APPENDIX III
AIR MODELING SUMMARY

Air Pollution

An important component of environmental risk in the City of Chester is air pollution. Air pollutants are airborne contaminants that can be particulate (including smoke or dust particles and fine liquid mists) or gaseous in form. The primary route of exposure to these pollutants is through inhalation.

AIR QUALITY MONITORING

Pursuant to federal regulations (40 CFR 58), the Pennsylvania Department of Environmental Resources (PADER) maintains a statewide network of air quality monitors in order to determine compliance with health-based National Ambient Air Quality Standards (NAAQS). NAAQS exist for the six criteria pollutants: carbon monoxide (CO), lead, nitrogen dioxide (NO_2), ozone[1], particulate matter (expressed as particulate smaller than 10 micrometers in diameter, PM-10), and sulfur dioxide (SO_2).

In Chester, PADER samples the air for five of these pollutants (all except CO) at its monitoring station on Philadelphia Gas Works (PGW) property at Front & Norris Streets. Table 1 summarizes air quality with respect to the five pollutants monitored at the PGW site.

Note that monitored concentrations for ozone exceed national standards. More than the other pollutants for which NAAQS exist, ozone exceedances are caused by the release of other substances (especially volatile organic compounds, nitrogen oxides, and carbon monoxide) that cause the formation of ozone downwind, sometimes after travel distances of hundreds of miles. Tens of million of Americans, including most citizens of the northeast corridor in a contiguous area that stretches from Virginia to Maine, live in areas that violate the ozone NAAQS. The Clean Air Act, as amended in 1990, has established a number of requirements for areas exceeding the ozone NAAQS in an effort to reduce emissions of ozone precursors and meet the NAAQS. See EPA's Ozone-- Good Up High, Bad Nearby (EPA-451/F-93-010) and Smog: Its Nature and Effects (Inside EPA, October 1987), for more information.

Although enforceable ambient standards exist for only six criteria pollutants, many other contaminants threaten human health. Because routine monitoring is limited to the criteria

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[1]In this context, we are discussing ground-level (tropospheric) ozone, which can irritate and damage the lungs and other sensitive tissue. Ozone in the upper atmosphere (the stratosphere) helps shield the earth from certain ultra-violet radiation emitted by the sun. This "good" ozone is formed naturally and independently from ground-level ozone pollution.

pollutants and this monitoring may not be representative of the entire City of Chester, air quality modeling has been used to estimate potential inhalation risks to Chester residents. This modeling is described below.

MODELING OF POINT AND AREA SOURCES

Air quality models are mathematical representations of the way contaminants move in the atmosphere. Models are useful in characterizing air pollution in the City of Chester for a number of reasons. First, the number of monitors and the location of suitable monitoring sites in the city are finite, while a model can accomplish estimates of air quality impacts at any location. Second, while it is impractical to monitor for every conceivable contaminant that may be in the air, modeling can be used to estimate concentrations of most non-reactive contaminants for which an emission rate can be estimated. Finally, monitoring can only provide information regarding the pollutants being monitored, at the time and location the monitoring is performed. The information gathered during short-term monitoring studies is not always representative of typical conditions or long-term averages, nor can it generally be used to predict the effectiveness of control strategies.

In order to estimate ambient concentrations, air quality models require data that describes the emissions, the meteorology, and the terrain of the area to be modeled. For the Chester Study, meteorological data collected at Philadelphia International Airport and terrain data from the United States Geological Survey were used. The emissions inventory was developed by using inventories of criteria air pollutants and ozone precursors, maintained by the states of Pennsylvania, New Jersey, and Delaware (pursuant to Title I of the Clean Air), and limited air toxics inventories (Toxics Release Inventory) maintained by EPA (pursuant to Title III of the Clean Air Act) to identify as many potential sources of air pollution as possible. Then, emissions of specific air contaminants were estimated using information found in a variety of references. All of the emission sources and methods used to estimate the emission rates are found in the report Air Toxic Emission Inventory and Dispersion Modeling for Chester, Pennsylvania, prepared by Pacific Environmental Services (PES) under contract to EPA.

Figure 1 summarizes the emissions inventories in terms of emissions of volatile organic compounds (VOCs) and particulate (PM) from point and area sources. Point sources are emissions from stacks and vents that are handled as discrete sources in the modeling. Area sources are emissions such as consumer solvent use that occur reasonably uniformly over some geographical area. Point, area, and mobile source inventories are discussed in detail in the report Air Toxic Emission Inventory and Dispersion Modeling for Chester, Pennsylvania,

Once emission rates were estimated for the 700-odd pollutants that were identified, the model was run once for each pollutant to generate estimates of annual average concentrations at locations throughout the City of Chester. Shorter-term averages were estimated for some of the criteria pollutants. The results of this modeling are found in the report Air Toxic Emission Inventory and Dispersion Modeling for Chester, Pennsylvania.[2]

MODELING OF MOBILE SOURCES

While emissions from mobile sources were included with the area source inventory, a special modeling study was made of emissions from vehicular traffic on Second Street, between Thurlow and Montgomery Streets. Pennsylvania Department of Transportation traffic counts and estimates from the Delaware County Resource Recovery Facility solid waste permit application were used, along with the MOBILE and PART5 emissions of VOCs and particulate, respectively. Then, the CAL3QHC model, which is specifically designed to accomplish estimates of short-term average pollutant concentrations from roadway emissions, and the ISC model were used to estimate ambient concentrations of VOC and particulate. Speciation profiles were applied to the particulate and VOC concentrations to produce contaminant-specific concentration estimates. the methodology and results of this modeling are documented in Appendix J of the report Air Toxic Emission Inventory and Dispersion Modeling for Chester, Pennsylvania.

UNCERTAINTY

While the air quality analysis provides a reasonable estimate of airborne the contaminant levels in Chester, there are a variety of sources of uncertainty associated with the study, most notably:

- Incompleteness of the emissions inventory;
- Unrepresentative and/or inaccurate the toxic profiles;
- Errors in the source emission estimates;
- Errors/omissions in the emissions source characteristics

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[2]The modeling of ozone, which requires emissions and meteorological data representing many thousands of square miles, was beyond the scope of this study. Because ozone is formed and transported over large distances, ground-level concentrations tend not to vary substantially from location to location. For the purpose of the current study, the monitored ozone concentrations will suffice to characterize current conditions.

(e.g., stack exit velocity, building heights);

- Uncertainties in the dispersion model algorithms; and
- Representativeness of the meteorological data.

The problem of the incompleteness of the source inventory is troubling as it is impossible to account for non-reported emissions in a rigorous, representative way.

The problem of unrepresentative or inaccurate toxic profiles results, in part, from the use of very broad source categories. For many of the VOC sources, especially those related to solvent use and chemical and petrochemical manufacture, the existing inventories are not specific in describing the industrial activities that are producing emissions. (For example, "chemical manufacturing-- average" and "organic solvent use-- general" were not uncommon).

Reliance on the SPECIATE database for many of the profiles of VOC emissions is also an important source of uncertainty. SPECIATE was developed for use in ozone modeling and, consequently, has drawbacks for use in the Chester emissions inventory.

First, because ozone is a secondary pollutant (formed by the photo-oxidation of VOCs and other precursor emissions), the ozone domains are quite large and concentration gradients are correspondingly small. Correctly estimating the constituent chemical species of VOC emissions from any single emission point (even a large one) is much less important than the correctness of large geographical portions of the inventory as a whole. For these types of inventories, the speciation of source categories only needs to be accurate <u>on average</u> for a fairly broad region. (In statistical terms, the estimate of the average that is important, but the deviation of any given source from the average is inconsequential.) In contrast, the modeling for Chester, did was quite local, and if a large emission points source's profile deviates greatly from the estimate from the SPECIATE database, then estimates of local pollutant concentrations will be effected.

Also, in the development of the SPECIATE database, emphasis was placed on reactivity with respect to the potential ozone formation-- toxicity was a secondary concern at best. There may be instances were chemical is in a SPECIATE profile is used to represent a class of compounds of similar reactivity. While the compounds may have similar reactivity, they may not have similar toxicities.

Uncertainty is discussed in more detail in Section 5 of <u>Air Toxic Emission Inventory and Dispersion Modeling for Chester, Pennsylvania</u>.

Table 1

Pollutant	NAAQS ($\mu g/m^3$ unless indicated)	1993 Monitored Concentration
O_3, 1-hr(a)	120 ppb	123 ppb
PM-10, annual(b)	50	27
PM-10, 24-hr(a)	150	60
Pb, cal. quarter(c)	1.5	0.04
SO_2, annual(c)	80	24
SO_2, 24-hour(d)	365	69
SO_2, 3-hour(d)	1300	121
NO_2, annual(c)	100	39
CO, 8-hour(d)	10	not monitored
CO, 1-hour(d)	40	not monitored

Data shown are from 1993, the most recent year for which complete data are available.

(a) Standard is attained when the expected number of exceedances per year is less than or equal to 1. (Reported monitored concentration is the second-high.)

(b) Standard is attained when the expected annual arithmetic mean is less than or equal to 50.

(c) Never to be exceeded. (Reported monitored concentration is the average of one quarter of available data from 1994.)

(d) Not to be exceeded more than once per year. (Reported monitored concentration is the second-high.)

Figure 1: Modeling Emissions Inventory

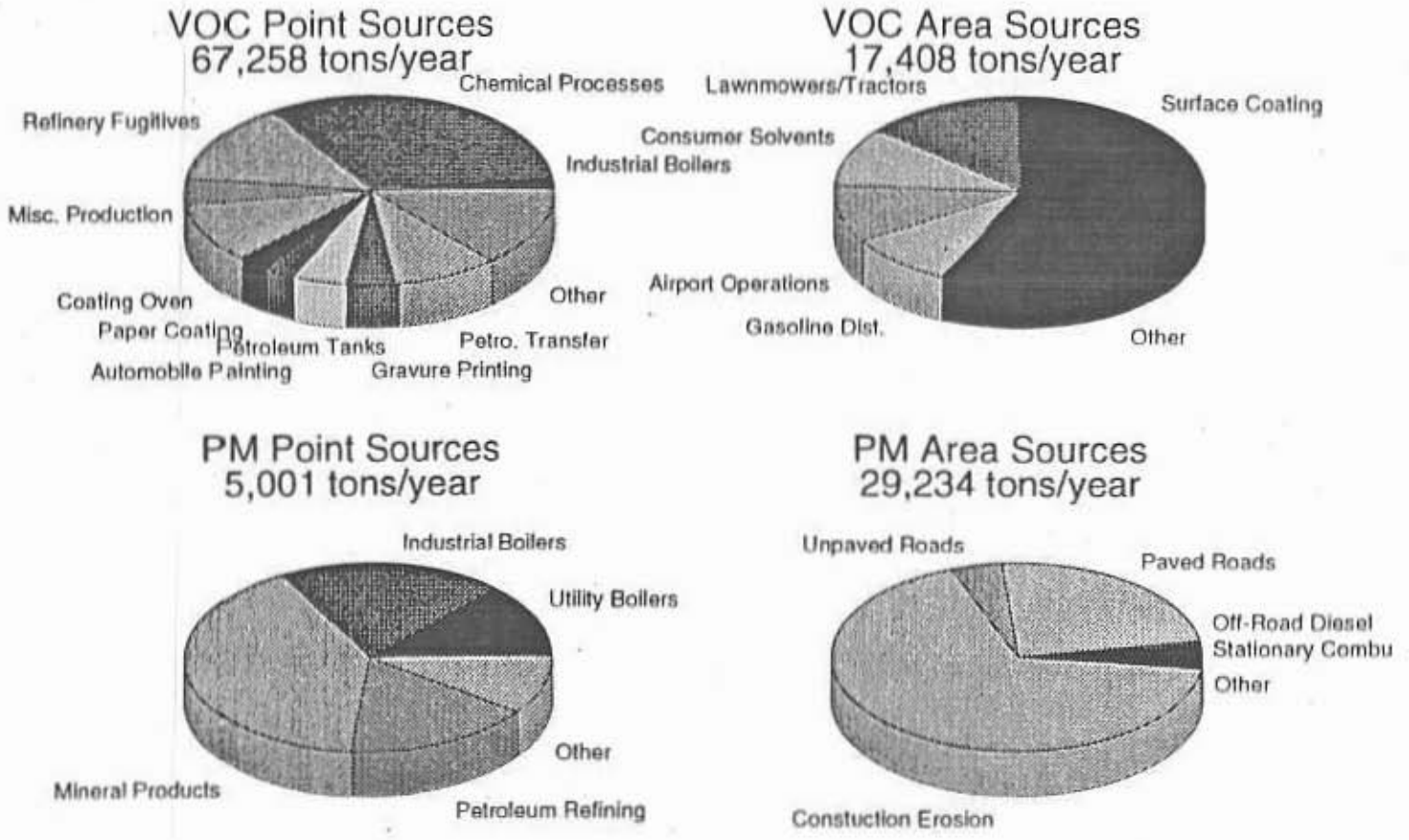


Figure 1 displays the major emission sources from the point and area source modeling inventories. (Mobile sources are excluded.) It should be noted that, as a modeling inventory, this inventory is biased toward larger sources (especially sources outside of Chester) because only those sources which were believed to have the potential to significantly impact Chester were included. For example, a 1,000 ton/year source in Wilmington would be included in the inventory while a 10 ton/year source may not.

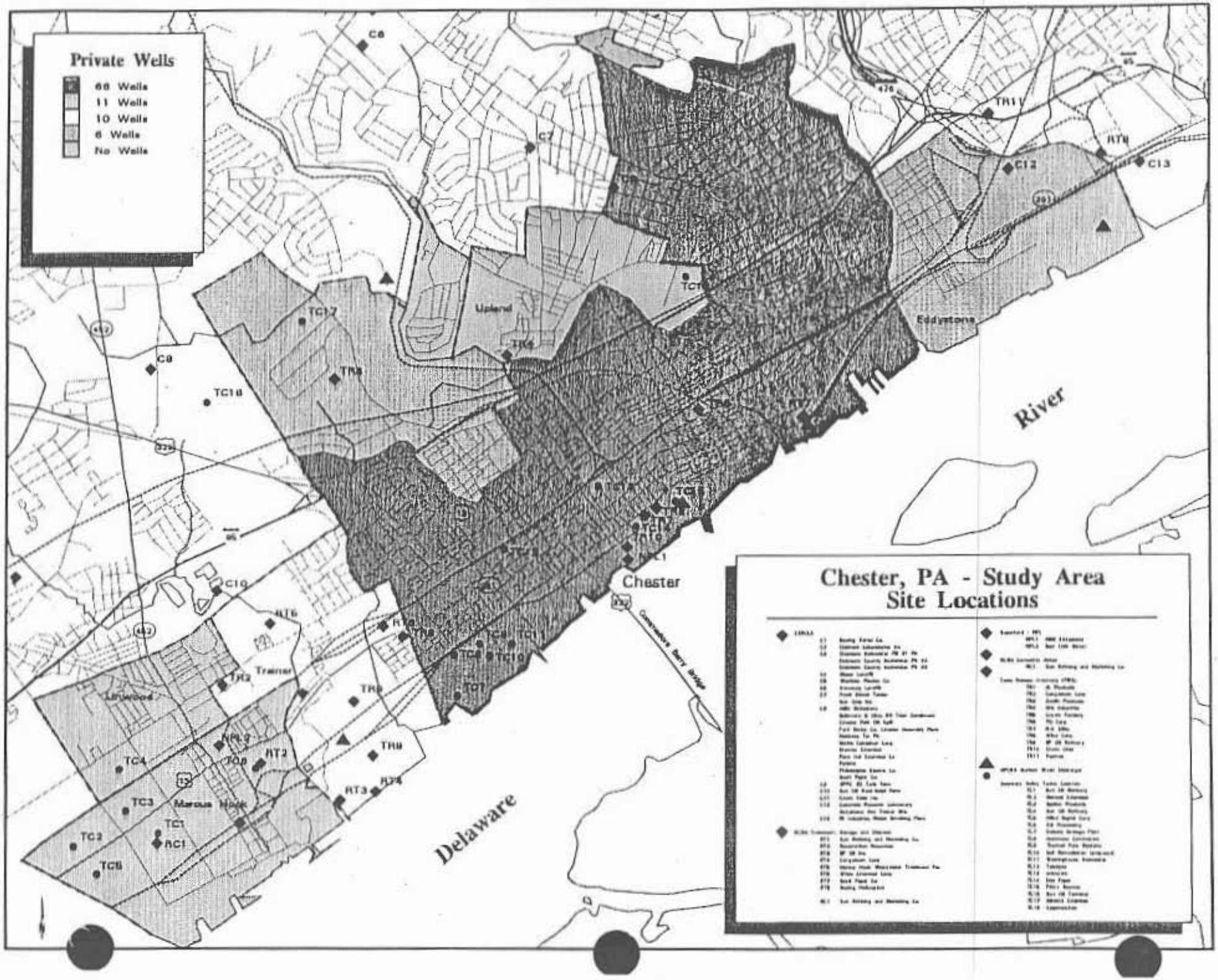

Private Wells
68 Wells
11 Wells
10 Wells
6 Wells
No Wells
Chester, PA - Study Area
Site Locations
Upland
Eddystone
Chester
Trainer
Marcus Hook
Linwood
Delaware
River
Commodore Barry Bridge

