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Boston Harbor: Estimates of Loadings

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BOSTON HARBOR:
ESTIMATES OF LOADINGS

by Charles A. Menzie
Jerome J. Cura, Jr.
Jon S, Freshman
Bonniemay Potocki

Prepared For:
Massachusetts Water Resources Authority
Harbor Studies Group
Charlestown Navy Yard
Boston, Massachusetts 02129

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Prepared By:
Menzie-Cura & Associates, Inc.
One Courthouse Lane
Suite Two
Chelmsford, Massachusetts 01824

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MASSACHUSETTS WATER RESOURCES AUTHORITY
Charlestown Navy Yard
100 First Avenue
Boston, Massachusetts 02129

Telephone: (617) 242-6000
Facsimile: (617) 241-6070

ERRATA SHEET
for
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Boston Harbor: Estimates of Loadings.
Menzie, C.A., J.J. Cura, J.S. Freshman, and B. Potocki. 1991.

p.14 In the 2nd para. under CSO Loadings, beginning "Total loading to North Harbor,"

change TKN from	20 kg to	249 mtons
phosphorus	96 kg	96 mtons
lead	354 kg	5,149 kg
zinc	854 kg	12,756 kg
fecal coliform	4.92E+16	1.08E+17 counts

Table A19 Change representative load for Boston Edison (Everett) 002A from 3.66E+05 to 4.20E+03.
Change total load 3.81E+05 1.89E+04.

Table C-1 FCB (count) column was erroneously divided by 2.2. Actual column should read as follows:

change	2.36E+15 to	5.19E+15
	2.82E+14	6.20E+14
	2.65E+15	5.83E+15
	1.86E+14	4.09E+14
	1.86E+14	4.09E+14
	3.73E+14	8.21E+14
	4.14E+16	9.11E+16
	3.82E+15	8.40E+15
	4.52E+16	9.94E+16
	0.00E+00	0.00E+00
	9.55E+14	2.10E+15
	9.55E+14	2.10E+15
	4.92E+16	1.08E+17

Table D-1 Change washout ratio for lead from 140 to 76.

Table D-2 Change units from km^2 to m^2.

Table D-3 Loadings to N. Harbor should be modified as follows:

change	dry deposition from	3,331 to	1,573
	wet deposition	2,420	1,390
	total	5,751	2,963

Table D-4 Loadings to S. Harbor should be modified as follows:

change	wet deposition from	1,278 to	1,553
	total	3,036	3,311

Table E-1 River flows were not adjusted to account for the difference between the drainage area at the gauge and the total drainage area. In Menzie-Cura and Associates (1991, Table 3), flows were adjusted by calculating total flow as the product of the gauged flow and the total area divided by gauged area. Adjusted flows and loads are as follows:

Constituent	North Harbor	South Harbor
Total Flow (m3/sec)	17.94	5.91
Charles	12.09	
Mystic	0.82	
Neponset	5.03	
Weymouth Fore		0.28
Back		5.58
Weir		0.05
Conventionals (mtons/yr)		
Total BOD	2,637	871
Total Nitrogen	843	280
Total Phosphorus	88	31
Total Solids	5,626	1,852
Total Coliforms	1.4E+16	4.4E+15
Metals (kg/yr)		
Cadmium	1,693	560
Chromium	5,099	1,680
Copper	5,099	1,680
Lead	<4,395	<1,448
Mercury	264	89
Nickel	6,857	2,257
Silver		
Zinc	29,889	9,847
Organics (kg/yr)		
PCBs	<2,637	<869
PAHs	5.7 - 57	1.8 - 18
Phthalates	<5,275	<1,737

Table G-1	North Harbor:	Change River load from	11.02	to 17.94
	South Harbor:	Change River	1.3	5.91
Table G-2	North Harbor:	Change River load from	1,620	to 2,637
		Airport	176	529
	South Harbor:	Change River	100	871
Table G-3	North Harbor:	Change River load from	3,456	to 5,626
		NPDES	0.38	18.9
	South Harbor:	Change River	417	1,852
Table G-4	North Harbor:	Change River load from	518	to 843
	South Harbor:	Change River	62	280
		Groundwater, High	5.7	15.7
Table G-5	North Harbor:	Change River load from	54	to 88
	South Harbor:	Change River	6.5	31
Table G-6	North Harbor:	Change River load from	3,100	to 5,099
	South Harbor:	Change River	378	1,680
Table G-7	North Harbor:	Change River load from	2,700	to 4,395
		Air	2,716	2,963
	South Harbor:	Change River	325	1,448
		Air	3,036	3,311
Table G-8	North Harbor:	Change River load from	18,360	to 29,889
	South Harbor:	Change River	2,215	9,847
Table G-9	North Harbor:	Change River, Low from	3.5	to 5.7
		High	35	57
		Groundwater, Low		0.02
	South Harbor:	Change River, Low	0.4	1.8
		High	4	18
		Groundwater, Low		0.02

References:

Menzie-Cura and Associates, 1991. Sources and Loadings of Pollutants to the Massachusetts Bay. Report to the Mass Bays Program, MBP-91-01.

Compiled by:

M. Alber
July 12, 1993

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1.0 INTRODUCTION

1.1 Statement of Objectives

The objective of this report is to provide estimates of loadings of various substances to Boston Harbor. The estimates reflect the general magnitudes of the sources, and are not more precise because of lack of data on the concentration of the substance in the transport medium, the rate at which the transport medium brings the substance to Boston Harbor, and the chemical kinetics of the release of the substance from the transport medium to the Harbor. The certainty placed on the various estimates varies according to the quality of the data. For example, estimates for the POTW and other NPDES outfalls are based on measurements of flow and concentrations while estimates for groundwater discharge are based on estimates of flow and estimates of concentrations. Comparison of the relative magnitudes of the sources and consideration of the underlying assumptions provide a basis for identifying the more significant sources or areas where additional data should be obtained if more precise estimates appear warranted. For example, if the loading of a particular source appears to be relatively large but is based on uncertain assumptions, closer inspection of the assumptions or measurements should be undertaken.

1.2 General Approach

Geographic Areas Considered

We divided Boston Harbor into the North Harbor and South Harbor (Map 1) for the purpose of estimating loadings. The following land areas are considered to contribute to each of these regions:

North Harbor	South Harbor
Boston	Hingham
Chelsea	Hull
Everett	Quincy
Winthrop	Weymouth
Logan Airport	

We estimated direct discharges and runoff for those regions of the harbor below the dams on the Charles and Mystic Rivers. This report treats Logan Airport as a separate entity in the north harbor based on its large size, proximity to the harbor, and locally unique use.

Selection of Substances for Evaluation

This report provides estimates for loadings of substances judged to have the potential for impairing human uses or natural resources of Boston Harbor. This study limits the selection of substances for consideration to compounds or classes of compounds which have been identified as "important" in previous investigations and for which there are adequate data for making estimates. There are many individual synthetic organic compounds that might be present in effluents or runoff but for which data are very limited or non-existent. The substances selected for consideration include those that are typically included as indicators of POTW wastewater inputs.

Based on the above considerations the following substances were selected for analysis:

- oxygen consuming substances (BOD);
- suspended solids (many chemicals adsorb to solids);
- nutrients (nitrogen and phosphorous);
- the metals copper, lead, and zinc for which there are estimates available for a number of sources;
- other metals;
- Polycyclic Aromatic Hydrocarbons (PAHs);
- petroleum hydrocarbons;
- PCBs.

2.0 METHODS

2.1 POTW Effluents and Sludges

The Massachusetts Water Resources Authority (MWRA) provided combined loadings associated with MWRA effluents and sludge for their Nut Island and Deer Island plants. In advance of more facility-specific information, the contribution of each of the facilities was estimated to be 70% from Deer Island and 30% from Nut Island.

2.2 Other NPDES Discharges

We compiled pollutant monitoring data from two general sources: United States Environmental Protection Agency Permit Compliance System (PCS) and Massachusetts Department of Environmental Protection, Division of Water Pollution Control "Water Quality and Wastewater Discharge Data Survey Reports".

Permit Compliance System is a computer database which contains National Pollutant Discharge Elimination Permit information. At our request, EPA Region I Resource Information Center performed a retrieval from PCS. This retrieval consisted of two reports for each Massachusetts Major NPDES discharger:

an effluent Statistical Summary Report which summarizes effluent data on an annual basis for 1988, 1989, and 1990;

and,

a Facility Information Report, which provides general permit information on the facility (the discharger).

In the Massachusetts DEP Wastewater Discharge Survey reports, additional monitoring data for 1986 was available for only a few NPDES dischargers. Typically, the Massachusetts Division of Water Pollution Control surveys report results from grab samples taken at various outfalls within a particular River Basin.

The criteria used to select NPDES dischargers from the two sources included:

the permitee was not an MWRA discharge;

the permitee must have been a major industrial or municipal discharger (i.e. greater than 10,000 gallons per day);

the permittee must be an active discharger;

and,

the receiving water body was either the Mystic River, Weymouth River, Weir River, Chelsea River, Neponset River, or Boston Harbor).

The PCS system indicated no major industrial or municipal dischargers for the Chelsea, Weymouth and Weir Rivers. In the South Harbor area, no major industrial or municipal dischargers were found.

We estimated loadings for the following parameters: biochemical oxygen demand, phosphorus, total suspended solid, oil & grease, total toxic organics, cadmium, chronmuim, copper, lead, nickel, and zinc. Mercury, total kjeldahl nitrogen, ammonia nitrogen, nitrate-nitrogen, total organics and silver were required in NPDES permits or listed as measured parameters in Massachusetts Division of Water Pollution Control surveys, but no concentrations were provided. In PCS's effluent summary reports, loads were often cited in kg/day for BOD, phosphorus, and total suspended solids. If the monitoring reports did not give loads, we calculated them as:

Load = [contaminant] * flow

The annual mean concentration was specified in each NPDES facility's effluent summary report. Depending on the type of permit, the reported mean concentration was either a monthly or weekly average. If the report did not include mean concentration we used the daily maximum concentration. Since the Massachusetts Division of Water Pollution Control takes grab samples and the length of the surveys consist of only a few days or months out of the year, the 1986 estimated loads are subject to greater uncertainty. After calculating annual loads for the various parameters from the selected NPDES dischargers, we chose a representative year which we arbitrarily defined as the highest annual load for that particular facility among the three years available.

We then assessed loads based on location of discharge. The three areas considered were: North Harbor, South Harbor, and tributaries (Neponset, Charles, and Mystic Rivers) upstream of their respective dams.

2.3 CSOs and Stormwater Discharges

We estimated urban runoff in two ways: The first involved using information developed for MWRA by CH2M HILL (1989). The second involved applying the Nationwide Urban Runoff

Program (NURP) model to the Boston Harbor area.

CH2M HILL Study

Estimates of pollutant loading to Boston Harbor from CSOs and storm drains are from the Facilities Plan (CH2M HILL, 1989). The study area for the Facilities Plan includes the Dorchester Bay Basin, the Neponset Estuary Basin, the Inner Harbor Basin, and the Quincy Bay/Outer Harbor Basin, which comprise the North Harbor as defined for the present analysis. The Alewife/Mystic Basin, the Upper Charles River Basin, and the Lower Charles River Basin are other basins for which loadings were estimated by CH2M HILL; these are not included in the estimates of direct loading to Boston Harbor since their contribution is included as tributary sources. None of the CSO or storm drain load in these estimates directly enters the South Harbor.

Annual pollutant loadings due to CSOs and storm drains were calculated by CH2M HILL using a sewer model that was calibrated with measured concentrations and flow rates taken during wet and dry conditions during the spring and summer of 1988 (CH2M HILL Tech. Mem. 3-10).

The Facilities Plan provides estimates of dry weather overflow (DWO), and wet weather overflow from combined sewers (CSO) and storm drains (SWO). The DWO estimate was subtracted from the sum of the CSO and SWO estimates to obtain the net discharge associated with storm events.

Application of NURP Model

We estimated pollutant loading to Boston Harbor due to direct urban runoff from the cities and towns within the coastal drainage basin using the methodology adopted by the US EPA Nonpoint Source Branch (described in the National Urban Runoff Program Report available from EPA Office Of Water). The NURP methodology is a stochastic approach. It models the episodic rainfall events which cause urban runoff. In the model, pollutant concentration in runoff derives from land use category and rainfall event statistics. The NURP approach calculates loadings from total rainfall and the area within each land use category.

Event statistics were calculated from long-term, hourly rainfall records from four gaging stations in eastern Massa-chusetts (Table C-2). Mean and coefficient of variation for storm duration, intensity, volume, and time between storms were calculated using SYNOP, a computer program developed specifically to provide input for the NURP analysis.

Pollutant concentration and runoff coefficient for each land use type were taken from the NURP report (Table C-3) based on the event statistics provided by SYNOP. The area of each land use category within the cities and towns bordering Boston Harbor was from Hruby et al. (1988) and is based on the land use maps of MacConnell et al. (1985). These areas include only the portion of cities and towns within the coastal drainage basin (Table C-4).

Pollutant loadings by land use category were calculated by multiplying the mean concentration by the runoff coefficient and an annual rainfall of 44 inches. Total loading was calculated by summing over land use categories.

Loadings are estimated for total suspended solids, BOD and COD combined, total phosphorous, total nitrogen, TKN, copper, lead, and zinc (Table C-6). Estimates of loadings for other pollutants are not validated sufficiently using the NURP methodology to allow their presentation.

2.4 Atmospheric Sources

We estimated atmospheric loading of pollutants to Boston Harbor with a simple depositional model which uses aerosol concentration and depositional velocity to calculate dry deposition, and a washout ratio to calculate wet deposition. For some pollutants, wet depositional loading has been measured directly.

Dry deposition is the direct settling of aerosols from the atmosphere. McMahon (1979) reviewed measurements of deposition velocity for aerosol-bound chemicals (Table D-1). The deposition velocity implicitly accounts for the association of the chemical with aerosols having a particular size distribution and the average settling velocity for that size distribution. Dry deposition over marine areas is complicated by the high humidity in the boundary layer immediately above the ocean surface, which tends to aggregate aerosols, and the tendency for wind-capped waves to resuspend aerosols. The deposition velocity does not account for these factors; models which do include these factors have not been adequately verified because of the extreme difficulty in obtaining appropriate measurements.

Dry deposition flux is calculated by multiplying the volumetric concentration of the chemical by the deposition velocity. Loading is calculated by multiplying the flux by the area of the receiving basin (Table D-2) and integrating over the appropriate time interval, one year.

Wet deposition is the load carried in precipitation. The

concentration of pollutants in precipitation in the Boston area has been measured directly for some chemicals, e.g. nitrogen (NADP, 1989). Loading is calculated by multiplying the concentration in precipitation by the annual rainfall, 1.1 meters. Where direct measurements are lacking, wet concentration is estimated by multiplying dry concentration by the washout ratio, which is a measurement of the scavenging efficiency of rainfall. Washout ratios for the pollutants considered in the present analysis are listed in Table D-1.

2.5 Tributaries

Loads for tributaries to Boston Harbor were estimated by MWRA and provided to us for most of the substances. In the case of PAHs, we estimated loadings via tributaries by multiplying the riverine flows by a range in PAH concentrations of 10 to 100 ng/l. This range was selected based on a literature review conducted by Menzie et al. (1990) of PAH levels in the environment. The range of 10 to 100 ng/l is considered to approximate the range that may occur in urbanized areas.

2.6 Groundwater Discharges

Estimates of loadings associated with groundwater discharges were made for the harbor as a whole by making estimates of possible groundwater discharge and estimating the concentrations of substances in groundwater. (In section 2.7, we make an estimate of groundwater contribution from locations of hazardous wste sites that border the harbor.)

An estimate of groundwater discharge to the harbor was made indirectly from the application of the NURP methodology. It was assumed that the areas considered for the purpose of runoff calculations were the same areas that would provide recharge to the harbor. Areas further landward were presumed to discharge groundwater to the major tributaries (e.g., Charles, Mystic, Neponset Rivers) and not directly to the harbor.

The NURP methodology provided an estimate of the amount of rainfall that becomes runoff and enters the harbor. By difference, the remaining rainfall either is lost to the atmosphere via evapotranspiration or recharges the shallow groundwater aquifers underlying the land masses considered in our analysis. Based on discussions with the USGS at Boston and Arlington, Virginia, it appears that approximately 50% of the rainfall that does not runoff would become groundwater and would eventually discharge to Boston Harbor. This is the basis of our flow estimate.

The concentrations of substances in the groundwater were estimated based on a review of the literature and an examination of groundwater data for several sites around Boston.

The following groundwater concentrations were used for our estimates:

Nitrogen

A concentration range of 0.1 to 1.0 mg/l is used. The lower end of this range is considered representative of coastal areas and the higher end may provide an upper bound of average groundwater conditions. The Maximum Contaminant Level for nitrate in groundwater is 10 mg/l. Levels at and exceeding the MCL can typically be found in the immediate vicinity of subsurface sewage disposal systems and in agricultural areas.

Phosphorous

Phosphorous occurs in low concentrations in groundwater. Jones and Lee (1977) report a range of 0.01 to 0.06 ug/l nationwide. This range was used to estimate loadings.

Metals

Metals in groundwater can exhibit wide ranges in values (i.e., over several orders of magnitude). In developing ranges for groundwater discharging to Boston Harbor, we examined the groundwater monitoring results for three study sites in the Boston area, considered other information on the general levels of metals in groundwater and considered the existing Maximum Contaminant Level values for metals. The ranges we provided are probably on the high side for average natural groundwater conditions but are intended to give some indication of the implications of discharging slightly contaminated groundwater to the harbor.

Cadmium: A range of 2 to 20 ug/l was selected. Groundwater levels of 2 to 29 ug/l and 6 to 20 ug/l were reported for studies at the Monsanto Site in Everett and the Quincy Shipyard site respectively. The MCL for cadmium in drinking water is 10 ug/l (proposed value is 5 ug/l).

Chromium: A range of 10 to 100 ug/l was selected. Groundwater levels of 3 to 1,900 ug/l were reported for the Quincy Shipyard. Typical values for chromium appear to be at or less than 10 ug/l. The MCL for chromium is 50 ug/l (proposed level is 100 ug/l)

Copper: A range of 10 to 100 ug/l was selected. Groundwater levels of 7 to 28 ug/l and 20 to 1,100 ug/l were reported for the Monsanto Plant in Everett and the Quincy Shipyard, respectively. The MCL for copper is 1,300 ug/l.

Lead: A range of 1 to 100 ug/l was selected. Groundwater levels of 1 to 200 ug/l were reported for the Quincy Shipyard. The MCL for lead in raw drinking water is 5 ug/l.

Nickel: A range of 10 to 100 ug/l was selected. Groundwater levels of 25 to 120 ug/l, 110 to 230 ug/l, and 20 to 165 ug/l were reported for the Monsanto, Parcel 18, and Quincy Shipyard sites respectively. The MCL for nickel is 100 ug/l.

Zinc: A range of 10 to 100 ug/l was selected. Groundwater levels of 17 to 230 ug/l, 6 to 11 ug/l, and 12 to 30,500 ug/l were reported for the Monsanto, Parcel 18, and Quincy Shipyard Sites.

Polycyclic Aromatic Hydrocarbons (PAHs)

A range of 1 to 10 ng/l was selected based on the literature review carried out by Menzie et al. (1990). The proposed MCL for the PAH compound Benzo(a)pyrene is 200 ng/l.

Volatile Organic Compounds

Volatile organic compounds such as benzene, toluene, and xylene are mobile in groundwater and also are the substances that are most likely to be transported away from locations of petroleum spills or leaks of underground storage tanks. Based on our knowledge of the levels that occur in contaminated groundwaters (10s to 1,000s of ug/l), we have selected a range of 1 to 10 ug/l to represent average conditions for groundwater entering Boston Harbor.

2.7 Confirmed Coastal Disposal Sites

To estimate the loadings associated with groundwater discharges from confirmed hazardous waste sites bordering the harbor we:

identified the confirmed hazardous waste sites which occur along the nearshore areas of Boston Harbor;

provided the type of subsurface contamination at

each site;

calculated the equilibrium concentrations of selected organics in groundwater at the "typical" site;

calculated a loading from a "typical" site;

and,

estimated the total loading of selected compounds for north harbor and south harbor areas.

Identification of Sites

The Massachusetts Department of Environmental Protection's (DEP) "List of Confirmed Disposal Sites and Locations To Be Investigated" provided a listing of confirmed disposal sites in towns abutting Boston Harbor. This listing includes site addresses and type of contamination for disposal sites reported to the DEP under Massachusetts General Law 21E. Note that this analysis includes only confirmed sites and does not extend to sites identified as locations to be investigated. In this sense, the number of sites used in the present analysis is a conservative estimate of the actual number. We included a site only if it was within approximately 100 meters of the shoreline based upon reference to street maps.

We characterized the "typical" site as a petroleum contaminated site with contaminated soils extending four meters below the water table over a width of 10 meters. We assumed that groundwater from the site discharged directly to the harbor and that the contaminants in groundwater are polyaromatic hydrocarbons (PAH's), benzene, toluene, and xylene.

