COMMUNITY ENVIRONMENTAL PROFILES – A TOOL FOR MEETING ENVIRONMENTAL JUSTICE GOALS:

An Analysis of the City of Wilmington

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for the
Science, Engineering &Technology Services Program

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Preface

It is a pleasure to present you with this report of the 2002 Science, Engineering & Technology (SET) Services Program. The report is designed to provide the Delaware General Assembly and the citizens of this State with an environmental profile that encompasses social, economic and environmental conditions in the City of Wilmington.

CEEP received valuable assistance in preparing this report from many individuals in academia, state and local government. We owe our debt to Sally Wasileski, analytical chemist, and Terra Dassau, atmospheric chemist, both PhD. students at Purdue University Department of Chemistry. Their technical expertise of the properties and conversion equations of the chemical compounds discussed in this report was a critical component of our analysis. We would also like to show our gratitude to Marcos Luna of the University of Delaware for his GIS expertise. The staff of the Water Resources Agency has also contributed a great deal of GIS knowledge and technical information. We would like to specifically thank Gerald Kauffman, Vern Svatos, Martin Wollaston and Justin Bower for their tireless help. DNREC also supported our research efforts and assisted us in obtaining essential information. We would like to specifically show our gratitude to David Fees, William Fischer, Betsy Frey, Rick Greene, R. Peder Hansen, Karissa Hendershot, Paul J. Janiga, Lynn Krueger and Dennis Murphy. The health data in this report depended upon our cooperation with the Delaware Health Statistics Center and the Department of Public Health. We would like to express thanks to Mawuna D. Gardesey, Ted Jarrell, Tony Ruggierio, and George Yoker, as well as Dr. Jaime Figueras of the City of Wilmington for their assistance. We would also like to thank Tom Fikslin of the Delaware River Basin Commission and Bijaya Cherya of the City of Wilmington Water Quality Laboratory.

I hope that this report will be useful in your discussions and deliberations on sustainability issues regarding our towns and neighborhoods. With knowledge of the environmental concerns faced by our communities and existing policy responses, the communities of our State can be leaders in building a livable future for Delaware.

John Byrne
Director

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EXECUTIVE SUMMARY

1. Introduction

National efforts to address the issue of environmental justice (EJ) include the 1994 adoption of Executive Order (EO) 12898.[1] This order directs federal agencies to achieve environmental justice as part of their mission by identifying and addressing "disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations" (President of the United States, 1994).

The Delaware Department of Natural Resources and Environmental Control (DNREC) has recognized the need for a state-level response consistent with national policy. In this regard, DNREC recently established a Community Involvement Advisory Committee to develop recommendations for actions and procedures that ameliorate community stresses associated with existing conditions of disproportionate environmental risk to reduce the likelihood of future disproportionate risk. One recommendation currently under review by the Committee involves analysis of, and public access to, a statewide database of social and environmental stress indicators within communities. According to the Committee, a community-level environmental profile could provide a common source of information for everyone to consider, from grassroots groups to industries, regarding the siting of industrial facilities and the making of environmental decisions.

This project creates a GIS-based community-level environmental profile in which social and environmental stresses are mapped by community boundary. More specifically, a community environmental profile (CEP) is developed as an objective source of information for understanding the pattern of social-environmental risks in the State. It is based on a pressure-state-impact-response (PSIR) model, a modification of the pressure-state-response (PSR) model that is widely used as a tool in environmental policy research (OECD, 1998).

2. Status of Existing Research

Research has revealed a limited amount of literature on environmental profiles for Delaware or cities within the State, including Wilmington. However, there have been recent efforts at the State and regional levels to develop environmental indicators. This information is presented on an aggregated level -- e.g., for DNREC's Whole Basin Management Program and the Delaware Estuary Program. A CEP contributes to our understanding of indicators on a more focused geographical level -- the City of Wilmington and its communities.

To be relevant for policy purposes, indicators used in the CEP should provide a representative picture of pressures on a community and its environmental conditions, how such pressures might affect communities and their environment (qualitatively and quantitatively), and available community responses. Indicators selected for the

[1] 59 Fed. Reg. 7629 (Feb. 11, 1994).

Wilmington profile reflect the interaction of natural and socioeconomic factors in the environment. These include air, land, water and socio-economic characteristics.

3. The City of Wilmington

The growth and prosperity of Wilmington, including the growth of industries, commerce, population and use of automobiles have all had, and will continue to have, short- and long-term effects on the City's environment. Consideration of the environmental impacts of economic activity is necessary, not only to understand the dynamics that have led to economic development, but also to initiate policies that enable the City to avoid repeating past mistakes.

Wilmington faces pressing ecological problems. The production of new products and the interaction between these newly created compounds and the environment result in unforeseen changes to the biology and chemistry of ecosystems. This is in addition to more familiar stress factors such as urbanization and increases in automobile traffic, which have also elevated air pollutants.

These ecological problems will have to be addressed as quickly as possible if the City is to play an integral role in attaining the goals of the "Livable Delaware" agenda initiated by Governor Minner. This profile will provide a benchmark by which progress or regress of environmental conditions can be determined.

4. Air Quality

Air Quality indicators for Wilmington are divided into two main categories: criteria air pollutants and air toxins. Criteria air pollutants are managed under the Clean Air Act (CAA) 1970 (as amended in 1990), while all other air pollutants, including air toxins, are not yet under any regulatory framework. The Clean Air Act established National Ambient Air Quality Standards (NAAQS) for six pollutants ("criteria" pollutants) -- ozone (O_3) carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter (PM_{10}) and lead (Pb) (DNREC, 1996). These standards represent the level at which the pollutants are considered dangerous to human health.

Delaware has been in attainment of NAAQS standards for all criteria air pollutions except ozone, for the past ten years. New Castle County has failed to meet attainment levels for ozone every year for the past 18 years, except for 1996. The county has been classified as in "severe" non-attainment for ozone. Delaware's main air quality goal has been to reduce ozone to the ambient levels stipulated by the CAA, with a special focus on Wilmington, its largest and, perhaps, most polluted city. The State has not tested for ambient lead levels since 1989. Between 1978 and 1988 ambient levels plunged by 94% due to the removal of lead from gasoline.

The City of Wilmington and its environs are also home to 13 Toxics Release Inventory (TRI) sites, the majority of which are located in the southern half of the City. Pollutants released from these sites are largely emitted into the local atmosphere, some in quantities that have been found to cause health problems. Other chemical releases, those not captured by the TRI, are also of concern. Ambient levels of a number of chemical pollutants are currently tested by the State of Delaware at the Wilmington monitoring station. The State monitors for 41 air toxics in Wilmington in order to establish baseline concentrations to detect future changes. This will provide a point to compare Wilmington levels with other areas. Because there are no ambient air standards for air toxics, this data cannot determine if Wilmington's air quality is meeting a standard.

Response

To implement federal air quality standards the State has established, within DNREC, a Division of Air and Waste Management (DAWM) responsible for enforcing air pollution and waste management standards. DAWM has a separate specialized section, the Air Quality Management Section (AQMS), specifically designed to enforce the NAAQS.

The City of Wilmington has the authority to take action against polluters, especially in areas that are not directly covered by the Federal government and the State. This power to regulate the environment is embodied in the Wilmington City Code, as revised September 6, 2001. The City does not have an environmental department and therefore continues to rely heavily on the State for enforcement of air quality standards. However, it can, and in practice does, circumvent these restrictions through the Code and Ordinances that regulate land use and nuisance type of activities with a view to maintaining the health and welfare of its residents. The City can also regulate environmental quality through land use planning, specifically through zoning laws.

5. Land

The main sources of pressure on the state of land in Wilmington include underground storage tanks (USTs), abandoned tannery sites, hazardous waste generating operations and industrial sites. The City is home to 453 UST, 20 of which are currently active, and DNREC has identified 53 former tannery sites. Issues of concern at these sites include:

- potential health risks, especially among children;
- current use of the site;
- presence and extent of bare surface soils;
- current construction and excavation; and
- other earth-disturbing activities.

The health risks of abandoned tannery sites result primarily from the use of arsenic in tanning processes. Arsenic remains in the soils of these sites.

There are also a number of facilities that generate hazardous waste as part of industrial and commercial processes. 24.47% of all land in Wilmington is contaminated. Arsenic, lead and PCBs -- the most dangerous chemicals -- have been found at numerous sites within the City at levels that exceed the limits for risk based concentrations (RBC) for exposure to carcinogenic and non-carcinogenic soil contaminants as established by the EPA.

Response

The federal Superfund program was established to manage the cleanup of a National Priority List of contaminated sites across the country. At the State level, Delaware's 1990 Hazardous Substance Cleanup Act (HSCA) established a Site Investigation and Restoration Branch (SIRB), which is mandated to manage designated sites suspected of releasing hazardous substances. There are 132 SIRB sites in the City of Wilmington.

6. Water

Water Quality

Water quality in the City of Wilmington is influenced by indirect factors such as air quality and land contamination, and direct pressures, including waste water discharges, sewer overflows and storm water runoff.

Combined Sewer Overflows (CSOs) contribute a significant amount of PCBs to Delaware's Waterways. The City of Wilmington has 37 CSOs, sixteen of which are located in the Christina River watershed, 20 on the Brandywine River and 1 in the Shellpot Creek watershed. During periods of wet weather PCB levels may increase by 386%, and account for 88.3% of the total PCB loadings.

Within the City there are also several sites at which pollutant discharges are permitted under the National Pollution Discharge Elimination Program (NPDES). Through NPDES the State regulates point source pollution into water bodies. There are16 general NPDES permit holders and six individual permit sites in the City.

Impervious cover also negatively impacts water quality. The City is partitioned into three watersheds -- Christina River, Brandywine River and Shellpot Creek -- all three having impervious cover in excess of 51%. The Christina watershed, comprising the southwestern portion of Wilmington, is highest at 60%. Storm water runoff due to impervious cover places increased demands on a sewage system comprised of combined sewer overflows, increasing the likelihood that raw sewage will overflow into the City's rivers.

Fish contamination is the leading indicator of water quality in Wilmington. Contaminants entering the water from point and non-point sources have had negative impacts on the fish population, leading the State to issue fish consumption advisories. All water bodies within the City have fish consumption advisories. Advisories concerning PCBs have been issued for all water bodies; arsenic, dioxin and chlorinated pesticides for the Delaware River; dioxins for the non-tidal BrandywineRiver; chlordane for Shellpot Creek; and dieldrin for the tidal Christina River. Levels of mercury in the fish in the Brandywine and Christina Rivers are above the minimum daily consumption limits for chronic toxicity for a 100-pound person, and levels in Shellpot Creek are just below this consumption threshold.

Water Supply and Demand

The key issue regarding water supply and demand is periodic drought. New Castle County has faced a number of periods of water shortage within the past five years.

The City of Wilmington Public Water Supply System serves a population of 140,000 people within a service area of 40 square miles. The normal daily water demand of 25 million gallons per day (mgd) can increase to as much as 36 mgd during periods of peak demand. The City has a maximum intake capacity of 44 mgd -- provided sufficient water flow in the Brandywine River -- and a treatment capacity of 56 mgd at its two water treatment plants. Despite monthly fluctuations in water demand, the amount of withdrawals has remained relatively stable during the past 15 years.

Response

Water Quality

The first significant piece of legislation that was created to protect the nation's water quality was the Clean Water Act (CWA) of 1972, which requires industries to meet pollution control standards, and instructs States to set individual water quality standards and develop pollution control programs. Congress recognized the need to address non-point source pollution when it reauthorized the CWA in the Water Quality Act of 1987, the key component of which was the Non-point Source Management Program (NSMP), Section 319. Although no standards were set, states were instructed to conduct studies and provide plans for diffused pollution abatement. Congress authorized $400 million for the NSMP. Over the 15 years since it became law, Congress has granted over $8.2 million to EPA Region 3 -- Delaware, Pennsylvania, Virginia, West Virginia and Washington D.C. Within this Region overall funding has ranged from $826,446 for Delaware to $2.4 million for Pennsylvania.

For the purpose of eliminating pollutant discharges through regulatory action, the Federal Water Pollution Control Act Amendments established the NPDES permit program in 1972. State and federal law mandates that all discharges to surface waters must have a permit administered through the NPDES. The Surface Water Discharges Section (SWDS) of DNREC's Division of Water Resources has been delegated authority to direct the program within the State of Delaware. Regulatory control is mandated by the EPA through Section 402 of the federal Clean Water Act, as amended, and Title 7, Part VII, Chapter 60: "Environmental Control" of the Delaware Code. Federal regulations also address combined sewer overflows (CSOs).

At the local level, the Wilmington Wastewater Treatment Plant (WWTP) serves the larger region of New Castle County and a small portion of Pennsylvania. The City of Wilmington has been providing its customers with an annual water quality report since 1999, in compliance with federal specifications. Water samples met the minimum requirements specified by the EPA.

Water Supply and Demand

Wilmington follows a water conservation program that is under the jurisdiction of the Delaware River Basin Commission (DRBC). The DRBC recommends new water conservation measures to state enforcement agencies (e.g., DNREC), facilitates water conservation awareness among stakeholders, recommends and approves water conservation rate structures for investor-owned utilities and makes demand-side management recommendations to utilities.

At the state level DNREC, the Public Service Commission (PSC), and Delaware's Water Resources Agency (WRA) manage policies that govern water resources. DNREC allocates the responsibility among its Division of Water Resources, Division of Soil and Water Conservation, and Division of Fish and Wildlife.

The City of Wilmington applies a flat rate to its water customers. Flat rates apply a uniform rate to customers regardless of level of consumption, in comparison to inclining block rates that apply an increase in price as water consumption increases.

7. Socio-Economic Profile

According to the 2000 Census, the population of Wilmington is 72,327, with 28,554 households. The highest concentrations are in the northeastern part of the City Lowest concentrations are in the east, where the landfill is located, and in the center. There are 5,214 children under the age of 5 years, the highest proportions of whom live in the southern portion of the City.

The spatial distribution of population is clearly defined along racial lines. African Americans reside primarily in the eastern part of the City; White residents live in the northwest. There is also a defined Hispanic presence in west-central Wilmington.

In 1990, 26,350 people, or 38% of the residents of Wilmington, were within 200% of poverty, with the highest concentrations in the southern part of the City. The southern and eastern sections have the highest proportions of households with incomes less than $10,000, and the northeastern section has the highest proportion of wealth, with household incomes greater than $100,000. Unemployment is also greater in the southeastern portion of the City.

Although zip code boundaries do not match the City's municipal boundary, clear patterns in residents and recipients of public assistance within the City boundary can be observed. For example, more adult food stamp recipients reside in zip codes that fall within the City limits, than in zip codes that fall outside the City. A similar pattern is observed among child food stamp recipients, and for families who receive Delaware's "A Better Chance Welfare Reform."

Compared to other cities the total family tax burden in Wilmington is considerably high, especially for low-income residents. In 1999 residents of Wilmington paid disproportionately higher taxes than residents of Dover or Seaford.

Residential electricity rates in Wilmington are comparable to other cities in the U.S., while industrial service rates are much lower. There is a heavy reliance on coal for electricity generation.

Some census tracts have up to 25% of adult residents with less than a 9th grade education. Adults with higher levels of educational attainment live primarily in the northwestern portion of the City.

There are 31,242 housing units within the City of Wilmington, 15,177 of which are owner-occupied. The distribution of owner-occupied and renter-occupied housing, as well as housing values and rents, corresponds generally to the high income and higher educational attainment areas.

There were 1501 vacant properties listed in 2002. Vacant housing and house age are indicators of housing condition, the latter being the primary cause of lead poisoning among children in Wilmington. All of the zip codes within the City have been adjudged “lead priority areas.”

High levels of lead encephalopathy (between 70 and 100 μg/dL -- micrograms per deciliter) is life threatening, while blood lead levels as low as >10 μg/dL are enough to adversely influence cognitive development, behavior and learning. During 1994 and 1996 over 30% of all children tested in areas of Wilmington were at or above this level of exposure. The percentage was reduced in 2000.

The Delaware Health Statistics Center has compared mortality rates for 10 different types of cancers and six other diseases in Wilmington with those for New Castle County, the State of Delaware and the United States between 1994 and 1999. While there are some variations by race and gender, the mortality rates from cancers and other diseases for Wilmington are generally higher than the county, state and national averages.

I. Introduction

1.1 Background

National efforts to address the issue of environmental justice (EJ) include the 1994 adoption of Executive Order (EO) 12898. This order directs federal agencies to achieve environmental justice as part of their mission by identifying and addressing "disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations" (President of the United States, 1994). Following the Executive Order, the U. S. Congress formally promised to "develop strategies to bring justice to Americans who are suffering disproportionately … [by] develop[ing] strategies to ensure that low-income and minority communities have access to information about their environment, and that they have an opportunity to participate in shaping the government policies that affect their health and environment" (Foreman, 1998).

The Delaware Department of Natural Resources and Environmental Control (DNREC) has recognized the need for a state-level response consistent with national policy. In this regard, DNREC recently established a Community Involvement Advisory Committee to develop recommendations for actions and procedures that ameliorate community stresses associated with existing conditions of disproportionate environmental risk and to reduce the likelihood of future disproportionate risk. Ensuring that minority and low-income communities have access to public information on patterns of environmental risk provides them the opportunity to effectively participate in DNREC's programs, services, and public decision-making processes that address such patterns.

One recommendation currently under review by the Committee involves analysis of, and public access to, a statewide database of social and environmental stress indicators within communities. According to the Committee, a community-level environmental profile could provide a common source of information for everyone to consider, from grassroots groups to industries, regarding the siting of industrial facilities and the making of environmental decisions.

Research that assesses stresses in the community has traditionally focused upon two separate matters:

1) ***social stresses***——including health-related factors, economic conditions, the extent of social problems, and the existing level of community response to the array of stresses impinging upon it;

2) ***environmental stresses***—such as threats to air and water quality, the concentration of contaminated areas, and increases in the severity of environmental degradation. Indicators are used by various agencies and organizations to separately address such stresses and their levels of impact.

An integrated approach that evaluates social and environmental stresses is needed if questions of environmental justice are to be effectively anticipated and avoided. This work proposes an analytically sound development of this approach through the use of indicators.

The Community Environmental Profile (CEP) comprises an examination of a set of broad environmental and socio-economic themes, including air, water, land and socio-economic factors. For each theme a set of indicators is used to analyze environmental quality utilizing the pressure-state-impact-response (PSIR) format. With this format, environmental states and trends are discussed in the context of the root causes and driving forces of those trends (pressures), impacts on humans and other ecosystem components, and policy responses to those trends and impacts. The CEP begins with a review of the current literature on the community for policy alternatives and indicators. The status of relevant research on Wilmington and Delaware is followed by an examination of the historical development of the City. Such an approach achieves a level of integration that reflects the interrelationships among social, economic and environmental conditions.

1.2 Purpose of the Report

The use of Geographic Information Systems (GIS) is a critical component of the CEP. The GIS-based CEP developed by the Center for Energy and Environmental Policy (CEEP) illuminates the spatial relationships between social and environmental stresses mapped by community boundary. As an objective source of information for understanding the pattern of social-environmental risks, the CEP provides a useful tool for community groups to empower themselves with greater knowledge of stresses in their communities. Regulators and industries also benefit as they consider both facility design and siting questions. The CEP is the first part of a multi-phase environmental justice strategy. The second phase will constitute a series of community workshops to achieve involvement, raise awareness and obtain feedback from the community at large. It is anticipated that similar projects will be developed for the wider New Castle County and eventually for Kent and Sussex Counties as well.

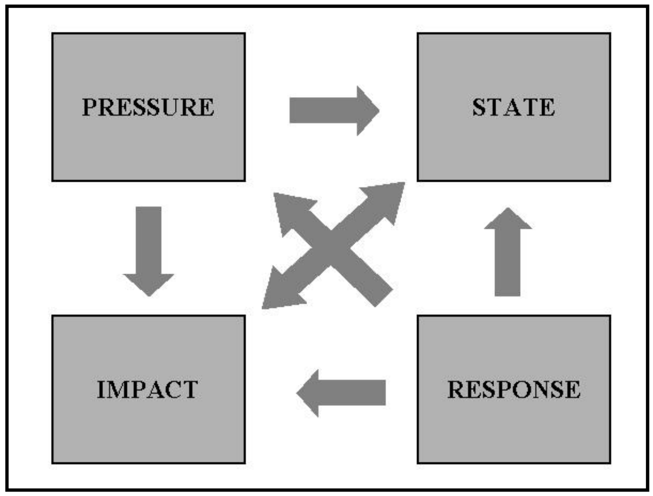
There are five main purposes for building a CEP, as proposed in this study:

1. identify community-level environmental and social conditions;
2. monitor the extent of progress in environmental and social conditions of individual communities;
3. ensure that low-income and minority communities can participate in private and public decisions that affect their health and environment with appropriate information;
4. enable private and public activities to take environmental risks faced by individual communities into consideration; and
5. assist environmental regulators in addressing "environmental justice in minority populations and low-income populations" in communities (President of the United States, 1994).

1.3 Methodology

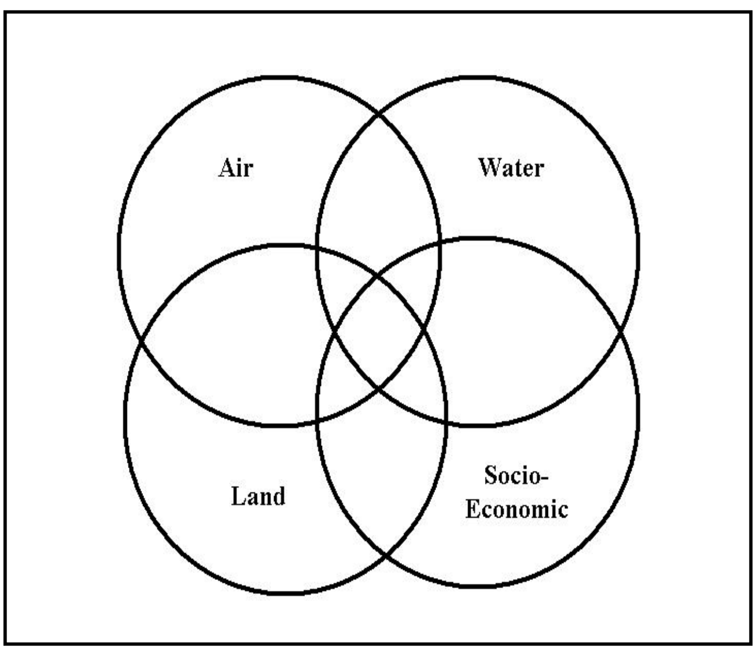
The CEP developed by CEEP is based upon a pressure-state-impact-response (PSIR) model. The selected indicators for creating CEP are built on a modified pressure-state-response (PSR) model that is widely used as a tool in environmental policy research (OECD, 1998). Pressures (P) in the PSIR model are private and public activities that can affect residents and the environment in communities. States (S) indicate the changed quality of human life and the changed quantity and quality of natural resources affected by pressures (P). Impacts (I) include the social effects of pressures (P) and states (S) on community residents. Responses (R) are strategic actions available to communities to change states (S); these include policies, planning, capacity building, and infrastructure and organizational development that together can improve awareness and change behavior in communities and in the pressures and states they address. Figure 1.1 demonstrates these relationships.

Figure 1.1 PSIR Model



Indicators of environmental pressures include activities and trends of environmental significance, as well as uses of resources, discharges of pollutants and waste flows into communities. Indicators of environmental and social states are designed to show the community situation, including the human and natural environments and their quality over time. Indicators of community responses reveal the degree to which communities possess the infrastructure and organizations to initiate collective actions to improve states/conditions.

Figure 1.2 Interrelationships Between Environmental Indicators



The selection of CEP indicators is based on policy relevance, analytical soundness and measurability. To be relevant for policy purposes, indicators should provide a representative picture of pressures on a community and its environmental conditions, how such pressures might affect communities and their environment (qualitatively and quantitatively), and available community responses. They also measure a threshold or reference value against which users can assess the significance of changes in values. Analytically, indicators should be theoretically well founded in technical and scientific terms. The data required to support the indicators should be readily available, of high quality and able to be updated at regular intervals.

Indicator categories are selected to reflect the interaction of natural and socioeconomic factors in the environment. These include air, land, water and socio-economic characteristics (Figure 1.2). In each of these categories, indicators were selected based on the qualities described above.

The data for the profile indicators were obtained from several sources, including DNREC, the U.S. Census and EPA reports. Data on health were gathered from the State Department of Public Health. The New Castle County Comprehensive Plan was also utilized. Data on air, land, water and demography were obtained from respective reports and databases of DNREC and the City of Wilmington, and other related State and local agencies. A list of agencies and personnel is provided.

ArcView GIS-based techniques were applied using site-specific data. GIS is an ideal tool to support the goals of this project and those of future efforts. Information about the environment, distributions of populations, socio-economic data, land use, and pollution sources all have a spatial component. GIS enables a comparison of environmental and social factors in geographic space to a high degree of specificity, making the spatial patterns of the indicators and their relationship to the community visible.

CEEP created the GIS-based CEP, determining the data that is included, collecting that data, relating and presenting it to provide a clear picture of the spatial distribution and relationships among environmental stresses and conditions, socio-economic conditions and institutional responses in the City of Wilmington. GIS was the primary tool for the management, maintenance and presentation of data for the CEP.

II. Overview of Research and Literature

2.1 What is an Environmental Profile?

The World Bank defines an urban environmental profile as "a report that describes the quality of environmental media, the causes of environmental degradation, and the institutional setting for addressing environmental issues in the urban region" (Leitman, 1992a). The Bank regards this as the second stage of a three-step process of rapid urban environmental appraisal, which includes completing an urban environmental indicators questionnaire – a tool for collecting specific data about key environmental indicators (Leitman, 1992b); preparing the profile; and undertaking a series of consultations to identify local public opinion regarding citywide environmental priorities (McNeil, 1991).

The environmental profile is virtually synonymous with the State of the Environment Report (SOER), the term more commonly used under the United Nations Environment Programme (UNEP). UNEP, as part of its mandate, routinely conducts annual state-of-the-world reports and supports the preparation of sub-regional and national state of the environment reports worldwide. These reports aim to provide accurate assessments and up-to-date reporting on the state of the world environment[2] or the environment of a country.

In 1997, UNEP published the Global Environmental Outlook (GEO) -1, under the same objectives to the SOER. The GEO is prepared at the global, regional, sub-regional and national levels. It dentifies priority environmental issues under broad themes and analyses these issues within a PSIR format. State trends are discussed in the context of driving forces and root causes (pressures), impacts on humans and other ecosystem components, and policy responses – all in an integrated manner rather than as separate sections.

Several city environmental profiles appear in the literature. In 1991, under the auspices of the World Bank, seven profiles were prepared for six cities (Accra, Jakarta, Katowice, Sao Paulo, Tianjin and Tunis) and one urbanizing area (the Singrauli region of India). A global synthesis of these profiles was subsequently prepared, with evaluations on the basis of the quality of the environmental systems and the presence of environmental hazards (Leitman, 1995).

In 1996 UNEP, in collaboration with the Norwegian Industrial and Regional Development Fund (GRID), launched the pilot phase of an on-going program for cities to publish their environment reports on the Internet[3]. In general, the goals of CEROI, or City Environmental Reports on the Internet (CEROI), overlap with those of city environmental profiles. Namely: to increase awareness about the urban environment, to improve environmental policy making by providing better access to information, and ultimately to improve the cities' and the world environment. Also, under the CEROI program a set of indicators, defined as "representative, concise and easy-to-interpret parameters used to illustrate main features on an urban environment, as well as their

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[2] Information on State of the Environment Reports from various countries are available at http://www.grida.no/soe/index.htm

[3] Details on the project are available at http://ceroi.net/inform/progdesc.htm

development over time and space," has been developed and used by the more than 25 cities to date[4].

2.2 Purpose and Benefits of Environmental Profiles

Environmental profiles have been used to provide information on the status of the environment in geographically defined regions, be it a country, region, city or community. The content and focus of each profile is largely a function of the overall purpose and objectives of its preparation, and also of the particular characteristics of the area for which it is being prepared.

An environmental profile is useful as an educational tool to inform urban community members of the environmental issues and initiatives that affect the city. The reports and studies of diverse sectors can be centralized and organized in one publication, and can also serve as a guide to the literature on environmental issues for a particular city (Leitman, 1992a). Moreover, the environmental profile can provide a sound information base for environmental planning and policy development, leading to improvements in the quality of the urban environment.

From the experiences of the programs described above, there are important benefits to be derived from the preparation of urban environmental profiles/state of the environment reports/environmental outlooks. In an ex post evaluation of their 1991 seven cities project, the World Bank identified the following benefits:

- it summarized information on causal relationships between environmental quality development activities and the institutional dimensions of urban environmental issues that were not collected in the environmental indicators questionnaire;
- it brought together conclusions from reports developed in different sectors or over time that referred to a common problem; and
- it served as a useful background document for the consultants, government agencies, non-governmental organizations (NGOs), donors and others inter alia.

The principal drawback is that it is a static document. Each profile has a relatively short lifespan unless provisions are made to formalize its updating. It is worth noting that UNEP's GEO has made provisions for periodic updating, (GEO-2 was published in 2000 and GEO-3 in May 2002), countries preparing State of the Environment reports are also making provisions for periodic updating, and several countries have already produced periodic reports[5]. Cities that participated in the CEROI project have also indicated plans for periodic updating and expansion of reports.

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[4] Details on CEROI's indicators program can be found at http://ceroi.net/ind/index.htm
[5] See 2 above.

2.3 What is an Environmental Indicator?

A necessary component of preparing an environmental profile is the selection of indicators based on the identification of a set of environmental priorities. This depends on the scope of the profile, which can vary from a description of the state of the biophysical environment to an integrated assessment of the interrelationship of physical, socio-economic, and political factors and how they affect the environment.

Harris and Scheberle (1998) have conducted an extensive literature review on environmental indicators. They found that the literature focused ultimately on ecosystem integrity, which is defined as "the ability to support and maintain a balanced, integrated, adaptive biological community having a species composition, diversity and functional organization comparable to that of a natural habitat in the region" (R. Karr and D.R. Dudley, 1981: 56, cited by Harris and Scheberle, 1998). The concept of ecosystem integrity suggests that the attributes of ecosystem structure and function should be metrics of concern for ecosystem management (p. 181).

Based on this assessment, one definition of an *indicator* has been adopted[6] that focuses on it as a measure of the attributes of habitat, the degree of stress, and either the level of exposure to the stressor or the response to that stressor. A second defines an *indicator* as "a measurable feature which singly or in combination provides managerially and scientifically useful evidence of environmental and ecosystem quality, or reliable evidence of trends in quality" (U.S. Intergovernmental Task Force on Monitoring Water Quality, 1994: TF-1, cited by Harris and Scheberle, 1998). In both of these definitions, the indicator reveals meaningful information about how a stress or sets of stressors have impacted the structure and function of the ecosystem or community under observation.

A 1994 report on environmental indicators commissioned by UNEP[7] provides a broader perspective on environmental indicators. Based on a comprehensive literature review of the status of research on the subject, the report defines an indicator as a piece of information that:

- is a part of a specific management process and can be compared with the objectives of that management process (e.g. management of surface water quality – environmental status; discharges and pollution runoff – environmental stress; costs of waste water treatment – societal/policy response); and
- has been assigned a significance beyond its face value: it must represent a larger phenomenon (e.g. sulphur dioxide => air quality).

A clear distinction is, therefore, made between indicators and environmental statistics. Statistics, along with monitoring, may serve as input for the definition of an indicator.

[6] This definition was adopted by the Council of Great Lakes Research Managers from C.T. Hunsaker and D. E. Carpenter (1992) for use in the Great Lakes Water Quality Agreement between the US and Canada (ibid).

[7] This report, prepared by the National Institute of Public Health and Environmental Protection (RIVM, the Netherlands) and the University of Cambridge (United Kingdom), was commissioned to, among other things, conduct a comprehensive literature review on the present status of research on environmental indicators at national, regional and global levels, and to identify key areas where more work or coordination is required at the international level.

2.4 Purpose of Environmental Indicators

Specific purposes of environmental indicators include:

- to assess environmental conditions and trends;
- to compare countries and regions;
- to forecast and project trends;
- to provide early warning information; and
- to assess conditions in relation to goals and targets (Bakkes *et al*, 1994, citing Tunstall, 1992).

Ecosystem indicators may have a different purpose that focuses, for example, on ecosystem recovery. Notably, the OECD distinguishes three major purposes, each of which requires its own indicators:

- measurement of environmental performance;
- integration of environmental concerns into sectoral policies; and
- more general integration of environmental concerns into economic policies (ibid.).

This latter group of purposes relates to the broader perspective on indicators alluded to earlier. It is based on a conceptual model of the environment that consists of both socio-economic system and environmental (natural) systems. These two systems interact in such a way that the socio-economic system changes the environment through:

1) the use and management of resources; and

2) restructuring the environment through: physical, biological and chemical changes, depositing wastes, and counter-measures against earlier disturbances (the social response).

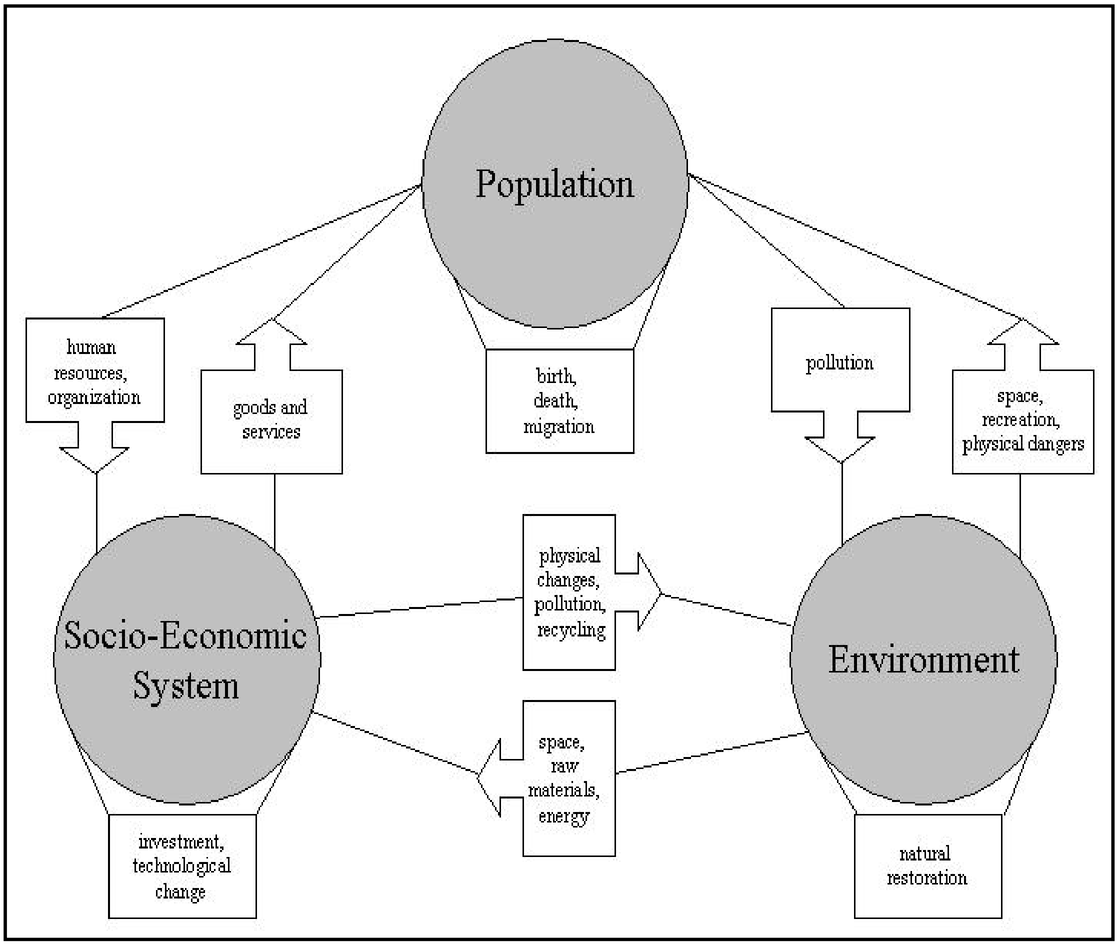
Further, since the human presence is at the center of important and specific relationships with the environment and with other socio-economic factors, this adds a third sub-system -- population, so that all three have a two-way relationship with each other. Figure 2.1 illustrates the relationships between the environment, population and socio-economic systems.

2.5 Indicators and the Community Environmental Profile

This multi-dimensional perspective on the environment provides an apt framework within which to prepare a CEP. All three subsystems are captured in a generic outline for the Urban Environmental Profile proposed by the World Bank (Leitman, 1992a), which includes:

(1) an overview of the geo-physical and socio-economic settings along with environment-development linkages,
(2) a description of the state of the environment in the urban region
(3) environment-development interactions and
(4) the institutional setting for environmental management.

Figure 2.1 Environmental, Socio-Economic and Population Sub-Systems



Adapted from Bakkes, *et. al.,* 1994: 2

The complete outline is presented in Appendix A-1. Once environmental priorities are identified, such an approach necessitates a cross section of indicators that cover the physical environment, socio-economic conditions, and political and policy issues. Similarly, the UNEP *State of the Environment* (SOE) and *Environmental Outlook* (GEO) reporting, which utilize the PSIR framework, also incorporate this interdisciplinary approach.

The CEP provides the opportunity to select indicators that are more closely focused on, and more directly generated by the city. Indicators also meet the criteria of broader application and comparability. For example, in 1998 the International Center for Local Environmental Initiatives (ICLEI) launched the Cities 21 pilot project aimed at engaging the 30 participating members in evaluating their local sustainable development strategies and performance in the following areas of mutual concern:

- governance (Local Agenda 21---LA21);
- climate change; and
- freshwater management.

Among the principle objectives of the project was the development a common ICLEI framework for evaluating environmental performance, and testing the tools and methods required for the collection and analysis of indicator data. A secondary objective was the identification of possible linkages to establish global environmental trends among urban areas, assessment of the availability and quality of data among ICLEI member cities, and creation of a mechanism to share information between cities. While the project was initiated in part to identify global environmental trends, the data collected and analyzed in the indicators programs also helped local participating governments by identifying specific actions, which could be undertaken to work towards their environmental and sustainable development goals (ICLEI, 2000).

Among the major challenges, however, was the realization that many cities do not always have readily available data. Rather, data was generally aggregated at the national level. For cities to address their direct concerns, mechanisms for primary data collection need to be established.

2.6 Status of Relevant Research on the City of Wilmington

Research has revealed a limited amount of literature on environmental profiles for Delaware or cities within the State, including Wilmington. However, there have been recent efforts at the State and regional levels to develop environmental indicators.

The Delaware Department of Natural Resources and Environmental Control (DNREC) is conducting a "Whole Basin Management" (WBM) program that involves monitoring, assessing, and managing all of Delaware's biological, chemical, and physical environments by drainage basin. The program is an attempt to look at the environment from multiple perspectives to understand the relationships that exist in nature between the air, land, water and living resources as they interact in a dynamic system (DNREC, 1997a). The five major drainage basins in Delaware will be covered in this five-year, eight-phase program. To date environmental profiles have been completed for the Piedmont, the Chesapeake Bay Drainage, and the Inland Bays/Atlantic Ocean basins. DNREC's 2002-2004 Strategic Plan anticipates completion of all six profiles by 2003 (DNREC, 2000a), at which time a multi-disciplinary assessment of the entire State, based on the WBM approach, will have been conducted.

The Piedmont basin is composed of six sub-basins two of which, the Brandywine and Christina watersheds, comprise sections of the City of Wilmington. The Piedmont Environmental Profile (DNREC, 1997a) constitutes the smallest geographical level at which existing literature assesses the environment in the vicinity of Wilmington. The assessment includes such areas as land use and comprehensive planning, watershed hydrology, air quality, recreation, biodiversity and contaminant sources. Since the information is presented as an aggregate for the whole basin, or at the sub-basin level, an environmental profile for the city of Wilmington remains relevant.

2.7 Use of Environmental Indicators

The Delaware Estuary Program (DELEP) covers a larger geographical area than the combined environmental profiles of Delaware's Whole Basin Management (WBM) program. The DELEP comprises large sections of New Jersey and Pennsylvania, and most of eastern Delaware extending as far south as Lewes, encompassing the City of Wilmington. Committed to improving and maintaining the state of the environment of the Delaware Estuary, the DELEP has developed an initial suite of nine land and water indicators as tools to measure progress towards achievement of specific goals (DELEP, 2000). The indicators cover ecological as well as socio-economic elements, and include changes in farmland acreage, population of American shad, developed land versus population, water use efficiency, acreage of public parkland, dissolved oxygen, contaminated sediments (benthic toxicity, organic contaminants toxicity), shellfish resource population and suitability of the estuary waters for swimming.

Other more localized initiatives are under way, but still not specific to Wilmington. DNREC's 1998 Vision and Strategic Plan identifies a number of indicators of environmental stressors, which are in turn used to establish objectives within the Plan. It further notes that the Plan will be used to identify and track appropriate environmental indicators, enabling the use of environmental conditions as a better gauge of success, and a signal of the need for change. The 2002-2004 Plan specifically states that, in protecting Delaware's coastal zones, activities will be undertaken to "[d]evelop integrated data management systems in order to implement environmental indicators to assess the health of the Coastal Zone and help determine the effectiveness of the regulations" (DNREC 2000a: 18).

Under Delaware Coastal Programs, work has begun on building a Coastal Zone Environmental Goals and Indicators Program to develop tools that will assist resource managers in measuring and monitoring the health of the Coastal Zone (DNREC, 2000b).

2.8 Other Environmental Assessments

Several recent (post 1990) studies have looked at various aspects of the environment in Delaware and in Wilmington. These include surveys and assessments of various brownfields and superfund sites (e.g. DNREC, 1995;1998a; Tetra Tech, Inc., 1995; City of Wilmington, 1996a; 1996b; CEEP, 1996; 1999), most of which concentrate on the City of Wilmington. The City has also published a Water Quality Report (2001a). In addition, DNREC routinely publishes periodic reports on a wide range of environmental areas including watershed, water quality and air quality assessments, air emission and toxic release inventories, and the status of recycling. The databases for these reports, along with DNREC's plan to develop an Integrated Environmental Information System (IES) by 2002 (DNREC, 2000a), may eventually constitute an important source of data for an indicators program for Wilmington.

III. The City of Wilmington: An Overview

3.1 History and Location

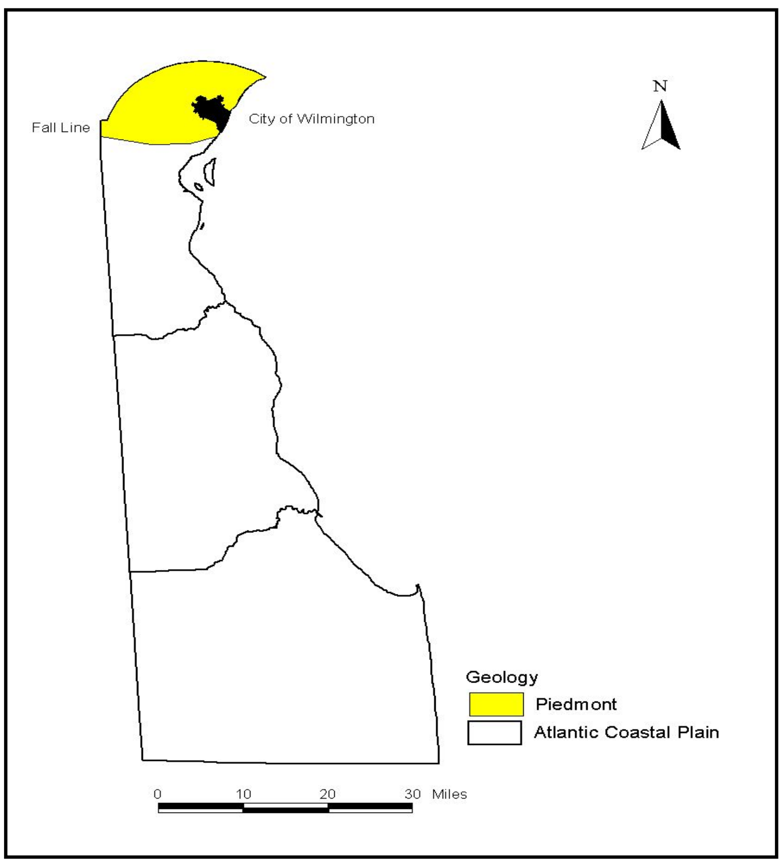
Wilmington is Delaware's largest city, centrally located along the New York-Washington metropolitan corridor, with a population of 73,000 people. Its natural and physical environment, together with its proximity to the coastline makes it an ideal location for settlement and economic activity. These factors have contributed to the early rise of Wilmington as an industrial city and its later progression into a commercial center.

Historically, the Wilmington area was inhabited by the Lenni-Lenape, more commonly known as the Delaware Indians. Like the rest of the eastern United States, the region came under colonial occupation during the 16th and 17th centuries. Initially occupied by the Swedes and later by the Dutch, this locale acquired the name "Willington" in 1731 after Thomas Willington, the region's first developer. Wilmington secured its current name eight years later (City of Wilmington, 2001b) and in 1832 the City received its charter.

3.2 The Physical and Natural Environment

The City lies on the Fall Line, the boundary between the sand, silt and gravel sediments of the Mid-Atlantic Costal Plain and the metamorphic rocks of the Piedmont (Figure 3.1.). The Fall Line bisects the northern section of Delaware, generally following Route 2 from Newark to Wilmington (Delaware State Planning Office—DSPO, 1970a:20; Plank and Schenck, 1998). Geologically, the Wilmington Complex, one of the five distinct rock formations of the Delaware Piedmont, underlies most of the Wilmington area. It is a diverse mixture of both metamorphic (primarily amphibolite and gneiss) and igneous (gabbro,

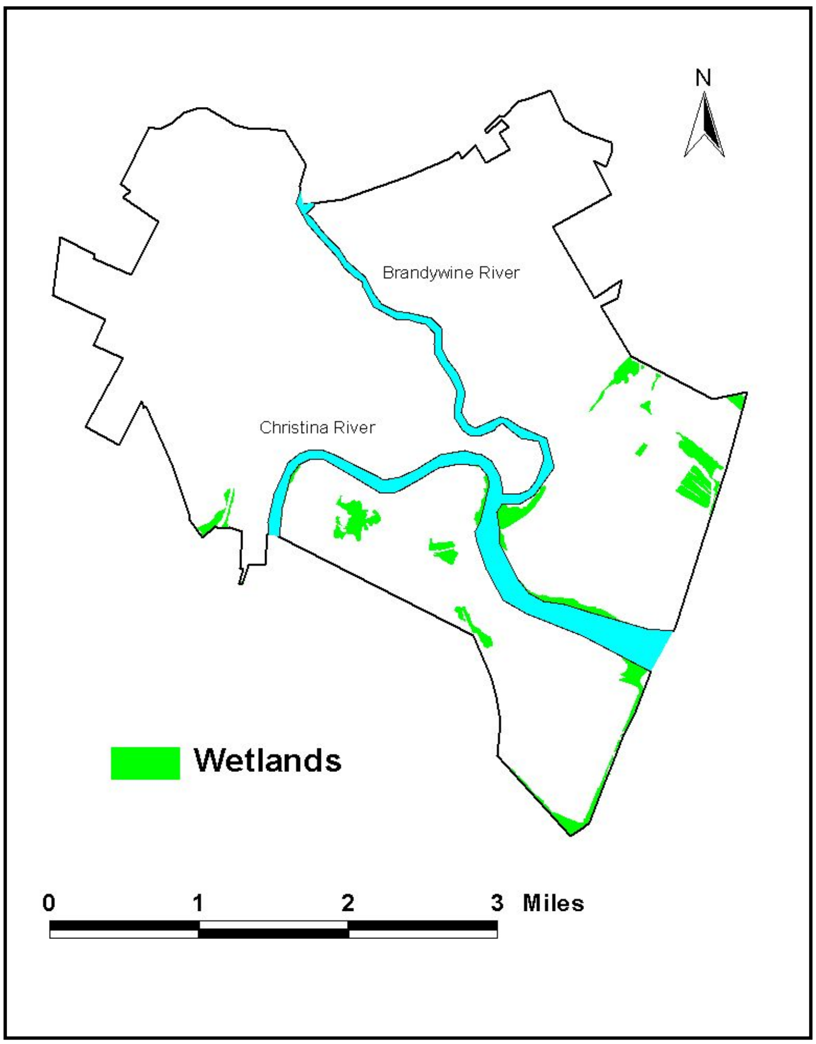
Figure 3.1 Geological Map of Delaware



diorites and granite) rocks that are the remnants of an extinct volcano (ibid.). The Wilmington Complex has endowed the region with its fertile soils and mineral resources that supported agricultural production and the extraction of raw materials such as sand-gravel, clay and stone for construction. The permeability and porosity of the bedrock in the Piedmont facilitated easy accessibility to ample supplies of water for residential and industrial use (DSPO, 1970a: 50).

Wilmington's primary surface water systems are the Christina and Brandywine Rivers. Together with several networks of smaller surface streams from northern Delaware and southeastern Pennsylvania, these rivers drain the Christina-Brandywine watershed. This river system supplies freshwater for residential, commercial and industrial use in the City. Reservoirs have also been established on the Brandywine River to manage the regional water supply. They include the Hoopes Reservoir at Barley Mill Road, Porter Raw Water Reservoir at Augustine Cut-off, and Cool Spring Reservoir at 10th and Franklin Streets. (City of Wilmington, 2001a; DNREC, 1997a). In addition to contributing potable water to the City, the Christina and Brandywine rivers are used for recreational activities, for navigation and sustaining aquatic ecosystems in the area.

Figure 3.2 Wetlands in the City of Wilmington



Few wetland areas remain within the City limits (Figure 3.2). The high level of wetland loss within the Northern Piedmont drainage system,results from the region's position as the smallest and most urbanized drainage basin in the State (DNREC, 2000c). The freshwater wetlands that do persist within the City are located along the lower banks of the Brandywine and Christina Rivers as well as the Delaware River.

Despite the dramatic loss of wetlands within the City, there are a number of established open spaces for use as parks and natural recreation sites. These areas include the Brandywine State Park, Rockford Park, H. Fletcher Brown Park, and Alopocas Woods Natural Area (Wildernet, 2001).

3.3 Industry, Commerce and Economic Development

The City's reputation as a manufacturing and commercial center precedes the Industrial Revolution. While climate, topography, geology, and location provided the foundation for Wilmington's early settlement and urbanization, transportation technologies were also decisive in shaping its economic environment. The existence of a deepwater harbor and a railroad network were critical to its industrial growth. These factors of early industrialization shaped the City's current spatial distribution of industrial facilities and environmental concerns. Industrial activity was located near the waterfront to maximize transportation opportunities. Ships provided access to heavy and bulky raw materials, such as iron and cotton, as well as a means for distributing finished goods. Transportation by water was cheaper in comparison to other methods of transporting goods. Fuels for industrialization, for example anthracite and bituminous coal, could be readily transported by water from the coalfields of Pennsylvania to the iron steel industries in the Delaware Valley (Delaware State Chamber of Commerce, 1958: 84).

Wilmington was also important to the construction of a national railroad network in the U.S. Rail lines were first built between Philadelphia and Wilmington in 1838 (USGS, 2000). The Philadelphia-Wilmington-Baltimore line soon followed, extending the city's commercial reach to Baltimore. As the establishment of railroads expanded the region's transportation opportunities, a greater concentration of industrial activity developed near these hubs. By the outbreak of the Civil War Wilmington had an established industrial base that became an important source of supplies, including ships, railroad cars, gunpowder, shoes, and tents (City of Wilmington, 2001b). Early industrial activities included printing, textiles, shipbuilding, carriages, leather, machines, carpentry, foundries, boots and shoes, hosiery and iron and steel industries (Table 3.1). These were later followed by car manufacturing by the turn of the 19th century (Amuti, 2001).

Table 3.1 Ten Leading Industries by Number of Workers in Wilmington, Delaware for 1860, 1880, and 1900

Industry	1860	Industry	1880	Industry	1900
Cotton Goods	1,109	Shipbuilding	1,454	Cars	2,897
Shipbuilding	558	Leather	914	Leather	2,454
Carriages	523	Cars	860	Foundries	2,009
Leather	384	Foundries	779	Iron & Steel	1,327
Machines	325	Iron & Steel	610	Hosiery	470
Boots & Shoes	307	Cotton Goods	469	Carpentry	199
Car Wheels	200	Carriages	384	Bakeries	160
Iron & Steel	193	Brickmaking	234	Carriages	176
Cooperage	170	Paper/Printing	230	Shipbuilding	176
Cars	100	Carpentry	105	Printing	162
Totals	**3,939**		**6,039**		**10,030**

Source: Amuti, 2001

The nature and pattern of early industrialization and their attendant ecological impacts are quite different from today's mixture of chemicals, automobiles, oil refining, and the predominantly service-oriented industries of banking, legal services and insurance.

Wilmington's economy has continued to change in consonance with national and global economic trends. The transition from heavy manufacturing to a more service-oriented economy arose during the mid-1950s. Advancements in science and technology, as well as the information and communication revolution, enabled the City to develop a new economic focus. Similar to many industrial centers of the 19th century, Wilmington's manufacturing base collapsed while the vestiges of this earlier period of industrialization remain, primarily in the form of abandoned industries, contaminated sites and brownfields. Nevertheless, industry has not completely left the City and some manufacturing continues to be a source of economic development and environmental stress.

Current economic growth in Wilmington is based primarily in service-oriented businesses. As this sector of the economy emerged, it created a new spatial dimension on top of the existing landscape. The service sector is spatially dispersed in comparison to early heavy industries that were constrained by their transportation requirements. Service industries are dependent on communication networks and are located within a more regional metropolitan area. As a result, the City has expanded beyond its municipal boundary into its hinterland regions.

3.4 Current Infrastructure

Industrial growth and commerce were made possible by, and contributed to, Wilmington's present infrastructure. The Port of Wilmington, located at the convergence of the Delaware and Christina Rivers, is one of the City's most important infrastructures (Delaware State Chamber of Commerce, 1958: 67). The low-lying topography of the coastal plain facilitated the development of the Port, which continues as a hub for the importation of goods both nationally and internationally.

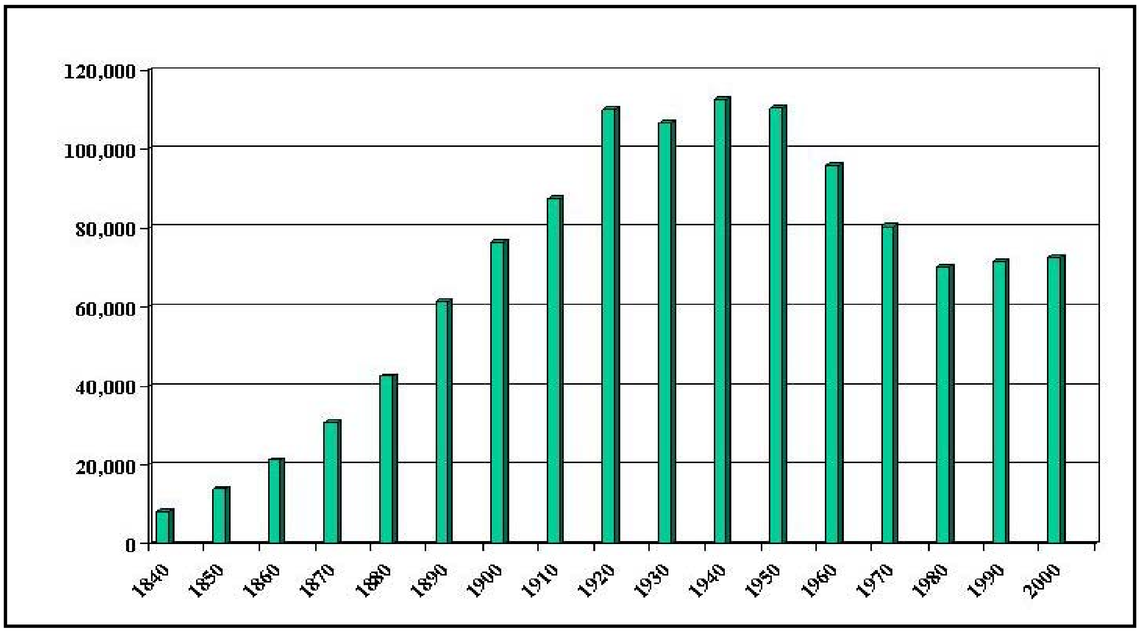
The development of a major highway system through the City began as early as the 17th century with the construction of the King's Highway (parts of U.S. Route 7 and 40 currently follow the original King's Highway route) when Delaware was still under Dutch control (USGS, 2000). By the turn of the 20th century, the highway system had been transformed into four turnpikes - Philadelphia, Concord, Kennett and Lancaster. The advent and popularity of automobiles brought more highways, such as U.S. 40 and Interstate 95. By the 1960s highways connected Wilmington with all major metropolitan areas in the mid-Atlantic region. The growth of these road networks further increased traffic and commerce to and from the City, facilitating Wilmington's transformation from an industrial center to a service center.

In recent years air transportation has become increasingly important to the local economy. A few minutes away from New Castle County Airport and Philadelphia International Airport, Wilmington is also within close driving distance to the Baltimore-Washington, Newark, NJ and JFK international airports.

3.5 Demographic Characteristics

The growth of industries and businesses in Wilmington attracted settlement in the City and its hinterlands. It is estimated that by 1988 over two-thirds of Delaware's population lived in metropolitan areas, of which Wilmington was the most populous. (DSPO, 1988: 8). This percentage is likely to have increased as the City continued to absorb surrounding suburban areas. This situation has created the need to assess the health and quality of life in Delaware's cities, including the impact of industrial activity. Wilmington's demographic characteristics should be examined with this in mind.

Figure 3.3 Population Change in Wilmington, 1840-2000



Data Source: USGS, 2002; U.S. Census Bureau, 2000a

As Figure 3.3 shows, Wilmington's population grew steadily between 1840 and 1940 and dropped thereafter up to around 1990. Although the population has rebounded since 1990, it is yet to hit the 110,356 mark it registered in 1950 (Delaware State Chamber of Commerce, 1958). The steady increase in population between 1840 and 1940 coincided with an era of economic growth. The City's population fell slightly during the Great Depression before it rose again in the 1940s, and thereafter declined. It should also be noted that although the population has been on an upward trend since 1980, in general, Although the City's share as a percentage of the total population in New Castle County and Delaware has gradually declined. Specifically, Wilmington accounted for 10.7% and 16.1% of the population of Delaware and New Castle County, respectively, in 1990. This dropped in 1997 to 9.9% and 15.1% and in 2000 to 9.2% and 14.5% for the State and County, respectively (CCDFP, 2001). Population growth in other parts of New Castle County and in the State has continued to outpace population growth in Wilmington in the same period, even though Wilmington has continued to experience a positive, rather than negative, absolute increase.

While the economy has historically been a magnet for attracting people to Wilmington, there are remarkable differences in patterns of population growth especially in the two periods that show an upward trend (1840-1940 and 1990-present). These differences help explain why: (i) the population of Wilmington fell between the 1950s and 1990s while the population of Delaware, overall, continued to increase; and (ii) the City's population growth rate trails County and State growth rates in the 1990-present period. The relatively underdeveloped transportation system may have played a key role in influencing settlements closer to the City in the first phase of prolonged steady increase in population. Difficulties in commuting may have influenced relocation for employment and for enjoyment of social amenities not available in the rural areas. Subsequent advancements in transportation have resulted in an increasingly high rate of suburbanization.

3.6 The City, the Future and the Ecosystem

Wilmington's growth and prosperity have not come without costs. The growth of industries, commerce, population and use of automobiles have all had, and will continue to have, short- and long-term effects on the City's environment. Consequently, its prosperity cannot be divorced from the environmental impacts of economic development. Development and environmental concerns are inextricably intertwined as sustained prosperity depends upon stewardship of the environment. Consideration of the environmental impacts of economic activity is necessary, not only to understand the dynamics that have led to economic development, but also to initiate policies that enable the City to avoid repeating past mistakes.

The recognition of environmental problems is not new to the City of Wilmington (DSPO, 1970b; 1988). Instead, it is part of a growing national and global awareness of the inextricable link between human economic activity and the health of ecosystems. Wilmington's economic prosperity and deteriorating ecosystems cannot therefore be treated in isolation from neighboring regions, national and international trends. The transboundary problems of air and water pollution impact global environmental conditions, including the global dilemmas of ozone depletion and global warming.

Wilmington faces pressing ecological problems. As science and technology advances, these problems become even more complex than previously thought. The production of new products and the interaction between these newly created compounds and the environment result in unforeseen changes to the biology and chemistry of ecosystems. This is in addition to more familiar stress factors, such as urbanization, which have reduced forested areas, open space and biodiversity, and increases in automobile traffic, which have also elevated air pollutants.

These ecological problems will have to be addressed as quickly as possible if the City is to play an integral role in attaining the goals of the "Livable Delaware" agenda initiated by Governor Minner. The strategies for attaining these goals as defined in "Managing Growth in 21st Century Delaware: Strategies for State Policies and Spending," require urban centers, which are categorized as communities, to increase "transportation options, improve water and wastewater systems, and ensure community identity and vitality" (State of Delaware, 1999). The successful implementation of the "Livable Delaware's" agenda requires the development of an environment profile for the City. This profile will provide a benchmark by which progress or regress of environmental conditions can be determined.

