
Zinc	15.0%	4.3%	

Sources: Gaged runoff loads from Mueller et al 1976*b*

[a]Industrial wastewater sources IF2-IF6; EPA and NPDES permits

[b]Industrial wastewater sources IF7-IF11; EPA and NPDES permits

[c]Industrial wastewater source IF1

nitrogen, which is oxidized to nitrate (nitrification) in the receiving water. Secondary treatment plants can be designed to obtain nitrification, but this requires much greater air quantities and detention times. Approximately 54% of the municipal wastewater flow in the Bight area presently receives secondary treatment, most with no significant nitrification. In the future, all wastewater treatment plants in the Bight area are expected to be upgraded to secondary effluent quality to comply with policy based on the 1972 amendments to the Federal Water Pollution Control Act (PL 92-500), but most will be without nitrification.

Contaminants remaining in wastewaters after secondary treatment can be removed to varying degrees by using different sequences of advanced wastewater treatment processes. Biological nitrification and denitrification effectively remove nitrogen; phosphorus is typically removed by chemical precipitation, which also removes heavy metals as hydroxides at higher pHs. Ammonia nitrogen can be removed by physical or chemical processes. Carbon adsorption removes residual organic matter; sand or mixed media filtration removes residual suspended solids. Membrane separation processes such as electrodialysis and reverse osmosis remove dissolved solids.

Although current federal regulations call for higher levels of wastewater treament in the future, as the level of waste treatment increases, so do system complexity and cost. For most wastewater discharges into New York Bight, advanced treatment may have little further effect on water quality due to the large assimilative capacity of the receiving waters as well as to contaminant inputs from uncontrolled sources. For some industrial discharges, advanced treatment may be required to meet standards for certain substances. When water reuse assumes a high priority, in industries as well as in municipalities, advanced treatment will normally be required to supply the desired water quality. Advanced treatment is now planned for two discharges to Long Island Sound (Interstate Sanitation Commission 1976). Also, an advanced wastewater pilot plant has been designed for the Cedar Creek facility in Nassau County to produce 5 MGD of high quality effluent to be injected back into the ground for drinking water reuse.

Following any treatment, wastewater is generally disinfected with chlorine in the northern New Jersey-New York City area to protect swimming beaches during summer. Continual disinfection of wastewaters to protect shellfish areas is still controversial, in part because of the possibility of discharging chlorinated hydrocarbons to the environment. Other disinfection techniques, such as ozonation and ultraviolet radiation, are being investigated. However, chlorine will probably continue to be the major disinfectant in the Bight area. Industrial discharges produce insignificant coliform loads (a measure of pathogenic contamination); separate industrial discharges should generally not need disinfection if they are segregated from sanitary wastes.

All treatment processes produce enough byproduct sludge so that major portions of total plant costs must go toward treatment and ultimate disposal. Primary sludge consists of settleable solids from raw sewage; secondary sludge is the excess biological solids produced during biological oxidation. Sludges from advanced wastewater treatment may be biological or chemical, depending on processes used.

Combinations of sludge thickening, destruction, dewatering, and disposal processes are utilized for wastewater sludges. Sludge thickening, typically by gravity or air flotation, inexpensively removes most water from solids, leaving total solids of 4% to 10%. Most common in the Bight area is anaerobic digestion—sludge is held in closed tank reactors for 20 to

Table 9. Industrial contributions of heavy metals to Middlesex County Sewerage Authority wastewater

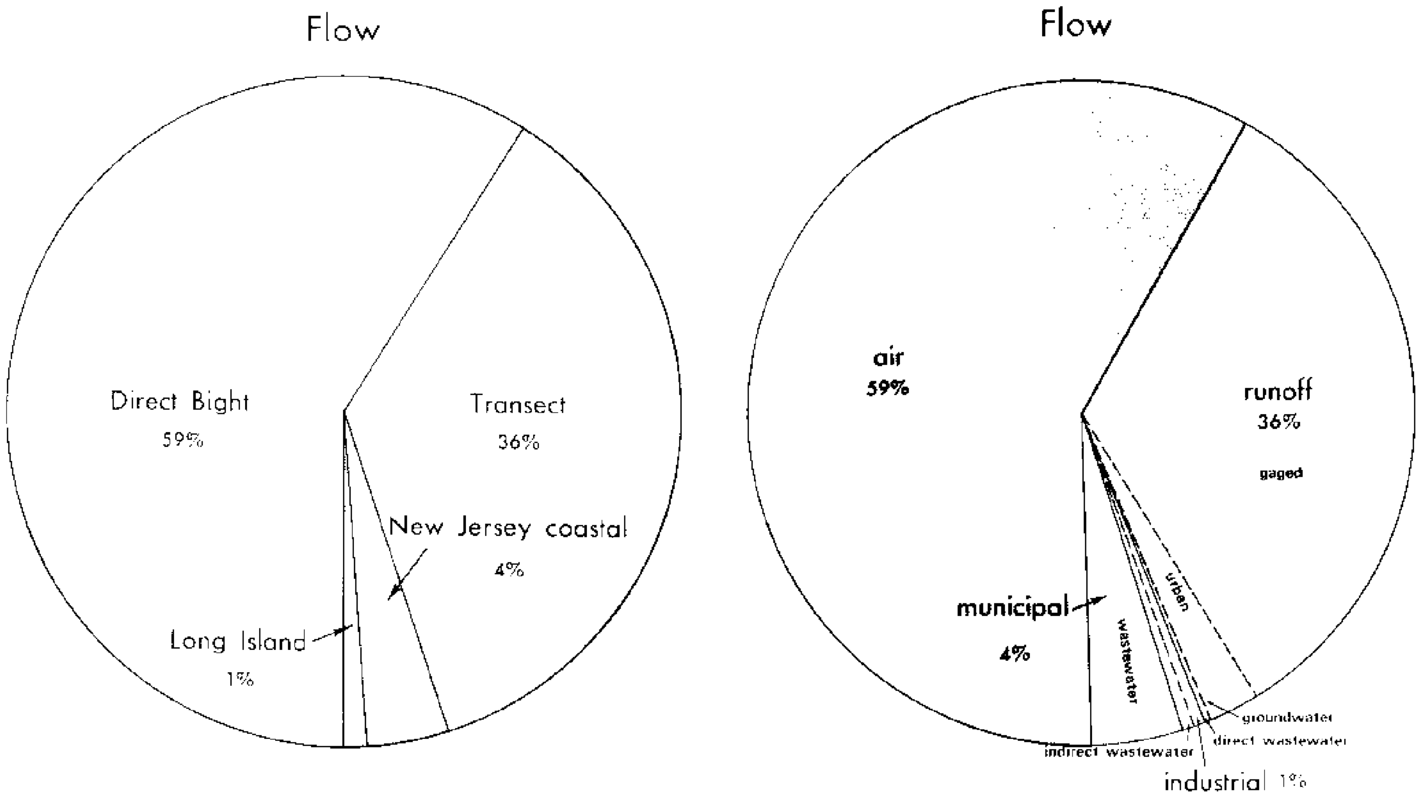
Cadmium	53%
Chromium	93%
Copper	>99%
Lead	74%
Zinc	65%
Average	77%