Calculation OF Equilibrium Concentrations

We calculated groundwater water concentrations of the specified contaminants. The equilibrium partitioning approach is an appropriate method to estimate the soil pore water concentrations of hydrophobic, non-ionic, organic contaminants (Shea, 1988). The selected organic contaminants of concern fall into this category. We have therefore used an equilibrium partitioning approach to estimate the groundwater concentrations. The equilibrium partitioning approach assumes that:

a) the partitioning between soils and interstitial

groundwater largely depends upon the organic carbon content of the soils with little dependence upon other emirical or physical factors. There is much empirical evidence to support this assumption (Curtis et al., 1986);

b) equilibrium steady state conditions exist in groundwater systems (Karickhoff, 1984, estimates that adsorption/desorption equilibria may require more than a month to reach equilibrium);

c) available partition coefficients which are based on sorption experiments with relatively low soil/water ratios are applicable to the natural soil environment in which very high soil/water ratios exist.

This approach is only valid for non-polar organic compounds. At present, the complexity of metal interactions in soil and the various research data gaps associated with metal adsorption reactions in soil (Shea, 1988) preclude the use of the equilibrium approach for metal contaminants.

We estimated groundwater water concentrations using the relationship from Karickhoff et al. (1979):

$$C(pore) = \frac{C(sol)}{F(oc) * 0.62 * K(ow)}$$

where:

C(sol) = assumed soil concentration
C(pore) = calculated pore water concentration
F(oc) = the fraction of organic carbon in soil
K(ow) = the octanol water partition coefficient
0.62 = empirically derived proportionality constant.

We obtained octanol-water partition coefficients from The Superfund Public Health Evaluation Manual (SPHEM, 1986).

We assumed an organic fraction in soils as 1%.

Calculation Of Groundwater Flow And Loadings

We calculated groundwater flow off the "typical" site as:

$$Flow = A * K * I$$

where:

A = the area through which groundwater discharges from the site

K = the hydraulic conductivity at the site

I = the hydraulic gradient

We fixed the parameter A as an area defined by a four meter deep layer of petroleum contaminated soil (below the water table extending 10 meters along the downgradient end of the "typical" site). We chose a K of 10-6 meters/second. This hydraulic conductivity is in the high range for glacial till and in the lower end of the range for silty sands (Freeze and Cherry, 1979). We assumed a hydraulic gradient of 0.04 based upon local experience. We applied the appropriate conversions to obtain annual flow.

Loadings of PAH compounds are:

C(pore) * Flow * number of identified sites

where: C(pore) and Flow are defined as above.

3.0 RESULTS

3.1 POTW Effluents and Sludges

Table 3-1 presents loadings associated with POTW effluents and sludges.

3.2 Other NPDES Discharges

Appendix A provides the estimated annual loads by parameter for the NPDES facility discharging directly to North Harbor. There are also NPDES discharges to the tributaries. The summarized total loads to the North Harbor and tributaries are:

Parameter	North Harbor	Tributaries
Flow (MGD)	1.15	11.5
Contaminants (Kg/Yr)		
BOD	0	2.25E5
Cadmium	19	55.2
Chromium	28.6	106
Copper	63.6	32.9
Lead	47.6	10.8
Nickel	740	30.7
Zinc	173	21.5
Phosphorus	0	17,000

Table 3-1

Loadings to Boston Harbor From MWRA Discharges

Constituent	Sludge	Effluents (Deer and Nut)
Conventionals (mtons/yr)		
Total BOD	15,000	77,000
Total Nitrogen	1,100	11,000
Total Phosphorus	70	2,500
Total Solids	23,000	62,000
Fecal Coliforms (#)	9.0E+15	3.0E+16
Metals (kg/yr)		
Cadmium	370	1,700
Chromium	3,700	12,000
Copper	22,000	44,000
Lead	7,000	11,000
Mercury	110	110
Nickel	2,200	7,300
Silver	180	3,600
Zinc	47,000	73,000
Organics (kg/yr)		
PCBs	150	<250
PAHs	46 - 2,162	20,000
Phthalates	1,800	7,000
Benzene	<3	2,700

TSS	381,000	3,100,000
Toxic Organics	25.1	325
Oil & Grease	6,330	34,200

The discharger with the highest flow rate (0.03 m3/sec) was Exxon Oil. The average total annual flow to North Boston Harbor Area from non-MWRA NPDES discharges is 0.05 m3/sec; The estimated annual flow from NPDES major discharges to tributaries is 0.5 m3/sec. The highest flow from a NPDES discharger to a tributary is Plymouth Rubber Company's discharge to the Neponset River.

Biological oxygen demand is not monitored for the industrial dischargers on Boston Harbor or associated tributaries. Most of the major NPDES dischargers on the tributaries are municipalities. Total BOD load to the Boston Harbor tributaries is 2.25E+05 kg/year.

Chromium, and cadmium loads were available for two NPDES dischargers, Boston Edison, Mystic Station and Foxboro Company, Neponset Plant (Tables A5-A8). Foxboro Company Neponset Plant is classified as metal plating and finishing operation. Metal plating facilities discharges are monitored for metals. The Boston Edison facilities are power stations. Cooling water from heat exchangers often requires monitoring for toxic metals.

The copper loads from the two Boston Edison power stations in Boston Harbor were twice those of Foxboro Company.

Lead, nickel and zinc are other toxic metals tested by Boston Edison power stations and Foxboro Company, Neponset Plant. Tables A11-A14 show that Boston Edison Mystic stations have higher nickel and lead loads,(4.76E+01 kg/yr Pb, 6.56E+02 Ni, 4.03E+01 Ni) than Foxboro Company (1.08E+01 Pb and 3.07E+01 Ni).

Total zinc loadings were similar for North Harbor and tributaries (Tables A23 and A24).

Table A15 and A16 demonstrate that oil & grease is a common measurement for industrial dischargers. Industrial dischargers to the tributaries contributed a higher oil & grease load (6.33E+03 kg/yr) than North Harbor industrial facilities (3.42E+04 kg/yr).

Sewage treatment plants regulate their phosphorus loading to prevent eutrofication in the receiving water body. Since all municipalities are discharging to the tributaries and not to the North Harbor, there is a phosphorus loading only to the

tributaries.

Major NPDES dischargers to the tributaries and directly to North Harbor had similar total suspended solid loads.

Tables A21 and A22 imply that the toxic organics are infrequently monitored at only a few facilities.

3.3 CSOs and Stormwater Discharges

Appendix C provides tables of results for CSO loadings and NURP estimates.

CSO Loadings

Estimates of loadings of total suspended solids, BOD, phosphorus, and copper to North Harbor are presented in Table C-1. These estimates were taken from the facilities plan authored by CH2M HILL and are presented according to their selected basins-Dorchester Bay, Neponset Estuary, Inner Harbor, and Quincy Bay/Outer Harbor. All these basins are contained within North Harbor as defined for the present analysis. No estimates of CSO loadings were available for the South Harbor.

Total loading to North Harbor is estimated to be 8,855 mtons total suspended solids, 3,905 mtons BOD, 20 kg TKN, 96 kg phosphorus, 4,278 kg copper, 354 kg lead, 854 kg zinc, and 4.92E+16 counts fecal coliform.

NURP Loadings

The methodology of the National Urban Runoff Program was used to estimate loadings to the North Harbor from Boston, Chelsea, Everett, Winthrop, and Logan Airport and to the South Harbor from Hingham, Hull, Quincy, and Weymouth. Table C-2 presents a summary of total loadings to North and South harbor. Table C-3 provides detailed loadings according to source, i.e. by city/town and land usage category. The pollutants included in the NURP analysis are total suspended solids, BOD, phosphorus, nitrogen (NO2 + NO3), TKN, copper, lead, and zinc.

The estimated loadings for lead, 6,585 kg for North Harbor and 1927 kg for South Harbor, may be higher than present loadings due to decreased use of leaded gasoline since the time the NURP methodology was developed. The NURP estimate is much lower than the estimated lead loading reported by Hruby et al. (1988), which is roughly 60,000 kg/yr to North and South Harbors combined. Hruby et al. relied on the methodology of Midwest Research Institute (McElroy et al., 1976), using lead loadings which are likely outdated.

The summarized total loads to the North and South Harbors are:

Pollutant	North Harbor	South Harbor
TSS (mton)	5,047	2,135
BOD (mton)	2,822	1,010
t-P (kg)	9,647	4,154
t-N (kg)	21,716	9,869
TKN (kg)	46,924	20,434
Copper (kg)	1,236	473
Lead (kg)	6,585	1,927
Zinc (kg)	7,543	2,772

Logan Airport Storm Drainage System

An extensive storm water system drains Logan Airport. The drainage system consists of approximately 57 storm water discharges. Five of these are NPDES discharges: North outfall, West outfall, Porter Street Outfall, the new Fire Training Facility and Maverick Street Outfall. The remaining 52 outfalls drain sections of the airport which consist of taxiways. The North Outfall serves fuel farms, the hangar, freight and terminal aprons; and Terminals D and E and their adjacent taxi ways. The North Drainage Area encompasses approximately 100 acres on the north side of the airport. The West outfall serves Terminals A, B and C, most of the automobile parking areas, taxiways, the Air Cargo, and Bird Island Flats development. In summary, the West Drainage Area includes most of north, south, and southwest terminal aprons and covers approximately 250 acres on the southwest side of the Airport. Approximately 120 acres of the airport, which includes the north hangar area, a portion of the south hangar area and car rental areas drain through the Porter Street outfall. Runoff from major access roads to and from the Airport is discharged by the Porter Street Outfall. The Porter Street outfall also serves offsite airport property, East Boston and is a combined sewer overflow. Both the Porter Street and West outfalls discharge into Boston Harbor from Bird Island Flats section of the airport which is filled in. The Maverick Outfall mainly drains East Boston and approximately 35 acres of the airport. The Maverick Airport Drainage Area, the former General Aviation Terminal, the Post Office Facility and some of the car rental facilities. The Maverick outfall is located west of the Massachusetts Technology Center building and is a combined sewer overflow. Massport has recently commissioned an extensive stormwater sampling and analysis study to be conducted in 1991.

3.4 Atmospheric Sources

Appendix D provides tables of estimates for atmospheric loadings to North (Table D-3) and South (Table D-4) harbors separately. Note that the loadings are dependent on surface area and depositional processes are assumed to be the same in both areas.

Dry and wet deposition models were used to obtain estimates of total loading to the North Harbor and South Harbor for nitrogen, phosphorus, cadmium, chromium, copper, lead, mercury, nickel, silver, zinc, PCB, and PAH (Tables D-3 and D-4).

Nitrogen loading is based on aerosol measurements made from aircraft at a location 50 km east of Boston as part of the WATOX program (Galloway et al., 1987) and on wet deposition measured in Waltham as part of the National Atmospheric Deposition Program. Total annual loading to North Harbor is estimated to be 25,523 kg; for South Harbor the estimate is 28,525 kg.

Phosphorus loading is based on estimates of wet deposition for Long Island Sound, which in turn depends on flux estimates for Chesapeake Bay. No estimates of dry deposition are available. Total annual loading to North Harbor is estimated to be 623 to 3,590 kg; for South Harbor the estimate is 696-4,013 kg.

Cadmium loading is based on aerosol measurements in Cambridge by Olmez (1990) and a single wet deposition measurement at Woods Hole reported in the summary paper by Galloway (1982). Most of the aerosol measurements were below detection; the high end of the dry deposition range represents the maximum concentrations measured. Total annual loading to North Harbor is estimated to be 24 to 32 kg; for South Harbor the estimate is 19 to 49 kg.

Chromium loading is based on aerosol measurements by Hopke et al. (1976) at several locations around Boston Harbor. Wet deposition is calculated from the washout ratio. Total annual loading to North Harbor is estimated to be 50 kg; for South Harbor the estimate is 56 kg.

Copper loading is based on aerosol measurements by Thurston & Spengler (1985) at a location in Watertown. Wet deposition is calculated from the washout ratio. Total annual loading to North Harbor is estimated to be 235 kg; for South Harbor the estimate is 263 kg.

Lead loading is based on aerosol measurements by Thurston &

Spengler (1985). Wet deposition is calculated from the washout ratio. Total annual loading to North Harbor is estimated to be 2,716 kg; for South Harbor the estimate is 3,036 kg. There may be some reduction in the current loading of lead due to decreased usage of leaded gasoline.

Mercury loading is based on wet deposition measured at Cape Cod by Fogg & Fitzgerald (1979). No data is available on dry deposition. Total annual loading to North Harbor is estimated to be 1 to 2 kg; for South Harbor the estimate is 0 to 1 kg

Nickel loading is based on aerosol measurements by Thurston & Spengler (1985). Wet deposition is calculated from the washout ratio. Total annual loading to North Harbor is estimated to be 201 kg; for South Harbor the estimate is 263 kg.

Silver loading is based on aerosol measurements by Olmez (1990) in Cambridge and wet deposition concentrations for urban areas summarized by Galloway et al. (1982). Total annual loading to North Harbor is estimated to be 180 to 183 kg; for South Harbor the estimate is 201 to 204 kg.

Zinc loading is based on aerosol measurements by Thurston & Spengler (1985) at a location in Watertown and by Hopke et al. (1976) at locations around Boston Harbor; the higher concentrations are attributed to Hopke et al. Wet concentration is calculated from the washout ratio. Measurements in Cambridge made in the 1970s (e.g., Gladney et al., 1974, and Zoller & Gordon, 1970) are in accord with Hopke et al.; recent measurements in Cambridge (Olmez, 1990) agree with the measurements of Thurston & Spengler. This suggests a temporal decrease in aerosol concentration of zinc in the Boston area. Estimates from both data sources are presented in this analysis, but more credence should be given to the lower range. Total annual loading to North Harbor is estimated to be 711 to 3,493 kg; for South Harbor the estimate is 795 to 3,904 kg.

PCB loading is based on aerosol measurements by Harvey & Steinhauer (1974) at locations on Georges Bank and in Vineyard Sound. PCB concentrations may have decreased since these data were collected, but they represent a more remote location than Boston. The above estimates are used to calculate dry deposition in the present analysis. Wet deposition is calculated from the washout ratio. Total annual loading to North Harbor is estimated to be 10 to 29 kg; for South Harbor the estimate is 12 to 33 kg.

PAH loading is based on measurements of benzo[a]pyrene made by US EPA in Boston and Chelsea and extrapolated to total

PAH based on relative abundances of PAH compounds in urban air. The depositional velocity used for PAH is a mass-weighted mean velocity, which at least partially accounts for the higher settling velocity of the large fraction of PAH aerosols in the 10 to 15 um range. This treatment differs from that used for other pollutants which are principally in the submicron size range. This approach is appropriate only for areas such as Boston Harbor which are proximate to the pollution source--at longer distances the larger-sized particles will have settled out of the atmosphere. The annual loading to North Harbor is estimated to be 24 to 32 kg; for South Harbor the estimate is 27 to 36 kg.

3.5 Tributaries

Loadings associated with tributary flows into the North and South Harbor are presented in Appendix E. Over 90% of the flow goes into the North harbor via the Charles, Mystic, and Neponset Rivers.

3.6 Groundwater Discharges

Groundwater Discharges To North And South Harbor

Groundwater discharges to the North and South Harbors was estimated to be approximately the same and were on the order of 0.5 m3/sec. The estimated loadings of substances associated with the discharge of groundwater is provided in Appendix F.

Groundwater Contamination At Logan Airport

In the past several years on Logan Airport, excavations during construction projects and underground storage tank removals have revealed fuel contamination. The presence of fuel contamination suggests pockets of floating product may exist on the groundwater table. Possible groundwater contamination sources include leaking of underground storage tanks (UST), leaks from the hydrant system, and the fuel farms.

To characterize the petroleum contamination already discovered, Massport has received approval for DEP to undertake a more comprehensive, Logan-wide study of subsurface conditions. The present status of this study, the Logan Groundwater Study, is that more than 100 monitoring wells will be installed in 1991 based on an extensive preliminary study of past and present sources of contamination. Subsurface work necessitated by the Third

Harbor Tunnel Project is also underway at Logan under the direction of the Massachusetts Department of Public Works (DPW).

Massport has a Tank Management Program and Environmental Audit Program, both aimed at upgrading or removing equipement, installing preventive devices and implementing safe management practices where fuels and chemicals are used. Like other major airports located in Northern regions of the country, Massport is examining the deicing practices at Logan Airport. With the assistance of MWRA's Toxic Reduction and Control (TRAC) Department, Massport completed a survey of all oil/water separators on the airport identifying their location, function and condition. Responsible parties (Massport or tenant) are following up on the findings of this survey.

3.7 Confirmed Coastal Disposal Sites

Appendix B provides the estimated loadings for individual PAH compounds, benzene, toluene, and xylene from the "typical" petroleum contaminated site, and the location, and type of contamination at the confirmed sites.

There are forty-two confirmed hazardous waste disposal sites along the nearshore perimeter of Boston Harbor. Thirty-four of these are petroleum and/or coal tar contaminated sites. Such sites are likely sources of PAH compounds. Among these sites, twenty-one discharge to the North Harbor area, and thirteen discharge to the South Harbor area.

If we assume that the concentrations of individual PAH compounds ranges from 10 to 100 ppm at the "typical" site, that site will discharge an annual total PAH load of 0.056 to 0.56 kilograms of total PAH compounds. The estimated load from the twenty-one sites along the North Harbor area ranges from 1.18 to 18 kg PAH compounds per year. The South Harbor PAH load ranges from 0.73 to 7.3 kg PAH compounds per year.

The estimated volatile load (benzene, toluene, xylene) from the listed sites in kg per year is:

	North Harbor	South Harbor
benzene	1.3 to 13	0.84 to 8.4
toluene	0.04 to 0.4	0.03 to 0.3
xylene	0.08 to 0.8	0.05 to 0.5

4.0 COMPARISON OF LOADS

A graphical comparison of the relative magnitude of the pollutant loadings from all sources is made to identify the most significant and to determine the implications on remediation plans.

4.1 Comparison of pollutant sources.

The relative importance of the sources of pollutants to Boston Harbor is shown by plotting the loadings and associated parameters for each source on the same plot (Figures 1 through 18 and Tables G-1 to G-9). These are presented for North and South Boston Harbor as defined for the present study with a boundary formed along Peddocks Island and neighboring islands. Note that the vertical axis is plotted on a logarithmic scale. Low estimate and high estimate in these Figures refer to groundwater loadings based on a range of estimated concentration in pore water (subsection 2.6).

The pollutant sources are effluent, sludge, runoff, rivers, air, groundwater, NPDES, and airport runoff. There are no sludge or NPDES inputs to the South Harbor. Runoff is estimated from the CH2M HILL data on CSO and storm sewer input and NURP runoff. These data are complementary in that the CH2M HILL estimates are based on measured data, but include only the runoff diverted into the sewer system; the NURP estimates include the sheet flow that is not diverted into sewers, but are based on generic urban loadings, not measurements from the Boston area. The CSO estimates are generally higher than the NURP estimates, which probably is due to the larger collection area, which extends landward of the surface drainage basin.

Flow Rate

Effluent and tributaries dominate flow into the North Harbor (Figure 1, Table G-1). Runoff, groundwater flow, NPDES, and airport runoff are all at least a factor of 10 lower than the combined effluent and river flow.

Effluent and river flow also dominate the South Harbor with much lower flow estimates for NURP runoff and groundwater (Figure 2). The total flow to the South Harbor is less than to the North Harbor.

BOD

Effluent and sludge dominate the loading of BOD to the North Harbor (Figure 3, Table G-2). Runoff and river inputs are lower than the combined effluent and sludege by more than a factor of 10.

Effluent is the only significant contributor to BOD in the South Harbor (Figure 4). Total loading is much lower than in the North Harbor.

Total Suspended Solids

Effluent and sludge dominate the loading of total suspended solids to the North Harbor (Figure 5, Table G-3), but loading from runoff and rivers is also significant.

Effluent dominates the loading of total suspended solids to the Souther Harbor (Figure 6), but is more than an order of magnitude lower than for the North Harbor.

Nitrogen

Effluent dominates the loading of nitrogen to the North and South Harbors (Figures 7 and 8, Table G-4).

Phosphorus

Effluent dominates the loading of phosphorus to the North and South Harbors (Figures 9 and 10, Table G-5)). All other sources are at least a factor of 10 lower.

Copper

Effluent and sludge dominate the loading of copper to the North Harbor (Figure 11, Table G-6). Two estimates of groundwater loading are presented. The high estimate is based on 100 ug/l concentration in pore water; the low estimate is based on 10 ug/l.

Effluent dominates the loading of copper to the South Harbor (Figure 12, Table G-6).

Lead

Many sources contribute significantly to the loading of lead to the North Harbor (Figure 13, Table G-7). Effluent and sludge are the largest sources, but urban runoff, rivers, atmospheric deposition, and airport runoff are also significant contributors. Groundwater is only significant at the high estimate based on a concentration of 100 ug/l. These levels were measured at the Quincy Shipyard, but perhaps are not typical of the average conentration of lead in groundwater. NPDES input is not significant with respect to these other sources. This is the only pollutant for which the NURP estimate exceeds the CSO/Storm Drain estimate of CH2M HILL, and probably indicates that the NURP loadings for lead are too large and should be updated.

Multiple sources also contribute to the loading of lead to the South Harbor (Figure 14, Table G-7). Atmospheric deposition is nearly equal to the the loading from effluent and runoff is also significant. Groundwater is significant at the high estimate, but not at the low estimate.

Zinc

Multiple sources contribute to the loading of zinc to the North Harbor (Figure 15, Table G-8). Effluent, sludge, runoff and rivers are all significant sources of zinc. The contribution of atmospheric deposition, groundwater, NPDES, and airport runoff are about an order of magnitude lower than the contribution of the significant sources.