Figure 4-1

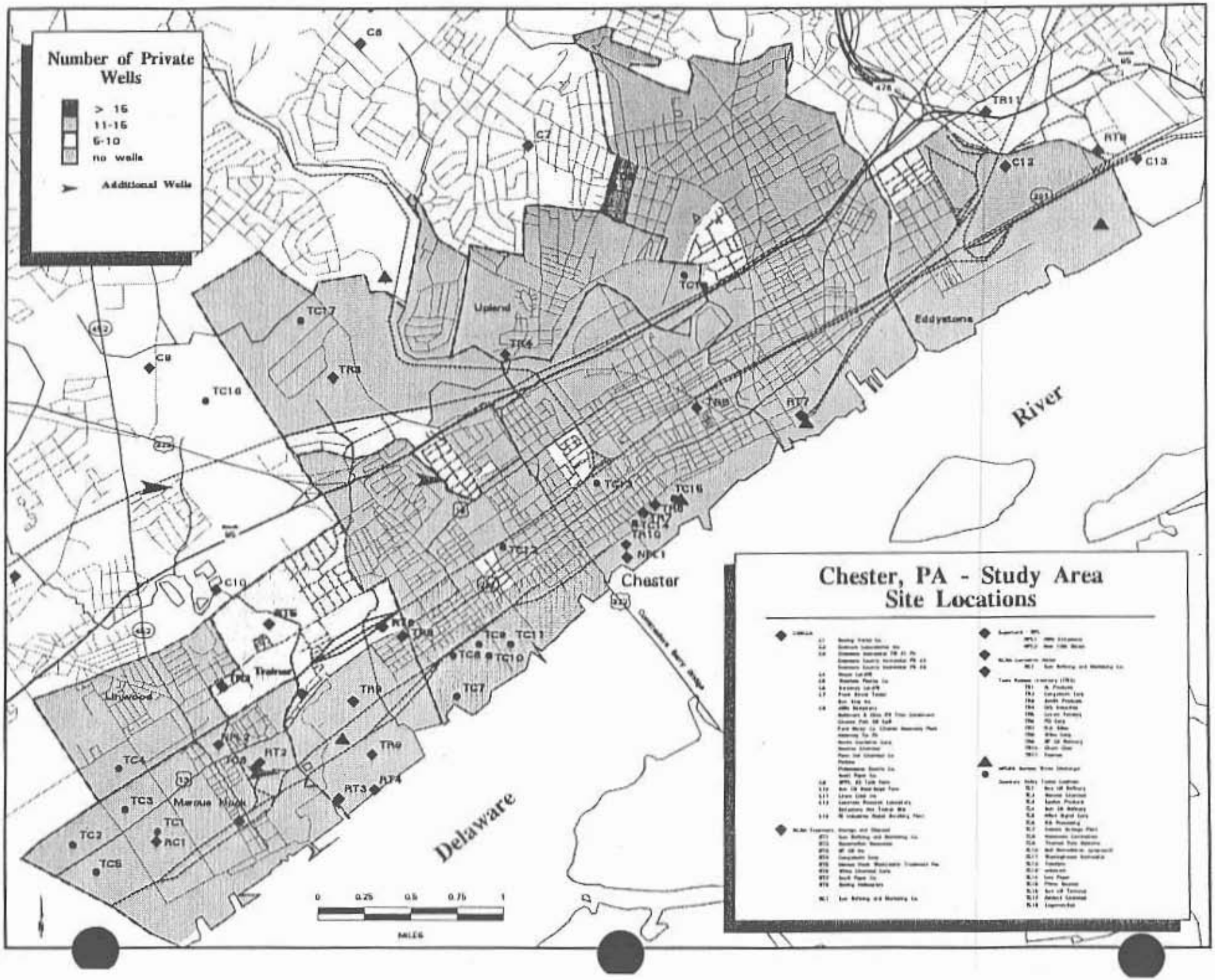

Number of Private Wells
> 15
11-15
6-10
no wells
Additional Wells
Chester, PA - Study Area
Site Locations
Uplend
Eddystone
River
Chester
Delaware
Trainer
Linwood
Marcus Hook
MILES

Figure 4-2

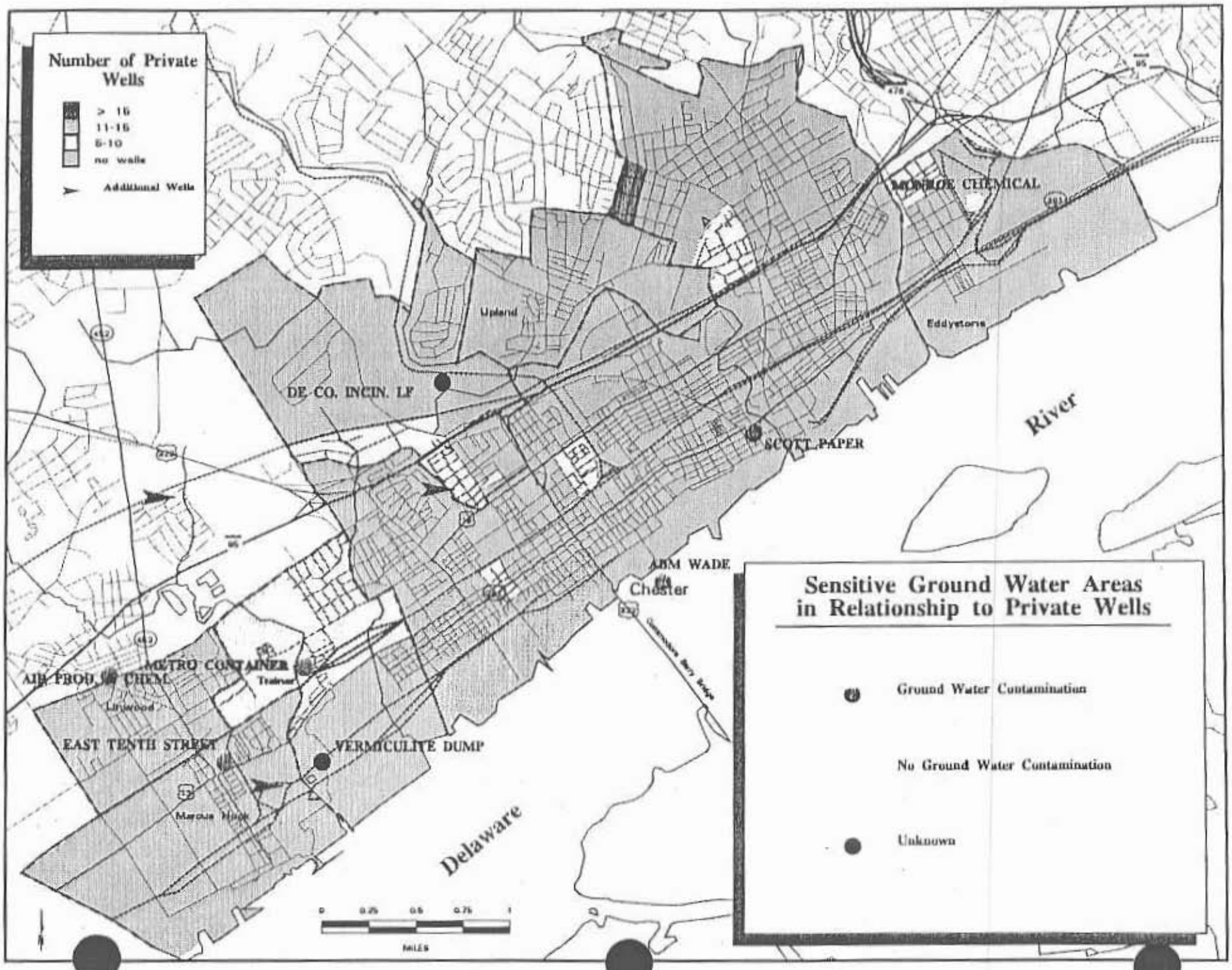
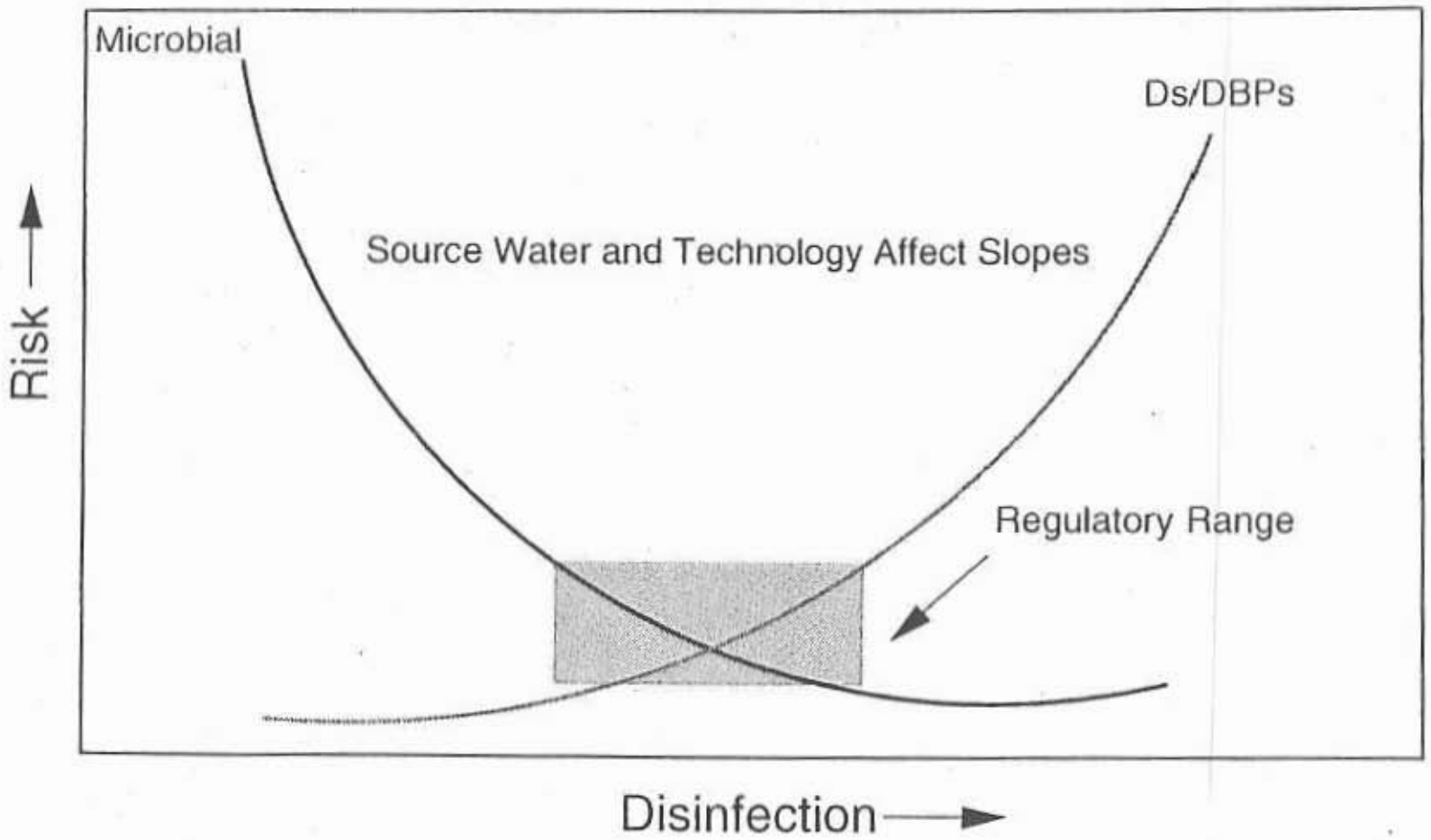

Number of Private Wells
> 16
11-15
6-10
no wells
Additional Wells
Upland
Eddystone
MORTON CHEMICAL
DE CO. INCIN. LF
SCOTT PAPER
River
ABM WADE
Chester
METRO CONTAINER
AIR PROD & CHEM
Linwood
EAST TENTH STREET
VERMICULITE DUMP
Marcus Hook
Delaware
0 0.25 0.5 0.75 1
MILES
Sensitive Ground Water Areas in Relationship to Private Wells
Ground Water Contamination
No Ground Water Contamination
Unknown

Figure 4-3

CHESTER RISK PROJECT

FIGURE 4-4 - RISK TRADE-OFFS

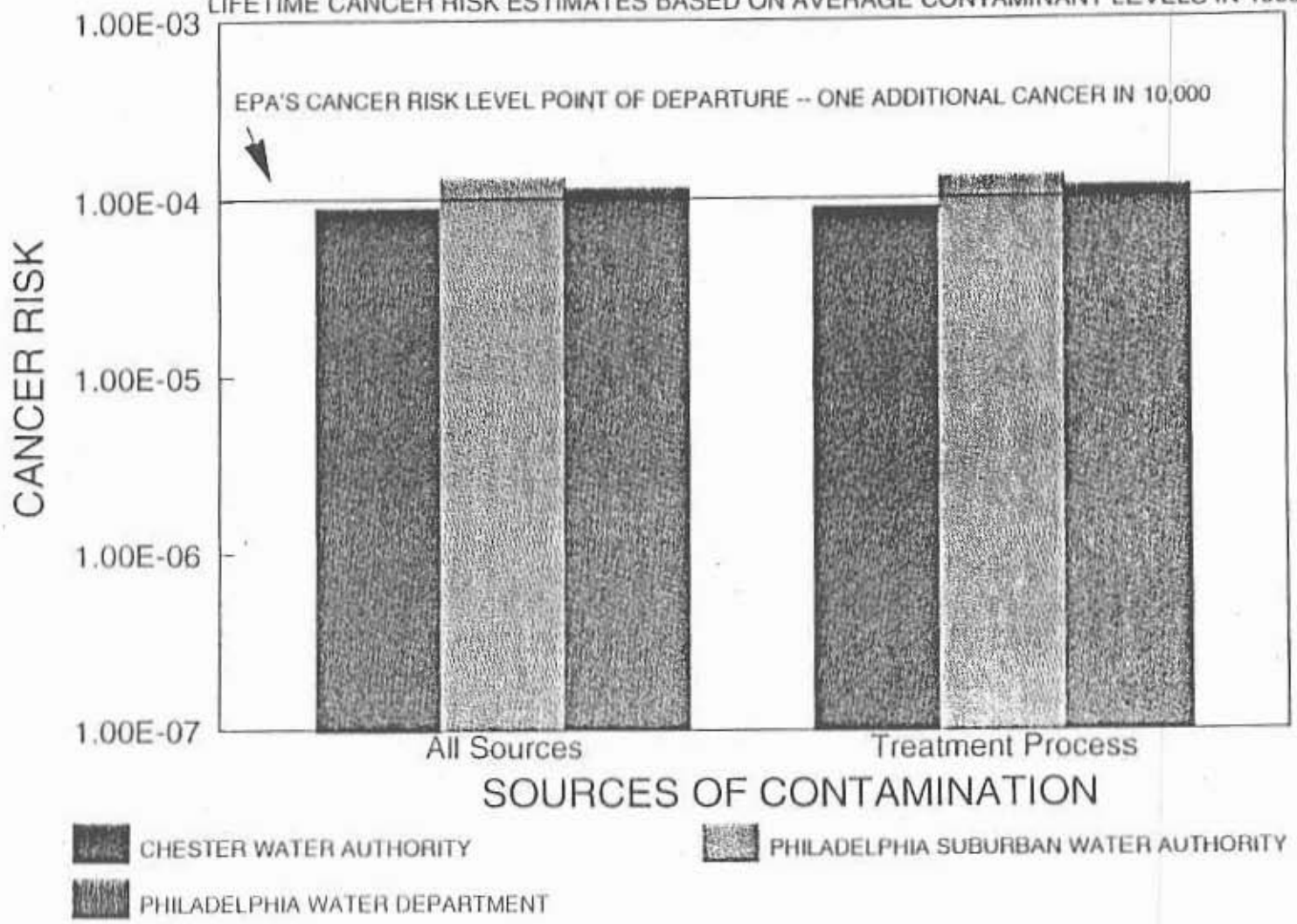
DISINFECTION BYPRODUCTS VS. MICROBIAL GROWTH