Source: Rowe 1971

Table 10. Metals sources in New York City municipal wastewater

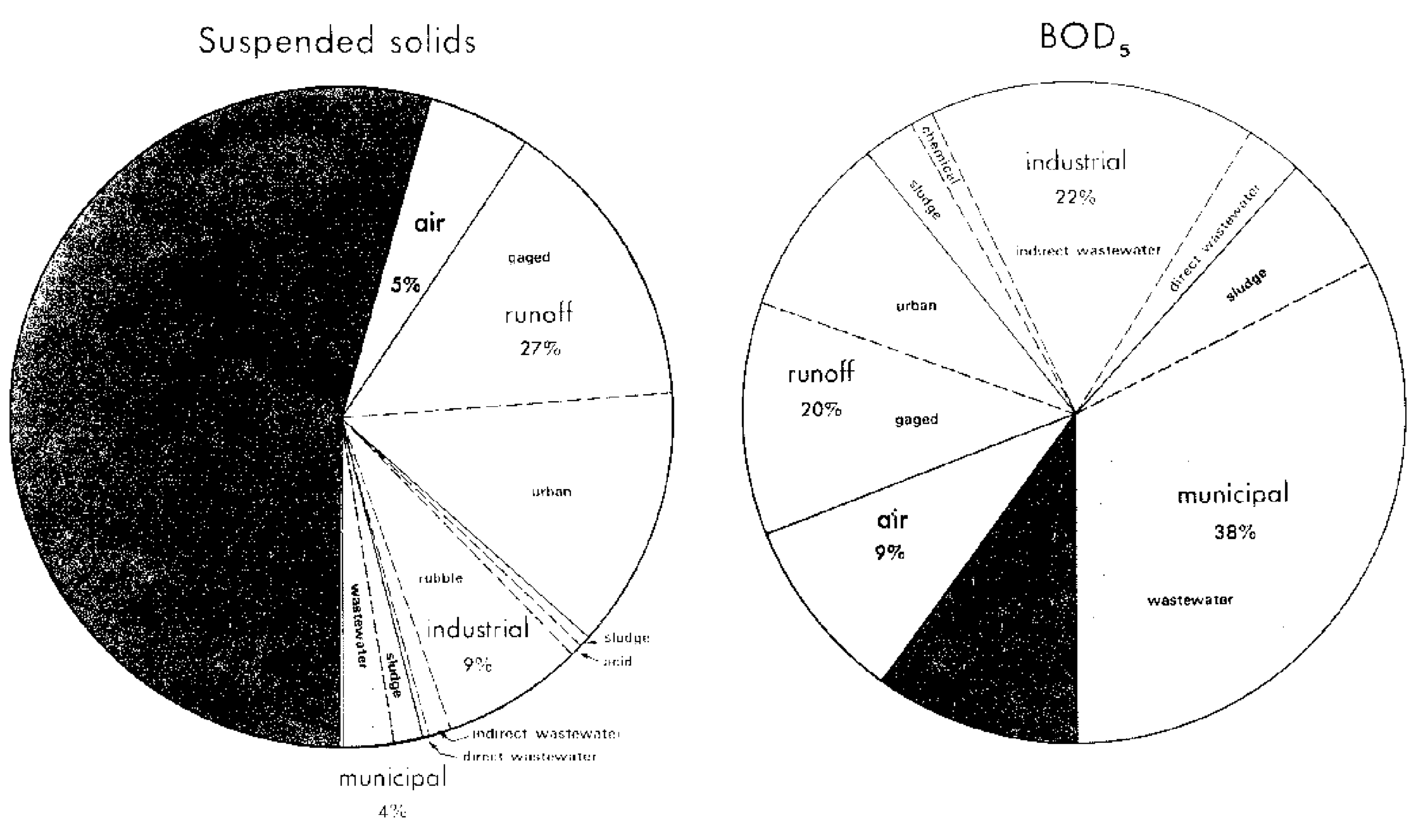
	Cadmium	Chromium	Copper	Zinc
Total industrial	39%	52%	19%	20%
Electroplaters	33%	43%	12%	13%
Other industries	6%	9%	7%	7%
Water supply	0	0	20%	7%
Runoff	12%	9%	14%	31%
Residential	49%	28%	47%	42%
Unknown	0	11%	0	0