Effluent is the most significant source of zinc to the South Harbor (Figure 16, Table G-8). All other sources are about an order of magnitude lower than the effluent loading.

PAH

Effluent dominates the loading of PAH to the North Harbor (Figure 17, Table G-9). Effluent loading is nearly an order of magnitude larger than the high estimate for sludge loading. Other sources are much lower than sludge.

Effluent also dominates the loading of PAH to the South Harbor (Figure 18, Table G-9). It is more than an order of magnitude larger than loading due to runoff, the next largest contributor.

4.2 Implications of the Estimated Relative Loadings.

The relative magnitude of sources of pollution to the North and South areas of Boston Harbor were compared based on data available from previous studies of the Boston area and on data from studies of other urban areas. The sources of the pollutants are effluent, sludge, urban runoff, tributaries, atmospheric deposition, groundwater, NPDES discharges, and airport runoff. The pollutants and associated data considered in this analysis are flow discharge, BOD, TSS, nitrogen, phosphorus, copper, lead, zinc, and PAH.

Effluent and sludge dominate the loading to both North and South Harbors for all pollutants except lead. Loadings of BOD, nitrogen, phosphorus, copper, and zinc from effluent and sludge combined are at least a factor of 5 greater than loadings from other sources and are usually greater by a factor of 10 or more. In addition to identifying these significant sources, this analysis also shows that loadings will not be completely eliminated following the implementation of additional controls on effluent and sludge--roughly 10 to 20% of the present loadings of the above pollutants may remain.

Lead has multiple sources which contribute significantly to loading; these include non-point sources such as urban runoff and atmospheric deposition which are difficult or impossible to control. These high loadings from nonpoint sources may be indicative of the ubiquity of lead in the urban environment, providing many transport pathways to the Harbor. The present estimates of lead loading indicate that measures taken to reduce the loading of effluent and sludge to Boston Harbor will have a marginal effect on the total lead loading to the Harbor. The estimates of loading from non-point sources may be biased towards high values because measurements of atmospheric concentrations and loadings in urban runoff were made in the early- to mid-1980s when the use of unleaded gasoline was somewhat lower than at present. The current loading is not known, and represents a data gap that should be addressed.

The loadings from the airport are not significant, even for PAHs according to estimates reported in [Camp, Dresser, & Mckee, 1990]. Loadings are generally on the same order as atmospheric deposition.

The estimated loading from groundwater sources are the first such estimates to our knowledge. They are founded on realistic estimates of pollutant concentration in pore water, transmissivity of the soil, and hydraulic gradient. Low and high estimates of loading were made based on the extremes of the concentration range. Loading from groundwater was not a significant contribution even at the high estimates, except for lead.

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MAPS AND FIGURES

Map 1: **Map of Boston Harbor showing the communities draining directly to the harbor and the delineation between North Harbor and South Harbor as used in the text.**