CHESTER RISK PROJECT

FIGURE 4-5 - COMPARISON OF RISK LEVELS FOR FINISHED WATER SUPPLIES

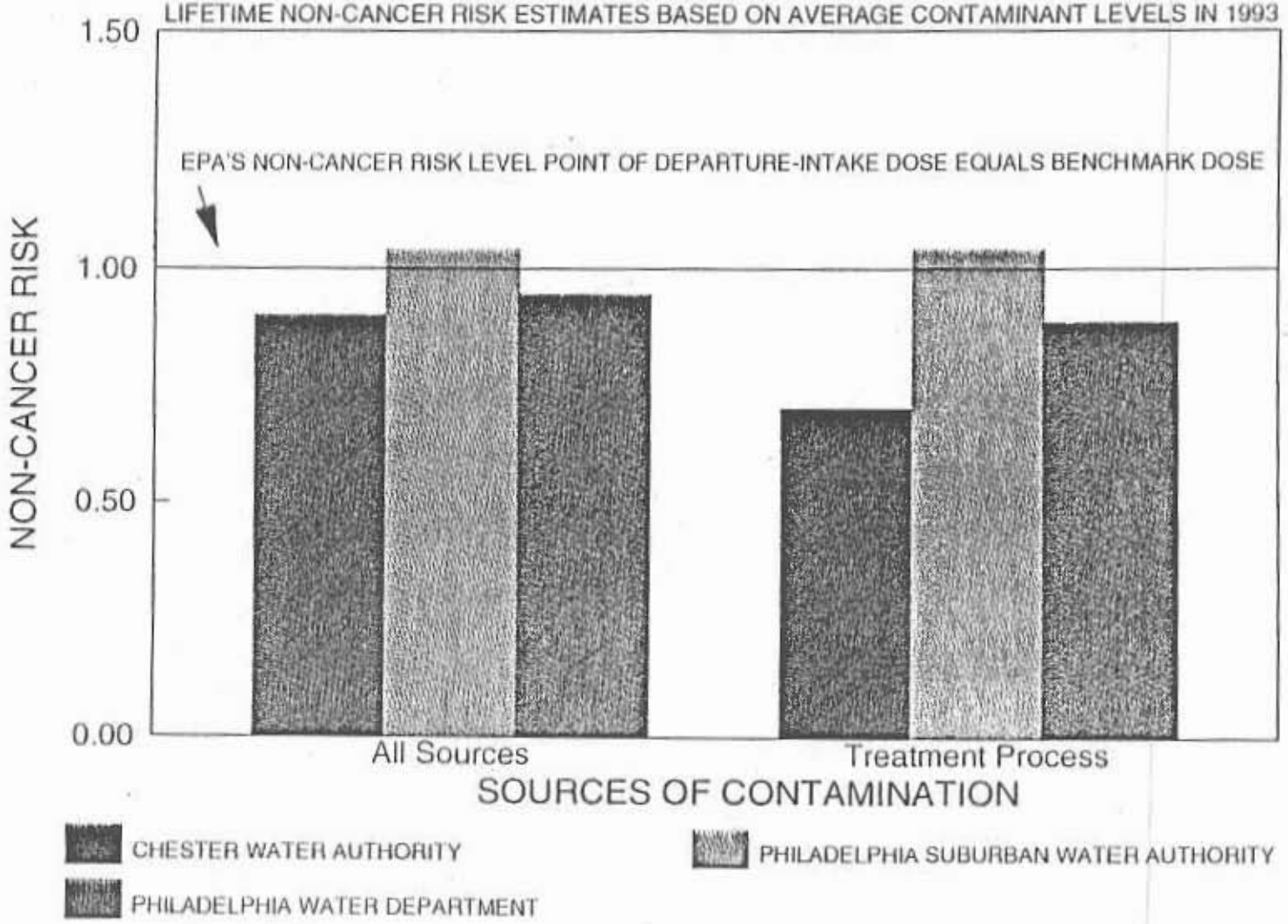
LIFETIME CANCER RISK ESTIMATES BASED ON AVERAGE CONTAMINANT LEVELS IN 1993



CHESTER RISK PROJECT

FIGURE 4-6 - COMPARISON OF RISK LEVELS FOR FINISHED WATER SUPPLIES

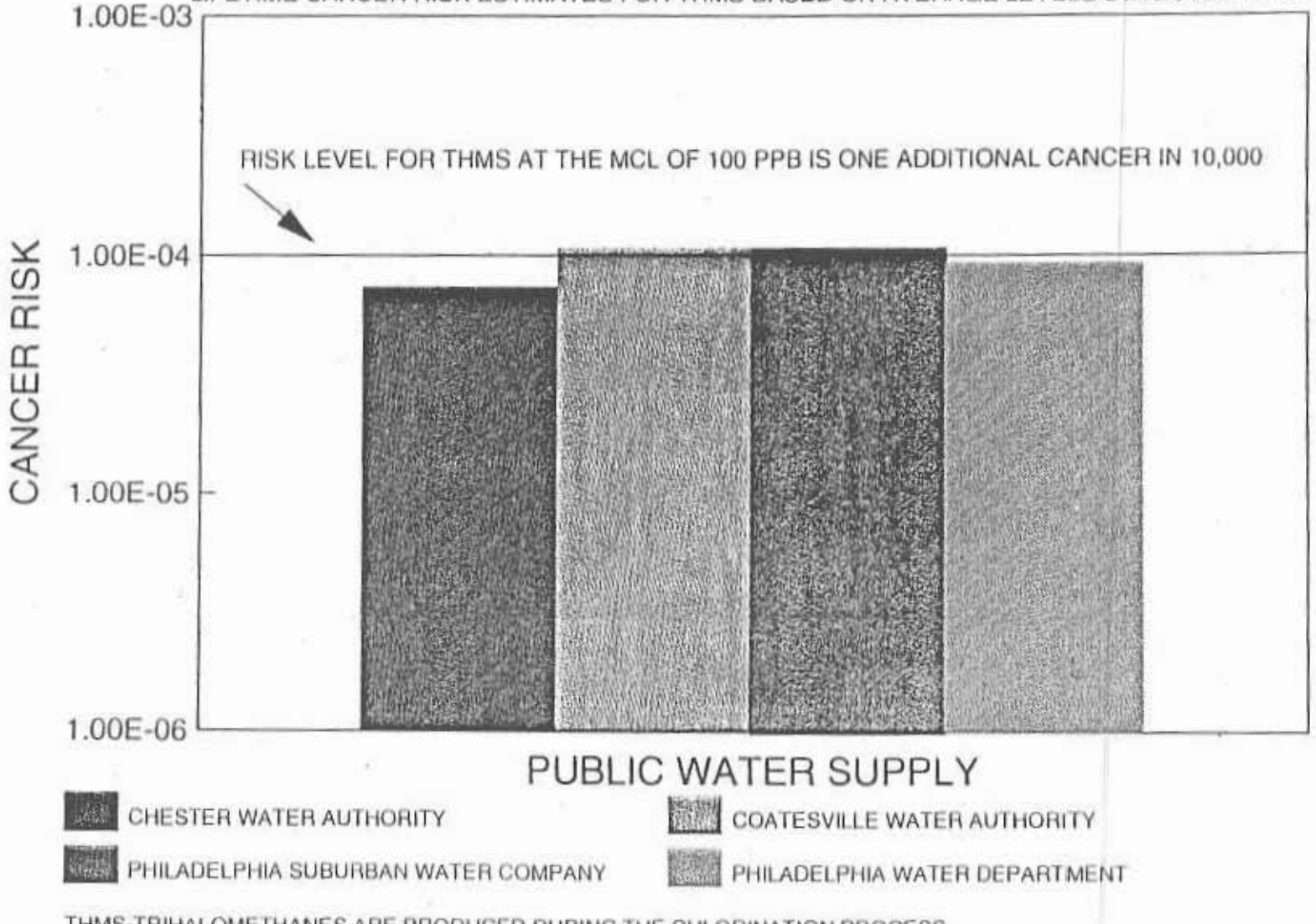
LIFETIME NON-CANCER RISK ESTIMATES BASED ON AVERAGE CONTAMINANT LEVELS IN 1993



CHESTER RISK PROJECT

FIGURE 4-7 - COMPARISON OF RISK LEVELS FOR FINISHED WATER SUPPLIES

LIFETIME CANCER RISK ESTIMATES FOR THMS BASED ON AVERAGE LEVELS DETECTED IN 1993

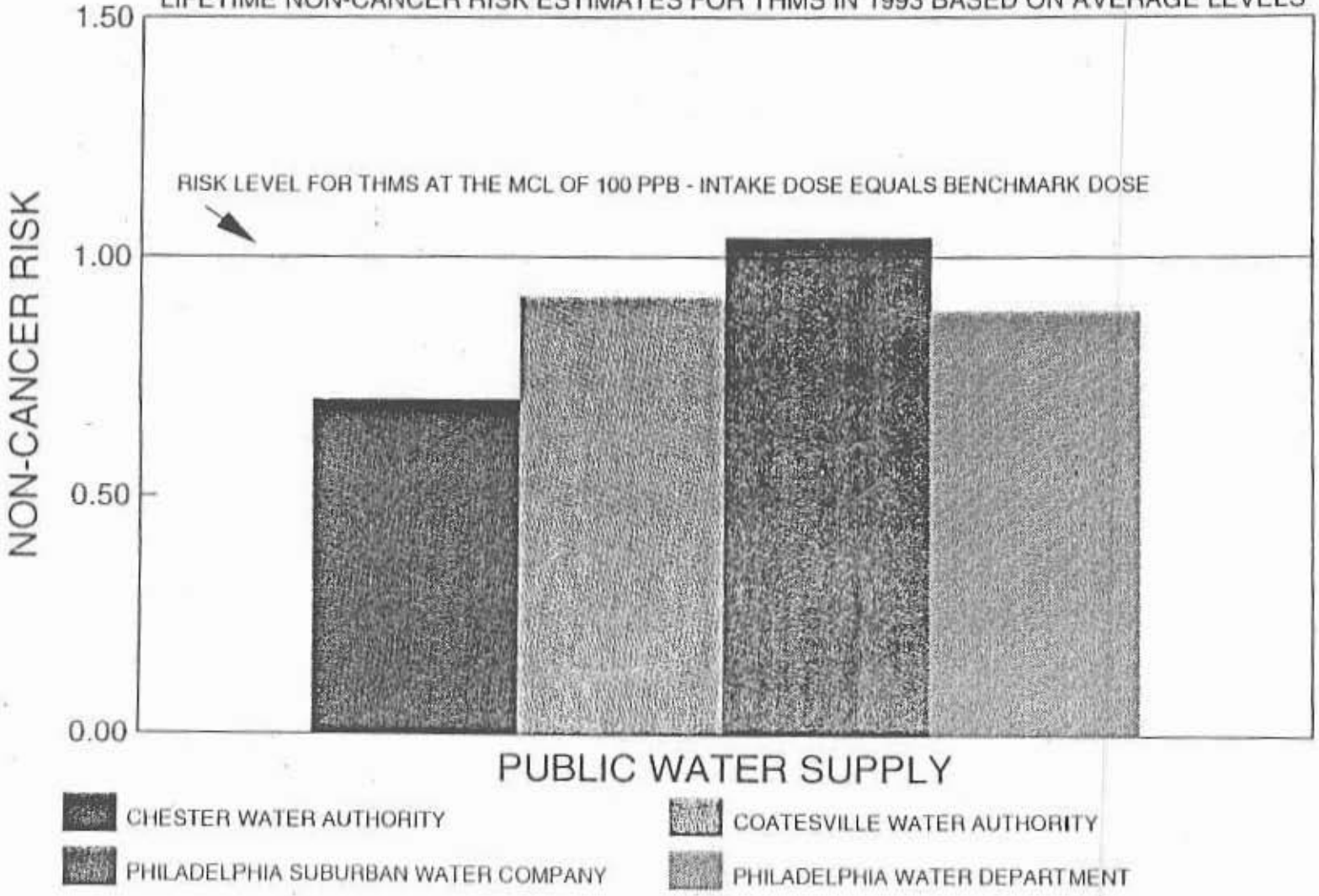


THMS-TRIHALOMETHANES ARE PRODUCED DURING THE CHLORINATION PROCESS
MCL-MAXIMUM CONTAMINANT LEVEL; PPB-PARTS PER BILLION

CHESTER RISK PROJECT

FIGURE 4-8 - COMPARISON OF RISK LEVELS FOR FINISHED WATER SUPPLIES

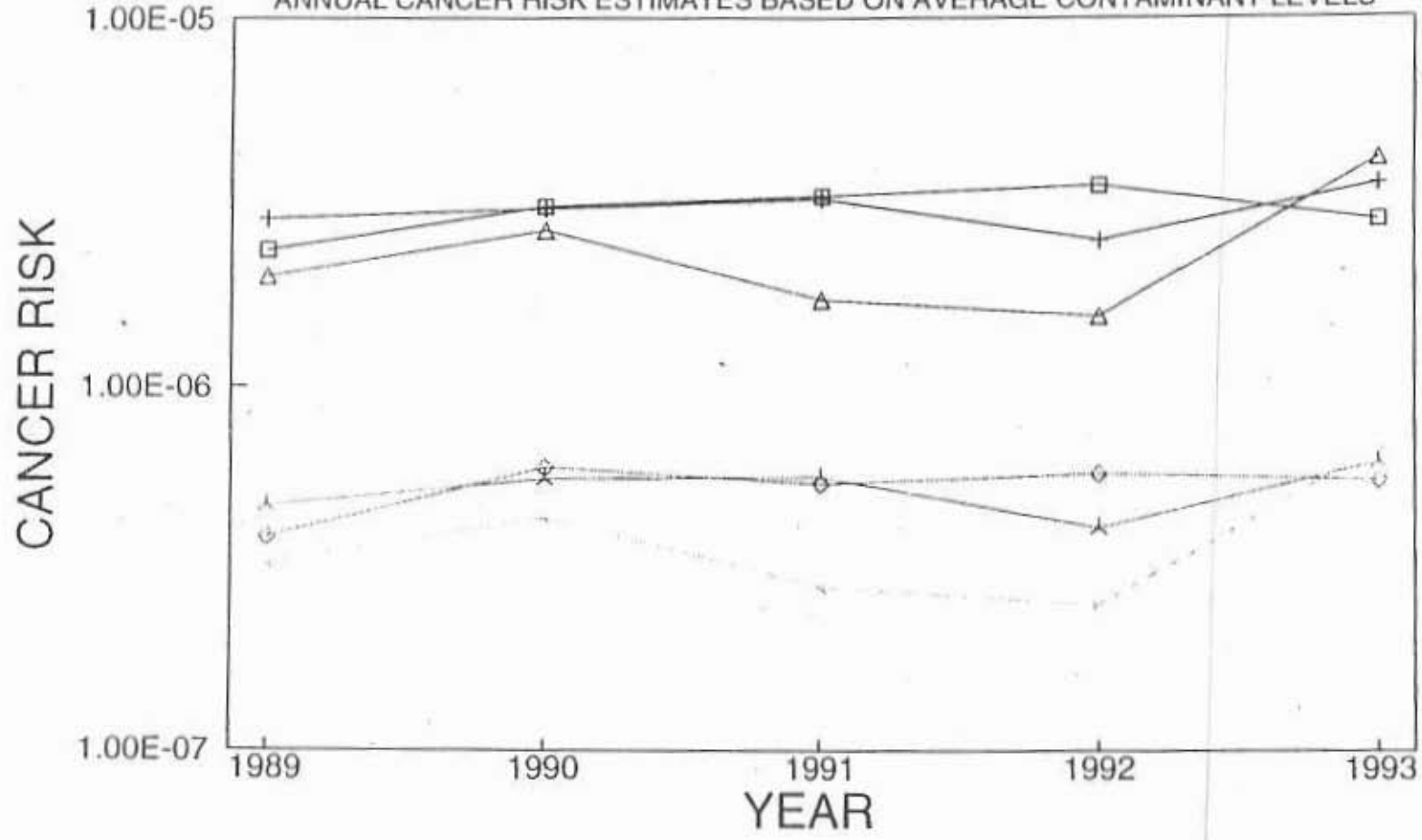
LIFETIME NON-CANCER RISK ESTIMATES FOR THMS IN 1993 BASED ON AVERAGE LEVELS



CHESTER RISK PROJECT

FIGURE 4-9 - COMPARISON OF RISK LEVELS FOR FINISHED WATER SUPPLIES

ANNUAL CANCER RISK ESTIMATES BASED ON AVERAGE CONTAMINANT LEVELS

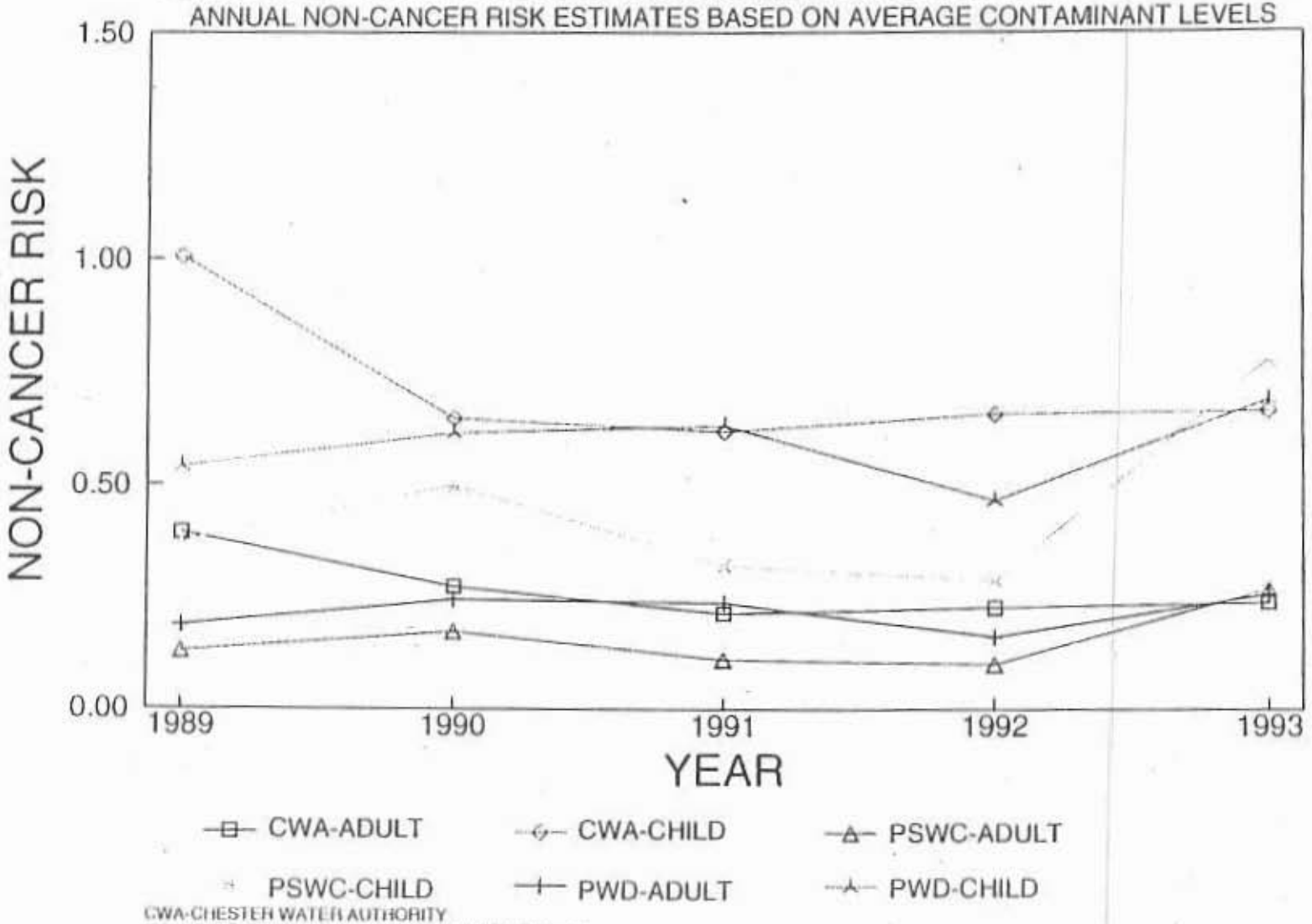


CWA-CHESTER WATER AUTHORITY
PSWC-PHILADELPHIA SUBURBAN WATER COMPANY
PWD-PHILADELPHIA WATER DEPARTMENT NOTE: RISK ESTIMATES BASED ON AN EXPOSURE DURATION OF ONE YEAR ONLY

CHESTER RISK PROJECT

FIGURE 4-10 - COMPARISON OF RISK LEVELS FOR FINISHED WATER SUPPLIES

ANNUAL NON-CANCER RISK ESTIMATES BASED ON AVERAGE CONTAMINANT LEVELS



CWA-CHESTER WATER AUTHORITY
PSWC-PHILADELPHIA SUBURBAN WATER COMPANY
PWD-PHILADELPHIA WATER DEPARTMENT NOTE: RISK ESTIMATES BASED ON AN EXPOSURE DURATION OF ONE YEAR ONLY

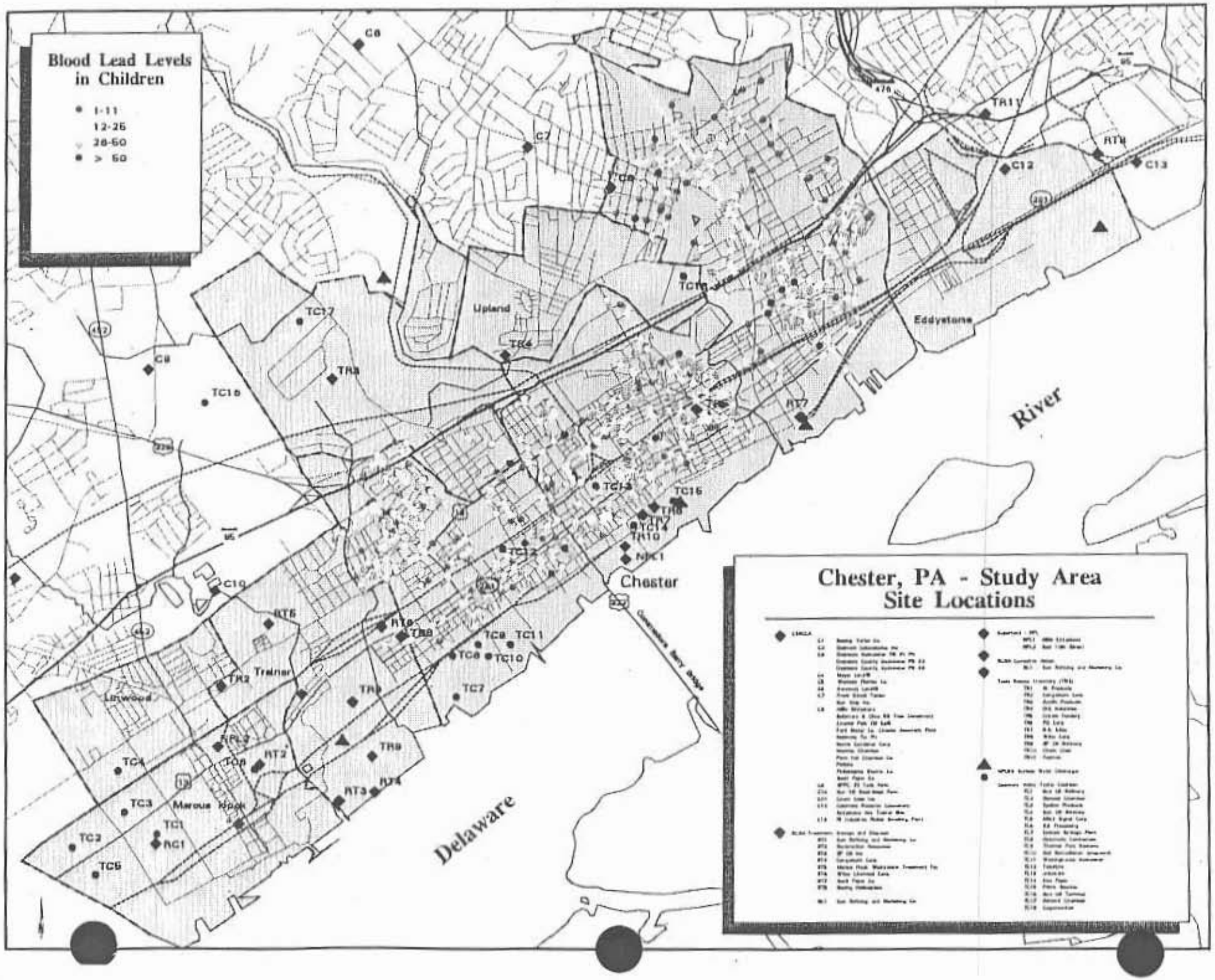

Blood Lead Levels in Children
1-11
12-25
26-50
> 50
Chester, PA - Study Area Site Locations
Uplend
Eddystone
Chester
Trainer
Linwood
Marcus Hook
Delaware
River
Commodore Barry Bridge