IV. AIR QUALITY

Air pollution "is a by-product of the manner in which we produce our goods, transport ourselves and our goods, and generate the energy to heat and light places where we live, play and work" (Mark and Warner, 1992). A large portion of air pollution is produced through combustion -- a process through which hydrogen and carbon in fuel combine with oxygen from the air to produce heat, light, carbon dioxide, and water vapor. The results of this process include pollutants, such as carbon monoxide, sulfur oxides, nitrogen oxides, fly ash and unburned hydrocarbons, which occur in the air as particulate matter, organic compounds (mainly sulfur and nitrogen) halogens and radioactive compounds. Other types of air pollutants, including air toxics, also result from industrial processes. While it is difficult to catalog all the negative impacts of air pollution, the health and environmental effects are becoming increasingly clear. Air pollution is associated with reduced visibility, acid rain, corrosion of structures and buildings, and diseases such as asthma, pneumonia, emphysema, cardiovascular conditions and toxicity.

Air pollution is not a new phenomenon in the City of Wilmington, given the City's long history of industrialization. Similarly, efforts to limit, mitigate or alleviate air pollution have a substantial background, beginning with the use of tort law actions in nuisance, trespass and strict liability. This tort system failed due to a number of reasons. These include limited corporate liability, the need to show proof of fault of the alleged polluter, tort defenses like contributory negligence, assumption of risk, fellow-servant rule, and the exemption of charities and governmental entities from tort actions. The failure of the tort system to protect the public from the ill effects of pollution led industrial-based cities, such as Wilmington and Philadelphia, to rely upon ordinances to abate air pollution through public nuisance actions. This new system was also based on tort law but, unlike its predecessor, which was based purely on common law, the new system allowed cities to specifically provide for where courts could not. Even with the shift to air pollution abatement ordinances, the major pollutant of concern was smoke -- which in most instances limited visibility. Although almost every major city had a smoke abatement program by 1912, efforts to address photochemical smog did not begin until the 1940s, when Los Angeles took the lead (Reitze, Jr., 1999: 683-685).

4.1 Air Quality Indicators

Air Quality indicators for Wilmington are divided into two main categories: criteria air pollutants and air toxins. Criteria air pollutants are managed under the Clean Air Act, while all other air pollutants, including air toxins, are not yet under any regulatory framework.

4.1.1 Criteria Air Pollutants

The 1970 Clean Air Act identifies six criteria air pollutants that pose risks to human health. These are tropospheric ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, particulate matter (PM) and lead. Criteria Air Pollutants enter the air via a number of natural and human-made sources. Human-made emissions originate from industrial sites, automobiles and residential sources, such as furnaces and fire places (Emmert, 1996: 51).

Table 4.1 illustrates the application of the Pressure State Impact Response (PSIR) model to criteria air pollutants. Pressures include emissions and sources of pollutants; state involves the attainment status; impact entails the health hazards associated with exposure to pollutants; and response is the pollutant testing, abatement infrastructure and expenditures by the state, as well as environmental legislation, health management and education initiatives.

Table 4.1 Criteria Air Pollutant Indicators

Indicator	Pressure	State	Impact	Response
Ozone	Emission of Ozone Precursors: VOC, NO_X, CO	NAAQS Attainment Status Number of days that exceeded NAAQS	Health hazards of exposure	Pollutant Testing Air pollution abatement infrastructure Current Expenditures on Air Pollution Abatement and Control Regulatory and Administrative Controls
Carbon Monoxide	Source of Pollutant (Number of Vehicle Miles Traveled)			
Sulfur Dioxide	Source of Pollutant			
Nitrogen Dioxide	Source of Pollutant (Number of Vehicle Miles Traveled)			
Particulate Matter (PM_{10} and $PM_{2.5}$	Source of Pollutant			
Lead	Source of Pollutant			

The Clean Air Act sets National Ambient Air Quality Standards (NAAQS) for the six criteria air pollutants determined to threaten human health. If monitoring sites test at levels that exceed the NAAQS, the State is said to be in “non-attainment.” Delaware has been in attainment of all standards, with the exception of ozone, for the past ten years. $PM_{2.5}$ has not had a sufficient number of years of monitoring to officially determine its attainment status (DNREC, 2001a: 1, 46).

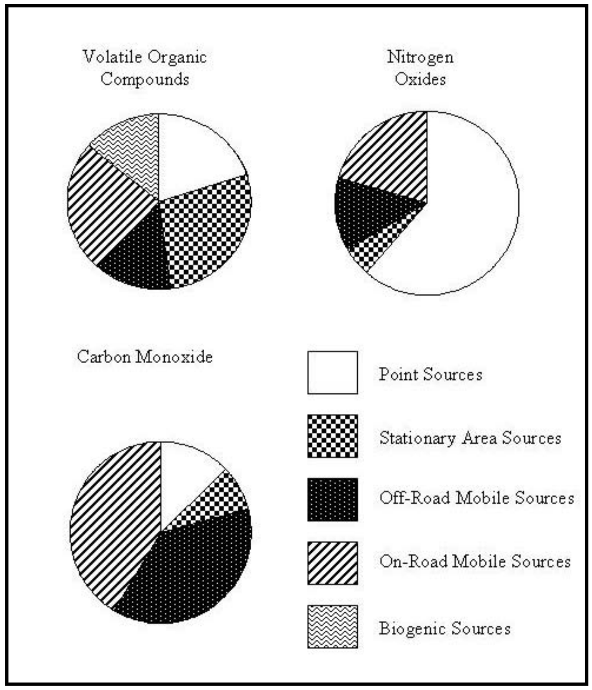
Ozone

Unlike other air pollutants, ozone is not directly emitted into the atmosphere from a particular source. It is created in the lower atmosphere as direct sunlight and warm temperatures cause photochemical reactions with carbon monoxide (CO), volatile organic compounds (VOC) and nitrogen oxides (NO_X). Therefore, the highest ozone concentrations occur in the summer months. VOCs are emitted by gasoline vapors, primarily from automobiles, and from industrial and commercial sources that utilize chemical compounds, including paint thinners and chemical solvents. Nitrogen oxides are emitted by combustion sources, including automobiles and power plants. (ibid.: 14; Ohio cooperative Risk Project -- OCRP, 1995: 43).

Figure 4.1 and Table 4.2 illustrate point sources, such as industrial locations, that contribute a significant amount of NO_X and VOC. Other notable sources include on-road mobile sources, such as automobiles and road equipment. Annually, anthropogenic sources emit 105,352 tons of ozone-producing pollutants in New Castle County.

New Castle County has been classified as in "severe" non-attainment for ozone. However, this pollutant is measured at only six of the ten air quality monitoring stations in Delaware, three of which are in New Castle County, one in Kent County and two in Sussex County. None of the monitoring stations in New Castle County are located within the City of Wilmington. Two of them, Brandywine and Bellefonte, are north of Wilmington and the third is in Southern New Castle County, south of the canal. (DNREC, 2001a: 46; 1997b: 3).

Figure 4.1 New Castle County Daily Air Emissions by Source Category



Source: DNREC, 1997b: 17-21

Table 4.2 New Castle County Air Emissions by Source Category

	Point Sources		Stationary Area Sources		Off-Road Mobile Sources		On-Road Mobile Sources		Biogenic Sources		Total	
	Annual (tons)	Daily (tons)	Annual (tons)	Daily (tons)	Annual (tons)	Daily (tons)	Annual (tons)	Daily (tons)	Annual (tons)	Daily (tons)	Annual (tons)	Daily (tons)
VOC	7,366	24.913	10,636	35.271	3,678	16.824	N/A	30.510	N/A	17.510	21,680	125.028
NO_X	28,757	90.021	3,251	7.623	4,946	18.713	N/A	30.350	X	X	36,954	146.707
CO	11,450	36,011	9,129	23.060	26,139	107.225	N/A	117.70	X	X	46,718	380.466

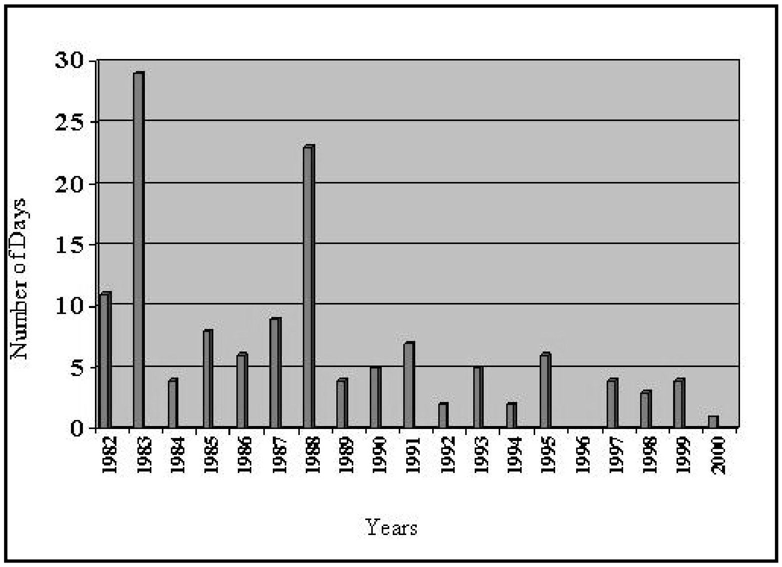
N/A (Not Applicable): There is no method for determining annual emissions for these source categories.
X : NO_X and CO are not generated by biogenic sources, according to the model used by DNREC.
Source: DNREC, 1997b: 17-21

New Castle County has failed to meet attainment levels for ozone every year for the past 18 years, except for 1996. Non-attainment is determined by the total number of days that any monitoring stations record ozone levels that exceed the NAAQS during a one-hour period (Figure 4.2).

Impacts of Ozone

Ground-level ozone is dangerous to human and ecosystem health. The main component of smog, ozone is a powerful pulmonary irritant. It can lead to respiratory inflammation and reduced lung function in individuals that suffer from impaired respiratory systems as well as in healthy persons. Symptoms include lung congestion, coughing and chest pain. While smokers are particularly at risk, ozone also impacts lung function during exercise, and has led to increases in summertime hospital admissions for respiratory conditions[7] and increases in cases of asthma.[8] Ozone has been shown to reduce growth-rates in vegetation, damage foliage and diminish crop production. Studies of laboratory animals have also identified negative effects from ozone exposure, including respiratory problems (DNREC, 2001a: 14; OCRP, 1995: 43; Emmert, 1996: 59).

Figure 4.2 New Castle County Exceedances of One-Hour Ozone NAAQS



Source: DNREC, 2001a: 47

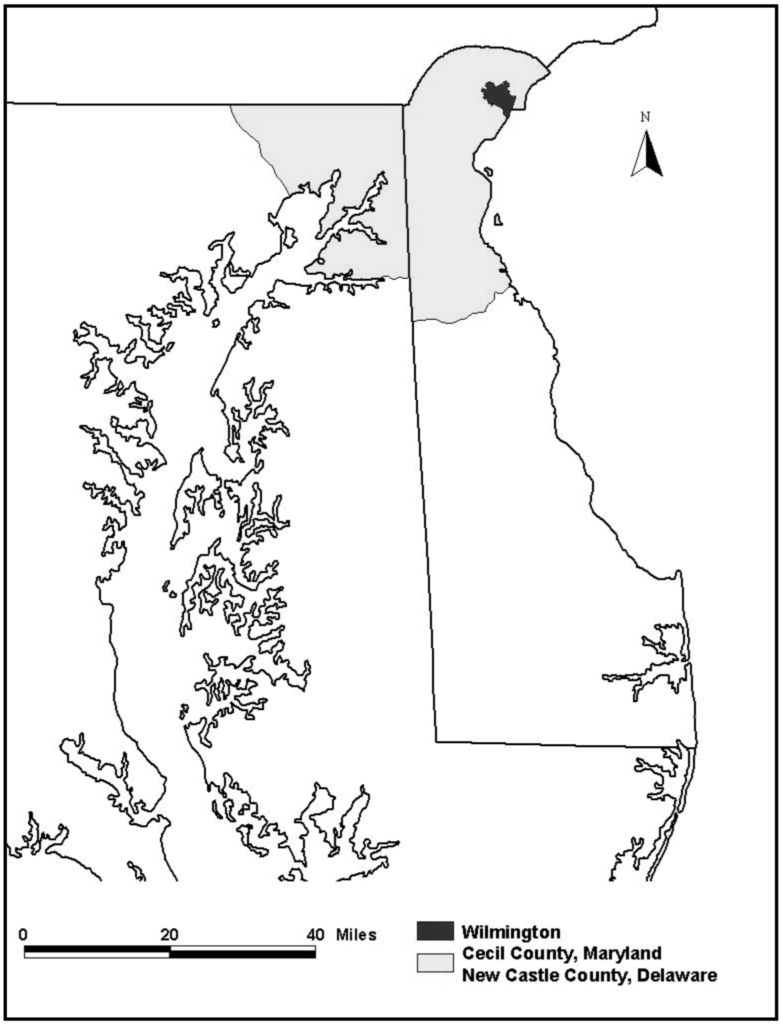
Carbon Monoxide

Carbon monoxide is a poisonous gas formed when the carbon in fossil fuels is not completely burned during combustion. It is transformed into ozone when it reacts with heat and light (DNREC, 2001a: 10). Automobile exhaust is a leading producer of carbon monoxide emissions, but other sources include industrial processes, furnaces, wood stoves and incinerators.

[7] "There have been several studies conducted over the last decade on summertime daily hospital admissions for respiratory conditions. These studies have shown that ozone air pollution accounted for about 1 to 3 total excess respiratory hospital admissions per hundred parts per billion (ppb) of ozone per million persons." (Emmert, 1996: 59)

[8] "A report published by the American Lung Association found that approximately 27.1 million children aged 13 and under and 1.9 million children with asthma reside in areas that experience unhealthy levels of ozone pollution at least four times during 1991-93" (Emmert, 1996: 59)

Figure 4.3 WILMAPCO Planning Region



The Wilmington Area Planning Council (WILMAPCO) has assessed regional travel characteristics that can help to determine the pressure imposed by carbon monoxide. In addition to reporting data on past years (1993 and 1998), WILMAPCO has made projections based upon a travel demand model, using data from all of New Castle County, Delaware and Cecil County, Maryland (see Figure 4.3). The assessment showed that vehicle miles traveled increased by 61% between 1993 and 1998, and are projected to increase by 71.5% above 1998 levels by 2025.

During the past decade, carbon monoxide levels have been in attainment at both of New Castle County's monitoring locations—Wilmington and Delaware City. During 2000 the Wilmington monitoring station's maximum daily values were well below the NAAQS (Table 4.3).

Table 4.3 Carbon Monoxide Values in Wilmington, 2000					
1 hour average			8 hour average		
Highest Recorded Level	2nd Highest Recorded Level	NAAQS Level	Highest Recorded Level	2nd Highest Recorded Level	NAAQS Level
3.7 ppm	3.5 ppm	35 ppm	2.6 ppm	2.6 ppm	9 ppm
Source: DNREC, 2001a: 44					

Impacts of Carbon Monoxide

Moderate carbon monoxide exposure results in headache, impaired reflexes and judgment, and fatigue. At higher levels exposure can lead to unconsciousness and death.

Carbon monoxide also produces ozone, a leading cause of respiratory illness (DNREC, 2001a: 10).

Sulfur Dioxide

Sulfur Dioxide is emitted through fossil fuel combustion by power plants, refineries, industrial boilers and smelters. Coal-fired power plants emit most of the sulfur dioxide in the atmosphere. However the transition to low-sulfur coal has resulted in decreased emissions on a national scale (ibid.: 12, 51).

Wilmington and the State of Delaware have been in attainment for sulfur dioxide standards during the past decade. Ambient concentrations for 2000 have been well below the NAAQS in Wilmington for both the twenty-four-hour and three-hour values (Table 4.4).

Table 4. 4 Sulfur Dioxide Values in Wilmington, 2000

24 hour average			3 hour average		
Highest Recorded Level	2nd Highest Recorded Level	NAAQS Level	Highest Recorded Level	2nd Highest Recorded Level	NAAQS Level
0.028 ppm	0.025 ppm	0.14 ppm	0.052 ppm	0.050 ppm	0.5 ppm
Source: 2001a: 51					

Impacts of Sulfur Dioxide

Sulfur dioxide is a respiratory irritant than aggravates pre-existing respiratory diseases, including bronchitis, asthma and emphysema. Because high levels restrict breathing, it can increase the death rates of individuals who suffer from heart and lung disease. Sulfur dioxide is also a contributor to acid rain, which negatively impacts ecosystem health (ibid.: 23).

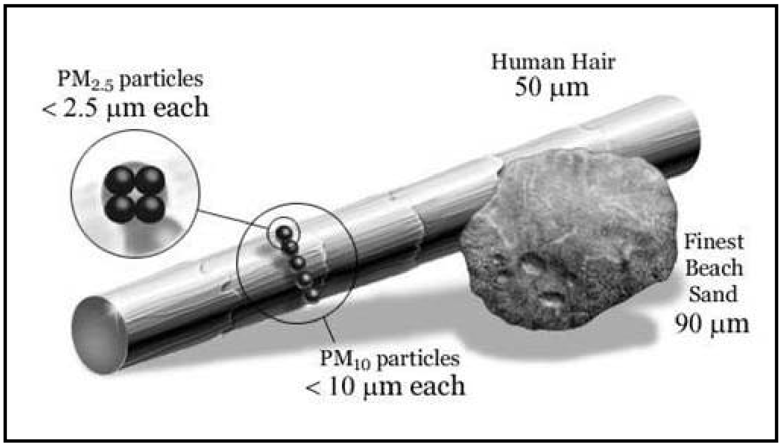
Nitrogen Dioxide

Nitrogen dioxide is caused by fossil fuel combustion at high temperatures. Power plants, industrial boilers and automobiles contribute to nitrogen dioxide emissions (DNREC, 2001a: 12). This pollutant, which is monitored in the urban areas of Wilmington and Bellefonte, has tested below NAAQS levels since testing began in 1978. However, during the period between 1992 and 1999 it was not tested at the Wilmington monitoring station, and in 2000 insufficient data was collected to calculate an annual average (ibid.: 12, 45).

Impacts of Nitrogen Dioxide

Nitrogen dioxide is a toxic gas that can irritate the respiratory system, causing decreased resistance to infection. Exposure to high concentrations can be fatal. It can also damage vegetation, directly by stunting growth and seed production, and by combining with other atmospheric compounds to form acid rain. When nitrogen dioxide enters water bodies it contributes to excess nutrient loading, a leading cause of algal blooms in estuary ecosystems such as the Inland Bays. It is considered a volatile organic compound that reacts with sunlight to generate ozone (ibid.: 12).

Figure 4.4 Particulate Matter: PM_{10} and $PM_{2.5}$



Source: New Zealand Ministry for the Environment, 2002.

Particulate Matter

There are two types of particulate matter that cause concerns for air quality -- PM_{10} and $PM_{2.5}$ Figure 4.4 illustrates the minute width of particulates categorized by their size. PM_{10} are solids and liquids that measure less than 10 microns in diameter. They comprise soot, dust and unburnt fossil fuel particles emitted from a number of point and non-point sources, including motor vehicles, unpaved roads, steel mills, power plants and industrial facilities. Particulate matter of this size can be inhaled into the lungs. $PM_{2.5}$, particulate matter smaller than 2.5 microns in diameter, is produced by the same processes as $PM_{10.}$ These fine particles can even more easily enter the lungs (DNREC, 2001a; Emmert, 1996: 60, 61).

Delaware has been below the NAAQS attainment levels for PM_{10} during the past decade and, as Table 4.5 shows, the four highest recorded levels in Wilmington are well below the NAAQS (DNREC, 2001a: 19).

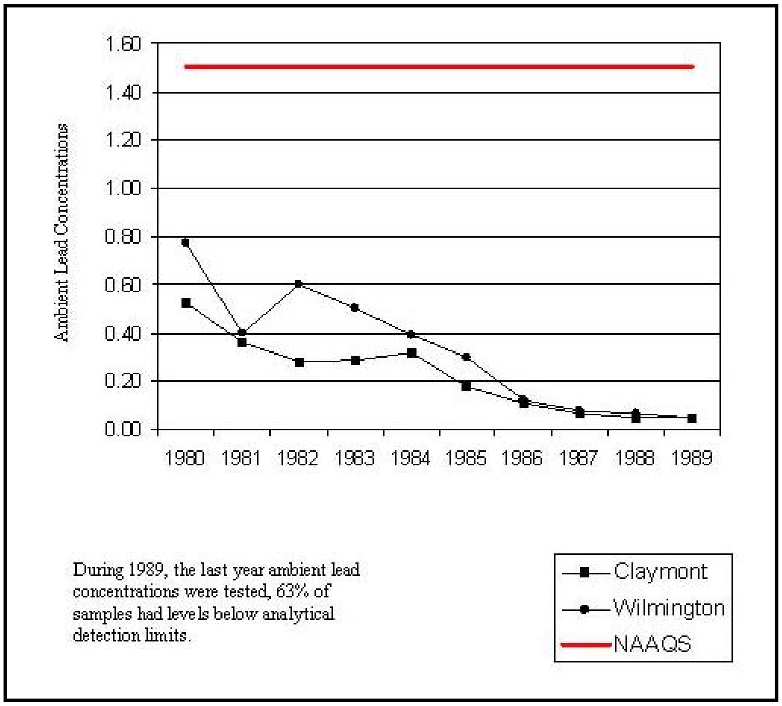
The EPA initiated standards for $PM_{2.5}$ as recently as 1997, and Delaware began testing in 1999. Therefore, there is insufficient data to calculate the three-year annual average required by the EPA standard. Samples taken during 2000, however, indicate a problem with $PM_{2.5}$ in New Castle County. The 2000 annual average for Wilmington exceeded the NAAQS three-year average, and annual average levels were also high at the other New Castle County monitoring sites. However, on the twenty-four-hour average testing limit, none of the Delaware testing locations exceeded the NAAQS limit (ibid.: 21).

Table 4.5 PM_{10} Values in Wilmington, 2000				
24 hour average				
Highest Recorded Level	2nd Highest Recorded Level	3rd Highest Recorded Level	4th Highest Recorded Level	NAAQS Level
58 μg/m^3	46 μg/m^3	45 μg/m^3	44 μg/m^3	150 μg/m^3
Source: DNREC, 2001a: 49				

Impacts of Particulate Matter

Particulate matter easily penetrates the lungs during inhalation and can transport chemicals that damage lung tissue. Breathing PM_{10} can aggravate the condition of individuals who suffer from cardiac and respiratory diseases. Depending upon the specific chemical inhaled, PM_{10} can introduce carcinogens into the body. Children, the elderly, asthmatics and individuals with pulmonary or cardiovascular diseases are particularly at risk from the negative effects. Because the particle size of $PM_{2.5}$ is much smaller than that of PM_{10}, its effects are amplified. Studies have shown a relationship between $PM_{2.5}$ and increased hospital admissions, emergency room visits and premature death (ibid.: 19, 21).

Figure 4.5 Delaware Lead Trends: 1980-1989 Maximum Quarterly Means



Source: DNREC, 1996: 12; Elizabeth Frey, QA Coordinator, Division of Air and Waste Management, DNREC.

Lead

Lead is emitted into the atmosphere from several sources. The leading source has historically been the use of leaded fuel in automobiles, but metal smelters and battery plants also contribute.

The State of Delaware has not tested for ambient lead levels since 1989. Between 1980 and 1989 lead was tested at two air monitoring stations, Claymont and Wilmington. Between 1978 and 1988 ambient levels plunged by 94% due to the removal of lead from gasoline. Of samples taken during 1989, 63% tested below the analytical detection limit (DNREC, 1996; pers. com., Elizabeth Frey, DNREC, January 14, 2002).

Figure 4.5 compares ambient lead concentrations at Wilmington and Claymont with the NAAQS for the period 1980 to 1989, after which testing was discontinued. The figure shows a steep decline in lead concentrations during the 1980s.

Impacts of Lead

Lead is an extremely toxic substance that biaccumulates in human tissue. It causes a number of debilitating health effects, including damage to physiological and reproductive processes and to the nervous system and kidneys. Lead disproportionately impacts infants and children and can cause serious health problems including mental retardation, learning disabilities, anemia and seizures. (DNREC, 2001a: 25).

4.1.2 Air Toxics

The 1986 Emergency Planning and Community Right-To-Know Act (EPCRA) requires facilities that use or emit toxic chemicals to report their emissions, for the purpose of compiling the Toxic Release Inventory (TRI). The objective of the EPCRA and TRI is to provide information to assist emergency planners and emergency technicians, such as fire fighters, in their response to chemical spills. The TRI also serves to inform the community of hazardous materials by providing public access to toxic release information. Businesses and manufacturers are required to report the location of their facilities and their releases and off-site transfers, for over 600 designated toxic chemicals (DNREC, 2002).

Under the EPCRA and TRI, only facilities that employ 10 or more full-time employees, fall under one of the "covered industries,"[9] and process or manufacture in excess of 25,000 pounds or use more than 10,000 pounds of a recognized toxic chemical during a calendar year, are required to report to their State regulatory agency and the EPA. Some sources of toxic chemicals, therefore, are excluded from the TRI. For example, small businesses, motor vehicles and agricultural operations do not fall under TRI, even though these sources may also emit toxic chemicals (DNREC, 2001a: 1-3).

Table 4.6 illustrates the application of the PSIR model to toxic release indicators. Pressures include sources and emissions of pollutants; state involves the levels of these pollutants in the ambient air, and impact is the effect of these pollutants on air quality and the health hazards associated with exposure to them. Response relates to pollutant testing, abatement infrastructure and expenditures by the State in addition to environmental legislation, health management and education initiatives.

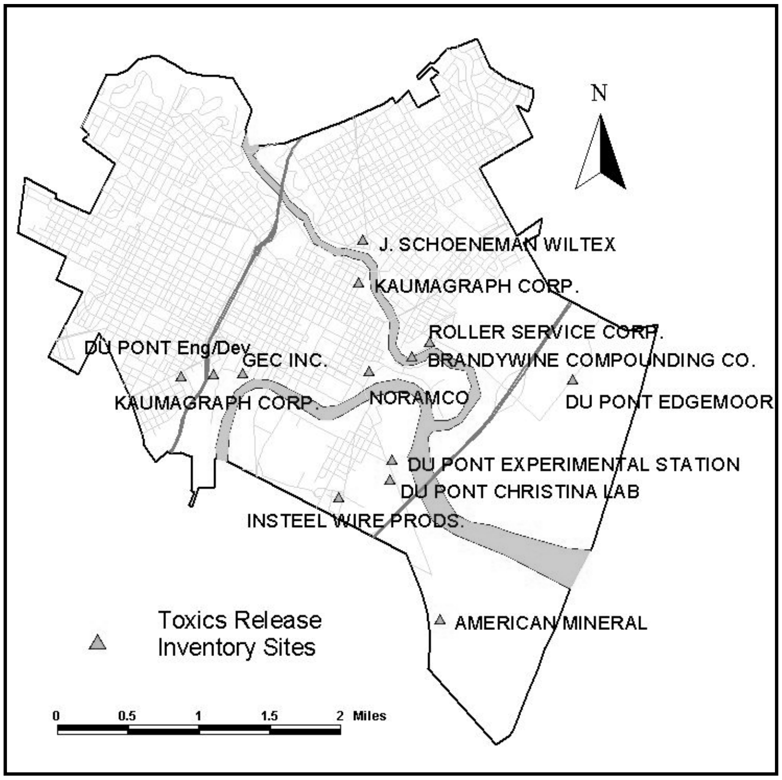
Table 4.6 Toxic Release Indicators

Indicator	Pressure	State	Impact	Response
Toxic Release Inventory Sites	Point-Source Air Emissions from Local Industries	Levels of Pollutants in Ambient Air	Health Hazards of Exposure	Pollutant Testing Air pollution abatement infrastructure Current Expenditures on Air Pollution Abatement and Control Environmental Legislation
Air Toxins	Point and Non-Point Emissions			

The City of Wilmington and its environs are home to 13 Toxics Release Inventory sites, the majority of which are located in the southern half of the City (Figure 4.6).

[9] "Covered industries" include the metal mining, coal mining, manufacturing, oil- and coal-fired electric utilities, facilities regulated under RCA Subtitle C, wholesale chemical distributors, wholesale petroleum stations and terminals, solvent recovery services and federal facilities.

Figure 4.6 Toxics Release Inventory Sites in Wilmington



Pollutants released from these sites are largely emitted into the local atmosphere, some in quantities that have been found to cause health problems.

Table 4.7 lists all of the TRI sites in the Wilmington area and the quantity of each pollutant that these facilities emit into the local atmosphere. A main concern is the emission of chromium.

Chromium has several different forms, which cannot be differentiated by the TRI. Chromium (III) occurs in the environment naturally and is an essential nutrient in the human diet. Chromium (0) and Chromium (VI) are produced through industrial processes such as stainless steel welding, chemical manufacturing, leather tanning, dye manufacture, and textile industries. Chromium compounds are emitted into the air as fine dust particles that settle over land or water within 10 days of emission. Humans can be exposed to chromium through breathing contaminated air, ingesting contaminated food or water, or through direct skin contact (DNREC, 2001a; ASTDR, 2002a).

The Agency for Toxic Substances and Disease Registry (ATSDR) has determined that people who live near specific industries and land-use applications are at risk for chromium exposure. These include landfill sites with chromium-containing wastes, industrial facilities that manufacture or use chromium and chromium-containing compounds, cement-producing plants, industrial cooling towers that previously used chromium as a rust inhibitor, waterways that receive industrial discharges from electroplating, leather tanning, and textile industries and busy roadways[10] (ASTDR, 2002a). Additional activities are listed in Table 4.8.

[10] Emissions from automobile brake lining and catalytic converters contain chromium.

Table 4.7 Toxics Release Inventory Sites		
Facility Name	**Pollutant**	**Air Releases (pounds)**
Alloy Surfaces	Nickel*◇	232
	1,1,1-Trichloroethane◇	229
American Minerals	Barium◇	106
	Chromium Compounds*◇	6,400
	Lead*◇	57
	Manganese Compounds◇	5,400
Brandywine Compounding	Antimony Compounds◇	0
	Copper Compounds◇	0
	Decabromodiphenyl Oxide	0
DuPont Christina Lab[1]	N/A	
DuPont Edge Moor	Carbonyl Sulfide	290,000
	Chlorine	2,458
	Hydrochloric Acid (Aerosol)	10,403
	Phosgene	800
	Titanium Tetrachloride◇	30
	Toulene◇	1,381
Dupont Eng/Dev Lab[1]	N/A	
Dupont Experimental Station[2]	N/A	
GEC Industries[1]	N/A	
Insteel Wire Products	Zinc Compounds◇	0
J. Shoenaman-Wilte[1]	N/A	
Kaumagraph[1]	N/A	
Noramco	1,3-Dichlorobenzene	400
	Dichloromethane*	3,100
Roller Service	DI(2-Ethylhexyl) Phthalate (1)* ◇	0

N/A: No information listed in the *1998 Data Summary: Delaware Toxics Release Inventory Report*
* Pollutant is considered a carcinogen by DNREC and the U.S. EPA
◇ Health Implications for chemical have been assessed by the Agency for Toxics and Disease Registry
[1] Facilities have ceased operations prior to 1998.
[2] Facility determined prior to the 1998 reporting cycle that they do not meet the definition as a covered facility under the EPCRA Section 313 (TRI) program

Source: DNREC, 2001a; personal communication with David F. Fees, Program Manager, Emissions Inventory Development Program, Delaware Air Quality Management Section, January 9, 2002.

Table 4.8 Industries that can lead to Occupational Exposure to Chromium Compounds	
Industry	**Chromium Compound**
Stainless steel welding	Chromium (VI)
Chromate production	Chromium (VI)
Chrome plating	Chromium (VI)
Ferrochrome industry	Chromium (III) and Chromium(VI)
Chrome pigments	Chromium (III) and Chromium(VI)
Leather tanning	Mostly Chromium (III)
Occupations that may Involve Chromium Exposure	
Occupation	**Chromium Compound**
Painters	Chromium (III) and Chromium (VI)
Workers involved in the maintenance and servicing of copying machines, and the disposal of some toner powders from copying machines	Chromium (VI)
Battery makers	Chromium (VI)
Candle makers	
Dye makers	Chromium (III)
Printers	Chromium (III) and Chromium(VI)
Rubber makers	Chromium (III) and Chromium(VI)
Cement workers	Chromium (III) and Chromium(VI)

Source: ASTDR, 2002b

The U.S. EPA does not require that the specific form of chromium compound -- a (III), (0) or (VI) -- be distinguished in the reporting system. As a consequence, the TRI program does not receive any information regarding the speciation of metal compounds (U.S. EPA, 2001a; David F. Fees, pers. com., January 9, 2002). Other chemicals, many of which are not captured by the TRI, are of concern and are currently tested by the State of Delaware at the Wilmington monitoring station. These are presented in Appendix B.

The State of Delaware monitors for 41 air toxics in Wilmington (Table 4.9) in order to establish baseline concentrations to detect future changes. This will provide a point to compare Wilmington levels with other areas. Because there are no ambient air standards for air toxics, this data cannot establish if Wilmington's air quality is meeting a standard (Elizabeth Frey, pers. com., January 24, 2002).

Table 4.9 Summary Data from MLK Monitoring Station for the Year 2000

Compound	Average Level Detected (ppb)	Maximum Level Detected (ppb)	Minimum Level Detected (ppb)	# Samples with Detected Amounts
1,1,1-Trichloroethane	0.07	0.11	0.05	59
1,1,2,2-Tetrachloroethane	0	0.02	0	27
1,1,2-trichloro-1,2,2-trifluoroethane	0.1	0.19	0.08	59
1,1,2-Trichloroethane	0	0.01	0	29
1,1-Dichloroethane	0	0.01	0	14
1,1-Dichloroethene	0	0.01	0	49
1,2,4-Trichlorobenzene	0	0.01	0	57
1,2,4-Trimethylbenzene	0.21	0.76	0.06	59
1,2-Dibromoethane	0	0.01	0	14
1,2-Dichloro-1,1,2,2-tetrafluoroethane	0.02	0.04	0.01	59
1,2-Dichlorobenzene	0.01	0.06	0	59
1,2-Dichloroethane	0.01	0.02	0	59
1,2-Dichloropropane	0	0.01	0	34
1,3,5-Trimethylbenzene	0.08	0.3	0.02	59
1,3-Butadiene	0.12	0.37	0	59
1,3-Dichlorobenzene	0.01	0.04	0	55
1,4-Dichlorobenzene	0.04	0.11	0.01	59
1-Ethyl-4-methylbenzene	0.05	0.19	0.01	59
Benzene	0.55	1.41	0.23	59
Bromomethane	0.05	1.2	0.01	59
Carbon tetrachloride	0.11	0.16	0.09	59
Chlorobenzene	0.01	0.1	0	31
Chloroethane	0.02	0.08	0.01	59
Chloroethene	0.02	0.22	0	59
Chloroform	0.04	0.09	0.02	59
Chloromethane	0.56	0.84	0.42	59
Chloromethylbenzene	0	0.01	0	48
cis-1,2-Dichloroethene	0	0.01	0	50
cis-1,3-Dichloropropene	0	0	0	10
Dichlorodifluoromethane	0.63	1.27	0.48	59
Ethylbenzene	0.18	0.53	0.06	59
Hexachloro-1,3-butadiene	0	0.01	0	42
meta & para-Xylene	0.6	3.76	0.21	59
Methylene chloride	0.4	1.71	0.09	59
Ortho-Xylene	0.23	0.66	0.08	59
Styrene	0.05	0.25	0.01	58
Tetrachloroethene	0.12	0.47	0.02	59
Toluene	1.27	5.31	0.46	59
trans-1,3-Dichloropropene	0	0.01	0	9
Trichloroethene	0.11	2.35	0.01	59
Trichlorofluoromethane	0.32	0.5	0.25	59

Source: DNREC 2000a: 56.

Impact of Toxic Releases

Without federal regulatory oversight through the Clean Air Act, the number of consumption thresholds for air toxins that one can consult is numerous. Different federal and state agencies have developed their own standards in accordance with their individual needs, each using a different quantitative standard. As a consequence, the impacts of toxics substances on human health are, on the surface, confusing. The measurement standard used by the State of Delaware is explained in Appendix C.

Among the federal agencies that have developed exposure thresholds, the EPA and the ATSDR are at the forefront. However, these agencies have no regulatory oversight over air pollutants that exceed their recommendations. The major thresholds developed, along with a discussion of the ambiguities associated with them, are presented in Appendix D. Table 4.10 compares air toxins in Wilmington to the major thresholds.

Part of the ambiguity experienced in making sense of the health effects of air toxins stems from the way that threshold levels of exposure are measured. Because the same toxic chemical can affect the human body in a number of ways depending upon the level and mechanism of exposure, there are actually a number of different thresholds for any one chemical depending upon the "endpoint" -- the physical impact of exposure on human health. For each air toxin and chemical there are several, in some cases many, reactions to exposure within the human body according to the dose to which an individual is exposed. These "dose-response relationships" can cause minor irritation at low levels of exposure, and death under acute conditions.

Many air toxics released from point and non-point sources have been determined to cause a number of health risks. Symptoms of exposure, target organs and carcinogenic risk are assessed for each air toxic. These are presented in Appendix E. Toxic releases that fall under the TRI are emitted from point sources; industries release air toxins from their smokestacks.

Air toxins threaten air quality in the City of Wilmington. Air quality is an important factor in determining human health. Air toxins, when inhaled, can cause or escalate human illnesses. While each air toxin is analyzed in the following pages individually, the cumulative impact of breathing many different air toxins must be recognized.

Table 4.10 Wilmington Air Toxics (ppb)

Summary Data from MLK Monitoring Station for the Year 2000				EPA Assessments				ASTDR MRL	NIOSH	State of California REL	State of California Basis for Regulatory Action
Compound	Ave	Max	Min	(RfC)	E-4 1 in 10 thousand	E-5 1 in 100 thousand	E-6 1 in 1 million				
1,1,1-Trichloroethane	0.07	0.11	0.05					700			
1,1,2,2-Tetrachloroethane	0	0.02	0		0.292	0.0292	0.0022	400	1,000*		0.0003297
1,1,2-trichloro-1,2,2-trifluoroethane	0.1	0.19	0.08								
1,1,2-Trichloroethane	0	0.01	0		1.098	0.1098	0.01098				
1,1-Dichloroethane	0	0.01	0								0.0000003
1,1-Dichloroethene	0	0.01	0					20			
1,2,4-Trichlorobenzene	0	0.01	0								
1,2,4-Trimethylbenzene	0.21	0.76	0.06								
1,2-Dibromoethane	0	0.01	0								
,2-Dichloro-1,1,2,2-tetrafluoroethane	0.02	0.04	0.01								
1,2-Dichlorobenzene	0.01	0.06	0								
1,2-Dichloroethane	0.01	0.02	0		0.998	0.0998	0.00998	600	1,000#		
1,2-Dichloropropane	0	0.01	0	0.126				7			0.0000038
1,3,5-Trimethylbenzene	0.08	0.3	0.02	0.864							
1,3-Butadiene	0.12	0.37	0		0.18	0.018	0.0018				0.000000768
1,3-Dichlorobenzene	0.01	0.04	0								
1,4-Dichlorobenzene	0.04	0.11	0.01					100		116.37	
1-Ethyl-4-methylbenzene	0.05	0.19	0.01								
Benzene	0.55	1.41	0.23		2.38	0.238	0.0238	50		22.21	
Bromomethane	0.05	1.2	0.01					5		1.544	
Carbon tetrachloride	0.11	0.16	0.09	.001287	1.113	.1113	.01113	50		15.197	
Chlorobenzene	0.01	0.1	0							378	
Chloroethane	0.02	0.08	0.01							1	
Chloroethene	0.02	0.22	0								
Chloroform	0.04	0.09	0.02		0.82	0.082	0.0082	20		7.61	
Chloromethane	0.56	0.84	0.42					50			
Chloromethylbenzene	0	0.01	0								
cis-1,2-Dichloroethene	0	0.01	0								
cis-1,3-Dichloropropene	0	0	0								
Dichlorodifluoromethane	0.63	1.27	0.48								
Ethylbenzene	0.18	0.53	0.06	.230				1000			
Hexachloro-1,3-butadiene	0	0.01	0		0.47	0.047	0.0047				
Meta & para-Xylene	0.6	3.76	0.21								
Methylene chloride	0.4	1.71	0.09	1007				300		1007	
Ortho-Xylene	0.23	0.66	0.08								
Styrene	0.05	0.25	0.01	234		N/A	N/A	60		164	
Tetrachloroethene	0.12	0.47	0.02					40		1002	
Toluene	1.27	5.31	0.46	106				80			
Trans-1,3-Dichloropropene	0	0.01	0	0.0044							
Trichloroethene	0.11	2.35	0.01					100			
Trichlorofluoromethane	0.32	0.5	0.25								

* During an 8-hour workday, 40 hour work week
\# During a 10 hour workday, 40 hour work week

Source: California Air Resources Board, 2001; U.S. EPA,2001j; ASTDR 2002b

4.2 Legislative, Judicial and Administrative Responses to Air Pollution in Wilmington

Federal

As noted previously, institutional responses to air pollution in the City of Wilmington cannot be looked at in isolation from State and Federal initiatives. In this regard, the Federal and State levels are good starting points to understanding the nature and direction of local responses to air pollution. The Clean Air Act (CAA) 1970 (as amended in 1990) is the main piece of legislation that addresses air pollution. The CAA has established the National Ambient Air Quality Standards (NAAQS) for six pollutants ("criteria" pollutants) -- ozone (O_3) carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter (PM_{10}) and lead (Pb) (DNREC, 1996). These standards (Table 4.11) represent the level at which the pollutants are considered dangerous to human health. However, there are a number of non-criteria pollutants which do not have ambient standards. These include acid rain, air toxics and volatile organic compounds (VOCs) (ibid.).

Figure 4.7 Philadelphia-Wilmington-Trenton Consolidated Metropolitan Statistical Area

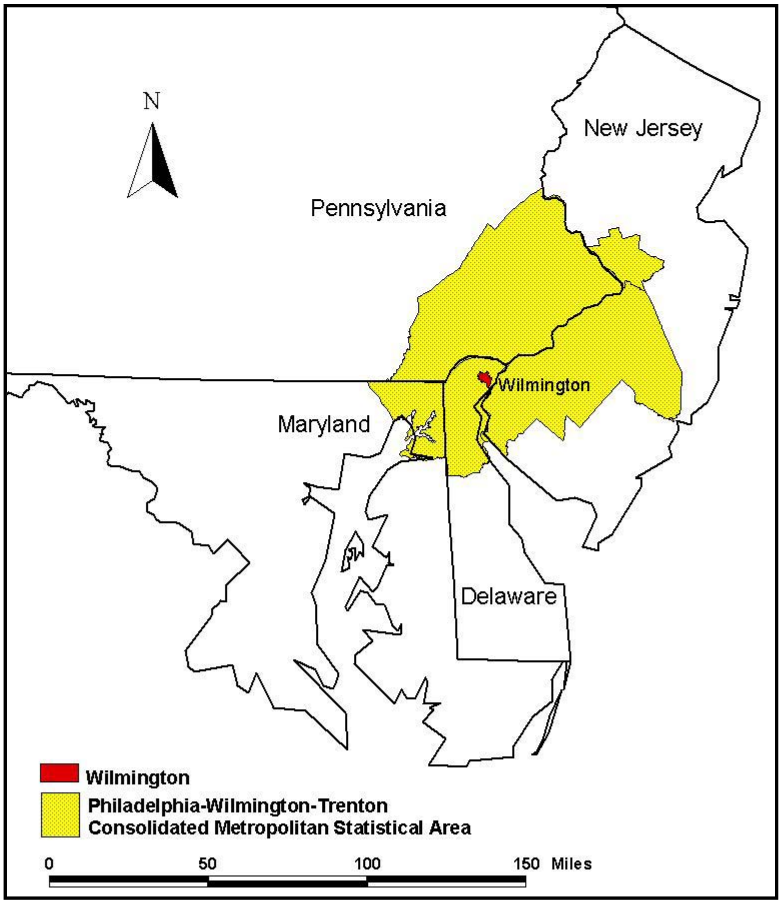


Table 4.11 National Ambient Air Quality Standards						
Pollutant	**Maximum 1 hour average**	**Maximum 3 hour average**	**Maximum 8 hour average**	**Maximum 24 Hour Average**	**Annual Arithmetic Mean**	**Notes:**
Carbon Monoxide	35 ppm (40 µ/m³)		9 ppm (10 µ/m³)			Not to be exceeded more than once per year
Nitrogen Dioxide					0.053 pm (100 µ/m³)	
Ozone	0.08 ppm		0.12 ppm			
Particulate Matter (PM_{10})				150 µg/m³	50 µg/m³	Not to be exceeded more than once per year averaged over three years
Particulate Matter – Fine ($PM_{2.5}$)				65 µg/m³	15 µg/m³	
Sulfur Dioxide		0.5 ppm (1300 µg/m³)		0.14 ppm (365 µg/m³)	0.03 ppm (80 µg/m³)	
Lead				1.5 µg/m³		
Source: DNREC, 2001a						

In Delaware, ground level ozone has been the major air pollution problem. Delaware (and specifically New Castle and Kent Counties), has been singled out under the CAA (1990), as a part of the severe non-attainment Philadelphia-Wilmington-Trenton Consolidated Metropolitan Statistical Area (the "Philadelphia CMSA -- Figure 4.7) for Volatile Organic Compounds (the "VOCs"), Nitrogen Oxides (NO_X) and Carbon Monoxide (CO) (DNREC, 2000f). These are areas that do not meet the CAA's 1-hour NAAQS for ozone and are required to submit, within two years (from 1990), an emissions inventory. This inventory is used as the baseline from which to measure subsequent reductions (CAA Section 182).

Section 182 also requires non-attaining states like Delaware to file periodic inventory reports every three years, starting in 1993, until the area is certified as in compliance with the final deadline set for the year 2005 (DNREC, 2000f). Under the CAA, Delaware was required to reduce its 1990 ozone levels by 15% by 1996 and by 3% per each subsequent year. Note, however, although VOCs do contribute to the ozone problem, no standards have been established for them. Despite this, the EPA and the State of Delaware are currently jointly collecting and sharing data with the view of developing an acceptable criterion for VOCs.

State and Regional

Delaware's main air quality goal has been to reduce ozone to the ambient levels stipulated by the CAA (1990). To implement federal air quality standards the State has set up, within DNREC, a Division of Air and Waste Management (DAWM) responsible for enforcing air pollution and waste management standards. DAWM, in turn, has a separate specialized section, the Air Quality Management Section (AQMS), specifically designed to enforce the National Ambient Air Quality Standards (NAAQS) as required by the CAA (as amended in 1990) (DNREC, 2000f).

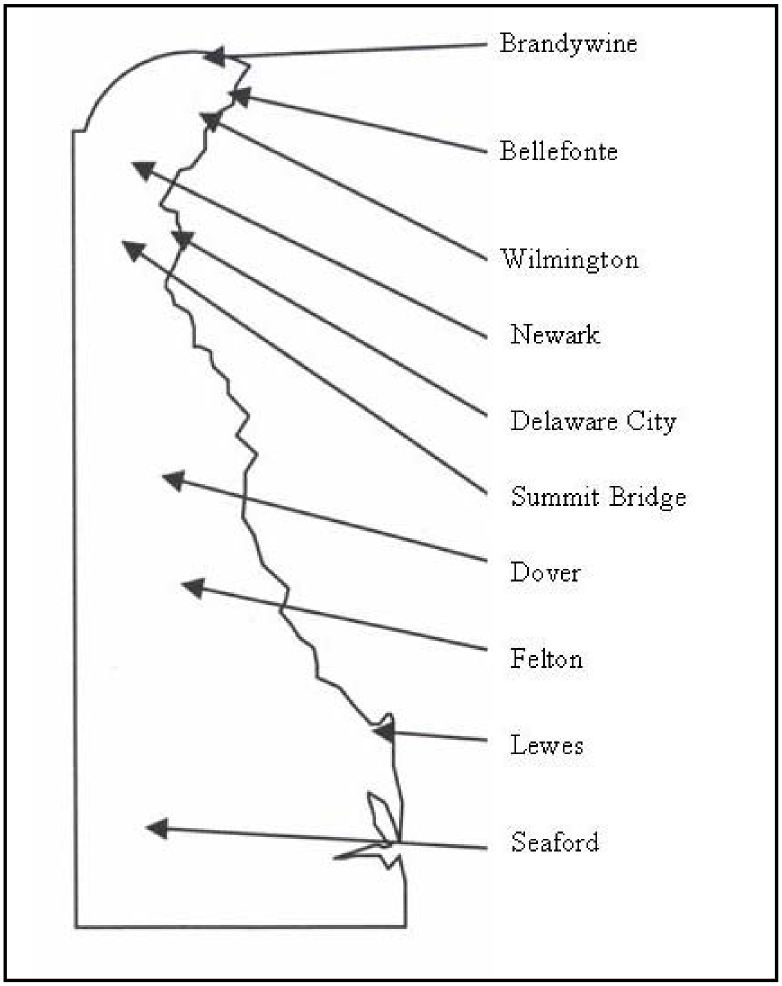
The AQMS has three branches (Engineering and Compliance, Air Surveillance and Planning and Community Protection) all of which are designed to handle different aspects of air pollution to ensure compliance with delegated federal mandates, with the view of protecting public health and welfare. The Engineering Branch is responsible for issuing pollution control permits, conducting inspections and developing regulations or permit conditions as needed. The Air Surveillance Branch (ASB) focuses on industrial sources. Specifically, the ASB ascertains the emission levels before permits are issued, determines when emission violations occur (under its Source Monitoring Program), and performs regular testing for specific chemicals to ensure ambient air quality standards are being met (through the Ambient Air Quality Monitoring Program). The Planning and Community Protection Branch has four programs which focus on accidental releases (the Accidental Prevention Program which encourages prevention of industrial accidents through better risk management methods), cataloguing emissions from all sources (through the Emission Inventory and Development Program), certification as attaining area (through Airshed Assessment and Improvement Program which develops the State Implementation Plans) and emergency planning (through the Emergence Planning and Community Right-to-Know [EPCRA] Reporting Program).

DNREC has promulgated air quality regulations which cover ambient air quality standards, particulate emissions from fuel burning equipment, industrial process operations and construction; emissions incinerators, sulfur and nitrogen oxides and compounds, carbon monoxide, open burning, control of odorous air pollutants, volatile organic compounds, motor vehicle emissions, the emission banking and trading program, the acid rain program, hazardous pollutants and the national low emission vehicle program (DNREC, 2001b; DNREC, 1996: 4; DNREC, 1998; DNREC, 1999:7; DNREC 2001: 8). Delaware still continues to test for all criteria pollutants except Lead (Pb).

In the year 2000 Delaware maintained ten air quality monitoring stations by a combination of Federal and State funding. Six of these stations are located in New Castle County: Brandywine, Bellefonte, Wilmington, Newark, Delaware City and Summit Bridge (Figure 4.8). While the City of Wilmington has only one air quality monitoring station, it does calculate an Air Quality Index (AQI) during every working day. The AQI is a standard established by the EPA to comparatively measure overall air quality (DNREC, 2001a: 9, 42; Elizabeth Frey, pers. com., January 7, 2001).

The Wilmington monitoring station tests for sulfur dioxide, carbon monoxide and both sizes of particulate matter. It does not test for nitrogen dioxide or ozone. Table 4.12 shows the air pollutants tested at each of Delaware's monitoring locations.

Figure 4.8 Locations of Air Quality Monitoring Stations in Delaware



Source DNREC, 2001a: 42

Table 4.12 Criteria Air Pollutants Delaware's Monitoring Stations

Monitoring Station	Sulfur Dioxide	Nitrogen Dioxide	Carbon Monoxide	Ozone	PM_{10}	$PM_{2.5}$	Lead
Brandywine							
Bellefonte							
Wilmington							
Newark							
Delaware City							
Summit Bridge							
Dover							
Felton							
Seaford							
Lewes							
Source: DNREC, 2001a: 41							

Delaware stopped testing for lead in 1989, after almost a decade of successful conversion from leaded to unleaded gasoline (DNREC, 1996; DNREC, 1998b; DNREC, 1999c; DNREC 2001a). In place of testing lead in the air, Delaware has promulgated the Childhood Lead Poisoning Prevention Act (Title 16 Chapter 26), which requires all children born after March 1, 1995 to be screened for lead poisoning at or around 12 months of age (§ 2602), prior to attending day care or school (§ 2603).

Although elimination of leaded gasoline may have reduced emissions to ambient levels that no longer threaten human health, new studies are needed. Lead may have ceased to be a major threat at the aggregate level but nonetheless is still one of the causes of ill-health and other related problems in places like Wilmington and other historic cities.

In an effort to deal with ozone, Delaware focused on Wilmington, its largest and, perhaps, most polluted city. The State specifically calculates and reports to the American Lung Association, for distribution to the local media (WILM 1450AM, WNRK 1260AM and telephone Weatherline), a Pollutant Standards Index (PSI) for Wilmington for every working day (DNREC, 1996: 5).

Regulating ozone is complex, however, as nitrogen and VOCs that cause it come from multiples sources, both natural and human-made, and travel over long distances. Efforts have mainly focused on regulating gasoline vapor emissions, inspecting automobile exhausts and regulating VOC and NO_x emissions from industrial sources (ibid.). While these efforts are welcome, more collaborative regional initiatives may be needed.

In addition to these regulations, the State of Delaware has an emergency program pursuant to the Emergency Planning and Community Right-to-Know Act (EPCRA). This reporting program is administered through DNREC's Air Quality Management Section (AQMS). The primary goal is to collect and disseminate information reported under Federal and State EPCRAs to emergency planning and response organizations throughout the State of Delaware (State of Delaware, 2002). Only facilities that have been listed with the EPA as possessing extremely hazardous substances, however, are subject to this regulation and therefore required to report any hazardous substance(s) that exceed(s) the minimum Threshold Planning Quantity (State of Delaware, 2002: Section 302). In complying with EPCRA, the Delaware State Emergency Response Commission (SERC) has established the City of Wilmington Local Emergency Planning Committee (LEPC) to facilitate coordination between government, the private sector, emergency organizations and the public (City of Wilmington, 2002).

DNREC enforces air quality standards primarily through suits and administrative action. Administrative action by far surpasses criminal and civil enforcement, perhaps because lawsuits take a long time to resolve. Administratively, DNREC may assess penalties or fines, require violators to stop the infraction and make good of the damage, or require the violator to spend a portion of the money on projects that promote the environment. Table 4.13 is a summary of the complaints, and DNREC's enforcement action, against violators of air quality and waste management standards.

Local

The City of Wilmington has the power to take action against polluters, especially in areas that are not directly covered by the Federal government and the State. This power to regulate the environment is embodied in the Wilmington City Code, as revised September 6, 2001. In addition to the powers delegated to it under the Constitution and the laws of Delaware (Sect. 1-102), the Code provides the City with the power to legislate. By section 1-104, the City can enter into any collaborative project or activity jointly or in cooperation with the State, the Federal government, the County or any branch of government. These powers, however, do not encroach on the authority of the Federal and State agencies, for instance, under the CAA. It follows, therefore, that the City of Wilmington can act: (i) jointly or in cooperation with the Federal government and the State, (ii) carry out any stated Federal or State mandate and (iii) act alone, where the State or Federal levels do not provide.

It is important to note that the City of Wilmington does not have an environmental department and therefore continues to rely heavily on the State for enforcement of air quality standards. The City can, and in practice does, go around these restrictions through the Code and Ordinances that regulate land use and nuisance type of activities (such as odors, open burning and provisions limiting or prohibiting specified industrial activity), with a view to maintaining the health and welfare of its people. The powers of the City in maintaining public health, welfare and safety, provide it with almost unlimited ways to control pollution through Codes and

Ordinances that are enforceable through civil and criminal suits. In practice, however, this has to be balanced with the need to attract businesses and industries to the area -- a major source of revenue for the City and income for its residents.

Table 4.13 Enforcement of Air and Waste Management Standards by DNREC 1995-2001

Year	County Type	New Cast.	Kent	Sussex	*Total*	%
1995	Comp.	3674	1263	1701	6638	9.45
	Action	380	149	98	627	
	%	**10.34**	**11.80**	**5.76**		
1996	Comp.	3888	1326	1614	6828	8.82
	Action	359	127	116	602	
	%	**9.23**	**9.58**	**7.19**		
1997	Comp.	3355	1365	1600	6320	11.99
	Action	478	151	129	758	
	%	**14.25**	**11.06**	**8.06**		
1998	Comp.	2884	1670	1601	6155	8.82
	Action	205	162	176	543	
	%	**7.11**	**9.70**	**10.99**		
1999	Comp.	3337	1365	1571	6273	9.10
	Action	263	131	177	571	
	%	**7.88**	**960**	**11.27**		
2000	Comp.	3100	1534	1694	6328	7.30
	Action	155	126	181	462	
	%	**5.00**	**8.21**	**10.68**		
2001[a]	Comp.	2017	1177	1243	4437	7.37
	Action	96	123	108	327	
	%	**4.76**	**10.45**	**8.69**		
Data Source: DNREC, 2002n						

The City can also regulate environmental quality through land use planning—and specifically through zoning laws. Since the Supreme Court in Village of Euclid v. Ambler Realty Company, a 'Euclidean Zoning" system -- in which industrial, commercial, multi-family residential, and single family residential areas are segregated has become the norm (Reitze, Jr. and Arnold, 1999: 691). The City can legitimately— determine the location of residential versus commercial buildings, the number and location of parking lots, for instance, all of which can affect the presence of industries and other businesses in the City, and the volume of traffic into the City. By default, this can control both mobile and stationary sources of air pollution within City limits. The City can do this through taxes and other disincentives.

4.3 Conclusion

The area of air toxics monitoring is rapidly developing. The State of Delaware expects more EPA guidance, some special studies, and potential funding shifts (to toxics from other areas) over the next few years. At this time most interest is focused on urban areas and populated areas impacted by nearby industrial sources (personal communication with Betsy Frey, QA Coordinator, Air Surveillance Branch, Air Quality Management Division, Air & Waste Management, Department of Natural Resources and Environmental Control January 24, 2002).

Standards for the reporting of toxic chemicals are becoming more stringent. In January 2001 the EPA lowered the TRI reporting threshold for lead emissions from plants under EPCRA. The new rule requires facilities that process or consume as little of 100 pounds of lead annually to report its releases. Lead was identified for these new emissions requirements because it is considered a Persistent Bioaccumulative Toxic (PBT) chemical that remains in the environment for extended periods of time and accumulates in body tissue (U.S. EPA, 2001d).

V. LAND

Wilmington's history of industrialization and economic development has left behind substantial areas of contaminated land. Table 5.1 presents the issues related to the state of the land in the PSIR format.

Table 5.1 Land Indicators

Indicator	Pressure	State	Impact	Response
Contaminated Land - petroleum products - arsenic - PCBs - lead - mercury - zinc - chromium	Underground Storage Tanks Abandoned Tannery Sites Hazardous Waste Generators Hazardous Substance Sites (SIRB)	Site Monitoring At Risk Zones for Children	Health Hazards of Pollutants Environmental Damage	State and Federal Programs Pollutant Testing Pollution abatement infrastructure Current Expenditures on Pollution Abatement and Control Remediation Assistance provided to land-owners Waste Prevention Activities Expenditures on Waste Prevention, Reuse and Disposal

The main sources of pressure on the state of land in Wilmington include underground storage tanks (USTs), abandoned tannery sites, hazardous waste generating operations and industrial sites.

5.1 Underground Storage Tanks

Underground storage tanks (USTs) are tanks that have a minimum of ten percent of their volume underground. The EPA has identified the following USTs as

- Farm and residential tanks of 1,100 gallons or less capacity holding motor fuel used for noncommercial purposes;
- Tanks storing heating oil used on the premises where it is stored;
- Tanks on or above the floor of underground areas, such as basements or tunnels;
- Septic tanks and systems for collecting storm water and wastewater;
- Flow-through process tanks;
- Tanks of 110 gallons or less capacity; and
- Emergency spill and overfill tanks (U.S. EPA, 2001i).

Prior to the mid-1980s, USTs were made of steel, which corrodes over time, allowing the contents to leak into the environment. Leaked hazardous substances such as petroleum products can contaminate soil, groundwater and surface water. USTs also pose the risk of explosion and fire (U.S. EPA, 2002d).

The City of Wilmington is home to 453 USTs, 20 of which are currently active (Figure 5.1). Inactive USTs pose the risks identified above.

5.2 Former Tannery Sites

Wilmington was home to a tannery industry from the 1840s through the 1970s. DNREC has identified 53 former tannery sites in the City (Figure 5.2). Issues of concern at these sites include:

- Potential health risks, especially among children
- Current use of the site
- Presence and extent of bare surface soils
- Current construction and excavation
- Other earth-disturbing activities.

(DNREC News, 2001b: Vol. 31, No. 353. November 14).