Source: Klein et al 1974



Source: Mueller et al 1976*b*

Figure 11. Distribution of flow inputs to Bight by location and source



Source: Mueller et al 1976*b*

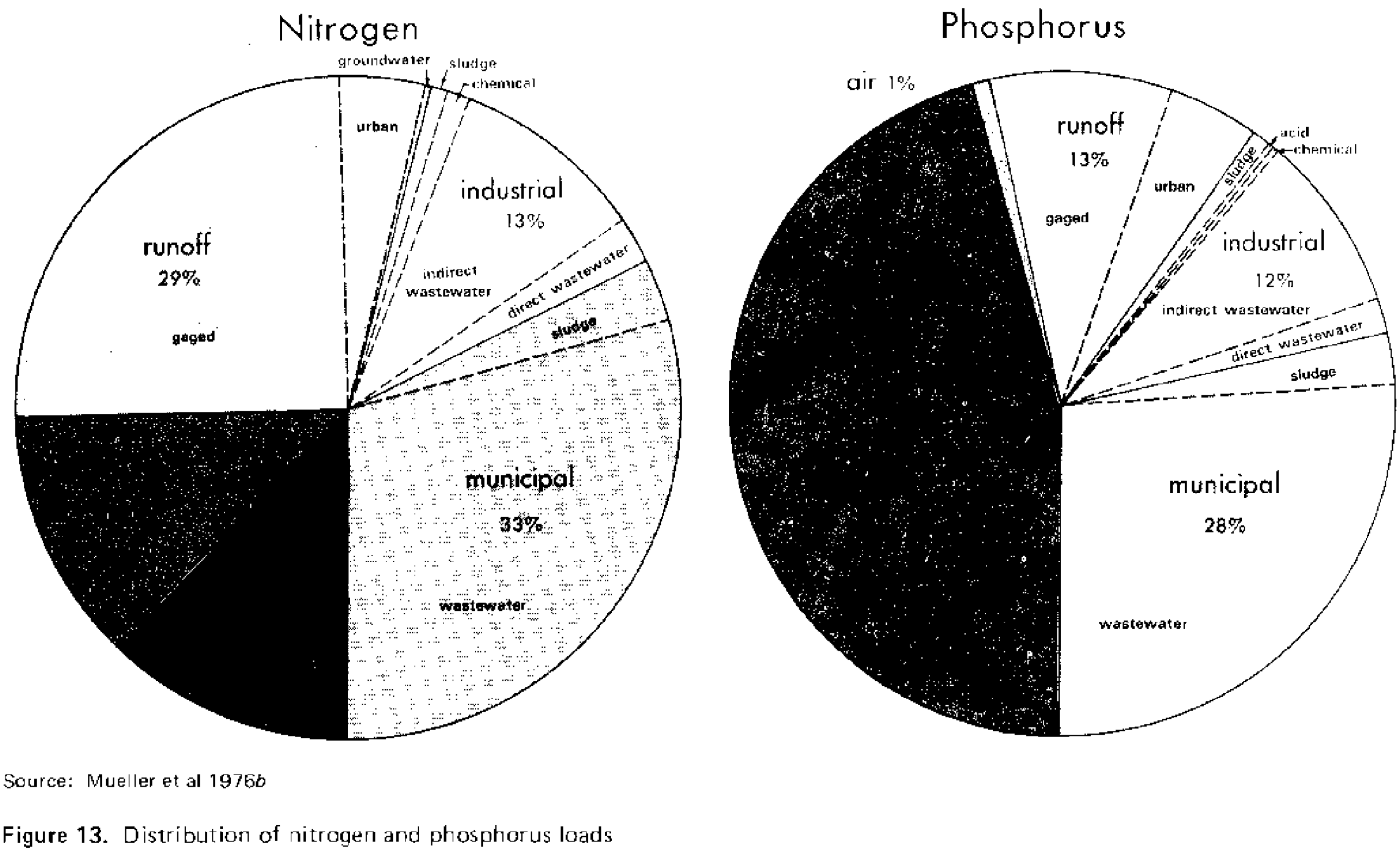
Figure 12. Distribution of suspended solids and BOD_5 loads

30 days under anaerobic conditions. About 50% of the volatile solids (organic carbon) in the sludge is biologically converted to methane and carbon dioxide gas; the remainder is a relatively stable, substantially odor-free material. Prior to ultimate disposal, the sludge may be further reduced in volume by a dewatering process such as vacuum filtration or centrifugation. This is a costly stage where chemical or thermal conditioning is required prior to dewatering to obtain a dry (20% to 30% solids) sludge cake. It is generally applied where ultimate sludge disposal is by sanitary landfill or incineration.