Figure 4-16

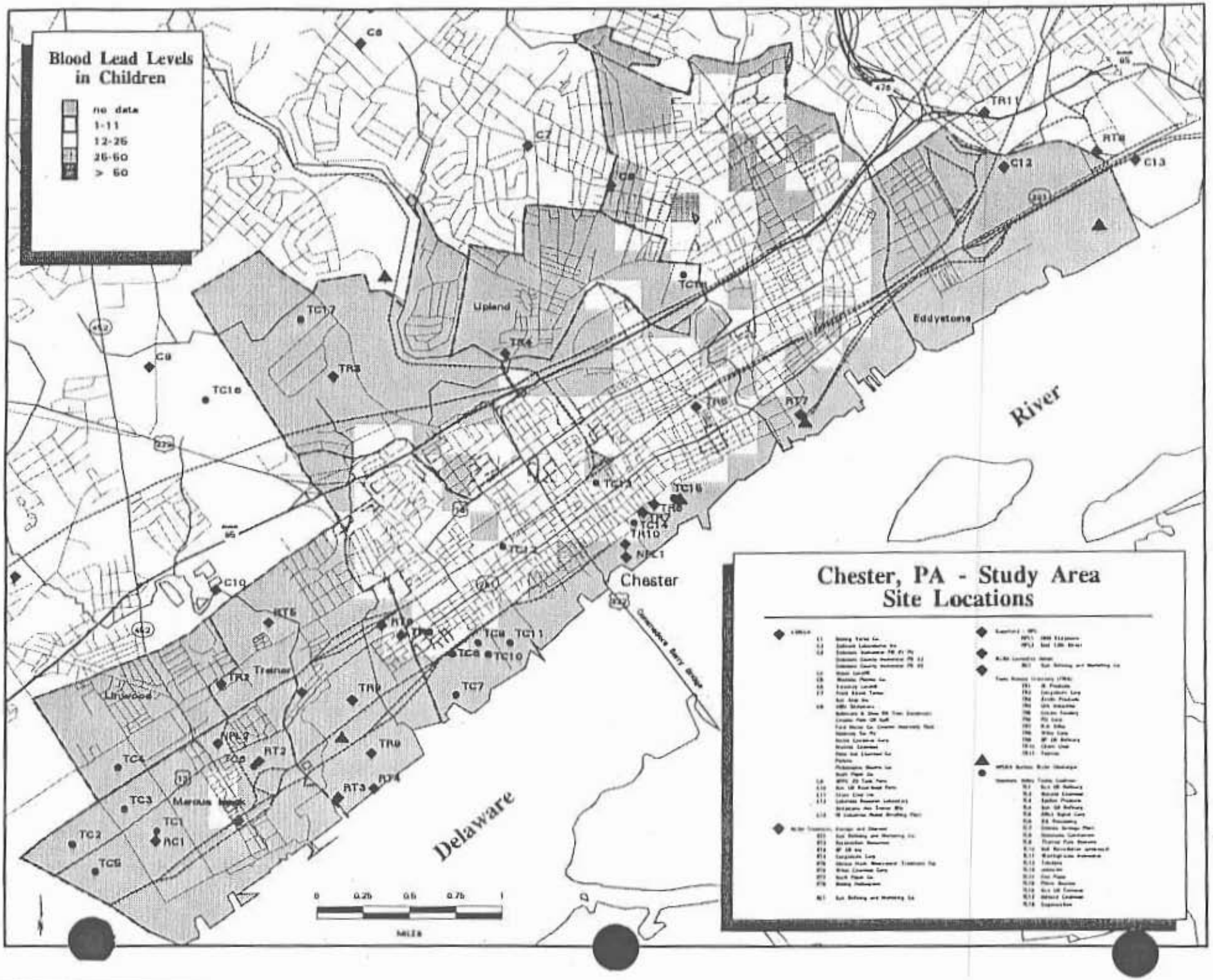

Blood Lead Levels in Children
no data
1-11
12-25
26-50
> 50
Chester, PA - Study Area Site Locations
Uplend
Eddystone
Chester
Trainer
Linwood
Marcus Hook
Delaware
River
Commodore Barry Bridge
MILES

Figure 4-17

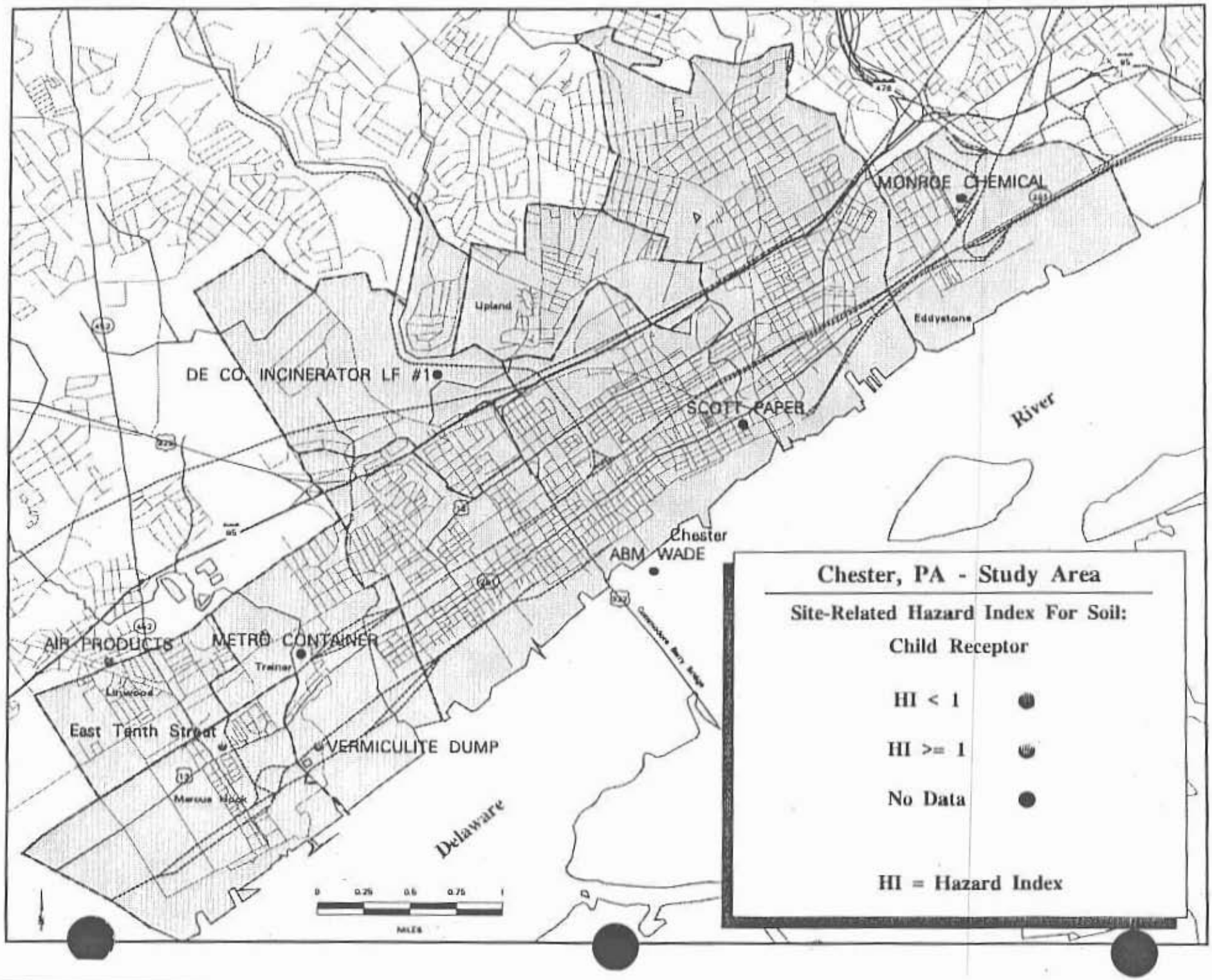

MONROE CHEMICAL
Upland
Eddystone
DE CO. INCINERATOR LF #1
SCOTT PAPER
River
Chester
ABM WADE
AIR PRODUCTS
METRO CONTAINER
Trainer
Linwood
East Tenth Street
VERMICULITE DUMP
Marcus Hook
Delaware
0 0.25 0.5 0.75 1
MILES
Chester, PA - Study Area
Site-Related Hazard Index For Soil:
Child Receptor
HI < 1
HI >= 1
No Data
HI = Hazard Index

Figure 4-18

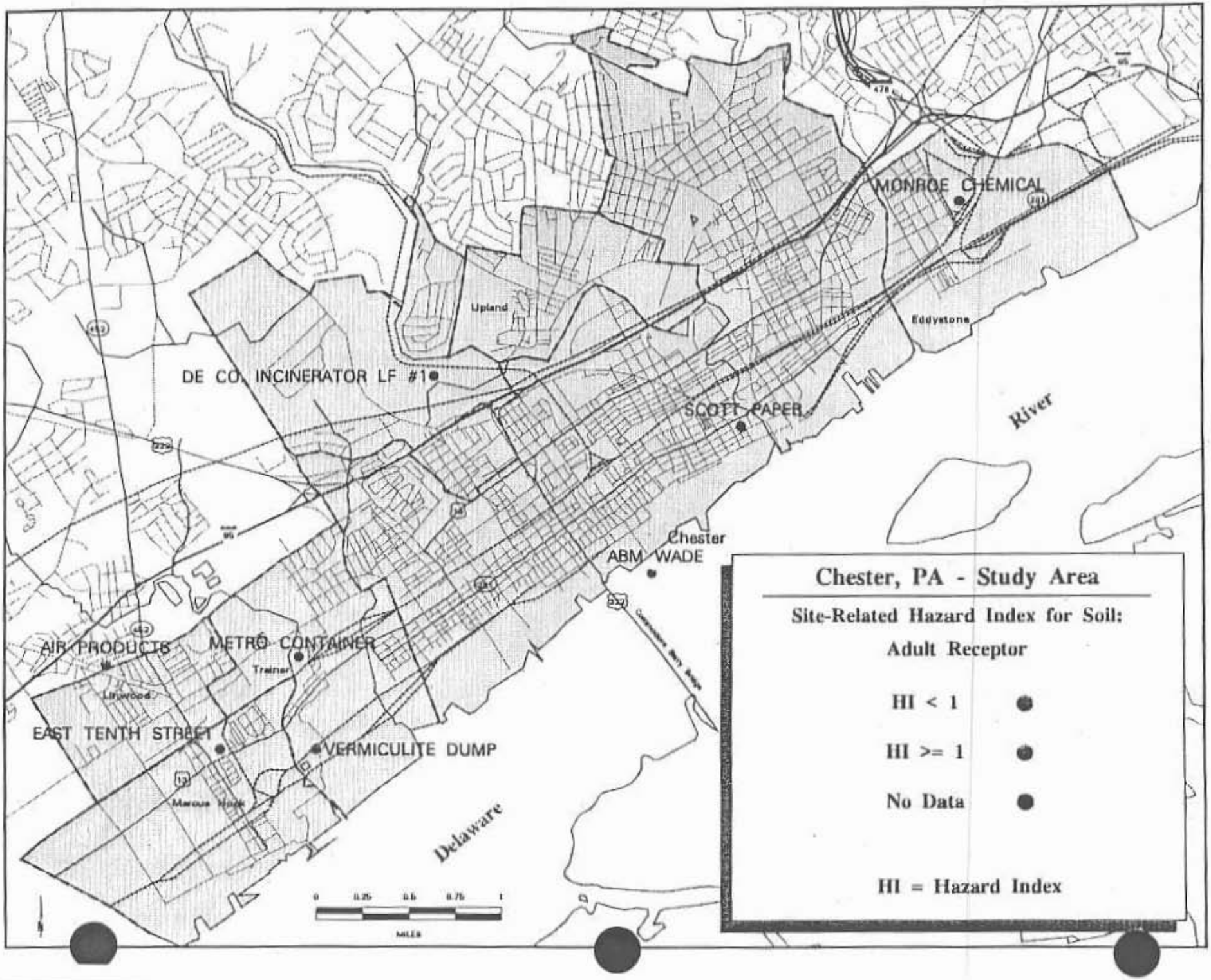

MONROE CHEMICAL
Upland
Eddystone
DE CO. INCINERATOR LF #1
SCOTT PAPER
River
Chester
ABM WADE
AIR PRODUCTS
METRO CONTAINER
Trainer
Linwood
EAST TENTH STREET
VERMICULITE DUMP
Marcus Hook
Delaware
Chester, PA - Study Area
Site-Related Hazard Index for Soil:
Adult Receptor
HI < 1
HI >= 1
No Data
HI = Hazard Index
MILES

Figure 4-19

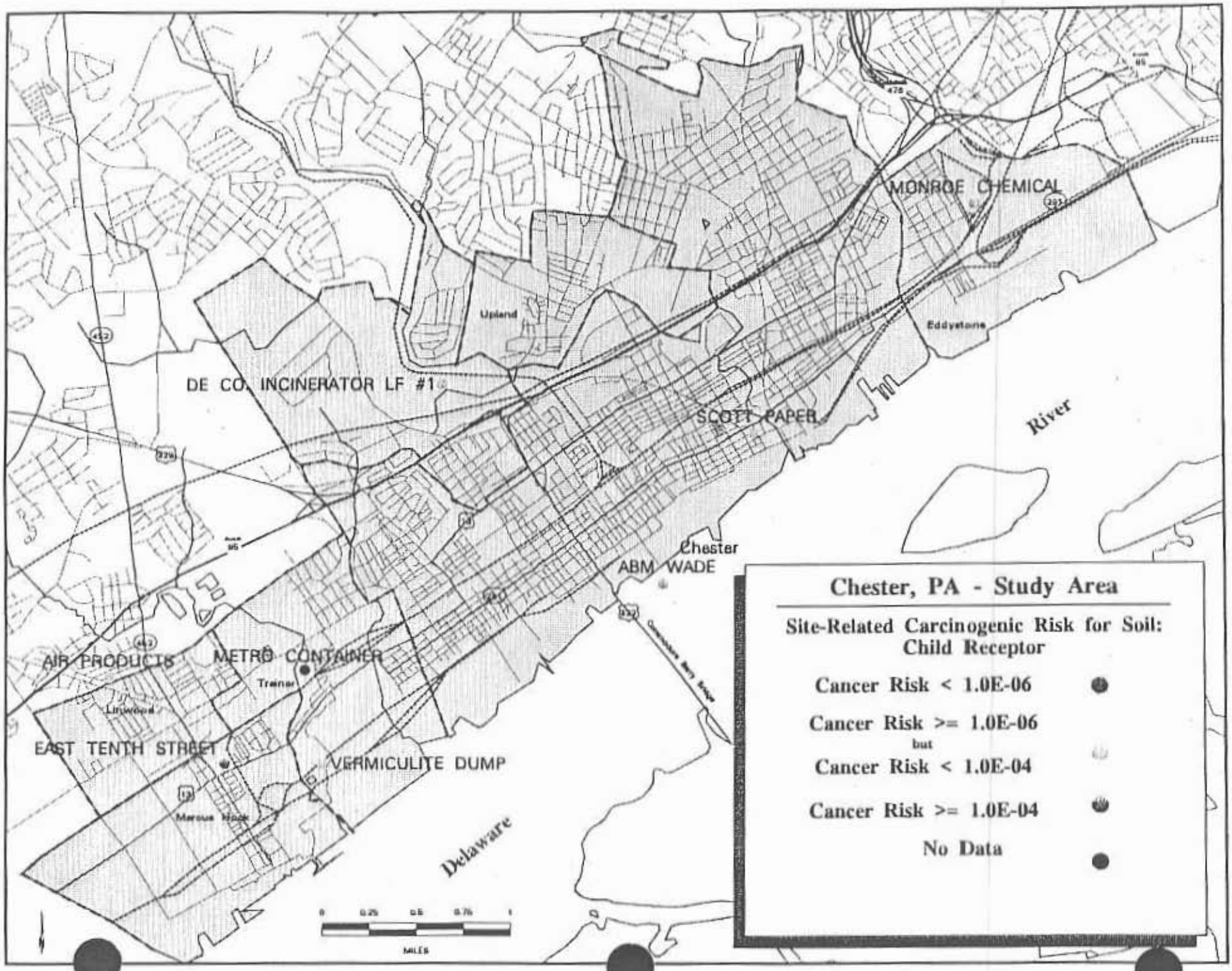

MONROE CHEMICAL
Upland
Eddystone
DE CO. INCINERATOR LF #1
SCOTT PAPER
River
Chester
ABM WADE
AIR PRODUCTS
METRO CONTAINER
Trainer
Linwood
EAST TENTH STREET
VERMICULITE DUMP
Marcus Hook
Delaware
MILES
Chester, PA - Study Area
Site-Related Carcinogenic Risk for Soil: Child Receptor
Cancer Risk < 1.0E-06
Cancer Risk >= 1.0E-06 but Cancer Risk < 1.0E-04
Cancer Risk >= 1.0E-04
No Data