The health risks result from the long-term exposure to arsenic which was used in tannery operations in 1950 and which now remains in the soils of these sites (DNREC News, 2001a: Vol. 31, No. 78, March 13). For example, investigations at the Compton Townhouse Apartments complex, a residential community located near 9th and Walnut Streets, have revealed arsenic levels above Delaware's acceptable levels for

Figure 5.1 Underground Storage Tanks in Wilmington

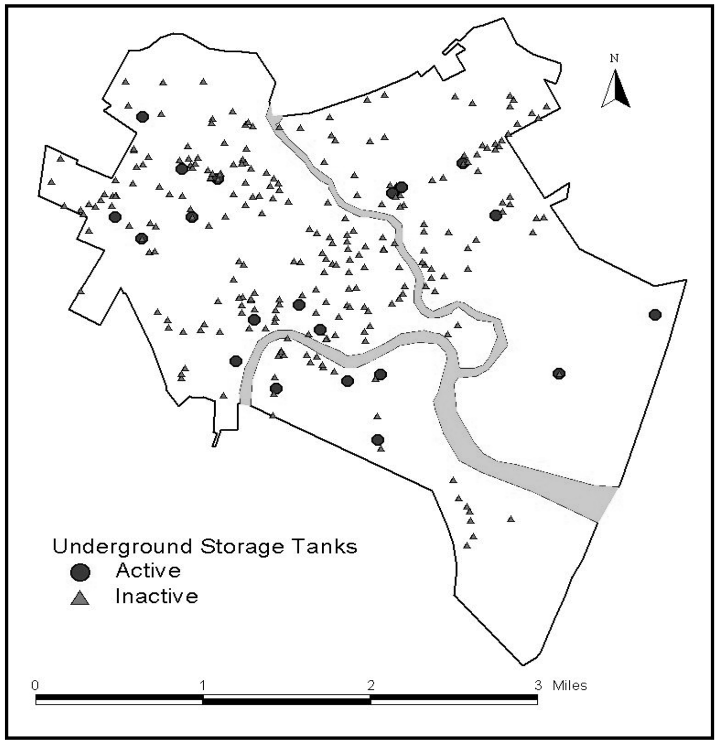
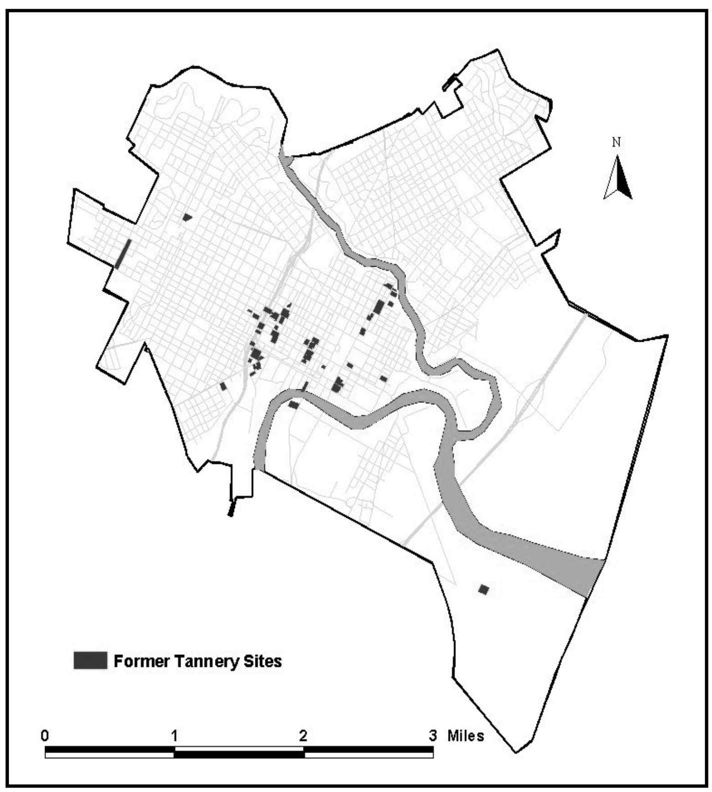


Figure 5.2 Former Tannery Sites in Wilmington



inadvertent ingestion of surface soils. Residents of the Compton community have therefore been advised to restrict their children from playing in yard areas that have bare soils, and from digging in the soil or disturbing the ground in any way as a precaution against exposure.

Other contaminants found at the Compton site include polynuclear aromatic hydrocarbons (PAHs) in the shallow soils, and PAHs, cadmium, mercury and lead in the subsurface soils (2.6 to 5.5 feet below grade) (ibid.).

5.3 Hazardous Waste Generators

The State of Delaware distinguishes among a number of different types of hazardous waste (Table 5.2).

Table 5.2 Hazardous Waste		
Aerosol	Fluorescent Light Bulbs	Paint Thinner - Solvent
Ammunition	Freon	Paints - Oil based - Enamels - small quantities
Antifreeze - Business	Fuels, waste gasoline, kerosene	PCB's
Antifreeze - Homeowner	Fungicides	Perfume
Asbestos	Gasoline	Personal Protective Equipment - PPE
Asbestos - Friable	Gunpowder	Pesticides
Asbestos - Non Friable	Herbicides	Photographic Chemicals
Batteries - Automobile	House - Demolished buildings	Pool Chemicals
Batteries - Household Use	Hydraulic Fluid	Prescription Medications
Battery Disposal for Businesses (lead acid) Batteries	Kerosene	Rags - Solvent Contaminated
Bird Feces	Lead - Household Paints	Smoke Detectors
Bleach	Lead - scrap metal	Solvents
Brake Fluid	Lead Contaminated Waste Stabilization	Spot Remover
Cathode Ray Tubes	Light Ballasts - PCB's	Stains
Chemistry Set	Mercury - Business	Strippers
Chlorobenzene	Mercury Thermometers	Syringes – used
Compressed Gas - small cylinders	Moth Balls	Thermometers - Mercury
Computers	Nail Polish, Removers	Thinners
Corrosive	Oil - Business or Large Quantities	Toilet Cleaner
Cylinders - small compressed gas	Oil - Homeowners Not mixed with other fuels	Transmission Fluid
Degreasers	Oils – Dielectric PCB's	Universal Waste
Disinfectants	Oven Cleaners	Varnish
Drain Cleaners	Paint - for bridges	Window Cleaner
Firecrackers	Paint – Latex	Wood - treated with creosote
Floor Wax	Paint – Lead	Wood Preservatives
Source: DNREC, 2002h		

There are a number of facilities in Wilmington which generate hazardous waste as part of industrial and commercial processes (Figure 5.3). DNREC has also established a database of the precise location of all hazardous sites in Wilmington. By superimposing this information onto a parcel map of the City, it was determined that 24.47% of all land is contaminated. Figure 5.4 shows that these areas are concentrated within the southern part of the City.

Figure 5.3 Hazardous Waste Generators

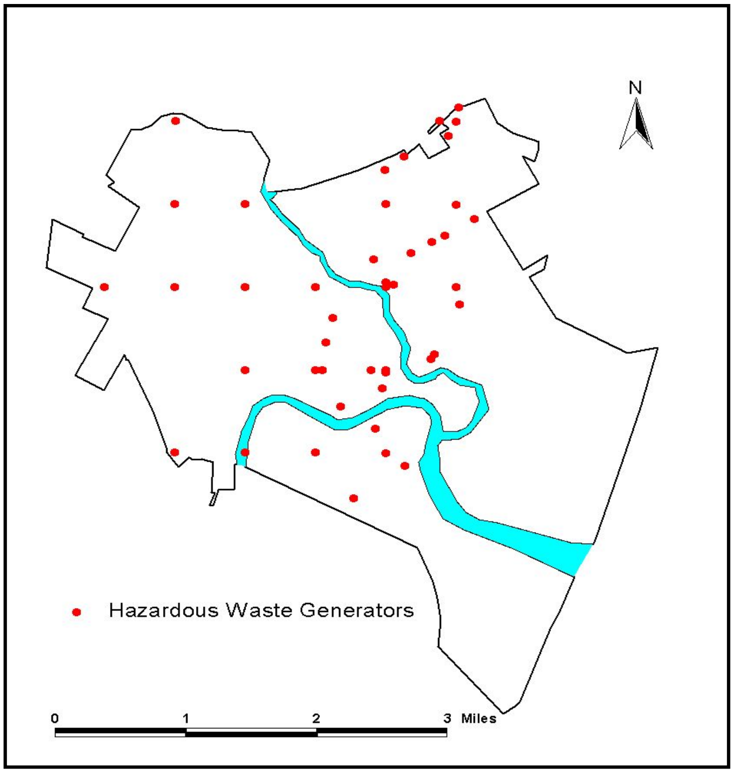
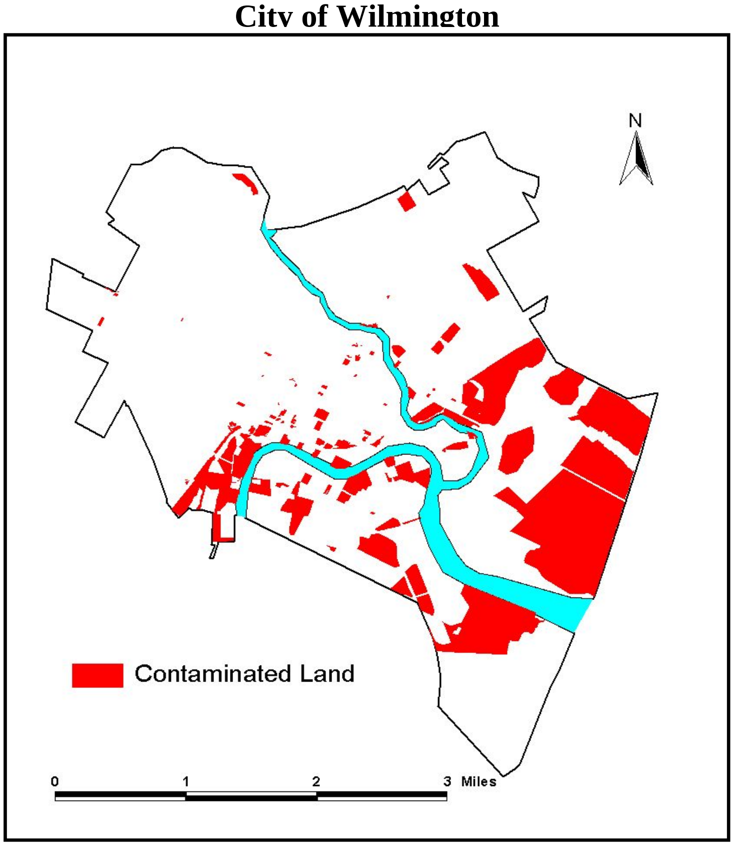


Figure 5.4 Contaminated Land within the City of Wilmington



Impacts of Exposure

The EPA, through the Mid-Atlantic Hazardous Site Cleanup Division of its Region III office, has established risk-based concentrations (RBC) for exposure to carcinogenic and non-carcinogenic soil contaminants (U.S. EPA, 2002e). Appendix F provides sample data and the RBC for contaminants that have been tested at sites in Wilmington. These tables show that arsenic, lead and PCBs -- the most dangerous chemicals -- have been found at numerous sites within the City at levels that exceed the EPA's risk-based concentrations. Mercury also exceeds the EPA/RBC at several sites.

Arsenic

Arsenic exposure can result from consuming contaminated air, water, soil or food. Contamination through skin exposure is small in comparison to ingestion. Arsenic is poisonous. Consumption of more than 60 ppm can cause death; between 0.3 to 30 ppm can irritate the stomach and intestines and cause stomach pain, diarrhea, nausea and vomiting. Exposure can also reduce the production of red and white blood cells, leading to abnormal heart rhythm, fatigue, damage to blood vessels and nerve function. Long-term oral exposure can result in a darkening appearance of the skin and "corns" or "warts" on the "palms, soles, and torso," which could develop into skin cancer. In addition, oral consumption of arsenic can lead to an increased risk of liver, prostate, bladder, kidney and lung cancer. Inhalation can cause throat and lung irritation and skin effects similar to those of oral exposure. Long-term inhalation exposure can disrupt circulatory and peripheral nervous system function. Some studies suggest that arsenic can obstruct fetal development. Children are more susceptible to the harmful effects of arsenic exposure.

The Department of Health and Human Services (DHHS), the International Agency for Research on Cancer (IARC), the EPA and the National Toxicology Program (NTP) all consider inorganic arsenic to be a known carcinogen (ATSDR, 2002b). Appendix F-1 shows arsenic exposure levels at contaminated sites in Wilmington.

PCBs

PCB exposure can occur by breathing air, drinking water and eating fish that are contaminated, and through skin contact. PCB exposure can lead to skin rashes and acne, nose and lung irritation, gastrointestinal pain, blood and liver changes, depression and fatigue. It can also cause liver and biliary tract cancer. As with arsenic, the hand-to-mouth behavior of children who play in contaminated areas can increase child susceptibility. In addition, children can be exposed prenatally, and by consuming breast milk if the mother is exposed. The DHHS and the IARC have determined that PCBs are a possible human carcinogen (ibid.). Appendix F-2 shows PCB exposure levels at contaminated sites in Wilmington.

Lead

Lead can enter the body by breathing contaminated dust, eating paint chips, or swallowing dirt. Only small amounts of lead pass through the skin, unless the skin is damaged by wounds, scrapes or scratches. Once it enters the body, lead travels through the blood to the “soft tissues” of the heart, brain, lungs, kidneys, spleen and muscles. Lead can also be stored in the bones, where it can re-enter the blood and re-contaminate soft tissues under specific conditions such as bone breakage, pregnancy, breast-feeding and aging (ibid.).

Lead targets the central nervous system and causes a number of negative health effects including brain and kidney damage, organ damage, elevated blood pressure, altered nervous system function, miscarriage among pregnant women and reduced sperm production. It is able to pass through the placental barrier, thereby exposing babies while they are still in the womb (ibid.).

Children and adults react differently to lead exposure. Adults can eliminate approximately 99% of the lead they ingest in waste within a few weeks, while children can only eliminate approximately 32%. A greater proportion therefore accumulates in the body tissues of children than of adults (ibid.).

Their play activities and behavior and their generally close contact with the ground render children more susceptible to lead poisoning than adults. The Center for Disease Control and Prevention (CDC) has determined that 900,000 children between the ages of 1 and five years have elevated blood lead levels. Lead can interrupt their mental development, resulting in lower intelligence. Other symptoms include kidney damage, colic, blood anemia, muscle weakness and brain damage. Severe exposure can cause death (ibid.).

The CDC recommends that all children between the ages of 1 and 2 have their blood tested for lead, and that all children who receive social services between the ages of 3 and 6 years be tested if they have not been tested previously. Children who have blood lead levels of 10 µg/dL or higher are considered to be exposed to lead. Medical treatment may be necessary for levels greater than 45 µg/dL (ibid.).

5.4 Legislative, Judicial and Administrative Response to Land Contamination in Wilmington

Before we examine the institutional responses to land pollution in Wilmington, the following points should be noted.

1) Environmental degradation in the city of Wilmington, as elsewhere, is a product of industrialization. Cities have historically borne the brunt of air, water and land pollution and, therefore, have been the first to respond to these menaces through local, city, or municipal codes and regulations whose enforcement was traditionally based on tort law.

2) The federalization of environmental laws is recent, and has been a product of the interstate or the trans-boundary nature of pollution. The federal system involves legislation and enforcement through judicial (civil or criminal) and administrative action. This regulatory framework is mostly media specific i.e. focuses on air, land, water, etc and sets minimum standards which states are mandated to attain. States, however, are free to adopt more stringent standards as long as they comply with federal law.

3) States have the primary responsibility of enforcing environmental laws as delegated to them from the federal government via the Environmental Protection Agency (EPA). But note that the EPA has the ultimate responsibility in enforcing federal environmental law and may intervene where states have failed to take remedial action(s) to curb pollution.

4) State and local enforcement of anti-pollution law continues to be an important feature of the environmental regulatory framework notwithstanding the federalization of environmental law.

5) Despite the media focus of the US environmental regulatory framework, pollution is a very complex phenomenon in that dumping hazardous waste on land, for instance, could affect air and underground water quality which, in turn, could have far reaching ramifications on the ecosystem beyond its immediate milieu.

Federal Regulation of Land Pollution

Federal regulation of land pollution has been mainly through the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (or the Superfund Law), which regulate the disposal of hazardous solid waste on land and cleanup of previously abandoned hazardous waste sites, respectively.[1]

The RCRA was enacted in 1976, and came into force in November 1980, to prevent land and underground water pollution. In enacting the RCRA, Congress declared the reduction or the expeditious elimination of hazardous waste, whenever feasible, and the treatment, storage or disposal of generated waste to "minimize the present and future threat to human health and the environment as the national policy of the United States (42 U.S.C. §6901(b))." To promote this national policy Congress set out eleven objectives, namely:

a) To provide states and local governments safe disposal of hazardous waste;
b) To provide training grants in occupations that involve the design, operation and maintenance of solid waste disposal systems;
c) To prohibit future dumping on land;
d) To ensure protection of the environment and human health, safe handling of hazardous waste in the first instance;
e) To minimize waste disposal on land through process substitution, resource recovery, recycling and reuse and treatment;
f) To establish a viable federal-state partnership in dealing with hazardous waste;
g) To promulgate regulations for the collection, transport, separation, recovery and disposal of solid waste
h) To promoting research in waste handling;
i) To promote waste handling that is consistent with air and water quality; and
j) To collaborate with state and local government and the private sector in the recovery of valuable materials and energy from solid waste.

Although eliminating hazardous waste altogether is part of the stated national policy, in practice most of the RCRA's provisions do not anticipate prevention of waste generation. To be specific, the RCRA regulates only those entities that generate, treat, store or dispose (TSDs) of hazardous waste and applies prospectively except for its cleanup programs. Its regulatory mandate is accomplished through promulgation of standards and permitting processes that regulate TSDs. Among the outstanding features of the RCRA is the 1984 Hazardous and Solid Waste Amendment (HSWA) that among other things created new programs such as the Land Ban which outlaws disposal of hazardous waste that do not meet EPAs treatment criteria, the Corrective Action Program that requires cleanup of pre-existing TSDs, and the minimum technology requirements for different types of land disposal facilities. The RCRA mandates the EPA to authorize states to administer their own programs as long as they demonstrate that such programs meet federal standards, are consistent with

[1] Note, however, other statutes such as the Toxic Substances Control Act and Solid Waste Disposal Act, to mention a few, are part of the broader federal legislative effort at regulating pollution. We have focused on RCRA and CERCLA here because they aim at dealing with land pollution more directly and comprehensively than any other statutes.

the federal program and provide adequate enforcement.[2] As with other environmental programs, states are at liberty to promulgate more stringent standard over and above those of the federal programs (42 U.S.C. §6929).

Also notable is:

1. The fact that the RCRA now applies to small generators of hazardous waste. Any entity that generates at least more than one hundred kilograms of hazardous waste in a calendar month is subject to RCRA regulations (42 U.S.C. §6921(d)(1)). The RCRA is strictly enforced and attracts serious penalties.[3]

2. *State Inventory Programs*: Each state is required to compile, publish and submit to the EPA an inventory of the location of each site within the state where hazardous waste has been stored or disposed of. Such information must include, if any, sites that predate the RCRA; amount, nature and toxicity of the waste, the identity and address of the owner; waste treatment methods used and any other activity being carried out on the site (42 U.S.C. §6933). If the state fails to do this the EPA will undertake the inventory, in which case the state looses grants from the Federal Government

3. *Prevention of Export of Hazardous Waste*. Exceptions include where the recipient country has consented and that consent is presented to the EPA, or where the country has an agreement with the United States.

4. *Application to Federal Facilities*.

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (or the Superfund law) was enacted in 1980 to fill a major loophole in US environmental laws -- the cleanup of previously contaminated hazardous waste sites which, until then, existing environmental law had not addressed. The cleanup of previously contaminated hazardous waste sites became an issue following the Love Canal Case in which hazardous waste began to seep into the basements of houses built on previously contaminated hazardous waste sites. The Love Canal Case brought to bear the inherent health risks of dumping hazardous waste on land and triggered the enactment of CERCLA as a regulatory response toward cleaning up previously abandoned hazardous waste sites which, until then, were not covered by the RCRA. In a way, CERCLA was enacted to supplement the RCRA's regulatory framework.

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[2] Note that the EPA reserves the right to intervene at any moment if it believes a particular state is not complying with federal mandate. See e.g. Sections 3007, 3008 and 3013 (cited at http://www.epa.gov/fedrgstr/EPA-WASTE/2002/February/Day-27/f4528.htm last visited 6/20/02).

[3] For example, a person who knowingly places another in imminent danger of death or serious bodily harm by handling hazardous waste can if convicted be fine up to $250,000 or imprisoned up to 15 years or both. Corporations or organizations that violate the Act may upon conviction be subject to a fine of up to $1,000,000 (42 U.S.C. §6928(e)).

CERCLA "empowers the EPA to respond to the actual or threatened release of a hazardous substance either by conducting the cleanup itself and suing a wide range of responsible parties for reimbursement (42 U.S.C. §§9604 and 9607), or by issuing an administrative order or seeking a court order requiring the responsible party to conduct the clean up themselves (42 U.S.C. §9606)."[4] CERCLA generally casts a broad net on people who may be held responsible for contamination. These "potentially responsible parties (PRPs)" include current owner and operator of the site, any past owners or operators (where hazardous material was disposed of during their ownership or operation, generators and transporters.[5] It should be noted that liability under CERCLA is strict and requires no proof of knowledge or intent. Consequently, one may be held liable for hazardous waste found on the property if, for instance, they own or lease the property even though they may not have had any knowledge of how the hazardous substances got there to begin with.

Because Wilmington is one of the oldest industrial cities in the United States, its hazardous waste problems pre-date both the RCRA and CERCLA. There exists a number of previously contaminated waste sites and abandoned underground storage tanks, which continue to pose health risks to the immediate residents of the city and its surrounding regions and which, therefore, fall within the purview of either or both statutes. Disposal of hazardous waste on land not only affects the quality and livability of land but also directly or indirectly contributes to air pollution when toxic wastes reacts with chemicals in the air, and water pollution when the pollutants are either dissolved or seep into the underground water system. Alleviating land pollution is as urgent as eliminating air and water pollution, if not more urgent given the presence of previously dumped waste whose threat to human health and welfare sometimes takes long to discover.

Responses at the State Level

Delaware has responded legislatively, through the promulgation of an array of environmental statutes designed to foster compliance with federal environmental mandates. Two of the most important such responses to land pollution are the Hazardous Waste Management Act (HWMA) 7 Del. C. 63, and the Hazardous Substance Cleanup Act (HSCA) 7 Del. C. 91 (as amended July 13, 1995). These two Acts mirror the RCRA and CERCLA, and provide the legislative basis for implementing them at the state level.

The HWMA provides for a Hazardous Waste Management Plan (HWMP) under which DNREC is authorized to take measures to curb and minimize the generation of hazardous waste as well as monitor its transportation, storage and disposal. The measures provide for taking inventory of the sources of hazardous waste (in particular by type and location of waste generators as well as treatment and disposal), a description of current state of hazardous waste management practices including costs involved in the treatment and disposal of waste, a reporting system that keeps tally of waste generated and handled, criteria for siting hazardous waste disposal facilities, and information on the reduction of waste through reuse, recycling, etc.[6] The HWMA requires every hazardous waste generator to

[4] Id. at 180.
[5] Id. at 180.
[6] 7 Del. C. 63, §§6303 and 6307.

report their inventory as well as their waste management practices to DNREC. The Act also imposes a penalty of up to $25,000 per every day of which these standards are violated. Moreover such infraction might lead to suspension or revocation of the permit of the business offender. Furthermore, DNREC has the power to enter any premises, with or without a warrant, for purposes of conducting any investigation of any hazardous waste generating, storing, transporting or disposing facility. More importantly, the provisions of this Act apply to all entities, foreign or local, that generate hazardous waste in the state of Delaware.[7]

The HSCA has attracted more attention than the HWMA, as CERCLA has attracted more attention than the RCRA. This is particularly evident from the array of regulations and guidelines that DNREC has promulgated in an effort to strengthen the HSCA's enforcement framework.[8] Like CERCLA, the HSCA requires "prompt containment and removal of …hazardous substances, to eliminate or minimize the risk to public health or welfare or the environment, and to provide a fund for the cleanup of facilities affected by the release of hazardous substances."[9] The HSCA's strategy is to require polluters who generate and dump hazardous waste to bear the costs of cleanup. However, due to the urgency of containing the debilitating effects of hazardous waste, DNREC may clean up the contaminated site and then seek to recover the costs of such cleanup from the polluter. Liability under the HSCA is typically similar to that under CERCLA in that anyone (owner, operator of facility; owner or possessor of hazardous material; who arranges its transportation and disposal; who generated, treated or disposed of the substance at the facility; who accepted any such hazardous material for transport to a facility which he/she choses) is generally a potentially liable person. Liability is strict and can be joint or several. Recovered costs and penalties are deposited in a special fund called the Hazardous Substance Cleanup Fund.

To enforce both statutes, DNREC has promulgated a series of regulations which govern waste management under the HWMA[10] and provide guidance on the investigation, evaluation and determination of potentially responsible parties, ascertainment of the priority list, cleanup, assessment of damage and certification of completion of remedy under the HSCA.[11]

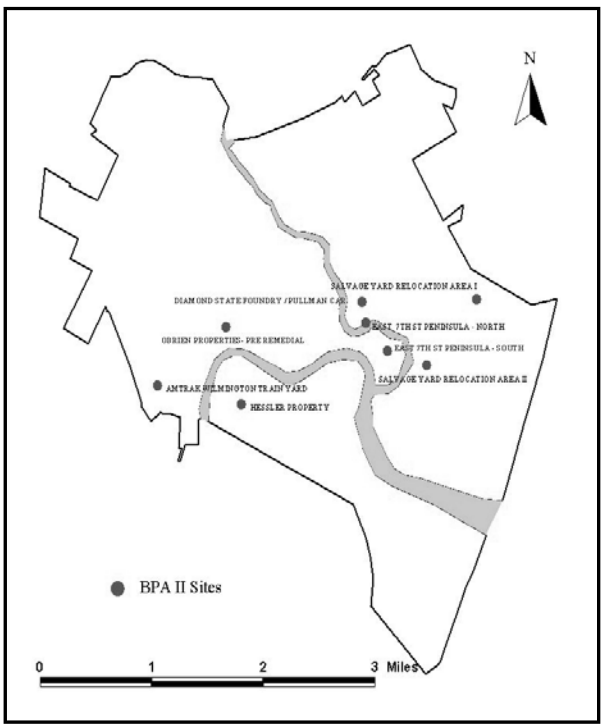
Under the HSCA, DNREC has also established a Site Investigation and Restoration Branch (SIRB) mandated to manage designated hazardous substances (SIRB) sites. There are 132 SIRB sites in the City of Wilmington, divided into 17 categories (Table 5.3). Further

[7] 7 Del. C. 63, §6311.
[8] DNREC has, for example, promulgated the "Delaware Regulations Governing Hazardous Substance Cleanup", September 1996, the "Hazardous Substance Cleanup Act Guidance Manual, October 1994, and the "Remediation Standards Guidance Under the Delaware Hazardous Substance Cleanup Act" Revised December, 1999. Available on DNREC's web site at http://www.dnrec.state.de.us/dnrec2000/ last visited June 20, 2002.
[9] See 7. Del. C. 91, §9102 Declaratory of Purpose; Applicability.
[10] See, Division of Air and Waste Management. 2002. "Solid & Hazardous Waste: Delaware Regulations Governing Hazardous Waste." Available at http://www.dnrec.state.de.us/DNREC2000/Divisions/AWM/hw/hw/drghw.htm last visited on June 20, 2002.
[11] See, "Delaware Regulations Governing Hazardous Substance Cleanup", September 1996.

details on these categories follow. A complete listing of all SIRB sites, their designation and their site identification number can be found in Appendix G.

Table 5.3 Hazardous Substance Sites in Wilmington	
Site Classification	**Number of Sites**
BPA II	8
EPA Removal	4
EPA Removal Complete	1
HSCA	21
HSCA No Action	1
Low Priority	9
Superfund National Priority List	1
No Further Action	3
Renamed/Regrouped	13
RI	1
SI	3
Solid Waste	3
ST_Referral	1
VCP	41
VCP O&M	11
VCP No Action	9
Not Yet Classified	2
Total	132

Figure 5.5 BPA II Sites in Wilmington



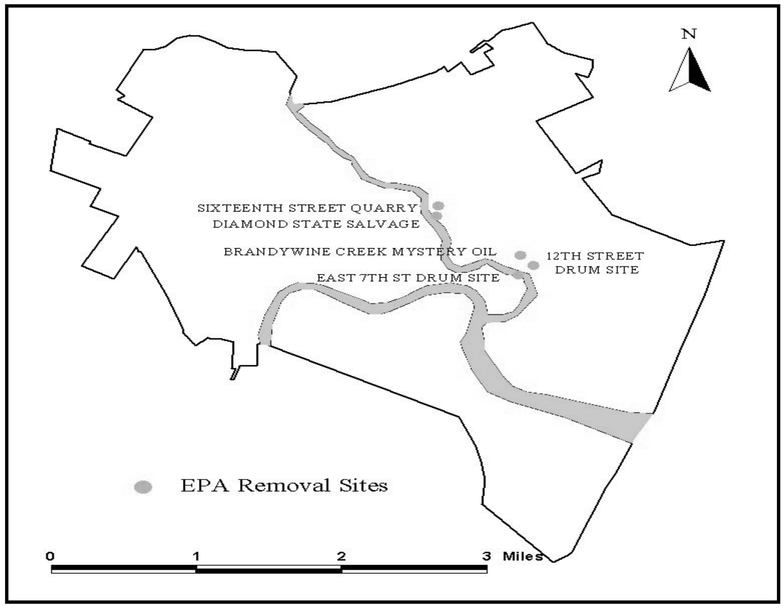
<u>Brownfield Preliminary Assessment II (BPA II)</u>

BPA II is a stage of investigation where a preliminary assessment is undertaken to verify if there are hazardous substances at a site location. Through the collection and analysis of soil, groundwater, surface water and sediment samples on and near the property, investigators can determine if contaminants, pollutants or hazardous substances are being released into the environment from the site. The findings of the BPA II analysis are submitted to regional EPA and state officials, who determine whether the site should come under federal jurisdiction in the Superfund program, or undergo further investigation as a State-supervised site (DNREC, 2002f). BPA sites in Wilmington are presented Figure 5.5.

EPA Removal

EPA Removal Sites are managed by the U.S. EPA and involve the emergency removal of contaminants due to “the immediate threat to human health, welfare and the environment from hazardous substances” (DNREC, 2002f). Figure 5.6 presents the EPA removal sites in Wilmington.

Figure 5.6 EPA Removal Sites



HSCA

HSCA sites are hazardous sites not under federal jurisdiction. State control over such sites was initiated in 1990 with the enactment of the Hazardous Substance Cleanup Act (HSCA). In July of 1995 an amendment to the HSCA encouraged both the voluntary cleanup and restoration of “brownfields” sites (DNREC, 2002f). Figure 5.7 presents the HCSA sites for Wilmington.

Figure 5.7 HCSA Sites in Wilmington

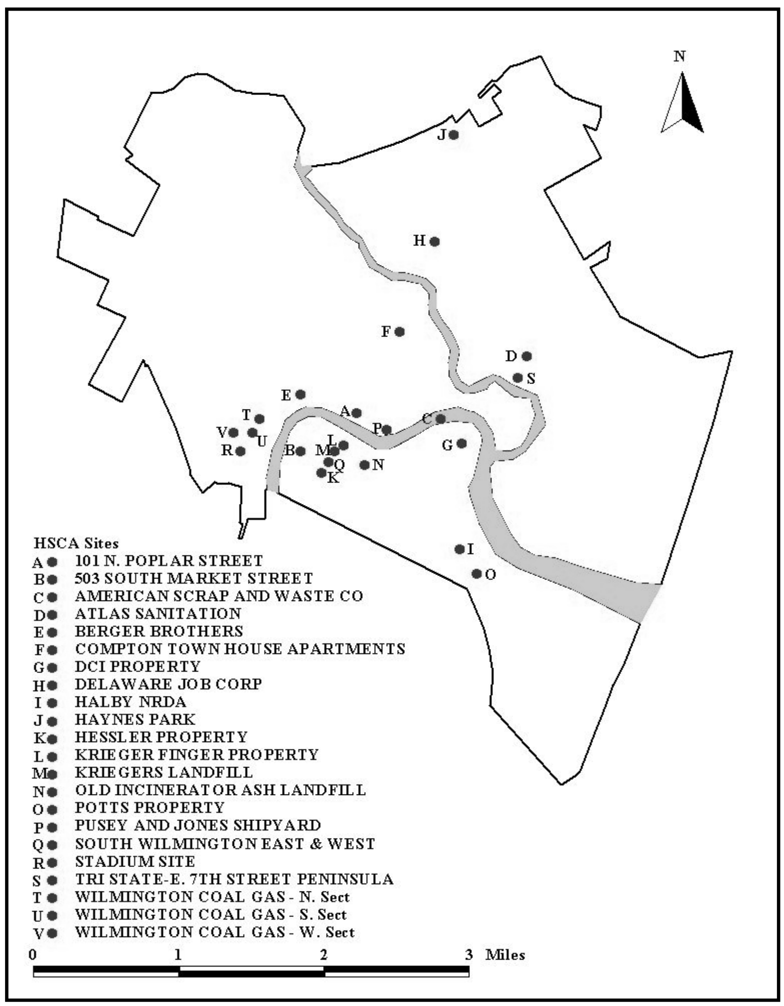
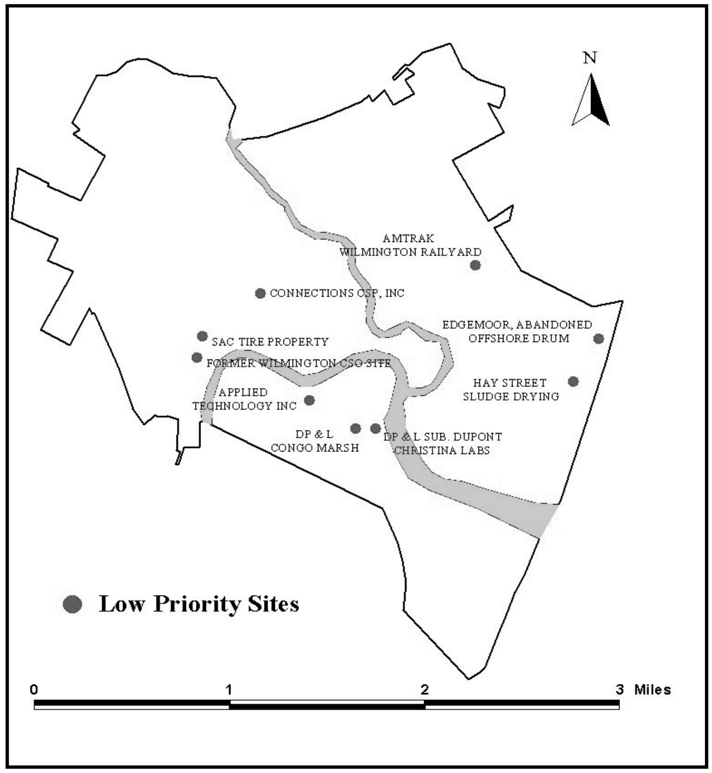


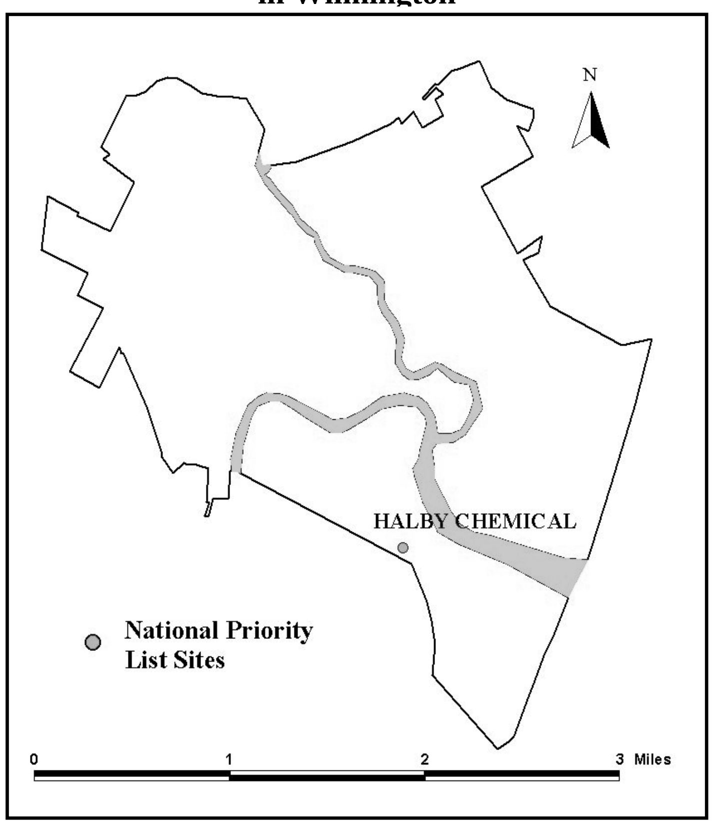
Figure 5.8 Low Priority Sites in Wilmington



Priority List

Sites are placed on a priority list according to the Delaware Hazard Ranking Model. Low priority sites have had an initial assessment and have been determined to pose "little to no threat to the public or environment." Further investigation of these sites will be carried out at a later time (DNREC, 2002f). See Figure 5.8 for the Low Priority sites in Wilmington.

Figure 5.9 National Priority List Sites in Wilmington



National Priority List Sites

Sites classified on the National Priority List fall under jurisdiction of the EPA under the 1980 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and are also known as Superfund sites. These sites are considered the most serious hazardous waste sites in the nation. There is only one such site in Wilmington (Figure 5.9). The EPA works in cooperation with the State to remediate hazardous sites. (DNREC, 2002j).

Renamed/Regrouped

Figure 5.10 Renamed/Regrouped Sites in Wilmington

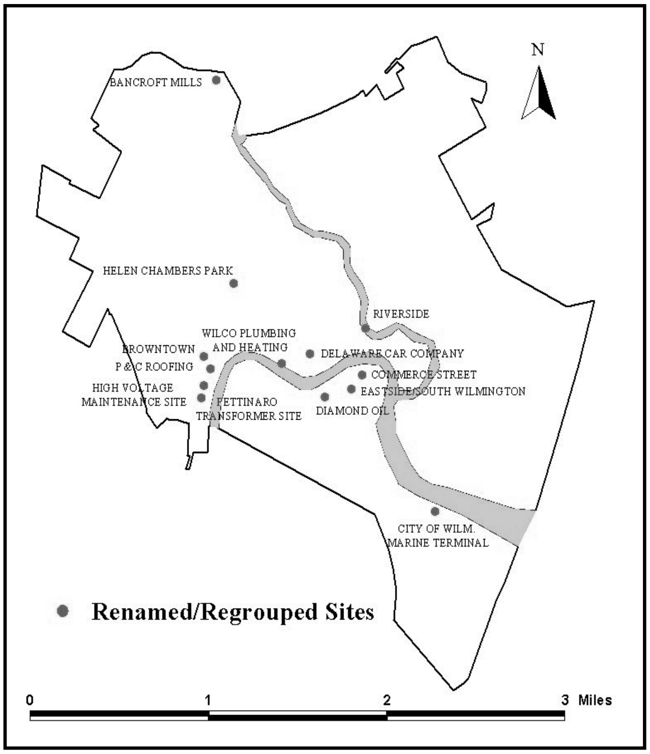
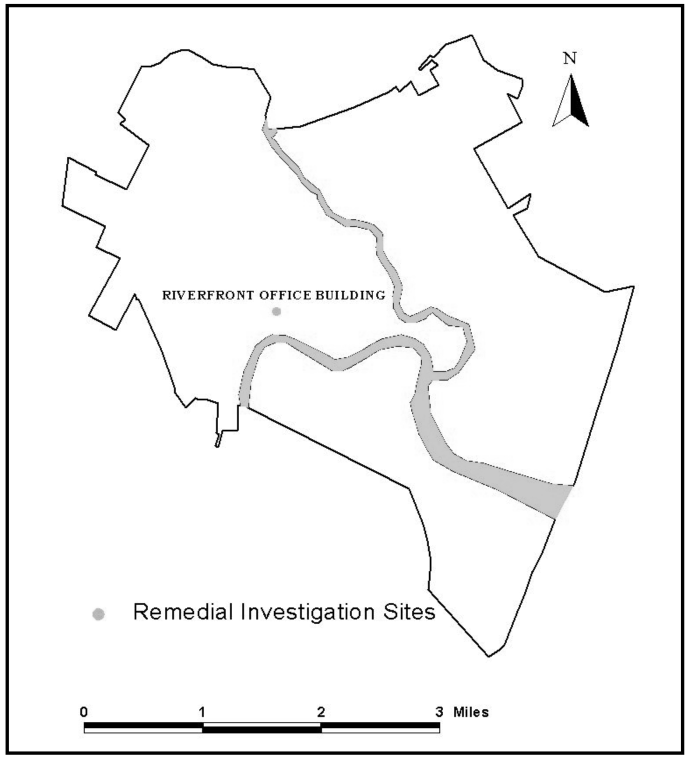


Figure 5.11 Remedial Investigation Sites in Wilmington



Remedial Investigation (RI)

Remedial Investigation (RI) sites have undergone a preliminary risk assessment -- including field investigation and site characterization -- prior to a “feasibility study and or remedial design.” (DNREC, 2002f). There is only one such site in Wilmington --Riverfront Office Building (ID: DE-1237) – (Figure 5.11).

Site Inspection (SI)

Sites classified as ‘site inspection’ (SI) involve EPA data sampling to determine exposure risks. As a result of this analysis, sites could be placed onto the National Priority List NPL or eliminated from Federal Superfund consideration (ibid.). See Figure 5.12 for Wilmington’s SI sites.

Solid Waste

The supervision of solid waste sites has been transferred to DNREC's Solid Waste Branch (DNREC, 2002f). These sites are located in Figure 5.13.

VCP

Voluntary Cleanup Program (VCP) sites are located near a "well developed infrastructure that was contaminated by previous industries. Because these sites are contaminated, they are not attractive to potential buyers. The VCP helps developers and buyers to clean up these properties so that they would not be liable for any future environmental problems associated with the past industrial uses (ibid.). These sites are subject to VCP Operations and Maintenance (O&M), a level of oversight where testing is conducted to determine if the sufficient cleanup of contaminants has been achieved (ibid.). The VCP sites in Wilmington are shown in Figure 6.14.

No Further Action (NFA)

Sites categorized as No Further Action (NFA) have undergone investigation and cleanup. These sites no longer pose a hazard to the community. No Further Action can be issued at the end of an investigation or the completion of the remedy. NFA means that no danger exists at the site

Figure 5.12 Site Inspection Sites in Wilmington

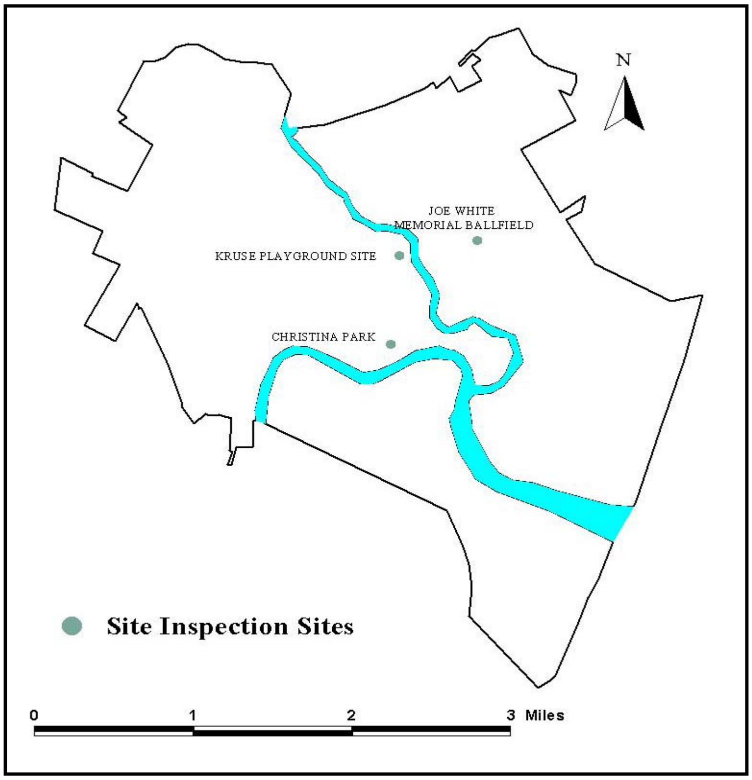
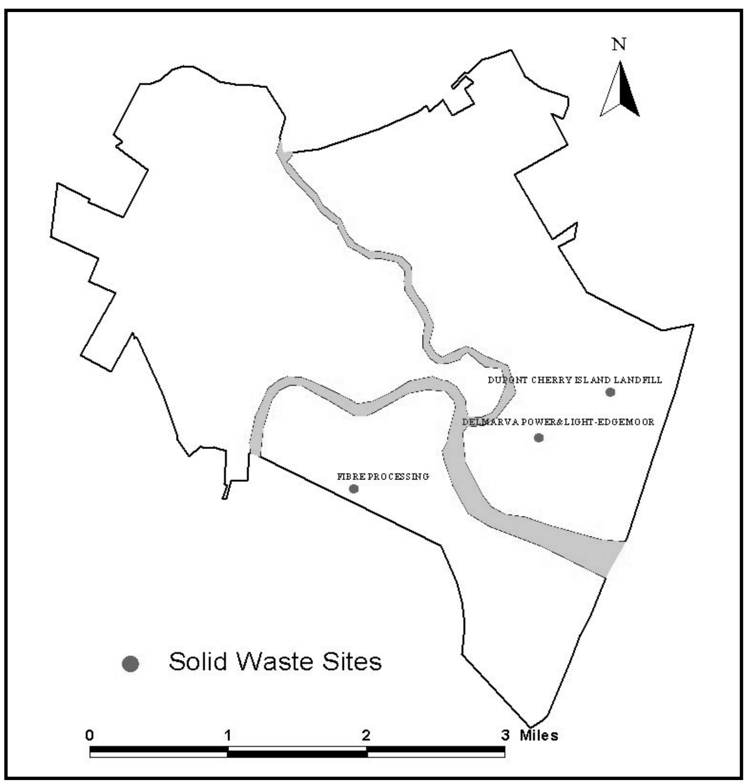
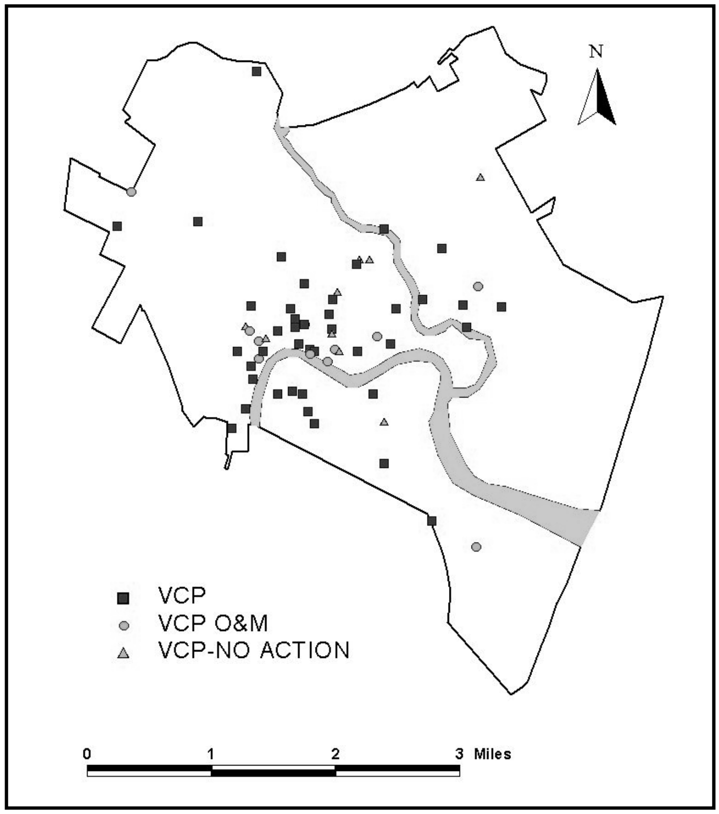


Figure 5.13 Solid Waste Sites in Wilmington



(DNREC, 2002f). The three NFA sites in Wilmington are listed in Appendix G.

Figure 5.14 VCP Sites in Wilmington



5.5 Conclusion

Just like in the enforcement of other environmental laws, DNREC has generally employed myriad strategies in enforcing land pollution legislation. These include administrative action, judicial enforcement and voluntary action.[12] For instance, DNREC has signed a Memorandum of Understanding with the EPA on (a) a Voluntary Cleanup program,[13] (b) a Hazardous Substance Site Cleanup Loan Program established in 1992, which provides loans for cleanup designed to improve, restore, or protect underground or surface water,[14] and (c) a Brownfields Program which aims at cleaning up previously abandoned or under-utilized

[12] There is a Volunteer Cleanup Program (VCP) in which owners or operators of contaminated site can undertake remedial measures before DNREC moves in to enforce the law. The VCP, however, is only limited to four types of sites: first those that do not pose imminent danger to public health and the environment; second, those that do not contaminate public or private drinking water; or those that do not pollute surface water; and, lastly, those which are not currently under the auspices of RCRA. See, Site Investigation & Restoration Branch. 2002. Voluntary Cleanup Program Overview. Available at: www.dnrec.state.de.us/DNREC2000/Divisions/AWM/sirb/Vcp.asp last visited June 20, 2002.

[13] See "Superfund Memorandum of Agreement Between the Delaware Department of Natural Resources & Environmental Control and the United States Environmental Protection Agency Region III Concerning Delaware's Voluntary Cleanup Program." Available at: www.dnrec.state.de.us/dnrec2000/Divisions/AWM/sirb/docs/fivcpmoa.doc last visited June 20, 2002.

[14] See, Site Investigation & Restoration Branch. 2002. Hazardous Substance Cleanup Loan Program (HSSCLP). Available at: www.dnrec.state.de.us/DNREC2000/Divisions/AMW/sirb/bf_loan.asp last visited June 20, 2002. This program is funded from the Delaware Water Pollution State Revolving Fund (SRF).

industrial or commercial properties as a consequence of hazardous waste contamination. The Brownfields program offers tax credits and financial assistance to developers of brownfields.

It should be noted, however, that despite the array of federal and state environmental laws against dumping hazardous waste on land, hazardous waste disposal continues to be a perennial problem in the city of Wilmington. There still exist previously contaminated hazardous waste sites and underground tanks that have not been cleaned since the enactment of these sweeping legislative enactments. This is clear from the fact that, for instance, only four of the ten success stories of redevelopment of formerly blighted sites in Delaware are within the city limits of Wilmington.[15] It thus follows that although there exists an array of federal and state statutes that prohibit dumping hazardous waste, and although evidence of progress is emerging, much more is needed to protect the city's residents from the long-term effects of untreated or contaminated hazardous waste sites.

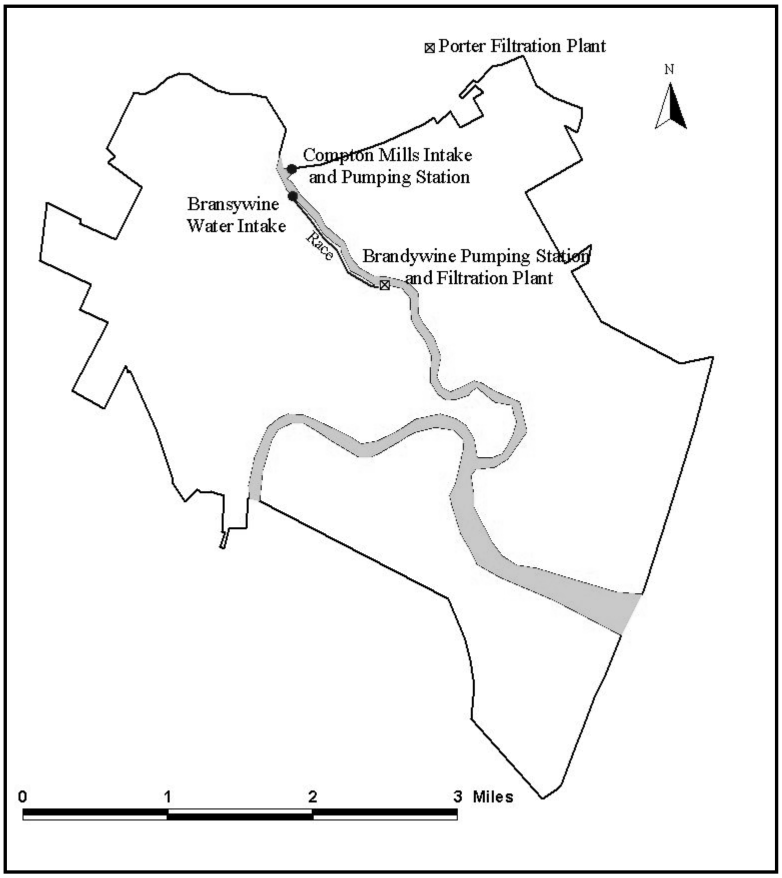
The Dupont Experimental Station and Hercules Research Center are both corrective action sites, meaning that these facilities are subject to RCRA Corrective Action Program, a cleanup program based upon the Superfund remedial action program (DNREC, 2002d; 2002o).

[15] See, Site Investigation & Restoration Branch. 2002. Brownfields Success Stories. Available at: www.dnrec.state.de.us/DNREC2000/Divisions/AWM/sirb/brown_success.asp last visited on June 20, 2002.

VI. WATER QUALITY

Wilmington's drinking water comes from the Brandywine River. Water is diverted at a dam 4,800 feet above the Brandywine Pumping Station at 16th and Market Street, where it flows through a raceway on the south shore of the river to the pumping station and filtration plant (Figure 6.1). During water-supply emergencies such as droughts and periods of heavy rain, water is released from the 2 billion gallon Edgar Hoopes Reservoir located off of Barley Mill Road, northwest of the City, as a secondary water supply source. Water can also be withdrawn from a second intake at the Compton Wills Pumping Station where it is diverted to the Porter Filtration Plant for treatment (Figure 6.1) (City of Wilmington, 2001; Kauffman and Wollaston, 2002: 3).

Figure 6.1 Wilmington Water Intakes



Research conducted as part of the *Source Water Assessment of the City of Wilmington, Delaware Public Water Supply Intake Located on the Brandywine Creek* (Kauffman and Wollaston, 2002) has determined that the surface water of the Brandywine River that feeds the City of Wilmington's drinking water supply is "highly vulnerable" to contamination. The report explains: "All surface water systems are considered **highly vulnerable** since rivers and streams and the intake are open to the atmosphere with relatively rapid times of travel measured by hours or days as compared to years for groundwater. Surface waters are considered highly vulnerable because a spill can enter the stream via overland flow and travel rapidly within hours along the stream to the downstream water supply intake" (Kauffman and Wollaston, 2002: 7).

DNREC has assessed the impact of hazardous releases on public drinking water supplies and has determined that the water treatment process is effective in removing water-borne pollutants. After testing 4 streams in New Castle County and 39 wells, DNREC determined that the proximity of hazardous waste sites located within one mile of water intakes does not negatively impact the quality of drinking water (DNREC News, 2002: Vol. 32, No. 67, March). The remaining pressures relate to periodic drought conditions and consumption levels.

Downstream of the drinking water intakes and in the remaining water bodies in Delaware and in Wilmington in particular, water quality is at risk from surface runoff and wastewater disposal systems. Several regulatory and programmatic responses are in place at the federal, regional, state and local levels, to address these pressures.

6.1 Water Quality Indicators

There are a number of factors that influence water quality in the City of Wilmington. These include indirect factors such as air quality and land contamination, and direct pressures such as waste water discharges, sewer overflows and storm water runoff. This section addresses the direct pressures, which are summarized in Table 6.1 in the PSIR model.

Table 6.1 Water Indicators

Indicator	Pressure	State	Impact	Response
Pollutant Discharges Fish Advisories - PCBs - Arsenic - Mercury - Chlordane - Dioxin	Combined Sewer Overflows NPDES Wastewater Discharges Impervious Cover/ Stormwater Runoff	Quality of Surface, Ground and Drinking Water Contaminants in Fish	Level of Source Water Protection Health Hazards of Drinking Contaminated Water Health Hazards of Eating Contaminated Fish	Current Expenditures on Water Pollution and Control Sewage Treatment Facilities Existing Water Pollution Abatement Infrastructure Fish Consumption Advisories Pollutant Testing
Water Supply and Demand	Seasonal Drought Consumption Levels	Extent of Seasonal Water Shortages Water Extracted for Consumer Use	Future Water Sources	Conservation Strategies Water Supply Prices Supply Strategies

6.2 Pollutant Discharges

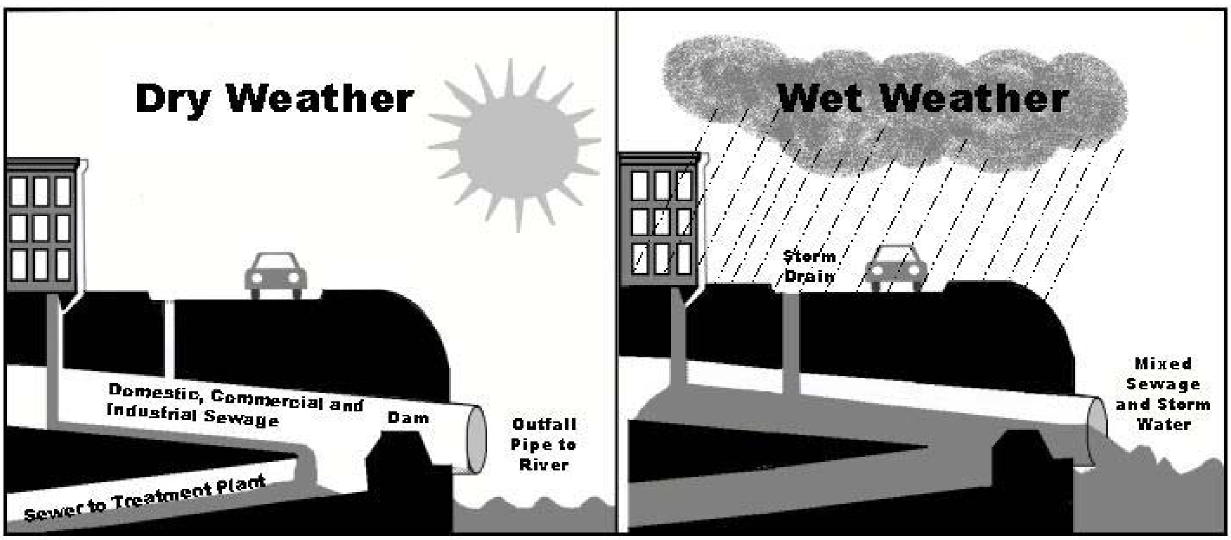
There are a number of point and nonpoint sources that impact water quality. For the purposes of the PSIR model, these sources are categorized as air-emitted pollutants, land-based pollutants and direct water discharges (Table 6.2).

Table 6.2 Sources that Impact Water Quality		
Air-Emitted Pollutants	**Land-Based Pollutants**	**Direct Water Discharges**
Automobile Emissions	Hazardous Substance Sites (SIRB)	Combined Sewer Overflows
Toxics Release Inventory Sites (TRI) Sites	Underground Storage	NPDES Wastewater Discharges
	Landfills/Dumps	Impervious Cover
	Hazardous Waste Generators	
	Salvage Yards	
	Large On-Site Septic Systems	
	Dredge Spoils	
	Domestic Septic Systems	

Combined Sewer Overflows

Combined sewer overflows (CSOs) are sewer systems that collect domestic sewage, industrial wastewater and rainwater runoff in the same pipe. Normally, these pipes are able to accommodate the combined flows. During periods of heavy rain and snowmelt, however, the increased volume of water can overwhelm the system. When discharges exceed the capacity of the sewer, the excess is released into nearby streams (Figure 6.2).