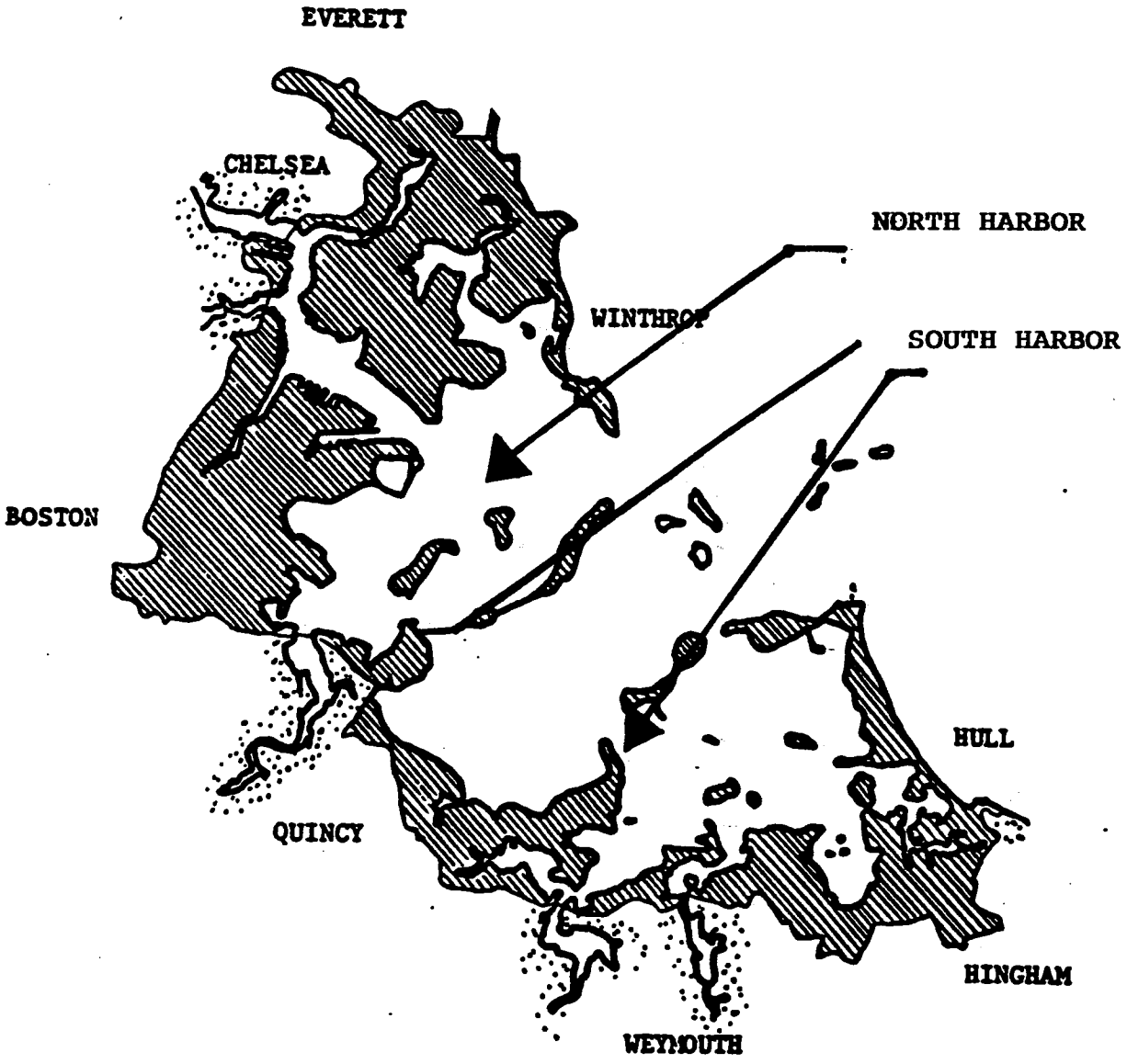

Figure 1. Flows of Discharges (m3/sec) Northern Boston Harbor

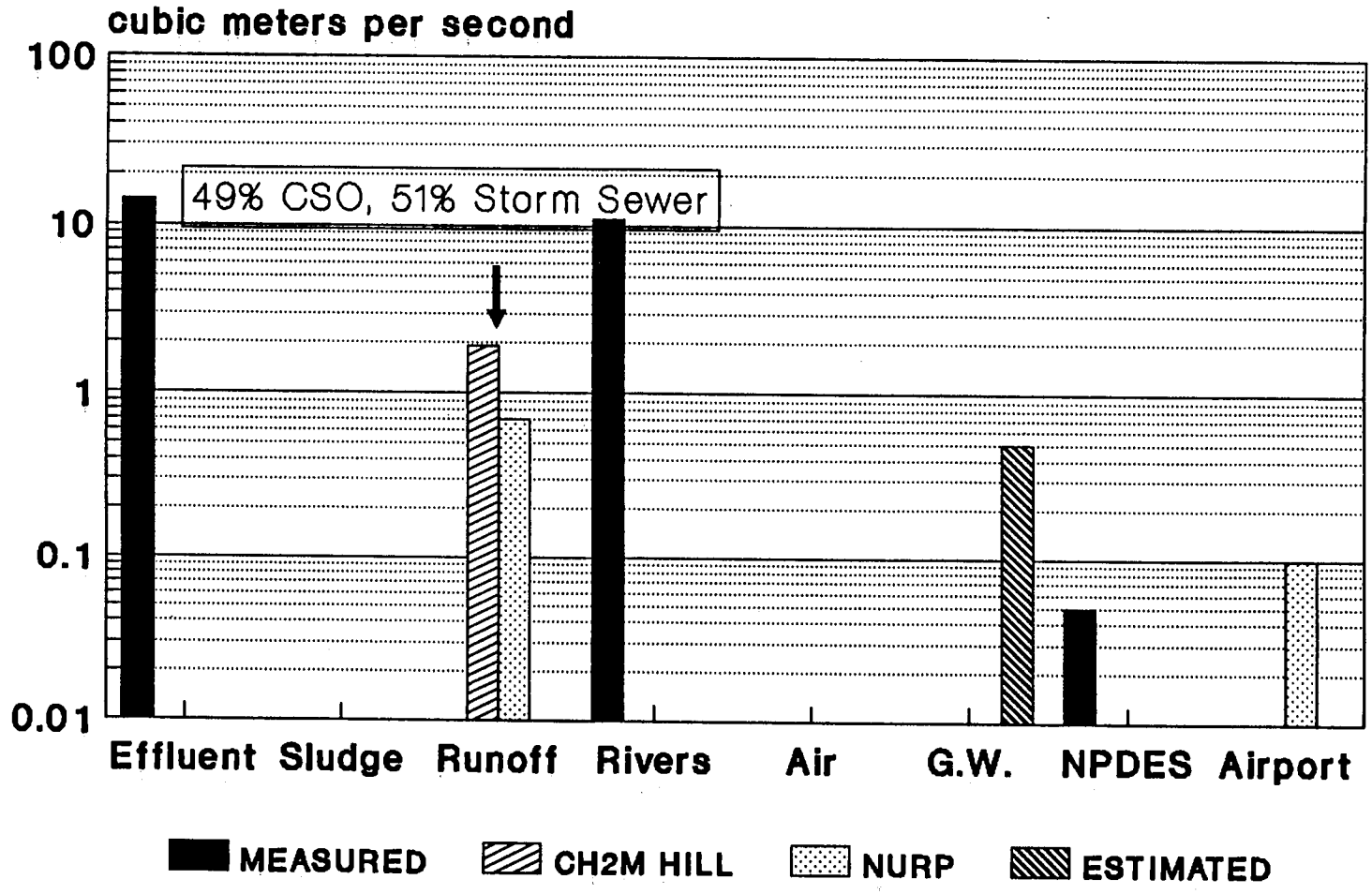

Figure 2. Flows of Discharges (m3/sec) Southern Boston Harbor

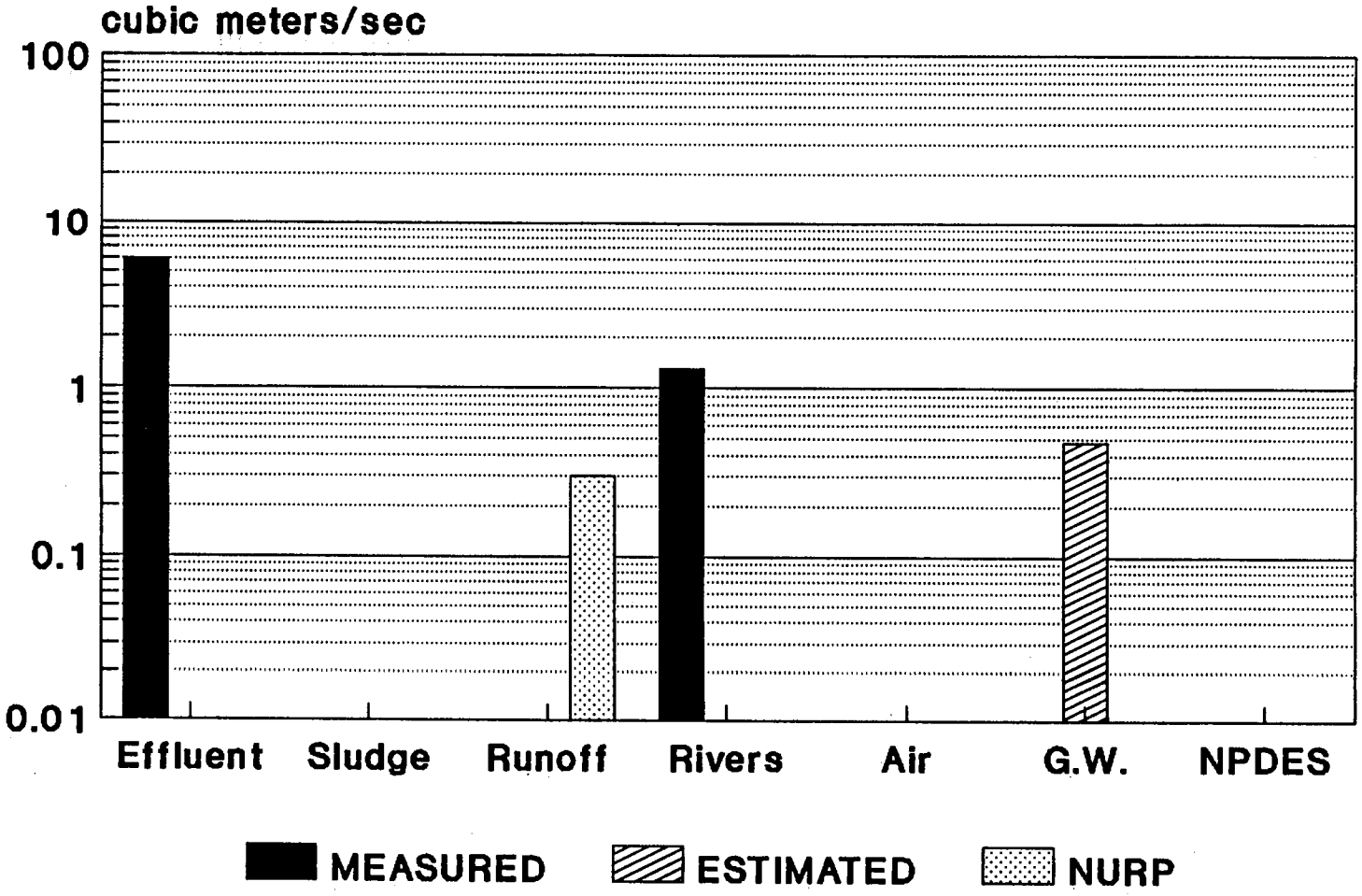

Figure 3. Loadings of BOD (metric tons) Northern Boston Harbor

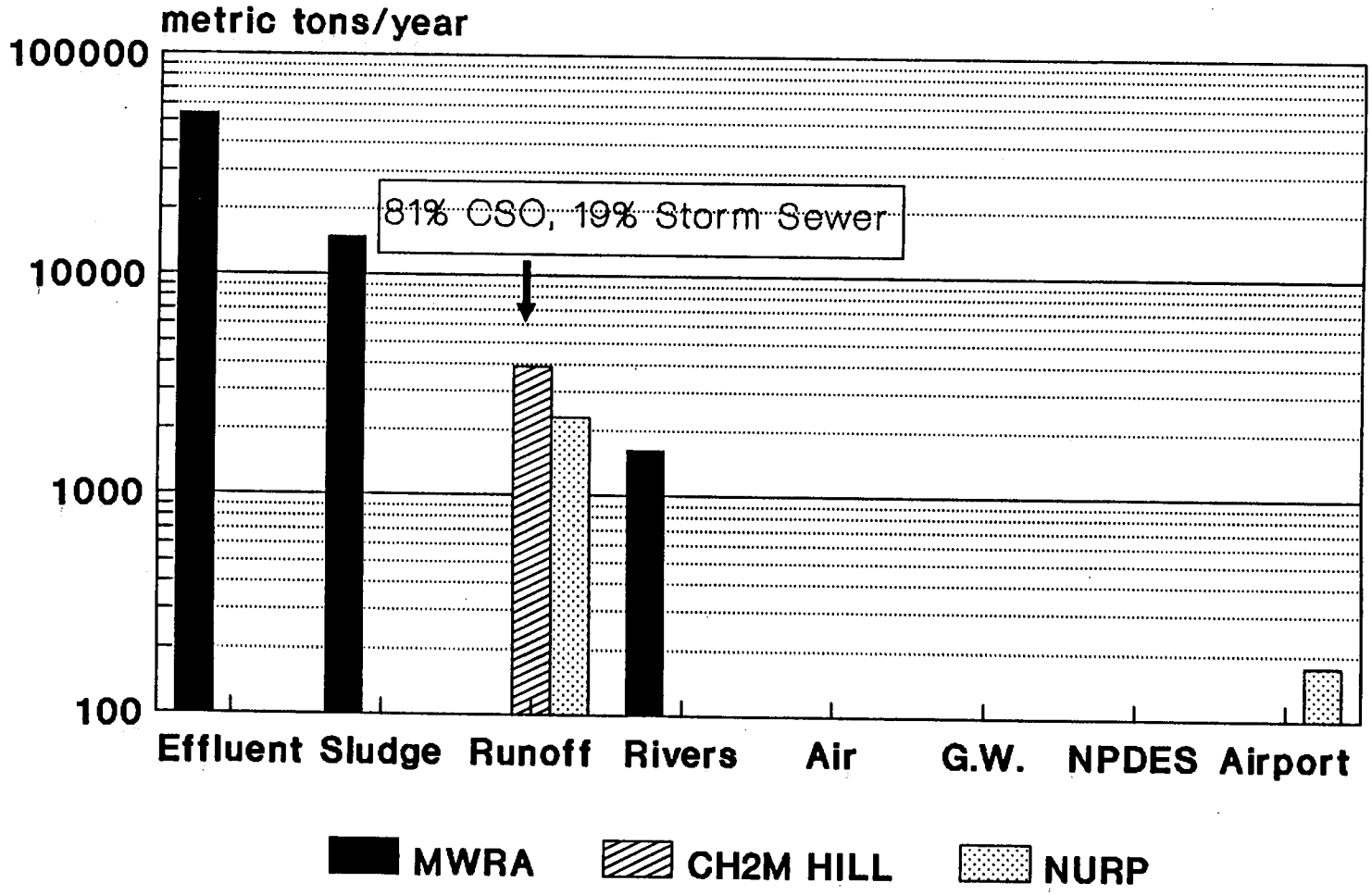

Figure 4. Loadings of BOD (metric tons) Southern Boston Harbor

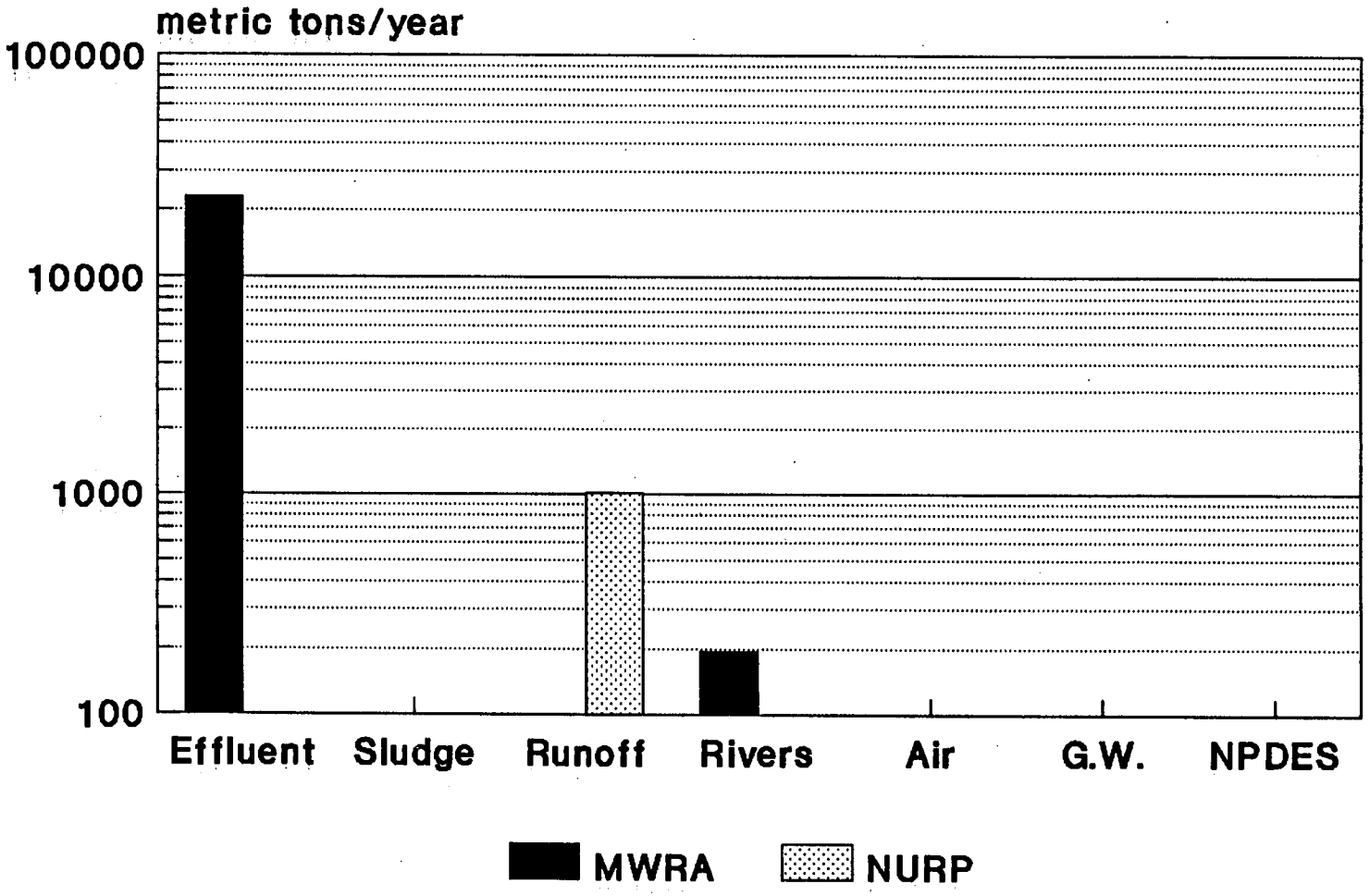

Figure 5. Loadings - Solids (metric ton)
Northern Boston Harbor

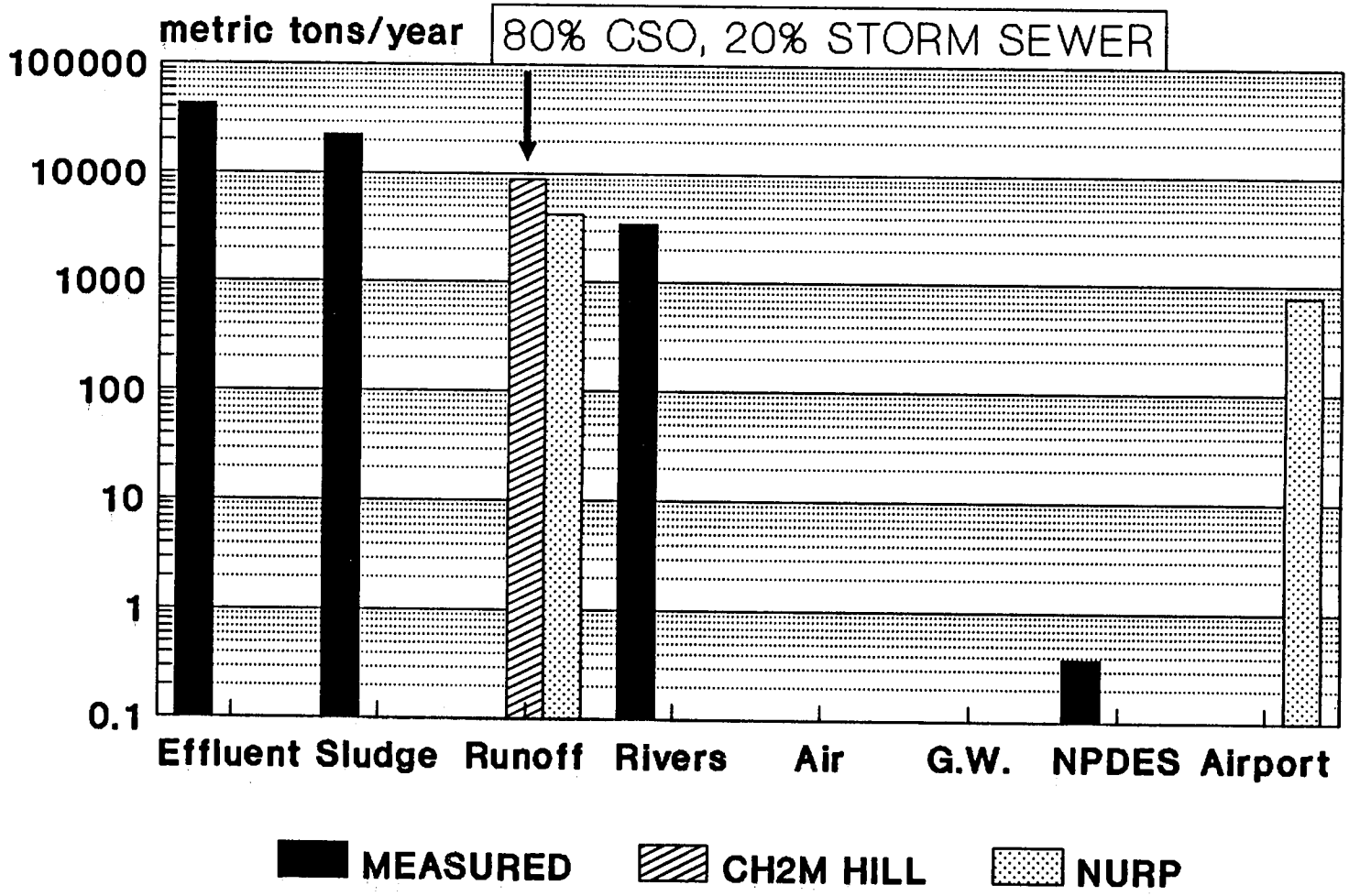

Figure 6. Loadings - Solids (metric ton)
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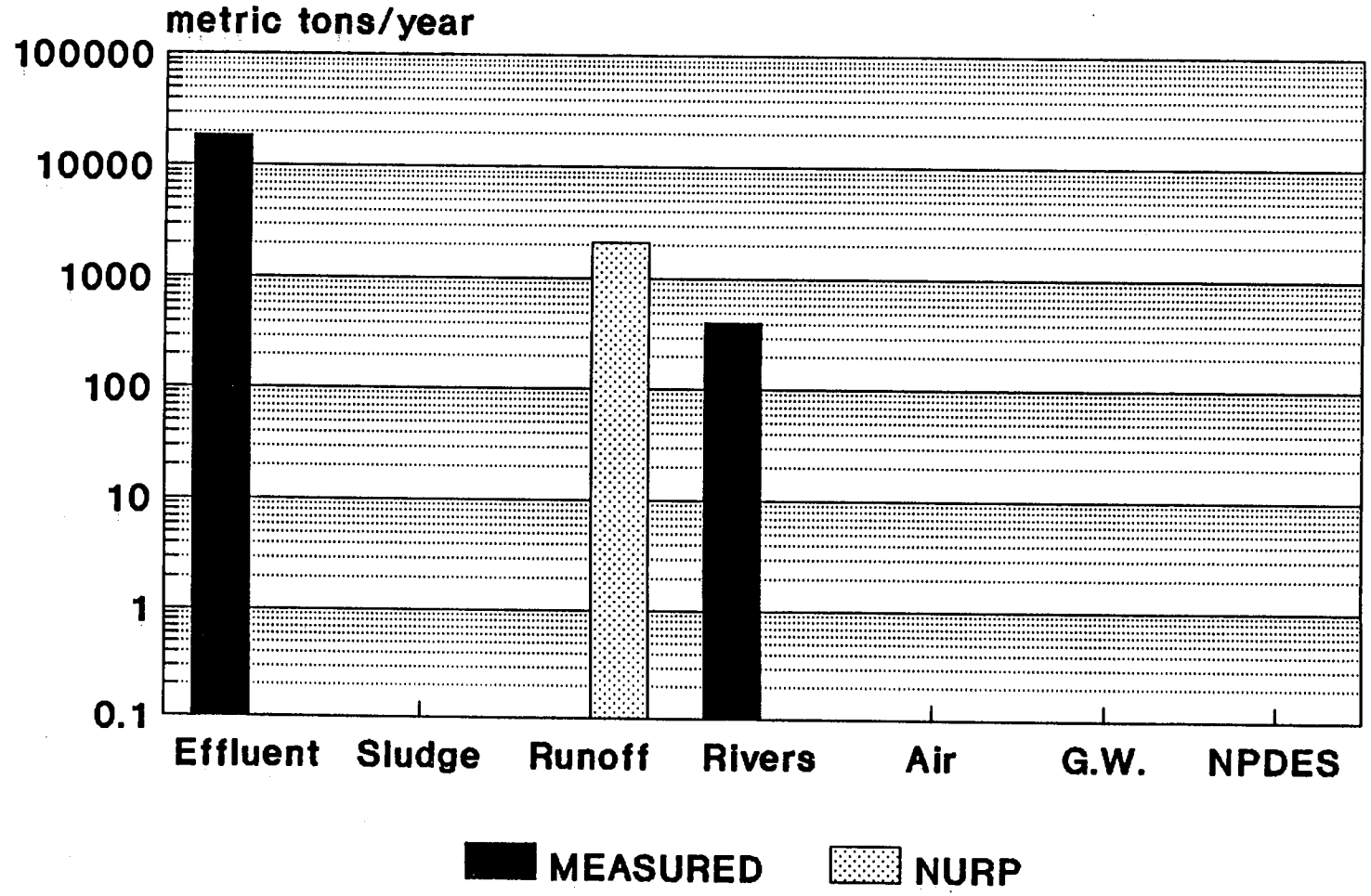

Figure 7. Loadings-Nitrogen (metric ton) Northern Boston Harbor

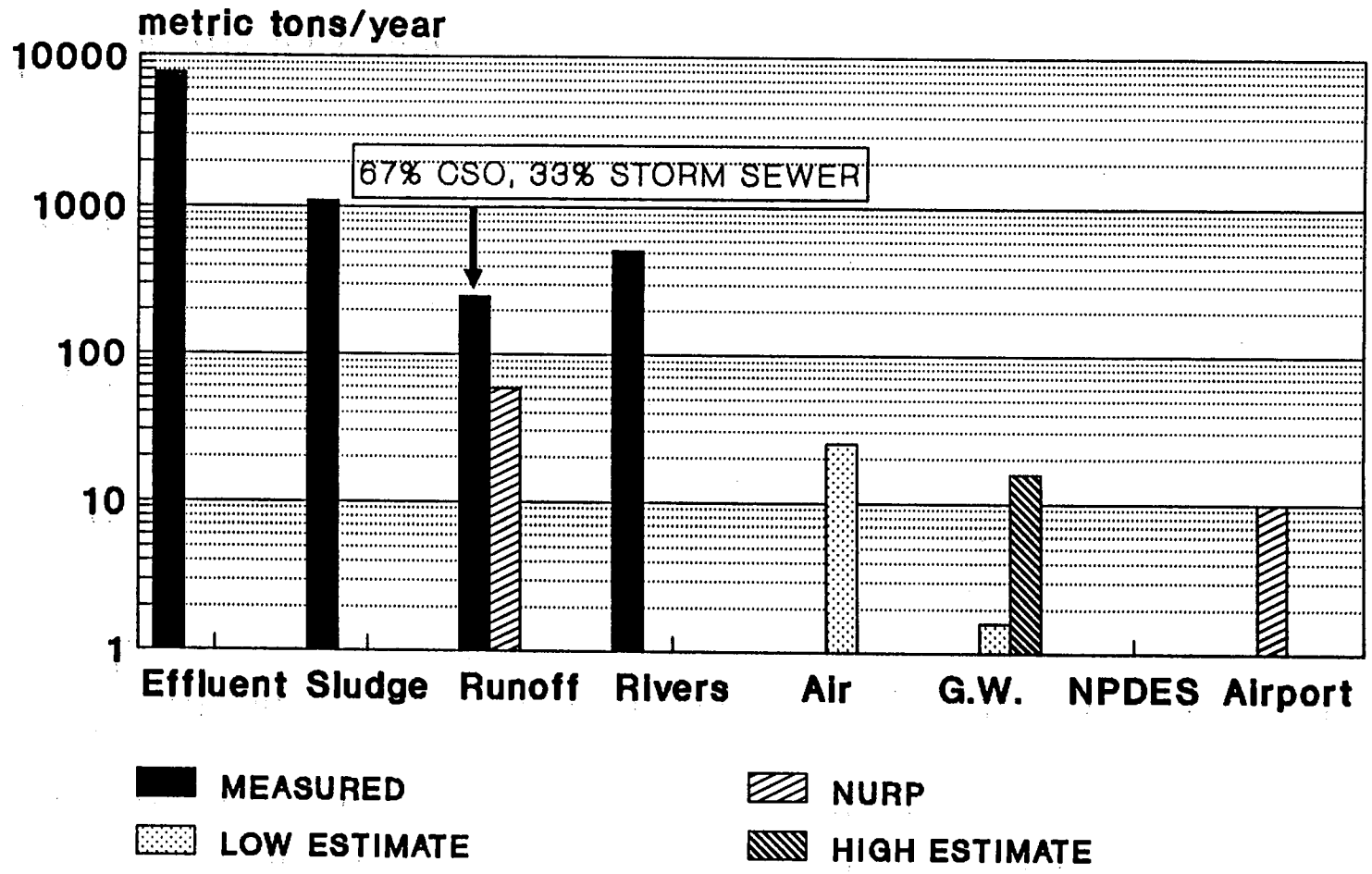

Figure 8. Loadings-Nitrogen (metric ton) Southern Boston Harbor

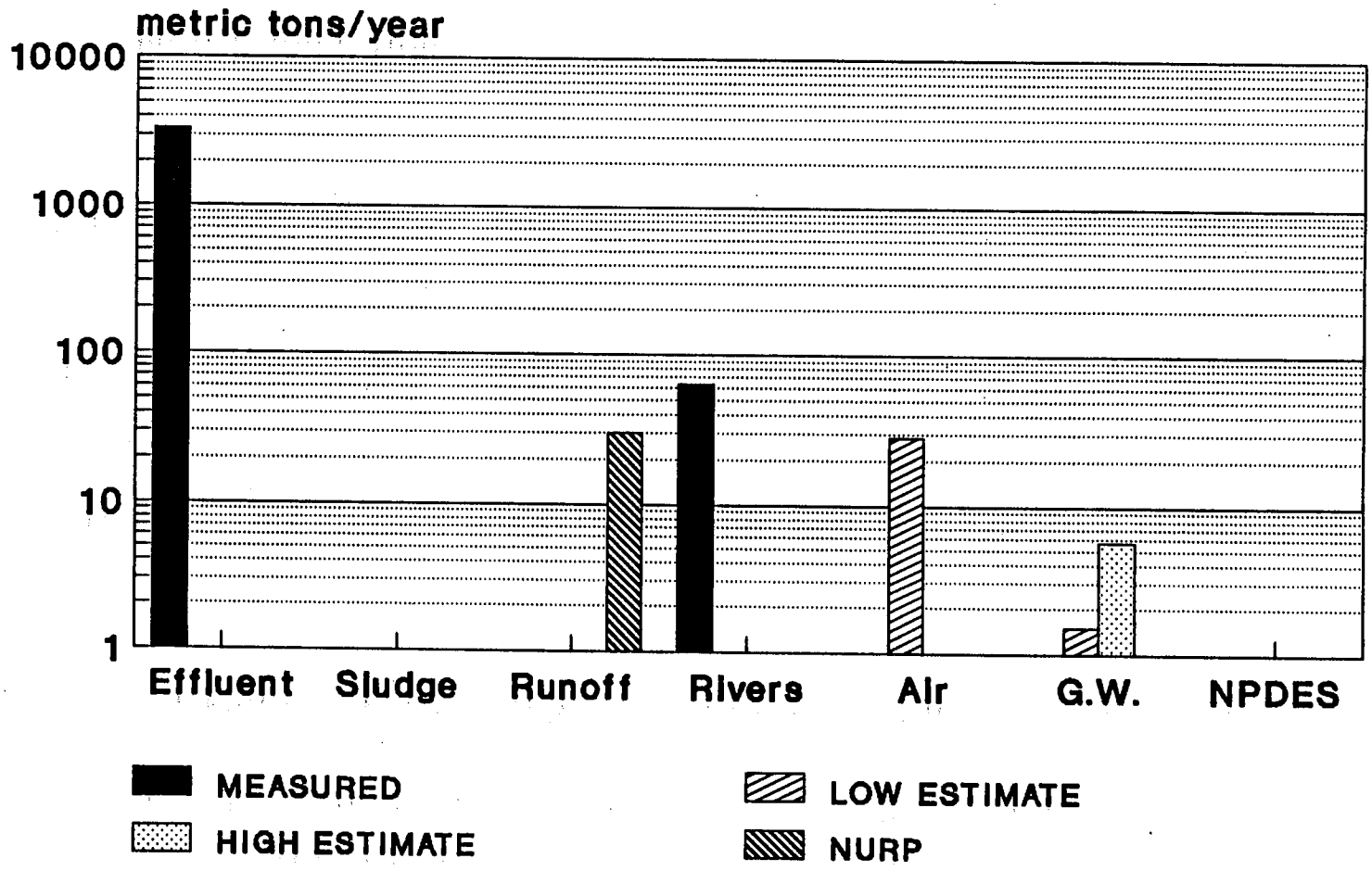

Figure 9. Loadings-Phosphorus
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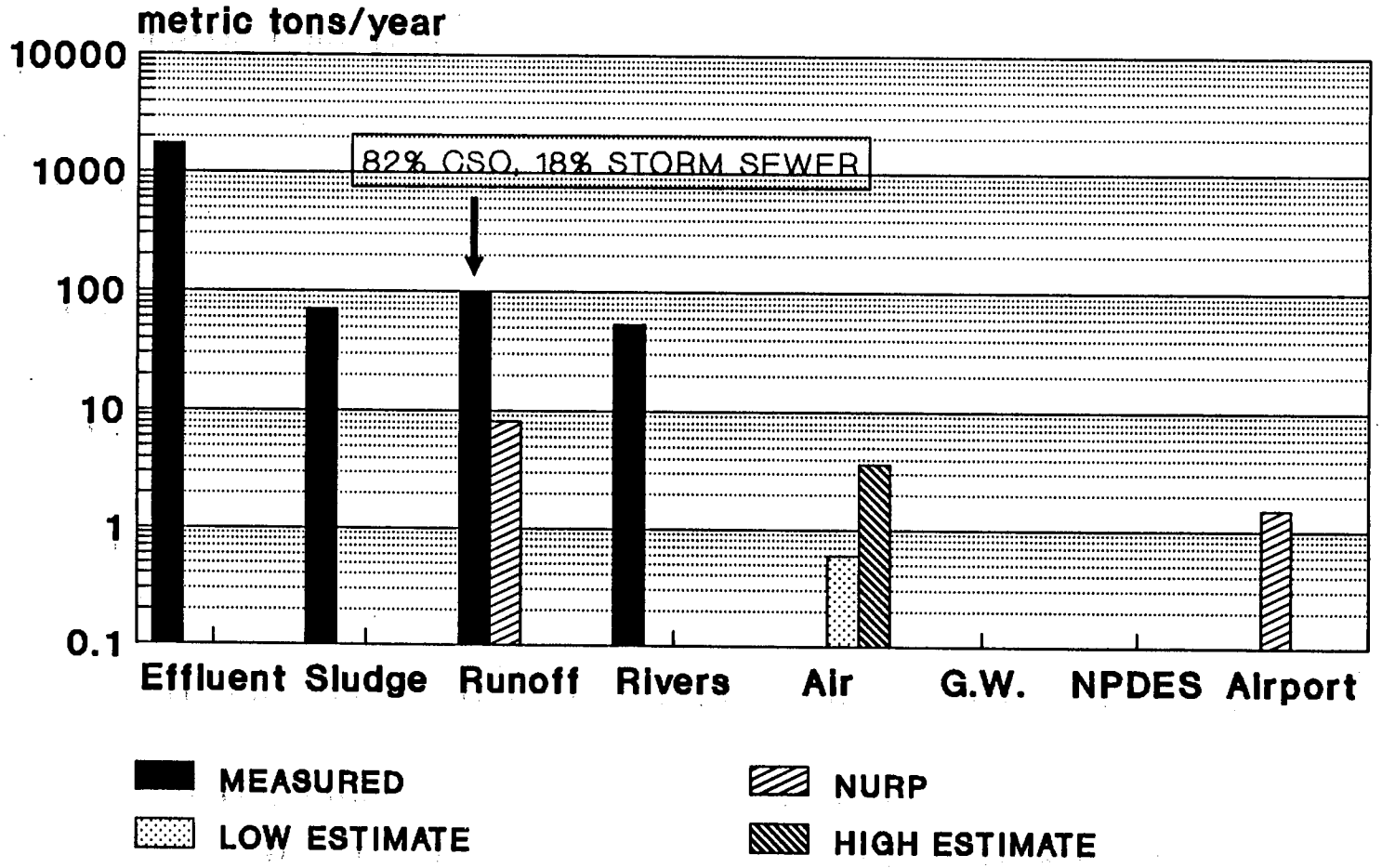