Figure 4-20

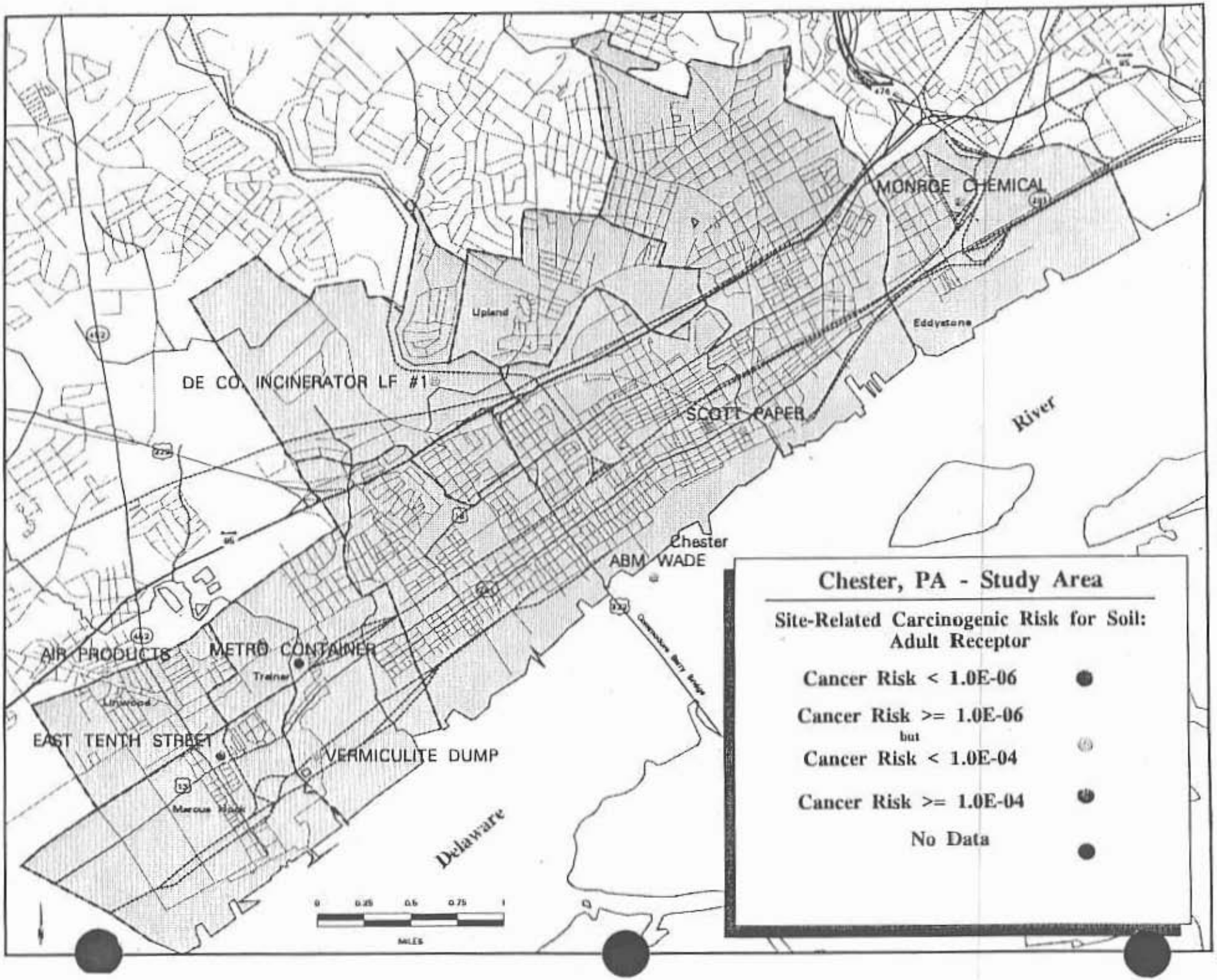

MONROE CHEMICAL
Upland
Eddystone
DE CO. INCINERATOR LF #1
SCOTT PAPER
River
Chester
ABM WADE
AIR PRODUCTS
METRO CONTAINER
Trainer
Linwood
EAST TENTH STREET
VERMICULITE DUMP
Marcus Hook
Delaware
0 0.25 0.5 0.75 1
MILES
Chester, PA - Study Area
Site-Related Carcinogenic Risk for Soil: Adult Receptor
Cancer Risk < 1.0E-06
Cancer Risk >= 1.0E-06 but Cancer Risk < 1.0E-04
Cancer Risk >= 1.0E-04
No Data

Figure 4-21

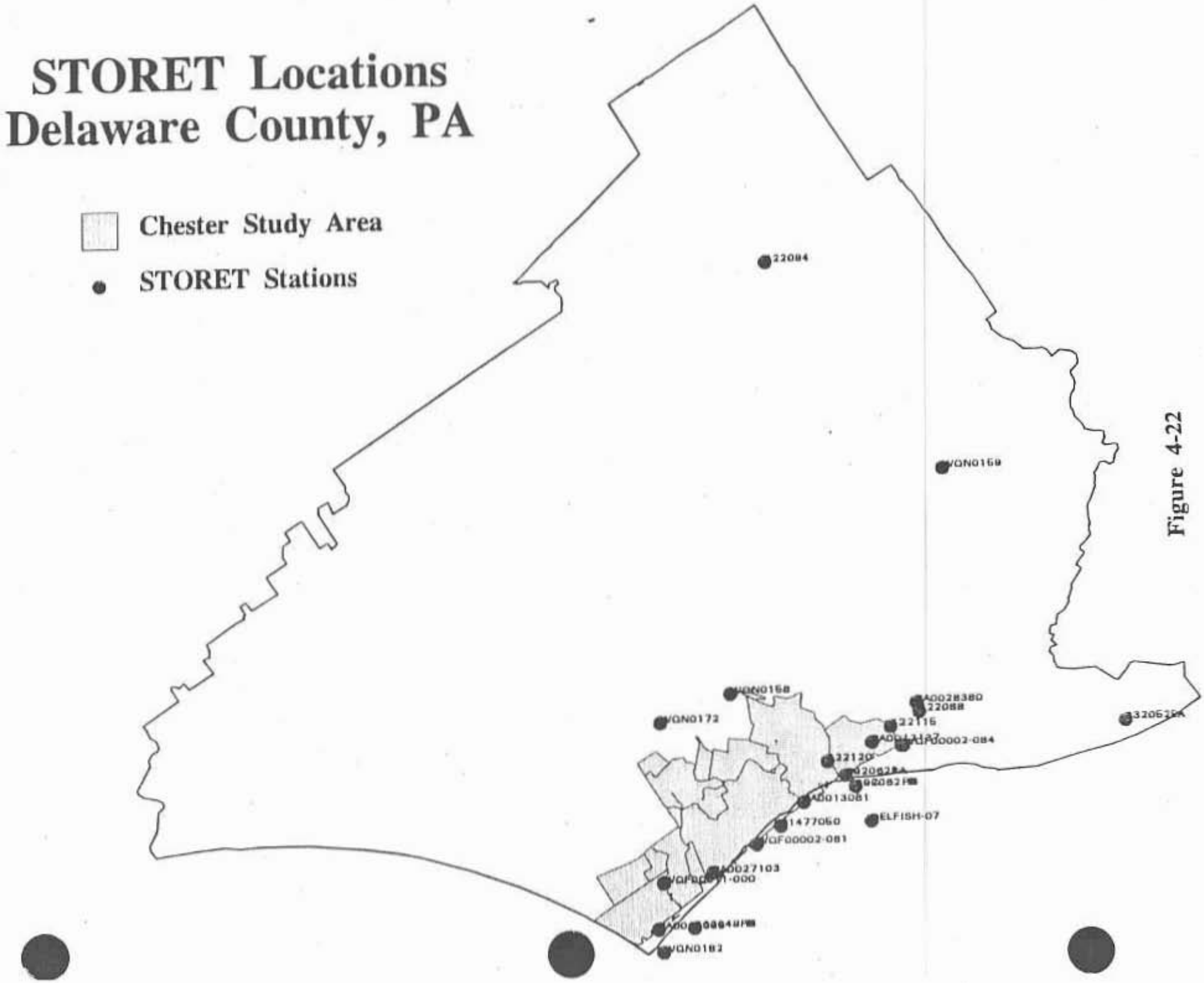

STORET Locations
Delaware County, PA
Chester Study Area
STORET Stations
22084
VQN0169
VQN0168
VQN0172
22115
22130
1477050
ELFISH-07
VQF00002-081
VQN0183

Figure 4-22

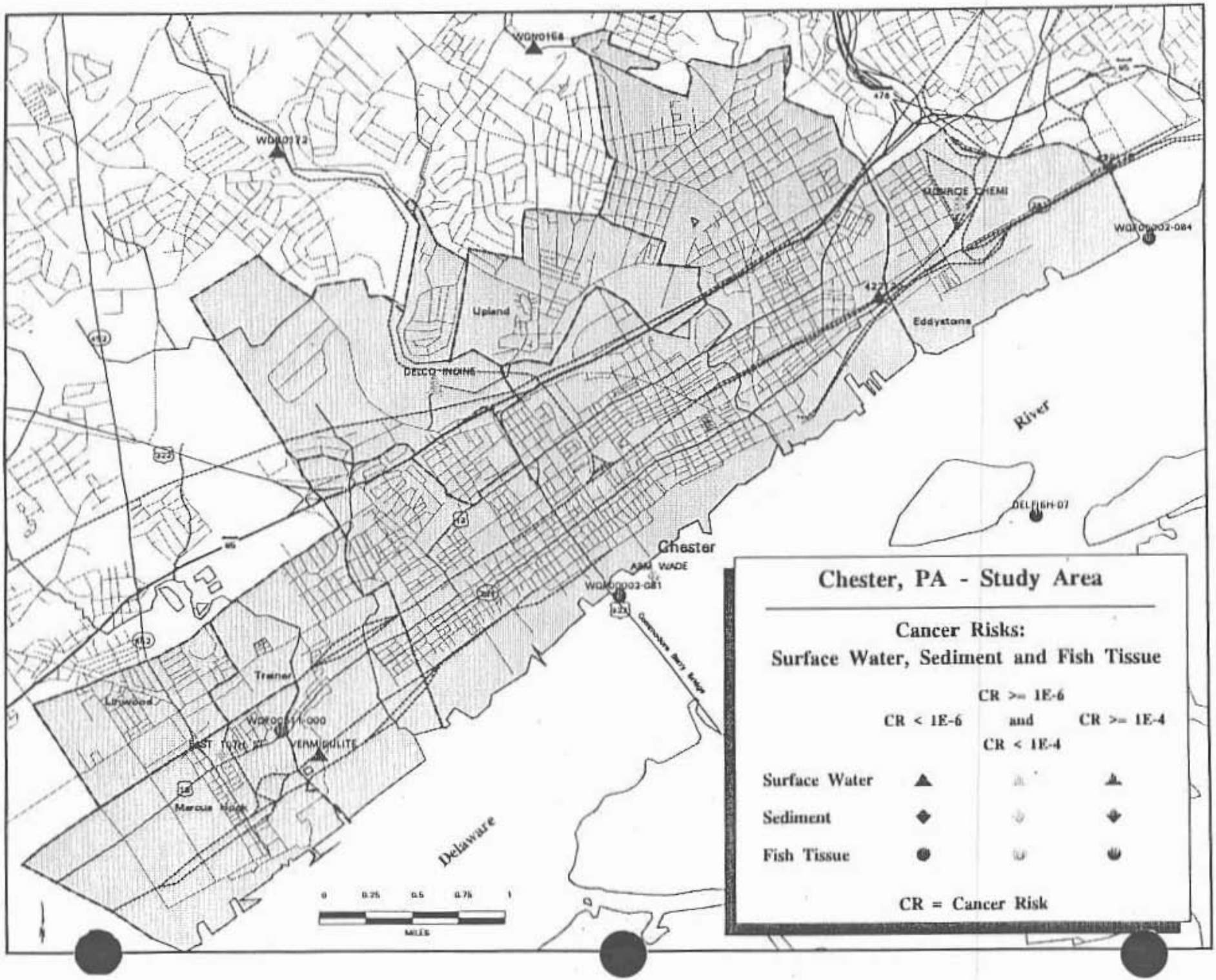

Chester, PA - Study Area
Cancer Risks:
Surface Water, Sediment and Fish Tissue
CR < 1E-6
CR >= 1E-6 and CR < 1E-4
CR >= 1E-4
Surface Water
Sediment
Fish Tissue
CR = Cancer Risk
Upland
Eddystone
Chester
Trainer
Linwood
Marcus Hook
Delaware
River
DELCO-INDINE
ASHLAND WADE
VERMICULITE
0
0.25
0.5
0.75
1
MILES

Figure 4-23

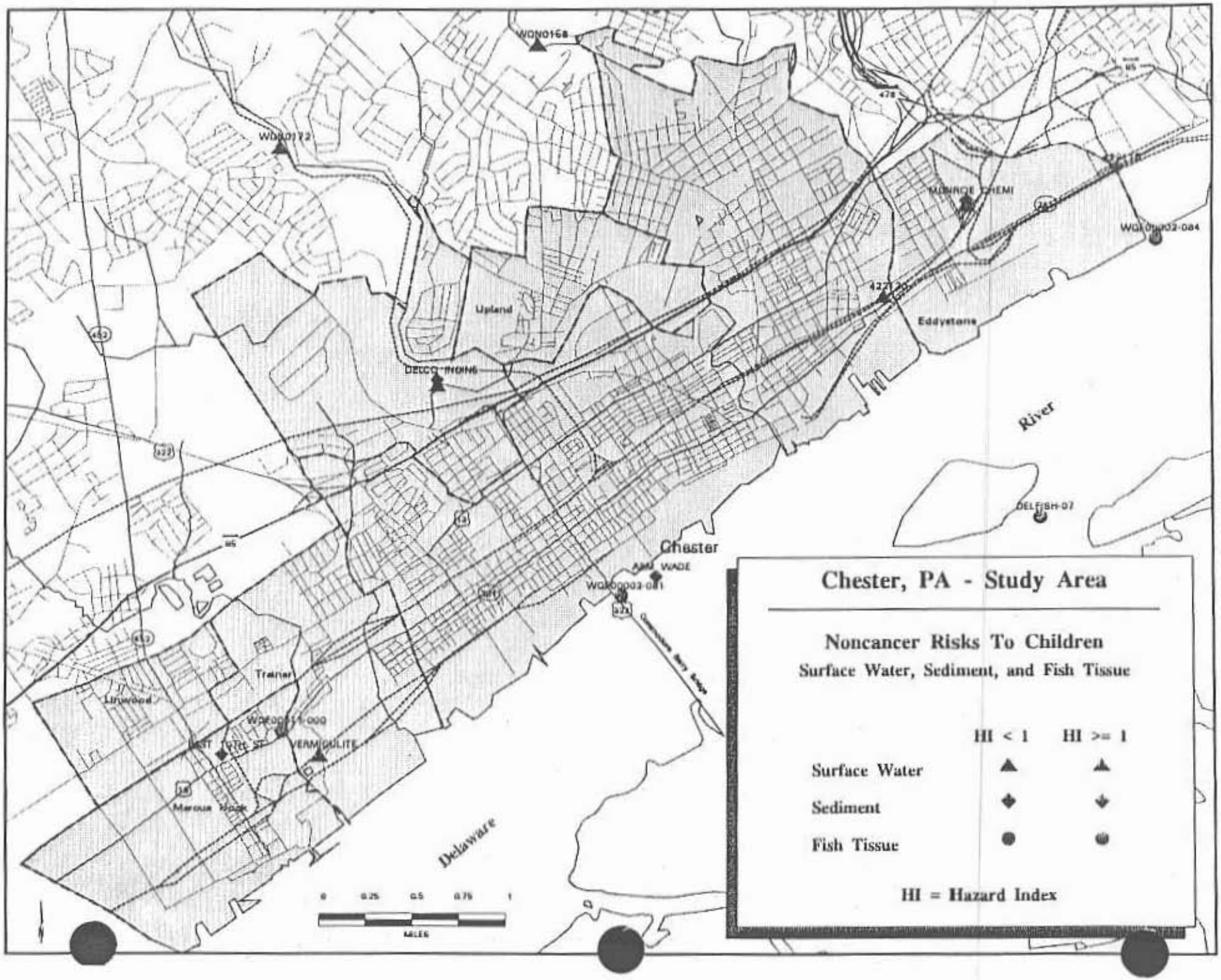

Chester, PA - Study Area
Noncancer Risks To Children
Surface Water, Sediment, and Fish Tissue
HI < 1
HI >= 1
Surface Water
Sediment
Fish Tissue
HI = Hazard Index
Upland
Eddystone
Chester
Trainer
Linwood
Marcus Hook
Delaware
River
DELFISH-07
DECCO-INORG
MORINCE CHEMI
AMI WADE
0 0.25 0.5 0.75 1
MILES

Figure 4-24

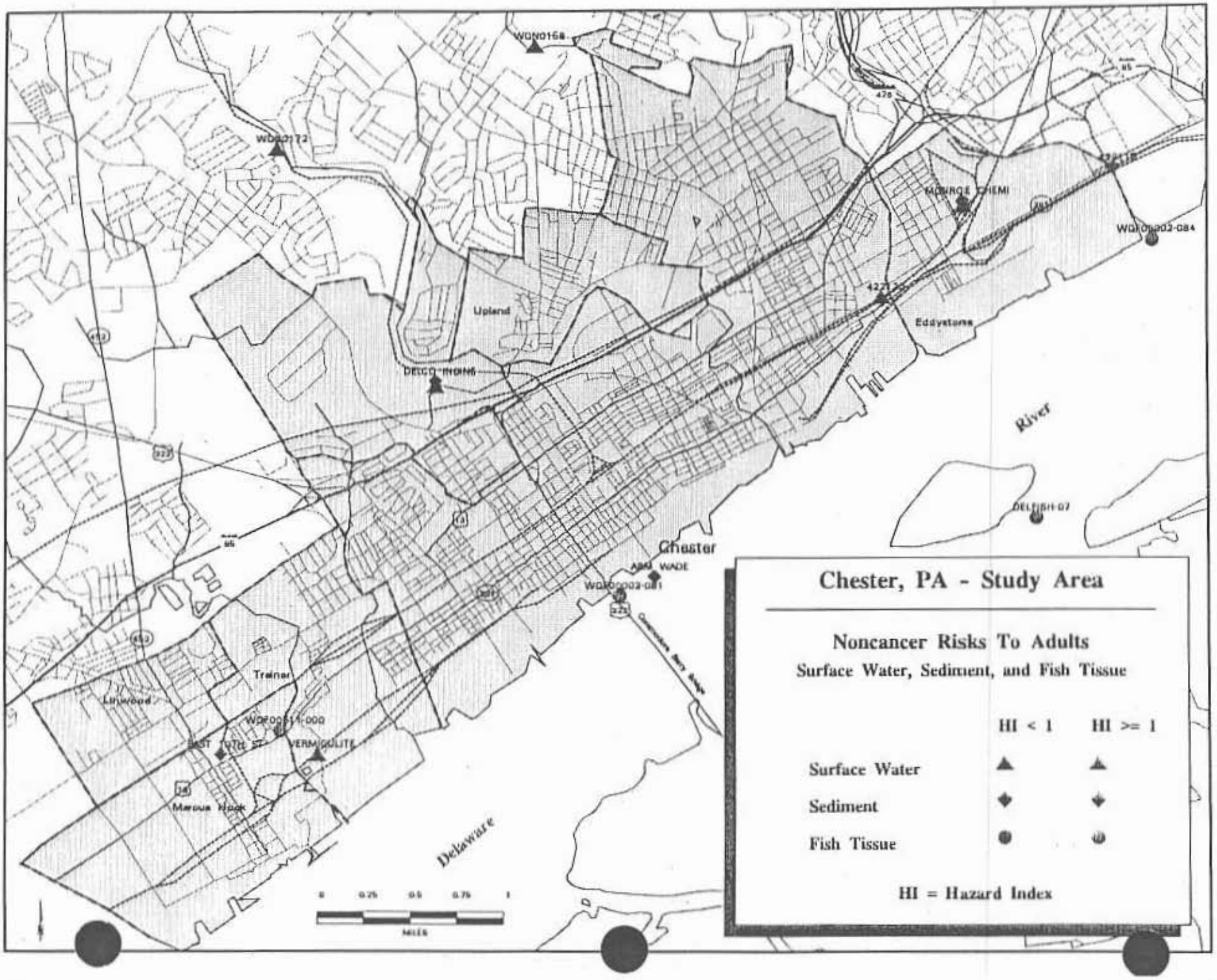

Chester, PA - Study Area
Noncancer Risks To Adults
Surface Water, Sediment, and Fish Tissue
HI < 1
HI >= 1
Surface Water
Sediment
Fish Tissue
HI = Hazard Index
Uplend
Eddystone
Chester
Trainer
Linwood
Marcus Hook
Delaware
River
DELCO-INORM
MONROE CHEMI
ABM WADE
VERM CULITE
EAST 10TH ST
WQN0168
WQN0172
WQF0002-084
WQF0002-081
WQF0611-000
DELFISH-07
MILES