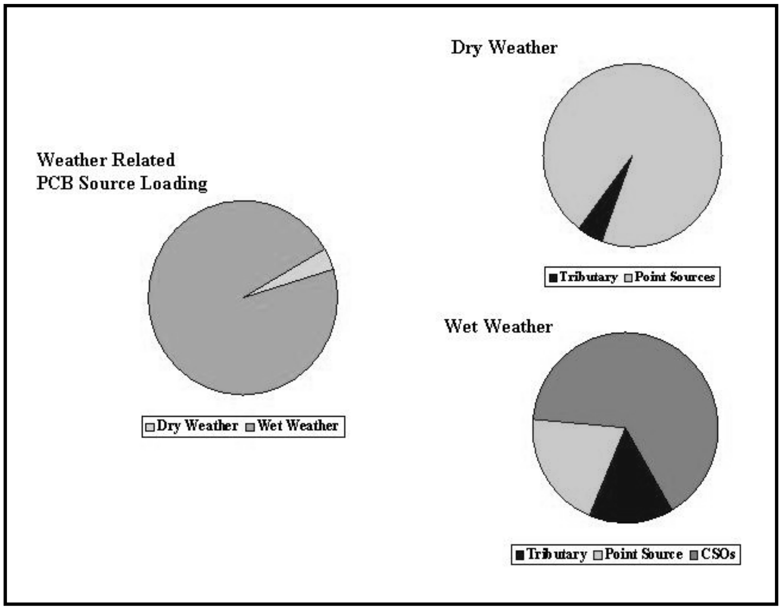
Figure 6.2 Combined Sewer Overflows



Adapted from U.S. EPA. 2001e

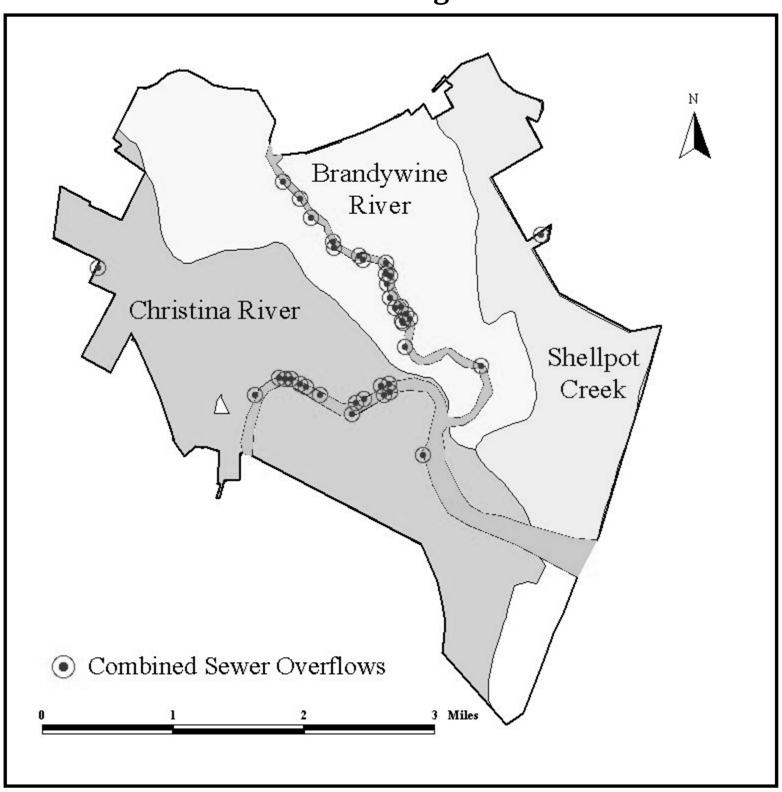
When CSOs overflow a variety of dangerous pollutants are released into local water bodies. These include raw sewage, industrial waste, toxic materials, oils and grease, suspended solids and pathogenic micro-organisms. CSOs contribute a significant amount of PCBs to Delaware's Waterways. During periods of wet weather PCB levels may increase by 386%, and account for 88.3% of the total PCB loadings (Figure 6.3). (DRBC, 1998: 47). The City of Wilmington has 37 CSOs, sixteen of which are located in the Christina River watershed, 20 on the Brandywine River and 1 in the Shellpot Creek watershed (Figure 6.4).

Figure 6.3 Percent of Total PCB Loading By Source Category



Source: DRBC, 1998: 47

Figure 6.4 Combined Sewer Overflows in Wilmington



Impacts of CSOs

Pollution caused by CSOs threatens public health, aquatic species and habitat, and causes significant concerns for water quality and safety. Pollutants released from CSOs have contributed to fish kills, beach closures, restrictions on shellfish harvesting, foul odors, solids deposits, and limitations in the recreational use of water bodies. (U.S. EPA. 2001b; U.S. EPA. 1999b).

NPDES Wastewater Discharges

The National Pollution Discharge Elimination Program (NPDES) permits and regulates point source pollution into water bodies -- that is, discharges that come from a specific location, such as a pipe or a man-made ditch. Only those sources that discharge liquids directly into a stream or river are covered by the NPDES permit process (U.S. EPA. 2001c). Point sources, including individual homes and industries that discharge into a municipal wastewater treatment system, do not need a NPDES permit. The

Surface Water Discharge Section (SWDS) of DNREC issues construction permits for residential, municipal and industrial construction that generates, transports or treats wastewater.

There are several different types of NPDES Permits: individual permits, general permits for storm water runoff, land application of sludge and construction permits. Individual permits have specific “limitations, monitoring requirements and other terms and conditions that the permittee must meet in order to be allowed to discharge.” General permit holders for storm water runoff receive a permit that relates to the type of industrial activity. Standard Industrial Classification (SIC) Codes specify the conditions of the permit (Table 6.3). Wastewater treatment facilities that generate sludge as a solid waste are also considered a source pollutant discharge and require an NPDES permit.

Table 6.3 NPDES General Permit Holders SIC Designation

Permit Holders	SIC Code	SIC Category
A-1 Auto Parts	5015	Wholesale Trade, Durable Goods: Motor Vehicle Parts Used
American Minerals	N/A	N/A
Ashworks Inc.	3270	Manufacturing: Concrete, Gypsum and Plaster Products
Baker Petroleum	N/A	N/A
BFI Waste Systems	4212	Trucking and Courier Services: Local Trucking Without Storage
Citrosuco	4222 4226 2037	Public Warehouse and Storage: Refrigerated Warehouse Storage, Special Warehousing and Storage Manufacturing: Frozen Fruits, Fruit Juices and Vegetables
Delaware Compressed Steel	5093	Wholesale Trade Durable Goods: Scrap and Waste Materials
DuPont Experimental Station	8731	Research, Development and Testing Services: Commercial Physical and Biological Research
Diamond State Recycling Corp	5093	Wholesale Trade Durable Goods: Scrap and Waste Materials
Insteel Wire Products	3315	Manufacturing: Steel Wiredrawing, Steel Nails and Spikes
Noramco of Delaware	2833 2834	Manufacturing: Medicinal Chemicals and Botanical Products; Pharmaceutical Preparations
Northern Solid Waste Management	4953	Sanitary Services: Refuse Systems
Pure Green Industries, Inc.	2951	Manufacturing: Petroleum Refining and Related Industries
Port Contractors, Inc	4225	Motor Freight Transportation and Warehousing: Public Warehousing and Storage
Russell Stanley Corp.	3089	Manufacturing: Rubber and Miscellaneous Plastics Products
Two Guys Auto Parts and Sales	5015	Wholesale Trade, Durable Goods: Motor Vehicle Parts Used

N/A = Data Not Available
Source: R. Peder Hansen, P.E.,P.G. DNREC, Division of Water Resources, Surface Water Discharges Section; OSHA, 2002

Within the City of Wilmington there are 16 NPDES general permit holders (Figure 6.5). There are also six individual NPDES permit sites: Amtrak, Conectiv Edge Moor, Dupont Edge Moor, Hercules, IKO and Wilmington Wastewater Treatment Plant (R. Peder Hansen, DNREC Surface Water Discharges Division, pers. com., March 28, 2002).

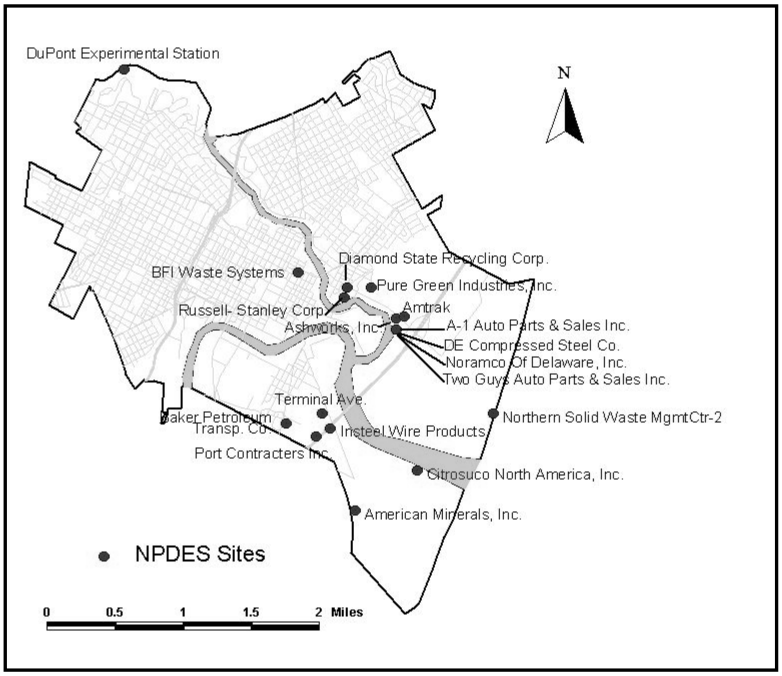
Amtrak has 7 point source outfalls, all for stormwater runoff. One outfall leads to Shellpot Creek and the remainder lead to Brandywine Creek. Effluent is monitored for oil and grease, pH, surfactants, PCBs and trichloroethane. The current NPDES Permit (Number DE 0050962) is effective January 2000 to December 2004. (Paul Janiga, P.E., Environmental Engineer, DNREC/SWDS, pers. com. April 22 2002).

The Conectiv Edge Moor Plant contributes 33 point source discharges to the Delaware River (16) and Shellpot Creek (17). Discharges emanate from condenser cooling water, boiler blow-down, screen backwash, wastewater from the Heat Recovery

System Generator, the fish hatchery and storm water runoff. The permit (Number DE 0000558) is for temperature discharges, oil and grease, total suspended solids and pH. (ibid.).

DuPont Edge Moor's NPDES permit (Number DE 0000051) is under objection by the EPA and is currently on hold. The facility has 4 outfalls including effluent from a water treatment plant, cooling water, and stormwater. The plant's previous permit was monitored for BOD5, total suspended solids, lead, iron, chromium, nickel, temperature and pH. The future status of the permit is pending government review (ibid.).

Figure 6.5 NPDES General Permit Wastewater Discharge Sites in Wilmington



Hercules, Inc. has a NPDES permit for two point source discharge outfalls. The first is cooling water from chemical process reactors and heat exchanger, along with stormwater and infiltrating groundwater. It is permitted for temperature, pH, BOD5 and total suspended sediments. The second outfall is stormwater runoff from the parking area and buildings. The current Permit (Number DE 0000230) is effective October 2001 to September 2006 (ibid.).

IKO has one point source outfall for stormwater and wastewater runoff from their industrial activity during rain events. The facility is monitored monthly for pH, oil and grease, total suspended solids, petroleum hydrocarbons, polycyclic aromatic hydrocarbons and organic halides. The current NPDES permit (Number DE 0050857) is effective March 2001 to February 2005 (ibid.).

The Wilmington Wastewater Treatment Plant, managed by U.S. Filter Operating Services of Wilmington Inc. for the City of Wilmington Department of Public Works, is permitted to discharge from one point source (001) outfall and the City's combined sewer overflows. The 001 point source discharge is monitored once per day for residual chlorine, three days per week for $BOD_{5,}$ once per week for CFOD5, CBOD20, TSS, cadmium, chromium, copper, lead, mercury, selenium and zinc, once per day for fecal coliform and enterococcus, pH and color, and once per quarter for bio-monitoring. Table 6.5 lists the effluent limitations of the primary point source outfall. The current NPDES permit (Number DE 0020320) is effective July 1, 2000 to June 30, 2005 (ibid.).

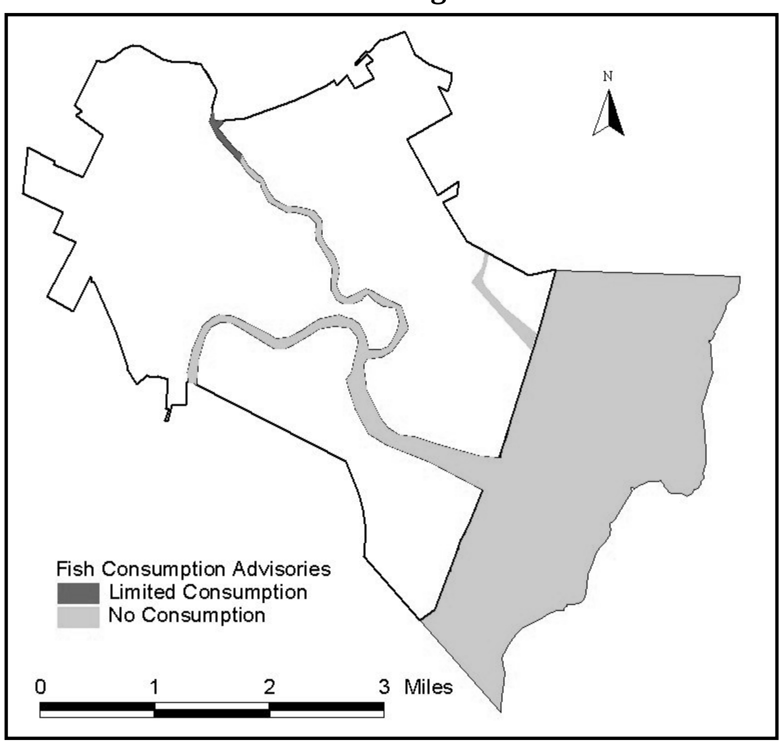
Table 6.4 Wilmington Wastewater Treatment Plant Effluent Limitations							
Parameter	Load			Concentration			
	Daily Average	Daily Maximum	Units	Daily Average	Daily Maximum	Maximum Instantaneous	Units
Flow	134		Mgd				
Total Residual Chlorine	Between 0.1 mg/L and 4.0 mg/L						
CBOD5	19,080	36,160	lbs/day	17	34		mg/L
CBOD20	31,1000		lbs/day				
TSS	22,334	44,668	lbs/day	20	40		mg/L
Cadmium	4.4	8.8	lbs/day	4	8		µg/L
Chromium	168	252	lbs/day	0.15	0.22		mg/L
Copper	25.2	42.1	lbs/day	23	38		µg/L
Lead	54.7	138	lbs/day	49	123		µg/L
Mercury	0.48	0.64	lbs/day	0.40	0.60		µg/L
Selenium	24	65	lbs/day	0.02	0.06		mg/L
Zinc	171	287	lbs/day	153	257		µg/L
Fecal Coliform				200		400	Col./100 mL
pH	Bettween 6.0 S.U. and 9.0 S.U. at all times						S.U.
Source: State NPDES Permit Number DE 0020320, Paul Janiga, P.E., Environmental Engineer, Surface Water Division Section. DNREC.							

Impacts of Point and Non-Point Source Water Contamination

Fish contamination is the leading indicator of water quality in Wilmington. Contaminants entering the water from point and non-point sources have had negative impacts on the fish population, leading the State to issue fish consumption advisories. These advisories are the result of joint action by the Department of Natural Resources and Environmental Control (DNREC) and the Department of Health and Social Service's Division of Public Health. Fish consumption advisories are designed to warn the public of safe levels of fish that they can consume from specific water bodies. (DNREC, 2001c).

Although the actual levels of these pollutants in the water may not cause concern, contaminants such as polychlorinated biphenials (PCBs) often bioaccumulate in edible fish tissue, leading to dangerous levels when humans consume the fish. The level of contaminants continues to increase up the food chain as larger fish consume smaller fish. (DNREC, 2001c).

Figure 6.6 Fish Consumption Advisories in Wilmington



All water bodies within the City of Wilmington have fish consumption advisories (Table 6.5). Figure 6.6 shows the advisory level for each water body.

Fish Contaminants are measured according to volume (parts per million -- ppm). In order to calculate the amount of contaminant that a person would likely eat in a single portion, the volume must be converted to mass (1 ppm = 1 mg/kg) and multiplied by the size of a portion (4 ounce portion = 0.11 kg). Table 6.6 presents consumption risk levels for those contaminants for which levels have been established.

While the standard for testing fish samples is by volume, risk levels for consuming fish are mass equivalents. Converting volume to mass in fish flesh requires the following conversion equation: 1 ppm = 1 µg/mg or 1 mg/kg. This figure must then be adjusted for the weight of the person by multiplying by their weight in kilograms (for a 100 pound person the metric equivalent is 45.36 kg).

Table 6.5 Fish Consumption Advisories in Wilmington February, 2002

Waterbody	Species	Geographical Extent	Contaminants of Concern	Advice
Delaware River	All Finfish	Delaware State Line to the C&D Canal	PCBs, Arsenic, Dioxin, Mercury, Chlorinated Pesticides	No Consumption
Tidal Brandywine River	All Finfish	River Mouth to Baynard Blvd.	PCBs	No Consumption
Non-Tidal Brandywine River	All Finfish	Baynard Blvd. To Pennsylvania Line	PCBs, Dioxin	No more than two 8-ounce meals per year
Shellpot Creek	All Finfish	Rt. 13 to the Delaware River	PCBs, Chlordane	No Consumption
Tidal Christina River	All Finfish	River Mouth to Smalley's Dam	PCBs, Dieldrin	No Consumption
Non-tidal Christina River	All Finfish	Smalley's Dam to I-95	PCBs	No more than six 8-ounce meals per year
Source: DNREC, 2002c				

Table 6.6 Risk Levels of Fish Contaminants

Contaminant	Chronic Toxicity	Carcinogenicity	Lethal Dose
Arsenic	3.0×10^{-4} mg/kg-day	1.5 per mg/kg-day	
Chlordane	5.0×10^{-5} mg/kg-day	0.35 per mg/kg-day	6 to 60 grams
Dioxin		$1.56 \times 10^{+5}$ mg/kg-day	
Mercury	1×10^{-4} mg/kg-day		10 to 60 mg/kg
PCBs	2×10^{-5} mg/kg-day	2.0 per mg/kg-day	
Source: U.S. EPA, 2001f			

Table 6.7 Risk Levels for Fish Contaminants Adjusted to a 100 pound (45.36 kg) person

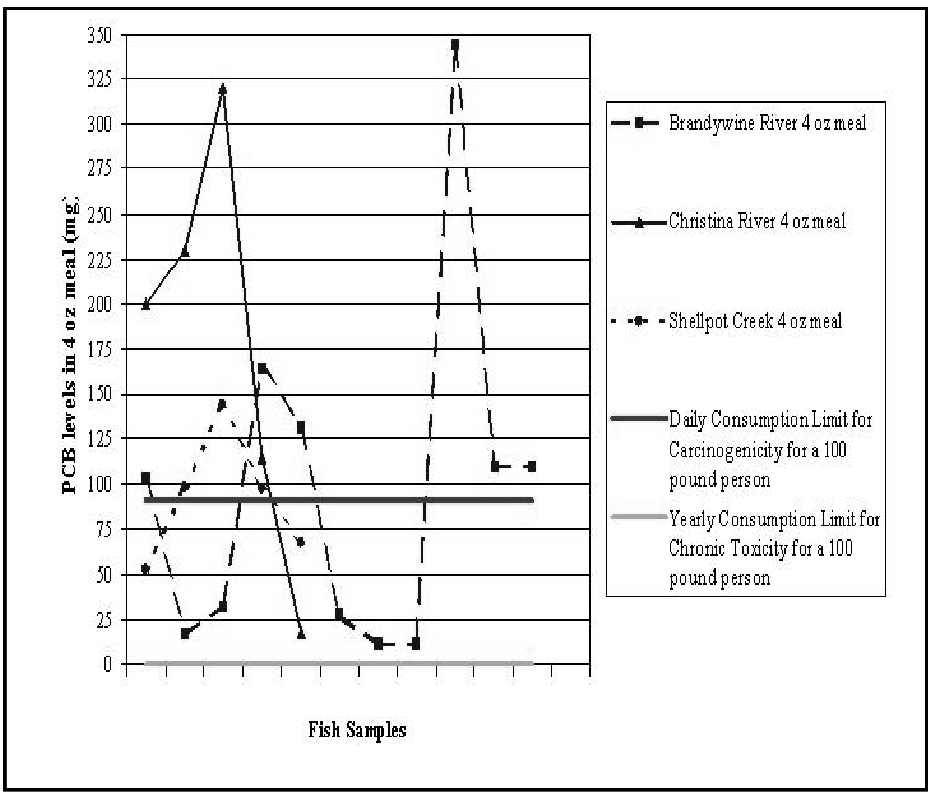
Contaminant	Chronic Toxicity		Carcinogenicity		Lethal Dose
Arsenic	0.0136 mg/day	4.9669 mg/year	68.0400 mg/day	24,834.6 mg/year	
Chlordane	0.0023 mg/day	0.8279 mg/year	15.8760 mg/day	5794.74 mg/year	6 to 60 grams
Dioxin			0.0007 mg/day	0.2583 mg/year	
Mercury	0.0045 mg/day	1.6556 mg/year			453 to 2,721.6 grams
PCBs	0.0009 mg/day	0.3311 mg/year	90.7200 mg/day	33,112.8 mg/year	

PCBs

By far the most important contaminants for fish consumption advisories in Delaware are PCBs (Rick Greene, DNREC Watershed Assmt. Sect., pers. com. March 25, 2002). All of Wilmington's waterways have advisories for this complex category of contaminant, which consists of 209 different congers. PCBs persist in the environment today, long after their use was banned in the United States in 1979. Once released into the environment, they continue to change, partitioning and transforming into more toxic forms that bioaccumulate in the food chain and edible fish tissue. When fish is consumed, 75% to 90% of the PCBs are absorbed into the human body through the gastrointestinal tract. The health effects in humans are still unclear. (U.S. EPA, 2001f: 94-101).

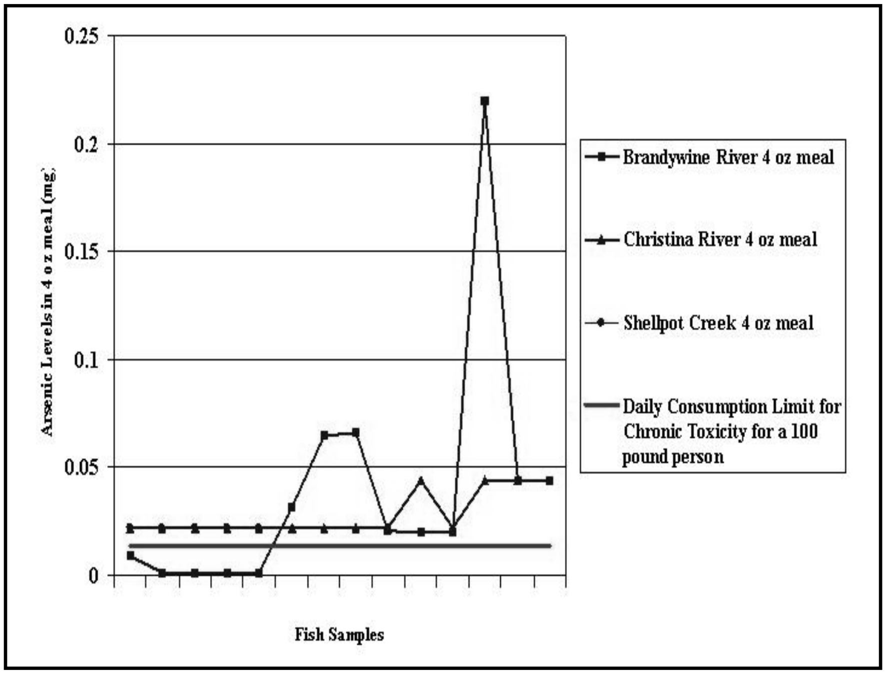
The amount PCBs present in the fish in Wilmington's waterways is much higher than the risk level for chronic toxicity for daily and yearly consumption, and carcinogenicity for daily consumption in a single 4 oz. portion. Figure 6.7 illustrates the relationship between a single meal and the level of risk for a 100-pound person. All fish samples taken from the Brandywine and Christina Rivers and Shellpot Creek had PCB levels above the daily and yearly consumption limit for chronic toxicity for a 100 pound person in a single 4 ounce meal. Many of the samples also had PCB levels above the daily consumption limit for carcinogenicity for a 100 pound person. As Figure 6.7 shows, fish from Wilmington's rivers pose a serious health risk to any individuals who consume them, even just once in a year. For specific PCB levels in individual samples, see Appendix H-1.

Figure 6.7 PCB levels in a Single 4 oz Meal Compared to Daily Consumption Limits for a 100 Pound Person



Arsenic:

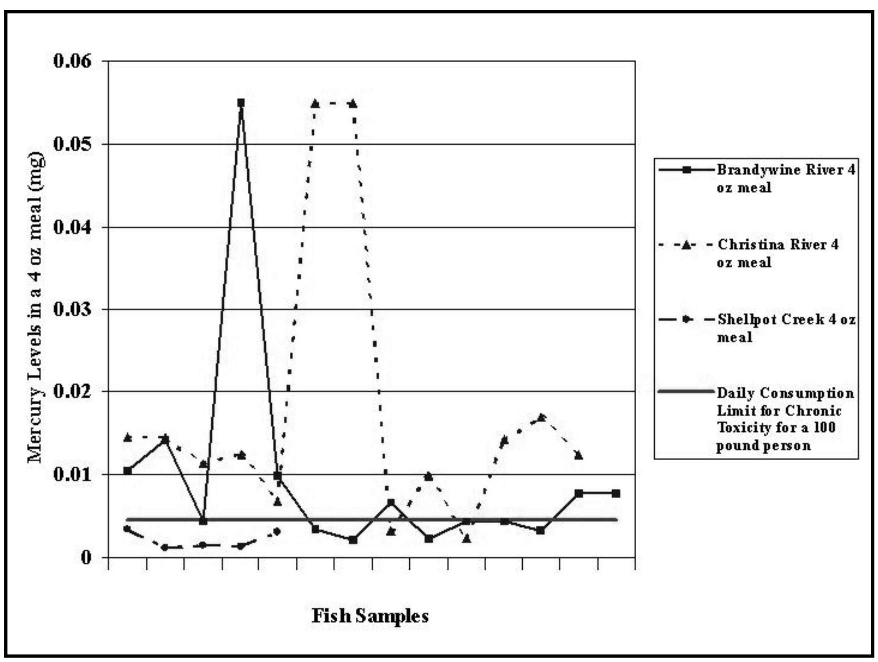
Figure 6.8 Arsenic Levels in a Single 4 oz meal Compared to Daily Consumption Limits for Chronic Toxicity for a 100 pound Person



Arsenic in its inorganic form is a known human carcinogen. Organic arsenic, including that found in edible fish tissue, is considered to be "nontoxic" and not a threat to human health (U.S. EPA, 2001f: 9-12). However, tests on Wilmington's fish showed elevated levels of arsenic, higher than the minimum daily consumption limit for chronic toxicity for a 100-pound person (Figure 6.8). Yet, the fish samples tested below minimum risk levels for carcinogenity. Fish advisories concerning arsenic have been issued for the Delaware River (Table 6.5). For specific arsenic levels in individual samples, see Appendix H-2.

Mercury:

Figure 6.9 Mercury Levels in a 4 oz Meal Compared to Daily Consumption Limits



The inorganic forms of mercury -- elemental mercury (Hg^0) and divalent mercury (Hg^{2+}) -- are converted by natural processes into organic methylmercury (MeHg). Methylmercury is the form that bioaccumulates in edible fish tissue. When mercury-contaminated fish is consumed, between 90% and 100% of it is absorbed into the human body through the gastro-intestinal tract. Mercury exposure leads to kidney and gastro-intestinal damage, nervous system dysfunction, cardiovascular collapse, shock and death. Contamination has been shown to have disproportionate impacts on children and developing fetuses (U.S. EPA, 2001f: 18-24).

Fish advisories concerning mercury have been issued for the Delaware River (Table 6.5). Levels in the fish in the Brandywine and Christina Rivers are above the minimum daily consumption limits for chronic toxicity for a 100-pound person (Figure 6.9). Levels in Shellpot Creek are just below this consumption threshold. Specific mercury levels in individual samples are provided in Appendix H-3.

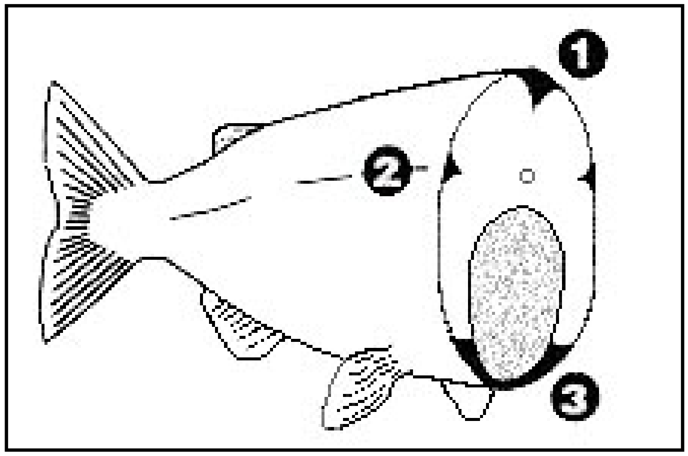
Chlordane: Chlordane has been used since 1947 as an insecticide, on agricultural crops and livestock, for termite control and on lawns. After binding to cellular macromolecules, chlordane disrupts cellular function and can lead to cell death. According to the Agency for Toxic Substances and Disease Registry (ATSDR) and the EPA, chlordane also leads to the following disorders: "increasing tissue production of superoxide radicals accelerates lipid peroxidation and disrupts the function of membranes; possible suppression of hepatic mitochondrial energy metabolism; alternation of neurotransmitter levels in various regions of the brain; prenatal reduction in bone marrow stem cells; and suppression of gap injunction intercellular communication." (U.S. EPA, 2001f: 33-36). Fish advisories concerning chlordane have been issued for the Shellpot Creek (Table 6.5).

Dieldrin: Dieldrin was used as an insecticide on cotton, citrus and corn crops, and to control insects including locusts, termites and mosquitoes. Use of Dieldrin is a contaminant and bioaccumulates in the food chain. It can cause a number of harmful health effects in humans, including: decreased immune system effectiveness, reproductive success, increased infant mortality and kidneys damage, and is thought to cause cancer and birth defects. (U.S. EPA, 2001d). Fish advisories concerning Dieldrin have been issued for the tidal Christina River (Table 6.5).

Dioxin: Dioxins are a complex category of synthetic organic chemicals that bioaccumulate in edible fish tissue. Once consumed, dioxins have half-lives in the human body that range from 2.9 to 26.9 years. They cause a number of health problems including disruption of Ah receptors, which regulate the synthesis of proteins in the lung, liver, placenta and lymphocytes. Although there is limited information on human health effects, dioxins are thought to cause damage to the liver, cardiovascular and respiratory systems and immuno-suppression. They are categorized by the EPA as a Group B2 carcinogen, indicating that although there is sufficient evidence in animal studies, there is insufficient human evidence to determine the carcinogenic effects of exposure (U.S. EPA, 2001f: 102-105). Fish advisories concerning dioxins have been issued for the Delaware River and the non-tidal Brandywine River (Table 6.5).

Some toxic chemicals tend to accumulate in the fatty tissue (Figure 6.11). However, contaminants such as mercury accumulate in fish flesh. By dressing a fish with the fatty tissue still intact, significant amounts of the contaminant will not be eliminated from the meat. In addition to cutting away these portions when preparing the fish, DNREC also recommends that fish taken from waters with advisories should not be consumed. They recommend that only smaller species should be eaten, and in smaller portions. Women of childbearing age should avoid consuming any fish suspected of contaminants (DNREC, 2002c).

Figure 6.10 Fatty Tissue Areas of Fish (1) Dorsal Area, (2) Lateral Line, (3) Belly Flaps



Source: DNREC, 2002c

6.3 Impervious Cover

There is a direct relationship between the percentage of impervious cover, as associated with various land uses, and ecosystem health. Buildings, sidewalks, roads, parking lots and other impervious surfaces prevent the natural infiltration of water into the ground, forcing storm water to "runoff." Table 6.8 demonstrates the relationship between land use and impervious cover. Transportation and utility uses have the highest percentage, followed closely by commercial and industrial land uses. Open spaces including parkland, woodland and agricultural areas have the lowest percentages of impervious cover.

Table 6.8 Impervious Cover by Land Use

Land Use	Impervious Cover
Single-Family Residential	30%
Multi-Family Residential	65%
Office	60%
Industrial	72%
Transport/Utility	90%
Commercial	85%
Institutional	55%
Public/Private Open Space	0%
Wooded	0%
Agricultural	0%
Personal Communication with Gerald Kauffman, Water Resources Agency	

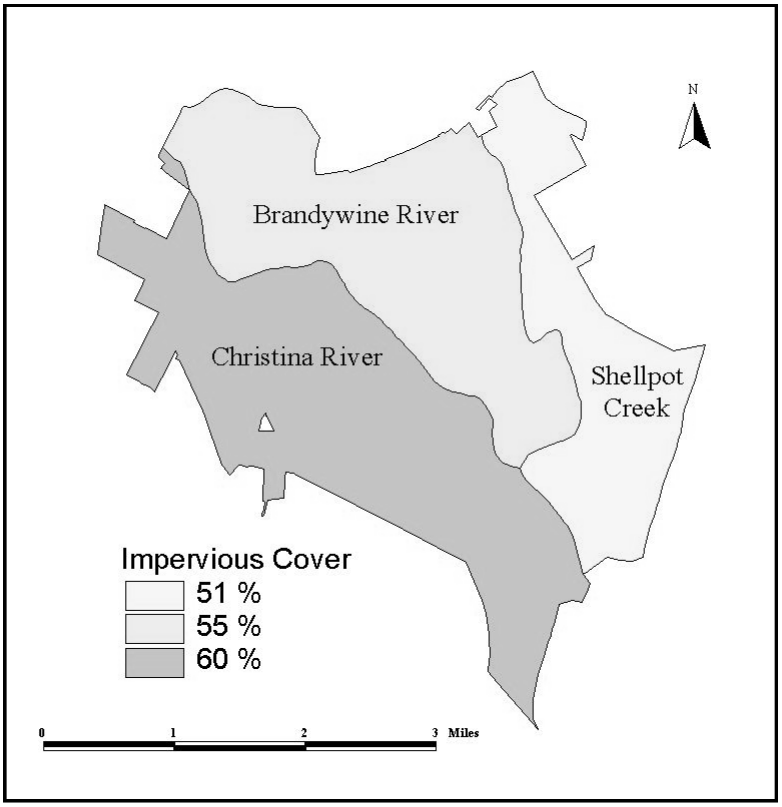
Urban areas tend to have a higher level of impervious cover than other land uses. While suburban areas may have lower levels than cities, it is better for overall watershed health to concentrate impervious cover in high-density urban areas rather than distributing it across the landscape. A "clustered" pattern provides the best protection for the watershed by reducing the pressures on sensitive areas (Kauffman, *et.al*. 2002: 4, 5).

Figure 6.11 illustrates the percentage of impervious cover in the City of Wilmington, which was calculated using 1997 land use coverages by watershed. The City is partitioned into three watersheds -- Christina River, Brandywine River and Shellpot Creek -- all three having impervious cover in excess of 51%. The Christina watershed, comprising the southwestern portion of Wilmington, is highest at 60%.

Impacts of Impervious Cover

The negative impacts of impervious cover appear at 10% imperviousness. Streams with high levels, between 10 and 15%, can experience "increased flood peaks, lower stream flow during dry weather periods, degradation in stream habitat structure, increased stream bank and channel erosion, fragmentation of riparian forest cover, and a decline in fish habitat quality" (ibid.: 5,2002)

Figure 6.11 Impervious Cover in the City of Wilmington by Watershed



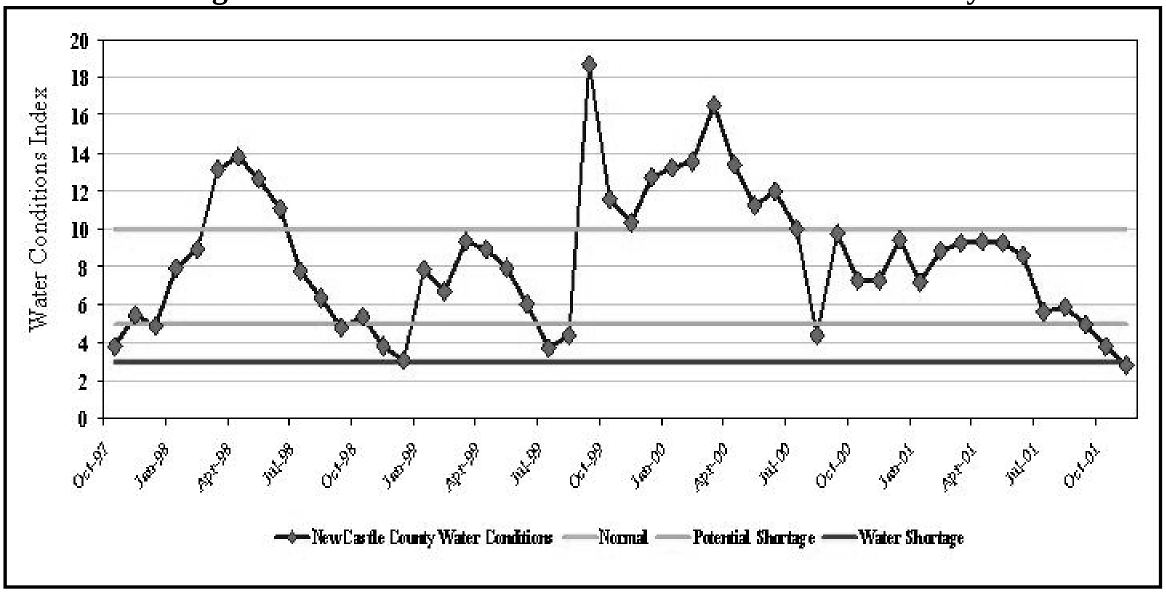
Impervious cover negatively impacts water quality in Wilmington. Storm water runoff places increased demands on a sewage system comprised of combined sewer overflows, increasing the likelihood that raw sewage will overflow into the City's rivers.

6.4 Water Supply and Demand

The key issue regarding water supply and demand in Delaware is periodic drought. New Castle County has faced a number of periods of water shortage within the past five years. The Delaware Geological Survey has created a Water Conditions Index for the County (Figure 6.12) in which levels of 0 to 3 indicate a water shortage, 3 to 5 a potential shortage, 5-10 normal water levels and greater than 10 show "wetter" water levels. Factors used in formulating the Index include ground water levels at a key observation well at Ogletown, monthly mean stream flows on Brandywine Creek at

Wilmington, and monthly precipitation recorded at New Castle Airport and the Porter Reservoir in Wilmington (Delaware Geological Survey, 2002).

Figure 6.12 Water Conditions Index in New Castle County



Source: Delaware Geological Survey, 2002

The Water Conditions Index shows that during the 50 months between October 1997 and November 2001, New Castle County was in the “potential water shortage” category or lower for 10 months, or 20% of the recorded measures.

A period of water shortage of considerable concern was the “drought of 1999.” Of all the water suppliers in New Castle County, the City of Wilmington “fared best” during that period. This lack of comparable hardship is due to several factors. Other utilities in northern New Castle County (United and City of Newark) must adhere to stream flow requirements when withdrawing water, to preserve the ecological integrity of the water body. The City of Wilmington, however, has no such limitation and is therefore able to pump from the stream indiscriminately, causing significant concerns for water quality and stream ecology. Wilmington also has access to water stored in the Hoopes Reservoir, which can supply the City when levels in the Brandywine are too low or when poor water quality caused by reduced rate of flow makes the water difficult to treat (DNREC, 2002a: 16).

During the drought of 1999 the “sluggish” Brandywine creek set fourteen “record-low daily flows.” Much of its flow was composed of treated wastewater discharged upstream in Pennsylvania. High summer temperatures combined with this treated wastewater contributed to algae blooms in the Creek. When the immense mats of algae died, the decaying matter depleted the dissolved oxygen levels in the stream (DNREC, 2002a: 16).

Although the drought of 1999 caused considerable problems for water quality and supply in northern New Castle County, it was not the most significant drought of the past 40 years. Table 6.9 demonstrates the severity of droughts in New Castle County from 1963 to 1981.

Table 6.9 Droughts in New Castle County: 1963-1981

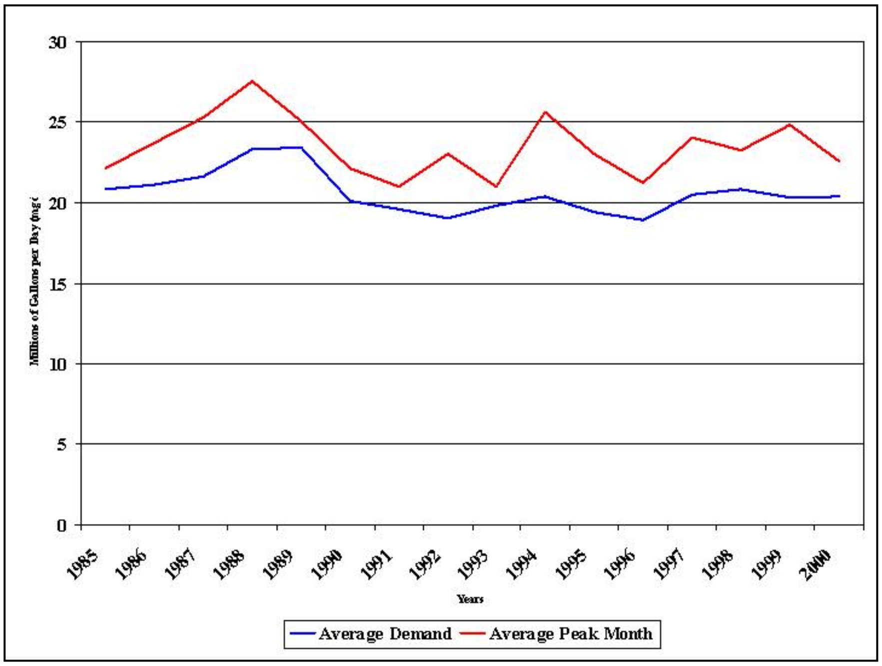
Rank Severity	Year	Start of Drought	End of Drought	Drought Duration (Days)
1	1963	June 18	November 6	115
2	1965	July 25	November 8	77
3	1966	July 3	September 14	68
4	1999	July 5	September 15	61
5	1995	July 25	September 16	44
6	1980	Sept 3	October 24	41
7	1964	August 15	October 16	41
8	1981	August 19	September 15	23
Source: DNREC, 2002a: 18				

The City of Wilmington Public Water Supply System serves a population of 140,000 people within a service area of 40 square miles. The City's normal daily water demand of 25 million gallons per day (mgd) can increase to as much as 36 mgd during periods of peak demand. The City has a maximum intake capacity of 44 mgd -- provided sufficient water flow in the Brandywine River -- and a treatment capacity of 56 mgd at the two water treatment plants (Kauffman and Wollaston, 2002: 4).

The City has identified Water stored in the Cool Springs Reservoir in northwestern Wilmington as a public health risk from contaminant exposure. This 40 million gallon reservoir, located in a more affluent neighborhood, is used by residents as a park. The reservoir, however, provides drinking water to the largely poor African American residents of southeastern Wilmington. The open reservoir is plagued by periodic algae blooms, which require rechlorination of the water. The byproducts of this treatment are potential carcinogens (City of Wilmington, 2000: 1, 2).

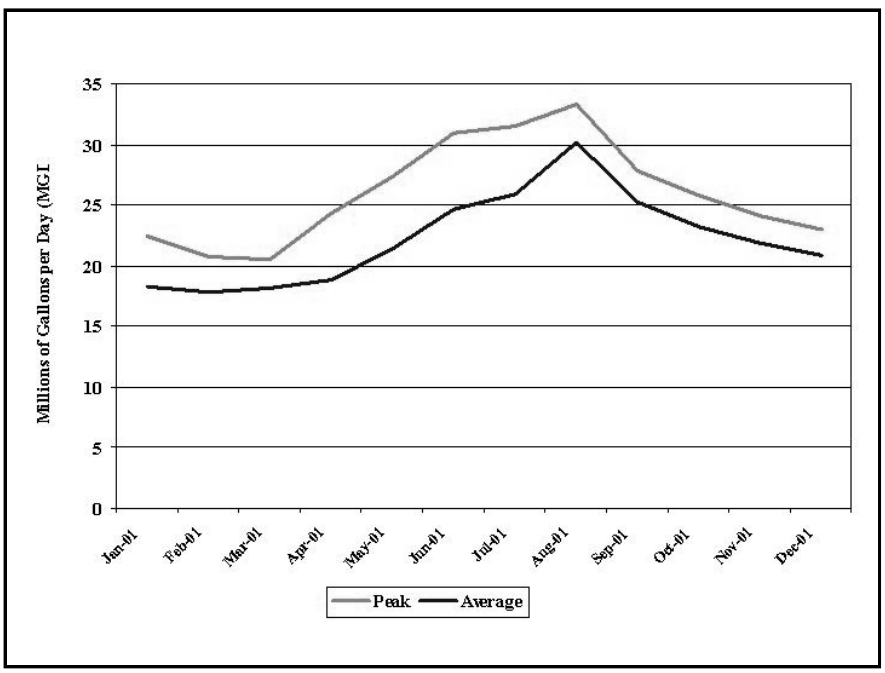
During 2001 the City withdrew, on average, between 17 and 30 million gallons per day (mgd) each month from its water supply system, with a peak withdrawal of 33.3 mgd in August 2001. Figure 6.13 shows the amount and variation in water withdrawals treated at both the Brandywine and Porter plants through the course of 2001. Despite monthly fluctuations in water demand, the amount of withdrawals has remained relatively stable during the past 15 years. (Figures 6.13 and 6.14).

Figure 6.13 City of Wilmington Average and Peak Monthly Water Withdrawals 1985-2000



Source: Water Resources Agency, University of Delaware Institute for Public Administration

Figure 6.14 City of Wilmington 2001 Water Withdrawals



Source: Water Resources Agency, University of Delaware Institute for Public Administration

6.5 Legislative, Judicial and Administrative Response to Water Pollution and Water Supply Issues in Wilmington

Federal

The first significant piece of legislation that was created to protect the nation's water quality was the Clean Water Act (CWA) of 1972. The CWA requires industries to meet pollution control standards, and instructs States to set individual water quality standards and develop pollution control programs. The CWA also seeks to preserve wetlands and other habitats by instituting a permitting process that would require development to be carried out in an environmentally sustainable manner (EPA, 2002c).

With development occurring along the shores of the Delaware River in Wilmington, it is important that the related pollutants be addressed. Section 404 of the CWA specifically addresses development issues. This section requires a landowner to obtain a permit from the Army Corps of Engineers (COE) before doing anything that may alter the navigable waters of the United States. To receive a section 404 permit, the applicant must provide proof that the project is in accordance with all other environmental laws as well as the CWA. Although the COE issues the permit, the EPA oversees its enforcement. States may apply to manage their own 404 permits. These states must follow the minimum enforcement guidelines established in the Act, but may also create more stringent requirements than those of the federal government (Dzurik, 1999: 54-57). Section 404 also requires restoration of habitats that are destroyed during development.

Prior to the CWA, only 30% to 40% of the assessed waters of the United States were suitable for fishing or swimming. Today, between 60% and 70% of these waters have met fishing and swimming standards (U.S. EPA, 1998b). Although the CWA was a great success, there is still much to be done. In 1996, 19% of the United States' stream miles were surveyed. Of these, 36% were partially or fully impaired and water quality was threatened in an additional 8%. The survey also extended to 40% of the nation's lakes, 39% of which were partially or fully impaired with an additional 10% threatened. Finally, only 16% of the watersheds in the U.S. have good water quality and 27% lacked the necessary information to make an assessment (U.S. EPA, 1998b). Since 1996, programs like the Source Water Assessment and Protection Plan (SWAPP) have provided more data, but diffused pollution remains a problem.

Greater water pollution control can be achieved through more treatment facilities and by addressing non-point source, or diffused pollution. Congress recognized the need to address non-point source pollution when it reauthorized the CWA in the Water Quality Act of 1987. The key component of the Water Quality Act was the Non-point Source Management Program (NSMP), Section 319. Although no standards were set, states were instructed to conduct studies and provide plans for diffused pollution abatement. Congress authorized $400 million for the NSMP, and also created the National Storm Water Program (NSWP) as a means of dealing with diffused pollution through the NPDES program (Dzurik, 1999: 54-7).

For the 1992-1993 fiscal year alone, Congress awarded over $98.4 million in Section 319 grants. Approximately 10% of this funding was earmarked for urban runoff control. The urban runoff funding, along with any other 319 funding, requires 40% matching funds from non-federal sources such as a local government or nonprofit organizations. Over the 15 years since Section 319 became law, Congress has granted over $8.2 million to EPA Region 3 -- Delaware, Pennsylvania, Virginia, West Virginia and Washington D.C. Within this Region overall funding has ranged from $826,446 for Delaware to $2.4 million for Pennsylvania (U.S. EPA, 2002c). The overall breakdown of 319 grants is provided in the Table 6.10.

Table 6.10 Section 319 Regional Grant Totals

EPA Region	Total Awarded	EPA Region	Total Awarded
Region 1	$5,545,958	Region 6	$12,464,548
Region 2	$5,857,875	Region 7	$8,095,410
Region 3	$8,274,311	Region 8	$8,366,788
Region 4	$17,577,825	Region 9	$9,395,383
Region 5	$17,299,520	Region 10	$5,523,516

Source: U.S. EPA, 2002c

Regions 4, 5 and 6 have clearly received the most 319 funding to date. This most likely reflects the early focus of diffused pollution control on agricultural and rural areas. As urban/suburban land use grows, however, and as the problems associated with urban/suburban runoff are better understood, it will be necessary for regions such as EPA Region 2 and 3 to receive more 319 funds. Regions 2 and 3 are home to the New York–Philadelphia–Washington D.C. megalopolis and represent the greatest concentration of urban/suburban land uses in the nation.

The CWA also addresses pollution discharges into water bodies through the National Pollution Discharge Elimination System (NPDES). The Federal Water Pollution Control Act Amendments, for the purpose of eliminating pollutant discharges through regulatory action, established the NPDES permit program in 1972. State and federal law mandates that all discharges to surface waters must have a permit administered through the NPDES. The Surface Water Discharges Section (SWDS) of DNREC's Division of Water Resources has been delegated authority to direct the program within the State of Delaware. Regulatory control is mandated by the EPA through Section 402 of the federal Clean Water Act, as amended, and Title 7, Part VII, Chapter 60: "Environmental Control" of the Delaware Code. The Delaware River Basin Commission (DRBC), which oversees water management in the Delaware River basin, also has regulations that pertain to NPDES discharges (DNREC, 2001i; U.S. EPA, 1993; U.S. EPA, 2001m).

While an NPDES permit allows the discharge of pollutants directly into the stream, it attempts to limit the release of pollutants that could negatively impact the receiving waters. The impact of pollutant discharges is measured according to the "designated uses" of the water body, which can include "protection of aquatic life" and "drinking water" (DNREC. 2002i). The designated uses of water bodies in Wilmington are described in Table 6.11

Table 6.11 Designated Uses of Water Bodies in the City of Wilmington								
Water Body	Public Water Supply	Industrial Water Supply	Primary Contact Recreation	Secondary Contact Recreation	Fish and Aquatic Wildlife	Cold Water Fish (Put & Take)	Agricultural Water Supply	Exceptional Recreational or Ecological Significance
Brandywine River	a	x	x	x	x	b	a	c
Christina River	a	x	x	x	x	d	a	
Shellpot Creek		x	x	x	x		a	
a = freshwater segements only; b = designated use from March 15 to June 30 on Beaver Run from PA/DE line to Brandywine and from Wilson Run Route 92 through Brandywine Creek State Park; c = designated from PA/DE line to Wilmington City Line; d = designated use from March 15 to June 30 on Christina River from MD/DE line through Rittenhouse Park; x = protected								
Source: DNREC, 1999: 40, 41								

NPDES permit holders are responsible for collecting, analyzing and reporting discharge samples. In addition to reviewing this reported data, SWDS conducts their own monitoring. Individual permittees are required to submit monthly reports in the form of a Discharge Monitoring Report form (DNREC, 2002i).

Federal regulations also address combined sewer overflows (CSOs), another major problem faced by developed areas such as Wilmington. CSOs combine stormwater drains with wastewater drains. They were originally designed to protect human health by overflowing wastes into nearby water bodies rather than directly into streets and basements. Approximately 900 cities in the United States have CSOs (U.S. EPA. 2001b; U.S. EPA. 1999b).

In 1994 the U.S. EPA published the *CSO Control Policy*, a national framework for controlling CSOs that provides guidance on their management in a ways that meet the goals of the Clean Water Act. (U.S. EPA. 2001b).

Regional

Wilmington follows a water conservation program that is under the jurisdiction of the Delaware River Basin Commission (DRBC), which was established to manage and protect the Delaware River Basin. The Delaware River originates in New York, passes through Pennsylvania and New Jersey and runs into the Delaware Bay at Wilmington (Figure 6.15).

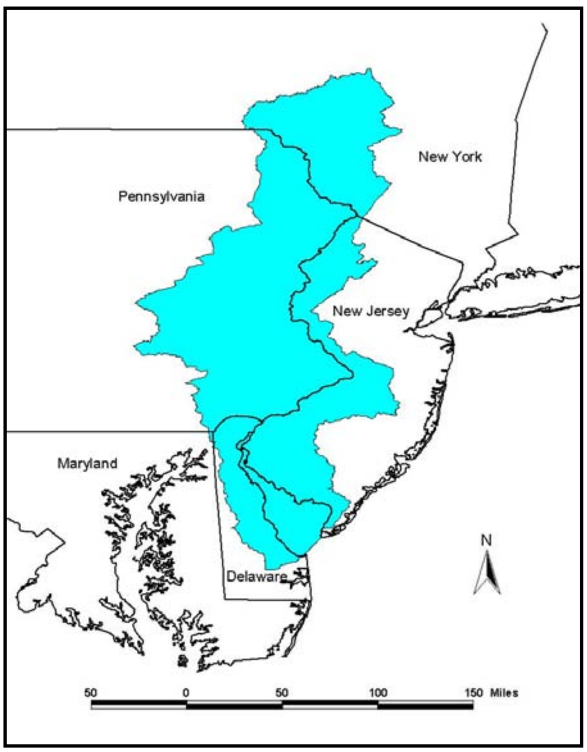
The DRBC plays a multi-functional role in managing water resources. It manages water conservation within the Delaware River Basin, recommends new water conservation measures to state enforcement agencies (e.g., DNREC), facilitates water conservation awareness among stakeholders, recommends and approves water conservation rate structures for investor-owned utilities and makes demand-side management recommendations to utilities.

The DRBC's current water conservation program went into effect on July 1, 1991. At that time, toilets, faucets, showerheads and urinals in the DRBC jurisdiction were required to conform to certain specifications. For example, the volume of water per flush was reduced from 3.5 gallons to 1.6 gallons. These regulations, which came one year prior to similar Federal regulations in the Energy Policy Act of 1992 (DRBC, 2002), are expected to have a significant impact in reducing Wilmington's water demand. For example, the 1.6 gallon per flush limit saves 3,500 gallons per person per year (Anderson, 1989). Therefore, the estimated 73,000 people that live in Wilmington will save 255,500,000 gallons a year. This goal has not yet been achieved but will be as older toilets and other fixtures are replaced by more water saving devices.

State

In addition to Federal law and the DRBC, DNREC, the State's Public Service Commission (PSC), and Delaware's Water Resources Agency (WRA) manage policies that govern water resources in Delaware at the state level. As the primary State agency in water resources management, DNREC allocates the responsibility among its Division of Water Resources, Division of Soil and Water Conservation, and Division of Fish and Wildlife (CEEP, 2001: 89).

Figure 6.15 Delaware River Basin

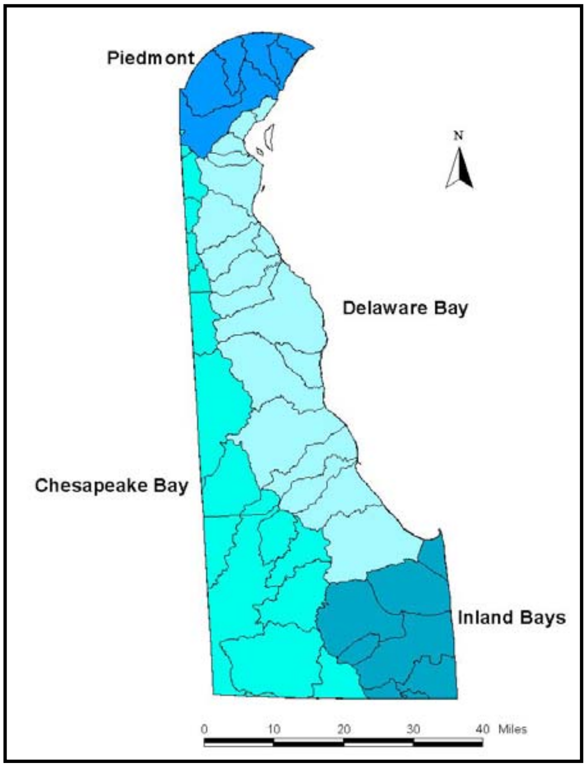


The Division of Water Resources provides technical information and education services, regulates water withdrawals including municipal water providers, provides grants and loans for pollution control projects, regulates tidal wetlands and underwater lands, monitors swimming areas and seafood and operates a laboratory for scientific testing and analysis. DNREC's Division of Soil and Water Conservation provides assistance in the planning and maintenance of tax ditches. In addition, it develops and implements the State's Sediment and Stormwater and Non-point Source Pollution Programs. DNREC's Division of Fish and Wildlife protects and manages fish and wildlife resources and habitats (ibid.: 89).

In Recognition of environmental interrelationships, DNREC has initiated a Whole Basin Management Program (WBMP). The program divides the State into five basins: the Piedmont, Chesapeake Bay, Delaware Bay, Delaware Estuary, and Inland Bays/Atlantic Ocean (Figure 6.16). Within Whole Basin Management, teams seek to integrate the assessment, management and monitoring of each basin's biological, chemical, and physical environments. Each team consists of representatives from DNREC's three water divisions, along with the Divisions of Air and Waste Management and Parks and Recreation (ibid.: 89).

DNREC also plays an important role in water conservation measures. It devises water conservation policy measures, implements and enforces regulations that require mandatory water conservation measures, finances water conservation projects, conducts public information and awareness campaigns, and coordinates water conservation measures taken by other water-related entities in the State (ibid.: 89).

Figure 6.16 Delaware's Watersheds



The Water Resources Agency (WRA) at the University of Delaware and DNREC are currently working on the Source Water Assessment and Protection Program (SWAPP) report for the Brandywine River. The report relies heavily on water quality testing data that has been compiled over the past decade to determine what pollutants threaten Wilmington's waterways. When complete it will provide conclusions on water quality prior to treatment, and will also provide information on the need for more pollution control.

The WRA initiates public information programs that stress the benefits of water conservation, devises programs that seek to modify the behavior of end-users to accord with conservation goals, and works with water purveyors to endorse adoption of a water conservation-oriented pricing structure (CEEP, 2001: 89).

Local

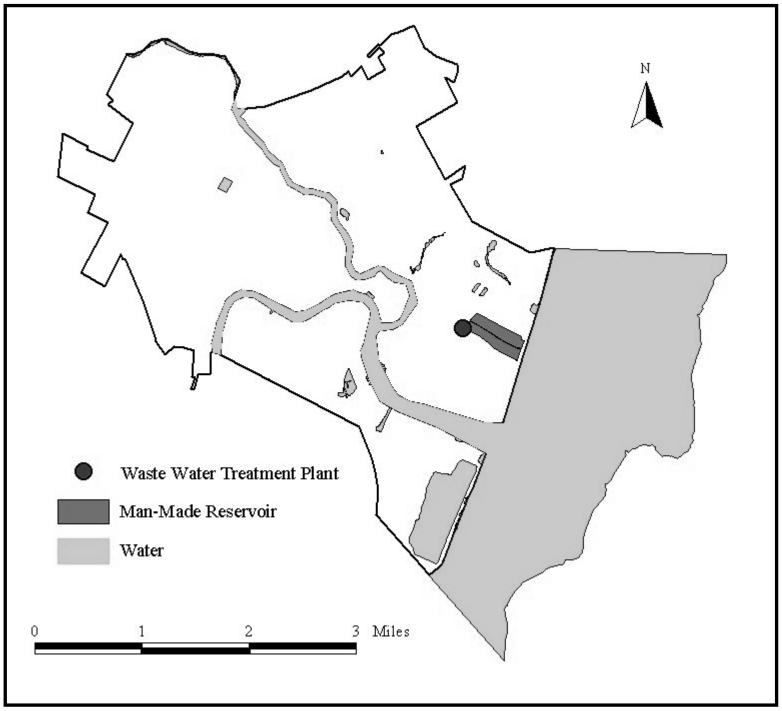
At the local level, the health of Wilmington's aquatic environment is vital to its own health and economic development. The Brandywine River is the City's primary drinking water source. The Christina River runs along the City's budding waterfront and empties into the Delaware River at the Port of Wilmington. Local action targets both water quality control and water supply and demand.

<u>Water Quality Control</u>

With respect to water quality, the Wilmington Wastewater Treatment Plant (WWTP), located near the Delaware River at 12th Street and Hay Road (Figure 6.17), serves the larger region of New Castle County and a small portion of Pennsylvania. The WWTP provides sewage treatment to a population of approximately 460,000 people. Wilmington, which accounts for 16% of the population in New Castle County, contributes 30% of the sewage treated at the plant. The City provides wholesale sewage treatment services to New Castle County, the City of Newark and South Delaware

County in Pennsylvania. New Castle County retails sewage treatment services to residential, commercial and industrial customers within the county.

Figure 6.17 Wilmington's Waste Water Treatment Plant



The relationship between the City of Wilmington and New Castle County for sewage treatment is governed by an inter-jurisdictional service agreement that sets the framework used to designate costs of sewage treatment that the County pays the City for its services. The County establishes retail rates based upon the costs of wastewater treatment, as well as its own maintenance and operation costs (U.S. EPA. 1998a).

In December 1997, the City of Wilmington established a 20-year public-partnership with U.S. Filter Operating Services to manage sewage treatment. One of the largest such partnerships in the U.S., the facility was permitted to discharge 90 million gallons per day and is seeking an upgraded permit that will allow discharges of 134 million gallons per day. U.S. Filter Operating Services is a national company that operates 280 facilities in North America and treats more than 1.75 billion gallons of water per day (U.S. Filter Operating Services, 2002).