Since most of the sludge from the Bight region is barged to the 19 km (12 mi) ocean dumpsite, minimum sludge treatment is economically attractive. Consequently, a significant amount of raw sludge is barged to the sludge dumpsite; the remainder is digested (Figure 9). Just as increased levels of wastewater treatment reduce detrimental effects on receiving water quality but create more sludge, increased levels of sludge treatment reduce oxygen demands and leaching rates of sludge deposits (Figure 17).

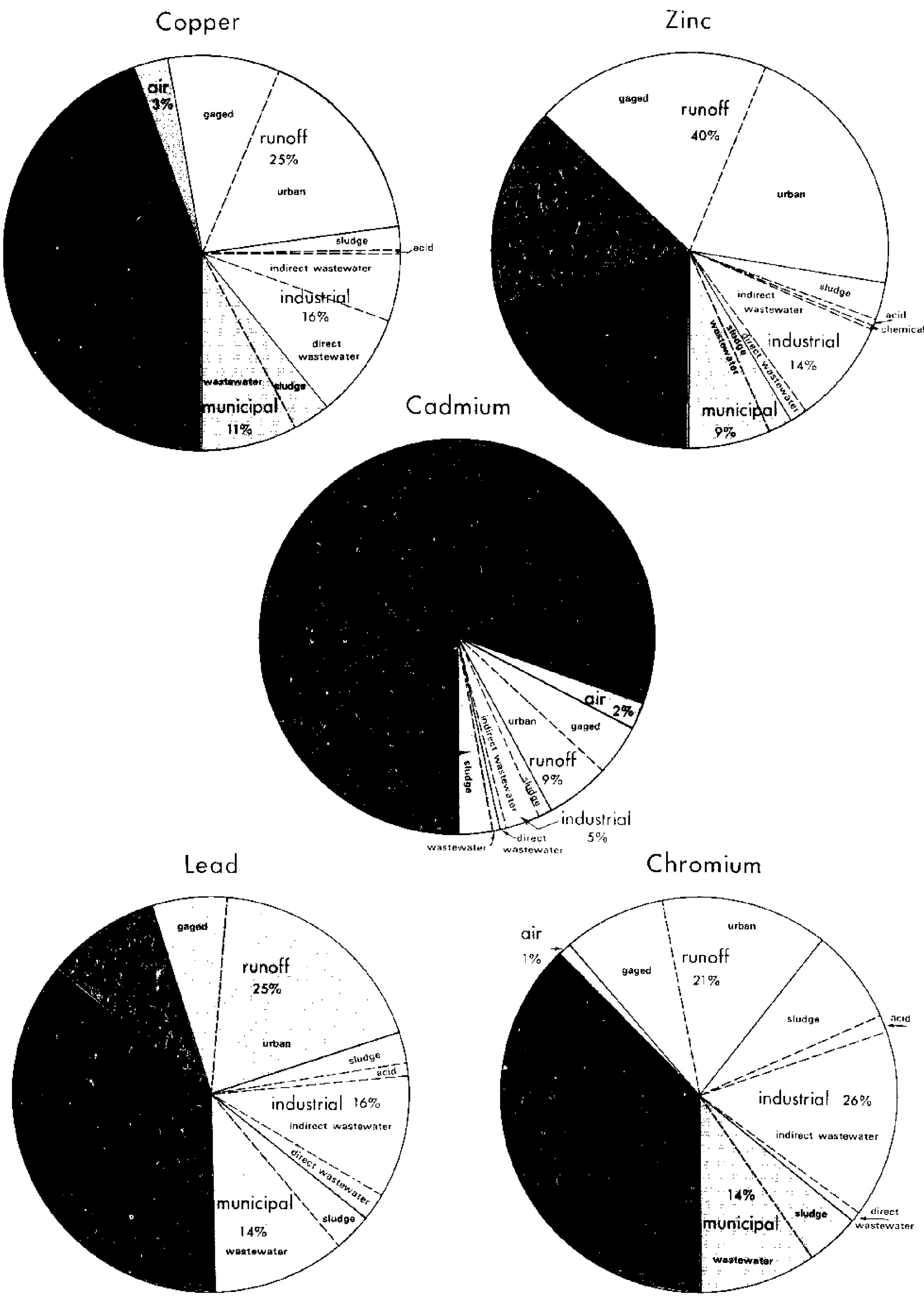
Typical secondary treatment with anaerobic sludge digestion reduces the mass loads of pathogenic bacteria, oxygen-demanding organic matter, organic carbon, and volatile suspended solids discharged in liquid and sludge effluents to the environment. The process does not modify very much the total discharge of nitrogen, phosphorus, and heavy metals. The removal rates of these relatively conservative materials from the wastewater effluents (Figure 15) reflect the quantities discharged in the sludge, with the exception of the nitrogen removed by denitrification in advanced wastewater treatment.