Figure 4-25

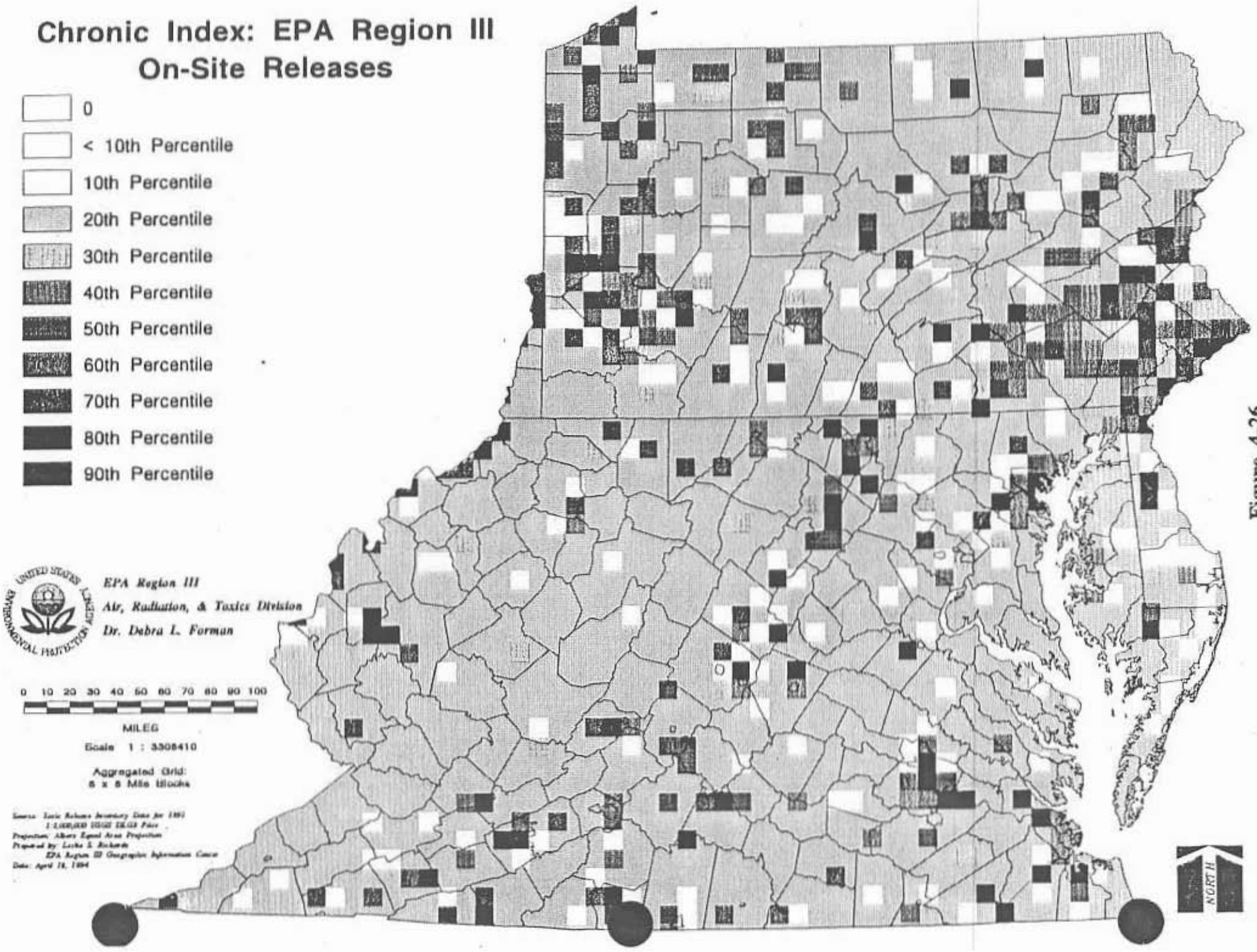

Chronic Index: EPA Region III
On-Site Releases
0
< 10th Percentile
10th Percentile
20th Percentile
30th Percentile
40th Percentile
50th Percentile
60th Percentile
70th Percentile
80th Percentile
90th Percentile
EPA Region III
Air, Radiation, & Toxics Division
Dr. Debra L. Forman
0 10 20 30 40 50 60 70 80 90 100
MILES
Scale 1 : 3308410
Aggregated Grid:
5 x 5 Mile Blocks
NORTH

Figure 4-26

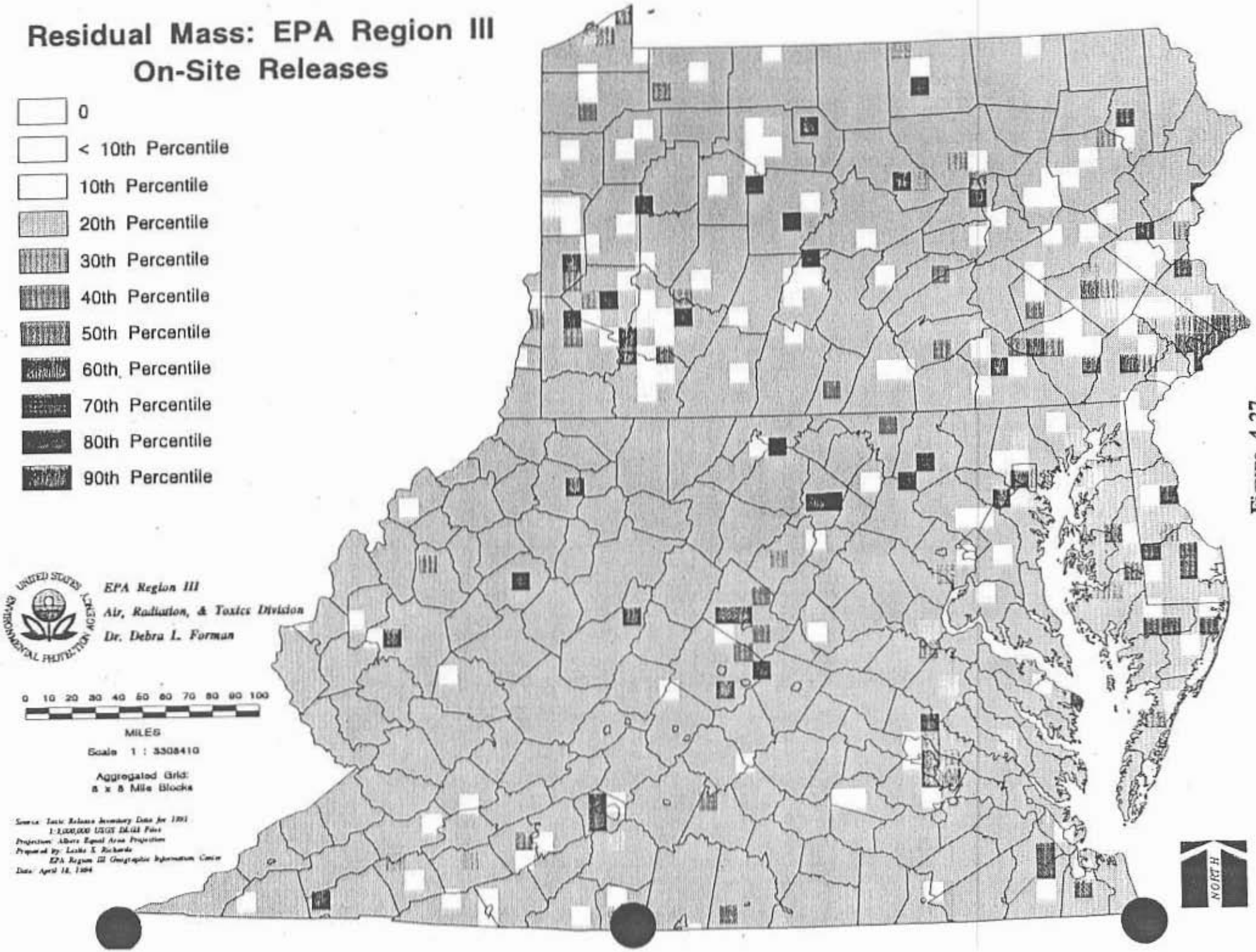

Residual Mass: EPA Region III
On-Site Releases
0
< 10th Percentile
10th Percentile
20th Percentile
30th Percentile
40th Percentile
50th Percentile
60th Percentile
70th Percentile
80th Percentile
90th Percentile
EPA Region III
Air, Radiation, & Toxics Division
Dr. Debra L. Forman
0 10 20 30 40 50 60 70 80 90 100
MILES
Scale 1 : 3308410
Aggregated Grid:
8 x 8 Mile Blocks
NORTH

Figure 4-27

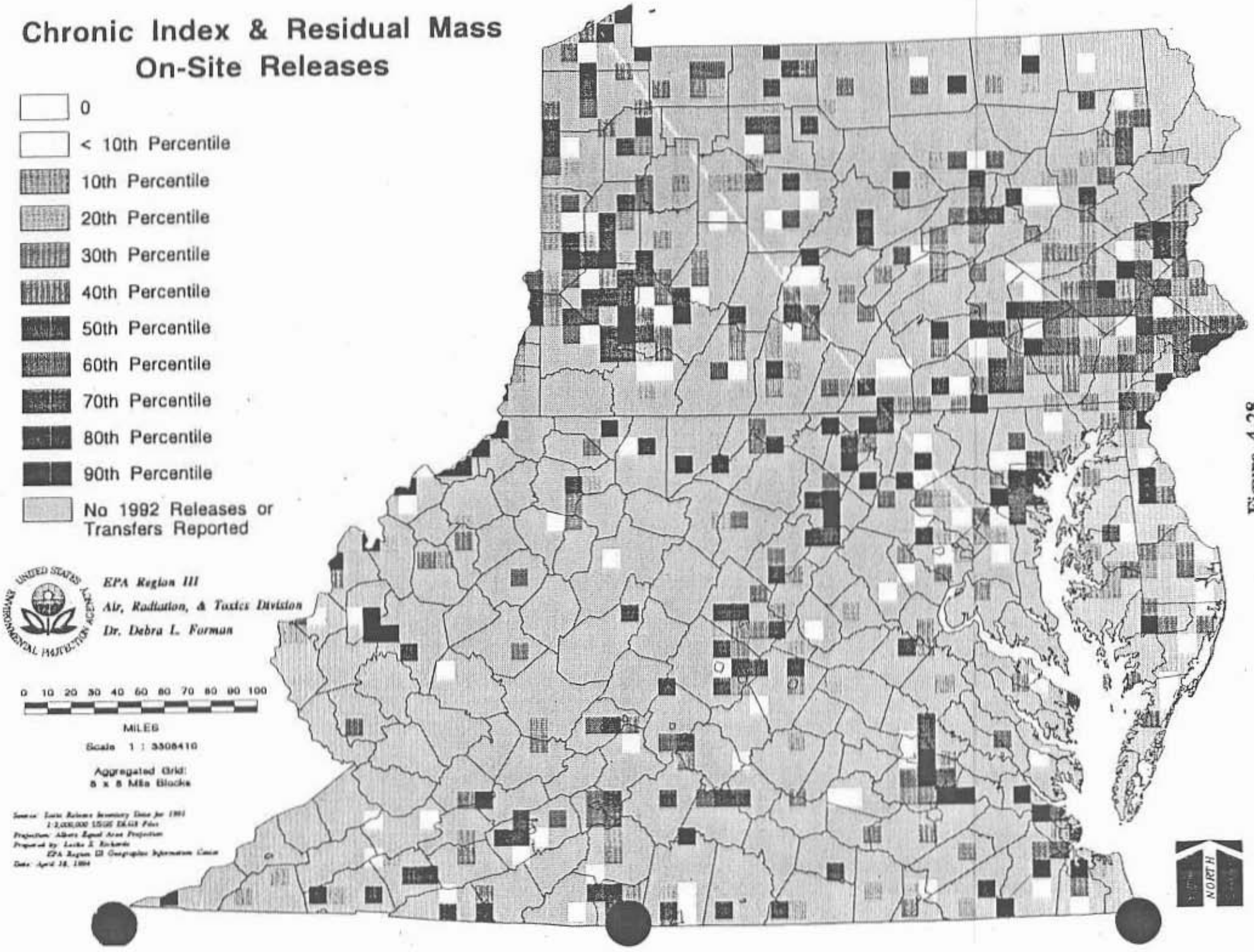

Chronic Index & Residual Mass
On-Site Releases
0
< 10th Percentile
10th Percentile
20th Percentile
30th Percentile
40th Percentile
50th Percentile
60th Percentile
70th Percentile
80th Percentile
90th Percentile
No 1992 Releases or Transfers Reported
EPA Region III
Air, Radiation, & Toxics Division
Dr. Debra L. Forman
0 10 20 30 40 50 60 70 80 90 100
MILES
Scale 1 : 3508410
Aggregated Grid:
8 x 8 Mile Blocks
NORTH

Figure 4-28

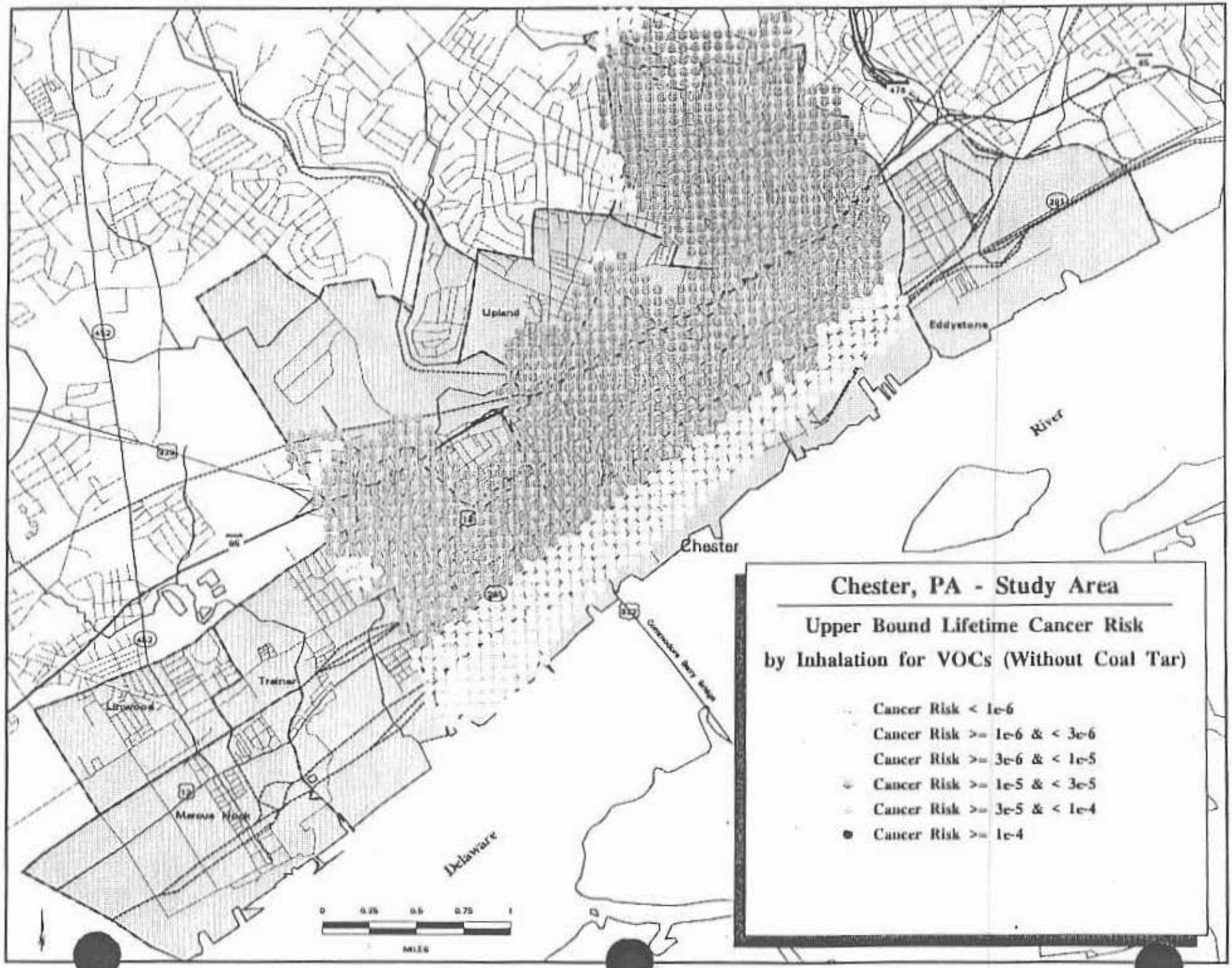

Chester, PA - Study Area
Upper Bound Lifetime Cancer Risk
by Inhalation for VOCs (Without Coal Tar)
Cancer Risk < 1e-6
Cancer Risk >= 1e-6 & < 3e-6
Cancer Risk >= 3e-6 & < 1e-5
Cancer Risk >= 1e-5 & < 3e-5
Cancer Risk >= 3e-5 & < 1e-4
Cancer Risk >= 1e-4
Upland
Eddystone
Chester
Trainer
Lawood
Marcus Hook
Delaware
River
Commodore Barry Bridge
MILES