The transition of sewage treatment responsibility from the City of Wilmington to U.S. Filter Operating Services has not been without difficulty. In November 2000 the company along with Wilmington Public Works were fined $91,000 for pollution violations. The penalty was levied because the sewage treatment plant exceeded its NPDES discharge permit and Delaware pollution control regulations during a spill on August 27, 2000, when 13 million gallons of sewage was discharged illegally into the Brandywine River over a 13-hour period. NPDES permit levels were also exceeded for six months between January 1999 and March 2000. At the time of the August 2000 spill there was a power failure at the 11th street pumping station, when its backup equipment was also down for repairs. DNREC determined that U.S. Filter Operating Services was responsible for the equipment failure and that the spill was entirely preventable (DNREC News, 2000: Vol. 30, No. 346, November).

The City of Wilmington has been providing its customers with an annual water quality report since 1999, in compliance with federal specifications (City of Wilmington, 2001: 3). Water samples meet the minimum requirements specified by the EPA.

Appendix H describes the frequency of water quality monitoring, as per state and federal regulations. Appendix I presents the contaminants tested within the City, their respective amounts, and the drinking water standards. The Wilmington Wastewater Treatment Plant is effective in eliminating 68% of PCBs from the water that it treats. (DRBC, 1998: 35).

Water Supply and Demand

Water quality is not the only issue that needs to be addressed: water supply is also at issue, especially as Wilmington and the entire East Coast continue to endure a serious drought. Along with the Brandywine Creek, Wilmington may also receive water from Hoopes Reservoir. The reservoir is filled with a usable capacity of 1.8 billion gallons. (DNREC, 2002n). According to the Water Resources Agency (WRA) at University of Delaware, the city's average water demand is 22.3 million gallons per day (mgd). This rate creates an 80-day supply in the reservoir. Therefore, for the sake of the reservoir supply and the health of the Brandywine, it is important that a water conservation program exist.

The City of Wilmington applies a flat rate to its water customers. Flat rates apply a uniform rate to customers regardless of level of consumption, in comparison to inclining block rates that apply an increase in price as water consumption increases. Table 6.12 shows the rate schedule, which came into effect in 1995. A lower rate is applied to residents who live within City limits than to those who live outside. In addition, it employs a lower rate for residential customers than it does for commercial and industrial customers.

Table 6.12 City of Wilmington Water Rates Schedule, Effective 1995

Customer Class	Rate Type	Rate per 1000 Gallons	
		Inside City	Outside City
Residential	Flat Rate	$1.284	$2.398
Commercial	Flat Rate	$1.874	$2.571
Industrial	Flat Rate	$1.499	$2.174
Apartment	Flat Rate	$1.769	$2.774

The City has a number of features that protect residents from feeling direct impacts of drought on their personal water use. There is abundant water storage in Hoopes Reservoir, and the City is not required to abide by minimum flow requirements at water withdrawals. Although infrastructure improvements, such as replacing antiquated pipes in the central city area, have become a common realization for many water utilities that service older cities, and could impact utility revenues, the City of Wilmington feels no direct threat to its water source and no need to seek out future sources at the present time. This sentiment is exhibited in its use of a flat rate structure, rather than one that encourages water conservation. Additionally, the price of water in the City has not increased since 1995.

VII. SOCIO-ECONOMIC PROFILE

7.1 Introduction

The socioeconomic environment is comprised of the social, economic and historical dimensions of the community that simultaneously reflect and impact the welfare of the community. A condition such as poverty may be tied to macroeconomic trends, and yet at the same time be a result of poor planning by the individual, missed opportunities or unforeseen calamity. Poverty may lead or contribute to poor health through inadequate nutrition, lack of access to healthcare, or confinement to inadequate or dangerous housing. In turn, poor health may lead or contribute to poverty through reduced ability to work, premature debility or death of the primary household income earner, or unmanageable debt from uninsured or underinsured health conditions or crises. For these reasons, it is difficult to separate causes from effects. Within the *pressure, state, impact, response* (PSIR) model, the conditions of the socioeconomic environment simultaneously occupy the positions of *pressures, states,* and *impacts*. In contrast to the preceding sections, this chapter is organized thematically with reduced emphasis on distinguishing between *pressures, states* and *impacts*. However, the regulatory response is clearly delineated.

The socioeconomic environment is a vital component of the Community Environmental Profile (CEP), not only because it is part of the myriad of factors that impact the welfare of the community, but because *it is the measure* of the physical and social welfare of the community.

7.2 Demographic and Environmental Profile

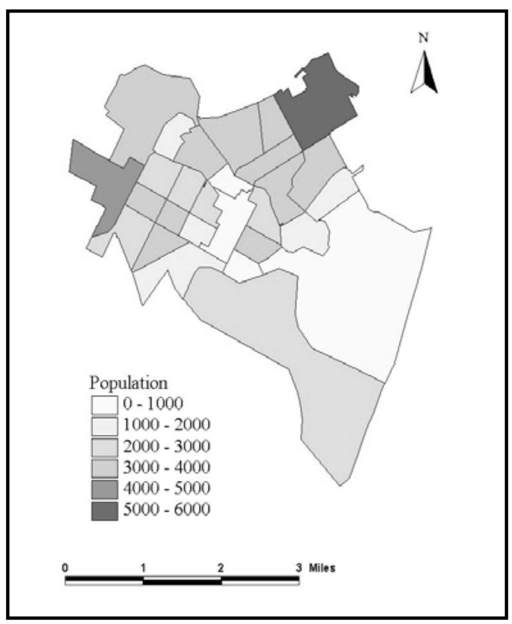
<u>**Population Distribution**</u>

According to the 2000 Census, the population of Wilmington is 72,327, with 28,554 households. This is an increase of 811 persons (1.13%) over the 1990 census. The majority of the City's population lives in its northeastern part (Figure 7.1). Very few people live in the east, where the landfill is located. Population density is also low in the center of the City, where most of the commercial development is located.

The 2000 census also recorded 5,214 children under the age of 5 years, the highest proportions of whom, in comparison to total population, are in the southern portion of the City (Figure 7.2).

The spatial distribution of population is clearly defined along racial lines. Figure 7.3 shows census tracts with over 40%

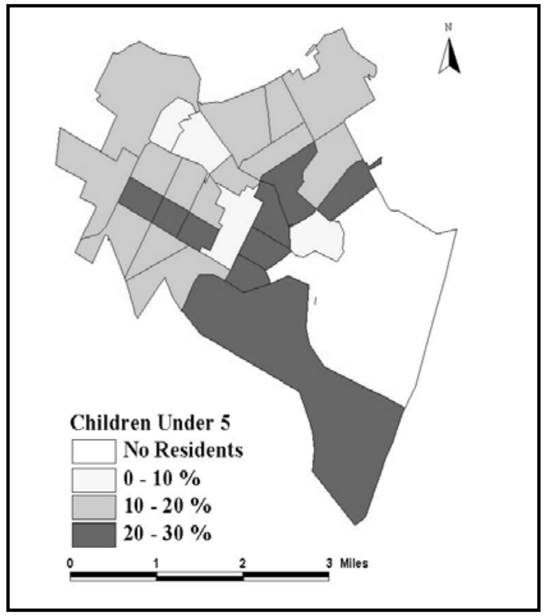
Figure 7.1 Population Distribution in the City of Wilmington



Data Source: U.S. Census Bureau, 2000a

African American and White populations and over 20% Hispanic populations. The map shows that African Americans reside primarily in the eastern part of the City, White residents live in the northwest, and there is a defined Hispanic presence in the west-central area.

Figure 7.2 Distribution of Children Under 5 Years of Age within the City of Wilmington

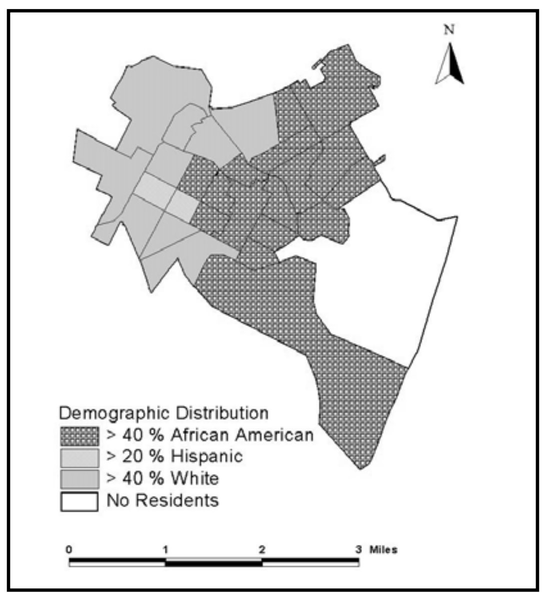


Data Source: U.S. Census Bureau, 2000a

Environmental Hazards Faced by Disadvantaged Minority Communities

African American communities in Wilmington are home to 64% of the City's contaminated land, 80% of abandoned tannery sites, 30% of toxic release inventory sites, 73% of hazardous waste generators, 60% of combined sewer overflows, and 56% of NPDES general wastewater discharge permit holders. None of the water bodies in African American communities support fish that are safe to eat. African American communities, therefore, are confronted by disproportionately high environmental risks in the City of Wilmington. Figure 7.4 and Table 7.1 illustrate the distribution of risks in comparison to community racial composition.

Figure 7.3 Population Distribution by Race in the City of Wilmington



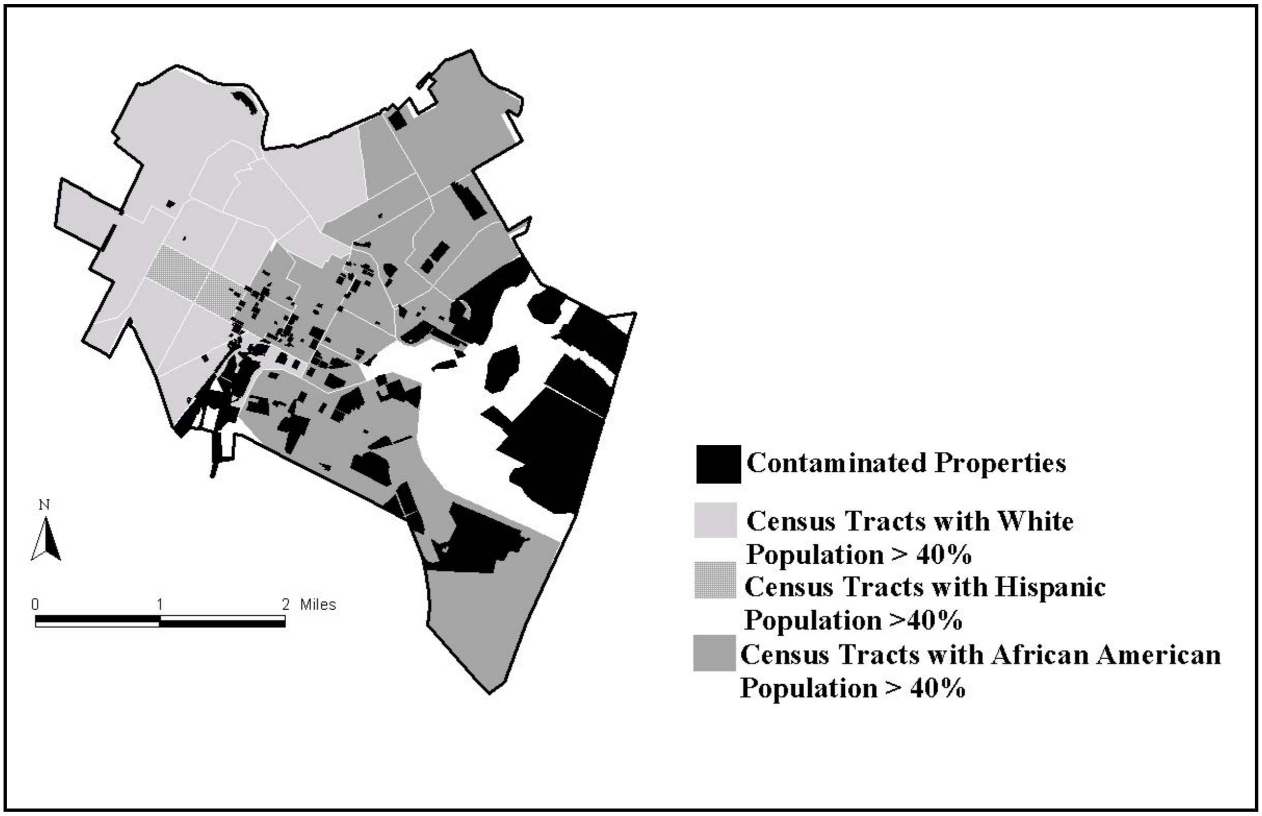
Data Source: U.S. Census Bureau, 2000a

7.3 Socio-Economic Profile

Forces influencing economic conditions in the City of Wilmington include global, regional and local economic trends, historical tax incentives for business and unemployment trends.

Table 7.1 Environmental Hazards by Community's Racial Composition				
Contaminant	Tracts with > 40 % African American Residents	Tracts with > 40 % White Residents	Tracts with > 20% Hispanic Residents	Total Number of Sites in the City
Contaminated Land (SIRB)	85	28	0	131
Abandoned Tanneries	41	13	6	51
Toxics Release Inventory Sites	4	3	0	13
Hazardous Waste Generators	78	33	0	106
Combined Sewer Overflows	22	12	0	37
NPDES General Permit Holders	10	1	0	18

Figure 7.4 Environmental Hazards by a Community's Racial Composition



Taxation

The State of Delaware has historically offered tax incentives for business. These incentives have affected, and continue to affect, the economic conditions of Wilmington residents. The Financial Center Development Act of 1981 (FCDA), initiated by Delaware Governor Pierre S. DuPont IV, provided favorable tax conditions for businesses, inviting them to move their operations to Delaware and the Wilmington area.

The FCDA is often viewed as a regulatory response to the economic crisis experienced during the 1970s. During this period, many Delawareans fell into unemployment (Forbes, 1999:xx). Wilmington census records indicate that unemployment within the City of Wilmington reached a record high of 9.5% in 1980, while the percentage of families below the poverty level grew to 20.2%. It was within this historical context that Governor DuPont encouraged the State Legislature to adopt the FCDA in 1981 (Novack, 1986). FCDA provided incentives for business by lowering "the state income taxes that banks must pay and eliminated the limit on how much interest and fees credit card companies could charge to customers nationwide" (Epstein, 2001). FCDA enabled Delaware to attract out-of-state banks and other businesses into the area. Attracting businesses was promoted as a way to create new jobs in the State. Between 1981 and 1989, forty-one out-of-state banks moved their operations into the Wilmington area (Karmin, 1989). The number of employed persons in Wilmington increased by 6,240 during the decade after the FCDA was passed (U.S. Census Bureau). FCDA of 1981 was followed by eight additional legislative pieces that served the needs of the financial businesses (Forbes, 1990).

Since the passage of the legislation to increase incentives for businesses, Wilmington residents have experienced positive economic trends, but only briefly and for selected indicators. For example, median income in Wilmington for 1990 was higher than the US median.

There is no personal property tax or sales tax for the residents of Delaware. The State and the City excise taxes on residents according to their income levels. The City taxes the incomes of all persons who reside or work in Wilmington at 1.25%. The City also charges a head tax of $5.00 per employee per month, with the first five employees being exempt from taxation (DEDO, 2002a). The State also imposes an individual income tax according to the scale shown in Table 7.2.

Compared to the other cities, the total family tax burden in Wilmington is considerably high, especially for low-income residents. In 1999, the Delaware Economic Development Office estimated local family tax burdens based upon a hypothetical family of four persons, who owned their own home and had two income earners within the household. Tables 7.3 and 7.4 show the results of their analysis for three cities. Residents of Wilmington paid disproportionately higher taxes than the residents of Dover or Seaford (Table 7.3). Seaford families with an income of $25,000 paid only 49%, and Dover families paid 52%, of the taxes paid by

Table 7.2 Delaware Individual Income Tax

Delaware Taxable Income	2000 Tax Liability
$ 0 – $ 2,000	$ 0.00% of income
$ 2,000 – $ 5,000	$ 0.00 + 2.2% of income > $ 2,000
$ 5,000 - $ 10,000	$ 66.00 + 3.90% of income > $ 5,000
$ 10,000 - $ 20,000	$ 261.00 + 4.80% of income > $ 10.000
$ 20,000 - $ 25,000	$ 741.00 + 5.20% of income > $ 20,000
$ 25,000 - $ 60,000	$ 1,001.00 + 5.55% of income > $ 25,000
$ 60,000 and over	$ 2,943.50 + 5.95% of income > $ 60,000
Source: DEDO, 2002a	

Table 7.3 Total Family Tax Burden by Income Level

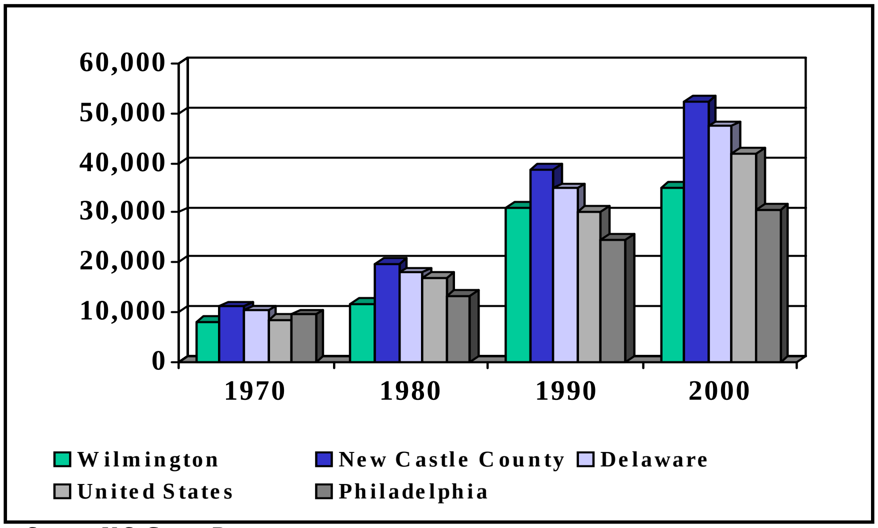
City	$ 25,000	$ 50,000	$75,000	$100,000
Wilmington	$ 1,260	$ 3,259	$ 5,208	$ 7,239
Dover	$ 663	$ 2,255	$ 3,821	$ 5,465
Seaford	$ 618	$ 2,188	$ 3,732	$ 5,354
Source: DEDO, 2002b				

Table 7.4 Details of Family Tax Burden for a $50,000 Income Family

City	Individual Income Taxes		Residential Property*	Total Burden
	State	Local		
Wilmington	$ 1,442	$ 576	$ 1,242	$ 3,259
Dover	$ 1,505		$ 750	$ 2,255
Seaford	$ 1,509		$ 678	$ 2,188
* Assumes a Property Value of $90,000				
Source: DEDO, 2002b				

Wilmington families. Table 7.4 details the total tax burden for families with an income of $50,000.

Figure 7.5 Median Household Income for Wilmington, New Castle County, Delaware, the United States and Philadelphia for 1970, 1980, 1990, and 2000



Source: U.S. Census Bureau

Household Income

Figure 7.5 compares the median household income of the City of Wilmington with that of New Castle County, the State of Delaware, the United States and the City of Philadelphia from 1970 to 2000. The median household income of Wilmington residents is dramatically lower than that of the residents of New Castle County or the State. The margin between Wilmington and Delaware residents has also increased, particularly between 1990 and 2000. Similar trends can also be seen in unemployment rates.

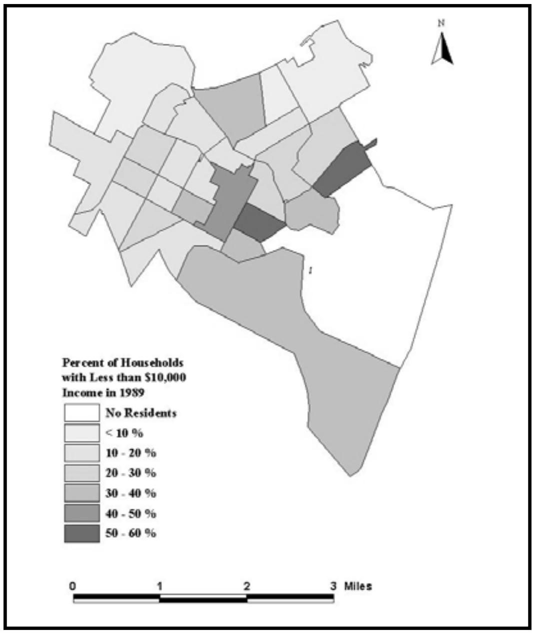
Table 7.5 Median Household Income by County

	1989	1979		1969	
County/State	**1989 Dollars**	**1989 Dollars**	**Current Dollars**	**1989 Dollars**	**Current Dollars**
Delaware	$34,875	$17,846	$29,904	$9,309	$29,297
Kent County	29,497	15,342	25,708	7,735	24,344
New Castle County	38,617	19,656	32,937	10,092	31,762
Sussex County	26,904	14,483	24,269	7,208	22,685

Source: U.S. Census Bureau. *Table C1. Median Household Income by County: 1969, 1979, 1989.*

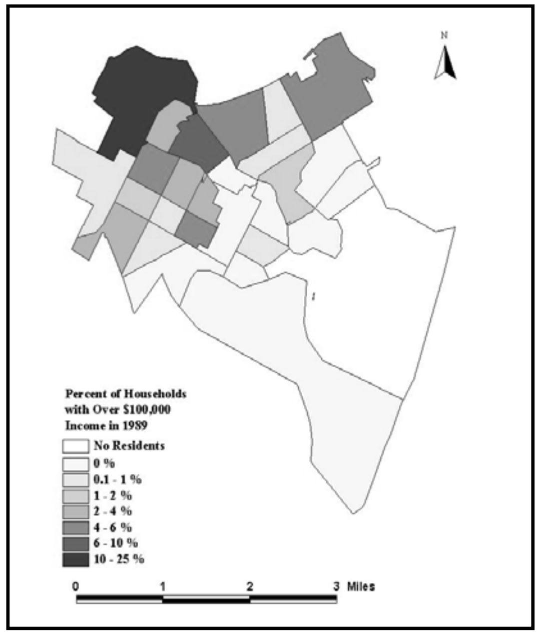
Household income in Wilmington is unequally distributed, reflecting a spatial income gradient (Figures 7.6 and 7.7). The southern and eastern sections of Wilmington have the highest proportions of households with incomes less than $10,000, and the northeastern section has the highest proportion of households with incomes greater than $100,000, according to 1990 Census data (Berry and Jardell, 1997). In 1989, the median household income of the Wilmington Metropolitan Statistical Area, which includes parts of Maryland and New Jersey in addition to Delaware, was $37,553 (U.S Census Bureau). For comparison, Table 7.5 shows the median household income for corresponding years by county, and for Delaware as a whole. In comparison to the State en masse and Delaware's counties, residents of New Castle County have consistently had higher mean incomes. However, when compared to the income distribution in Wilmington, it becomes evident that the wealth of the County is not located within the City.

Figure 7.6 Wilmington Households With Less than $10,000 Income in 1989



Data Source: MCDC, 2001

Figure 7.7 Wilmington Households With Over $100,000 Income in 1989



Data Source: MCDC, 2001

Unemployment

Table 7.6 shows the total number of employed persons from 1970 to 2000, and Table 7.7 categorizes those employed in 1980, 1990 and 2000, by industry type. Total employment has decreased from 1980 to 2000, with a decrease in manufacturing, construction and retail jobs. However, the percent employment in the finance and services sector increased.

Table 7.6 Total Employed Persons in Wilmington, 1970-1990

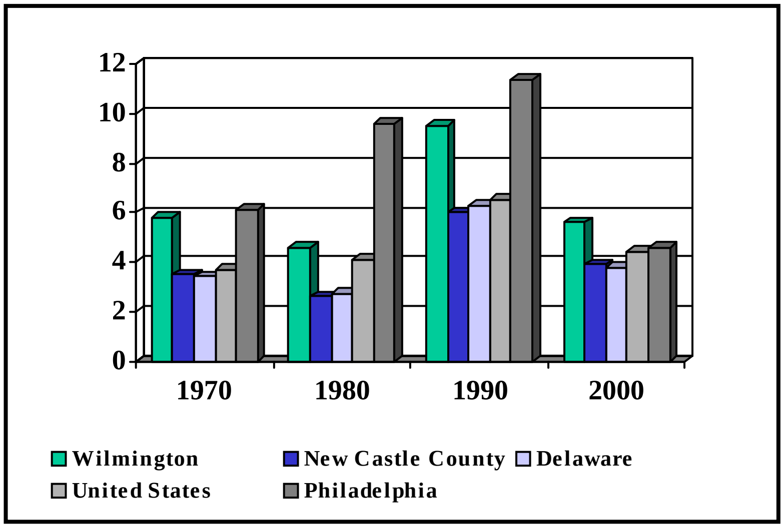
Year	Total Number
1970	31,103
1980	26,948
1990	33,188
2000	30,412
Source: U.S. Census Bureau	

Table 7.7 Total Employed Persons in Wilmington by Industry

INDUSTRY TYPE	1990		2000	
	Total	percent	Total	percent
	33,188	100%	30,412	100%
Agriculture, forestry, fishing and hunting, and mining	356	1.1	69	0.2
Construction	1,991	6.0	1,285	4.2
Manufacturing	5,301	15.9	2,925	9.6
Wholesale trade	798	2.4	659	2.2
Retail trade	4,511	13.5	2,850	9.4
Transportation and warehousing, and utilities	1,203	3.6	1,161	3.8
Information	601	1.8	699	2.3
Finance, insurance, real estate, and rental and leasing	4,334	13.0	4,544	14.9
Services	12, 212	36.8	14, 262	46.7
Public administration	1881	5.s7	1,958	6.4
Source: US Census.				

Compared with the State of Delaware and the United States, unemployment within the City of Wilmington is disproportionately high (see Figure 7.8). According to 1990 Census data, the percent of unemployment in some tracts is as high as 20%, concentrating in the southeastern portion of the City (Figure 7.9). However, when comparing unemployment to poverty within the City of Wilmington between 1970 and 1990 on census tract level, there is no spatial correlation between unemployment and poverty. Nevertheless, urban residents within the City of Wilmington are disconnected from the local labor market (Williamson, 1997: 115-117).

Figure 7.8 Percent Unemployment of Wilmington Residents Compared to New Castle County, the State of Delaware, the United States and the City of Philadelphia for 1970, 1980, 1990 and 2000

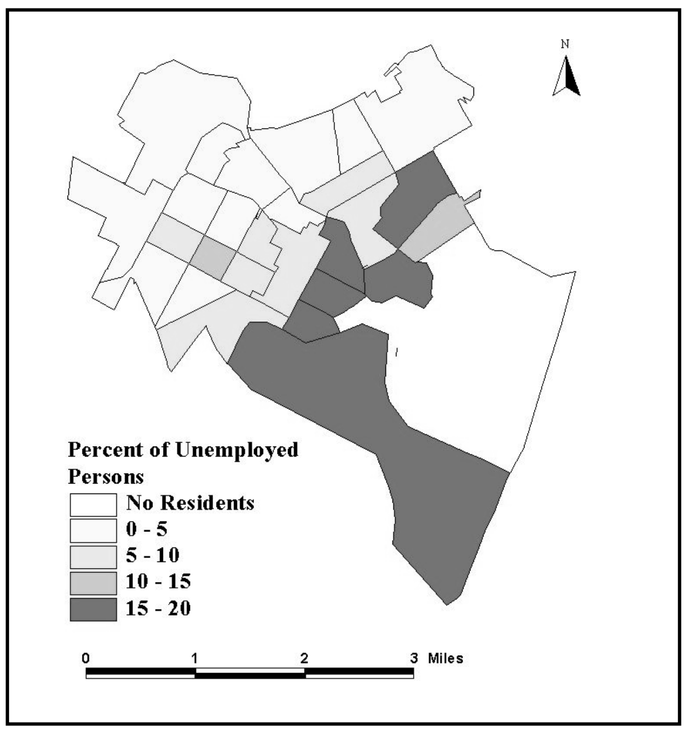


Source: U.S. Census Bureau

Several explanations exist for the disconnect between community residents and the local labor market. These include the post-industrialization decline in manufacturing employment within the City and a "spatial mismatch between suburban job opportunities and city residence" (Williamson, 1997: 117).

High unemployment rates have affected census tracts that are also predominantly African American. Unemployment rates within Wilmington, as well as in New Castle County, were higher for African American than for White populations for the decades spanning 1950 to 1990. Table 7.8 shows unemployment rates by race for the City of Wilmington from 1950 to 1990.

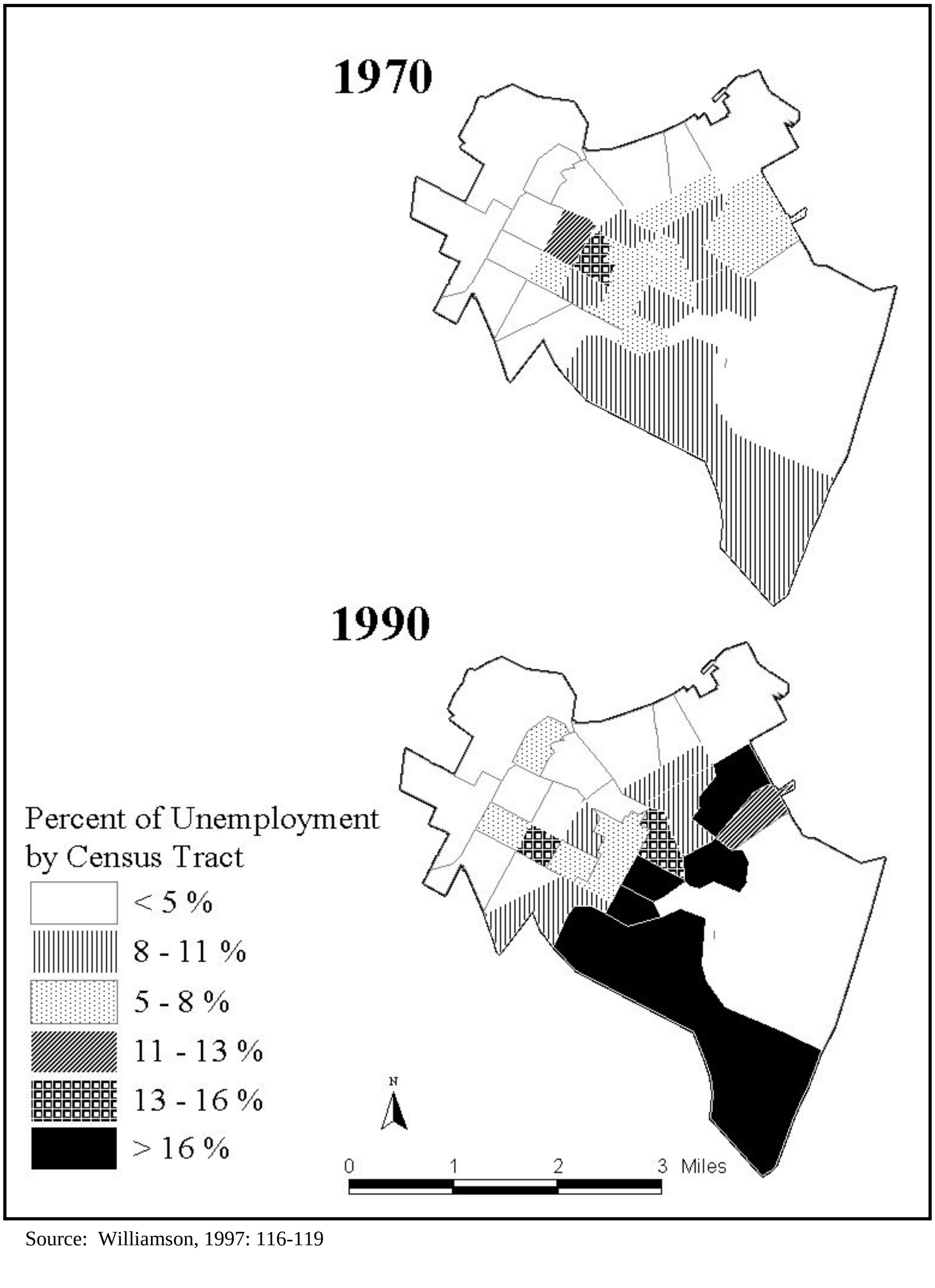
Figure 7.9 Percent of Unemployed Persons in 1990



Data Source: Berry and Jarrell, 1997

Table 7.8 Unemployment Rates for the City of Wilmington by Race, 1950-1990			
Year	**Black**	**White**	**Black/White Unemployment Ratio**
1950	8.2	3.4	2.4
1960	10.3	5.3	1.9
1970	8.0	4.1	1.9
1980	13.5	5.4	2.5
1990	10.6	3.4	3.1
Source: Williamson, 1997: 120			

Figure 7.10 Unemployment by Census Tract, Ages 16 and Over



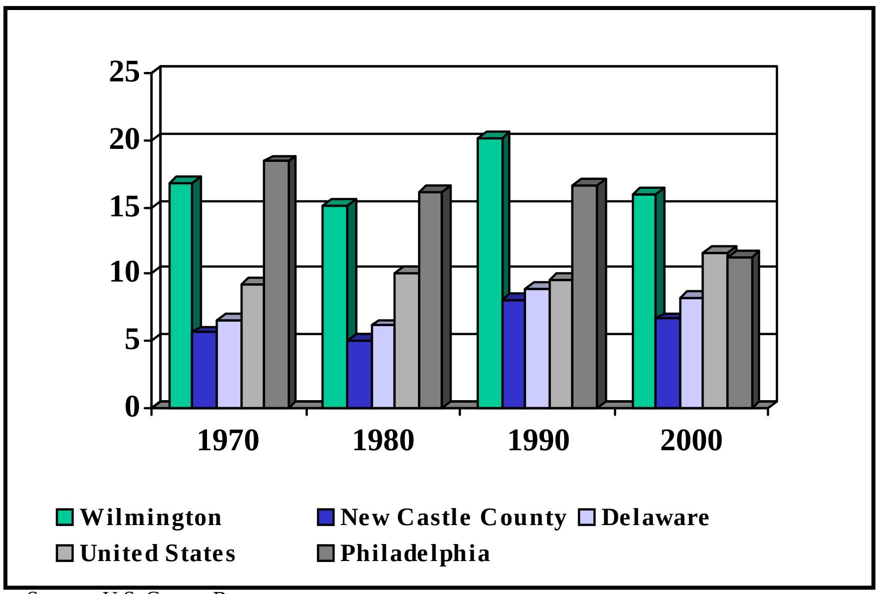
Source: Williamson, 1997: 116-119

Absolute unemployment rates increased significantly in 1980 for black Wilmington residents. The ratio between Black and White Wilmington unemployment rates rose consistently between 1970 and 1990. As this information shows, there have historically been disproportionate impacts in unemployment within the City of Wilmington, both spatially and racially. The socio-economic pressures of unemployment on the current residents of Wilmington are tied to a worsening unemployment rate, weaker attachment to the labor market, and significant population decline (Williamson, 1997: 121).

Poverty

The City of Wilmington has experienced a tradition of poverty that exerts pressure upon the local community. In 1999, approximately 17% of families in Wilmington were below the poverty level, while over 21% of individuals were below the poverty level. A large proportion of those below the poverty level are children. During the same period, nearly one-third of families in Wilmington with children under 5 years of age were below the poverty level. The concentration of poverty in Wilmington can be attributed to a number of social and economic factors. These include suburbanization and flight of particular categories of residents and businesses from the urban core, rising unemployment from the decline of industrialization emerging from a new information-based economy, and the social and demographic transitions that ensued from these historical processes. Figure 7.11 compares the percent of families below the poverty level for the City of Wilmington, New Castle County, the State of Delaware, the United States and the City of Philadelphia for 1970, 1980, 1990 and 2000.

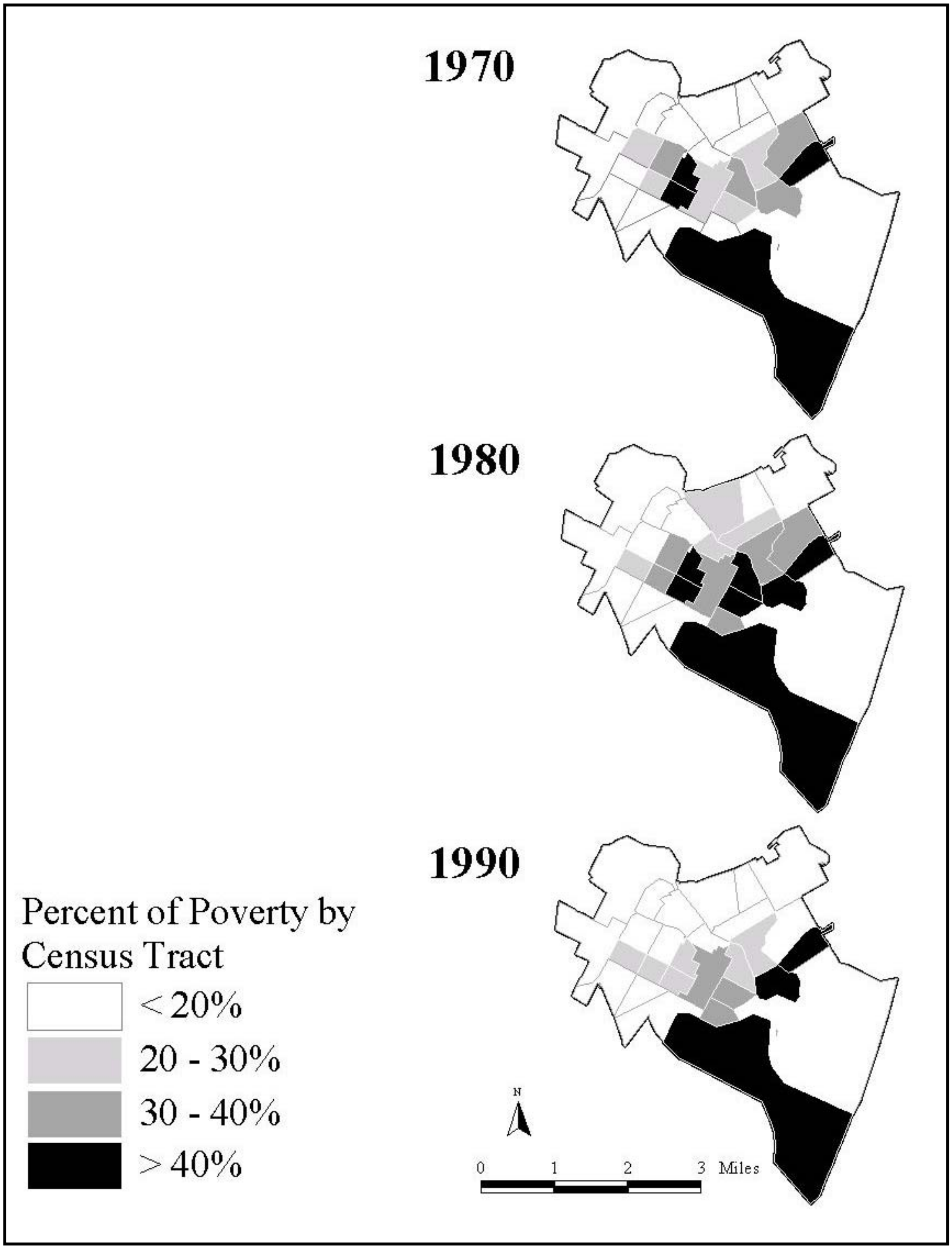
Figure 7.11 Percent of Families Below Poverty Level for the City of Wilmington, New Castle County, the State of Delaware, the United States and the City of Philadelphia for 1970,. 1980, 1990 and 2000



Source: U.S. Census Bureau.

Within the City of Wilmington, poverty has historically concentrated in particular areas. The southeastern portion of the City has borne the brunt of poverty in all of New Castle County since at least 1970. Many of the census tracts with the highest poverty rates are also communities with the highest minority populations. Figure 7.12 illustrates the distribution of poverty as measured by the U.S. Census Bureau for the years 1970, 1980 and 1990 (Williamson, 1997: 80-96).

Figure 7.12 Percent of Poverty by Census Tract: 1970, 1980 and 1990



Source: Williamson, 1997: 84-86

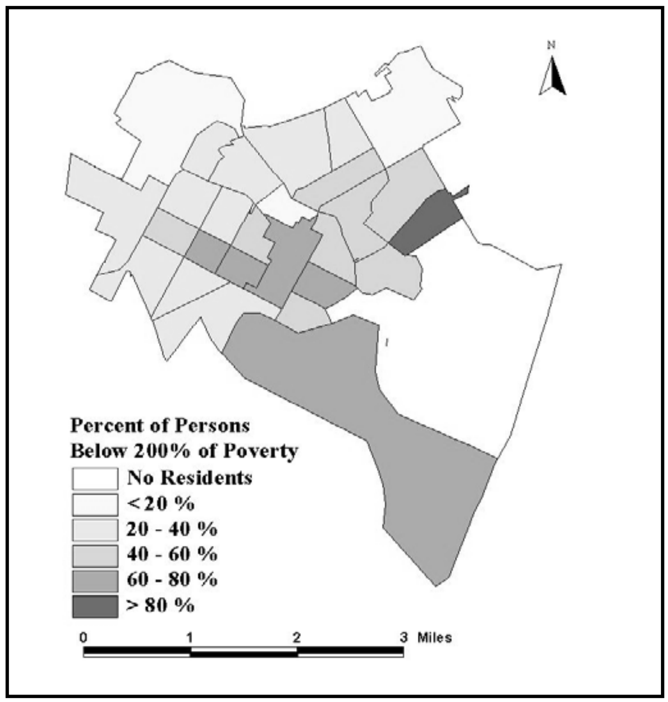
African Americans in poverty are concentrated within specific areas in the City of Wilmington. This can be attributed to several factors, including the out-migration of middle-class African Americans from the inner city to suburban areas; the constraints imposed by housing discrimination and segregation; and the "spatial mismatch" between employment opportunities and the residences of the urban poor (Williamson, 1997: 174). In short, "inner-city areas have undergone a social transformation which makes the experience of those presently residing in poverty significantly different from the poor of past decades" (Williamson, 1997:122)

Table 7.9 2001 Poverty Line (Annual Income)

Size of Family Unit	48 Contiguous States and D.C.
1	$ 8,590
2	11,610
3	14,630
4	17,650
5	20,670
6	23,690
7	26,710
8	29,730
For each additional person, add	3,020

Source: U.S. DHHS, 2001.

Figure 7.13 Percent of Persons Below 200% of Poverty, 1990 Census



Data Source: Berry and Jarrell, 1997

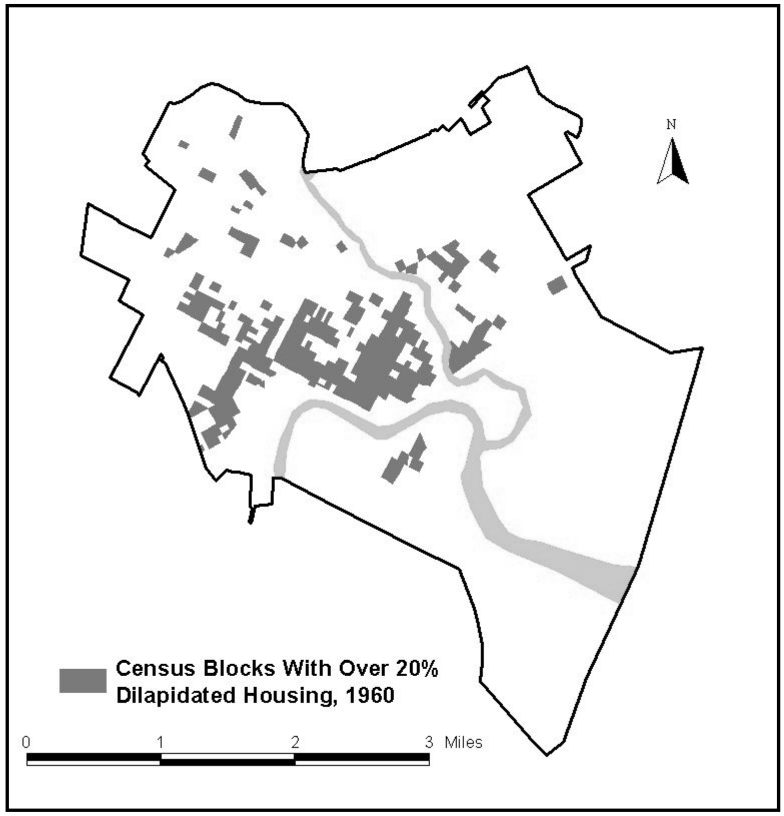
Housing Conditions

According to Census 2000 data, there are 31,242 housing units within the City of Wilmington, 15,177 of which are owner-occupied. The distribution of owner-occupied and renter-occupied housing is uneven, with concentrations of owner-occupied housing corresponding generally to the high income and higher-educational attainment areas (Figures 7.19 and 7.20). A similar correlation can be seen with respect to housing values and rents.

Poor housing conditions and the existence of dilapidated housing continue to impact the socio-economic condition of City residents. In 1964, the Wilmington Commission on Zoning and Planning published a report on the housing conditions within the City by census block (Wilmington Commission on Zoning and Planning, 1964). Comparisons of dilapidated housing in the 1960s with other social and economic conditions discussed in this chapter illuminate a chronic condition of community need in specific areas of the City. Figure 7.14 illustrates census blocks with over 20% dilapidated housing in 1960 (City of Wilmington Commission on Zoning and Planning, 1964). While only 3.1 percent of the City's 33,190 housing units were considered dilapidated in 1960, 15.4 percent was classified as deteriorating. Dilapidated housing, as shown in Figure 7.14, was concentrated in the southern portions of the City. Many of these same areas continue to experience difficulties with abandoned housing and vacant properties.

There were 1,501 vacant properties listed in 2002, 93% of which were successfully geocoded in GIS and overlaid onto a City parcel map (Figures 7.15 and 7.16). Vacant housing not only constitutes a locally undesirable land use, but is also

Figure 7.14 Census Blocks with More than 20% or Ten Housing Units with Deteriorating or Dilapidated Housing in 1960



Source: City of Wilmington Commission on Zoning and Planning, 1964)

Figure 7.15 Vacant Housing as % of Total Housing in Wilmington

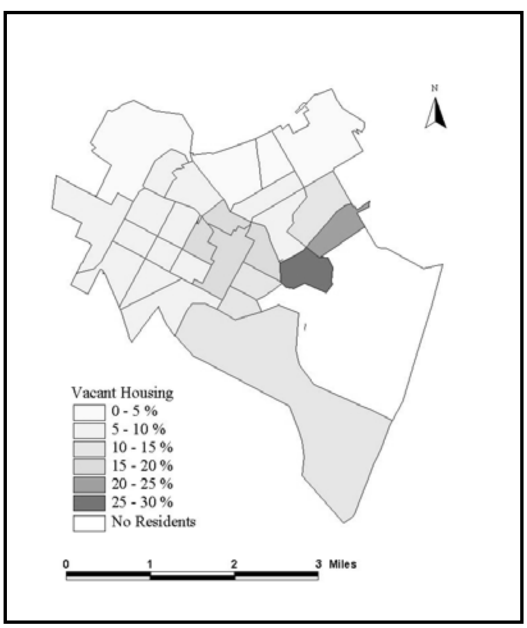
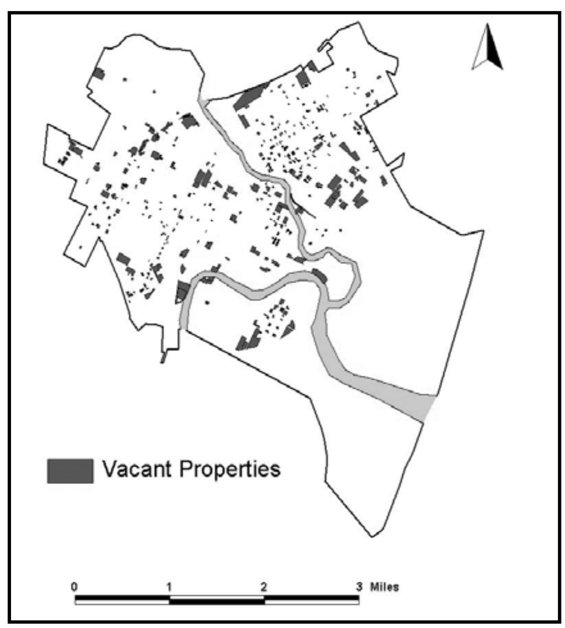


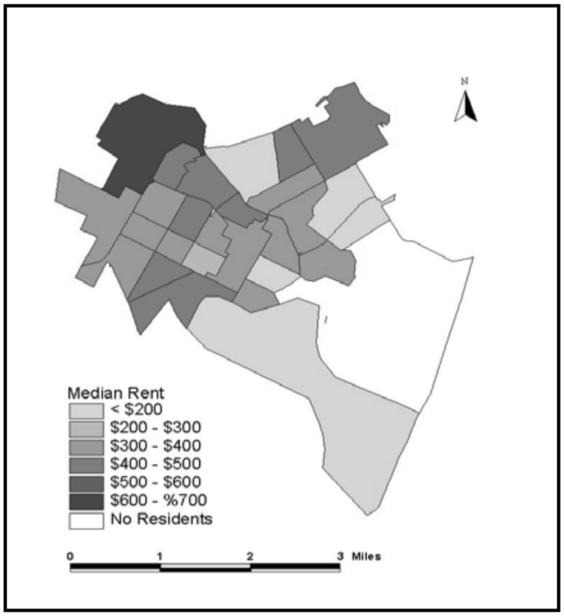
Figure 7.16 Distribution of Vacant Property in Wilmington, 2002



an indication of the housing condition. A second indicator is house-age, which is the primary risk for lead poisoning among children in Wilmington. *Delaware Kids Count 2001* has determined all of the zip codes within the city to be “lead priority areas”, based on the following criteria:

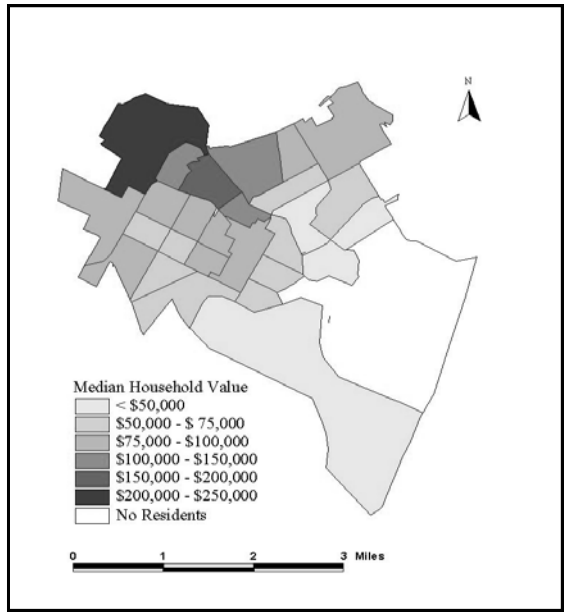
- 20% of the children under 6 years of age live below the poverty level, and
- 27% of the housing units were built before 1950 (CCDFP, 2001: 40)

Figure 7.17 Median Rent in Wilmington



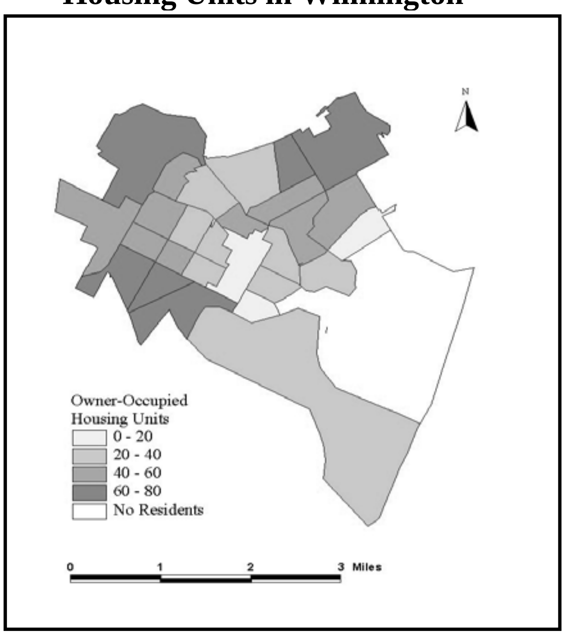
U.S. Census Bureau, 1990

Figure 7.18 Median Household Value in Wilmington



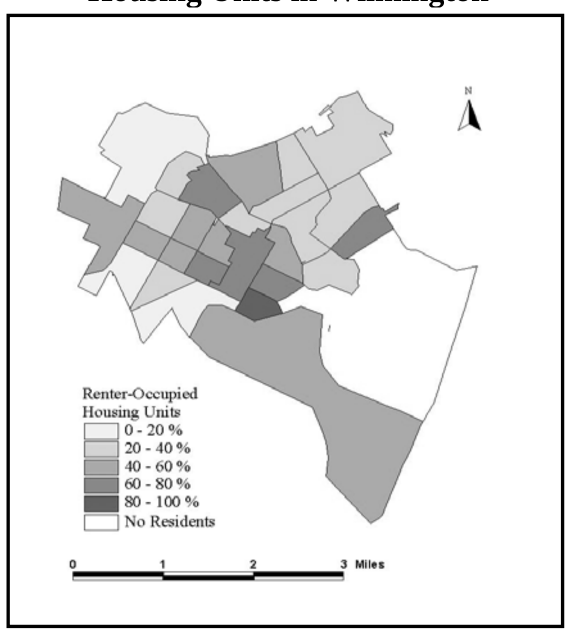
U.S. Census Bureau, 1990

Figure 7.19 Owner-Occupied Housing Units in Wilmington



U.S. Census Bureau, 1990

Figure 7.20 Renter-Occupied Housing Units in Wilmington

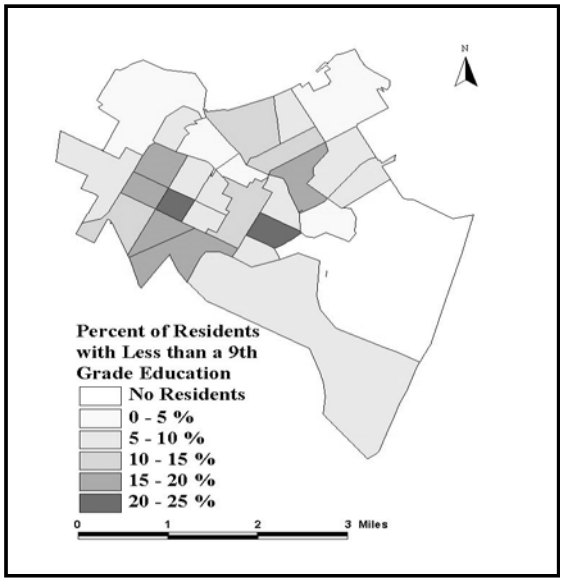


U.S. Census Bureau, 1990

Education

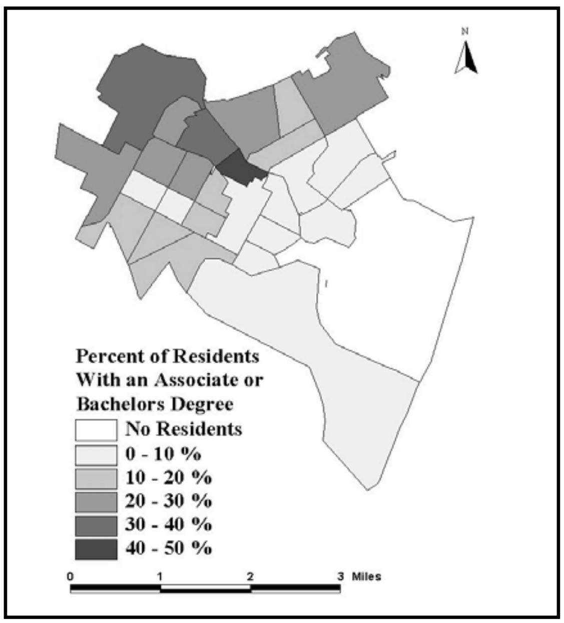
GIS analysis of 1990 Census data also reveals some clear spatial patterns in level of educational attainment within the City (Figures 7.21-7.23). Some census tracts have up to 25% of adult residents with less than a ninth grade education. Adults with higher levels of educational attainment live primarily in the northwestern portion of the City.

Figure 7.21 Wilmington Residents with Less than a 9th Grade Education in 1989



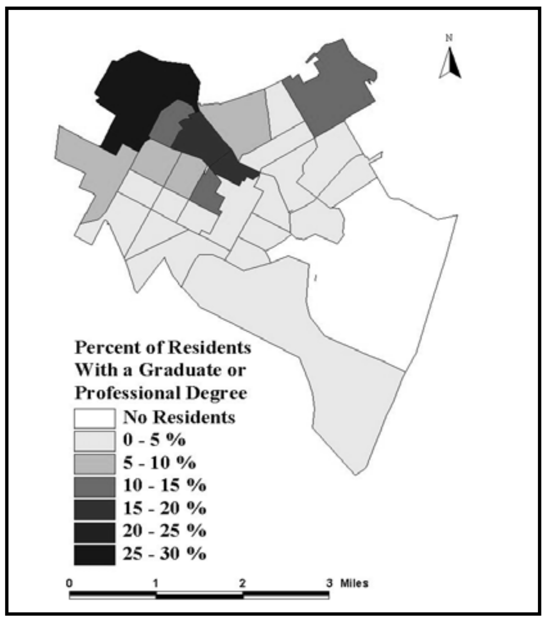
Data Source: MCDC, 2001

Figure 7.22 Percent of Residents with and Associate or Bachelors Degree in 1989



Data Source: MCDC, 2001

Figure 7.23 Percent of Residents with a Graduate or Professional Degree in 1989



Data Source: MCDC, 2001.

7.4 Regulatory Responses

<u>Poverty and Unemployment</u>

The federal government has established several safety-net programs for poor and low-income families. Delaware saw the establishment of these federal programs during the mid-1970s through the Division of Social Services (DSS), which is one of the eleven divisions of the Department of Health and Social Services (DHSS). Most of the DSS programs targeted at low-income families are jointly funded by the federal and the state governments. The aim of these programs is to provide economic and social services to low-income persons with disability, of old age or having young children who are dependent on them. These programs are guided by income and resource limits.

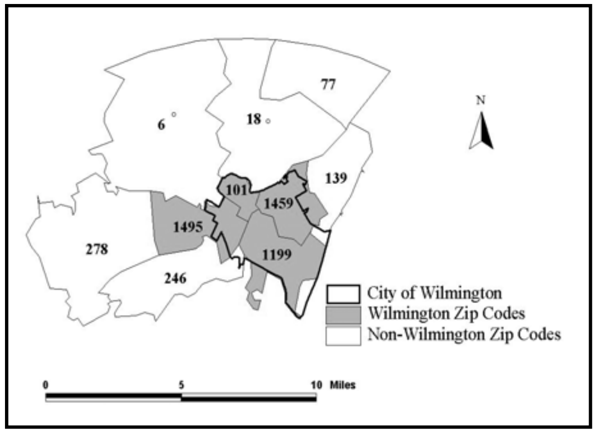
The Social Security Act of 1935, was the first legislation to establish social insurance programs in the United States. One of them was the Old Age, Survivors and Disability Insurance (OASDI), which was established as an insurance program for workers (more than 65 years old and have worked for more than 10 years) who have lost their income either due to retirement or disability. The Social Security Amendments of 1965, expanded federal funds to states for medical assistance programs for persons with low-income and resources.

Temporary Assistance for Needy Families (TANF) is a federal cash-assistance program, which the states have a great degree of freedom to design and implement. The Delaware TANF program was instituted in October 1995 (replacing the earlier instituted Aid to Families with Dependent Children – AFDC: 1935) and is named "A Better Chance". The departments of Heath and Social Services, Labor, Transportation and Economic Development have come together to design and implement this important welfare program, where both the state and the welfare recipients take equal responsibility for the former to become self-sufficient. The Emergency Assistance Program (EAS) or Crisis Alleviation Service (CAS), which are part of TANF, also serve to help those who are distressed by emergency situations. In 1972, the Supplemental Security Income (SSI) Program was instituted as a federally administered cash-program to assist the aged, the blind and the disabled. The General Assistance (GA) Program is a state-funded anti-poverty program, which provides financial assistance to unemployable, low-income families, who cannot avail of the federally funded cash assistance programs like TANF and SSI.

The Food Stamps Act was established in 1964, and is among the popular welfare programs in Delaware, which enables low-income families to purchase nutritional food through food coupons. The Special Supplemental Food Program for Women, Infants and Children (WIC) was established in 1974 to improve the nutrition of low-income families. Families or individuals who qualify for WIC also qualify for other federal programs such as Medicaid. Under the Social Security Act, Medicaid is a jointly funded cooperative venture between the Federal and State governments to assist States in the provision of adequate medical care to eligible needy persons. These include low-income pregnant women, infants, children, and the elderly, and disabled persons. In Delaware, Medicaid pays for: doctor visits, hospital care, labs, prescription drugs, transportation, routine shots for children, mental health and substance abuse services. Prenatal services are also paid for qualifying low-income pregnant women under Medicaid in Delaware. Most people receiving Medicaid in Delaware are enrolled with one of the managed care plans under the Diamond State Health Plan (Delaware Health and Social Services, 2002a). The Delaware Healthy Children Program helps children 19 years of age or younger from families at or below 200% of the federal poverty level who do not qualify for Medicaid, or otherwise do not have access to health care.