Figure 10. Loadings-Phosphorus
Southern Boston Harbor

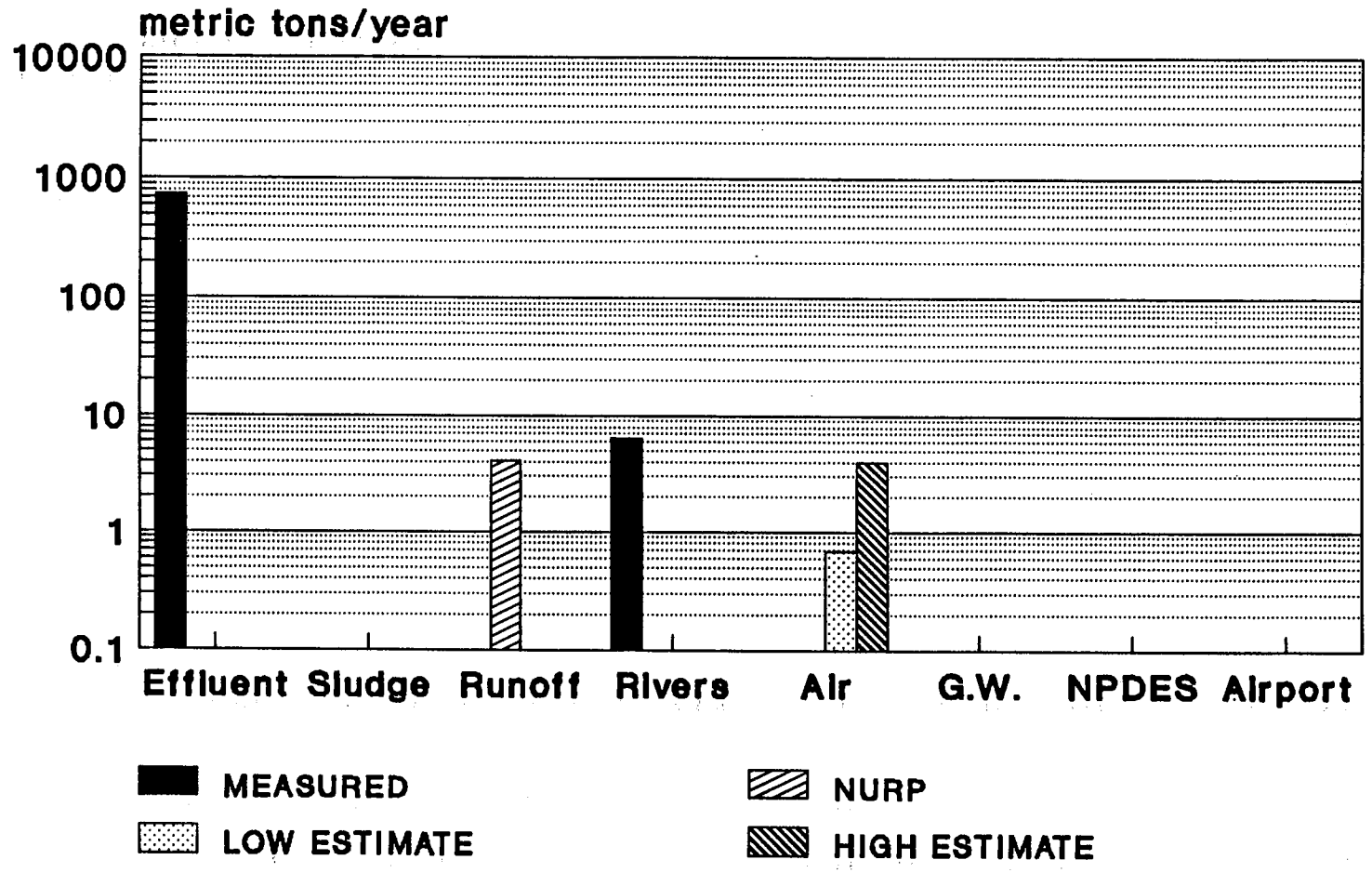


Figure 11. Loadings-Copper
Northern Boston Harbor

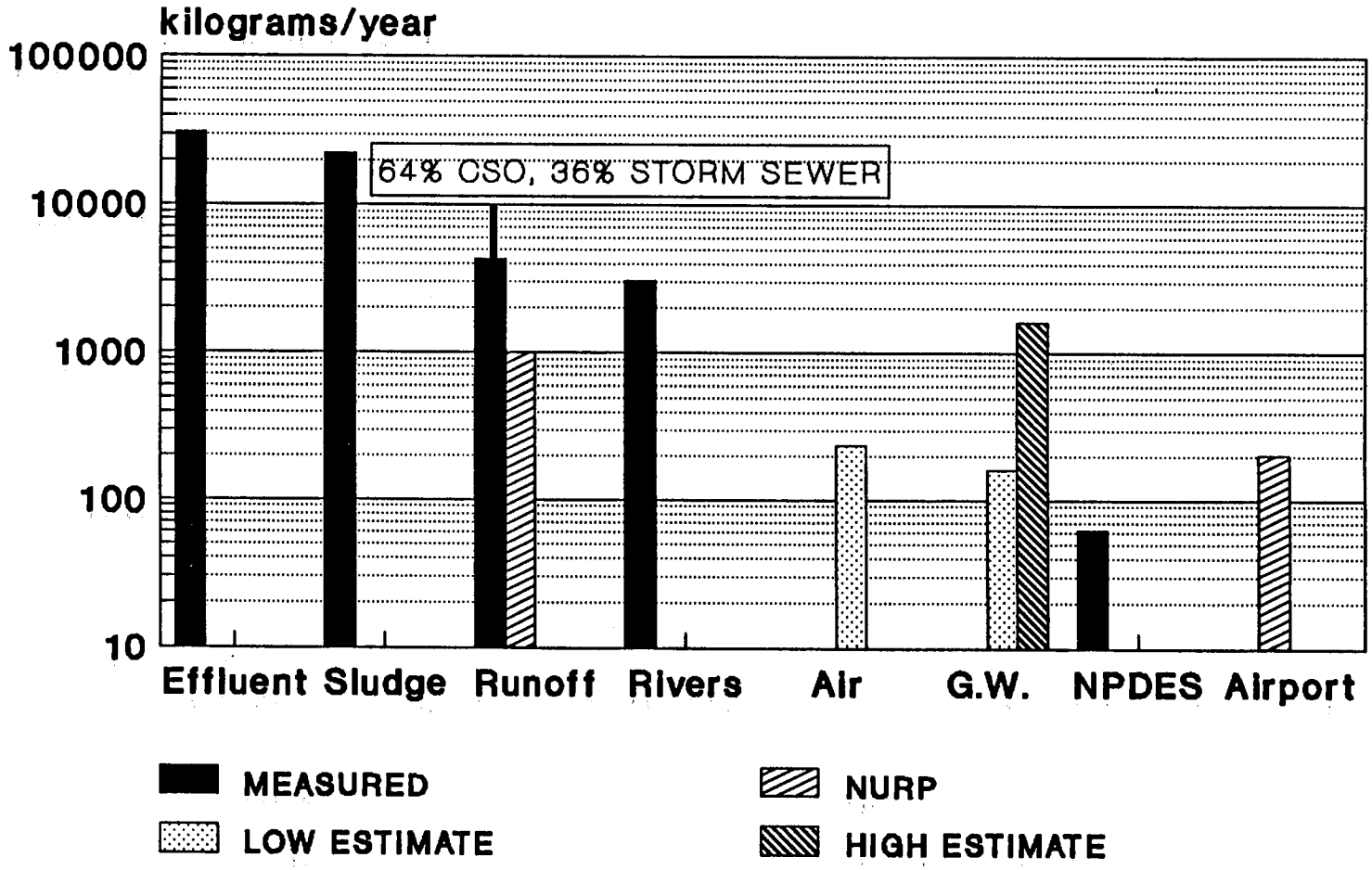


Figure 12. Loadings-Copper Southern Boston Harbor

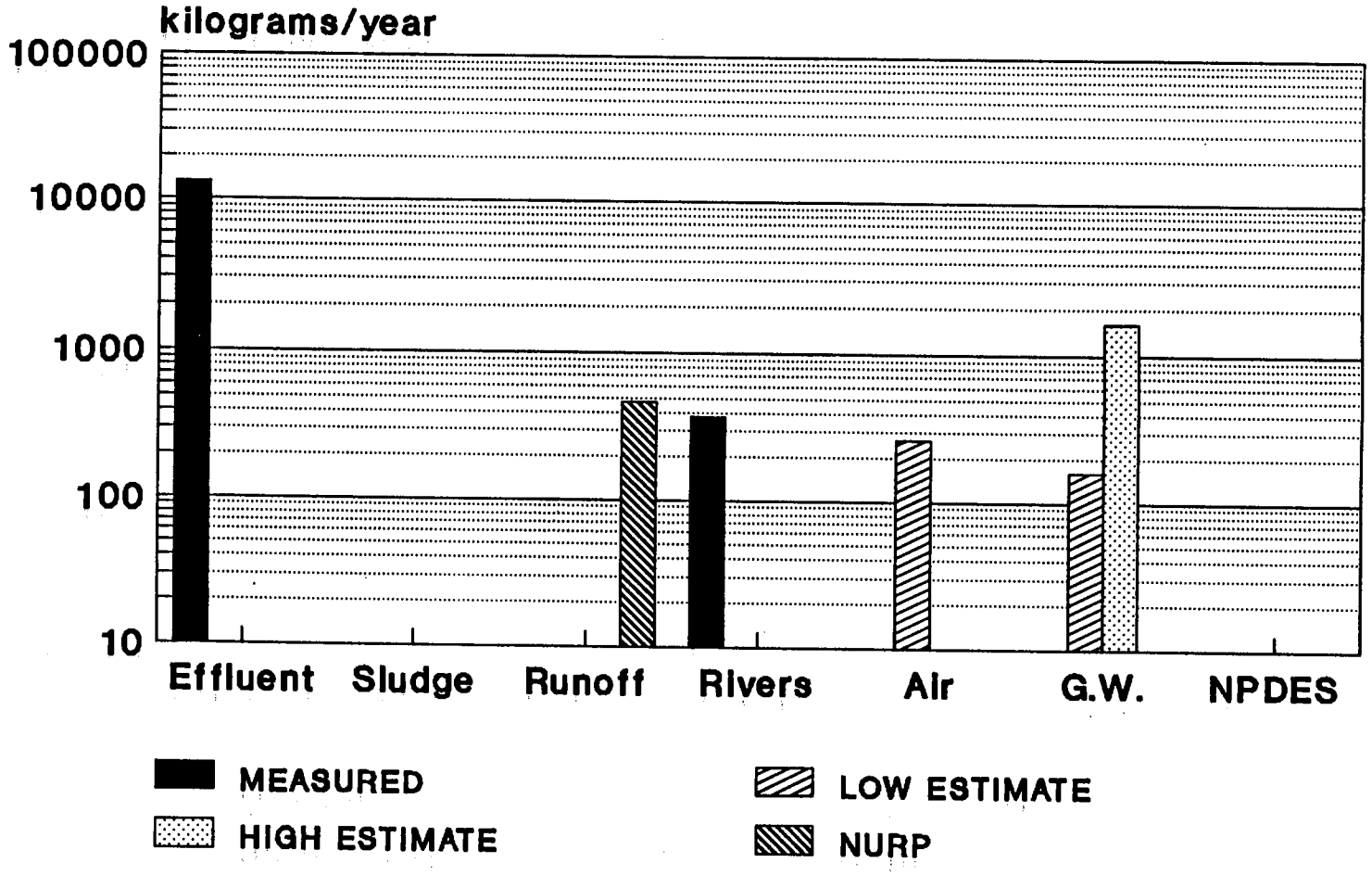


Figure 13. Loadings-Lead Northern Boston Harbor

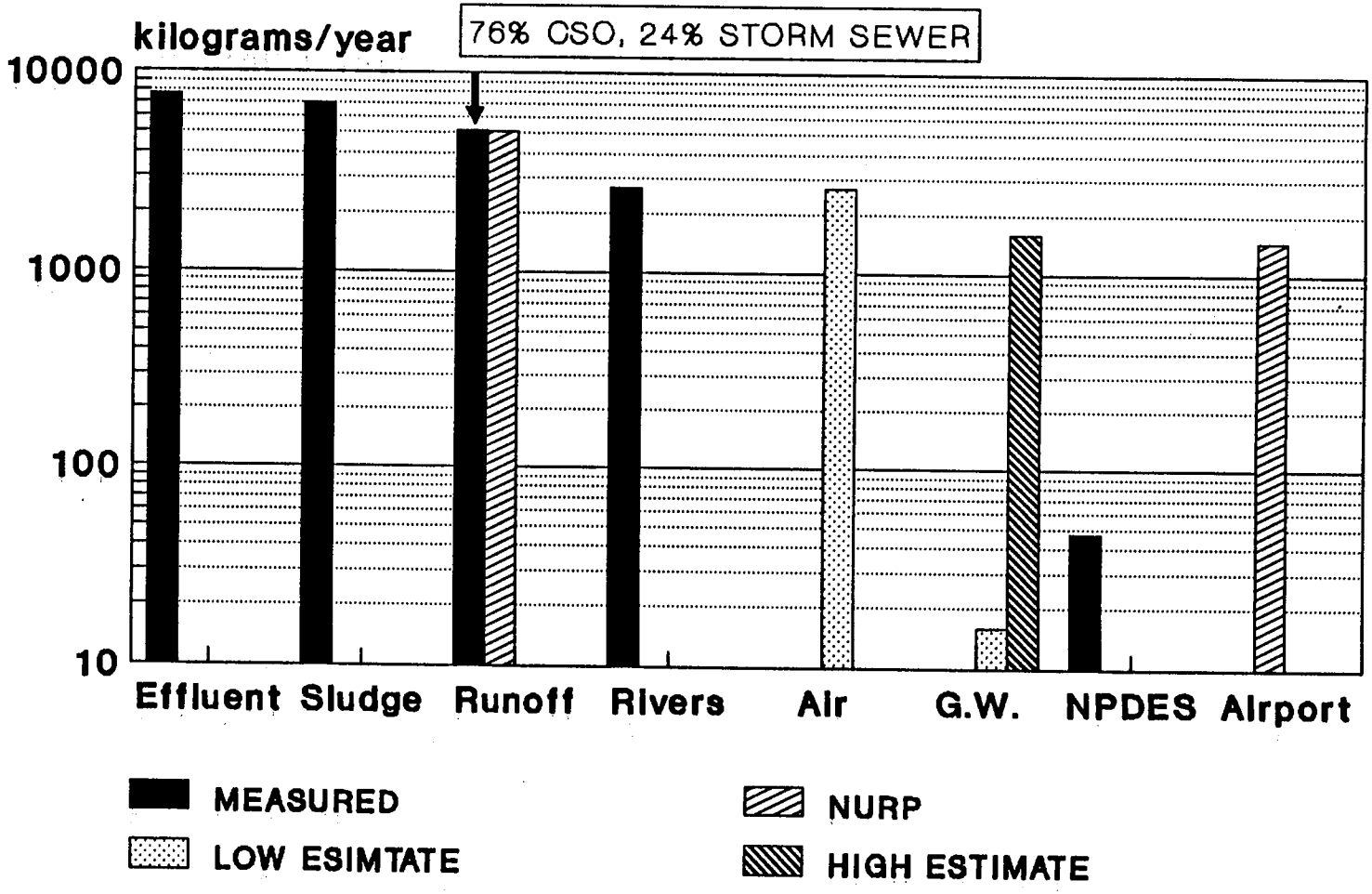


Figure 14. Loadings-Lead
Southern Boston Harbor

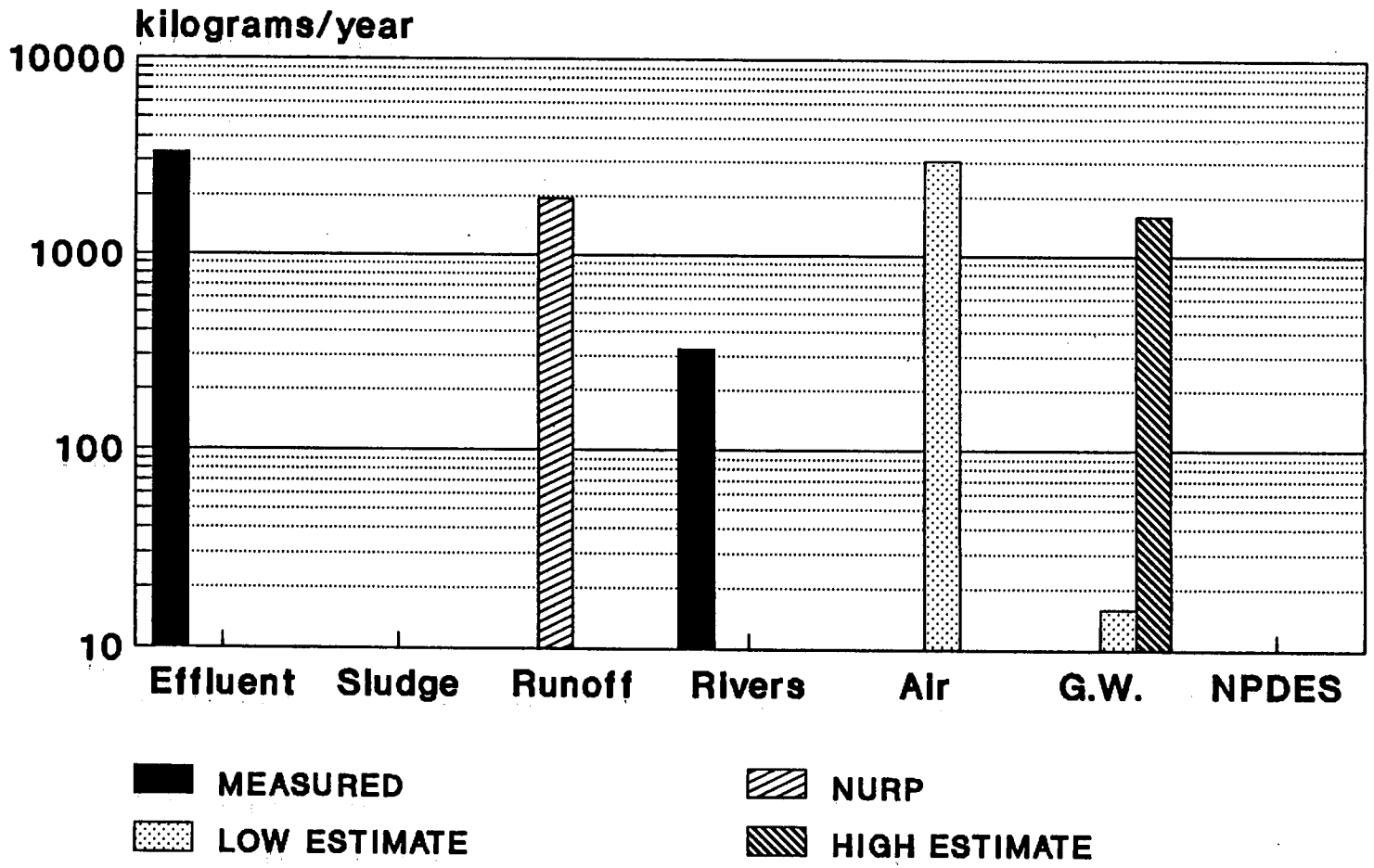


Figure 15. Loadings-Zinc
Northern Boston Harbor

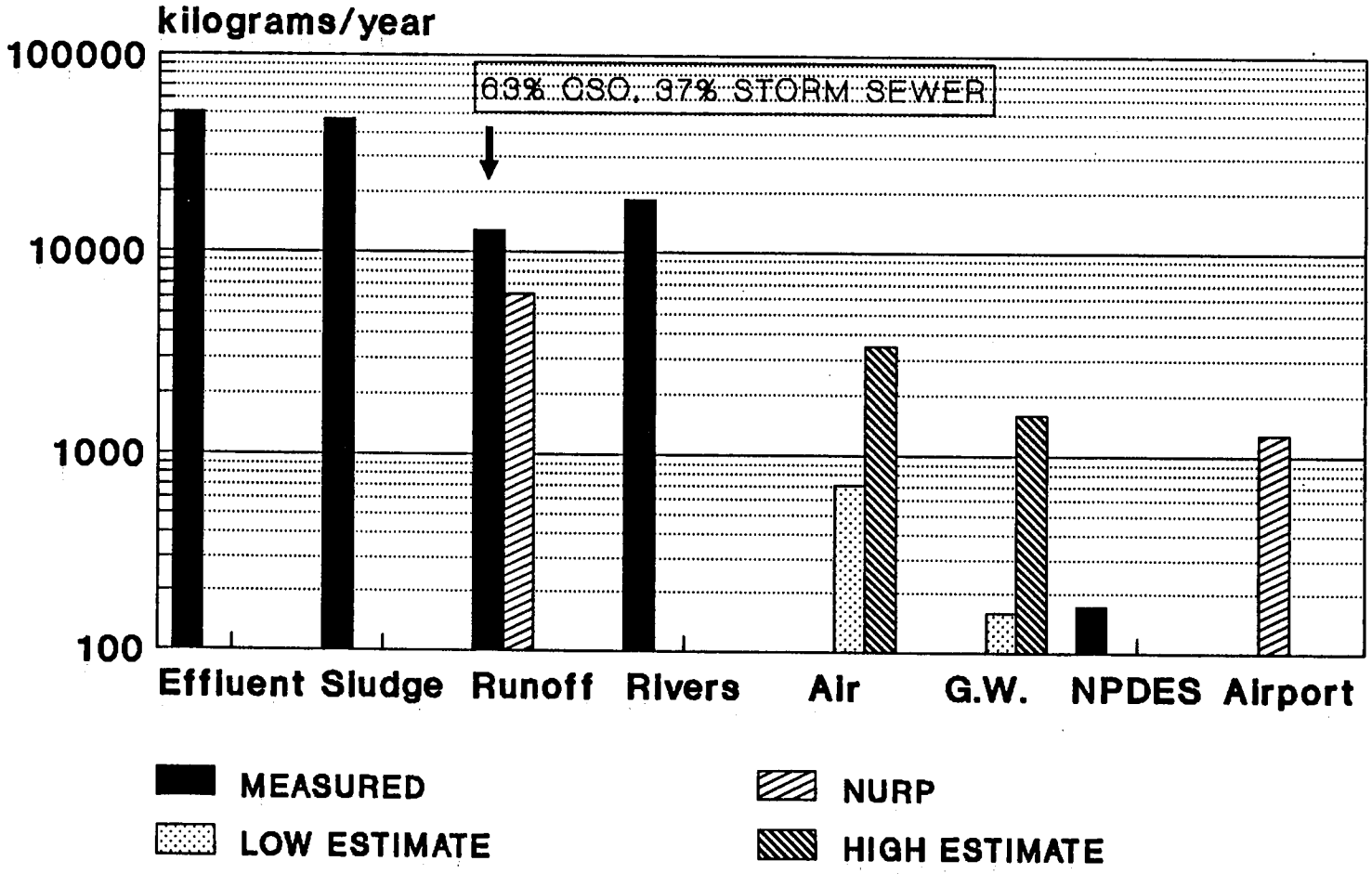


Figure 16. Loadings-Zinc
Southern Boston Harbor

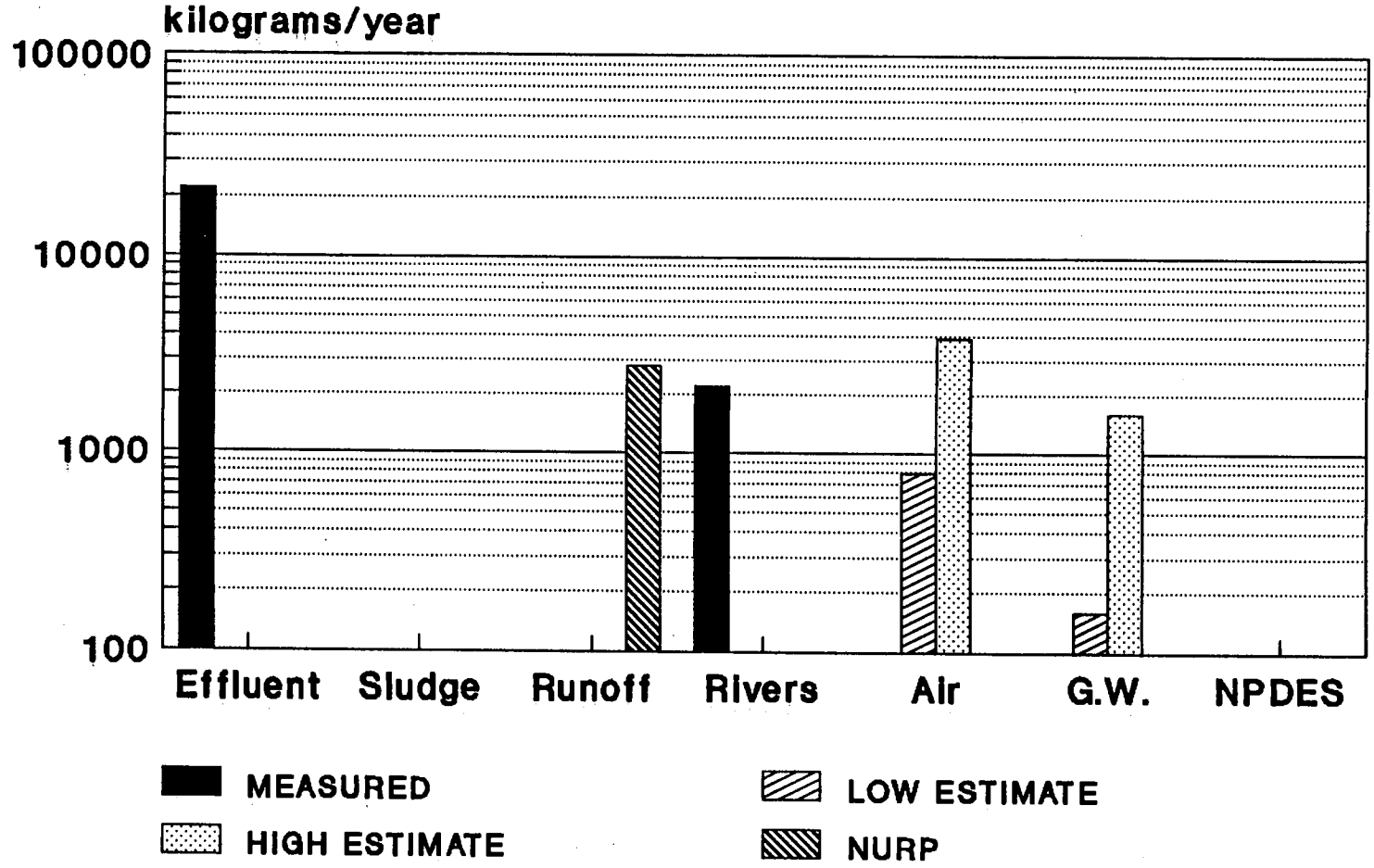


Figure 17. Loadings-PAHs
Northern Boston Harbor

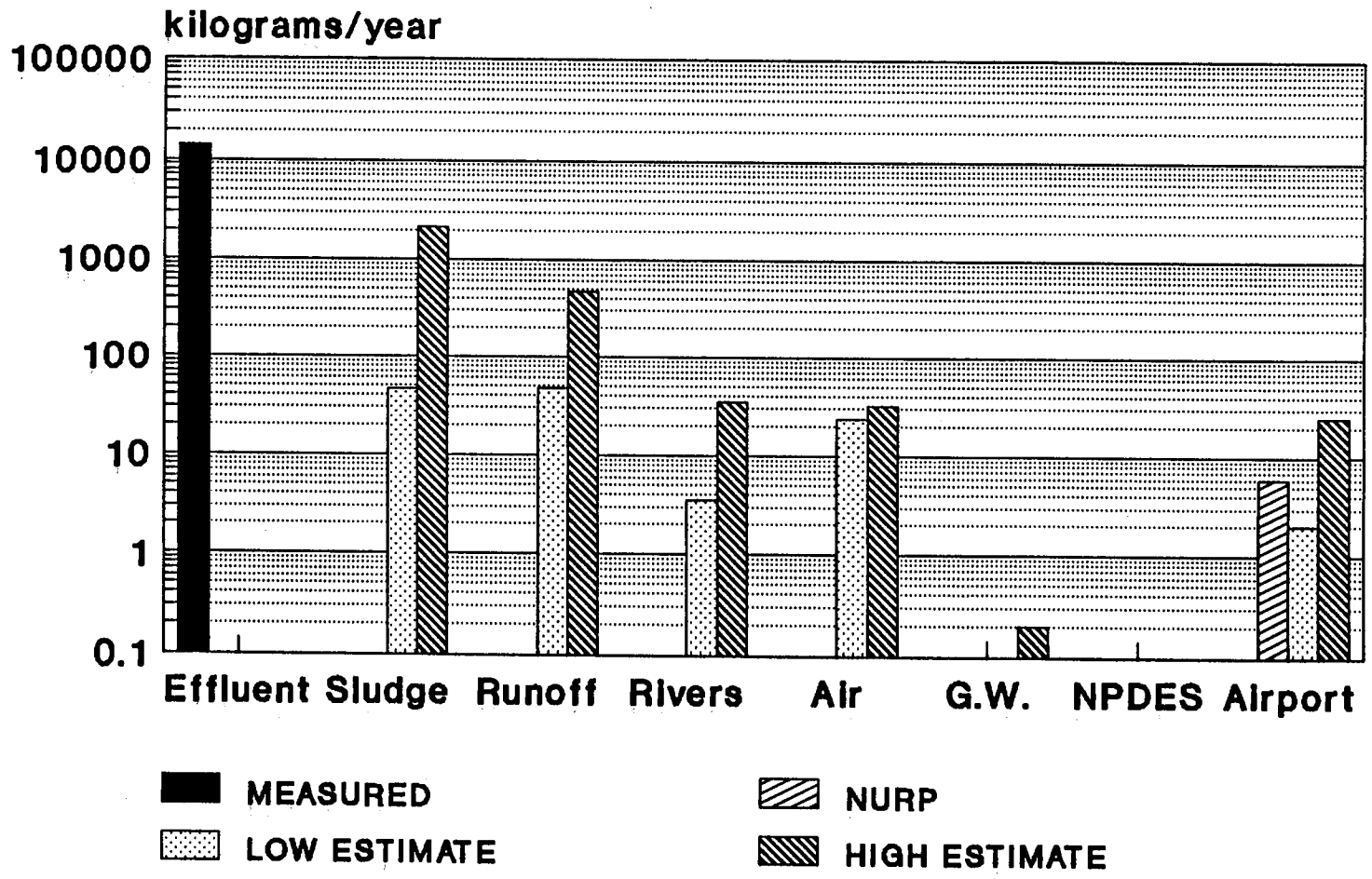
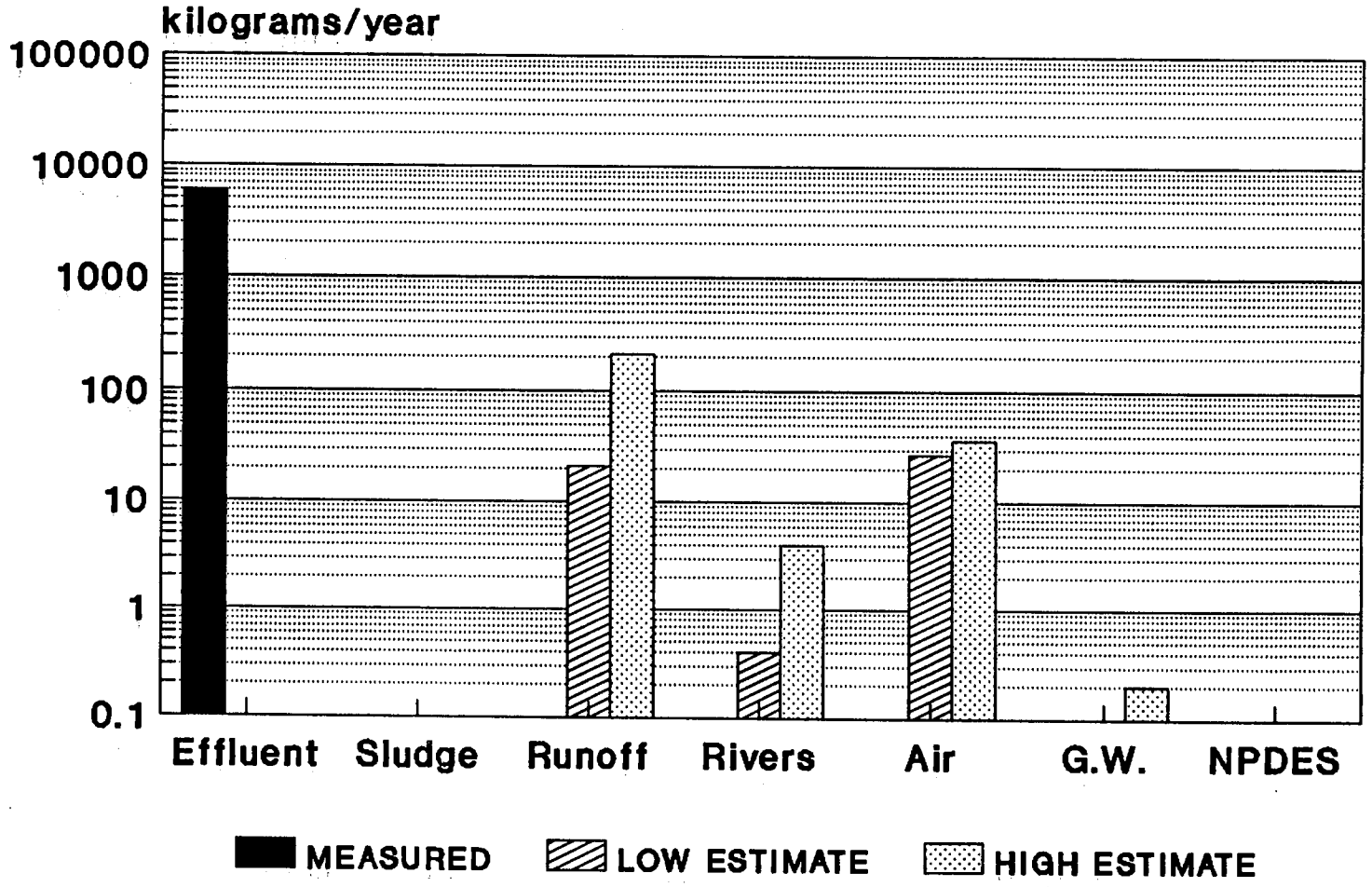


Figure 18. Loadings-PAHs
Southern Boston Harbor



APPENDIX A. LOADINGS FROM NPDES DISCHARGES

TABLE A1. Flow From NPDES Discharges to North Harbor Area

Facility	Receiving Water	Flow 1986	Flow Data (MGD) Flow 1988	Flow 1989	Flow 1990
Monsanto 001A	Mystic River		6.66E-02	1.83E-01	6.66E-02
Monsanto 002A	Mystic River		0.00E+00	0.00E+00	0.00E+00
Exxon Oil	Mystic River		0.00E+00	1.37E-01	6.18E-01
Boston Edison (Everett) 002A	Mystic River		5.51E-01	4.72E-01	2.87E-01
Boston Edison (Everett) 003A	Mystic River		4.00E-01	0.00E+00	0.00E+00
Boston Edison (Everett) 007A	Mystic River		0.00E+00	0.00E+00	0.00E+00
Boston Edison (Everett) 008A	Mystic River		0.00E+00	0.00E+00	0.00E+00
Boston Edison (Boston) 011A	Boston Harbor		2.74E-01	2.43E-01	1.50E-01
Boston Edison (Boston) 012A	Boston Harbor		0.00E+00	0.00E+00	0.00E+00
Boston Edison (Boston) 013A	Boston Harbor		0.00E+00	0.00E+00	0.00E+00
Boston Edison (Boston) 014A	Boston Harbor		0.00E+00	0.00E+00	0.00E+00
Total Flow			1.29E+00	1.03E+00	1.12E+00
Average Annual Flow			1.15E+00		

Table A2. Flow From NPDES Discharges To Tributaries In North Harbor

Facility	Receiving Water	Flow 1986	Flow Data (MGD) Flow 1988	Flow 1989	Flow 1990
Cambridge Electric	Charles River	1.00E+01	0.00E+00	0.00E+00	0.00E+00
Norfolk-Walpole 001A	Charles River			3.06E-01	3.12E-01
Norfolk-Walpole 001B	Charles River			3.18E-01	
Charles River PCD 011	Charles River		2.60E+00	3.33E+00	3.83E+00
Charles River PCD 012	Charles River		3.65E+00		
Charles River PCD 013	Charles River		3.38E+00		
Charles River PCD 014	Charles River		2.67E+00		
Medfield WWTP FACA	Charles River		7.60E-01		
Medfield WWTP FACC	Charles River				
Medfield WWTP FACB	Charles River				
Medfield WWTP 001A	Charles River		8.15E-01	9.13E-01	8.47E-01
Plymouth Rubber Co.	Neponset River		4.60E+00	3.07E+00	3.00E+00
Foxboro Co. Neponset 001A	Neponset River		6.57E-02	0.00E+00	0.00E+00
Foxboro Co. Neponset 001B	Neponset River		5.96E-02	7.38E-02	9.23E-03
Total Flow				1.86E+01	8.01E+00 8.00E+00
Average Annual Flow				1.15E+01	

Table A3. Biological Oxygen Demand From NPDES Discharges Directly To North Harbor

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representative Load (KG/YR)
Monsanto 001A	Mystic River					
Monsanto 002A	Mystic River					
Exxon Oil	Mystic River					
Boston Edison (Everett) 002A	Mystic River					
Boston Edison (Everett) 003A	Mystic River					
Boston Edison (Everett) 007A	Mystic River					
Boston Edison (Everett) 008A	Mystic River					
Boston Edison (Boston) 011A	Boston Harbor					
Boston Edison (Boston) 012A	Boston Harbor					
Boston Edison (Boston) 013A	Boston Harbor					
Boston Edison (Boston) 014A	Boston Harbor					

Table A4. Biological Oxygen Demand From NPDES Discharges Tributaries To North Harbor

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Cambridge Electric	Charles River					
Norfolk-Walpole 001A	Charles River			4.56E+03	8.94E+03	8.49E+03
Norfolk-Walpole 001B	Charles River			9.86E+03		9.86E+03
Charles River PCD 011	Charles River		2.49E+04	2.96E+04	8.83E+04	8.83E+04
Charles River PCD 012	Charles River		4.52E+04			4.52E+04
Charles River PCD 013	Charles River		4.98E+04			4.98E+04
Charles River PCD 014	Charles River		1.81E+04			1.81E+04
Medfield WWTP FACA	Charles River		2.61E+03			2.61E+03
Medfield WWTP FACC	Charles River					
Medfield WWTP FACB	Charles River					
Medfield WWTP 001A	Charles River		2.77E+03	3.01E+03	3.00E+03	3.00E+03
Plymouth Rubber Co.	Neponset River					