Figure 4-29

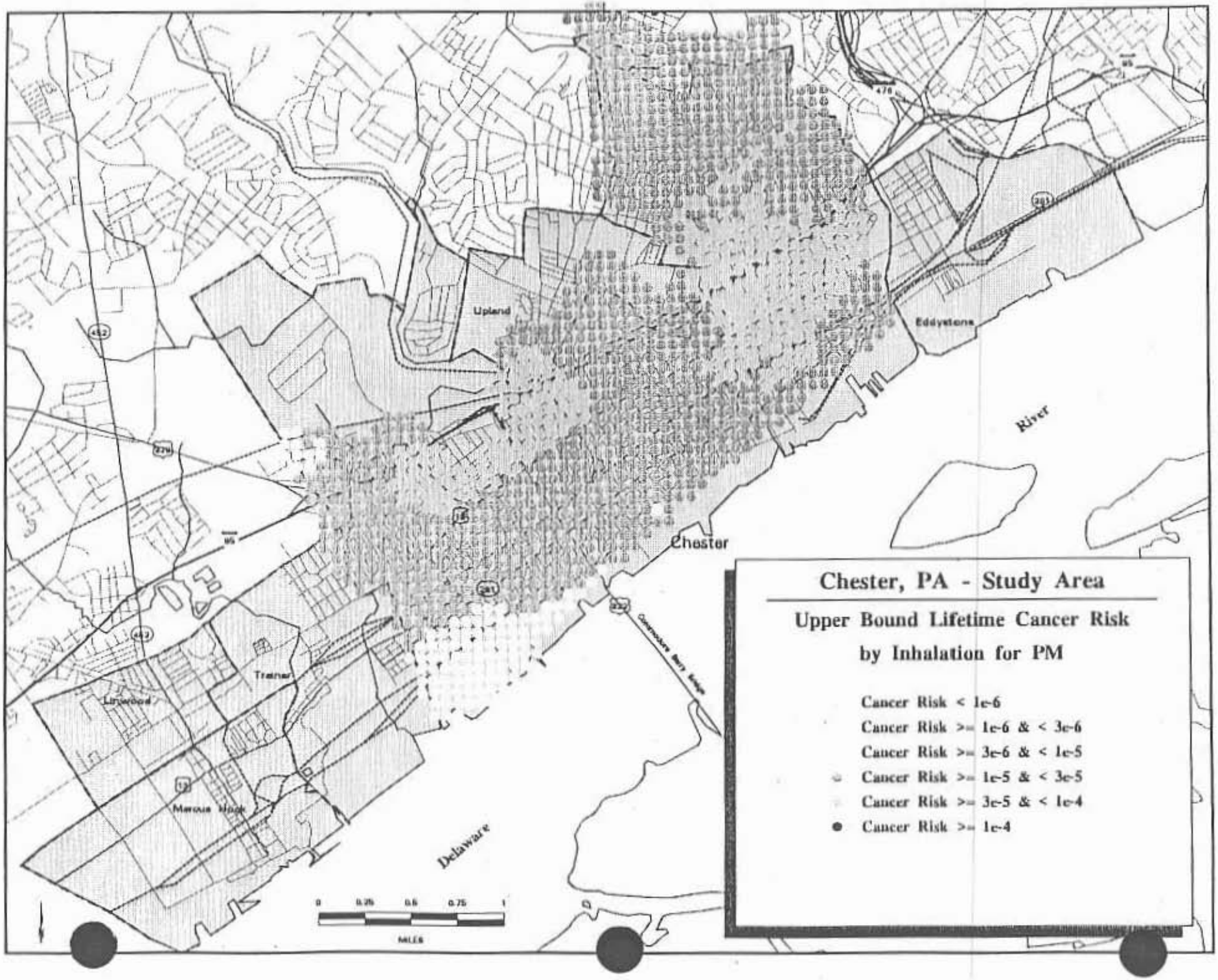

Upland
Eddystone
River
Chester
Trainer
Linwood
Marcus Hook
Delaware
Commodore Barry Bridge
0 0.25 0.5 0.75 1
MILES
Chester, PA - Study Area
Upper Bound Lifetime Cancer Risk
by Inhalation for PM
Cancer Risk < 1e-6
Cancer Risk >= 1e-6 & < 3e-6
Cancer Risk >= 3e-6 & < 1e-5
Cancer Risk >= 1e-5 & < 3e-5
Cancer Risk >= 3e-5 & < 1e-4
Cancer Risk >= 1e-4

Figure 4-30

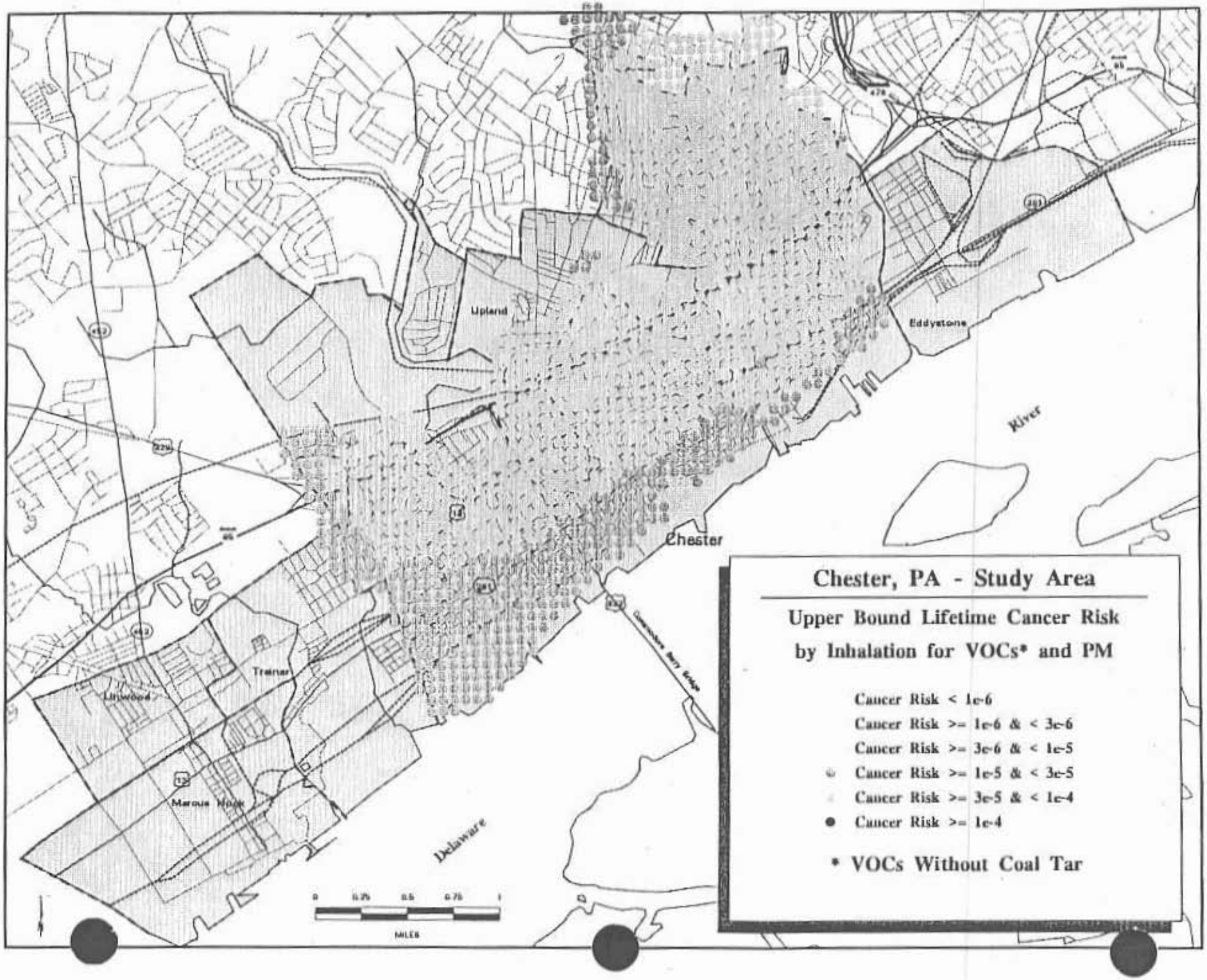

Upland
Eddystone
River
Chester
Tinicum
Linwood
Marcus Hook
Delaware
Commodore Barry Bridge
0 0.25 0.5 0.75 1
MILES
Chester, PA - Study Area
Upper Bound Lifetime Cancer Risk
by Inhalation for VOCs* and PM
Cancer Risk < 1e-6
Cancer Risk >= 1e-6 & < 3e-6
Cancer Risk >= 3e-6 & < 1e-5
Cancer Risk >= 1e-5 & < 3e-5
Cancer Risk >= 3e-5 & < 1e-4
Cancer Risk >= 1e-4
* VOCs Without Coal Tar

Figure 4-31

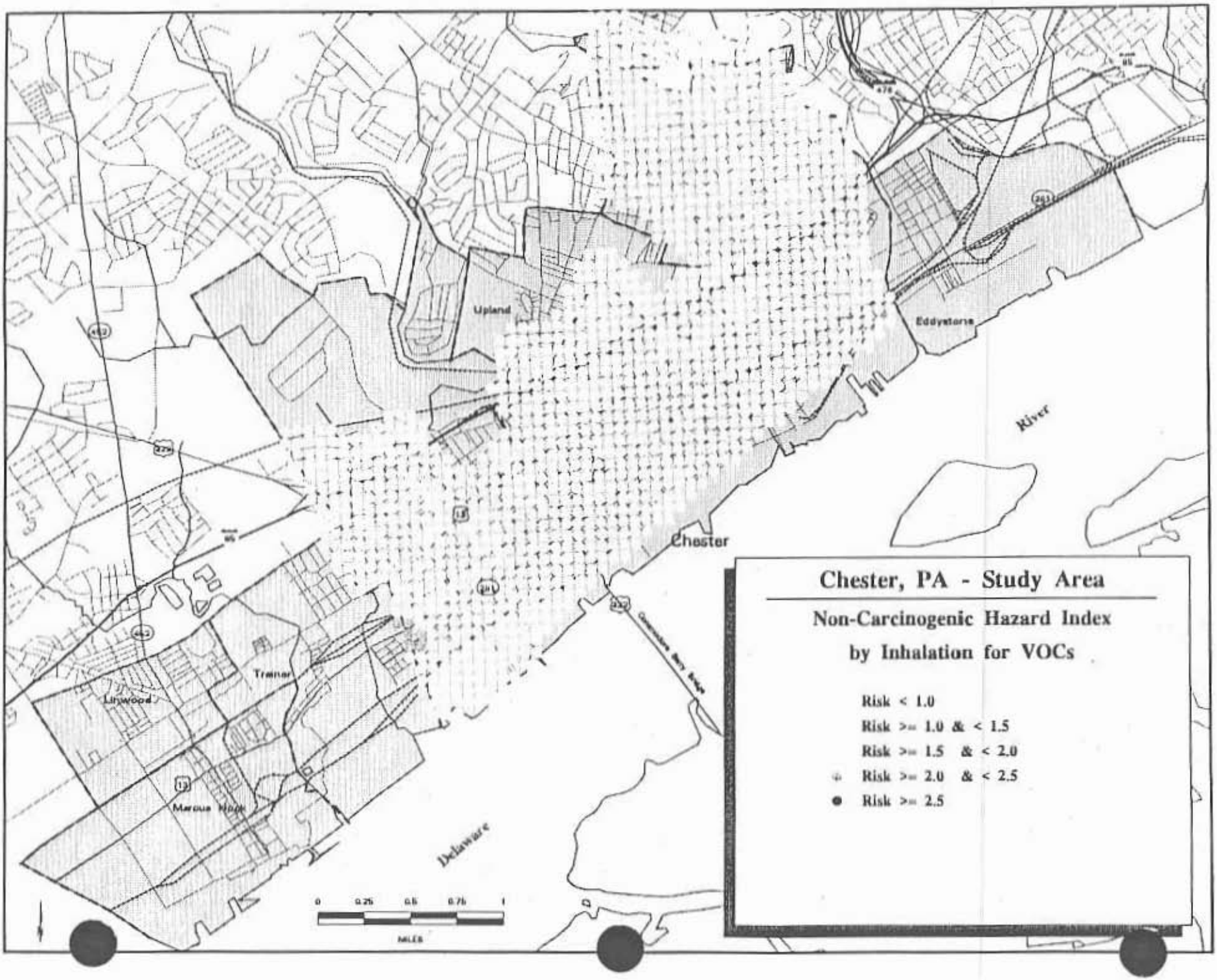

Upland
Eddystone
River
Chester
Tremar
Linwood
Marcus Hook
Delaware
Chester, PA - Study Area
Non-Carcinogenic Hazard Index
by Inhalation for VOCs
Risk < 1.0
Risk >= 1.0 & < 1.5
Risk >= 1.5 & < 2.0
Risk >= 2.0 & < 2.5
Risk >= 2.5
0 0.25 0.5 0.75 1
MILES

Figure 4-32

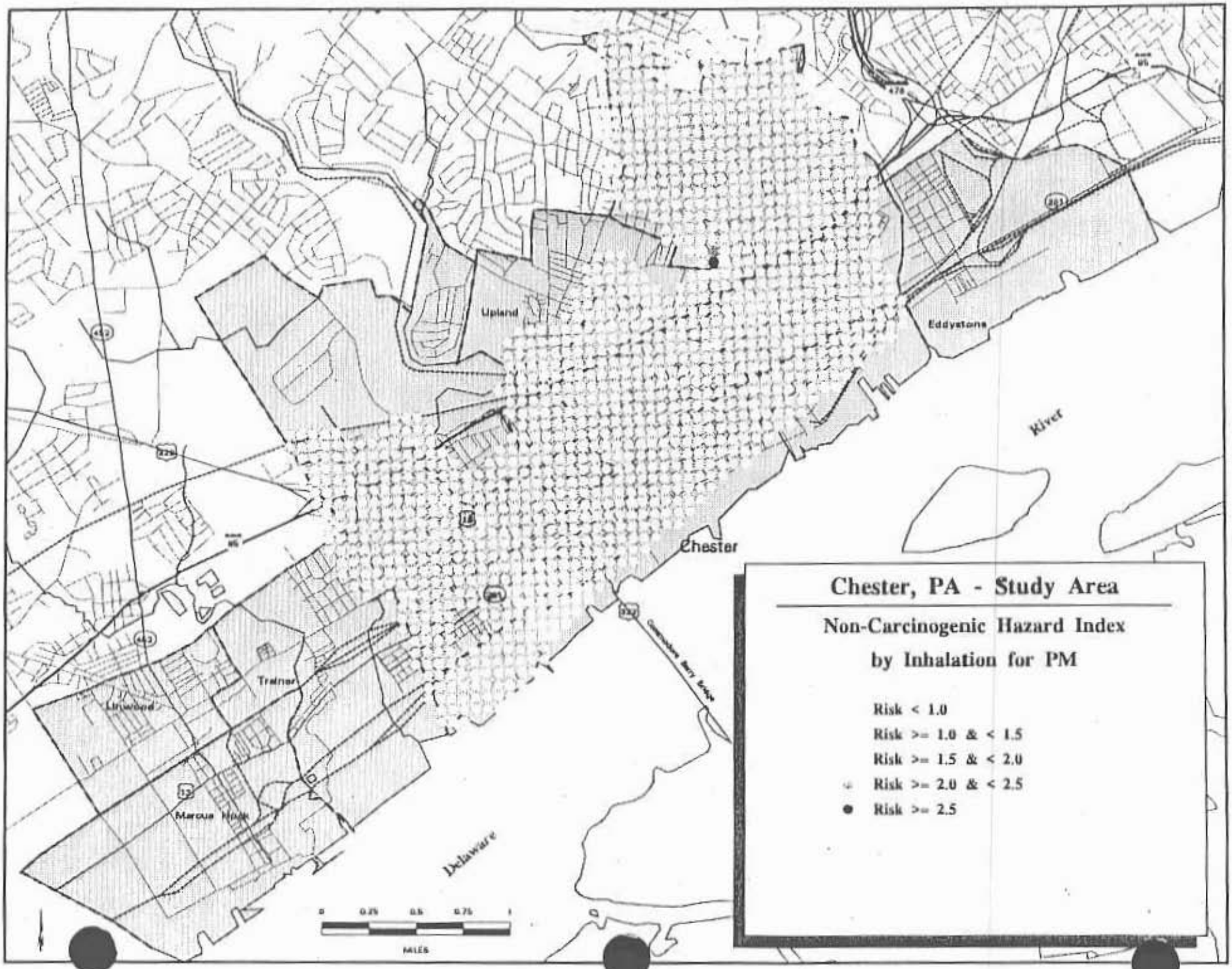

Upland
Eddystone
Chester
Trainer
Linwood
Marcus Hook
Delaware
River
Chester, PA - Study Area
Non-Carcinogenic Hazard Index
by Inhalation for PM
Risk < 1.0
Risk >= 1.0 & < 1.5
Risk >= 1.5 & < 2.0
Risk >= 2.0 & < 2.5
Risk >= 2.5
0 0.25 0.5 0.75 1
MILES

Figure 4-33

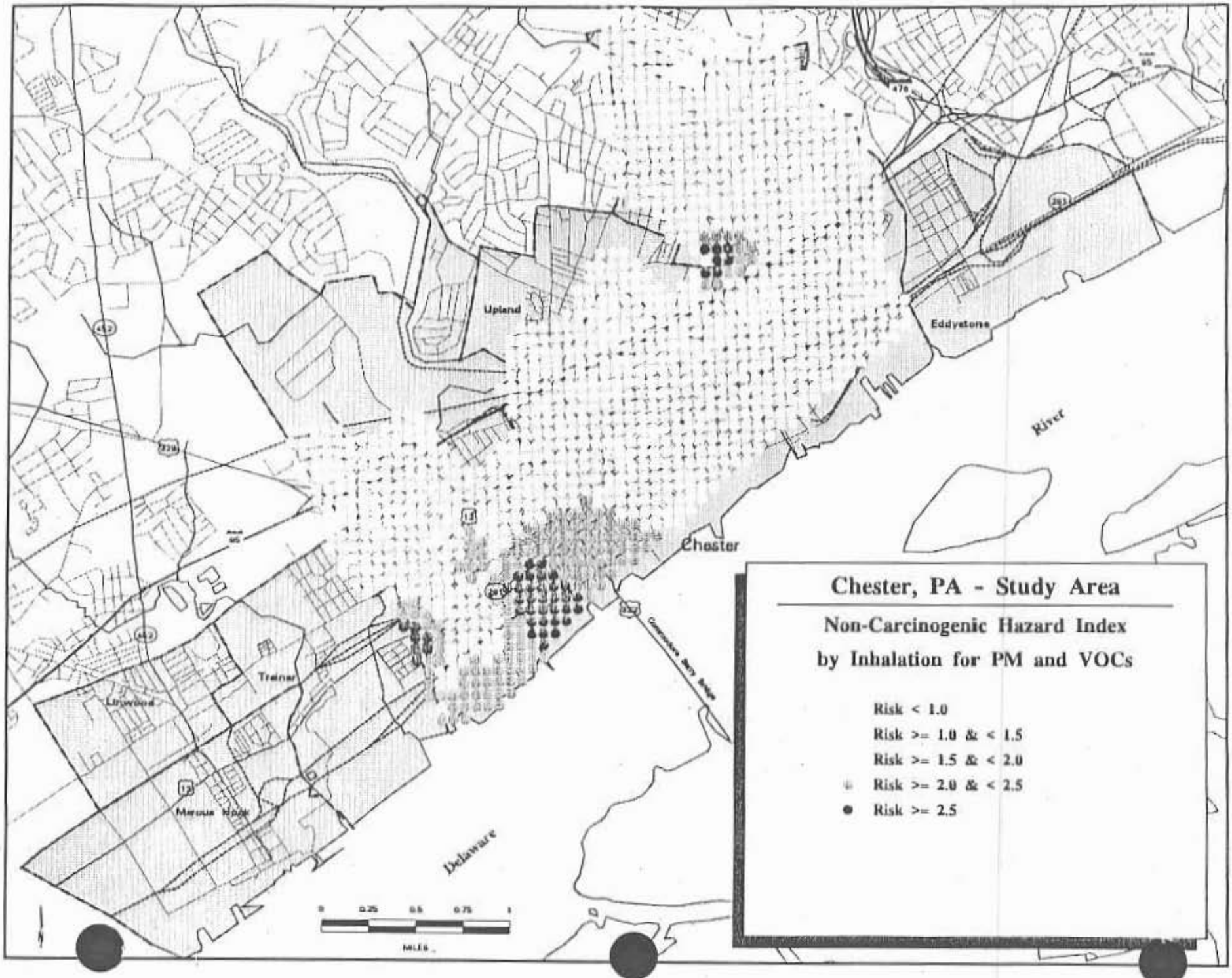

Upland
Eddystone
River
Chester
Trainer
Linwood
Marcus Hook
Delaware
Chester, PA - Study Area
Non-Carcinogenic Hazard Index
by Inhalation for PM and VOCs
Risk < 1.0
Risk >= 1.0 & < 1.5
Risk >= 1.5 & < 2.0
Risk >= 2.0 & < 2.5
Risk >= 2.5
0 0.25 0.5 0.75 1
MILES