Beside the above secondary treatment used for both municipal and organic industrial wastewaters, industrial wastes often require additional treatment. Among the petrochemical and electroplating industries in the New York-New Jersey metropolitan area, treatment for removal of oil, metals, and cyanide may be provided. Oil is removed by gravity separation or air flotation; heavy metals are generally removed by chemical precipitation. For some metals, additional treatment—reduction of hexavalent chromium to trivalent state, for example—is required prior to chemical precipitation. For concentrated metal plating wastes, metal recovery by ion exchange or electro-chemical means may prove to be economically feasible, depending on future technological advances. Concentrated cyanide plating wastes have typically been treated by alkaline chlorination; diluted cyanide solutions can be treated biologically. For highly toxic exotic chemical wastes, such as the pesticide Kepone, or where concentrations must be reduced to insignificant levels, advanced or entirely new treatment processes will be necessary.



Source: Mueller et al 1976*b*

Figure 13. Distribution of nitrogen and phosphorus loads



Source: Mueller et al 1976*b*

Figure 14. Distribution of heavy metals loads

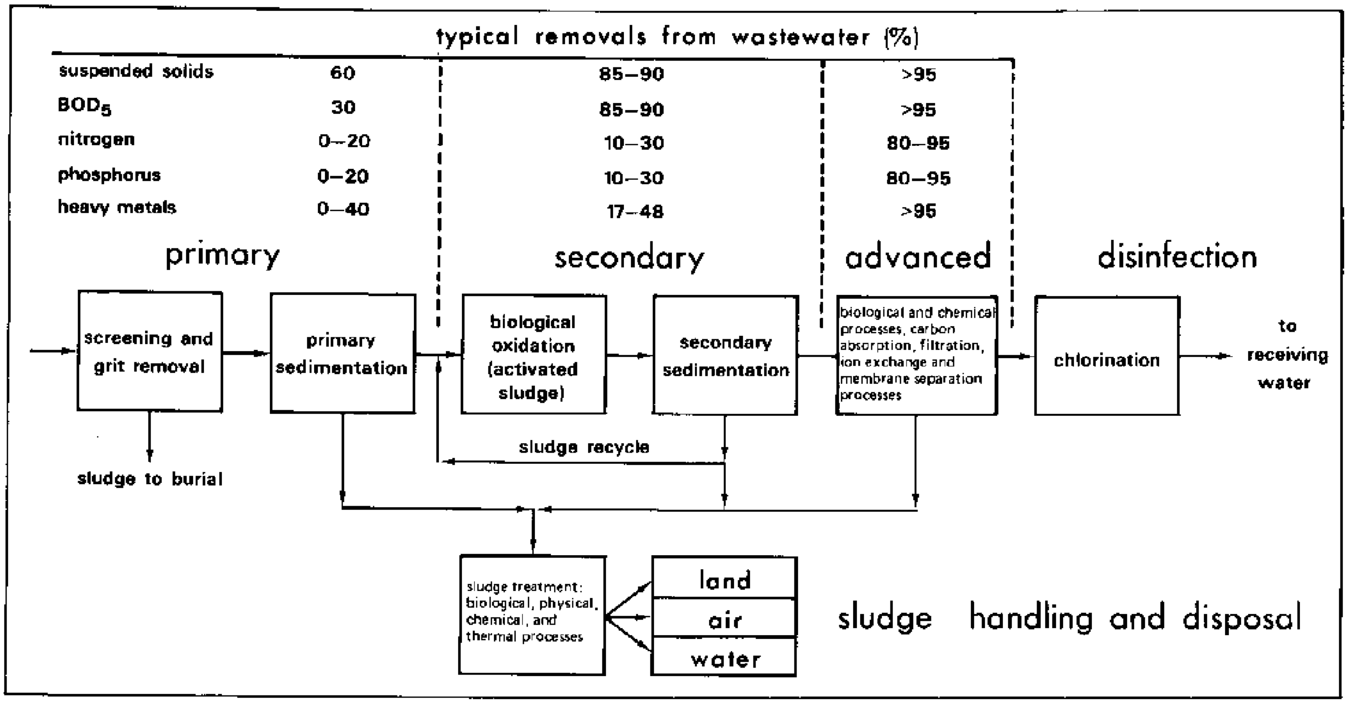


Figure 15. Wastewater treatment flow diagram and typical removals

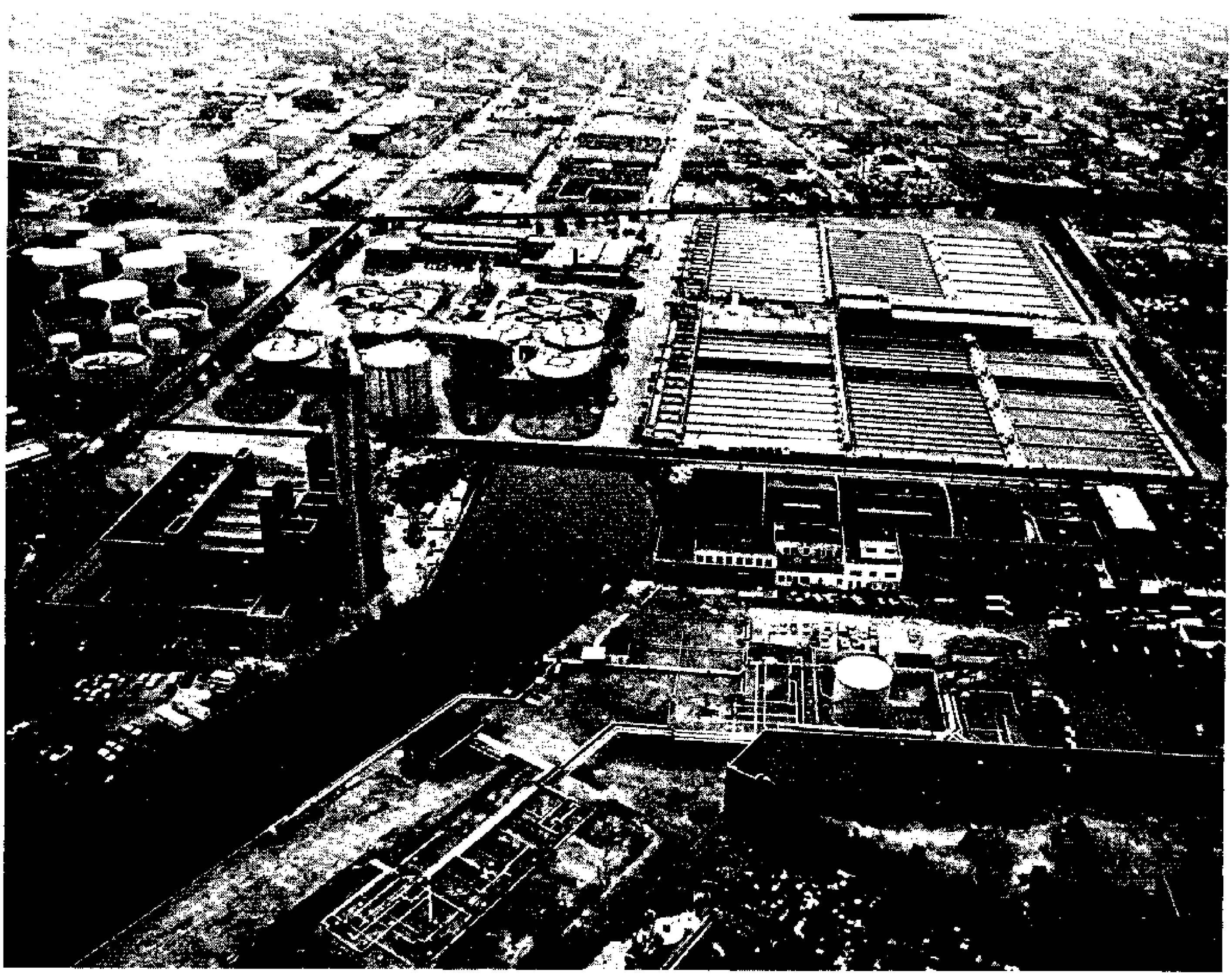


Figure 16. Aerial view of Newtown Creek water pollution control plant, Brooklyn, NY. Foreground channel is tributary to Newtown Creek, which is tributary to East River; thickeners, digesters, sludge holding tanks at left; grit chambers, activated sludge aeration tanks, final clarifiers on right; municipal refuse incinerator in left foreground. (Courtesy of NYC Environmental Protection Administration)