Foxboro Co. Neponset 001A	Neponset River					
Foxboro Co. Neponset 001B	Neponset River					
						2.25E+05

Table A5 Cadmium Loads From NPDES Discharges Directly To North Harbor

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Monsanto 001A	Mystic River				0.00E+00	
Monsanto 002A	Mystic River					
Exxon Oil	Mystic River					
Boston Edison (Everett) 002A	Mystic River	1.90E+01				1.90E+01
Boston Edison (Everett) 003A	Mystic River					
Boston Edison (Everett) 007A	Mystic River					
Boston Edison (Everett) 008A	Mystic River					
Boston Edison (Boston) 011A	Boston Harbor					
Boston Edison (Boston) 012A	Boston Harbor					
Boston Edison (Boston) 013A	Boston Harbor					
Boston Edison (Boston) 014A	Boston Harbor					
						1.90E+01

Table A6 Cadmium Loads From NPDES Discharges To North Harbor Tributaries

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Cambridge Electric	Charles River					
Norfolk-Walpole 001A	Charles River					
Norfolk-Walpole 001B	Charles River					
Charles River PCD 011	Charles River					
Charles River PCD 012	Charles River					
Charles River PCD 013	Charles River					
Charles River PCD 014	Charles River					
Medfield WWTP FACA	Charles River					
Medfield WWTP FACC	Charles River					
Medfield WWTP FACB	Charles River					
Medfield WWTP 001A	Charles River					
Plymouth Rubber Co.	Neponset River					
Foxboro Co. Neponset 001A	Neponset River	55.20	2.49E-05			55.20
Foxboro Co. Neponset 001B	Neponset River					
						5.52E+01

Table A7. Total Chromium From NPDES Discharges Directly To North Harbor

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Monsanto 001A	Mystic River					
Monsanto 002A	Mystic River					
Exxon Oil	Mystic River					
Boston Edison (Everett) 002A	Mystic River	2.86E+01				2.86E+01
Boston Edison (Everett) 003A	Mystic River					
Boston Edison (Everett) 007A	Mystic River					
Boston Edison (Everett) 008A	Mystic River					
Boston Edison (Boston) 011A	Boston Harbor					
Boston Edison (Boston) 012A	Boston Harbor					
Boston Edison (Boston) 013A	Boston Harbor					
Boston Edison (Boston) 014A	Boston Harbor					
						2.86E+01

Table A8. Total Chromium From NPDES Discharges To North Harbor Tributaries

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Norfolk-Walpole 001A	Charles River					
Norfolk-Walpole 001B	Charles River					
Charles River PCD 011	Charles River					
Charles River PCD 012	Charles River					
Charles River PCD 013	Charles River					
Charles River PCD 014	Charles River					
Medfield WWTP FACA	Charles River					
Medfield WWTP FACC	Charles River					
Medfield WWTP FACB	Charles River					
Medfield WWTP 001A	Charles River					
Plymouth Rubber Co.	Neponset River					
Foxboro Co. Neponset 001A	Neponset River	1.06E+02	3.13E-05			1.06E+02
Foxboro Co. Neponset 001B	Neponset River					
						1.06E+02

Table A9. Copper From NPDES Discharges Directly To North Harbor

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Monsanto 001A	Mystic River					
Monsanto 002A	Mystic River					
Exxon Oil	Mystic River					
Boston Edison (Everett) 002A	Mystic River			5.73E+01	2.77E+01	5.73E+01
Boston Edison (Everett) 003A	Mystic River					
Boston Edison (Everett) 007A	Mystic River					
Boston Edison (Everett) 008A	Mystic River					
Boston Edison (Boston) 011A	Boston Harbor			6.04E+00	6.22E+00	6.22E+00
Boston Edison (Boston) 012A	Boston Harbor					
Boston Edison (Boston) 013A	Boston Harbor					
Boston Edison (Boston) 014A	Boston Harbor					
						6.36E+01

Table A10. Copper From NPDES Discharges To North Harbor Tributaries

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Cambridge Electric	Charles River					
Norfolk-Walpole 001A	Charles River					
Norfolk-Walpole 001B	Charles River					
Charles River PCD 011	Charles River					
Charles River PCD 012	Charles River					
Charles River PCD 013	Charles River					
Charles River PCD 014	Charles River					
Medfield WWTP FACA	Charles River					
Medfield WWTP FACC	Charles River					
Medfield WWTP FACB	Charles River					
Medfield WWTP 001A	Charles River					
Plymouth Rubber Company	Neponset River					
Foxboro Co. Neponset 001A	Neponset River	2.29E+01	3.29E+01			3.29E+01
Foxboro Co. Neponset 001B	Neponset River					
						3.29E+01

Table A11. Lead From NPDES Discharges Directly to North Harbor.