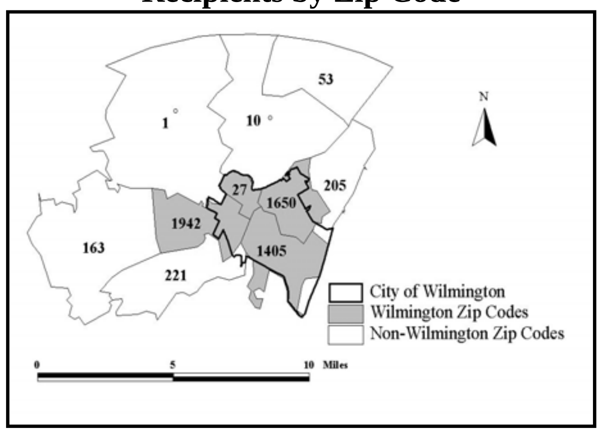
Delaware also has a minimum wage act, according to which no worker will be paid less than $ 6.50 per hour. This is higher than the federal minimum wage of $5.15 per hour.

Figure 7.24 Adult Food Stamp Recipients By Zip Code



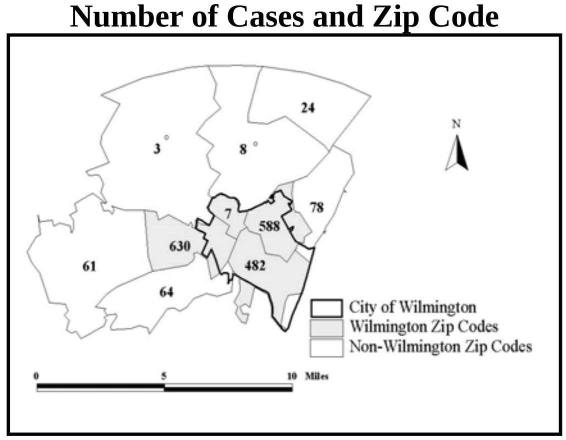
Data Source: CCDFP, 2001 77

Figure 7.25 Child Food Stamp Recipients by Zip Code



Data Source: CCDFP, 2001: 77

Figure 7.26 Delaware's "A Better Chance" Welfare Reform Recipients by Number of Cases and Zip Code



Data Source: CCDFP, 2001: 79

The agency that is concerned with employment in Delaware is the Department of Labor. The Economic Policy Institute rates Delaware's unemployment compensation system as average, basing it upon a national comparison of eligibility, benefit and funding rules. The Delaware Unemployment Compensation Law was signed in 1932. This law facilitated the institutions of State Unemployment Insurance for employees who lose their jobs for reasons not under their control. Among Delaware's unemployed, 47% file claims, while the national average is about 43%. The department also makes referrals for insurance beneficiaries to re-employment services. Delaware also has a Welfare Employment Program (WEP) to help welfare recipients to acquire job skills toward economic independence and self-sufficiency.

Housing

The U.S. Department of Housing and Urban Development (HUD) is the agency in charge of addressing all housing-related issues in the country. It has, as its aim "ending chronic homelessness in 10 years" and "helping the disadvantaged people move from rental to home ownership". The department gives a lot of housing counseling grants to state agencies and non-profit organizations, which in turn, work to help HUD realize its goals.

The Delaware State Housing Authority (DSHA) was established in 1968 in Wilmington to help low-income families access housing. DSHA provides these communities assistance to rehabilitate existing homes and to access low-interest loans to buy quality homes. Low-interest loans are also given to builders who build affordable rental housing for low-income communities. DSHA has several types of assistance targeting specific groups. There are counseling programs like the Elderly Housing Counseling Program (EHCP) for the elderly and adults with physical disabilities, whose responsibility it is to develop and coordinate a continuum of housing options for older Delawareans. The Slum Clearance and Development Authority (SCDA) Law was enacted to rehabilitate any slum or blighted area within Delaware.

The Housing Capacity Building Program (HCBP) assists low-income communities build or access affordable housing. Low Income Housing Tax Credits are also provided to organizers who build, acquire or rehabilitate houses for low-income communities. These organizers, in turn, charge lower than market rate rents to those who cannot afford market rate rents.

The Super NOFA (Super Notice of Funding Availability) Task Force of the Homeless Planning Commission (HPC) was created in 1998.

An important piece of legislation is the Fair Housing Act instituted in 1968. This was further revised in 1988. According to President Lyndon Johnson, who instituted the act, "it is the policy of the United States to provide, within constitutional limitations, for fair housing throughout the United States". The Fair Housing Assistance Program (FHAP) and the Fair Housing Initiatives Program (FHIP) help marginalized immigrant populations, and racial and ethnic minorities acquire fair housing through education and outreach programs on the right to fair housing.

The State also has a Lead Based Paint Hazard Control Grant Program (with a budget of $ 80 million for 2002) to identify and control lead-based paint hazards in privately owned housing in partnership with community-based organizations.

Education

The Child Nutrition Program Reauthorization (1998) through its many nutrition programs in schools encourages children from low-income communities to attend school. The schools selected under these programs usually have relatively large numbers of low-income students, and provide universal (free) breakfast and lunch to all students attending the schools following the National School Lunch Act. Delaware is one of the 12 states in which this program is being carried out. Delaware is one of the six states with the 'After-school Meals Program' providing free dinners in low-income neighborhoods to children through 18 years of age or younger.

Approximately 71% of students in Wilmington received free or reduced-price lunches in 2000-2001, and 32% of the school-going children in New Castle County received free and reduced-price breakfast during 1999-2000. Besides these, the U.S. Department of Agriculture has started the Special Milk Program, the Summer Food Service Program, and the Child and Adult Care Food Program for children from low-income families.

7.5 Health

The most consistent predictor of the health status of individuals or communities is socioeconomic status – economic and political power, and social integration. There is in fact a socioeconomic gradient of health; the less wealthy one is, the less healthy (Krieger 2001). The exact relations between health and socioeconomic status are myriad and confounding. These include nutrition, access to healthcare, stress, personal behavior, occupation, residential segregation, and environmental exposure in the community or at work.

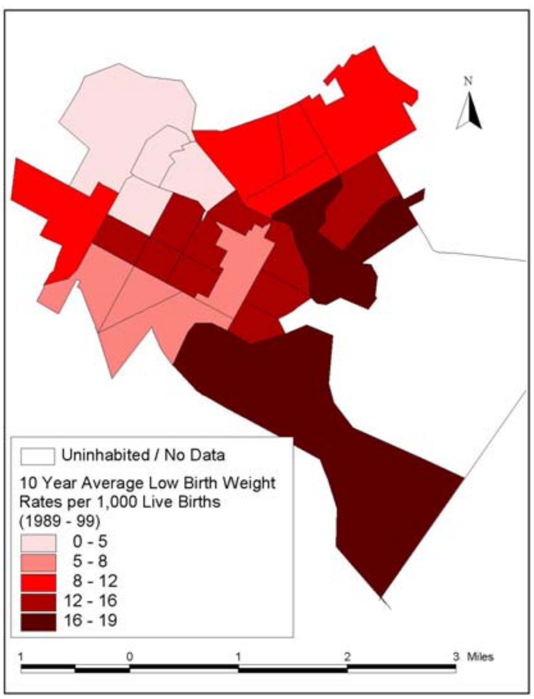
Although environmental influences on health are receiving increased attention, this is still a relatively dark area for researchers in terms of data or understanding. Many known toxins such as lead, PCBs, and arsenic continue to be under-investigated or inadequately monitored. At the same time, the great majority of industrial chemicals released into the environment have yet to be tested for their possible impacts on health (General Accounting Office 2000 "Toxic Chemicals: Long-Term Coordinated Strategy Needed to Measure Exposures in Humans"; Pew Environmental Health Commission 2000).

The following is a profile of selected morbidity and mortality patterns within Wilmington, without reference to likely causation.

Low Birth Weight

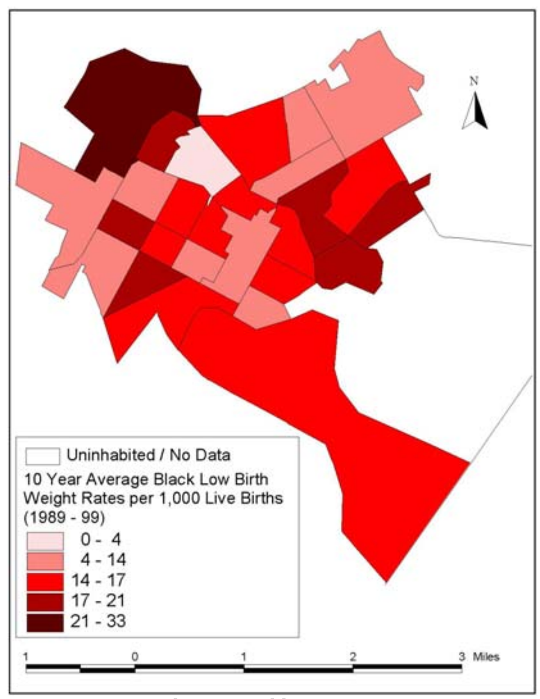
Infants weighing less than 2,500 grams (5.5 lbs) at birth are classified as Low Birth Weight. Low Birth Weight children have a higher risk of dying before their first birthdays and are more vulnerable to infections, as well as neurological and developmental problems. In the long run this can mean increased difficulties at school and chronic health problems. African-American infants are twice as likely as white infants to be born at a low birth weight (Kids Count 2001; DHSC 2001). This disparity is mirrored in Wilmington. The ten-year average Low Birth Weight rate for the city as a whole was approximately 11.36 per 1,000 live births from 1989 – 1999. Spatially, low birth weight rates are concentrated in the southern half of the City and are coincident with areas that are predominantly minority and poor, as well as being burdened by environmental hazards. Though black residents are most impacted by the incidence of low birth weight, the trend for low birth weight rates has risen for all groups over the last decade. Figures 7.27 and 7.28 illustrate the spatial distribution of low birth weight rates for Wilmington per 1,000 live births.

Figure 7.27 10 Year Average Low Birth Weight Rates for Wilmington Per 1,000 Live Births



Data Source: Delaware Health Statistics Center

Figure 7.28 10 Year Average Black Low Birth Weight Rates for Wilmington Per 1,000 Live Births



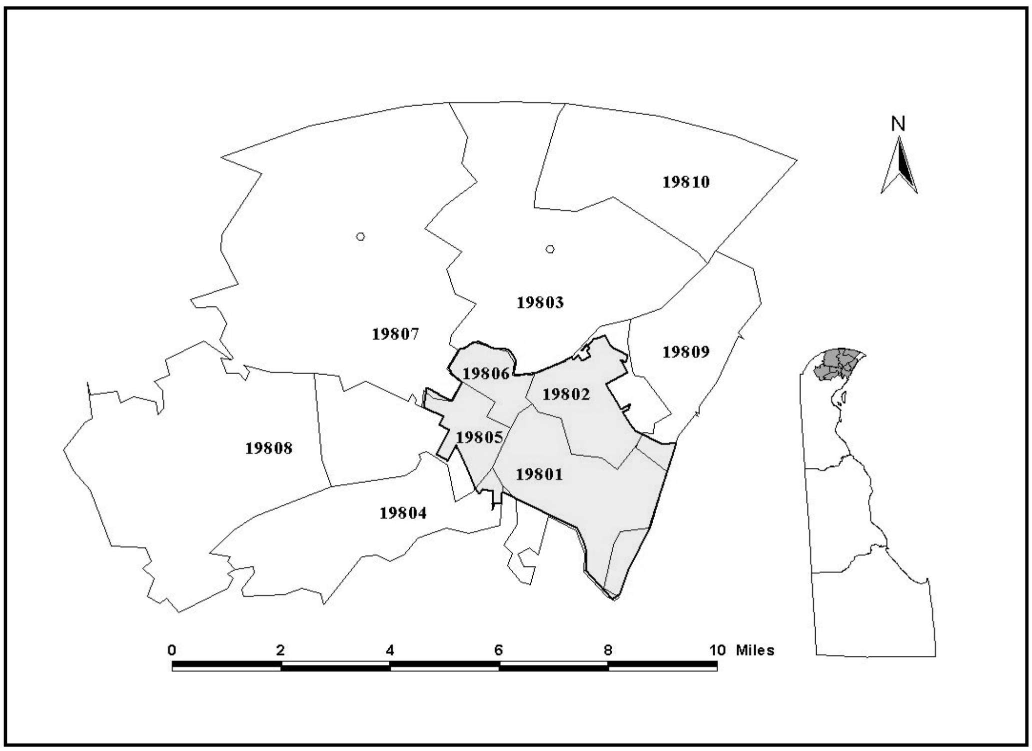
Data Source: Delaware Health Statistics Center

Incidence of Childhood Lead Poisoning

Exposure to high levels of lead (between 70 and 100 μg/dL— micrograms per deciliter) is life threatening. Nonspecific symptoms including sporadic vomiting, lethargy and constipation can occur at blood levels of 50 and 70 μg/dL. While blood lead levels of this magnitude are extremely dangerous, levels as low as 10 μg/dL are high enough to adversely influence cognitive development, behavior and learning. The U.S. Center for Disease Control (CDC) has defined an elevated blood lead level to be $\geq$10 μg/dL. Negative impacts, however, have also been observed at blood lead levels below 10μg/dL (U.S. CDC, 2000; 2001).

The State of Delaware's Department of Health Statistics keeps records of lead testing and blood lead levels. For zip codes that include the City of Wilmington 3,239 children were tested in 1994, 2,722 in 1996, and 3,016 in 2000. Figure 7.29 illustrates the overlap between relevant zip codes and the Wilmington city boundary. Zip codes 19801, 19802, 19805 and 19806 fall within the City of Wilmington.

Figure 7.29 Zip Codes in Northern New Castle County and the City of Wilmington



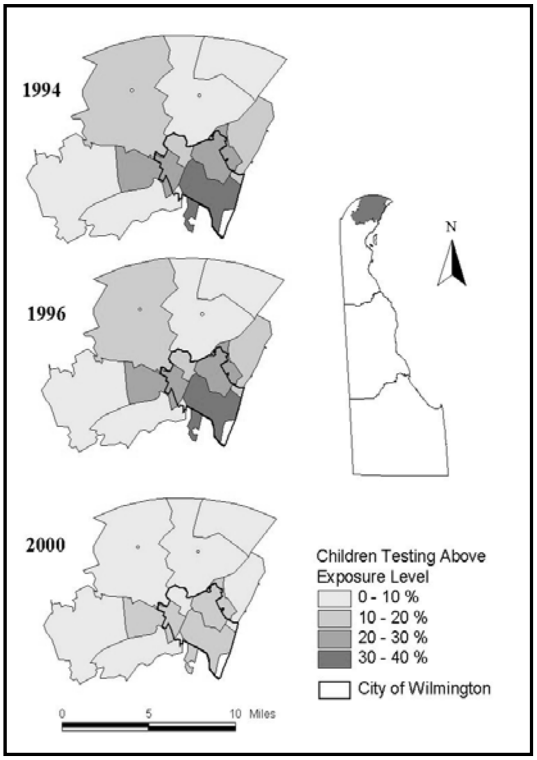
However, substantial portions of zip codes 19802 and 19805 fall outside of the City. Table 7.10 presents the results of statistical summaries of lead sampling in zip codes in northern New Castle County for 1994, 1996, and 2000.

There are variations in the number of children tested in each zip code in any given year. Table 7.10 reveals that there has been an overall decrease in lead blood level testing in the southeast part of the city, and an increase in lead testing in the northwest part of the city.

Table 7.10 Lead Exposure Statistical Analysis												
Zip Code 19---	1994				1996				2000			
	Number of Samples	Mean (µg/dL)	Median (µg/dL)	Maximum (µg/dL)	Number of Samples	Mean (µg/dL)	Median (µg/dL)	Maximum (µg/dL)	Number of Samples	Mean (µg/dL)	Median (µg/dL)	Maximum (µg/dL)
801	627	11.07	8	67	405	9.422	7	43	359	6.421	4	35
802	1108	11.02	9	78	621	8.704	7	65	458	6.793	5	27
803	55	6.182	4	23	81	4.741	4	25	164	2.86	2	13
804	102	6.294	5	24	157	4.987	4	37	170	3.959	4	17
805	953	11.54	8	61	860	7.487	5	60	1061	5.778	4	36
806	22	9.05	7.5	24	43	6.767	6	22	73	4.849	3	49
807	2	7	7	9	18	4.722	4	14	33	2.788	2	8
808	104	6.837	5	37	249	4.205	4	15	367	3.45	3	36
809	173	8.318	6	39	161	6.075	4	30	182	4.44	4	37
810	93	5.968	4	19	122	4.902	4	18	149	3.174	3	20

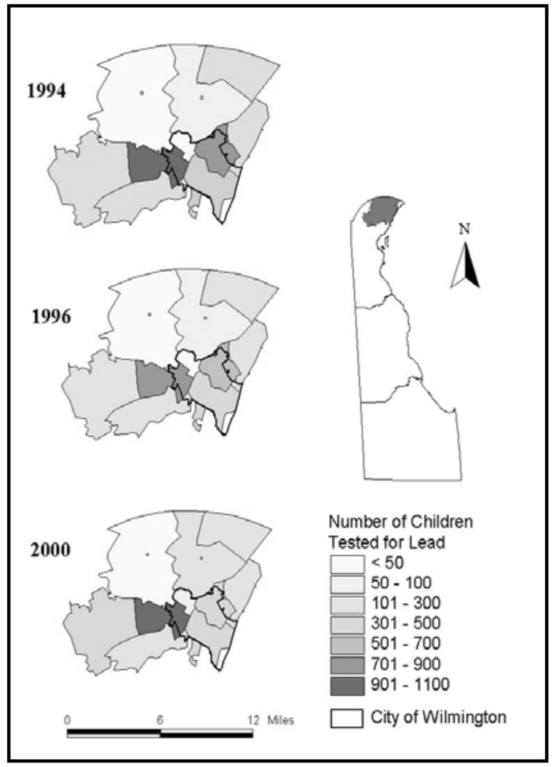
Children with blood lead levels ≥10µg/dL are at risk of adverse health effects from lead poisoning. During 1994 and 1996, the number of children tested at or above this level of exposure included over 30% of all children tested in areas of Wilmington. However, the percentage was reduced for these geographic areas in 2000. Figures 7.30 and 7.31 illustrate these trends.

Figure 7.30 Degree of Lead Exposure in Children by Zip Code for 1994, 1996 and 2000



Data Source: Delaware Health Statistics Center

Figure 7.31 Number of Children Tested for Lead Exposure by Zip Code for 1994, 1996 and 2000



Data Source: Delaware Health Statistics Center

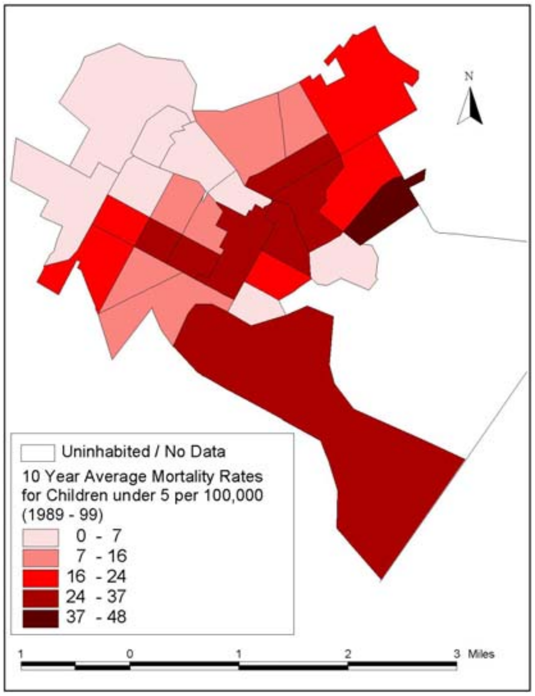
Mortality

The three leading causes of death in Wilmington for the period 1994 – 1998 were heart disease, cancer, and HIV infection/AIDS, respectively. This contrasted with the leading causes of death in Delaware and the US, for which stroke was the third leading cause of death. The overall mortality rates in Wilmington have remained marginally, though consistently, higher than the county, state, or nation. Mortality rates at the Census tract level reveal significantly higher rates in the southern half of the city, particularly in tracts with high minority populations and low incomes. However, the highest rates are found in the center of the city, while the lowest are in the northwest. The mortality rate for children under 5 years of age is particularly high in Wilmington. The overall mortality rate for children under 5 years of age in Wilmington was at least twice that of New Castle County, the state of Delaware, or the US. The spatial variation mirrors that of the total mortality rate.

Infant Mortality

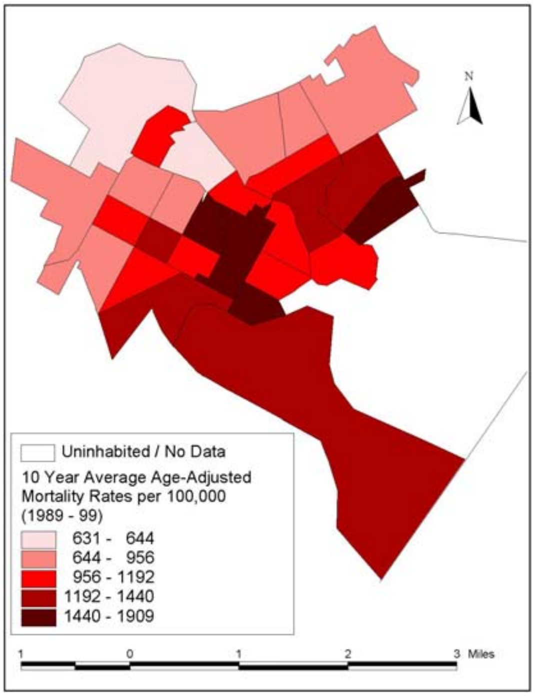
Infant mortality in Wilmington has been trending downward at a faster rate than the rest of the nation as a whole. Since the period 1986 – 1990, the infant mortality rate in Wilmington has dropped by more than one third (from 20.9 to 13.7 per 1,000), as compared to the nation's one quarter drop (9.9 to 7.5 per 1000), though Wilmington's infant mortality rate is still nearly twice that of the US or the state of Delaware. In addition, the racial disparity in infant mortality rates is particularly acute and has actually increased in Wilmington. While Black infant mortality rates have remained steady at nearly twice that of Whites for the nation and the State, the infant mortality rate for Blacks in Wilmington was nearly 3 times that of Whites in Wilmington in the period 1995 – 1999 (6.2 versus 18 per 1000). The primary proximate causes of infant mortality in Wilmington were conditions originating in the perinatal period (including low birth weight) (55%), followed by Sudden Infant Death Syndrome (SIDS) and other ill-defined conditions (12%), birth defects (10%), and finally respiratory diseases and infectious diseases (7%)(Kids Count 2001).

Figure 7.32 10 Year Average Mortality Rates for Children Under the Age of Five in Wilmington per 100,000 (1989-99)



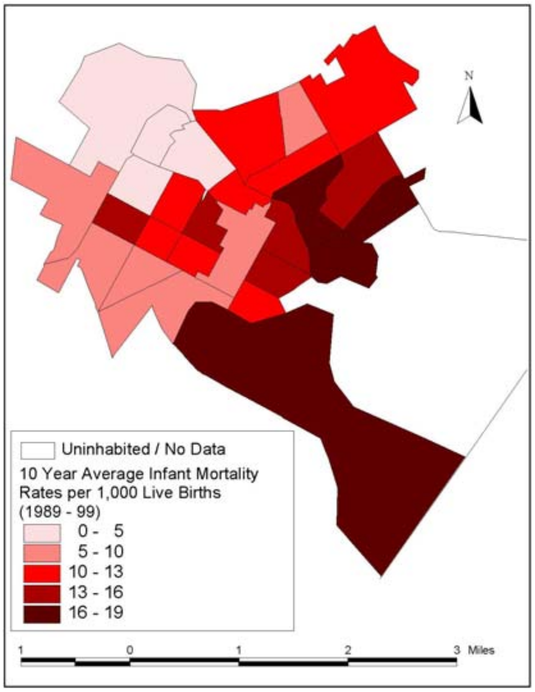
Data Source: Delaware Health Statistics Center

Figure 7.33 10 Year Average Age-Adjusted Mortality Rates in Wilmington per 100,000 (1989-99)



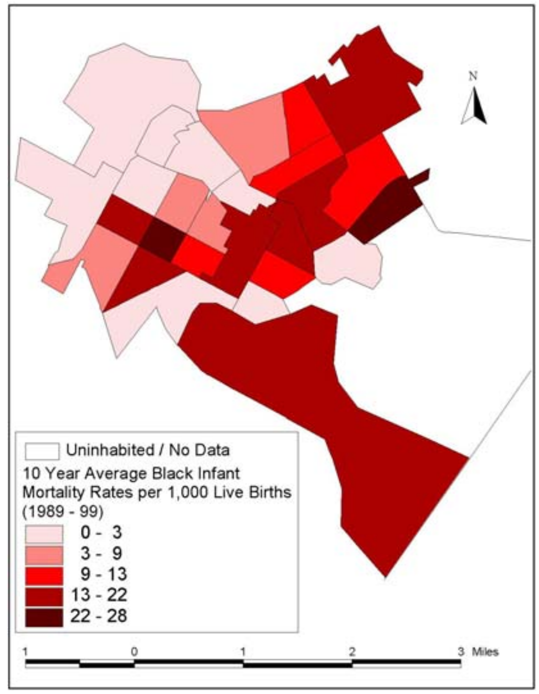
Data Source: Delaware Health Statistics Center

Figure 7.34 10 Year Average Infant Mortality Rates in Wilmington per 1,000 Live Births



Data Source: Delaware Health Statistics Center

Figure 7.35 10 Year Average Black Infant Mortality Rates in Wilmington per 1,000 Live Births



Data source: Delaware Health Statistics Center

Cancer

Malignant neoplasms, more commonly known as "cancer," result from carcinogenesis, or malignant transformations of the deoxyribonucleic acid (DNA) of normal cells. The uncontrolled proliferation of these new cells is a leading cause of death in the United States. While cancers have different causes, the medical community has acknowledged that some specific substances damage DNA and induce carcinogenesis. Asbestos has been recognized as a cause of mesothelioma of the lungs; vinyl chloride can lead to angiosarcoma of the liver; aromatic hydrocarbons and benzopyrene from polluted air contribute to lung cancer; alkylating agents can lead to leukemia; and tobacco has been linked to cancer of the lung, oral cavity, upper airways, esophagus, kidneys, pancreas and bladder (Holmes, 2001: 49).

Among states, Delaware is second only to Louisiana in cancer mortality rates. By contrast, Maryland ranks 8th, New Jersey ranks 15th, Pennsylvania is 18th, and New York is 29th. Wilmington's cancer mortality rate is significantly higher than the County, State, or Country. For the period 1994 – 1998, Wilmington's cancer mortality rate for all ages and races was 355 per 100,000. This is contrasted with neighboring Philadelphia where the cancer mortality rate was less than two-thirds that of Wilmington, at 229 per 100,000 for the same time period.

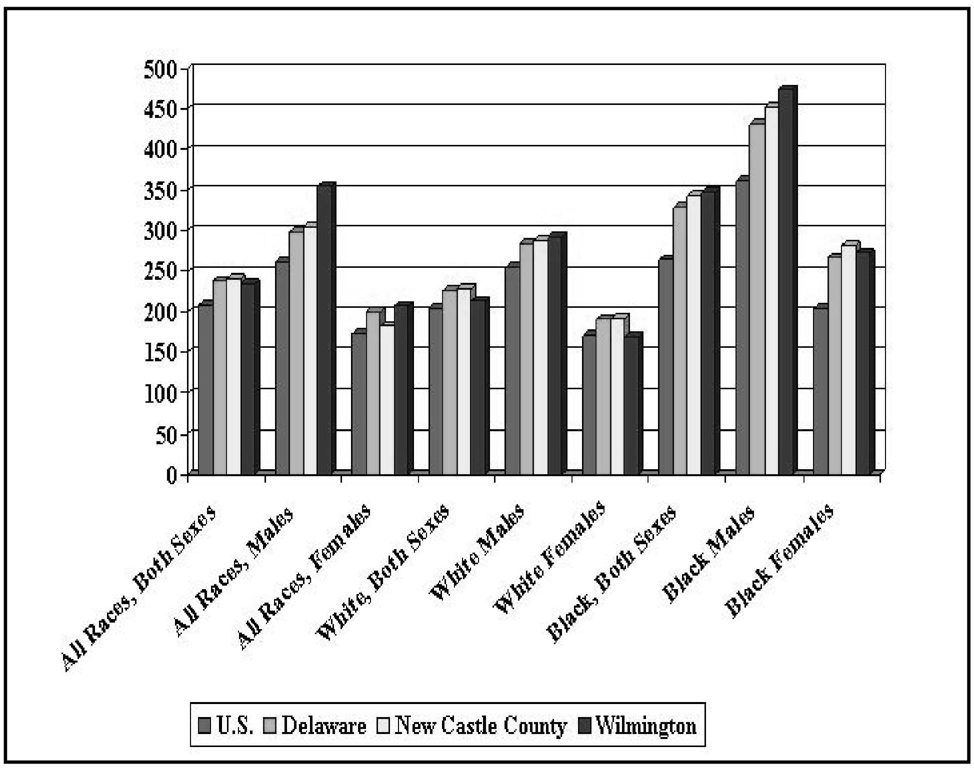
The Delaware Health Statistics Center has compared mortality rates for a number of cancers in Wilmington with those for New Castle County, the State of Delaware and the United States between 1994 and 1999. The types of cancers evaluated include (1) all cancers, (2) cancer of the lip, oral cavity and pharynx, (3) cancer of the digestive organs, (4) cancer of the respiratory system, (5) breast cancer, (6) genital organ cancer, (7) cancer of the urinary organ, (8) cancer of all other and unspecified sites, (9) leukemia, and (10) cancers of lymphatic and hematopoietic tissues (bone marrow). (DHSC, 2001: 287-322; Holmes, 2001). The results of these comparisons are presented in Figures 7.36 through 7.45. They are summarized as follows:

- **Malignant neoplasms**: Men who reside in Wilmington, both Black and White, have higher mortality rates than residents of New Castle County, the State of Delaware and the U.S.
- **Malignant neoplasms of the lip, oral cavity and pharynx**: Wilmington residents of all races and both sexes have higher mortality rates than New Castle County, the State of Delaware and the U.S. African Americans of both sexes and White males are particularly at risk.
- **Malignant neoplasms of the digestive organs and peritoneum**: African Americans of both sexes who reside within the City of Wilmington have higher mortality rates for malignant neoplasms of the digestive organs and peritoneum than residents of New Castle County, the State of Delaware and the U.S.
- **Malignant neoplasms of the respiratory and intrathoracic organs:** African American males who reside within the City of Wilmington have higher mortality rates for respiratory and intrathoracic malignant neoplasims than any other sex or racial group in New Castle County, the State of Delaware and the U.S.
- **Malignant neoplasms of the breast**: While the State of Delaware and New Castle County have higher breast cancer mortality rates than the U.S., mortality rates for residents of Wilmington in all age and racial groups are lower than the State. For White and Black females, the breast cancer rate is lower than the national level.
- **Malignant neoplasms of the genital organs**: Mortality rates for malignant neoplasms of the genital organs are higher for Wilmington residents than the U.S. average. However, with the exception of males of all races, the mortality rates for Wilmington are lower than State and County levels.
- **Malignant neoplasms of the urinary organs**: Mortality rates for malignant neoplasms of urinary organs are lower for residents of the City of Wilmington than the County and the State for all demographic groups. However, for Black females and White males, mortality rates for Wilmington residents are still higher than national rates.
- **Malignant neoplasms of all other and unspecified sites**: Mortality rates for all races and both sexes are higher in the City of Wilmington than in New

Castle County, the State of Delaware and the U.S. for malignant neoplasms of all other and unspecified sites. Mortality rates are particularly high among White males.

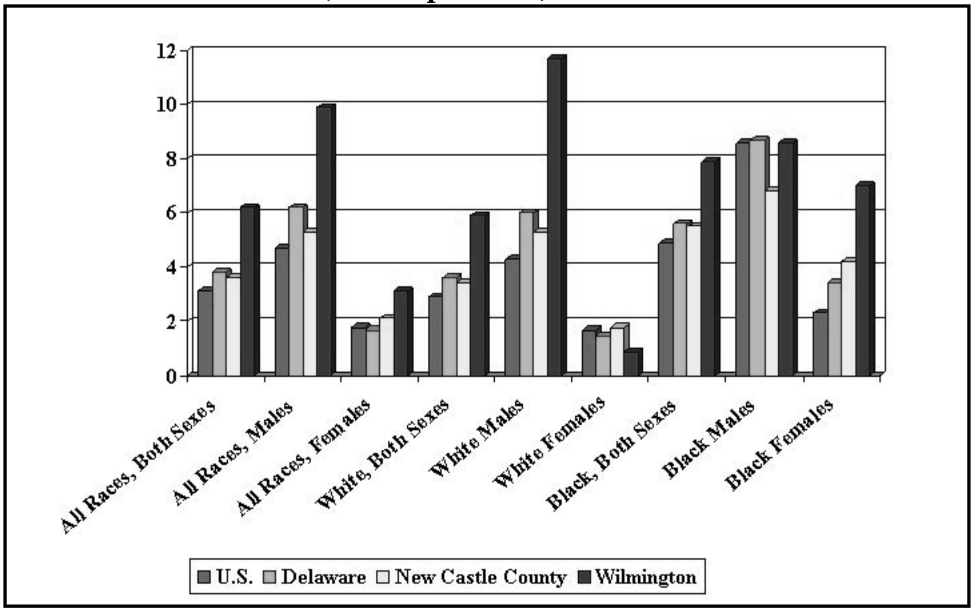
- **Leukemia**: mortality rates for all demographic groups are lower than the national average for leukemia.
- **Other malignant neoplasms of lymphatic and hematopoietic tissues**: Mortality rates among residents of Wilmington are comparable to the State, the County and the U.S. for non-leukemia malignant neoplasms of the lymphatic and hematopoietic tissues. African American males, however, have higher mortality rates than any other demographic group.

Figure 7.36 Malignant Neoplasms: Five Year Average Age Adjusted Mortality Rates per 100,000 Population, 1994-1998



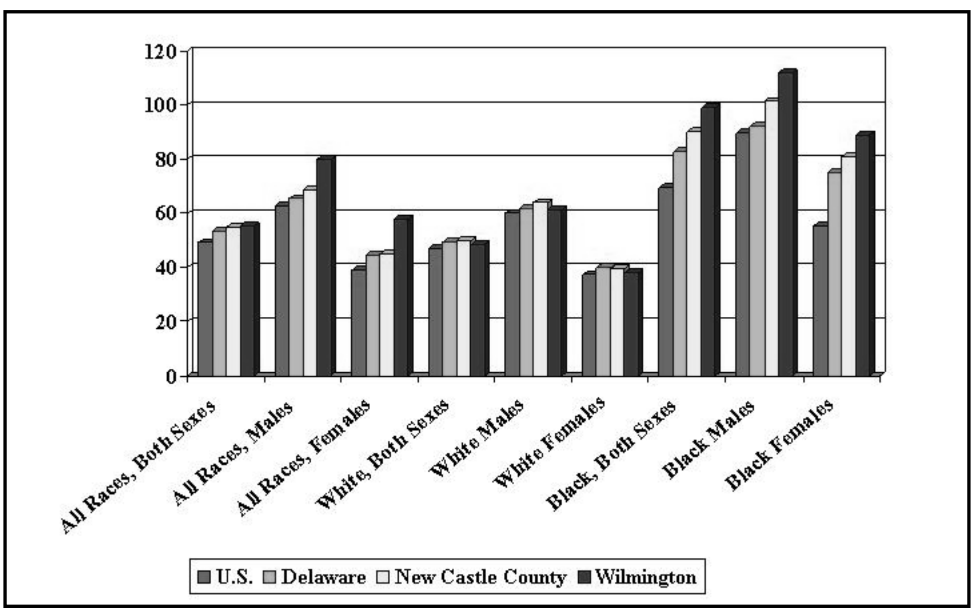
Data Source: DHSC, 2001: 287-322

Figure 7.37 Malignant Neoplasms of the Lip, Oral Cavity and Pharynx: Five Year Average Age Adjusted Mortality Rates per 100,000 Population, 1994-1998



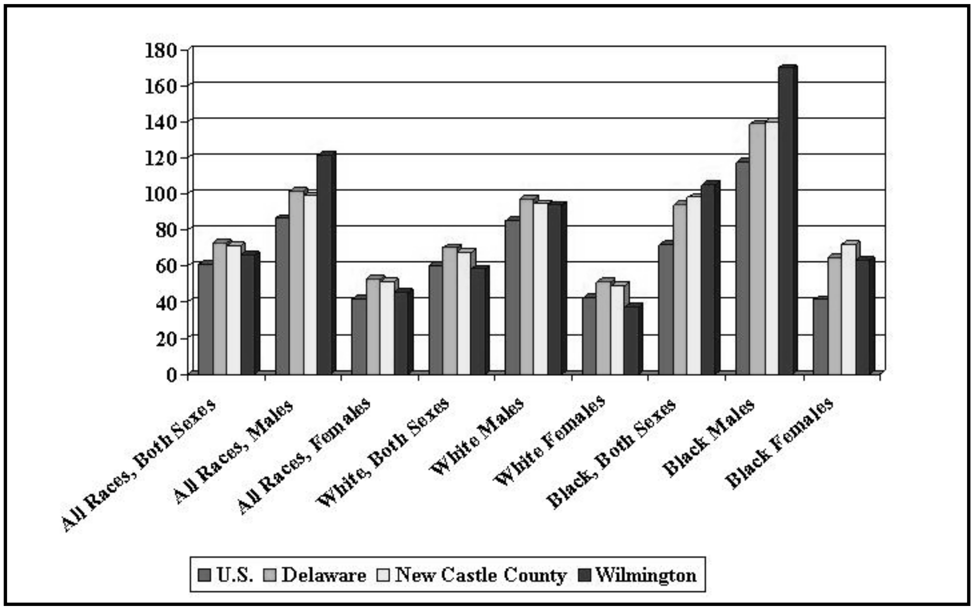
Data Source: DHSC, 2001: 287-322

Figure 7.38 Malignant Neoplasms of the Digestive organs and Peritoneum: Five Year Average Age Adjusted Mortality Rates per 100,000 Population, 1994-1998



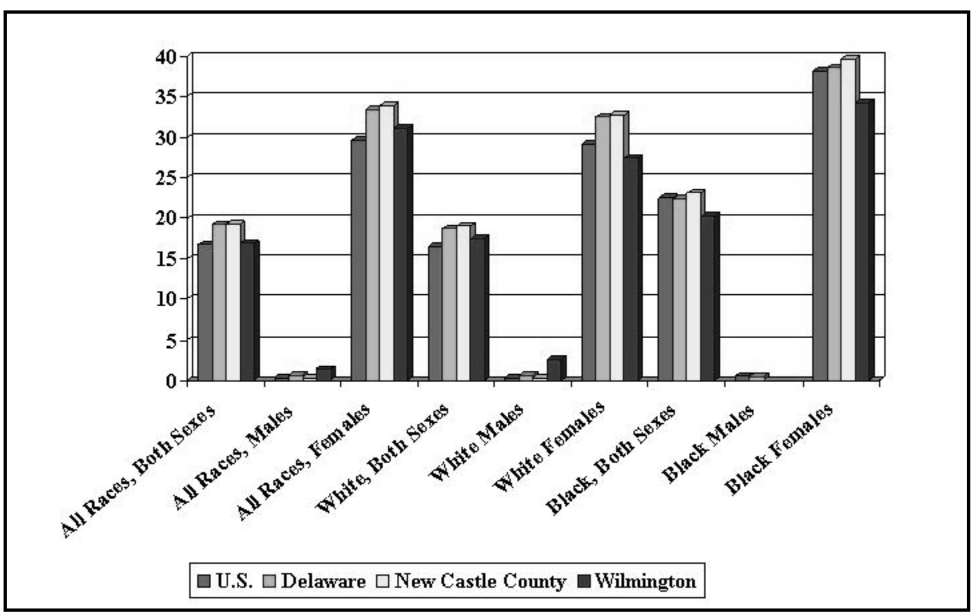
Data Source: DHSC, 2001: 287-322

Figure 7.39 Malignant Neoplasms of the Respiratory and Intrathoracic Organs: Five Year Average Age Adjusted Mortality Rates per 100,000 Population, 1994-1998



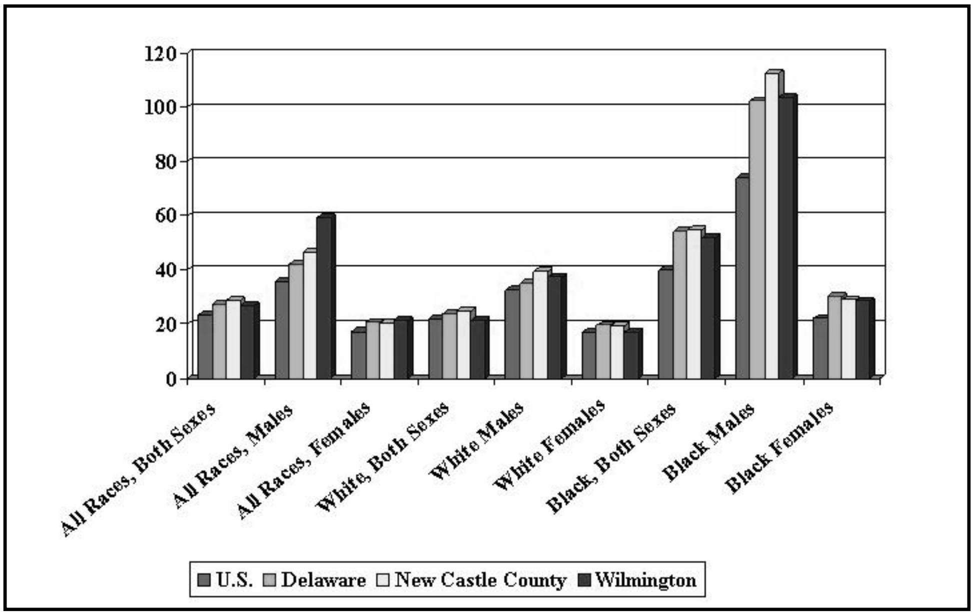
Data Source: DHSC, 2001: 287-322

Figure 7.40 Malignant Neoplasms of Breast: Five Year Average Age Adjusted Mortality Rates per 100,000 Population, 1994-1998



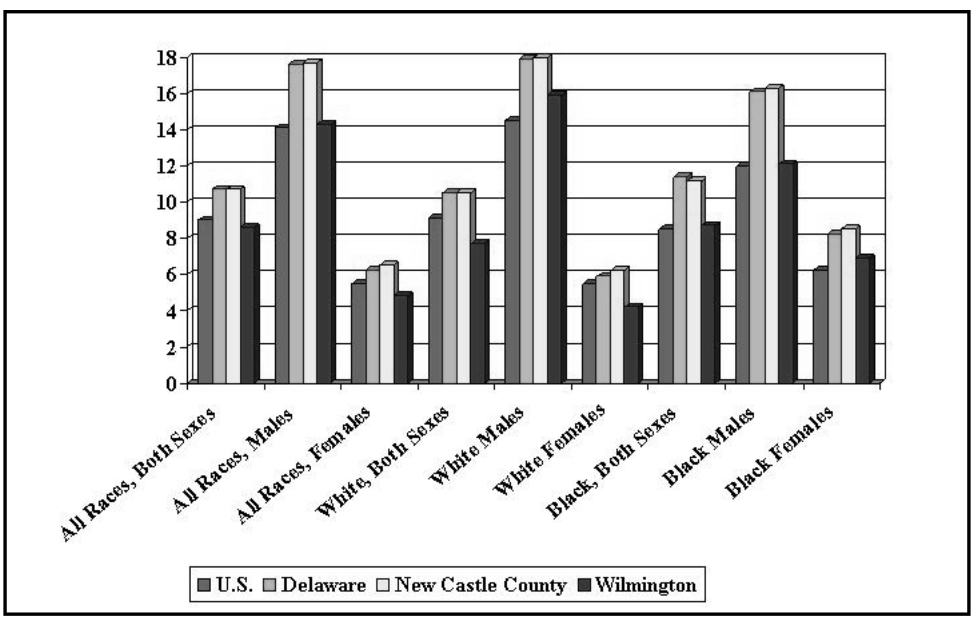
Data Source: DHSC, 2001: 287-322

Figure 7.41 Malignant Neoplasms of the Genital Organs: Five Year Average Age Adjusted Mortality Rates per 100,000 Population, 1994-1998



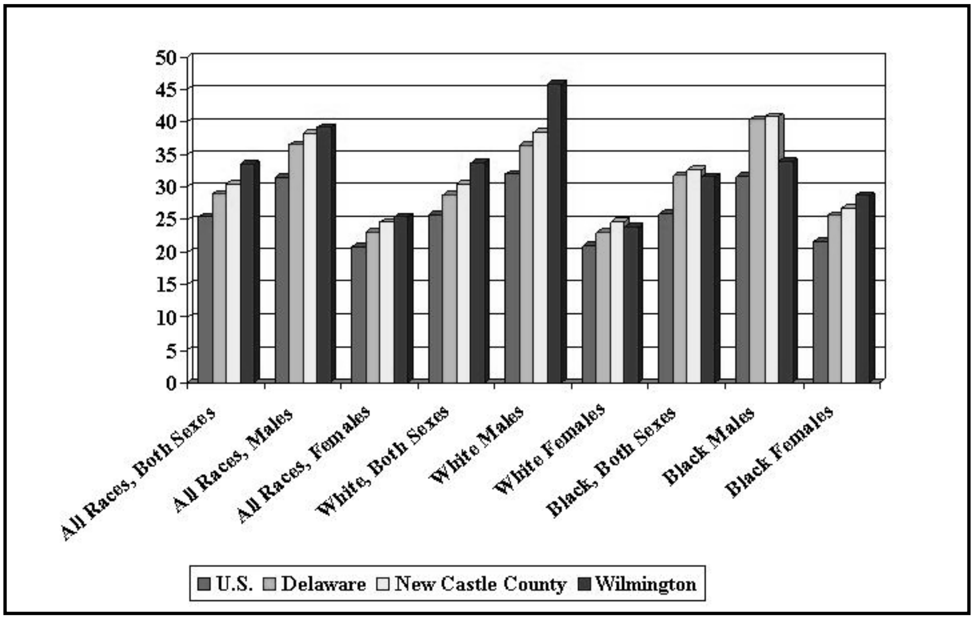
Data Source: DHSC, 2001: 287-322

Figure 7.42 Malignant Neoplasms of the Urinary Organs: Five Year Average Age Adjusted Mortality Rates per 100,000 Population, 1994-1998



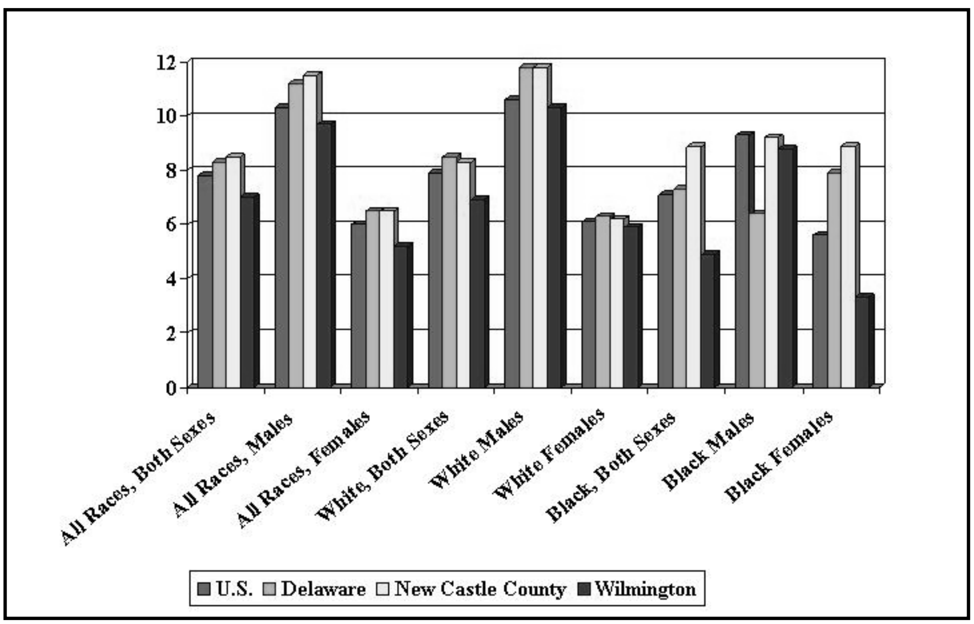
Data Source: DHSC, 2001: 287-322

Figure 7.43 Malignant Neoplasms of All Other and Unspecified Sites: Five Year Average Age Adjusted Mortality Rates per 100,000 Population, 1994-1998



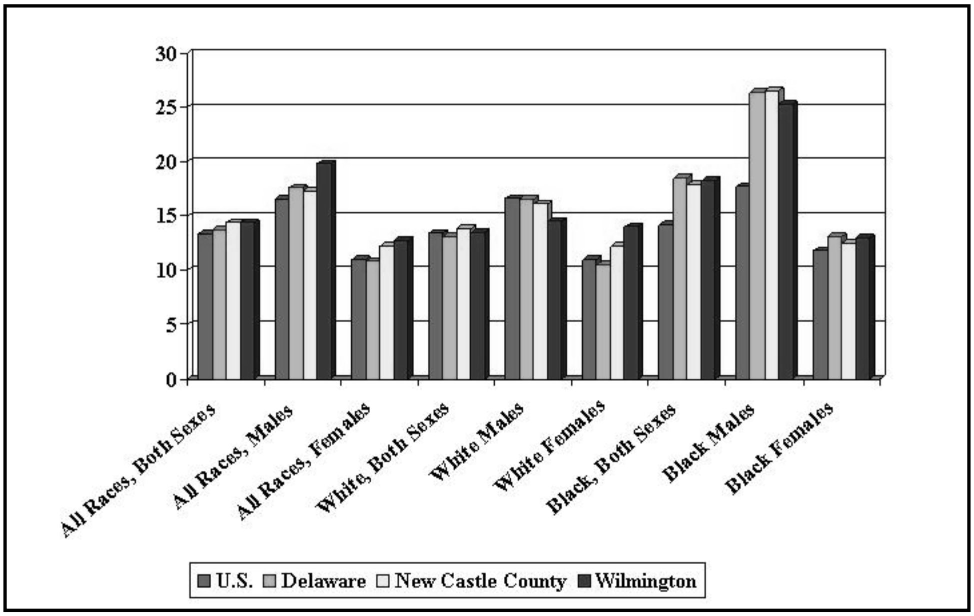
Data Source: DHSC, 2001: 287-322

Figure 7.44 Leukemia: Five Year Average Age Adjusted Mortality Rates per 100,000 Population, 1994-1998



Data Source: DHSC, 2001: 287-322

Figure 7.45 Other Malignant Neoplasms of Lymphatic and Hematopoietic Tissues: Five Year Average Age Adjusted Mortality Rates per 100,000 Population, 1994-1998



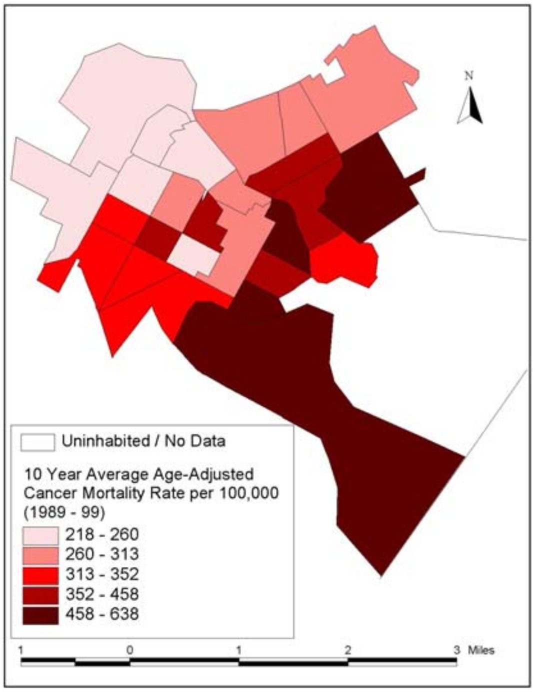
Data Source: DHSC, 2001: 287-322

Cancer mortality rates in Wilmington vary spatially and are concentrated in the southern half of the city, an area that is predominantly minority and lower income (Figure 7.46). This is also the part of the city where Brownfields, Toxic Release Inventory sites, and other environmentally compromising facilities are concentrated. There is a statistically significant association between the mortality rates from certain cancers and the spatial concentration of Brownfield sites. Preliminary analysis of mortality rates from Immunoproliferative cancers and the spatial concentration of Brownfield sites at the Census tract level shows a statistically significant correlation (Figure 7.47). While this should not be interpreted as a finding of causation, it does point to a possible area for more intense epidemiological investigation.

Malignant neoplasms of the trachea, bronchus and lung were the single largest source of cancer death, accounting for just under 10% of cancer deaths. These were concentrated in the central and east parts of the city. The next largest specific category of cancer mortality was all other and unspecified malignant neoplasms (Figure 7.48).

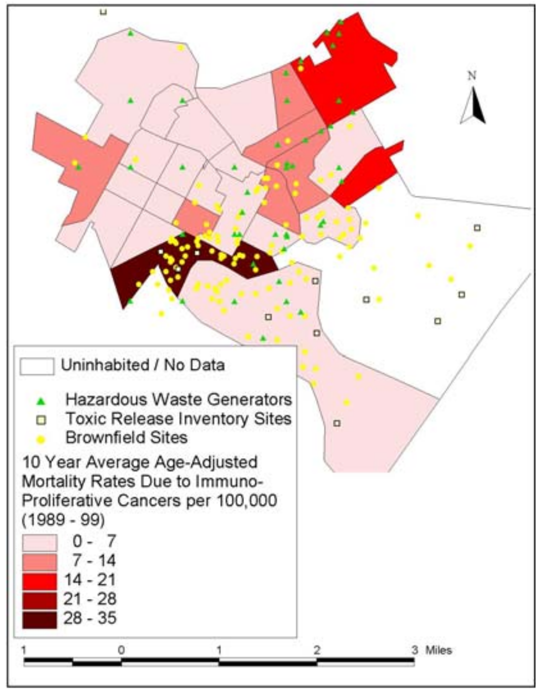
Mortality rates due to all cancers were significantly correlated with the spatial distribution of poverty at the census tract level ($r^2 = 0.51$ with 99% significance). More generally, high mortality rates for most diseases are associated with and are concentrated in the same tracts as poverty, minorities, and children. These are the same tracts where Brownfields and other environmentally compromising facilities are also concentrated. Mortality from non-cancer diseases of the lungs for children under 5 years old was also concentrated in the east-central part of the city. For the total population however, non-cancer lung diseases were concentrated in the west-central part of the City.

Figure 7.46 10 Year Average Age-Adjusted Cancer Mortality Rate per 100,000 (1989-99)



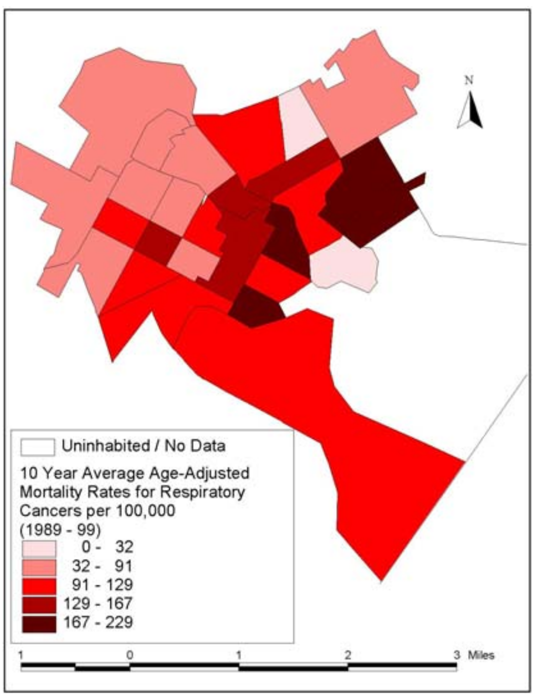
Data Source: Delaware Health Statistics Center

Figure 7.47 10 Year Average Age-Adjusted Cancer Mortality Rate Due to Immuno-Proliferative Cancers per 100,000 (1989-99)



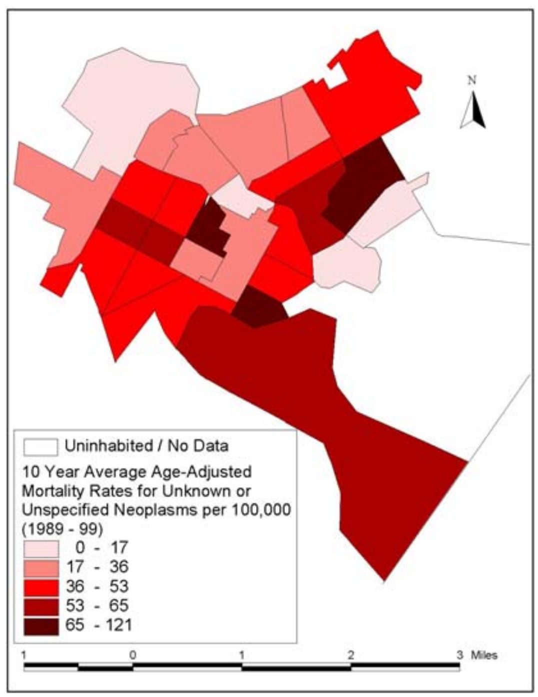
Data Source: Delaware Health Statistics Center

Figure 7.48 10 Year Average Age-Adjusted Mortality Rates for Respiratory Cancers per 100,000



Data Source: Delaware Health Statistics Center

Figure 7.49 10 Year Average Age-Adjusted Mortality Rates Unknown or Unspecified Neoplasms per 100,000



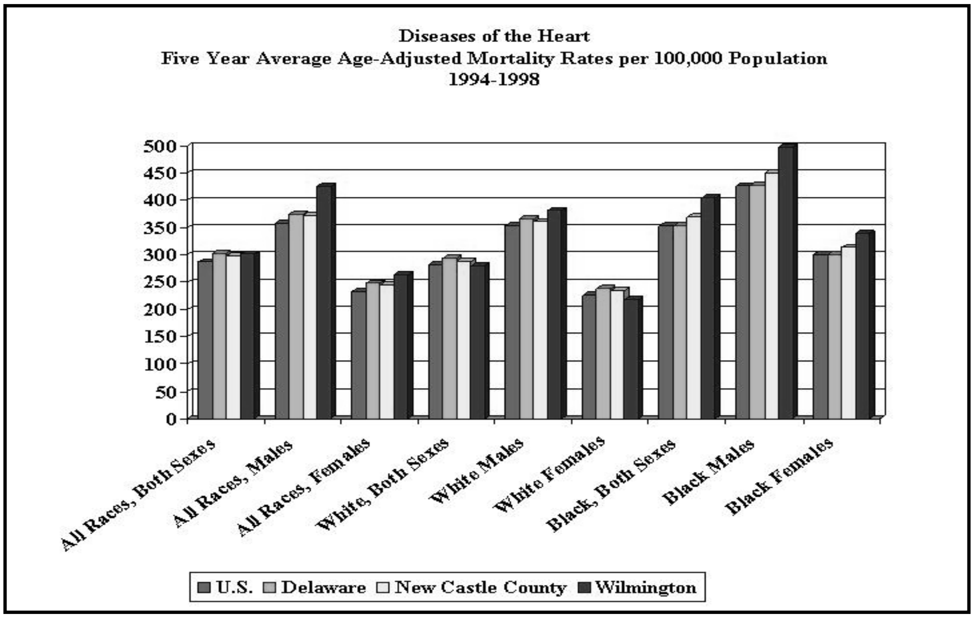
Data Source: Delaware Health Statistics Center

Other Diseases

The Delaware Health Statistics Center has compared mortality rates for a number of non-cancerous diseases in Wilmington with those for New Castle County, the State of Delaware and the United States between 1994 and 1999. Diseases assessed include: (1) diseases of the heart, (2) cerebrovascular diseases (brain and spinal cord, including stroke, embolism and hemorrhage), (3) chronic obstructive pulmonary artery diseases and allied conditions, (4) pneumonia and influenza, (5) chronic liver disease and cirrhosis, (6) nephritis, nephritic syndrome and nephrosis (urologic disorder including the renal gland), and septicemia (blood poisoning, toxins in bloodstream) (DHSC, 2001: 287-322; Holmes, 2001). The results of these comparisons are presented in Figures 7.50 through 7.57. They are summarized as follows:

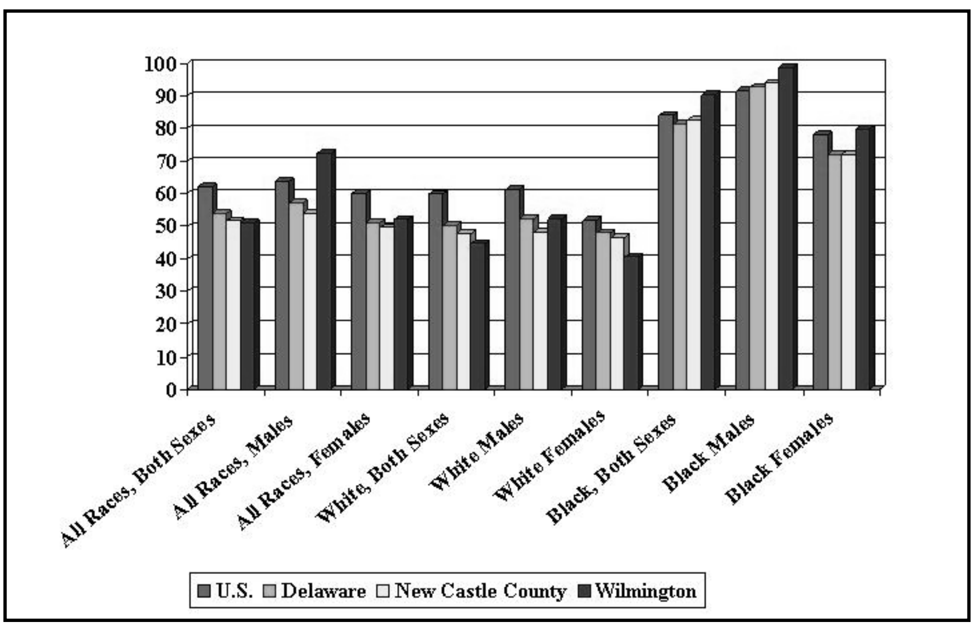
- **Diseases of the heart**: African American residents of Wilmington have higher mortality rates for diseases of the heart than any other racial group in New Castle County, the State of Delaware and the U. S.
- **Cerebrovascular diseases**: African Americans of both sexes in Wilmington have higher mortality rates for cerebrovascular diseases than those of New Castle County, the State of Delaware and the U.S.
- **Chronic obstructive pulmonary diseases and allied conditions**: While mortality rates for chronic obstructive pulmonary diseases and allied conditions among Wilmington residents is comparable with State and national levels, White females and Black males have higher rates.
- **Pneumonia and influenza**: White residents of Wilmington, especially White males, have higher mortality rates for Pneumonia and influenza than New Castle County, the State of Delaware and the U.S.
- **Chronic liver disease and cirrhosis**: Residents of the City of Wilmington have consistently higher mortality rates than New Castle County, the State of Delaware and the U.S. for all racial and sex groups. Rates are particularly high among African American males.
- **Nephritis, nephrotic syndrome and nephrosis**: All sex and racial groups within the City of Wilmington have higher mortality rates than the State of Delaware and the U.S. for nephritis, nephritic syndrome and nephrosis. Mortality rates are particularly high among African Americans.
- **Septicemia**: with the exception of black males, all groups within the City of Wilmington have higher mortality rates for septicemia than residents of New Castle County, the State of Delaware and the U.S.
- **All causes**: For all causes of death, the mortality rates of residents of Wilmington are consistently higher than those of residents of New Castle County, the State of Delaware and the U.S.