As indicated in Tables 3 and 4, a number of industries, especially in northern New Jersey, discharge their wastewaters to municipal systems (in direct discharges). When wastewaters are compatible, this approach is economically advantageous to both the industry and the municipality. To insure compatibility, pretreatment of the industrial wastewaters to remove some contaminants may be required before discharge to municipal systems. The major indirect discharges in northern New Jersey are to primary treatment plants, which barge raw sludge to the dumpsite. For these low-efficiency plants, pretreatment is minimal—explosive or combustible materials are removed, pH is controlled. The higher the level of waste treatment, the greater the industrial pretreatment necessary to protect the biological system from shock loads of metals or other toxic materials. The sheer size of large municipal treatment plants damps shock loads of industrial waste so that no additional pretreatment may be required, according to pilot plant data collected at Middlesex County (Rowe 1971).

Table 11. Industrial loads compared to background loads

	Typical Seawater Composition (mg/l)	Background Mass Load (metric tons/day)	Ratio of Industrial Loads to Background Loads (%)
Flow (MGD)	–	1.3×10^7	0.004
Suspended solids	3	150,000	1.5
Total nitrogen	0.5	25,000	0.28
Total phosphorus	0.07	3,600	0.45
Cadmium	0.0001	5.1	2.2
Chromium	0.00005	2.5	63.
Copper	0.003	150	1.6
Lead	0.00003	1.5	140.
Zinc	0.01	510	0.97