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Monsanto 001A	Mystic River					
Monsanto 002A	Mystic River					
Exxon Oil	Mystic River					
Boston Edison (Everett) 002A	Mystic River	4.76E+01				4.76E+01
Boston Edison (Everett) 003A	Mystic River					
Boston Edison (Everett) 007A	Mystic River					
Boston Edison (Everett) 008A	Mystic River					
Boston Edison (Boston) 011A	Boston Harbor					
Boston Edison (Boston) 012A	Boston Harbor					
Boston Edison (Boston) 013A	Boston Harbor					
Boston Edison (Boston) 014A	Boston Harbor					
						4.76E+01

Table A12. Lead From NPDES Discharges Directly to North Harbor Tributaries.

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Cambridge Electric	Charles River					
Norfolk-Walpole 001A	Charles River					
Norfolk-Walpole 001B	Charles River					
Charles River PCD 011	Charles River					
Charles River PCD 012	Charles River					
Charles River PCD 013	Charles River					
Charles River PCD 014	Charles River					
Medfield WWTP FACA	Charles River					
Medfield WWTP FACC	Charles River					
Medfield WWTP FACB	Charles River					
Medfield WWTP 001A	Charles River					
Plymouth Rubber Co.	Neponset River					
Foxboro Co. Neponset 001A	Neponset River	1.08E+01				1.08E+01
Foxboro Co. Neponset 001B	Neponset River					
						1.08E+01

Table A13. Nickel From NPDES Discharges Directly to North Harbor.

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Monsanto 001A	Mystic River					
Monsanto 002A	Mystic River					
Exxon Oil	Mystic River					
Boston Edison (Everett) 002A	Mystic River		1.98E+01	4.43E+01	2.49E+01	4.43E+01
Boston Edison (Everett) 003A	Mystic River	6.56E+02				6.56E+02
Boston Edison (Everett) 007A	Mystic River					
Boston Edison (Everett) 008A	Mystic River					
Boston Edison (Boston) 011A	Boston Harbor		1.67E+01	4.03E+01	1.66E+00	4.03E+01
Boston Edison (Boston) 012A	Boston Harbor					
Boston Edison (Boston) 013A	Boston Harbor					
Boston Edison (Boston) 014A	Boston Harbor					
						7.40E+02

Table A14. Nickel From NPDES Discharges to North Harbor Tributaries.

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Cambridge Electric	Charles River					
Norfolk-Walpole 001A	Charles River					
Norfolk-Walpole 001B	Charles River					
Charles River PCD 011	Charles River					
Charles River PCD 012	Charles River					
Charles River PCD 013	Charles River					
Charles River PCD 014	Charles River					
Medfield WWTP FACA	Charles River					
Medfield WWTP FACC	Charles River					
Medfield WWTP FACB	Charles River					
Medfield WWTP 001A	Charles River					
Plymouth Rubber Co.	Neponset River					
Foxboro Co. Neponset 001A	Neponset River			1.63E+01		1.63E+01
Foxboro Co. Neponset 001B	Neponset River	1.43E+01				1.43E+01
						3.07E+01

Table A15. Oil & Grease From NPDES Discharges Directly to North Harbor.

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Monsanto 001A	Mystic River		1.92E+02	5.81E+02	1.23E+02	5.81E+02
Monsanto 002A	Mystic River					
Exxon Oil	Mystic River	3.81E+01	2.83E+01	1.07E+03	5.66E+03	5.66E+03
Boston Edison (Everett) 002A	Mystic River	9.52E+01	7.35E+02			9.52E+01
Boston Edison (Everett) 003A	Mystic River					
Boston Edison (Everett) 007A	Mystic River					
Boston Edison (Everett) 008A	Mystic River					
Boston Edison (Boston) 011A	Boston Harbor					
Boston Edison (Boston) 012A	Boston Harbor					
Boston Edison (Boston) 013A	Boston Harbor					
Boston Edison (Boston) 014A	Boston Harbor					
						6.33E+03

Table A16. Oil & Grease From NPDES Discharges to North Harbor Tributaries.

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Cambridge Electric	Charles River					
Norfolk-Walpole 001A	Charles River					
Norfolk-Walpole 001B	Charles River					
Charles River PCD 011	Charles River					
Charles River PCD 012	Charles River					
Charles River PCD 013	Charles River					
Charles River PCD 014	Charles River					
Medfield WWTP FACA	Charles River					
Medfield WWTP FACC	Charles River					
Medfield WWTP FACB	Charles River					
Medfield WWTP 001A	Charles River					
Plymouth Rubber Co.	Neponset River		3.36E+04	1.13E+04	9.67E+03	3.36E+04
Foxboro Co. Neponset 001A	Neponset River	1.58E+02	1.23E+02			1.58E+02
Foxboro Co. Neponset 001B	Neponset River		1.69E+02	5.10E+02	6.38E+01	5.10E+02
						3.42E+04

Table A17. Phosphorus From NPDES Discharges Directly to North Harbor.

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Monsanto 001A	Mystic River					
Monsanto 002A	Mystic River					
Exxon Oil	Mystic River					
Boston Edison (Everett) 002A	Mystic River					
Boston Edison (Everett) 003A	Mystic River					
Boston Edison (Everett) 007A	Mystic River					
Boston Edison (Everett) 008A	Mystic River					
Boston Edison (Boston) 011A	Boston Harbor					
Boston Edison (Boston) 012A	Boston Harbor					
Boston Edison (Boston) 013A	Boston Harbor					
Boston Edison (Boston) 014A	Boston Harbor					
						0.00E+00

Table A18. Phosphorus From NPDES Discharges to North Harbor Tributaries.

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Cambridge Electric	Charles River					
Norfolk-Walpole 001A	Charles River			3.76E+02	1.18E+03	1.18E+03
Norfolk-Walpole 001B	Charles River					
Charles River PCD 011	Charles River		6.10E+02	4.58E+03	9.76E+03	9.76E+03
Charles River PCD 012	Charles River		1.46E+03			1.46E+03
Charles River PCD 013	Charles River		1.64E+03			1.64E+03
Charles River PCD 014	Charles River					
Charles River PCD 015	Charles River		5.75E+02			5.75E+02
Medfield WWTP FACA	Charles River					
Medfield WWTP FACC	Charles River					
Medfield WWTP FACB	Charles River					
Medfield WWTP 001A	Charles River		5.81E+02	8.65E+02		8.65E+02
Plymouth Rubber Co.	Neponset River					
Foxboro Co. Neponset 001A	Neponset River		9.08E+01			9.08E+01
Foxboro Co. Neponset 001B	Neponset River	1.43E+03				1.43E+03
						1.70E+04

Table A19. Total Suspended Solids From NPDES Discharges Directly to North Harbor.

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Monsanto 001A	Mystic River					
Monsanto 002A	Mystic River					
Exxon Oil	Mystic River	1.72E+03	3.51E+02	4.37E+03	1.90E+04	1.72E+03
Boston Edison (Everett) 002A	Mystic River		6.35E+03	5.33E+03	9.24E+02	3.66E+05
Boston Edison (Everett) 003A	Mystic River	8.09E+03				8.09E+03
Boston Edison (Everett) 007A	Mystic River					
Boston Edison (Everett) 008A	Mystic River					
Boston Edison (Boston) 011A	Boston Harbor		4.00E+03	4.91E+03	1.15E+03	4.91E+03
Boston Edison (Boston) 012A	Boston Harbor					
Boston Edison (Boston) 013A	Boston Harbor					
Boston Edison (Boston) 014A	Boston Harbor					
						3.81E+05

Table A20. Total Suspended Solids From NPDES Discharges to North Harbor Tributaries.

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Cambridge Electric	Charles River					
Norfolk-Walpole 001A	Charles River			1.69E+03	2.81E+03	2.81E+03
Norfolk-Walpole 001B	Charles River			3.08E+03		3.08E+03
Charles River PCD 011	Charles River		2.67E+05	4.34E+05	1.36E+06	1.36E+06
Charles River PCD 012	Charles River		7.36E+05			7.36E+05
Charles River PCD 013	Charles River		8.03E+05			8.03E+05
Charles River PCD 014	Charles River		1.80E+05			1.80E+05
Medfield WWTP FACA	Charles River		3.77E+03			3.77E+03
Medfield WWTP FACC	Charles River					
Medfield WWTP FACB	Charles River					
Medfield WWTP 001A	Charles River		4.38E+03	5.63E+03	4.28E+03	5.63E+03
Plymouth Rubber Co.	Neponset River					
Foxboro Co. Neponset 001A	Neponset River		1.13E+03			1.13E+03
Foxboro Co. Neponset 001B	Neponset River	1.94E+03				1.94E+03
						3.10E+06

Table A21. Toxic Organics From NPDES Discharges Directly to North Harbor.

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Monsanto 001A	Mystic River					
Monsanto 002A	Mystic River					
Exxon Oil	Mystic River	2.51E+01				2.51E+01
Boston Edison (Everett) 002A	Mystic River					
Boston Edison (Everett) 003A	Mystic River					
Boston Edison (Everett) 007A	Mystic River					
Boston Edison (Everett) 008A	Mystic River					
Boston Edison (Boston) 011A	Boston Harbor					
Boston Edison (Boston) 012A	Boston Harbor					
Boston Edison (Boston) 013A	Boston Harbor					
Boston Edison (Boston) 014A	Boston Harbor					
						2.51E+01

Table A22. Toxic Organics From NPDES Discharges to North Harbor Tributaries.

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Cambridge Electric	Charles River					
Norfolk-Walpole 001A	Charles River					
Norfolk-Walpole 001B	Charles River					
Charles River PCD 011	Charles River					
Charles River PCD 012	Charles River					
Charles River PCD 013	Charles River					
Charles River PCD 014	Charles River					
Medfield WWTP FACA	Charles River					
Medfield WWTP FACC	Charles River					
Medfield WWTP FACB	Charles River					
Medfield WWTP 001A	Charles River					
Plymouth Rubber Co.	Neponset River					
Foxboro Co. Neponset 001A	Neponset River	2.91E+02	3.45E+00			2.91E+02
Foxboro Co. Neponset 001B	Neponset River		3.35E+01	5.81E+00	2.42E-01	3.35E+01
						3.25E+02

Table A23. Zinc From NPDES Discharges Directly to North Harbor.

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Monsanto 001A	Mystic River					
Monsanto 002A	Mystic River					
Exxon Oil	Mystic River					
Boston Edison (Everett) 002A	Mystic River	1.90E+01		7.95E+01	4.75E+01	7.95E+01
Boston Edison (Everett) 003A	Mystic River					
Boston Edison (Everett) 007A	Mystic River					
Boston Edison (Everett) 008A	Mystic River					
Boston Edison (Boston) 011A	Boston Harbor			9.40E+01	7.67E+01	9.40E+01
Boston Edison (Boston) 012A	Boston Harbor					
Boston Edison (Boston) 013A	Boston Harbor					
Boston Edison (Boston) 014A	Boston Harbor					
						1.73E+02

Table A24. Zinc From NPDES Discharges to North Harbor Tributaries.

Facility	Receiving Water	1986 Annual Load (KG/YR)	1988 Annual Load (KG/YR)	1989 Annual Load (KG/YR)	1990 Annual Load (KG/YR)	Representive Load (KG/YR)
Cambridge Electric	Charles River					
Norfolk-Walpole 001A	Charles River					
Norfolk-Walpole 001B	Charles River					
Charles River PCD 011	Charles River					
Charles River PCD 012	Charles River					
Charles River PCD 013	Charles River					
Charles River PCD 014	Charles River					
Medfield WWTP FACA	Charles River					
Medfield WWTP FACC	Charles River					
Medfield WWTP FACB	Charles River					
Medfield WWTP 001A	Charles River					
Plymouth Rubber Co.	Neponset River					
Foxboro Co. Neponset 001A	Neponset River	21.5				21.5
Foxboro Co. Neponset 001B	Neponset River					
						2.15E+01

APPENDIX B. LOADINGS FROM CONFIRMED COASTAL DIPOSAL SITES.

Table B-1. Coastal 21E Confirmed Sites surrounding Boston Harbor

Name of Site	Location	Coastal Area	Type of Contamination
Exxon Service Station	30 Beacham St. Everett	Mystic River	Petroleum & Hazard.
Federal Metal Finishing	46 Cross St. Somerville	Mystic River	Hazardous Material
Former Coal Gas Facility	Market/Beacham St. Everett	Mystic River	Petroleum & Hazard.
Gulf Station	931 Bennington St. East Boston	Chelsea River	Petroleum
Koppers Co	Foot of Beacham St. Everett	Mystic River	Petroleum & Hazard.
Monsanto	Mystic River Everett	Mystic River	Hazardous Material
Penn Transport	212 Beacham St. Everett	Mystic River	Petroleum
Belcher Tank Farm	99 Marginal St. Chelsea	Chelsea River	Petroleum
Cumberland Farms Oil Term.	123 Eastern Ave. Chelsea	Chelsea River	Petroleum & Hazard.
Northeast Petroleum	Marginal St. Chelsea	Chelsea River	Petroleum & Hazard.
Samuel Cabot Inc.	Marginal St. Chelsea	Chelsea River	Petroleum & Hazard.
Boston Edison Station	385 K St. South Boston	Boston Inner Harbor	Petroleum
Boston Junk	14 Louis St. South Boston	Boston Inner Harbor	Hazardous Material
Charlestown Condo.	Harvard St.	Boston Inner Harbor	Hazardous Material
Former Mobil Station	425 Summer St. South Boston	Boston Inner Harbor	Petroleum
King Terminal	Summer, East First & K Sts	Boston Inner Harbor	Hazardous Material
Loop Viaduct/Canal	169 Portland St. Boston	Boston Inner Harbor	Petroleum & Hazard.
Mobil Station	588 Commercial St. Boston	Boston Inner Harbor	Petroleum
Mobil Station	Maverick Square East Boston	Boston Inner Harbor	Petroleum
Property	123 Oliver St. Boston	Boston Inner Harbor	Petroleum & Hazard.
South Station Foundation	Summer St.	Boston Inner Harbor	Petroleum
Adams & Swett	376-384 Dorchester Ave.	Dorchester Bay	Petroleum
Electric Workers Local#103	194 Freeport St. South Boston	Dorchester Bay	Hazardous Material
Gas Station	815 Gallivan Blvd Dorchester	Dorchester Bay	Petroleum
Industrial Complex	296-300 Freeport St. South Boston	Dorchester Bay	Petroleum & Hazard.
Liquidator/Penn Central	140 Freeport South Boston	Dorchester Bay	Petroleum & Hazard.
Logan Airport	Hertz Corp.	Boston Harbor	Hazardous Material
Massport	Logan Airport	Boston Harbor	Petroleum
Deer Island Treatment Plant	Winthrop	Boston Harbor	Petroleum
Citgo Braintree Terminal	Quincy Ave. Braintree	Weymouth Fore River	Petroleum & Hazard.
Clean Harbors Inc.	Quincy Ave. Braintree	Weymouth Fore River	Petroleum & Hazard.
Flibotte's Auto Salvage	Columbia Ter./Cliff St.	Weymouth Fore River	Petroleum
Old Colony Property	589 Washington St. Braintree	Weymouth Fore River	Petroleum
Petar's Automotive	Independence Ave. Braintree	Weymouth Fore River	Petroleum
Beal's Cove Village	Beal's Cove Rd. Hingham	Hingham Harbor	Petroleum
Mobil Station	24 Summer St. Hingham	Hingham Harbor	Petroleum

Property	119 Beal St. Hingham	Hingham Harbor	Hazardous Material
Captain's Cove	Cove Rd. Quincy	Quincy Harbor	Petroleum & Hazard.
Former General Dynamics	97E Howard St. Quincy	Quincy Harbor	Petroleum & Hazard.
Gasoline Spill	Commander Shea Blvd	Quincy Harbor	Petroleum
Jordan Marsh	Commander Shea Blvd	Quincy Harbor	Petroleum
Quinoil Industries	Southern Artery Quincy	Quincy Harbor	Petroleum
Sunco Station	Southern Artery-Rte 3A	Quincy Harbor	Petroleum

APPENDIX C: LOADINGS FROM NON-POINT SOURCES.

Table C-1. Stormwater and CSO Annual Load Summary for North Harbor Drainage.

North Harbor Drainage Basin	BOD (mton)	TSS (mton)	TKN (mton)	TP (mton)	Cu (kg)	Pb (kg)	Zn (kg)	FCB (count)
Dorchester Bay Basin								
CSO	226	432	16	5	242	302	660	2.36E+15
Stormwater in Storm Sewers	30	72	3	1	63	51	193	2.82E+14
Total stormwater in sewers	255	504	20	5	305	354	854	2.65E+15
Neponset Estuary Basin								
CSO	9	15	1	0	10	12	29	1.86E+14
Stormwater in Storm Sewers	195	474	22	5	415	339	1,277	1.86E+14
Total stormwater in sewers	205	489	23	5	425	351	1,305	3.73E+14
Inner Harbor Basin								
CSO	2,656	5,983	136	67	2,251	3,235	6,634	4.14E+16
Stormwater in Storm Sewers	399	966	45	10	848	691	2,605	3.82E+15
Total stormwater in sewers	3,055	6,950	181	76	3,099	3,926	9,239	4.52E+16
Quincy Bay/Outer Harbor								
CSO	290	669	15	7	235	344	700	0.00E+00
Stormwater in Storm Sewers	100	244	11	2	214	175	658	9.55E+14
Total stormwater in sewers	390	913	26	10	449	518	1,358	9.55E+14
Boston Harbor stormwater in sewers	3,905	8,855	249	96	4,278	5,149	12,756	4.92E+16

Source: Combined Sewer Overflow Facilities Plan Executive Summary, MWRA 1989.

Table C-2. Event Statistics for Rainfall in Eastern Massachusetts.

Gage	No.	Rain fall (in)	Dura-tion (hr)	COV	Inten-sity (in/hr)	COV	Vol (in)	COV	Delta (hr)	COV
Blue Hill	65	46.98	12.60	0.83	0.0688	1.03	0.72	1.13	136	0.85
Rock-port	56	36.36	10.21	0.79	0.0785	0.91	0.65	1.00	150	0.98
Ster-ling	61	41.12	12.21	0.78	0.0659	1.01	0.67	1.01	136	0.82
Worces-ter	66	46.28	12.69	0.80	0.0704	1.06	0.70	1.00	134	0.80
Total	62	42.69	11.93	0.80	0.0709	1.00	0.69	1.04	139	0.86

Table C-3. Summary of NURP Land Use Data.

Mean EMCs	Units	Land Use Category					
		Residential	Commercial	Industrial	Transportation	Open	Runway
TSS	mg/l	180	126	541	256	126	256
BOD+COD	mg/l	93	85	194	175	50	175
t-P	ug/l	410	250	880	500	150	500
t-N (NO2+3)	ug/l	850	710	2,190	950	680	950
TKN	ug/l	1,880	1,480	4,130	2,290	1,210	2,290
Copper	ug/l	43	36	116	68	13	68
Lead	ug/l	180	130	438	500	38	500
Zinc	ug/l	200	283	625	411	244	411
Runoff Coefficient	---	0.3	0.8	0.8	0.5	0.1	0.8

Table C-4. Summary of Coastal Drainage Basin Land Use Areas.

North Harbor Drainage (acres)	Residential	Commercial	Industrial	Transportation	Open	Runway	Total
Boston	2,670	1,371	413	1,854	1,643	0	7,951
Logan Airport	0	0	0	0	837	806	1,643
Chelsea	349	97	231	56	86	0	819
Everett	150	0	0	0	16	0	166
Winthrop	762	18	8	199	340	0	1,327

South Harbor Drainage (acres)	Residential	Commercial	Industrial	Transportation	Open	Runway	Total
Hingham	1,355	90	134	36	1,781	0	3,396
Hull	1,049	58	14	16	645	0	1,782
Quincy	1,712	106	140	56	1,153	0	3,167
Weymouth	313	60	34	0	230	0	637

Source: Land Use in the Coastal Drainage Area in and around Boston Harbor
Hruby, T., S. Cotter, K. Barnes, Mass. Audubon Society, 1988.
(Based on land use maps prepared by W.P. MacConnell, University of Massachusetts Amherst)

Table C-5. Summary of Annual Pollutant Loads Using NURP data.

North Harbor Drainage Basin	TSS (mton)	BOD+COD (mton)	t-P (kg)	t-N (kg)	TKN (kg)	Copper (kg)	Lead (kg)	Zinc (kg)
Boston	3,252	1,819	6,248	14,362	30,824	802	4,076	4,967
Chelsea	619	260	1,087	2,629	5,199	139	562	778
Everett	38	19	85	178	391	9	37	42
Winthrop	345	194	714	1,521	3,376	83	438	466
Total	4,254	2,292	8,134	18,690	39,790	1,033	5,113	6,253
Logan Airport	794	529	1,514	3,027	7,134	203	1,472	1,291
South Harbor Drainage Basin								
Hingham	757	347	1,423	3,481	7,102	163	657	993
Hull	356	181	742	1,702	3,631	81	335	462
Quincy	839	395	1,636	3,831	7,948	188	773	1,069
Weymouth	183	87	352	855	1,754	42	162	249
Total	2,135	1,010	4,153	9,869	20,435	474	1,927	2,773

Table C-6. Estimates of Annual Pollutant Loads by Land Use Area Using NURP data.