• **Figure 7.50 Diseases of the Heart: Five Year Average Age Adjusted Mortality Rates per 100,000 Population, 1994-1998**



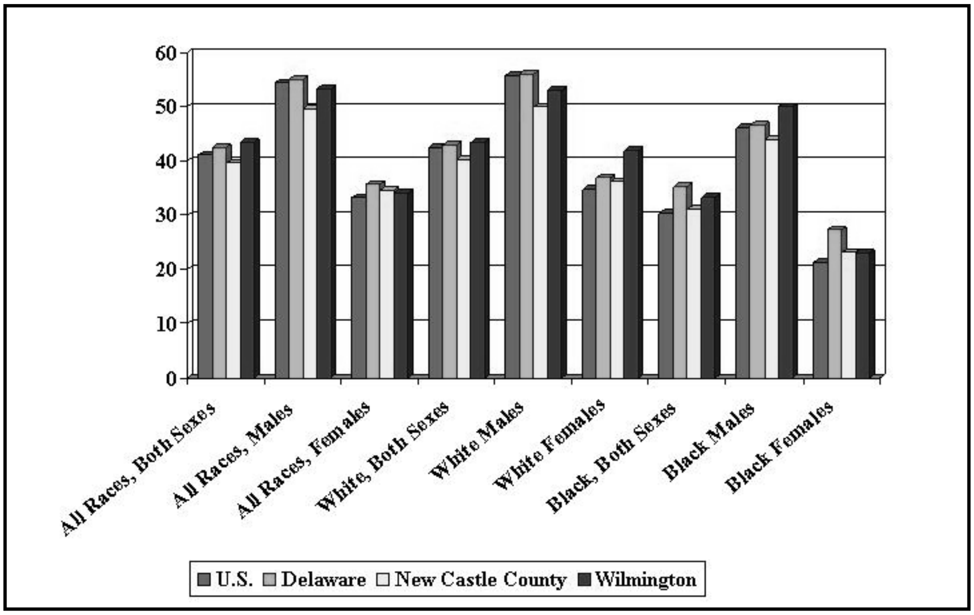
Data Source: DHSC, 2001: 287-322

Figure 7.51 Cerebrovascular Diseases: Five Year Average Age Adjusted Mortality Rates per 100,000 Population, 1994-1998



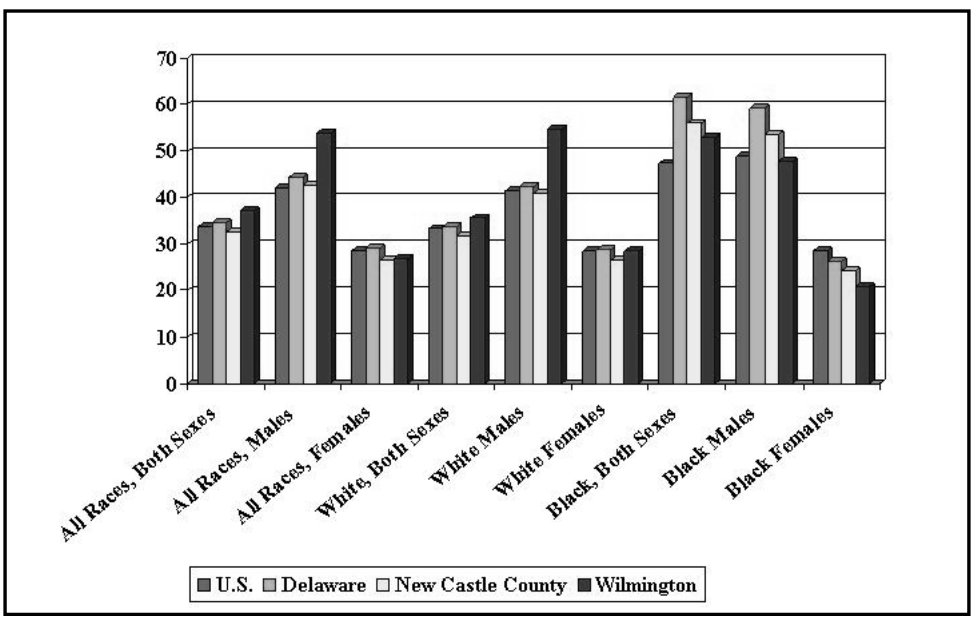
Data Source: DHSC, 2001: 287-322

Figure 7.52 Chronic Obstructive Pulmonary Diseases and Allied Conditions: Five Year Average Age Adjusted Mortality Rates per 100,000 Population, 1994-1998



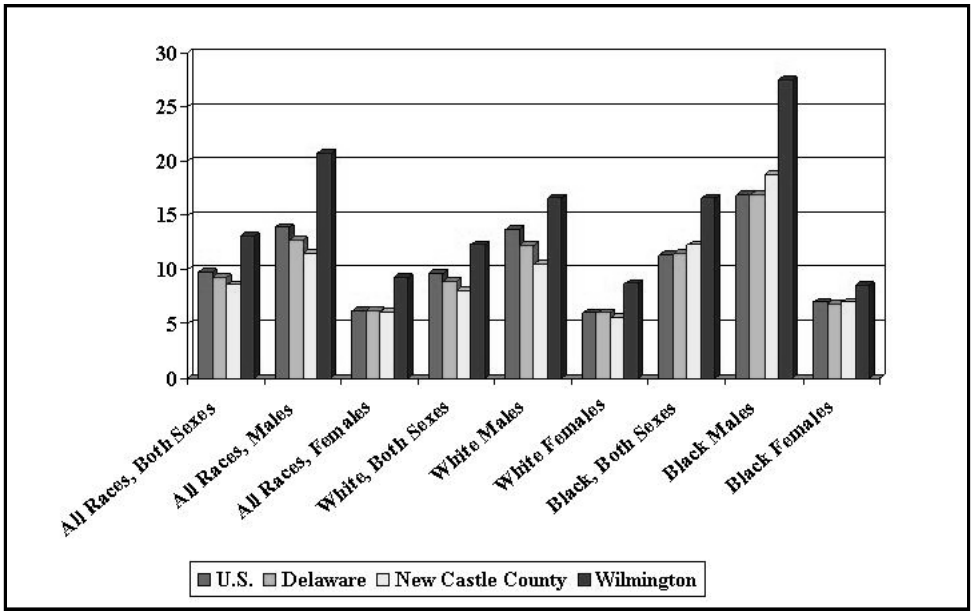
Data Source: DHSC, 2001: 287-322

Figure 7.53 Pneumonia and Influenza: Five Year Average Age Adjusted Mortality Rates per 100,000 Population, 1994-1998



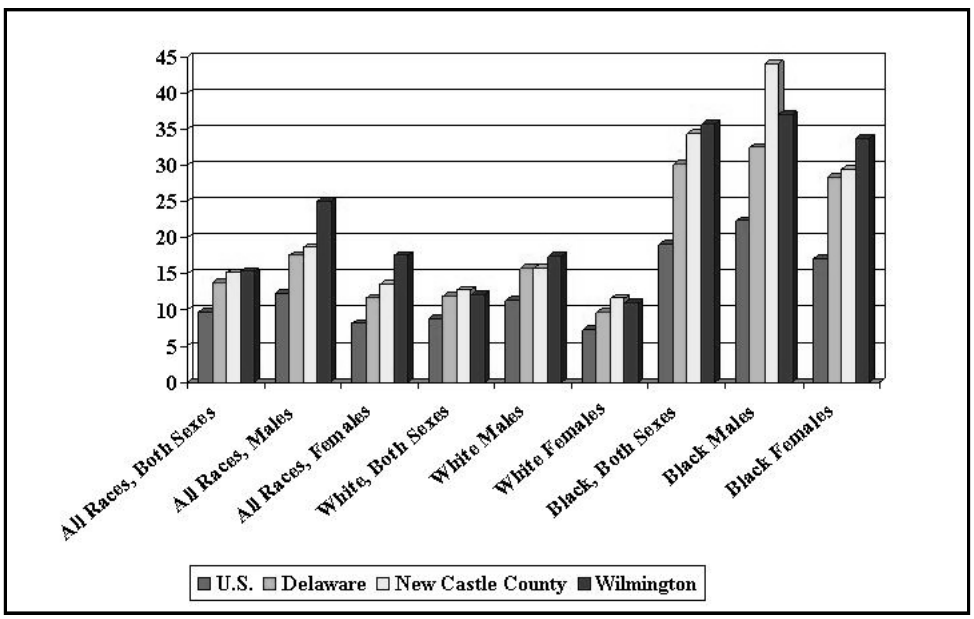
Data Source: DHSC, 2001: 287-322

Figure 7.54 Chronic Liver Disease and Cirrhosis: Five Year Average Age Adjusted Mortality Rates per 100,000 Population, 1994-1998



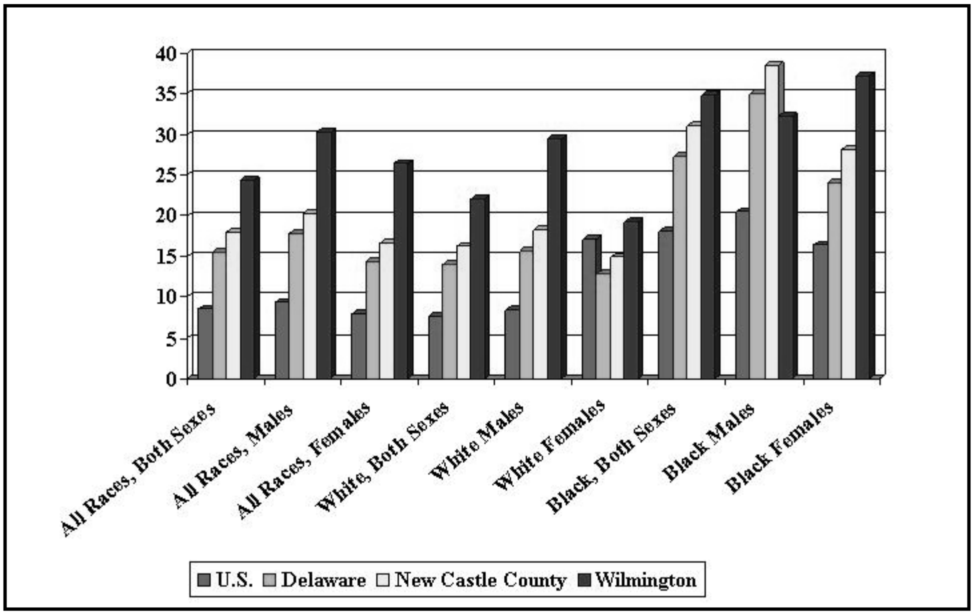
Data Source: DHSC, 2001: 287-322

Figure 7.55 Nephritis, Nephrotic Syndrome and Nephrosis: Five Year Average Age Adjusted Mortality Rates per 100,000 Population, 1994-1998



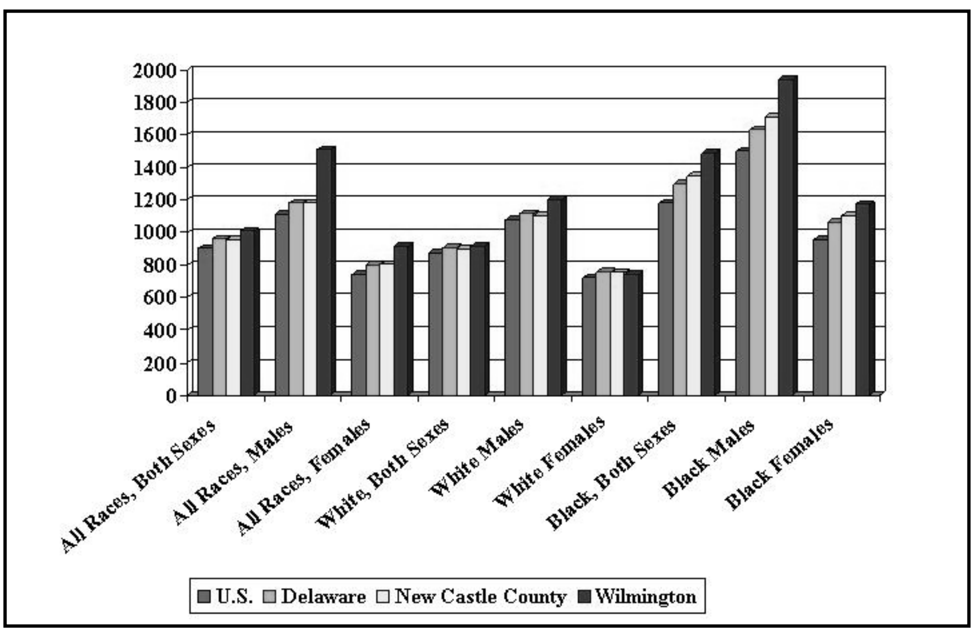
Data Source: DHSC, 2001: 287-322

Figure 7.56 Septicemia: Five Year Average Age Adjusted Mortality Rates per 100,000 Population, 1994-1998



Data Source: DHSC, 2001: 287-322

Figure 7.57 All Causes: Five Year Average Age Adjusted Mortality Rates per 100,000 Population, 1994-1998

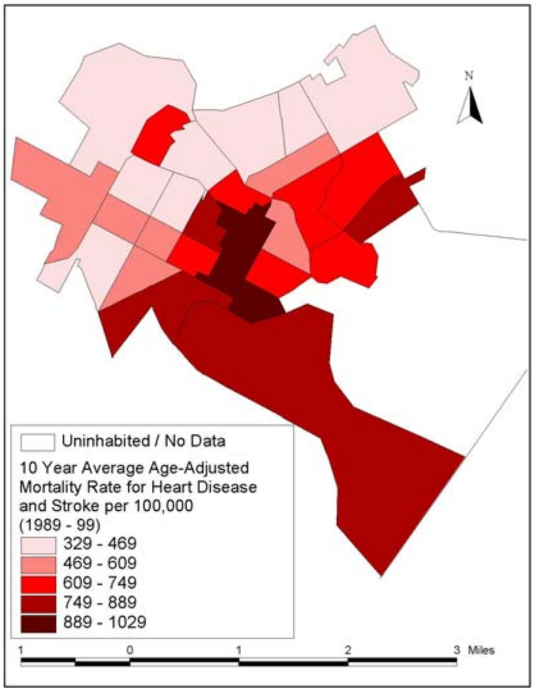


Data Source: DHSC, 2001: 287-322

Cardiovascular Diseases (CVD)

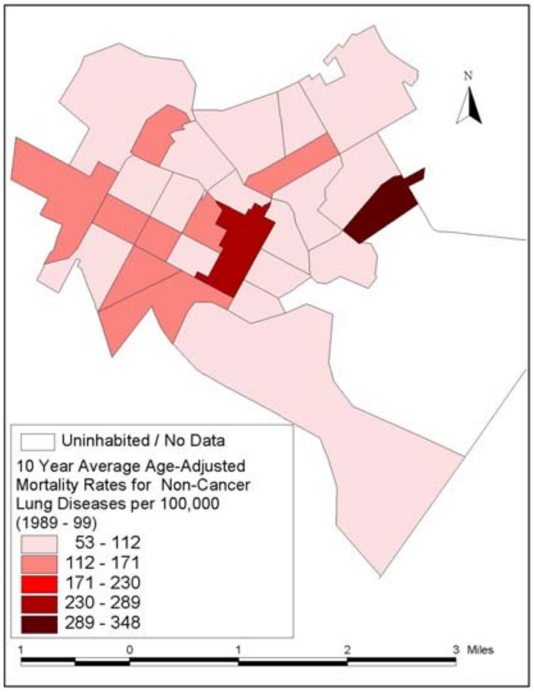
Cardiovascular diseases, which include diseases of the heart, stroke, high blood pressure, congestive heart failure, congenital heart defects, hardening of the arteries, and other diseases of the circulatory system, rank as the number one cause of death for Americans. More people die from these diseases than the next five leading causes of death combined, including cancer, chronic lower respiratory diseases, accidents, diabetes mellitus, and influenza and pneumonia. The major proximate risk factors for CVD are: diabetes mellitus, high blood cholesterol and other lipids, high blood pressure, overweight and obesity, physical inactivity, and tobacco smoke. (American Heart Association. *Heart Disease and Stroke Statistics — 2003 Update*. Dallas, Tex.: American Heart Association; 2002). African Americans are particularly susceptible to CVD. The rate of high blood pressure in African Americans is among the highest in the world. Compared with whites,

Figure 7.58 10 Year Average Age-Adjusted Mortality Rate for Heart Disease and Stroke per 100,000



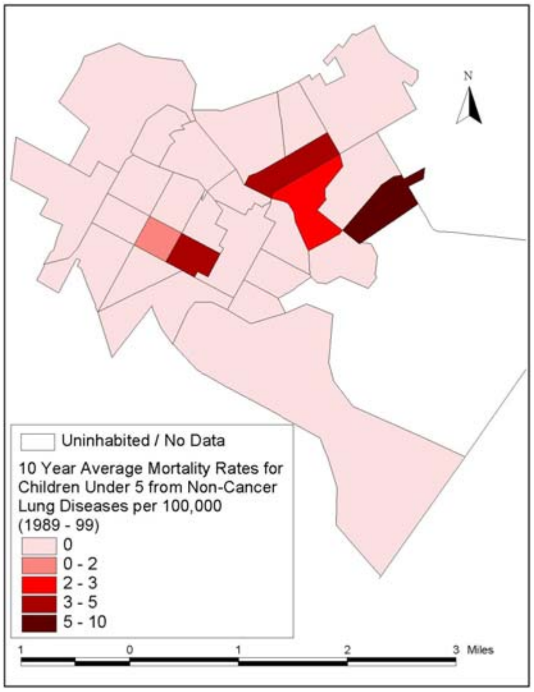
Data Source: Delaware Health Statistics Center

Figure 7.59 10 Year Average Age-Adjusted Mortality Rates for Non-Cancer Lung Diseases Per 100 ,000



Data Source: Delaware Health Statistics Center

Figure 7.60 10 Year Average Mortality Rates for Children Under 5 from Non-Cancer Lung Diseases Per 100 ,000



Data Source: Delaware Health Statistics Center

African Americans are much more likely to have high blood pressure, less likely to engage in physical activity, more likely to be overweight or obese, and more likely to have diabetes. All these factors increase the risk for CVD. Among CVDs, coronary heart disease accounts for over 50% of all deaths. This is followed by stroke, which is slightly less than 20%. In Wilmington, mortality rates from heart disease and stroke are highest in the center of the city, though the entire southern half of Wilmington has higher overall mortality rates.

7.6 Legislative and Administrative Responses to Health Issues in Wilmington

There is no single governmental entity charged with ensuring the public's health. Rather, this responsibility is distributed amongst a number of disparate agencies, from the local housing authority, to the Department of Natural Resources and Environmental Control (DNREC), to the state Medicaid authority. This is particularly the case for health issues that are environmentally influenced. In Wilmington, the Housing Authority addresses the issue of lead paint contamination in its units during renovations. These lead remediation efforts are in turn coordinated with the state Division of Public Health Office of Lead Poisoning Prevention, which is responsible for coordination of lead hazard control throughout the state of Delaware. Finally, Medicaid providers are responsible under federal law to regularly test for lead poisoning in children who receive Medicaid. For criteria or regulated pollutants, DNREC is the primary agency charged with monitoring and regulation of materials that are known to be a threat to public health.

In general however, most health issues are assumed to be the primary responsibility of the Department of Health and Social Services (DHSS), and its specific sub agencies. Environmental influences on health are rarely assumed. Consistent with every other major public health oriented agency in the US, DHSS begins most of its efforts from the premise that lifestyle is the single most important determinant of health. The leading cause categories of death in the US today are heart disease, cancer, lung diseases and intentional or unintentional injuries. The most proximate causes of these diseases are classified as personal behaviors – diet, smoking, hygiene, and healthcare utilization. Because these personal behaviors cannot be addressed by medical intervention alone, a large part of DHSS's efforts are devoted to health promotion, screening and education.

Among the initiatives to engage in health promotion is the Delaware Behavioral Risk Factor Surveillance System (BRFSS), an ongoing survey of Delaware's adult population about behaviors that put people at risk for the leading causes of disease and disability. It is a joint project of the U.S. Centers for Disease Control and Prevention (CDC) and the Delaware Division of Public Health. A 1997 sample survey of Delaware adults showed the most common behavioral risk factors. In descending order, these were: 1) Obesity 2) Failure to wear safety belts 3) Smoking 4) High blood pressure 5) Binge drinking 6) Lack of health insurance 7) Diabetes 8) Chronic drinking, and 9) Drinking and driving (U.S. Center for Disease Control, 1997).

In January 1994, The Delaware Division of Public Health published a state health plan, called *Healthy Delaware 2000*. It included analysis of Delaware's health problems, and objectives, which the state's health care community has been working to achieve by the year 2000. More than 30 of the plan's objectives were related to behavioral risks. The BRFSS and the Youth Risk Behavior Survey (YRBS) have accomplished baseline data and tracking of these objectives. *Healthy Delaware 2010*, the State of Delaware's prevention agenda and community health guide, followed up *Health Delaware 2000*. The report outlines the health and prevention goals and objectives for the state for the next 10 years. The plan was developed by a statewide steering committee, representing both the public and private sector. *Healthy Delaware 2010* emphasizes prevention as a strategy and the focus of health efforts, policy and resources in Delaware. The plan is divided into 13 focus groups, or leading health indicators. They are physical activity, nutrition, tobacco use, alcohol and drug use, responsible sexual behavior, environmental quality, violence, education, mental health, injury and disability, preventive services use, infant health and access to health care services. Delaware's progress will be tracked over the next 10 years, and Delaware results will be ranked with the other 49 states. *Healthy Delaware 2010* is part of *Healthy People 2010*, an initiative of the U.S. Department of Health and Human Services, dedicated to improving the health of citizens nationwide. ("Governor Minner Unveils Healthy Delaware 2010: Delaware's Health Agenda for the Next Decade" Delaware Health and Social Services News, Apr. 23, 2001, #22DPH-01)

The Environmental Health Evaluation Branch (EHE), a subdivision of DHSS, handles environmental risks to health in a similar manner. The EHE responds to citizen inquiries about health risks or risk from exposure to environmental hazards including carcinogenic compounds. It provides information regarding environmental cancer information and is a part of the Division of Public Health's Cancer Program. It also works closely with DNREC providing assistance and consultation for a variety of environmental incidents where a person may be directly or indirectly exposed to health hazards. Site visits, inspections, and audits are undertaken in response to specific incidents regarded as having adverse health implications.

Direct healthcare services in Delaware are available through DHSS, private providers, and some non-profit entities. Federal and state funded services are provided through these institutions.

Healthcare availability remains a problem in Wilmington. Much of central and south parts of the city have been designated as Medically Underserved Areas, qualifying these areas for additional federal funds in order to encourage the provision of medical services to Medicaid recipients in these areas. Lack of health insurance is also a problem. Recipients of Community Health Center (CHC) grant funds are legislatively required to serve areas or populations designated by the Secretary of Health and Human Services as medically underserved. Grants for the planning, development, or operation of community health centers under section 330 of the Public Health Service Act are available only to centers that serve designated MUAs or Medically Underserved Populations (MUPs). Statewide sample surveys indicate that at least 11% of Delaware residents do not have access to health insurance. Outside of private health insurance, all publicly funded medical services are provided through matching federal funds from federal programs such as Medicaid, Social Security, and the Children's Health Insurance Program (CHIP). These are based on strict eligibility criteria such as age, income, disability, and disease specificity. Expanding healthcare insurance and coverage remains a necessary priority of the state.

In the following, specific health issues in the City of Wilmington are reviewed as well as their regulatory responses.

Low Birth Weight and Infant Mortality

The biggest risk factor for low birth weight and infant mortality is lack of adequate prenatal care and infant health services. A number of federal and state programs, as well as non-profit organizations, are specifically targeted to preventing low birth weight and infant mortality.

Title XIX of the Social Security Act is a program that provides medical assistance for certain individuals and families with low incomes and resources. The program, known as Medicaid, became law in 1965 as a jointly funded cooperative venture between the Federal and State governments to assist States in the provision of adequate medical care to eligible needy persons. These include low-income pregnant women, infants, children, and the elderly, and disabled persons. In Delaware, Medicaid pays for: doctor visits, hospital care, labs, prescription drugs, transportation, routine shots for children, mental health and substance abuse services. Prenatal services are also paid for qualifying low-income pregnant women under Medicaid in Delaware. Most people receiving Medicaid in Delaware are enrolled with one of the managed care plans under the Diamond State Health Plan (Delaware Health and Social Services, 2002a).

The Early and Periodic Screening, Diagnostic, and Treatment (EPSDT) service is Medicaid's comprehensive and preventive child health program for individuals under the age of 21. EPSDT was defined by law as part of the Omnibus Budget Reconciliation Act of 1989 legislation and includes periodic screening, vision, dental, and hearing services. It is under this program that children who are Medicaid recipients receive immunizations, dental care, lead blood screening, and other necessary medical services. By law, the state Medicaid agency must inform all Medicaid-eligible persons under age 21 that EPSDT services are available. States must set distinct periodicity schedules for screening, dental, vision, and hearing services, and they must report EPSDT performance information annually to the federal government (Centers for Medicare and Medicaid Services, 2002).

The Delaware Healthy Children Program is a low cost health insurance program for Delaware's uninsured children who do not otherwise qualify for Medicaid. Delaware Healthy Children Program uses federal funds from Title XXI, the Children Health Insurance Program. This low cost medical insurance program is for children who cannot afford private health insurance, but do not qualify for Delaware Medicaid. Services covered include: well-baby and well-child checkups, immunizations, physical exams, prescription drugs, and other hospital care.

In addition to federal and state funded programs, non-profit organizations provide needed services, education, and advocacy. The Perinatal Association of Delaware is a grass-roots coalition working to reduce infant mortality, improve services to families with young children, and encourage parents to take responsibility for their children's healthcare. In 1989, the Perinatal Association of Delaware created its flagship program, the Delaware HealthyMothers/HealthyBabies Coalition, a maternal health education and outreach program for pregnant women, women of childbearing age and their families. The Resource Mothers Project was started in 1990 to find high-risk pregnant women and involve them in prenatal care, WIC, housing, and other needs they may have. In 1997, the

Perinatal Association, in partnership with the City of Wilmington, Christiana Care Health Systems, the Division of Public Health, and the University of Delaware, established the Wilmington Healthy Start Program to reduce infant mortality in the City of Wilmington (Perinatal Association of Delaware, 2001). After four years of service, this program ended in September 2001 with the discontinuance of federal funding, though efforts are currently under way to continue the consortium component of the project (Center for Disabilities Studies, 2001).

Planned Parenthood of Delaware is another important non-profit organization that provides prenatal care. The Better Beginnings program has aligned Planned Parenthood with Christiana Care in order to provide Parenting and childbirth education, nutrition and healthy lifestyles education, clinical services, including physical exams, lab tests, and risk assessment, labor and delivery at Christiana Hospital, and postpartum care. Women ages 18 to 35 with low-risk pregnancies are eligible for this program. Planned Parenthood offers reduced fee services based on ability to pay (Planned Parenthood of Delaware, 2003).

Lead

Lead is the number one environmental health hazard for children. Lead paint was banned entirely by federal law in 1978. Leaded gasoline was finally phased out in 1995. Lead exposure is still a problem, however, as it resides in soils or in leaded paint in older housing. According to the EPA, one in eleven children has elevated blood lead levels. The most at risk are families renovating older buildings and low-income families living in older housing built before 1978. The primary risk factors for lead poisoning are age of housing, condition of housing, education, income and poverty status, welfare recipient or Head Start participant, race or ethnicity, urban area of residence, age of child, and environmental exposure (Kuennen, 1999). The CDC estimates that 36% of poor, African-American, inner city children have elevated blood levels. Thus, lead is disproportionately an environmental health problem for poor, inner city minority populations.

Since 1989, Federal law has required routine screening of young children for lead poisoning as part of Medicaid's EPSDT services. The Center for Medicare and Medicaid Services (formerly HCFA) is the federal agency responsible for Medicaid. CMS's State Medicaid Manual explicitly requires blood lead screening of 1 and 2 year-old children.

Recently however, CMS announced at a March 12, 2002, public meeting of the CDC Advisory Committee on Childhood Lead Poisoning Prevention its plan to terminate federal oversight and leadership on screening Medicaid children for lead poisoning. A number of Members of Congress and Senators are now looking into CMS's plans to defer to the states all responsibility for Medicaid screening for lead poisoning (Alliance to End Childhood Lead Poisoning, 2002).

At the state level, Delaware's Childhood Lead Poisoning Prevention Act (Delaware Code Ann Title16 §§ 2602-2604 [1997]) permits DHSS to promulgate regulations for training and accreditation of individuals engaged in lead-based paint activities, such as remediation. This code also includes requirements that all child-care facilities, public and private nursery schools, preschools and kindergartens screen every child born after March 1, 1995, unless their parent objects; requires all individual health insurance polices that provide benefit out patient services to cover blood lead screening for children at 1 year of age; directs primary health care providers to screen children for lead poisoning at 1 year of age; and requires all laboratories doing testing to participate in a universal reporting system.

The state Division of Public Health Office of Lead Poisoning Prevention is responsible for coordination of lead hazard control through the state of Delaware, and supports lead paint remediation efforts within the city of Wilmington. The city has lead-based paint control standards as part of their pre-rental house inspection requirements.

All residential housing rehabilitation projects receiving city funding are inspected for lead paint hazards, and any identified lead paint is abated. The Wilmington Housing Authority addresses the issue of lead paint contamination in its units during renovations. The Authority cannot rent a long-term vacant unit unless the lead paint is abated.

An assessment of the location of homes with lead-based paint indicates that the problem is most prevalent within the City's Westside neighborhoods. The State of Delaware, in conjunction with the Latin American Community Center, applied for and received a three-year grant from the federal Department of Housing and Urban Development (HUD) for Lead Paint poisoning reduction in the Hilltop neighborhood. This grant will leverage $1 million HUD funds with an additional $2 million in State funds for the rehabilitation of housing and education of households in how to care for their homes and reduce the incidence of lead poisoning. The program will be administered by the Latin American Community Center. Up to $7,500 per home will be available for lead paint abatement. Lead paint hazards will be reduced in 225 homes. City Rehabilitation Staff have been trained and certified in lead paint regulations and abatement testing and clearance functions. In fiscal year 2003, the City is allocating $110,068 for Lead Paint abatement, the first time that funds have been set aside for this specific objective (Straw, Kise and Kolodner, 2000).

Heart Disease and Stroke

Cardiovascular diseases (CVD), principally heart disease and stroke, are among the nation's leading killers for both men and women and among all racial and ethnic groups. Individual level risk factors which put people at increased risk for cardiovascular diseases include: High Blood Pressure, High Blood Cholesterol, Tobacco Use, Physical Inactivity, Poor Nutrition, Overweight / obesity, and Diabetes. Until fiscal year 1998, no federal funding had been directed to states to specifically target cardiovascular diseases. Most state funds came through the general preventive health and health services block grant. In 1998, CDC received funding for states to develop comprehensive cardiovascular health programs. Delaware does not currently receive federal funding specifically for cardiovascular health programs. However, health promotion and healthy lifestyle are a part of DPH's general health promotional efforts.

Cancer

Cancer is a significant disease that has been targeted by a number of federal and state programs as both a lifestyle and an environmentally influenced disease. As mentioned above, publicly funded direct healthcare services are provided through Medicaid for those who meet eligibility requirements for age, income, or disability status. Disease surveillance, health promotion, and screening activities are publicly funded activities directed at cancer. Known carcinogenic materials, substances, and exposure sources are monitored and regulated by the Environmental Protection Agency, the Food and Drug Administration, and locally by DNREC.

The Delaware Cancer Registry is a cancer information center within the state Division of Public Health (DPH). The Registry collects information about new cancer cases, cancer treatment and cancer deaths. The Delaware Cancer Registry is a population-based registry, serving the entire State of Delaware. All hospitals, laboratories, physicians and other health care providers are required by state law to report all newly diagnosed or treated cancer cases.

DPH is responsible for conducting cancer cluster studies. The Centers for Disease Control and Prevention and other Federal agencies, which prior to 1990, were responsible for cluster studies, are now called in only for special situations. Delaware's Cancer Registry is used to compare expected cancer rates in certain categories, such as a geographic area or age or racial group, with rates reported in a suspected cancer cluster to determine whether there is a true excess of cases. It is estimated that fewer than five percent of cancer cluster investigations reach the final stage of actually conducting a comprehensive study (Delaware Health and Social Services, 2002b)

Health promotion to prevent cancer incidence and mortality forms a large part of the campaign against cancer. One of the more prominent campaigns surrounds smoking, both as lifestyle choice and as an involuntary source of exposure through secondhand smoke. Tobacco use is considered Delaware's primary behavioral health problem, contributing to heart disease, stroke, lung and other cancers, emphysema, and lung diseases.

DPH works to prevent the use of tobacco products through its Tobacco Prevention and Control Program. The program is funded primarily by a cooperative agreement with the U.S. Centers for Disease Control and Prevention (CDC). The Tobacco Prevention and Control Program collaborates with the Delaware Tobacco Prevention Coalition, with more than 40 member organizations including health-care, youth and community groups, educational organizations, grassroots networks, and state agencies. The coalition and its partners, including DPH, developed and published a new statewide tobacco prevention plan in January of 2000, to guide its activities through the year 2010 (Delaware Health and Social Services, 2003). QuitPower is Delaware's first major project funded by DPH's portion of the Master Tobacco Settlement. This program is a counseling telephone hotline that offers one-on-one counseling and support for Delaware residents who have decided they are ready to quit smoking ("Smoking Cessation Hotline "Quitpower" Opens Today" Delaware Health and Social Services News, Feb. 1, 2001, #008DPH-01).

In May 2002, Governor Ruth Ann Minner signed a law to ban smoking from most indoor public places in Delaware beginning November 27, 2002. Regulations pursuant to this law have been construed and applied to protect the nonsmoker from involuntary exposure to environmental tobacco smoke in most enclosed indoor areas to which the public is invited or in which the general public is permitted. The stated purpose of the

Clean Indoor Air Act is to preserve and improve the health, comfort and environment of the people of Delaware by limiting exposure to tobacco smoke (State of Delaware, 2002b).

Screening programs for specific cancers form an important part of the campaign against cancer. Aggressive early detection has been found to increase the likelihood of survival from some cancers. DPH and its community partners began a cooperative effort in 1993 to reduce breast and cervical cancer illness and death and to decrease the need for advanced stage treatment of breast and cervical cancer in Delaware. The Breast and Cervical Cancer Early Detection Project (BCCEDP) follows national guidelines provided by the Centers for Disease Control and Prevention. Screening services are provided for Delaware women (40-64) who are low-income and underinsured. For women age 65 and older, Medicare will pay for clients to receive yearly mammograms. The former Medicare guidelines, effective until 1998, provided cervical and breast cancer screenings; however, mammograms were only covered once every two years.

Through the BCCEDP, eligible women age 40 and older can receive pap smears, pelvic exams, clinical breast exams, and health education. Mammograms are also provided if the woman is 50 years of age or older, or if she has a personal or family history of breast cancer, or if she has had an abnormal clinical breast exam or breast self-exam within the past 6 months. The BCCEDP also pays for certain diagnostic tests for eligible women. Presently, treatment is not covered, but the BCCEDP staff will offer assistance in locating affordable treatment and support. All screening and diagnostic services are provided through agreements with private physicians, primary health care centers, hospitals, outpatient clinics, mammography facilities, and laboratories Delaware Health and Social Services, 2001).

DPH’s Screening for Life program helps Delaware's low-income women, ages 18-64, prevent breast and cervical cancers by covering the costs of clinical breast examinations, screening mammography, pelvic examinations and Pap smears. The program, when warranted, also covers diagnostic mammograms, breast ultrasounds and biopsies, and colposcopy services. Many of the program's patients have never been screened before because they could not afford the cost of a gynecological exam. A network of 61 primary care sites, 14 mammography facilities, five laboratories, four pathologists and 57 surgeons statewide provides services. In January 2002, the program began offering colorectal cancer screening as part of the benefits women receive from the program. Previously the program reimbursed health care providers for only the cost of breast and cervical cancer screening. Through the new colorectal screening benefit, women over 50 will be able to receive an at-home fecal occult blood test, and flexible sigmoidoscopy or colonoscopy, depending on their doctor’s recommendation. Treatment benefits will be provided to women enrolled in the Screening for Life program, who are eligible according to income, lack of private health insurance, Medicaid or Medicare eligibility or because they are under-insured. Women who have health insurance with a high deductible or no coverage for preventive health services also qualify for Screening for Life. Priority is given to racial and ethnic minorities, women with disabilities, women who live in hard-to-reach urban and rural communities, and women who have not received screening in recent years.

Those enrolled currently receive preventive services including mammograms, clinical breast exams, Pap smears and pelvic exams. Women will receive full Medicaid benefits through the duration of their treatment and are not limited to cancer care. The Screening for Life program is funded by the Centers for Disease Control and Prevention (CDC) and the State of Delaware. Treatment benefits are made possible by a new federal law, the Medicaid Treatment Act. The federal government pays 65 percent of the treatment cost while Delaware pays 35 percent. The program's new cancer screening benefits are funded through the Delaware Health Fund, which contains proceeds from the national Master Tobacco Settlement ("Public Health Releases 1999 Cancer Data" Delaware Health and Social Services News, Oct. 4, 2001, #62DPH-01; Delaware Health and Social Services News, Feb.19, 2002, #07DPH-02; "Cancer Treatment Benefits Offered to Under-Insured Women" Delaware Health and Social Services News, Dec. 28, 2001, #94DPH-01; "Screening for Life Program Enrollment Up 40 Percent" Delaware Health and Social Services News, Jul. 20, 2001, #44 DPH-01).

AIDS

In 1981, states began AIDS surveillance. In 1982, all 50 states were collecting confidential name based AIDS data. In 2001, Delaware began HIV reporting using a "name-to-code" system. Physicians who treat patients with HIV or AIDS are required by Delaware law to report their positive patients to the DPH. Names and other identifying information are removed from the data prior to any analysis. Federal granting agencies (CDC, Ryan White) use the information to adjust funding, education efforts and prevention focus in local communities.

Delaware ranks fifth in reporting new AIDS cases. There are 2,412 cases of AIDS with approximately 1,100 people living with AIDS in the State. Nationally, 743,534 AIDS cases have been reported through March 2000. The Division of Public Health offers prevention programs, education, HIV counseling and testing, Ryan White Services, and case management. However, most services are provided by a number of non-governmental organizations in Delaware that provide AIDS related services and information. At least three facilities operate in Wilmington. AIDS Delaware is a non-profit organization offering counseling and health care support; financial and social support to people with AIDS and their loved ones; legal assistance on matters related to health issues; and short and long term housing solutions for persons without resources. AIDS Hotline of Delaware offers counseling, information, and anonymous HIV testing. The AIDS Program Office in Wilmington performs disease surveillance (AIDS Delaware, 2003).

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APPENDIX A-1

General Outline for the Development of an Urban Environmental Profile

I. INTRODUCTION

Background
Geophysical and Land Use
Socio-economic Setting (demographics, economic structure, urban poverty)
Environment-Development Linkages

II. STATUS OF THE ENVIRONMENT IN THE URBAN REGION

Natural Resources
Air Quality
Water Quality (surface, ground, coastal, fisheries)
Land (forests and natural vegetation; agricultural land; parks, recreation and open space; historical sites and cultural property)
Environmental Hazards, Natural Risks, Human-induced Risks

III. DEVELOPEMNT-ENVIRONMENT INTERACTIONS

Water Supply
Sewerage and Sanitation
Flood Control
Solid Waste Management
Industrial Pollution Control/Hazardous Waste Management
Transportation and Telecommunications
Energy and Power Generation
Housing
Health Care
Other

IV. THE SETTING FOR ENVIRONMENTAL MANAGEMENT

Key Actors

Government (central, regional, local)
Private Sector Popular Sector (community groups and NGOs, media)
Management Functions

Instruments of Intervention (legislative and regulatory; economic and fiscal; direct investment; planning and policy development; community organizations; education, training and research; promotion and protest)

Environmental Coordination and Decision-making (mechanisms for public participation; intersectoral coordination; across levels of government; between public and private sector; intertemporal; information and technical expertise)

Constraints on Effective Management

Ongoing Initiatives for Institutional Strengthening

APPENDIX A-2

Outline for the Development of the Wilmington City Environmental Profile

Review of Literature

OUTLINE:

1. Overview of the City of Wilmington:
    - 1.1 History and Location
    - 1.2 The Physical and Natural Environment
    - 1.3 Industry, Commerce and Economic Development
    - 1.4 Infrastructure
    - 1.5 Demographic Characteristics
    - 1.6 The City, the Future and the Ecosystem

2. City Environmental Profiles and Indicators
    - 2.1 What is an Environmental Profile?
    - 2.2 Purpose and Benefits of Environmental Profiles
    - 2.3 What is an Environmental Indicator?
    - 2.4 Purpose of Environmental Indicators
    - 2.5 Indicators and the City Environmental Profile

3. Status of Relevant Research on the Environment of the City of Wilmington
    - 3.1 Environmental Profiles
    - 3.2 Environmental Indicators
    - 3.3 Other Environmental Assessments

APPENDIX B

Wilmington Air Toxics Non-TRI			
Air Toxic	Sources	Products	Comments
1,1,1-Trichloroethane	• Industrial Waste Sites • Hazardous Waste Sites • Household Products	• Glue • Paint • Degreaser • Spot-Cleaner • Aerosol Spray	• Remains in atmosphere for six years
1,1,2,2-Tetrachloroethane	• Industrial Facilities • Household Products	• Paint • Pesticides • Degreaser • Solvents	• The chemicals that result from its natural break-down are more toxic to humans than the original compound
1,1,2-Trichloroethane	• Industrial Facilities	• Solvents	• Half-life of 49 days in the atmosphere
1,1-Dichloroethane	• Industrial Facilities • Household Products	• Degreaser • Paint Solvent • Varnish and Finish Remover	• In the past 1,1-dichloroethane was used as a surgical anesthetic.
1,1-Dichloroethene	• Industrial Facilities	• Plastic packaging materials • Flexible plastic films • Flame-retardant coatings for fiber and carpet backing.	• Has a half-life of 4 days.
1,2-Dibromoethane	• Production facilities • Hazardous waste sites	• Pesticides • Gasoline additive	• Increases the fuel efficiency of leaded gasoline
1,2-Dichloroethane	• Industrial Facilities • Household Products • Automobile Emissions	• Degreaser • Solvent • Vinyl chloride • Chemical products • Gasoline	• In the past it was an important ingredient in household cleaners, pesticides, adhesives and paint removers. • Has a half-life of 47 to 182 days. • Used remove lead from leaded gasoline.
1,2-Dichloropropane	• Agricultural and industrial applications. • Hazardous Waste Sites • Household Products	• Soil fumigant • Furniture finish removers • Paint strippers • Varnishes	• Volatile organic compound (VOC) that reacts with sunlight to produce ground-level ozone. • Has a half-life greater than 23 days
1,3-Butadiene	• Industrial Facilities • Oil refineries • Automobile Exhaust • Chemical manufacturing plants • Plastic and rubber factories	• Petroleum production • Gasoline production • Plastics and rubber production • Cigarette smoke	• On sunny days it has a half-life of 2 hours
1,4-dichlorobenzene	• Industrial Facilities • Household Products	• Mothballs • Deodorant blocks used to freshen garbage cans, restrooms and animal-holding facilities	• Vapor deodorizes and kills insects
Benzene	• Industrial Facilities • Household Products • Gasoline Stations • Fossil Fuel Combustion • Automobile Emissions • Cigarettes	• Petroleum sources (tar and crude oil) • Produce chemicals, such as styrene, cumene, and cyclohexane • Detergents • Drugs • Dyes • Furniture Wax • Lubricants • Paint • Pesticides • Rubber • Tobacco	• Ranks in the top 20 chemicals for production volume in the United States

Bromomethane	• Industrial Facilities • Chemical Factories	• Fungicides • Insecticides • Pesticides • Make other chemicals	• Half-life of 11 months
Carbon tetrachloride	• Industrial Facilities • Household Products	• Refrigerant • Aerosol Propellant	• In the past carbon tetrachloride has been used as a cleaning fluid, degreasing agent, spot cleaner, fumigant, and as an ingredient in fire extinguishers • In the 1960s these uses were discontinued as carbon tetrachloride is thought to impact the ozone layer • Carbon tetrachloride remains in the atmosphere for several years before it degrades through interaction with other chemicals
Chlorobenzene	• Industrial Facilities	• Production of other chemicals • Solvent	• Degrades in the atmosphere within 3½ days. • Exposures are most likely to occur near chemical waste sites
Chloroethane	• Industrial Facilities • Automobile Emissions • Chemical Plants	• Lead additive in gasoline • Solvent • Refrigerant • Commercial chemicals • Dyes • Ethyl cellulose • Medicinal drugs	• Since the decline of leaded gasoline, chloroethane production has decreased • Degrades through the reaction with other chemicals • Half-life of 40 days sites • In minor medical procedures it is used to numb the skin
Chloroform	• Industrial Facilities • Chemical Facilities • Paper Mills	• Manufacture of other chemicals	• Once used as an anesthesia • An unintended byproduct of adding chlorine to drinking water in the process of water purification • When chloroform does eventually break down in becomes phosgene and hydrogen chloride, both toxic chemicals
Chloromethane	• Natural sources, including the ocean, and when biomass rots or is burned. • Industrial facilities	• Silicone • Agricultural chemicals • Methyl cellulose • Quaternary amines • Butyl rubber	• Was once used as a refrigerant, but because of its toxic effects, it is no longer used
Cis-1,2-Dichloroethene	• Chemical factories • Landfills • Hazardous waste sites • Burning of vinyl • Breakdown of chlorinated chemicals	• Vinyl	• Half-life 5-12 days
Cis-1,3-Dichloropropene	• Agriculture • Electrical power stations • Industrial facilities • Hazardous waste sites • Sewage treatment facilities	• Pesticides	

Ethylbenzene	• Automobile Emissions • Hazardous waste sites • Factories and industries that burn oil, gas or coal	• Carpet • Coal tar • Glues • Gasoline • Inks • Insecticides • Paints • Petroleum • Tobacco products • Varnishes	• Composes 2% of gasoline, by weight • Air emissions break down with other chemicals and sunlight to form smog within 3 days
Meta, Para and Ortho Xylene	• Industrial Facilities • Printing industry • Leather industries	• Airplane fuel • Chemicals • Cigarette smoke • Cleaners • Fabric coatings • Gasoline • Lacquers • Leather • Paint • Paint thinners • Pesticides • Petroleum and coal tar • Plastics • Polymers • Rubber • Rust preventatives • Solvent • Synthetic fibers • Varnish	• One of the top 30 chemicals produced in the United States • Degrades within several days into less harmful chemicals
Methylene chloride	• Chemical waste sites • Industrial Facilities • Household products	• Aerosol products • Automotive cleaners • Industrial solvent • Paint stripper • Pesticides • Spray paints	• Breaks down by exposure to sunlight through reactions with other chemicals • Half-life is 53–127 days
Styrene	• Industrial Facilities • Cigarette smoke • Automobile exhaust	• Automobile parts • Drinking cups • Fiberglass • Insulation • Packaging • Pipes • Plastics • Rubber	• Breaks down in the air within 1-2 days
Toluene	• Industrial Facilities • Hazardous waste sites • Landfills • Household Products	• Adhesives • Crude oil • Fingernail polish • Gasoline • Lacquers • Leather tanning • Paints • Paint thinners • Printing processes • Rubber • Solvent	• By-product of styrene manufacture
Source: ASTDR. 2002b			

APPENDIX C
Conversion Equations for Air Pollutants

All atmospheric concentration values were converted into parts per billion (ppb) in order to establish continuity in analysis. Because the State of Delaware measures air quality in parts per billion, converting standards for health risk allows one to more easily compare future ambient levels to these standards.

The CDC, the EPA, ASTDR and OSHA have published their air quality standards and consumption limits in micrograms per cubic meter ($\mu g/m^3$) rather than the ppb value used by the State of Delaware. Ppb is a pollutant's quantity of particles while $\mu g/m^3$ is a calculation of the pollutant's weight. By calculating the molecular weight of a chemical, $\mu g/m^3$ can be converted into ppb by using the following equation:

$$(MW / 24.44)\ \mu g/m^3 = 1\ ppb$$

All $\mu g/m^3$ measurements must be made at 25° C and 1 atmospheric pressure. MW = molecular weight of compound (units are amu or g/mol). This mass/volume conversion arises from:

$$1\,\text{ppb} = \frac{1\,\text{L X}}{10^9\ \text{L air}}\left(\frac{10^3\ \text{L air}}{\text{m}^3} * \frac{\text{mol X}}{24.44\,\text{L X}} * \frac{\text{MW g X}}{\text{mol X}} * \frac{10^6\ \mu\text{g X}}{\text{g X}}\right) = \frac{\text{MW X}}{24.44}\,\frac{\mu\text{g}}{\text{m}^3}$$

The following table shows the molecular formula and the molecular weight used to derive the conversion equations for each of the air toxics monitored in the City of Wilmington.

Molecular Composition of Air Toxics Monitored in the City of Wilmington					
Compound		**Molecular Formula**	**Molecular Weight**	**Conversion Equations**	
1	1,1,1-Trichloroethane	$C_2H_3Cl_3$	133.405	1 ppb = 5.458 µg/m^3	1 µg/m^3 = 0.183 ppb
2	1,1,2,2-Tetrachloroethane	$C_2H_2Cl_4$	167.850	1 ppb = 6.868 µg/m^3	1 µg/m^3 = 0.146 ppb
3	1,1,2-trichloro-1,2,2-trifluoroethane	$C_2Cl_3F_3$	187.377	1 ppb = 7.667 µg/m^3	1 µg/m^3 = 0.130 ppb
4	1,1,2-Trichloroethane	$C_2H_3Cl_3$	133.405	1 ppb = 5.458 µg/m^3	1 µg/m^3 = 0.183 ppb
5	1,1-Dichloroethane	$C_2H_4Cl_2$	98.960	1 ppb = 4.049 µg/m^3	1 µg/m^3 = 0.247 ppb
6	1,1-Dichloroethene	$C_2H_2Cl_2$	96.944	1 ppb = 3.967 µg/m^3	1 µg/m^3 = 0.252 ppb
7	1,2,4-Trichlorobenzene	$C_6H_3Cl_3$	181.450	1 ppb = 7.424 µg/m^3	1 µg/m^3 = 0.135 ppb
8	1,2,4-Trimethylbenzene	C_9H_{12}	120.196	1 ppb = 4.918 µg/m^3	1 µg/m^3 = 0.203 ppb
9	1,2-Dibromoethane	CH_2Br_2	173.845	1 ppb = 7.113 µg/m^3	1 µg/m^3 = 0.141 ppb
10	1,2-Dichloro-1,1,2,2-tetrafluoroethane	$C_2Cl_2F_4$	170.922	1 ppb = 6.994 µg/m^3	1 µg/m^3 = 0.143 ppb
11	1,2-Dichlorobenzene	$C_6H_4Cl_2$	147.005	1 ppb = 6.015 µg/m^3	1 µg/m^3 = 0.166 ppb
12	1,2-Dichloroethane	$C_2H_4Cl_2$	98.960	1 ppb = 4.049 µg/m^3	1 µg/m^3 = 0.247 ppb
13	1,2-Dichloropropane	$C_3H_6Cl_2$	112.987	1 ppb = 4.623 µg/m^3	1 µg/m^3 = 0.216 ppb
14	1,3,5-Trimethylbenzene	C_9H_{12}	120.196	1 ppb = 4.918 µg/m^3	1 µg/m^3 = 0.203 ppb
15	1,3-Butadiene	C_4H_6	54.092	1 ppb = 2.213 µg/m^3	1 µg/m^3 = 0.452 ppb
16	1,3-Dichlorobenzene	$C_6H_4Cl_2$	147.005	1 ppb = 6.015 µg/m^3	1 µg/m^3 = 0.166 ppb
17	1,4-Dichlorobenzene	$C_6H_4Cl_2$	147.005	1 ppb = 6.015 µg/m^3	1 µg/m^3 = 0.166 ppb
18	1-Ethyl-4-methylbenzene	C_8H_{12}	108.185	1 ppb = 4.427 µg/m^3	1 µg/m^3 = 0.226 ppb
19	Benzene	C_6H_6	78.115	1 ppb = 3.196 µg/m^3	1 µg/m^3 = 0.313 ppb
20	Bromomethane	CH_3Br	94.944	1 ppb = 3.885 µg/m^3	1 µg/m^3 = 0.257 ppb
21	Carbon tetrachloride	CCl_4	153.823	1 ppb = 6.294 µg/m^3	1 µg/m^3 = 0.159 ppb
22	Chlorobenzene	C_6H_5Cl	112.560	1 ppb = 4.606 µg/m^3	1 µg/m^3 = 0.217 ppb
23	Chloroethane	C_2H_5Cl	64.515	1 ppb = 2.640 µg/m^3	1 µg/m^3 = 0.379 ppb
24	Chloroethene	C_2H_3Cl	62.499	1 ppb = 2.557 µg/m^3	1 µg/m^3 = 0.391 ppb
25	Chloroform	$CHCl_3$	119.378	1 ppb = 4.885 µg/m^3	1 µg/m^3 = 0.205 ppb
26	Chloromethane	CH_3Cl	50.488	1 ppb = 2.066 µg/m^3	1 µg/m^3 = 0.484 ppb
27	Chloromethylbenzene	C_7H_7Cl	126.587	1 ppb = 5.180 µg/m^3	1 µg/m^3 = 0.193 ppb
28	cis-1,2-Dichloroethene	$C_2H_2Cl_2$	96.944	1 ppb = 3.967 µg/m^3	1 µg/m^3 = 0.252 ppb
29	cis-1,3-Dichloropropene	$C_3H_4Cl_2$	110.971	1 ppb = 4.541 µg/m^3	1 µg/m^3 = 0.220 ppb
30	Dichlorodifluoromethane	CCl_2F_2	120.914	1 ppb = 4.947 µg/m^3	1 µg/m^3 = 0.202 ppb
31	Ethylbenzene	C_8H_{10}	106.169	1 ppb = 4.344 µg/m^3	1 µg/m^3 = 0.230 ppb
32	Hexachloro-1,3-butadiene	C_4Cl_6	260.763	1 ppb = 10.670 µg/m^3	1 µg/m^3 = 0.094 ppb
33	meta & para-Xylene	C_8H_{10}	106.169	1 ppb = 4.344 µg/m^3	1 µg/m^3 = 0.230 ppb
34	Methylene chloride	CH_2Cl_2	84.933	1 ppb = 3.475 µg/m^3	1 µg/m^3 = 0.288 ppb
35	ortho-Xylene	C_8H_{10}	106.169	1 ppb = 4.344 µg/m^3	1 µg/m^3 = 0.230 ppb
36	Styrene	C_8H_8	104.153	1 ppb = 4.262 µg/m^3	1 µg/m^3 = 0.235 ppb
37	Tetrachloroethene	C_2Cl_4	165.834	1 ppb = 6.785 µg/m^3	1 µg/m^3 = 0.147 ppb
38	Toluene	C_7H_8	92.142	1 ppb = 3.770 µg/m^3	1 µg/m^3 = 0.265 ppb
39	trans-1,3-Dichloropropene	$C_3H_4Cl_2$	110.971	1 ppb = 4.541 µg/m^3	1 µg/m^3 = 0.220 ppb
40	Trichloroethene	C_2HCl_3	131.389	1 ppb = 5.376 µg/m^3	1 µg/m^3 = 0.186 ppb
41	Trichlorofluoromethane	CCl_3F	137.369	1 ppb = 5.621 µg/m^3	1 µg/m^3 = 0.178 ppb
Source: Personal Communication with Sally Wasileski, Purdue University Department of Chemistry.					

APPENDIX D
Exposure Risk Threshold Assessments

The U.S. EPA, through its Integrated Risk Information System has developed a reference concentration (RfC) benchmark for some air toxics.

> **Reference Concentration (RfC):** An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a NOAEL, LOAEL, or benchmark concentration, with uncertainty factors generally applied to reflect limitations of the data used. Generally used in EPA's noncancer health assessments (U.S. EPA. 1999a).

EPA IRIS Risk Levels: "The probability of injury, disease, or death from exposure to a chemical agent or a mixture of chemicals. In quantitative terms, risk is expressed in values ranging from zero (representing the certainty that harm will not occur) to one (representing the certainty that harm will occur)" (U.S. EPA. 1999a).

E-4: Risk of 1 in 10,000
E-5: Risk of 1 in 100,000
E-6: Risk of 1 in 1,000,000

The EPA also has a Weight of Evidence (WOE) categorization for carcinogenicity.

> **Weight-of-Evidence (WOE) for Carcinogenicity:** A system used by the U.S. EPA for characterizing the extent to which the available data support the hypothesis that an agent causes cancer in humans. Under EPA's 1986 risk assessment guidelines, the WOE was described by categories "A through E", Group A for known human carcinogens through Group E for agents with evidence of noncarcinogenicity. The approach outlined in EPA's proposed guidelines for carcinogen risk assessment (1996) considers all scientific information in determining whether and under what conditions an agent may cause cancer in humans, and provides a narrative approach to characterize carcinogenicity rather than categories (U.S. EPA. 1999a).

The Agency for Toxic Substances and Disease Registry (ATSDR) have developed Minimal Risk Levels (MRL); a threshold that they believe establishes safe levels of exposure.

> **Minimal Risk Levels (MRLs):** Estimates of exposure levels posing minimal risk to humans . . . An estimate of daily human exposure to a substance that is likely to be without an appreciable risk of adverse effects (noncarcinogenic) over a specified duration of exposure. (ASTDR. 2002b).

The State of California has also developed its own thresholds for some toxic substances. Two threshold categories ARE USED: Chronic Reference Exposure Level and basis for regulatory action.

> **Chronic Reference Exposure Level (REL): "**A chronic REL is an airborne level that would pose no significant health risk to individuals indefinitely exposed to that level. RELs are based solely on health considerations" (State of California OEHHA, 2001).

Part of the ambiguity experienced in making sense of the health effects of air toxins culminates from the way that threshold levels of exposure are measured. Because the same toxic chemical can affect the human body in a number of ways depending upon the level and mechanism of exposure, there are actually a number of different thresholds for any one chemical depending upon the "endpoint", the physical impact of exposure on human health. For each air toxin and chemical there are several, in some cases many, reactions to exposure within the human body according to the dose that an individual is exposed. These "dose-response relationships" can cause minor irritation at low levels of exposure and death under acute conditions. Dose-response relationships are plotted according to a sigmoid curve that reflects the percentage of the population that responds to different levels of exposure to a toxic chemical. The sigmoidal plot of exposure limits is not absolute. Because this curve is essentially a mathematical plot of a physical state, it reflects statistical responses. Individual variation among laboratory animals of the same species is observed when testing exposure levels. One animal may show dramatic negative health effects while another seems to be unaffected. Additionally, because the relationship between dose and response is transformed into a mathematical structure, where zero response culminates from zero exposure, a true threshold dose level where there is no response to a specific dose, cannot be achieved. Unless the type of endpoint is specified determining a safe threshold is "meaningless" (OSHA, 2002c).