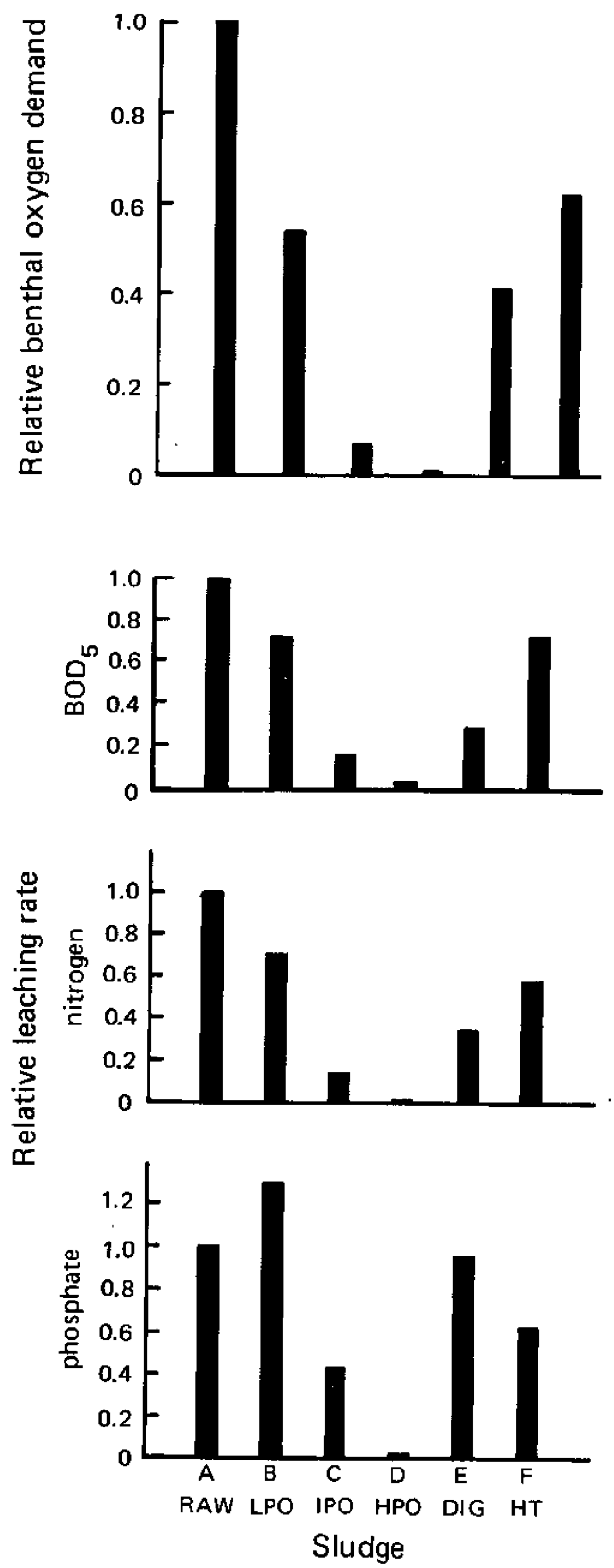
Source: Mueller et al 1976*b*

Federal Water Quality Improvement Policy

Federal policy regarding water quality improvement is based on the Water Pollution Control Act Amendments of 1972 (PL 92-500). The avowed purpose of this act is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." Toward this end, the national goal by 1985 is to eliminate the pollutant discharge into navigable waters and by 1983 to achieve water quality that allows for the protection and propagation of fish, shellfish, and wildlife, and provide for recreational uses.

PL 92-500 mandates EPA to develop effluent guidelines for municipal discharges as well as direct industrial discharges by specific industrial classifications. In general, the law calls for effluent limitations for existing waste sources, based on "best practicable control technology available" by 1977 and "best available technology economically achievable" by 1983. New waste sources must have "best available demonstrated control technology."

Effluent limitations generally set numerical values for allowable average monthly discharges (average values over 30 consecutive days) as well as maximum daily values to account for effluent quality fluctuations. Stricter standards may be imposed if necessary to attain water quality for the protection of public water supplies, agricultural and industrial uses, wildlife, and recreational uses. To insure compliance with effluent standards, a National Pollutant Discharge Elimination System (NPDES) has been put into effect. This system, initially administered by



Source: Mueller and Su 1972

Figure 17. Relative benthal oxygen demands and leaching rates of sludges after treatment

EPA, requires permits for discharging to receiving waters. Permits are issued for fixed terms (maximum five years) and may be terminated or modified for cause. Though industries are responsible for monitoring their own effluents, they may be checked by EPA. Upon demonstration of capability, state regulatory agencies will take charge of the permit system, with provision for EPA review.

PL 92-500 also authorizes EPA to develop, by industrial classification, standards for pretreatment of wastes before discharge to municipal systems. These standards serve to control the discharge of toxic materials and other pollutants that may interfere with, pass through, or are otherwise incompatible with municipal treatment facilities. EPA is developing two sets of standards: one for prohibited wastes and one with numerical limitations for other parameters. Prohibited wastes that would hinder operation of a municipal plant cannot be discharged after 1977. Included are those that present a fire or explosion hazard, corrosive material that would damage treatment equipment, solid or viscous wastes that would cause obstructions, and thermal or slug waste discharges in a volume or load that would upset treatment processes.

Numerical limitations of nonhazardous wastes are to be applied to "major contributing industries"— those having a discharge of at least 50,000 gallons per day or 5% of the municipal plant's capacity. Limitations may be in either concentration or load standards; compliance is required by 1983. While nonmajor industries need not meet numerical standards, they are still prohibited from discharging pollutants in a quantity that would have harmful effects on the equipment or function of the municipal works. For these standards, EPA has developed three categories of pollutants. The first category consists of substances similar to those in municipal sewage for which a municipal treatment plant is designed; there is no pretreatment required and no discharge limitations. The second category consists of those materials that would interfere with plant operations in large quantities but are treatable in limited amounts; pretreatment standards allow discharge in treatable amounts. The last category consists of those that require maximum feasible treatment to prevent their passing through or disrupting municipal works; these wastes must be pretreated to the "practical limits of technology."

Ocean Dumping

The Marine Protection, Research and Sanctuaries Act of 1972 (PL 92-532) regulates dumping in ocean waters. The act prohibits dumping of radiological, chemical, or biological warfare agents, and radioactive wastes. EPA issues permits for other materials, except dredge spoils, where dumping would not harm human health, welfare or amenities, the marine environment, ecosystems, or economic potentials. Permits for dredged materials are issued by the Corps of Engineers; enforcement is under US Coast Guard jurisdiction. The National Oceanic and Atmospheric Administration (NOAA) is responsible for conducting research and for monitoring the effects of ocean dumping.