TSS Annual Loads (mton)

North Harbor Drainage	Residential	Commercial	Industrial	Transportation	Open	Runway	Total
Boston	652	625	808	1,073	94	0	3,252
Chelsea	85	44	452	32	5	0	619
Everett	37	0	0	0	1	0	38
Winthrop	186	8	16	115	19	0	345
Total	960	677	1,276	1,221	119	0	4,253
Logan Airport	0	0	0	0	48	746	794

South Harbor Drainage	Residential	Commercial	Industrial	Transportation	Open	Runway	Total
Hingham	331	41	262	21	101	0	757
Hull	256	26	27	9	37	0	356
Quincy	418	48	274	32	66	0	839
Weymouth	76	27	67	0	13	0	183
Total	1,082	143	630	63	217	0	2,135

BOD+COD Annual Loads (mton)

North Harbor Drainage	Residential	Commercial	Industrial	Transportation	Open	Runway	Total
Boston	337	422	290	734	37	0	1,819
Chelsea	44	30	162	22	2	0	260
Everett	19	0	0	0	0	0	19
Winthrop	96	6	6	79	8	0	194
Total	496	457	458	885	47	0	2,292
Logan Airport	0	0	0	0	19	510	529

South Harbor Drainage	Residential	Commercial	Industrial	Transportation	Open	Runway	Total
Hingham	171	28	94	14	40	0	347
Hull	132	18	10	6	15	0	181
Quincy	216	33	98	22	26	0	395
Weymouth	39	18	24	0	5	0	87
Total	559	97	226	43	86	0	1,010

t-P Annual Loads (kg)

North Harbor Drainage	Residential	Commercial	Industrial	Transportation	Open	Runway	Total
Boston	1,485	1,240	1,315	2,096	111	0	6,248
Chelsea	194	88	735	63	6	0	1,087
Everett	83	0	0	0	1	0	85
Winthrop	424	16	25	225	23	0	714
Total	2,187	1,344	2,076	2,385	141	0	8,133
Logan Airport	0	0	0	0	57	1,458	1,514

South Harbor Drainage	Residential	Commercial	Industrial	Transportation	Open	Runway	Total
Hingham	754	81	427	41	121	0	1,423
Hull	584	52	45	18	44	0	742
Quincy	952	96	446	63	78	0	1,636
Weymouth	174	54	108	0	16	0	352
Total	2,464	284	1,025	122	258	0	4,154

t-N (NO2+3) Annual Loads (kg)

North Harbor Drainage	Residential	Commercial	Industrial	Transportation	Open	Runway	Total
Boston	3,079	3,522	3,272	3,983	505	0	14,362
Chelsea	402	249	1,830	120	26	0	2,629
Everett	173	0	0	0	5	0	178
Winthrop	879	46	63	428	105	0	1,521
Total	4,534	3,817	5,166	4,531	641	0	18,689
Logan Airport	0	0	0	0	257	2,770	3,027

South Harbor Drainage	Residential	Commercial	Industrial	Transportation	Open	Runway	Total
Hingham	1,563	231	1,062	77	548	0	3,481
Hull	1,210	149	111	34	198	0	1,702
Quincy	1,974	272	1,109	120	355	0	3,831
Weymouth	361	154	269	0	71	0	855
Total	5,108	807	2,551	232	1,171	0	9,869

TKN Annual Loads (kg)

North Harbor Drainage	Residential	Commercial	Industrial	Transportation	Open	Runway	Total
Boston	6,811	7,341	6,171	9,601	899	0	30,824
Chelsea	890	519	3,452	290	47	0	5,199
Everett	383	0	0	0	9	0	391
Winthrop	1,944	96	120	1,031	186	0	3,376
Total	10,027	7,957	9,743	10,921	1,141	0	39,790
Logan Airport	0	0	0	0	458	6,676	7,134

South Harbor Drainage	Residential	Commercial	Industrial	Transportation	Open	Runway	Total
Hingham	3,456	482	2,002	186	975	0	7,102
Hull	2,676	311	209	83	353	0	3,631
Quincy	4,367	568	2,092	290	631	0	7,948
Weymouth	798	321	508	0	126	0	1,754
Total	11,297	1,681	4,812	559	2,084	0	20,434

Copper Annual Loads (kg)

North Harbor Drainage	Residential	Commercial	Industrial	Transportation	Open	Runway	Total
Boston	156	179	173	285	10	0	802
Chelsea	20	13	97	9	1	0	139
Everett	9	0	0	0	0	0	9
Winthrop	44	2	3	31	2	0	83
Total	229	194	274	324	12	0	1,033
Logan Airport	0	0	0	0	5	198	203

South Harbor Drainage	Residential	Commercial	Industrial	Transportation	Open	Runway	Total
Hingham	79	12	56	6	10	0	163
Hull	61	8	6	2	4	0	81
Quincy	100	14	59	9	7	0	188
Weymouth	18	8	14	0	1	0	42
Total	258	41	135	17	22	0	473

Lead Annual Loads (kg)

North Harbor Drainage	Residential	Commercial	Industrial	Transportation	Open	Runway	Total
Boston	652	645	654	2,096	28	0	4,076
Chelsea	85	46	366	63	1	0	562
Everett	37	0	0	0	0	0	37
Winthrop	186	8	13	225	6	0	438
Total	960	699	1,033	2,385	36	0	5,113
Logan Airport	0	0	0	0	14	1,458	1,472

South Harbor Drainage	Residential	Commercial	Industrial	Transportation	Open	Runway	Total
Hingham	331	42	212	41	31	0	657
Hull	256	27	22	18	11	0	335
Quincy	418	50	222	63	20	0	773
Weymouth	76	28	54	0	4	0	162
Total	1,082	148	510	122	65	0	1,927

Zinc Annual Loads (kg)

North Harbor Drainage	Residential	Commercial	Industrial	Transportation	Open	Runway	Total
Boston	725	1,404	934	1,723	181	0	4,967
Chelsea	95	99	522	52	9	0	778
Everett	41	0	0	0	2	0	42
Winthrop	207	18	18	185	38	0	466
Total	1,067	1,522	1,474	1,960	230	0	6,253
Logan Airport	0	0	0	0	92	1,198	1,291

South Harbor Drainage	Residential	Commercial	Industrial	Transportation	Open	Runway	Total
Hingham	368	92	303	33	197	0	993
Hull	285	59	32	15	71	0	462
Quincy	465	109	317	52	127	0	1,069
Weymouth	85	61	77	0	25	0	249
Total	1,202	322	728	100	420	0	2,772

APPENDIX D: LOADINGS FROM ATMOSPHERIC DEPOSITION

TABLE D-1. Deposition Velocity and Washout Ratio for Atmospheric Pollutants.

Pollutant	Deposition Velocity (cm/s)	Washout Ratio	Reference
t-N	0.4	--	1
t-P	--	--	
TSS	--	--	
Oil & Grease	--	--	
Cadmium	0.45	--	2
Chromium	0.5	150	2
Copper	0.5	140	2
Lead	0.3	140	2
Mercury	--	--	
Nickel	0.45	125	2
Silver	0.24	--	3
Zinc	0.62	179	2
PCB	0.16	86	3,4
PAH	0.99	variable	3,5

References:

1. Galloway et al. (1987). WATOX study.
2. McMahon (1979). Survey report.
3. McVeety & Hites (1988).
4. Mackay et al. (1986).
5. Ligocki et al. (1985a&b). Measured scavenging ratios.

Table D-2. Area of Boston Harbor Embayments.

Bay	Area (km2)
Inner Harbor	1.0E+07
North Harbor	4.1E+07
Quincy Bay	3.8E+07
Hingham Bay	1.9E+07

Table D-3. Annual Loading to North Harbor from Atmospheric Sources.

Pollutant	Dry Deposition (kg)	Wet Deposition (kg)	Total (kg)	Ref.
t-N	10,937	14,586	25,523	1,2
t-P	--	623-3,590	623-3,590	3
TSS	--	--	--	--
Oil & Grease	--	--	--	--
Cadmium	0-26	17	17-43	4,5
Chromium	27	22	50	6
Copper	129	106	235	7
Lead	3,331	2,420	5,751	7
Mercury	0	1-2	1-2	8
Nickel	96	105	201	4,5
Silver	0-4	180	180-183	4,5
Zinc	386-1,895	325-1,599	711-3,493	6,7
PCB	4-10	7-19	10-29	9
PAH	24-32	0	24-32	10

References:

1. Galloway, et al. (1987): WATOX study 50 km east of Boston.
2. NADP (1989): Nutrient wet deposition, Cape Cod.
3. Connecticut DEP (1987): Estimated loadings for L.I. Sound.
4. Olmez (1990): Aerosol concentrations, Cambridge.
5. Galloway et al. (1982): Survey of wet deposition flux.
6. Hopke, et al. (1976): Aerosol concentrations, Boston Harbor.
7. Thurston & Spengler (1985): Aerosol conc's, Watertown.
8. Fogg & Fitzgerald (1979): Wet deposition, Cape Cod.
9. Harvey & Steinhauer (1974): Marthas Vineyard, Georges Bank.
10. EPA (1990): P[a]B concentration in Boston, Chelsea.

Table D-4. Annual Loading to South Harbor from Atmospheric Sources.

Pollutant	Dry Deposition (kg)	Wet Deposition (kg)	Total (kg)	Ref.
t-N	12,223	16,302	28,525	1,2
t-P	--	696-4,013	696-4,013	3
TSS	--	--	--	--
Oil & Grease	--	--	--	--
Cadmium	0-29	19	19-49	4,5
Chromium	31	25	56	6
Copper	145	118	263	7
Lead	1,758	1,278	3,036	7
Mercury	0	0-1	0-1	8
Nickel	108	117	225	4,5
Silver	0-4	201	201-204	4,5
Zinc	431-2,118	364-1,787	795-3,904	6,7
PCB	4-11	8-21	12-33	9
PAH	27-36	1	27-36	10

References:

1. Galloway, et al. (1987): WATOX study 50 km east of Boston.
2. NADP (1989): Nutrient wet deposition, Cape Cod.
3. Connecticut DEP (1987): Estimated loadings for L.I. Sound.
4. Olmez (1990): Aerosol concentrations, Cambridge.
5. Galloway et al. (1982): Survey of wet deposition flux.
6. Hopke, et al. (1976): Aerosol concentrations, Boston Harbor.
7. Thurston & Spengler (1985): Aerosol conc's, Watertown.
8. Fogg & Fitzgerald (1979): Wet deposition, Cape Cod.
9. Harvey & Steinhauer (1974): Marthas Vineyard, Georges Bank.
10. EPA (1990): P[a]B concentration in Boston, Chelsea.

APPENDIX E: LOADINGS FROM TRIBUTARY FLOW.

Table E-1. Loadings to Boston Harbor Associated with Tributary Flow to the South and North Harbors (1).

Constituent	North Harbor	South Harbor (3)
Total Flow (m3/sec)	11.02	1.33
Charles	7.50	
Mystic	0.82	
Neponset	2.70	
Weymouth Fore		0.84
Back		0.33
Weir		0.16
Conventionals (mtons/yr)		
Total BOD	1,620	196
Total Nitrogen	518	63
Total Phosphorous	54	7
Total Solids	3,456	417
Total Coliforms	8.532E+15	1.0E+15
Metals (kg/yr)		
Cadmium	1,040	126
Chromium	3,132	378
Copper	3,132	378
Lead	<2700	<325.9
Mercury	162	20
Nickel	4,212	508
Silver		
Zinc	18,360	2,216
Organics (kg/yr)		
PCBs	<1620	<195.5
PAHs (2)	3.5 to 35	0.4 to 4
Phthalates	<3240	<391
Benzene		

1. Source: Mike Conner of MWRA based on CH2M HILL data.

2. Estimated by multiplying the flows by a range in PAH concentrations of 10 to 100 ng/l from Menzie et al (1990).

3. Estimated based on flow proportional to North Harbor.

APPENDIX F: LOADINGS FROM GROUNDWATER FLOW.

Table F-1. Loadings to Boston Harbor Associated with Groundwater Flow to Either the Northern or Southern Harbors (1).

Constituent	Low Estimate		High Estimate
Total Flow (m3/sec)	---------->	0.5	
Conventionals (mtons/yr)			
Total BOD		not determined	
Total Nitrogen	1.6		15.7
Total Phosphorous	1.60E-04		9.50E-04
Total Solids		not determined	
Total Coliforms		not determined	
Metals (kg/yr)			
Cadmium	32		320
Chromium	160		1600
Copper	160		1600
Lead	16		1600
Mercury		not determined	
Nickel	160		1600
Silver		not determined	
Zinc	160		1600
Organics (kg/yr)			
PCBs		not determined	
PAHs (2)	0.02		0.2
Phthalates		not determined	
Volatile Organics	16		160

1. Estimated as the product of an estimated groundwater flow and estimated ranges in concentrations.

APPENDIX G: SUMMARY OF LOADINGS

Table G-1
Flows of Discharges (cubic meters/sec)

Northern Harbor

	Measured	CH2M Hill	NURP	Estimated
Effluent	14			
Runoff		1.92	0.7	
Rivers	11.02			
Ground-water				0.5
NPDES	0.05			
Airport			0.1	

Southern Harbor

	Measured	CH2M Hill	NURP	Estimated
Effluent	6			
Runoff			0.3	
Rivers	1.3			
Ground-water				0.48

Table G-2
Loadings of BOD (metric tons/year)

Northern Harbor

	MWRA	CH2M Hill	NURP	Estimated
Effluent	53900			
Sludge	15000			
Runoff		3905	2292	
Rivers	1620			
Airport			176	

Southern Harbor

	MWRA	CH2M Hill	NURP	Estimated
Effluent	22000			
Runoff			1010	
Rivers	100			

Table G-3
Loadings - Solids (metric tons/year)

Northern Harbor

	Measured	CH2M Hill	NURP	Estimated
Effluent	43400			
Sludge	23000			
Runoff		8855	4254	
Rivers	3456			
NPDES	0.38			
Airport			794	

Southern Harbor

	Measured	CH2M Hill	NURP	Estimated
Effluent	18600			
Runoff			2135	
Rivers	417			

Table G-4
Loadings - Nitrogen (metric tons/year)

Northern Harbor

	Measured	NURP	Low Estimate	High Estimate
Effluent	7700			
Sludge	1100			
Runoff	250	58.4		
Rivers	518			
Air			25	
Ground-water			1.6	15.7
Airport		10		

Southern Harbor

	Measured	NURP	Low Estimate	High Estimate
Effluent	3300			
Runoff		30		
Rivers	62			
Air			29	
Ground-water			1.6	5.7

Table G-5
Loadings - Phosphorus (metric tons/year)

Northern Harbor

	Measured	NURP	Low Estimate	High Estimate
Effluent	1750			
Sludge	70			
Runoff	96	8.1		
Rivers	54			
Air			0.6	3.6
Airport		1.5		

Southern Harbor

	Measured	NURP	Low Estimate	High Estimate
Effluent	750			
Runoff		4.1		
Rivers	6.5			
Air			0.69	4.01

Table G-6
Loadings -Copper (kg/year)

Northern Harbor

	Measured	NURP	Low Estimate	High Estimate
Effluent	30800			
Sludge	22000			
Runoff	4278	1000		
Rivers	3100			
Air			235	
Ground-water			160	1600
NPDES	63			
Airport		203		

Southern Harbor

	Measured	NURP	Low Estimate	High Estimate
Effluent	13200			
Runoff		470		
Rivers	378			
Air			263	
Ground-water			160	1600

Table G-7
Loadings - Lead (kg/year)

Northern Harbor

	Measured	NURP	Low Estimate	High Estimate
Effluent	7700			
Sludge	7000			
Runoff	5150	5113		
Rivers	2700			
Air			2716	
Ground-water			16	1600
NPDES	47.6			
Airport		1472		

Southern Harbor

	Measured	NURP	Low Estimate	High Estimate
Effluent	3300			
Runoff		1927		
Rivers	325			
Air			3036	
Ground-water			16	1600

Table G-8
Loadings - Zinc (kg/year)

Northern Harbor

	Measured	NURP	Low Estimate	High Estimate
Effluent	51100			
Sludge	47000			
Runoff	12757	6253		
Rivers	18360			
Air			711	3493
Ground-water			160	1600
NPDES	173			
Airport		1291		

Southern Harbor

	Measured	NURP	Low Estimate	High Estimate
Effluent	21900			
Runoff		2773		
Rivers	2215			
Air			795	3904
Ground-water			160	1600

Table G-9
Loadings - PAHs (kg/year)

Northern Harbor

	Measured	NURP	Low Estimate	High Estimate
Effluent	12775			
Sludge			46	2162
Runoff			47	467
Rivers			3.5	35
Air			24	32
Ground-water				0.2
Airport		6	2	25

Southern Harbor

	Measured	NURP	Low Estimate	High Estimate
Effluent	5475			
Runoff			21	213
Rivers			0.4	4
Air			27	36
Ground-water				0.2

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Charlestown Navy Yard
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Boston, Massachusetts 02129

Telephone: (617) 242-6000
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July 12, 1993

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You may be interested to know that we are currently in the process of updating the loading estimates to the Harbor, based on new information that was not available at the time the above report was written. The new estimates will be issued this fall as an MWRA technical report. If you would like a copy of the new report, please contact Ms. Bernadette McCarthy at 242-6000.

Sincerely,

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Harbor Studies

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p.14 In the 2nd para. under CSO Loadings, beginning "Total loading to North Harbor,"

change TKN from	20 kg to	249 mtons
phosphorus	96 kg	96 mtons
lead	354 kg	5,149 kg
zinc	854 kg	12,756 kg
fecal coliform	4.92E+16	1.08E+17 counts

Table A19 Change representative load for Boston Edison (Everett) 002A from 3.66E+05 to 4.20E+03.
Change total load 3.81E+05 1.89E+04.

Table C-1 FCB (count) column was erroneously divided by 2.2. Actual column should read as follows:

change	2.36E+15	to 5.19E+15
	2.82E+14	6.20E+14
	2.65E+15	5.83E+15
	1.86E+14	4.09E+14
	1.86E+14	4.09E+14
	3.73E+14	8.21E+14
	4.14E+16	9.11E+16
	3.82E+15	8.40E+15
	4.52E+16	9.94E+16
	0.00E+00	0.00E+00
	9.55E+14	2.10E+15
	9.55E+14	2.10E+15
	4.92E+16	1.08E+17

Table D-1 Change washout ratio for lead from 140 to 76.

Table D-2 Change units from km^2 to m^2.

Table D-3 Loadings to N. Harbor should be modified as follows:

change	dry deposition	from 3,331	to 1,573
	wet deposition	2,420	1,390
	total	5,751	2,963

Table D-4 Loadings to S. Harbor should be modified as follows:

change	wet deposition	from 1,278	to 1,553
	total	3,036	3,311

Table E-1 River flows were not adjusted to account for the difference between the drainage area at the gauge and the total drainage area. In Menzie-Cura and Associates (1991, Table 3), flows were adjusted by calculating total flow as the product of the gauged flow and the total area divided by gauged area. Adjusted flows and loads are as follows:

Constituent	North Harbor	South Harbor
Total Flow (m3/sec)	17.94	5.91
Charles	12.09	
Mystic	0.82	
Neponset	5.03	
Weymouth Fore		0.28
Back		5.58
Weir		0.05
Conventionals (mtons/yr)		
Total BOD	2,637	871
Total Nitrogen	843	280
Total Phosphorus	88	31
Total Solids	5,626	1,852
Total Coliforms	1.4E+16	4.4E+15
Metals (kg/yr)		
Cadmium	1,693	560
Chromium	5,099	1,680
Copper	5,099	1,680
Lead	<4,395	<1,448
Mercury	264	89
Nickel	6,857	2,257
Silver		
Zinc	29,889	9,847
Organics (kg/yr)		
PCBs	<2,637	<869
PAHs	5.7 - 57	1.8 - 18
Phthalates	<5,275	<1,737

Errata, p.3

Table G-1	North Harbor:	Change River load from	11.02	to	17.94
	South Harbor:	Change River	1.3		5.91
Table G-2	North Harbor:	Change River load from	1,620	to	2,637
		Airport	176		529
	South Harbor:	Change River	100		871
Table G-3	North Harbor:	Change River load from	3,456	to	5,626
		NPDES	0.38		18.9
	South Harbor:	Change River	417		1,852
Table G-4	North Harbor:	Change River load from	518	to	843
	South Harbor:	Change River	62		280
		Groundwater, High	5.7		15.7
Table G-5	North Harbor:	Change River load from	54	to	88
	South Harbor:	Change River	6.5		31
Table G-6	North Harbor:	Change River load from	3,100	to	5,099
	South Harbor:	Change River	378		1,680
Table G-7	North Harbor:	Change River load from	2,700	to	4,395
		Air	2,716		2,963
	South Harbor:	Change River	325		1,448
		Air	3,036		3,311
Table G-8	North Harbor:	Change River load from	18,360	to	29,889
	South Harbor:	Change River	2,215		9,847
Table G-9	North Harbor:	Change River, Low from	3.5	to	5.7
		High	35		57
		Groundwater, Low			0.02
	South Harbor:	Change River, Low	0.4		1.8
		High	4		18
		Groundwater, Low			0.02

References:

Menzie-Cura and Associates, 1991. Sources and Loadings of Pollutants to the Massachusetts Bay. Report to the Mass Bays Program, MBP-91-01.

Compiled by:

M. Alber
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Charlestown Navy Yard
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