Figure 4-34

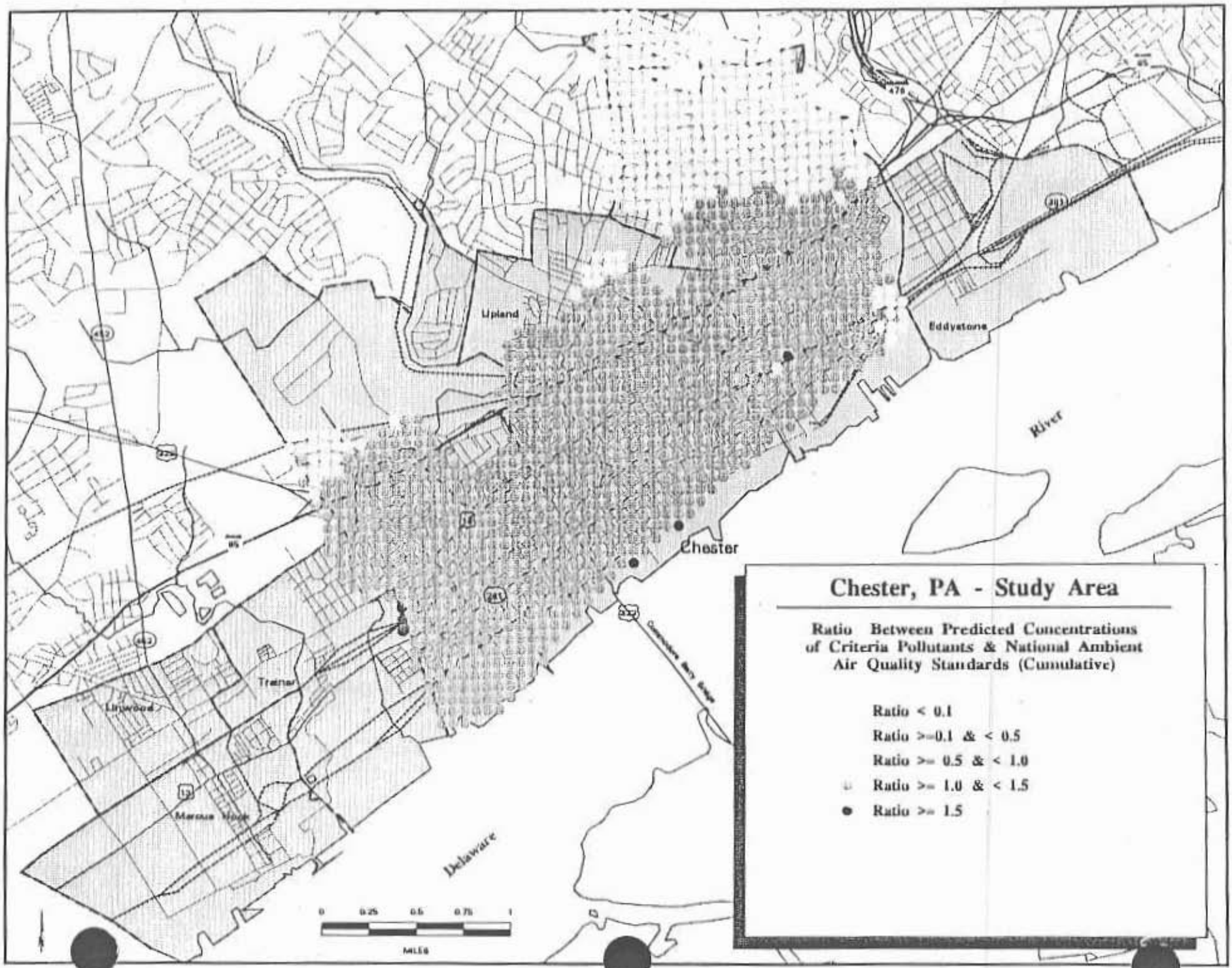

Upland
Eddystone
River
Chester
Trainer
Linwood
Marcus Hook
Delaware
Chester, PA - Study Area
Ratio Between Predicted Concentrations of Criteria Pollutants & National Ambient Air Quality Standards (Cumulative)
Ratio < 0.1
Ratio >=0.1 & < 0.5
Ratio >= 0.5 & < 1.0
Ratio >= 1.0 & < 1.5
Ratio >= 1.5
0 0.25 0.5 0.75 1
MILES

Figure 4-35

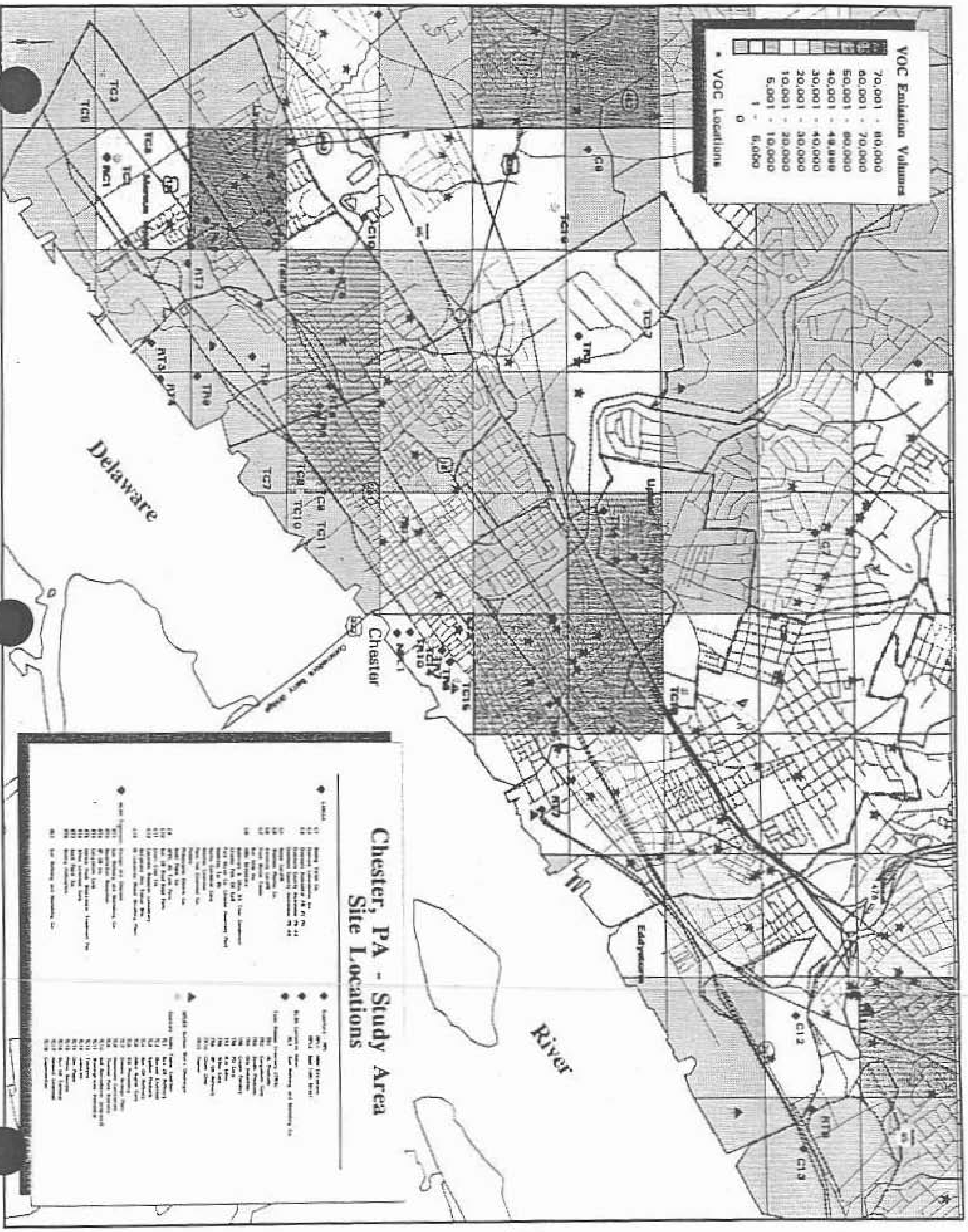

VOC Emission Volumes
70,001 - 80,000
60,001 - 70,000
50,001 - 60,000
40,001 - 49,999
30,001 - 40,000
20,001 - 30,000
10,001 - 20,000
5,001 - 10,000
1 - 5,000
0
VOC Locations
Chester, PA - Study Area
Site Locations
Delaware
River
Chester
Eddystone

Figure 4-36

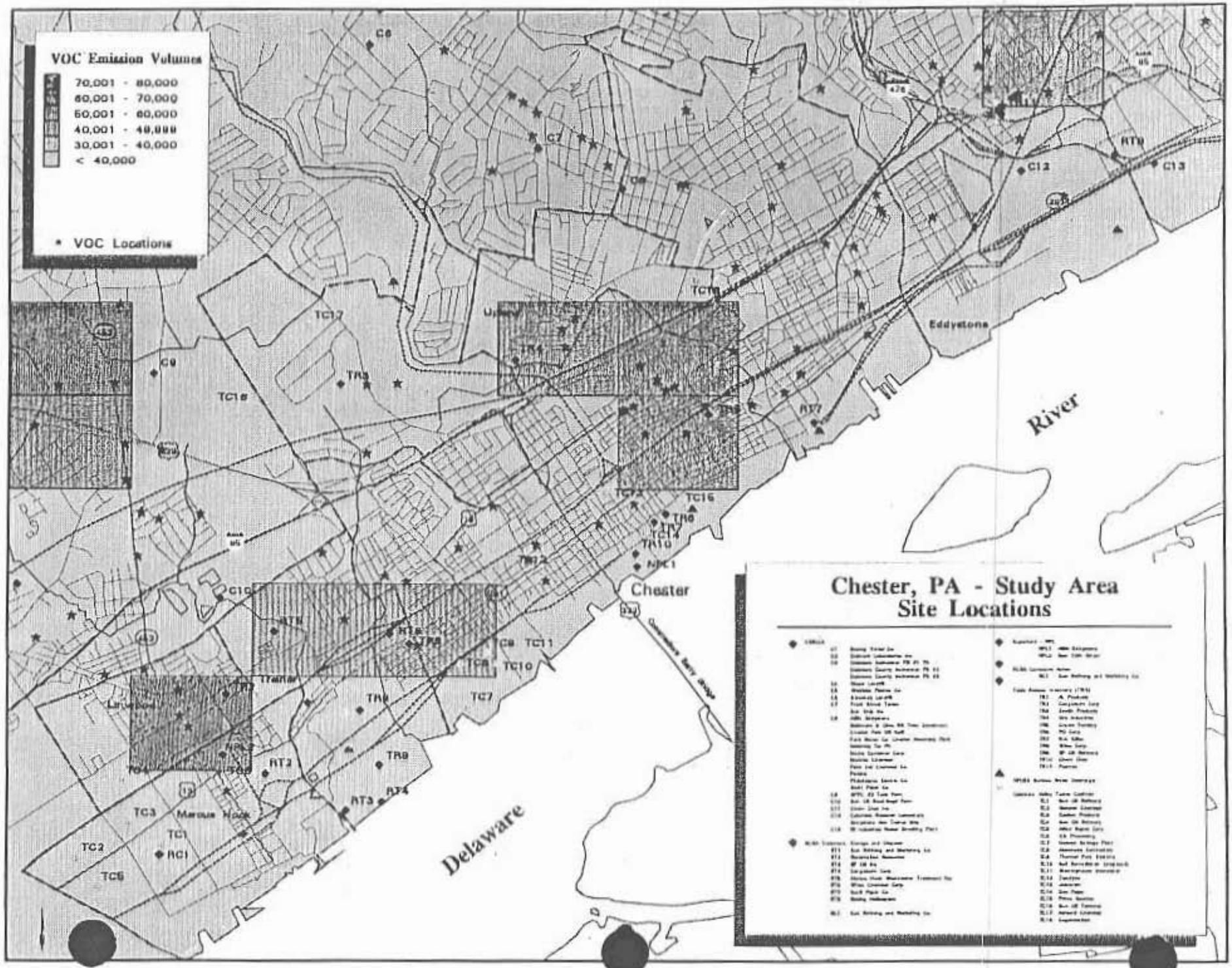

VOC Emission Volumes
70,001 - 80,000
60,001 - 70,000
50,001 - 60,000
40,001 - 49,999
30,001 - 40,000
< 40,000
* VOC Locations
Chester, PA - Study Area
Site Locations
Delaware
River
Eddystone
Chester
Marcus Hook
Trainer
Lamokin
C6
C7
C8
C9
C10
C11
C12
C13
TC1
TC2
TC3
TC5
TC6
TC7
TC8
TC9
TC10
TC11
TC12
TC13
TC14
TC15
TC16
TC17
TC18
TR1
TR2
TR3
TR4
TR5
TR6
TR7
TR8
TR9
TR10
RT1
RT2
RT3
RT4
RT5
RT6
RT7
RT8
RT9
RC1
RC2

Figure 4-37

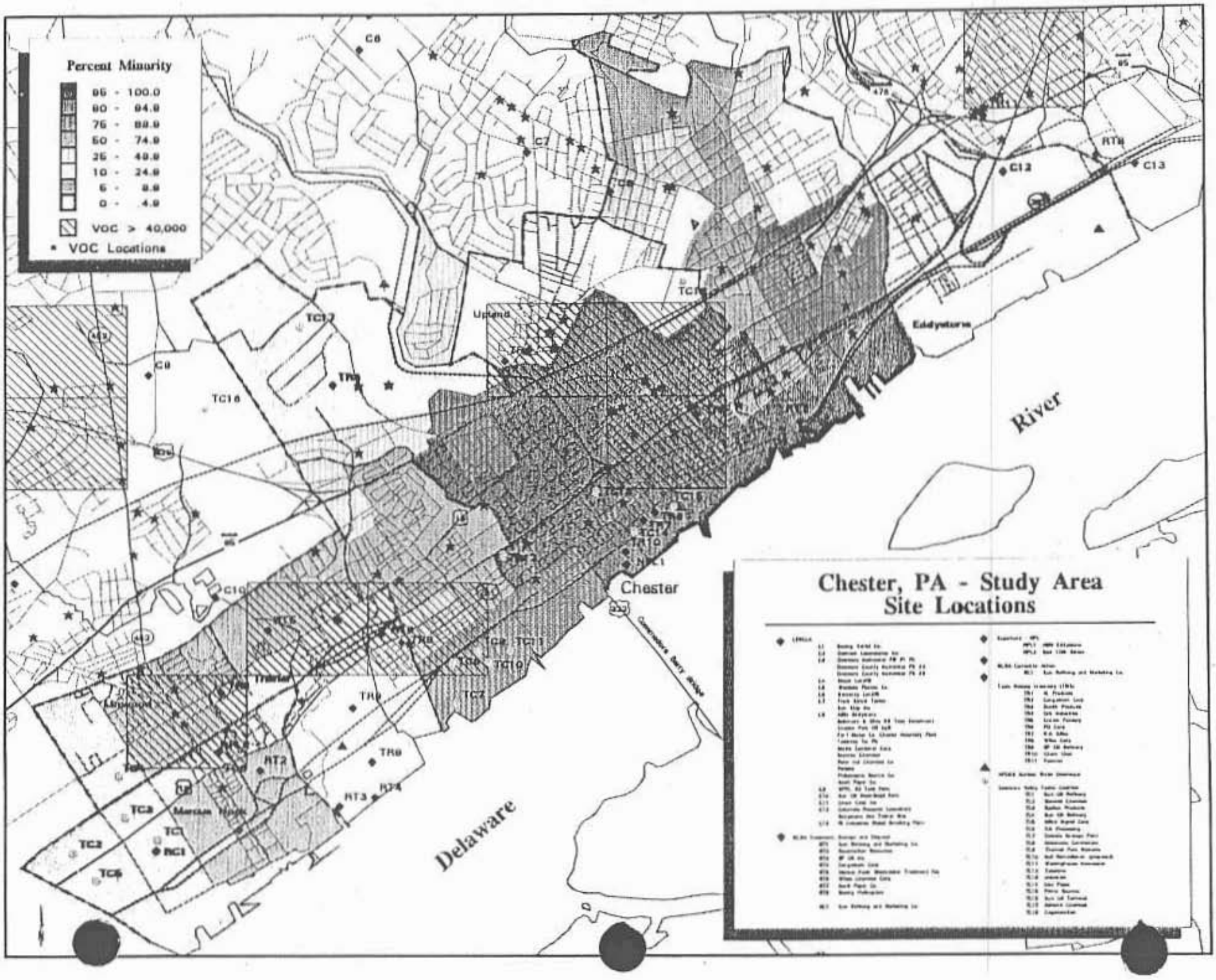

Percent Minority
85 - 100.0
80 - 84.9
75 - 79.9
50 - 74.9
25 - 49.9
10 - 24.9
5 - 9.9
0 - 4.9
VOC > 40,000
VOC Locations
Chester, PA - Study Area
Site Locations
Delaware
River
Chester
Upland
Eddystone
Marcus Hook
Trainer
Linwood
C6
C7
C8
C9
C10
C12
C13
TC1
TC2
TC3
TC5
TC6
TC7
TC8
TC9
TC10
TC11
TC12
TC13
TC16
TR1
TR2
TR3
TR4
TR5
TR6
TR7
TR8
TR9
TR10
RT2
RT3
RT4
RT5
RT6
RC1

Figure 4-38