Present Status for Bight Region

All major discharges in EPA Region II (New York, New Jersey, Puerto Rico, Virgin Islands) are under the NPDES permit system, most have appropriate treatment or are on a compliance schedule to attain it. Nonmunicipal permits for direct discharges in all of New York and New Jersey totaled 453 major discharges and 676 minor discharges as of 31 January 1976. However, pretreatment guidelines for indirect industrial discharges have not yet been implemented. As of October 1975 the New York State Department of Environmental Conservation began issuing permits. The New Jersey Department of Environmental Protection currently lacks the capabilities necessary for undertaking this function (M.P. Bronchonsky, personal communication).

Based on PL 92-532, EPA Region II has set a long-range goal of phasing out ocean disposal by 1981 (EPA 1975). Toward this end, dumping permits have been issued only to those dischargers active before passage of the law, disallowing any new discharges. Also, industrial permits are issued only where phasing-out schedules are included in the permit application. Use of acid and chemical dumpsites is permitted only where no alternate disposal means exist.

Future Outlook

Industrial and municipal compliance with 1977 wastewater discharge standards requiring high quality secondary effluent will generally be attained in the New York Bight area soon (M.P. Bronchonsky, personal communication). A reduction in suspended solids and organic carbon inputs to the Bight means that the major oxygen-demanding substances remaining in wastewater effluents will be organic and ammonia nitrogen. The quality of receiving waters in estuaries should increase when gross pollution from existing raw sewage and primary effluent discharges stop. The quality of dredged material may also improve with the removal of the readily settleable contaminants from wastewaters. Contaminants from combined sewer discharges and urban runoff will be the principal pollution sources to inland receiving waters and sediments. The advisability of attaining the higher treatment levels in the 1983 guidelines may be difficult to demonstrate, considering the high cost of removing contaminants from secondary effluents by advanced treatment and in light of the magnitude of nonpoint pollution sources and projected improvements in water quality. Completion of the Section 208 (PL 92-500) regional waste treatment planning study presently being conducted in the New York area should provide a basis for quantitative evaluation of this question.

Increased wastewater treatment in the New York Bight area will generate significantly greater quantities of wastewater sludge: by 2000 over 1,200 tons of dry solids/day after digestion—almost three times the quantity now barged to sea (Anderson and Mueller, in press). With the planned phaseout of ocean sludge dumping by 1981, alternate sludge disposal processes are being considered for use in the New York area. These include land application, composting, drying, wet-air oxidation, incineration, and pyrolysis (heating in an oxygen-deficient atmosphere). A report by Camp, Dresser, and McKee (1975) found incineration or pyrolysis to be the most attractive alternative, considering environmental, economic, and energy impacts.

The degree of improvement in New York Bight water quality to be attained by cessation of ocean dumping of sludge has yet to be demonstrated. Since the sludge contains significant quantities of nitrogen and phosphorus nutrients, it is a food source in the Bight ecosystem. However, the sludge also contains relatively toxic heavy metals, which have been associated with detrimental ecological effects. Species diversity of benthic organisms has been found to be generally lower in the dumping grounds, indicating environmental stress. Heavy metals concentrations have been found in the tissues of organisms, including finfishes, collected at dumpsites. Metals intake has been inconclusively linked with finrot disease in fishes. The long-term effects of such contaminants on organisms is still unknown (Pararas-Carayannis 1973).

Industrial waste pretreatment for metals removal at the source or recovery in the industrial operation would take a major source of heavy metals from wastewater sludges as well as from wastewater effluents. The level of metals removal to be practiced in industrial wastewater pretreatment has not yet been delineated. Until this matter is settled, the attractiveness of ocean and land sludge disposal techniques is questionable.

Conclusion

Industrial waste discharges, especially metals and organic matter, presently contribute a significant portion of contaminant inputs to New York Bight. Most industrial wastes, generated by the petrochemical industries in northern New Jersey, are discharged to New York Bight through low-efficiency municipal primary treatment plants. As secondary treatment is implemented in the Bight area, gross pollution by suspended solids and organic carbon through the continuous raw sewage discharges from New York City and the primary effluents from New Jersey will cease, producing improvement in the quality of estuarine waters and sediments. Discharge of urban runoff through combined sewer systems in the New York area, a relatively nonindustrial and nonpoint source, will then contribute much of the contaminants to estuarine waters.

The conservative contaminants in wastewater discharges—such as nitrogen, phosphorus, and metals—are not destroyed by secondary treatment; what is removed from the effluent appears in the sludge. A reduction in metals discharged from wastewater effluents and sludge sources requires control by industrial process change or metals recovery at the source. Depending on the degree of metal source control implemented in the Bight area in the future, methods of wastewater sludge disposal such as land reclamation and ocean disposal, now considered environmentally unfeasible, may ultimately become environmentally and economically attractive. Similarly, the choice of ultimate sludge disposal techniques should be consistent with future levels of industrial waste pretreatment.

In evaluating alternative management decisions for control of environmental quality in the Bight area, the effects of all contaminant sources as well as the interrelationships among them must be considered.

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