Whether or not the true threshold of a chemical is reflected in those determined in a laboratory depends upon a number of factors, including the number of animals, the number of trials and the amount of variation among the subjects. Other environmental conditions, including diet and health of the animals, affect the outcome of experiments. The issues surrounding laboratory experimentation to determine safe threshold levels for air toxins have drawn criticisms from the scientific community. Statistical limitations in experimental studies can bring about inaccurate results. An OSHA report highlights these discrepancies:

> In a recent publication (Tardiff and Rodricks 1987), David W. Gaylor of the National Center for Toxicological Research explained that experimentally derived thresholds represent statistical limitations in study design rather than biological characteristics:
>
> The existence of dose-response relationships might lead one to assume incorrectly the existence of threshold doses below which no toxic effects could occur. As dosage is decreased, the prevalence of an observable toxic effect...diminishes to zero. Eventually, a dosage is reached below which the experiment has essentially no resolving power to distinguish between the spontaneous background rate and small induced toxic effects....
>
> If no toxic effects are detected at a specified dosage, this dosage is called the no-effect, or more correctly the no-observed-effect dosage. Because of the

> limitations of any given experiment, the no-observed-effect dosage is not a precise estimate of a true no-effect level. Lack of statistical significance is not equivalent to no toxic effect. It may or may not be, and further experimentation would be required to resolve this equivocal issue.... The no-observed-effect level is not a biological property, but, rather, a statistical property or operational threshold that is highly dependent on sample size (OSHA, 2002c).

NOAELs, therefore, are not true thresholds for no effects to a contaminant by humans in the natural environment. Taking these problems into account, OSHA has established permissible exposure limits (PEL) that are lower than NOAELs (OSHA, 2002c).

Additionally, the safety factors used in the equation to develop NOAELs and exposure thresholds have been called into question. The use of safety factors "often create the impression that human population thresholds have been identified and that there is virtually no risk below that level of exposure" (Tardiff and Rodricks 1987, p. 421, cited in OSHA (2002c). NIOSH agrees that "safety factors cannot be used to estimate human risk and are therefore not related to the magnitude or significance of a risk; instead, NIOSH believes that safety factors are intended to reflect uncertainty in the available data. This comment echoes the observation made by Tardiff and Rodricks, i.e., that safety factors do not necessarily identify a human population threshold" (OSHA, 2002c)

MRLs are also acknowledged to be ambiguous depending upon the level of exposure. According to the ATSDR, MRLs are calculated "when reliable and sufficient data exist to identify the target organ(s) of effect or the most sensitive health effect(s) for a specific duration within a given route of exposure. MRLs are based on noncancerous health effects only and do not consider carcinogenic effects. MRLs can be derived for acute-, intermediate-, and chronic-duration exposures for inhalation and oral routes . . . Furthermore, ATSDR acknowledges additional uncertainties inherent in the application of the procedures to derive less than lifetime MRLs. As an example, acute inhalation MRLs may not be protective for health effects that are delayed in development or are acquired following repeated acute insults, such as hypersensitivity reactions, asthma, or chronic bronchitis. As these kinds of health effects data become available and methods to assess levels of significant human exposure improve, these MRLs will be revised" (ASTDR, 2002b).

Exposure thresholds, as these criticisms show, are controversial issues. Because of the discrepancies between information and quantitative results, the thresholds developed by the various state and federal agencies are quite diverse.

APPENDIX E-1
Symptoms of Exposure to Air Toxics

Air Toxic	Sour	Abdo	Adren	Anest	Anem	Anorr	Anxie	Blurr	Blood	Blood	Bone	Brain	Bron	Ches	Com	Confusion
1,1,1-Trichloroethane	1															
1,1,2,2-Tetrachloroethane	1,2	■														
1,1,2-trichloro-1,2,2-trifluoroethane	7															
1,1,2-Trichloroethane	1,2															
1,1-Dichloroethane	1,2															
1,1-Dichloroethene	1															
1,2,4-Trichlorobenzene	4		■													
1,2,4-Trimethylbenzene	7															
1,2-Dibromoethane	1															
1,2-Dichloro-1,1,2,2-tetrafluoroethane	7															
1,2-Dichlorobenzene	7															
1,2-Dichloroethane	1															
1,2-Dichloropropane	1				■										■	
1,3,5-Trimethylbenzene	7															
1,3-Butadiene	1,2								■							
1,3-Dichlorobenzene	5,6				■				■							
1,4-Dichlorobenzene	1								■							
1-Ethyl-4-methylbenzene	7															
Antimony	5															
Barium	1,5															
Benzene	1,2				■	■					■					■
Bromomethane	1															
Carbon tetrachloride	1,2															
Carbonyl Sulfide	3,5														■	
Chlorine	3,5												■	■		
Chromium (VI)	1															
Chlorobenzene	1,2															
Chloroethane	1	■														■
Chloroethene	3								■							
Chloroform	2			■												■
Chloromethane	1							■		■					■	■
Chloromethylbenzene	3															
Copper	1,5															
Decabromodiphenyl Oxide	3,5															
cis-1,2-Dichloroethene	1															
cis-1,3-Dichloropropene	2															
Dichlorodifluoromethane	3															
Dichloromethane	3,5														■	
Di(2-ethylexhyl)phalate	1,5															
Ethylbenzene	1,2														■	
Hexachloro-1,3-butadiene	2															
Hydrochloric Acid	3,5															
Lead	1,5				■					■		■				
Manganese	1,5															
Nickel	1,5															
Meta-Xylene	1,2	■				■										
Para-Xylene	1,2	■				■										
Methylene chloride	1,2															
Ortho-Xylene	1,2	■				■										
Phosgene	3,5															
Styrene	1,2															■
Tetrachloroethene	3															
Toluene	2						■									■
trans-1,3-Dichloropropene	7															
Titanium Tetrachloride	1												■			
Trichloroethene	3															
Trichlorofluoromethane	3															
Zinc	1,7															

Source: (1) ASTDR. Toxicological Profile Information Sheet; (2) U.S. CDC. NIOSH Pocket Guide to Chemical Hazards; (3) Material Safety Data Sheet; (4) U.S. EPA, TNN-WEB; (5) 1998 Data Summary: Delaware Toxics Release Inventory Report; (6) West Virgina Toxics Release Inventory (7) No Data Available

Symptoms of Exposure to Air Toxics

Air Toxic	Sourc	Corn… olization	Conv	Depr	Derm	Dilate… pils	Diarr	Dizzi	Drow	Dysp	Emot… Disturbances	Euph	Excit	Eye I	Head	Heart Disease
1,1,1-Trichloroethane	1															
1,1,2,2-Tetrachloroethane	1,2				■			■								
1,1,2-trichloro-1,2,2-trifluoroethane	7															
1,1,2-Trichloroethane	1,2				■				■					■		
1,1-Dichloroethane	1,2															
1,1-Dichloroethene	1															
1,2,4-Trichlorobenzene	4									■						
1,2,4-Trimethylbenzene	7															
1,2-Dibromoethane	1			■											■	
1,2-Dichloro-1,1,2,2-tetrafluoroethane	7															
1,2-Dichlorobenzene	7															
1,2-Dichloroethane	1															
1,2-Dichloropropane	1							■						■	■	
1,3,5-Trimethylbenzene	7															
1,3-Butadiene	1,2							■	■					■		■
1,3-Dichlorobenzene	5,6							■						■	■	
1,4-Dichlorobenzene	1							■							■	
1-Ethyl-4-methylbenzene	7															
Antimony	5						■							■		
Barium	1,5															
Benzene	1,2				■			■	■					■	■	
Bromomethane	1														■	
Carbon tetrachloride	1,2							■	■					■		
Carbonyl Sulfide	3,5		■												■	■
Chlorine	3,5							■						■		■
Chromium (VI)	1															
Chlorobenzene	1,2								■					■	■	
Chloroethane	1															
Chloroethene	3													■	■	
Chloroform	2							■						■	■	
Chloromethane	1		■					■								
Chloromethylbenzene	3							■						■	■	
Copper	1,5						■							■		
Decabromodiphenyl Oxide	3,5													■		
cis-1,2-Dichloroethene	1								■							
cis-1,3-Dichloropropene	2							■						■	■	
Dichlorodifluoromethane	3															
Dichloromethane	3,5							■						■	■	
Di(2-ethylexhyl)phalate	1,5															
Ethylbenzene	1,2				■			■						■	■	
Hexachloro-1,3-butadiene	2													■		
Hydrochloric Acid	3,5													■		
Lead	1,5															■
Manganese	1,5										■					
Nickel	1,5															
Meta-Xylene	1,2	■			■			■	■				■	■		
Para-Xylene	1,2	■			■			■	■				■	■		
Methylene chloride	1,2							■	■					■		
Ortho-Xylene	1,2	■			■			■	■				■	■		
Phosgene	3,5							■						■	■	
Styrene	1,2				■			■	■					■	■	
Tetrachloroethene	3															
Toluene	2				■	■		■				■		■	■	
trans-1,3-Dichloropropene	7															
Titanium Tetrachloride	1													■		
Trichloroethene	3							■						■	■	
Trichlorofluoromethane	3													■		
Zinc	1,7															

Source: (1) ASTDR. Toxicological Profile Information Sheet; (2) U.S. CDC. NIOSH Pocket Guide to Chemical Hazards; (3) Material Safety Data Sheet; (4) U.S. EPA, TNN-WEB; (5) 1998 Data Summary: Delaware Toxics Release Inventory Report; (6) West Virgina Toxics Release Inventory (7) No Data Available

Symptoms of Exposure to Air Toxics

Air Toxic	Sourc	Heart	Hepa	Immu	Impa… e Coordination	Incoo… tion	Insom	Jaun	Kidne	Lassi	Leuk	Liver	Lung	Mala	Ment… ment Impeded	Menal Dullness
1,1,1-Trichloroethane	1											■				
1,1,2,2-Tetrachloroethane	1,2		■					■	■		■	■				
1,1,2-trichloro-1,2,2-trifluoroethane	7															
1,1,2-Trichloroethane	1,2			■					■			■				
1,1-Dichloroethane	1,2								■							
1,1-Dichloroethene	1											■				
1,2,4-Trichlorobenzene	4															
1,2,4-Trimethylbenzene	7															
1,2-Dibromoethane	1								■			■				
1,2-Dichloro-1,1,2,2-tetrafluoroethane	7															
1,2-Dichlorobenzene	7															
1,2-Dichloroethane	1								■			■	■			
1,2-Dichloropropane	1								■			■				
1,3,5-Trimethylbenzene	7															
1,3-Butadiene	1,2												■			
1,3-Dichlorobenzene	5,6								■			■				
1,4-Dichlorobenzene	1								■			■				
1-Ethyl-4-methylbenzene	7															
Antimony	5												■			
Barium	1,5															
Benzene	1,2			■						■						
Bromomethane	1								■							
Carbon tetrachloride	1,2					■			■			■				
Carbonyl Sulfide	3,5															
Chlorine	3,5												■			
Chromium (VI)	1												■			
Chlorobenzene	1,2					■			■			■				
Chloroethane	1			■	■											
Chloroethene	3															
Chloroform	2									■		■				■
Chloromethane	1	■			■				■			■				
Chloromethylbenzene	3															
Copper	1,5								■			■				
Decabromodiphenyl Oxide	3,5											■				
cis-1,2-Dichloroethene	1															
cis-1,3-Dichloropropene	2								■			■				
Dichlorodifluoromethane	3	■														
Dichloromethane	3,5	■							■			■				
Di(2-ethylexhyl)phalate	1,5															
Ethylbenzene	1,2				■				■			■				
Hexachloro-1,3-butadiene	2				■				■							
Hydrochloric Acid	3,5												■			
Lead	1,5								■			■	■		■	■
Manganese	1,5															
Nickel	1,5												■			
Meta-Xylene	1,2					■										
Para-Xylene	1,2					■										
Methylene chloride	1,2									■						
Ortho-Xylene	1,2				■	■										
Phosgene	3,5												■			
Styrene	1,2									■		■		■		
Tetrachloroethene	3															
Toluene	2						■		■	■		■				
trans-1,3-Dichloropropene	7															
Titanium Tetrachloride	1												■			
Trichloroethene	3											■				
Trichlorofluoromethane	3															
Zinc	1,7															

Source: (1) ASTDR. Toxicological Profile Information Sheet; (2) U.S. CDC. NIOSH Pocket Guide to Chemical Hazards; (3) Material Safety Data Sheet; (4) U.S. EPA, TNN-WEB; (5) 1998 Data Summary: Delaware Toxics Release Inventory Report; (6) West Virgina Toxics Release Inventory (7) No Data Available

Symptoms of Exposure to Air Toxics

Air Toxic	Sour	Motor ces	Mucc Irrita	Musc Damage	Narc	Naus	Nerv ression	Neur ffects	Nose n	Parer	Pneu	Repr	Resp y stem Irritation	Seizu	Skin atic	Splee	Stag	Thro	Thyr ge	Tingl imb	Ulcer	Unco usness	Vomiting
1,1,1-Trichloroethane	1						■						■										
1,1,2,2-Tetrachloroethane	1,2					■																■	■
1,1,2-trichloro-1,2,2-trifluoroethane	7																						
1,1,2-Trichloroethane	1,2						■		■														
1,1-Dichloroethane	1,2																						
1,1-Dichloroethene	1																					■	
1,2,4-Trichlorobenzene	4												■										
1,2,4-Trimethylbenzene	7																						
1,2-Dibromoethane	1												■										
1,2-Dichloro-1,1,2,2-tetrafluoroethane	7																						
1,2-Dichlorobenzene	7																						
1,2-Dichloroethane	1						■																
1,2-Dichloropropane	1					■												■					
1,3,5-Trimethylbenzene	7																						
1,3-Butadiene	1,2								■			■						■				■	
1,3-Dichlorobenzene	5,6												■										
1,4-Dichlorobenzene	1																						
1-Ethyl-4-methylbenzene	7																						
Antimony	5												■		■						■		■
Barium	1,5																						
Benzene	1,2					■						■	■				■					■	
Bromomethane	1					■							■	■									
Carbon tetrachloride	1,2					■	■																■
Carbonyl Sulfide	3,5												■										
Chlorine	3,5		■			■					■		■		■								
Chromium (VI)	1												■										
Chlorobenzene	1,2					■	■		■														■
Chloroethane	1					■		■														■	■
Chloroethene	3		■			■							■										■
Chloroform	2					■																	
Chloromethane	1					■	■																■
Chloromethylbenzene	3		■			■							■										
Copper	1,5												■										
Decabromodiphenyl Oxide	3,5		■												■				■				
cis-1,2-Dichloroethene	1					■																	
cis-1,3-Dichloropropene	2					■							■										■
Dichlorodifluoromethane	3																					■	
Dichloromethane	3,5		■		■	■									■								
Di(2-ethylexhyl)phalate	1,5																						
Ethylbenzene	1,2		■		■																		
Hexachloro-1,3-butadiene	2												■										
Hydrochloric Acid	3,5		■										■		■								
Lead	1,5	■		■								■				■							
Manganese	1,5	■											■										
Nickel	1,5												■										
Meta-Xylene	1,2					■			■								■	■					■
Para-Xylene	1,2					■			■								■	■					■
Methylene chloride	1,2					■														■			
Ortho-Xylene	1,2					■			■								■	■					■
Phosgene	3,5												■										■
Styrene	1,2				■				■			■	■				■						
Tetrachloroethene	3												■										
Toluene	2								■	■													
trans-1,3-Dichloropropene	7																						
Titanium Tetrachloride	1		■								■		■		■								
Trichloroethene	3						■															■	
Trichlorofluoromethane	3												■										
Zinc	1,7																						

Source: (1) ASTDR. Toxicological Profile Information Sheet; (2) U.S. CDC. NIOSH Pocket Guide to Chemical Hazards; (3) Material Safety Data Sheet; (4) U.S. EPA, TNN-WEB; (5) 1998 Data Summary: Delaware Toxics Release Inventory Report; (6) West Virgina Toxics Release Inventory (7) No Data Available

Appendix E-2
Air Toxics Target Organs

Air Toxic	Adrenal Gland	Blood	Bone Marrow	Brain	Cardiovascular	Central Nervous System	Eyes	Gastrointestinal Tract	Heart	Kidneys	Liver	Reproductive	Respiratory System	Skin	Spleen	Stomach	Thyroid
1,1,1-Trichloroethane						■					■		■				
1,1,2,2-Tetrachloroethane						■		■		■	■			■			
1,1,2-trichloro-1,2,2-trifluoroethane																	
1,1,2-Trichloroethane				■		■	■		■	■	■		■		■		
1,1-Dichloroethane										■							
1,1-Dichloroethene											■						
1,2,4-Trichlorobenzene	■												■				
1,2,4-Trimethylbenzene																	
1,2-Dibromoethane										■	■						
1,2-Dichloro-1,1,2,2-tetrafluoroethane																	
1,2-Dichlorobenzene																	
1,2-Dichloroethane						■			■	■	■			■			
1,2-Dichloropropane		■								■	■		■				
1,3,5-Trimethylbenzene																	
1,3-Butadiene		■				■	■		■			■	■				
1,3-Dichlorobenzene										■	■						
1,4-Dichlorobenzene		■								■	■						
1-Ethyl-4-methylbenzene																	
Antimony									■				■			■	
Barium																	
Benzene		■	■			■	■					■	■				
Bromomethane										■			■				
Carbon Sulfide													■				
Carbon tetrachloride						■	■			■	■		■	■			
Chlorine		■					■		■				■				
Chlorobenzene				■		■	■				■			■			
Chloroethane																	
Chloroethene		■		■		■					■						
Chloroform						■	■		■	■	■			■			
Chloromethane																	
Chloromethylbenzene													■				
Chromium (VI)													■				
Copper										■	■						
Decabromodiphenyl Oxide											■						■
Dichloromethane																	
cis-1,2-Dichloroethene																	
cis-1,2-Dichloropropene						■	■			■	■		■	■			
Dichlorodifluoromethane																	
Di(2-ethylhexyl)phalate																	
Ethylbenzene						■	■			■	■		■	■			
Hexachloro-1,3-butadiene							■			■			■	■			
Hydrochloric Acid													■				
Lead		■		■		■				■		■					
Manganese													■				
Nickel													■				
Phosgene													■				
Meta-Xylene		■				■	■	■		■	■		■	■			
Para-Xylene		■				■	■	■		■	■		■	■			
Methylene chloride					■	■	■							■			
Ortho-Xylene		x				■	■	■		■	■		■	■			
Styrene						■	■				■	■	■	■			
Tetrachloroethene																	
Titanium Tetrachloride													■				
Toluene						■	■			■	■		■	■			
trans-1,3-Dichloropropene																	
Trichloroethene											■	■					
Trichlorofluoromethane									■				■				
Zinc																	

Source: IARC, Overall Evaluations of Carcinogenicity to Humans; EPA, Integrated Risk Information System; U.S. CDC. NIOSH Pocket Guide to Chemical Hazards. U.S. EPA, Section 112 Hazardous Air Pollutants; Material Safety Data Sheet; ASTDR. Toxicological Profile Information Sheet.

Appendix E-3
Air Toxics Carcinogenic Risk

Air Toxic	EPA	IARC	Blad	Fore	Hem	Kidn	Liver	Luke	Lun	Mam	Saliv	Sinus
1,1,1-Trichloroethane	D	3										
1,1,2,2-Tetrachloroethane	C						■					
1,1,2-trichloro-1,2,2-trifluoroethane		3										
1,1,2-Trichloroethane	C	3					■					
1,1-Dichloroethane	C											
1,1-Dichloroethene												
1,2,4-Trichlorobenzene												
1,2,4-Trimethylbenzene												
1,2-Dibromoethane												
1,2-Dichloro-1,1,2,2-tetrafluoroethane												
1,2-Dichlorobenzene	D											
1,2-Dichloroethane	B2	2B										
1,2-Dichloropropane		3										
1,3,5-Trimethylbenzene												
1,3-Butadiene	B2	2A			■							
1,3-Dichlorobenzene	D											
1,4-Dichlorobenzene							■					
1-Ethyl-4-methylbenzene												
Antimony												
Barium												
Benzene	A	1						■				
Bromomethane	D	3										
Carbon tetrachloride	B2	2B					■					
Carbonyl Sulfide												
Chlorobenzene	D											
Chloroethane												
Chloroethene												
Chloroform	B2	2B				■	■					
Chlorine												
Chloromethane												
Chloromethylbenzene												
Chromium (VI)	A	1							■			
Copper												
Decabromodiphenyl Oxide												
cis-1,2-Dichloroethene												
cis-1,3-Dichloropropene			■	■			■		■			
Dichlorodifluoromethane												
Dichloromethane												
Di(2-ethylhexyl)phalate												
Ethylbenzene	D	2B										
Hexachloro-1,3-butadiene	C					■						
Hydrochloric Acid												
Lead												
meta & para-Xylene		3										
Methylene chloride		2B					■		■	■	■	
Ortho-Xylene		3										
Manganese												
Nickel											■	
Phosgene												
Styrene		2A										
Tetrachloroethene												
Titanium Tetrachloride												
Toluene		3										
trans-1,3-Dichloropropene												
Trichloroethene												
Trichlorofluoromethane												
Zinc												

EPA Assessment Designations: A = Known Human Carcinogen for All Routes of Exposure , B2=Possible Human Carcinogen, Based on Sufficient Evidence in Animals, C=Possible Human Carcinogen, D = Not Classifiable as a Human Carcinogen

IARC Assessment Designations: 1 = Carcinogenic to Humans, 2A = Probably Carcinogenic to Humans, 2B = Possibly Carcinogenic to Humans, 3 = Unclassifiable as to Carcinogenicity to Humans.

Source: IARC, *Overall Evaluations of Carcinogenicity to Humans*; EPA, *Integrated Risk Information System; U.S. CDC.* NIOSH Pocket Guide to Chemical Hazards. *U.S. EPA, Section 112 Hazardous Air Pollutants; Material Safety Data Sheet; ASTDR. T*oxicological Profile Information Sheet.

APPENDIX F-1

Arsenic RBC Exposure Levels and Samples from Contaminated Sites in Wilmington			
Site	**Soil Sample (ppm)**	**Industrial RFC (ppm)**	**Residential RFC (ppm)**
Commerce Street	22.5	3.8	0.43
Dravo Ship Yard- Amer Industrial Tec	19.4	3.8	0.43
Dravo Ship Yard- Amer Industrial Tec	12	3.8	0.43
Dravo Shipyard - Harbor Associates	27.7	3.8	0.43
Obrien Properties- Pre Remedial	2.9	3.8	0.43
Potts Property	672	3.8	0.43
Pusey And Jones Shipyard	10.4	3.8	0.43
121 N. Poplar St.	10000	3.8	0.43
400 South Madison Street	64.8	3.8	0.43
504 South Market Street	72.1	3.8	0.43
504 South Market Street	72.1	3.8	0.43
Amtrak Centralized National Operatio	18.2	3.8	0.43
East 7th St Peninsula - South	68	3.8	0.43
Halby Chemical	30000	3.8	0.43
Helen Chambers Park - Pre Remedial	2180	3.8	0.43
Madison Street Connection	110	3.8	0.43
Potts Property	199	3.8	0.43
Stadium Site	169	3.8	0.43
Terminal Avenue Widening	214	3.8	0.43
Wilco Plumbing And Heating	18.2	3.8	0.43
Wilmington Coal Gas - Southern Secti	155	3.8	0.43
Sardo And Sons	6810	3.8	0.43
Diamond State Foundry / Pullman Car	13.3	3.8	0.43
Site	**Ground Water Sample (ppm)**	**RFC Tap Water (ppm)**	
1121 Thatcher Street	0.7	0.045	
250 South Madison Street	0.0336	0.045	
Bancroft Mills- Pre Remedial	0.0157	0.045	
Diamond Oil- Pre Remedial	0.016	0.045	
Dp & L/ Congo Marsh	0.0482	0.045	
Dupont Cherry Island Landfill	0.093	0.045	
Hay Street Sludge Drying	0.053	0.045	
Potts Property	1.42	0.045	
South Wilmington East & West	0.0134	0.045	
Stadium Site	0.122	0.045	
Site	**Surface Water Sample (ppm)**	**RFC Tap Water (ppm)**	
East 7th St Drum Site	465	0.045	
Source: DNREC, 2002b, U.S. EPA, 2002e, ATSDR, 2002b			

APPENDIX F-2

PCB RBC Exposure Levels and Samples from Contaminated Sites in Wilmington			
Site	**Soil Sample (ppm)**	**Industrial RFC (ppm)**	**Residential RFC (ppm)**
Amtrak Centralized National Operation	0.98	2.9	0.32
Amtrak Wilmington Rail-yard	5770	2.9	0.32
Delaware Car Company- Pre Remedial	26400	2.9	0.32
Diamond State Salvage	164	2.9	0.32
East 7th St Drum Site	850	2.9	0.32
High Voltage Maintenance Site	2444	2.9	0.32
Krieger Finger Property	18	2.9	0.32
Krieger Finger Property	13	2.9	0.32
Krieger Finger Property	0.63	2.9	0.32
Kruse Playground Site	13	2.9	0.32
Penn Del	201	2.9	0.32
Port Of Wilmington - North American	15.66	2.9	0.32
Port Of Wilmington - North American	11	2.9	0.32
South Wilmington East & West	0.177	2.9	0.32
South Wilmington East & West	0.29	2.9	0.32
Wilco Plumbing And Heating	0.23	2.9	0.32
Wilmington Coal Gas - Northern Section	32.8	2.9	0.32
Wilmington Coal Gas - Southern Section	10	2.9	0.32
Wilmington Coal Gas - Western Section	3	2.9	0.32
Site	**Ground Water Sample (ppm)**	**RFC Tap Water (ppm)**	
Amtrak Wilmington Refueling Facility	2.6	0.033	
Amtrak Wilmington Refueling Facility	71	0.033	
Amtrak Wilmington Refueling Facility	20	0.033	
Source: DNREC, 2002b, U.S. EPA, 2002e, ATSDR, 2002b			

APPENDIX F-3

Lead RBC Exposure Levels and Samples from Contaminated Sites in Wilmington			
Site	**Soil Sample (ppm)**	**Industrial RFC**	**Residential RFC**
Bancroft Mills- Pre Remedial	153	N/D	N/D
Commerce Street	135	N/D	N/D
Dravo Ship Yard- Amer Industrial Tec	621	N/D	N/D
Dravo Shipyard - Harbor Associates	1650	N/D	N/D
Estate Of Lester Nolan	2720	N/D	N/D
Obrien Properties- Pre Remedial	892	N/D	N/D
121 N. Poplar St.	1323	N/D	N/D
122 N. Poplar St.	1323	N/D	N/D
509 South Market Street	5200	N/D	N/D
509 South Market Street	5200	N/D	N/D
Amtrak Centralized National Operatio	1520	N/D	N/D
Amtrak Centralized National Operatio	929	N/D	N/D
Amtrak Centralized National Operatio	683	N/D	N/D
Cabean Square	10400	N/D	N/D
City Of Wilm. Marine Terminal	465	N/D	N/D
East 7th St Drum Site	923	N/D	N/D
East 7th St Drum Site	14000	N/D	N/D
East 7th St Peninsula - South	3840	N/D	N/D
Estate Of Lester Nolan	86000	N/D	N/D
Estate Of Lester Nolan	57400	N/D	N/D
Helen Chambers Park - Pre Remedial	2370	N/D	N/D
Madison Street Connection	4228	N/D	N/D
Penn Del	12900	N/D	N/D
Proposed New Castle County Court Hou	6600	N/D	N/D
South Wilmington East & West	12900	N/D	N/D
Speakman Property	1260	N/D	N/D
Stadium Site	320	N/D	N/D
Sunday Breakfast Mission	2700	N/D	N/D
Terminal Avenue Widening	120	N/D	N/D
Wilco Plumbing And Heating	1520	N/D	N/D
Diamond State Salvage	3410	N/D	N/D
Fifth And Church Streets	437	N/D	N/D
Sardo And Sons	1350	N/D	N/D
Site	**Ground Water Sample (ppm)**	**RFC Tap Water**	
1121 Thatcher Street	0.17	N/D	
250 South Madison Street	0.0171	N/D	
Diamond Oil- Pre Remedial	0.0596	N/D	
Dravo Shipyard - Harbor Associates	0.0509	N/D	
Dupont Cherry Island Landfill	0.11	N/D	
Site	**Surface Water Sample (ppm)**	**RFC Tap Water**	
Commerce Street	0.0083	N/D	
Dp & L Sub./ Dupont Christina Labs	0.058	N/D	
Dp & L/ Congo Marsh	0.058	N/D	

Dravo Shipyard - Harbor Associates	0.0103	N/D
Estate Of Lester Nolan	0.94	N/D
Estate Of Lester Nolan	0.085	N/D
Port Of Wilmington - North American	1.04	N/D
Pusey And Jones Shipyard	0.0025	N/D
South Wilmington East & West	0.0099	N/D
N/D: Risk Based Concentrations have not been derived for Lead. ATSDR has not derived MRLs for lead. The EPA has not developed a reference concentration (RfC) for lead. EPA has also decided that it would be inappropriate to develop a reference dose (RfD) for inorganiclead (and lead compounds) because some of the health effects associated with exposure to lead occur at blood lead levels as low as to be essentially without a threshold (IRIS 1999).		
Source: DNREC, 2002b, U.S. EPA, 2002e, ATSDR, 2002b		

APPENDIX F-4

Mercury RBC Exposure Levels and Samples from Contaminated Sites in Wilmington			
Site	**Soil Sample (ppm)**	**Industrial RFC (ppm)**	**Residential RFC (ppm)**
Dravo Ship Yard- Amer Industrial Tec	3	200	7.8
Dravo Shipyard - Harbor Associates	37.5	200	7.8
Obrien Properties- Pre Remedial	0.6	200	7.8
Potts Property	0.82	200	7.8
511 South Market Street	13.4	200	7.8
511 South Market Street	13.4	200	7.8
Estate Of Lester Nolan	0.22	200	7.8
Potts Property	0.32	200	7.8
Terminal Avenue Widening	0.29	200	7.8
Diamond State Salvage	57.8	200	7.8
Site	**Surface Water Sample (ppm)**	**RFC Tap Water (ppm)**	
EAST 7TH ST DRUM SITE	4.2	3.7	
Source: DNREC, 2002b, U.S. EPA, 2002e, ATSDR, 2002b			

APPENDIX F-5

Zinc RBC Exposure Levels and Samples from Contaminated Sites in Wilmington			
Site	**Soil Sample (ppm)**	**Industrial RFC (ppm)**	**Residential RFC (ppm)**
Obrien Properties- Pre Remedial	480	61000	23000
Estate Of Lester Nolan	11800	61000	23000
Speakman Property	30135.51	61000	23000
Terminal Avenue Widening	105	61000	23000
Wilmington Coal Gas - Northern Secti	210	61000	23000
Sardo And Sons	3690	61000	23000
Site	**Surface Water Sample (ppm)**	**RFC Tap Water (ppm)**	
Commerce Street	0.082	11000	
Pusey And Jones Shipyard	0.0292	11000	
Source: DNREC, 2002b, U.S. EPA, 2002e, ATSDR, 2002b			

APPENDIX F-6

Chromium RBC Exposure Levels and Samples from Contaminated Sites in Wilmington					
Site	**Soil Sample (ppm) Total Chromium (III and VI)**	**Industrial RFC (ppm)**		**Residential RFC (ppm)**	
		III	**VI**	**III**	**VI**
Commerce Street	84.1	3100000	6100	120000	2300
Dravo Ship Yard- Amer Industrial Tec	86.8	3100000	6100	120000	2300
Dravo Shipyard - Harbor Associates	270	3100000	6100	120000	2300
South Wilmington East & West	5120	3100000	6100	120000	2300
1000 French Street Site	23	3100000	6100	120000	2300
Halby Chemical	4830	3100000	6100	120000	2300
506 South Market Street	253	3100000	6100	120000	2300
506 South Market Street	253	3100000	6100	120000	2300
City Of Wilm. Marine Terminal	523	3100000	6100	120000	2300
Terminal Avenue Widening	718	3100000	6100	120000	2300
Diamond State Salvage	97.7	3100000	6100	120000	2300
Sardo And Sons	1240	3100000	6100	120000	2300
Site	**Ground Water Sample (ppm) Total Chromium (III and VI)**	**RFC Tap Water (ppm)**			
		III		**VI**	
DuPont Cherry Island Landfill	0.4	55000		110	
Site	**Surface Water Sample (ppm) Total Chromium (III and VI)**	**RFC Tap Water (ppm)**			
		III		**VI**	
Port of Wilmington – North American	0.0315	55000		110	
Source: DNREC, 2002b, U.S. EPA, 2002e, ATSDR, 2002b					

APPENDIX G
SIRB Sites in Wilmington

Site Designation	ID Number	Site Name
	DE-1215	12th & Walnut Mbna
	DE-1222	12th Street Associates
BPA II	DE-0159	Amtrak Wilmington Train Yard
	DE-1144	Diamond State Foundry / Pullman Car Works
	DE-1128	East 7th St Peninsula - North
	DE-1127	East 7th St Peninsula - South
	DE-1169	Hessler Property
	DE-1106	Obrien Properties- Pre Remedial
	DE-1165	Salvage Yard Relocation Area I
	DE-1166	Salvage Yard Relocation Area Ii
EPA REMOVAL	DE-0294	12th Street Drum Site
	DE-0305	Brandywine Creek Mystery Oil Site
	DE-0281	Diamond State Salvage
	DE-1148	East 7th St Drum Site
EPA REMOVAL COMPLETE	DE-0097	Sixteenth Street Quarry
HSCA	DE-1134	101 N. Poplar Street
	DE-1068	503 South Market Street
	DE-1131	American Scrap And Waste Co
	DE-0280	Atlas Sanitation
	DE-0131	Berger Brothers
	DE-1233	Compton Town House Apartments
	DE-1104	Dci Property
	DE-1241	Delaware Job Corp
	DE-1191	Halby Nrda
	DE-1203	Hessler Property (Hsca)
	DE-1067	Krieger Finger Property
	DE-0156	Kriegers Landfill
	DE-1179	Old Incinerator Ash Landfill
	DE-0169	Potts Property
	DE-1051	Pusey And Jones Shipyard
	DE-0286	South Wilmington East & West
	DE-1004	Stadium Site
	DE-1216	Tri State-E. 7th Street Peninsula
	DE-1046	Wilmington Coal Gas - Northern Section
	DE-0114	Wilmington Coal Gas - Southern Section
	DE-1043	Wilmington Coal Gas - Western Section
HSCA-NO ACTION	DE-1002	Haynes Park
LOW PRIORITY	DE-0170	Amtrak Wilmington Railyard
	DE-0187	Applied Technology Inc
	DE-1078	Connections Csp, Inc
	DE-1074	Dp & L Sub./ Dupont Christina Labs

	DE-1073	Dp & L/ Congo Marsh
	DE-0257	Edgemoor, Abandoned Offshore Drum
	DE-1113	Former Wilmington Cso Site
	DE-0024	Hay Street Sludge Drying
	DE-1141	Sac Tire Property
NATIONAL PRIORITY LIST	DE-0067	Halby Chemical
NO FURTHER ACTION	DE-1220	1200 Walnut Street
	DE-1111	Wilmington Spill Site
	DE-1091	Wilmington Transit Center
RENAMED/REGROUPED	DE-1101	Bancroft Mills- Pre Remedial
	DE-0285	Browntown
	DE-1079	Christina Avenue South
	DE-0099	City Of Wilm. Marine Terminal
	DE-1072	Commerce Street
	DE-1059	Delaware Car Company- Pre Remedial
	DE-1112	Diamond Oil- Pre Remedial
	DE-1052	Eastside/South Wilmington
	DE-1145	Helen Chambers Park - Pre Remedial
	DE-0140	High Voltage Maintenance Site
	DE-1158	P & C Roofing(Pre - Remedial)
	DE-0191	Pettinaro Transformer Site
	DE-1053	Riverside
	DE-1062	Wilco Plumbing And Heating
RI	DE-1237	Riverfront Office Building
SI	DE-0300	Christina Park
	DE-0299	Joe White Memorial Ballfield
	DE-0111	Kruse Playground Site
SOLID WASTE	DE-0101	Delmarva Power&Light-Edgemoor
	DE-0026	Dupont Cherry Island Landfill
	DE-0032	Fibre Processing
VCP	DE-1114	100 Walnut Street
	DE-1097	1121 Thatcher Street
	DE-1217	200 & 206 Maryland Avenue
	DE-1228	201 And 205 A Street
	DE-1247	207 A Street
	DE-1080	210 Green Hill Ave
	DE-1248	415-427 Tatnall Street Property
	DE-1235	524 A&B South Walnut Street
	DE-1142	704 West 11th Street
	DE-1206	900/920 French Street
	DE-1172	A-1 Auto Parts
	DE-1180	American Tank Cleaning Co
	DE-0266	Amtrak Wilm. Refueling Facility
	DE-1130	Bancroft Mills
	DE-1109	Brandywine Fibers
	DE-1139	Christina River Pedestrian Walkway
	DE-1044	Csx Property

	DE-1182	Del. Tech Parking Lot Site
	DE-1187	Delaware Car Company
	DE-1157	Deldot West Street Connector
	DE-1129	Diamond Oil
	DE-1174	Don Wilson Auto Parts
	DE-1092	Dravo Ship Yard- Amer Industrial Tech
	DE-1096	Dravo Shipyard - Harbor Associates
	DE-0174	Electric Hose & Rubber Recon
	DE-0165	Estate Of Lester Nolan
	DE-1236	Fifth And Dupont Street
	DE-1184	Fourth Street Bridge
	DE-1138	George Gray School
	DE-0197	Harper Theil
	DE-1188	Helen Chambers Park
	DE-1176	Juniors Auto Parts
	DE-1197	Kent Building
	DE-1175	Merkin Auto Spring Company
	DE-1155	Mlk Boulevard, North - South Section
	DE-1137	Obrien Energy Services Company
	DE-1147	Peninsula Park Llc
	DE-1057	Penn Del
	DE-1146	Proposed New Castle County Court House
	DE-1164	River Walk Phase V & Vi Site
	DE-1105	Sardo And Sons
	DE-1178	Schusters Auto Salvage
	DE-1026	Terminal Avenue Widening
	DE-1183	Thermal Loop
	DE-1177	Two Guys Auto Parts
	DE-1090	Wilmington Public Works Yard
VCP O&M	DE-1066	121 N. Poplar St.
	DE-1055	250 South Madison Street
	DE-1040	400 South Madison Street
	DE-1084	Amtrak Centralized National Operations Center
	DE-1089	Del Tech - Wilmington
	DE-1082	Fifth And Church Streets
	DE-1099	Maryland Ave And I-95 Property
	DE-1063	Movable Feast
	DE-0230	Port Of Wilmington - North American Smelting Co
	DE-1054	Pure Green Industries, Inc.
	DE-1116	Riverfront Park
VCP-NO ACTION	DE-1115	1000 French Street Site
	DE-1081	Cabean Square
	DE-1094	Grays Fine Printing
	DE-1132	Kirk Building Property
	DE-1085	Madison Street Connection
	DE-1076	One Christina Center

	DE-1060	Speakman Property
	DE-1083	Sunday Breakfast Mission
	DE-1108	Wilson Street

APPENDIX H-1

PCB Levels in Fish, City of Wilmington 1985-2001				
Sample ID No.	WATER BODY	No.of Fish in Sample	PCBs Level (ppm)	Amount of PCBs in a 4 oz meal (mg)
933072	Christina	1	946.82	946.82
933073	Christina	1	1813.02	1813.02
933074	Christina	1	2091.50	2091.5
933075	Christina	1	2909.23	2909.23
933076	Christina	1	1049.21	1049.21
8003507	Brandywine	na	150	150
8003508	Brandywine	na	290	290
8104043	Brandywine	5	1500	1500
8104044	Brandywine	9	1200	1200
8203822	Brandywine	9	250	250
8303853	Brandywine	8	100	100
8403257	Brandywine	7	100	100
8603818	Brandywine	12	3130	3130
8804253	Brandywine	6	1000	1000
8804254	Brandywine	10	1000	1000
8903817	Christina	10	160	160
99044090	Shellpot Creek	1	477.42	477.42
99044100	Shellpot Creek	1	894.26	894.26
99044110	Shellpot Creek	1	1305.47	1305.47
99044120	Shellpot Creek	1	887.64	887.64
99044560	Shellpot Creek	1	611.93	611.93

APPENDIX H-2

Arsenic Levels in Fish, City of Wilmington 1985-2001

Sample ID No.	WATER BODY	No.of Fish in Sample	Arsenic Level (ppm)	Amount of Arsenic in a 4 oz meal (mg)
35300	Brandywine	3	0.08J	0.0088
8003507	Brandywine	Na	<0.01	0.0011
8003508	Brandywine	Na	<0.01	0.0011
8104043	Brandywine	5	<0.01	0.0011
8104044	Brandywine	9	<0.0094	0.001034
8203822	Brandywine	9	<0.29	0.0319
8303853	Brandywine	8	<0.59	0.0649
8403257	Brandywine	7	<0.6	0.066
8503417	Brandywine	10	<0.19	0.0209
8603818	Brandywine	12	<0.18	0.0198
8703537	Brandywine	8	<0.18	0.0198
8903147	Brandywine	10	<2	0.2200
9003361	Brandywine	12	<0.4	0.044
9204228	Brandywine	4	<0.4	0.044
933072	Christina	1	<0.2	0.022
933073	Christina	1	<0.2	0.022
933074	Christina	1	<0.2	0.022
933075	Christina	1	<0.2	0.022
933076	Christina	1	<0.2	0.022
1011600	Christina	5	< 0.2	0.022
1012510	Christina	4	< 0.2	0.022
8903817	Christina	10	<2	0.22
8903818	Christina	4	<2	0.22
9003805	Christina	4	<0.4	0.044
9003806	Christina	10	<0.4	0.022
9104330	Christina	1	<0.2	0.044
9204227	Christina	3	<0.4	0.044
99044090	Shellpot Creek	1	< 0.2	0.022
99044100	Shellpot Creek	1	< 0.2	0.022
99044110	Shellpot Creek	1	< 0.2	0.022
99044120	Shellpot Creek	1	< 0.2	0.022
99044560	Shellpot Creek	1	< 0.2	0.022

APPENDIX H-3

Mercury Levels in Fish, City of Wilmington 1985-2001				
Sample ID No.	**WATER_BODY**	**No.of Fish in Sample**	**Mercury Level (ppm)**	**Amount of Mercury in a 4 oz meal (mg)**
35300	Brandywine	3	0.095	0.01045
8503417	Brandywine	10	<0.019	0.00209
8303853	Brandywine	8	<0.02	0.0022
8003508	Brandywine	Na	<0.03	0.0033
8603818	Brandywine	12	0.031	0.00341
8003507	Brandywine	Na	0.04	0.0044
8203822	Brandywine	9	0.04	0.0044
9003361	Brandywine	12	0.04	0.0044
8403257	Brandywine	7	0.06	0.0066
8104043	Brandywine	5	<0.07	0.0077
8104044	Brandywine	9	<0.07	0.0077
8703537	Brandywine	8	0.09	0.0099
9204228	Brandywine	4	0.13	0.0143
8903147	Brandywine	10	<0.5	0.055
9104330	Christina	1	<0.02	0.0022
9003805	Christina	4	0.03	0.0033
933076	Christina	1	0.062	0.00682
9003806	Christina	10	0.09	0.0099
933074	Christina	1	0.103	0.01133
933075	Christina	1	0.113	0.01243
1012510	Christina	4	0.113	0.01243
9204227	Christina	3	<0.13	0.0143
933072	Christina	1	0.042	0.01463
933073	Christina	1	0.133	0.01463
1011600	Christina	5	0.155	0.01705
8903817	Christina	10	<0.5	0.055
8903818	Christina	4	<0.5	0.055
99044560	Shellpot Creek	1	0.028	0.00308
99044090	Shellpot Creek	1	0.031	0.00341
99044100	Shellpot Creek	1	< 0.01	0.0011
99044120	Shellpot Creek	1	0.012	0.00132
99044110	Shellpot Creek	1	0.013	0.00143

APPENDIX I-1

Frequency of Water Quality Monitoring, as per Regulations				
Contaminant Category	Contaminant		State of Delaware	EPA
Bacteriological Quality	Total Coliforms		120 samples per month	Tested monthly
	Fecal Coliforms			
	E. coli			
Inorganic and Organic Chemicals	PMCLs	Arsenic	Tested Annually	Tested Annually
		Barium		
		Cadmium		
		Chromium		
		Fluoride		
		Lead		
		Mercury		
		Nitrate Nitrogen		
		Selenium		
		Silver		
		Turbidity		
	SMCLs	Chloride	Tested at the Discretion of the Division of Public Health	Tested Annually
		Color		
		Copper		
		Corrosivity		
		Foaming Agents		
		Iron		
		Manganese		
		Odor		
		pH		
		Sulfate		
		Total Dissoved Solids		
		Zinc		
	Organic PMCLs	Chlorinated Hydrocarbons		
		Lindane		
		Methoxychlor		
		Toxaphene		
	Herbicides: Chlorophenoxys	2,4 Dichlorophenoxy-acetic acid		
		2,4,5-Trichloropehnoxypropionic acid		
	Total Trihalomethanes	TTHMs		
	Volatile Synthetic Organic Chemicals (VOCs)	Benzene	Tested at the Discretion of the Division of Public Health	Tested Annually
		Carbon Tetrachloride		
		1,2-dichloroethane		
		Trichloroethylene		
		Para-dichlorobenzene		
		1,1-dichloroethylene		
		1,1,1-trichloroethane		
		Vinyl Chloride		
	Radionuclides			Once every 4 years
Source: U.S. EPA, 1997: 10; State of Delaware, 1991				

APPENDIX I-2

Summary Results of Water Quality Testing in Wilmington										
Compound Category	**Compound**	**Date Tested**	**Unit**	**MCLG**	**MCL**	**Porter Filtration Plant**		**Brandywine Filtration Plant**		**Source of Contaminants**
						Highest Level Detected	**Range**	**Highest Level Detected**	**Range**	
Metals	Barium	2000	ppm	2	2	0.026		0.031		Discharge of drilling wastes: discharge from metal refineries; erosion of natural deposits
	Chromium	2000	ppb	100	100	nd		0.8		Discharge from steel and pulp mills; erosion of natural deposits
	Copper	1999	ppm	0	1.3	0.30		0.30		Corrosion of household plumbing systems; erosion of natural deposits; leaching from wood preservatives
	Lead	1999	ppb	0	15	7		7		Corrosion of household plumbing systems; erosion of natural deposits
	Sulfate	2000	ppb	n/a	N/a	19		18		Runoff/leaching from natural deposits; industrial wastes
Minerals	Fluoride	2000	ppm	4	4	1.2	0.2-1.2	1.2	0.2-1.2	Erosion of natural deposits; water additive which promotes strong teeth; discharge from fertilizer and aluminum factories
	Nitrate	2000	ppm	10	10	3.3	0.4-3.3	3.5	0.4-3.5	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits
	Nitrite	2000	ppm	1	1	0.01	Nd-0.01	0.02	0.001-0.02	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits
Micro-biological	Turbidity	2000	NTU	n/a	95% below 0.5	0.42	0.05-0.42	1.10	0.05-1.10	Soil runoff
	Total Coliform	2000	% of samples	100% negative	95% negative	99% negative		99% negative		Naturally present in the environment
Disinfectants	Chlorine	2000	ppm	MRDLG 4	M RDL 4	3.6	0.6-3.6	2.6	1.1-2.6	Water additive used to control microbes
Disinfection Byproducts	Total Trihalomethanes	2000	ppb	n/a	100	43	12-80	34	14-63	By-product of drinking water chlorination
	Total halocetic acids	2000	ppb	n/a	n/a	35	15-52	25	13-43	By-product of drinking water chlorination
	Total haloacetonitriles	1998	ppb	n/a	n/a	5.4	4.1-6.8	6.0	2.4-15	By-product of drinking water chlorination

	Chloropicrin	1998	ppb	n/a	n/a	1.0	1.6-1.4	0.7	0.5-1.6	By-product of drinking water chlorination
	Total haloketones	1998	ppb	n/a	n/a	2.6	1.4-3.7	3.0	1.1-6.8	By-product of drinking water chlorination
	Chloral hydrate	1998	ppb	n/a	n/a	6.0	3.2-9.3	4.1	1.8-10	By-product of drinking water chlorination
	TOX (Total Organic alides)	1998	ppb	n/a	n/a	145	100-200	118	87-170	By-product of drinking water chlorination
	Chlorate	1998	ppb	n/a	n/a	98	41-230	nd		By-product of drinking water chlorination
	Bromodichloromethane	2000	ppb	n/a	n/a	11	3.7-19	9.5	4.4-1.7	By-product of drinking water chlorination
	Bromoform	2000	ppb	n/a	n/a	0.1	nd-0.3	0.2	nd-1.3	By-product of drinking water chlorination
	Chlorodibromomethane	2000	ppb	n/a	n/a	2.4	1.7-2.9	2.5	1.3-5.4	By-product of drinking water chlorination
	Chloroform	2000	ppb	n/a	n/a	26	2.8-60	20	5.2-48	By-product of drinking water chlorination
Radiological	Alpha Emitters	2000	PCi/L	0	15	0.165		n/a		Erosion of natural deposits
	Beta/photon Emitters	2000	PCi/L	0	50	4.25		n/a		Decay of natural and man-made deposits
Unregulated Inorganic	Total Iron	2000	ppm	N/a	300	50		50		Runoff/leaching from natural deposits; industrial wastes
	Sodium	2000	ppm	n/a	n/a	36		50		Naturally-occurring salt present in the water
	Alkalinity	2000	ppm	n/a	n/a	43		38		Measure of carbonate molecules preset in the water
	PH	2000	units	n/a	6.5-8.5	7.3		7.1		Measure of hydrogen ions present in the water
	Chloride	2000	ppm	n/a	250	77		100		Runoff/leaching from natural deposits; seawater influence
	Total Dissolved Solids	2000	ppm	n/a	500	224		295		Runoff/leaching from natural deposits
	Total Hardness	2000	ppm	n/a	n/a	118		133		The sum of naturally-occurring polyvalent cations present in the water

MCLG = Maximum Contaminant Level Goal, MCL = Maximum Contaminant Level, AL = Action Level, TT = Treatment Technique, MRDLG = Maximu Residual Disinfectant Level oal, MRDL = Maximum Residual Disinfectant Level, ppm = parts per million, ppb = parts per billion, NTU = Nephelometric Turbidity Units, pCi/L = picocuries per leter, nd = none detected, n/a = not applicable

Source: City of Wilmington, 2001a

APPENDIX J

Contaminants Tested for, but not Detected, in 2001		
Metals:	**Pesticides & Herbicides:**	
Antimony	2,3,7,8-TDD (Dioxin)	Dinoseb
Arsenic	2,4-D	Diquat
Beryllium	2,4-Dinitrotoluene	Endothall
Cadmium	2,4,5-TP (Silvex)	Endrin
Iron	2,6-Dinitrotoluene	EPTC
Mercury	3-Hydroxycarbofuran	Gamma-BHC (Lindane)
Selenium	4,4'-DDE	Glyphosate
Silver	Acetochlor	Heptachlor
Thallium	Alachlor	Heptachlor epoxide
Inorganic Chemicals:	Aldicarb	Hexachlorobenzene
Ammonia	Aldicarb sulfone	Hexachlorocyclopentadine
Asbestos	Aldicarb sulfoxide	Methomyl
Color	Aldrin	Methoxychlor
Cyanide	Atrazine	Metribuzin
Perchlorate	Benzo(a)pyrene	Molinate
Radionuclides:	Butachlor	Oxamyl
Alpha emitters	Carbaryl	PCB's (Polychlorinated biphenyls)
Beta/photon emitters	Carbofuran	Pentachlorophenol
Radium 226	Chlordane	Picloram (Tordon)
Radium 228	Dalapon	Propachlor
Microbiological Organisms:	Dicamba	Simazine
Cryptosporidium	Di(ethylhexyl)adipate	Terbacil
Giardia	Di(ethylhexyl)phthalate	Toxaphene
	Dieldrin	
Volatile Organic Chemicals		
1,1,1,2-Tetrachloroethane	1,4-Dichlorobenzene	isopropylbenzene
1,1,1-Trichloroethane	2,2-Dichloropropane	Methyl-t-butyl ether (MTBE)
1,1,2,2-Tetrachloroethane	2,-Chlorotoluene	Methylene chloride
1,1,2-Trichloroethane	4-Chlorotoluene	n-Butylbenzene
1,1-Dichloroethane	4-Isopropyltoluene	n-Propylbenzene
1,1-Dichloroethene	Benzene	Napthalene
1,1-Dichloropropene	Bromobenzene	Nitrobenzene
1,2,3-Trichlorobenzene	Bromochloromethane	Sec-Butylbenzene
1,2,3-Trichlropropane	Bromomethane	Styrene
1,2,4-Trichlorobenzene	Carbon tetrachloride	Tert-Butylbenzene
1,2,4-Trimethylbenzene	Chlorobenzene	Tetrachloroethene
1,2-Dibromo-3-chloropropane	Chloroethane	Toluene
1,2-Dibromomethane	Chloromethane	Total xylenes
1,2-Dichlorobenzene	Cis-1,2-dichloroethene	Trans-1,2-dichloroethene
1,2-Dichloroethane	Cis-1,3-dichloropropene	Trans-1,3-Dichloropropene
1,2-Dichloropropane	Dibromomethane	Trichloroethene
1,2,5-Trimethylbenzene	Dichlorodifluoromethane	Trichlorofluoromethane
1,3-Dichlorobenzene	Ethylbenzene	Vinyl Chloride
1,3-Dichloropropane	Hexachlorobutadiene	
Source: City of Wilmington, 2001a: 15, 16		

APPENDIX K

Health Impacts of Water Pollutants	
Pollutant	**Health Impacts**
Cryptosporidium	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)
Giardia lamblia	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)
Heterotrophic plate count	HPC has no health effects, but can indicate how effective treatment is at controlling microorganisms.
Legionella	Legionnaire's Disease, commonly known as pneumonia
Total Coliforms (including fecal coliform and *E. Coli*)	Used as an indicator that other potentially harmful bacteria may be present
Turbidity	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria. These organisms can cause symptoms such as nausea, cramps, diarrhea, and associated headaches.
Viruses (enteric)	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)
Bromate	Increased risk of cancer
Chloramines (as Cl_2)	Eye/nose irritation; stomach discomfort, anemia
Chlorine (as Cl_2)	Eye/nose irritation; stomach discomfort
Chlorine dioxide (as ClO_2)	Anemia; infants & young children: nervous system effects
Chlorite	Anemia; infants & young children: nervous system effects
Haloacetic acids (HAA5)	Increased risk of cancer
Total Trihalomethanes (TTHMs)	Liver, kidney or central nervous system problems; increased risk of cancer
Barium	Increase in blood pressure
Beryllium	Intestinal lesions
Chromium (total)	Some people who use water containing chromium well in excess of the MCL over many years could experience allergic dermatitis
Copper	Short term exposure: Gastrointestinal distress. Long term exposure: Liver or kidney damage. People with Wilson's Disease should consult their personal doctor if their water systems exceed the copper action level.
Lead	Infants and children: Delays in physical or mental development. Adults: Kidney problems; high blood pressure
Nitrate (measured as Nitrogen)	"Blue baby syndrome" in infants under six months - life threatening without immediate medical attention. Symptoms: Infant looks blue and has shortness of breath.
Nitrite (measured as Nitrogen)	"Blue baby syndrome" in infants under six months - life threatening without immediate medical attention. Symptoms: Infant looks blue and has shortness of breath.
Source: U.S. EPA. 2002a	

APPPENDIX L

National Primary Drinking Water Regulations				
Microorganisms	**MCLG (mg/L)**	**MCL or TT (mg/L)**	**Potential Health Effects from Ingestion of Water**	**Sources of Contaminant in Drinking Water**
Cryptosporidium	as of 01/01/02: zero	as of 01/01/02: TT	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste
Giardia lamblia	Zero	TT	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste
Heterotrophic plate count	n/a	TT	HPC has no health effects, but can indicate how effective treatment is at controlling microorganisms.	HPC measures a range of bacteria that are naturally present in the environment
Legionella	Zero	TT	Legionnaire's Disease, commonly known as pneumonia	Found naturally in water; multiplies in heating systems
Total Coliforms (including fecal coliform and *E. Coli*)	Zero	5.0%	Used as an indicator that other potentially harmful bacteria may be present	Coliforms are naturally present in the environment; fecal coliforms and E. coli come from human and animal fecal waste.
Turbidity	n/a	TT	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria. These organisms can cause symptoms such as nausea, cramps, diarrhea, and associated headaches.	Soil runoff
Viruses (enteric)	Zero	TT	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste
Disinfectants & Disinfection Byproducts	**MCLG (mg/L)**	**MCL or TT (mg/L)**	**Potential Health Effects from Ingestion of Water**	**Sources of Contaminant in Drinking Water**
Bromate	as of 01/01/02: zero	as of 01/01/02: 0.010	Increased risk of cancer	Byproduct of drinking water disinfection
Chloramines (as Cl_2)	as of 01/01/02: MRDLG=4	as of 01/01/02: MRDL=4.0	Eye/nose irritation; stomach discomfort, anemia	Water additive used to control microbes
Chlorine (as Cl_2)	as of 01/01/02: MRDLG=4	as of 01/01/02: MRDL=4.0	Eye/nose irritation; stomach discomfort	Water additive used to control microbes
Chlorine dioxide (as ClO_2)	as of 01/01/02: MRDLG=0.8	as of 01/01/02: MRDL=0.8	Anemia; infants & young children: nervous system effects	Water additive used to control microbes
Chlorite	as of 01/01/02: 0.8	as of 01/01/02: 1.0	Anemia; infants & young children: nervous system effects	Byproduct of drinking water disinfection
Haloacetic acids (HAA5)	as of 01/01/02: n/a	as of 01/01/02: 0.060	Increased risk of cancer	Byproduct of drinking water disinfection
Total Trihalomethanes (TTHMs)	none ---------- as of 01/01/02: n/a	0.10 ---------- as of 01/01/02: 0.080	Liver, kidney or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection
Inorganic Chemicals	**MCLG (mg/L)**	**MCL or TT (mg/L)**	**Potential Health Effects from Ingestion of Water**	**Sources of Contaminant in Drinking Water**
Antimony	0.006	0.006	Increase in blood cholesterol; decrease in blood glucose	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder
Arsenic	None	0.05	Skin damage; circulatory system	Erosion of natural deposits; runoff

			problems; increased risk of cancer	from glass & electronics production wastes
Asbestos (fiber >10 micrometers)	7 million fibers per liter	7 MFL	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits
Barium	2	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits
Beryllium	0.004	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries
Cadmium	0.005	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints
Chromium (total)	0.1	0.1	Some people who use water containing chromium well in excess of the MCL over many years could experience allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits
Copper	1.3	TT; Action Level=1.3	Short term exposure: Gastrointestinal distress. Long term exposure: Liver or kidney damage. People with Wilson's Disease should consult their personal doctor if their water systems exceed the copper action level.	Corrosion of household plumbing systems; erosion of natural deposits
Cyanide (as free cyanide)	0.2	0.2	Nerve damage or thyroid problems	Discharge from steel/metal factories; discharge from plastic and fertilizer factories
Fluoride	4.0	4.0	Bone disease (pain and tenderness of the bones); Children may get mottled teeth.	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories
Lead	Zero	TT; Action Level=0.015	Infants and children: Delays in physical or mental development. Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits
Mercury (inorganic)	0.002	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and cropland
Nitrate (measured as Nitrogen)	10	10	"Blue baby syndrome" in infants under six months - life threatening without immediate medical attention. Symptoms: Infant looks blue and has shortness of breath.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits
Nitrite (measured as Nitrogen)	1	1	"Blue baby syndrome" in infants under six months - life threatening without immediate medical attention. Symptoms: Infant looks blue and has shortness of breath.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits
Selenium	0.05	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum refineries; erosion of natural deposits; discharge from mines
Thallium	0.0005	0.002	Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics, glass, and pharmaceutical companies
Organic Chemicals	**MCLG (mg/L)**	**MCL or TT (mg/L)**	**Potential Health Effects from Ingestion of Water**	**Sources of Contaminant in Drinking Water**
Acrylamide	Zero	TT	Nervous system or blood problems; increased risk of cancer	Added to water during sewage/wastewater treatment
Alachlor	Zero	0.002	Eye, liver, kidney or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops
Atrazine	0.003	0.003	Cardiovascular system problems; reproductive difficulties	Runoff from herbicide used on row crops
Benzene	Zero	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills

Benzo(a)pyrene (PAHs)	Zero	0.0002	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines
Carbofuran	0.04	0.04	Problems with blood or nervous system; reproductive difficulties.	Leaching of soil fumigant used on rice and alfalfa
Carbon tetrachloride	Zero	0.005	Liver problems; increased risk of cancer	Discharge from chemical plants and other industrial activities
Chlordane	Zero	0.002	Liver or nervous system problems; increased risk of cancer	Residue of banned termiticide
Chlorobenzene	0.1	0.1	Liver or kidney problems	Discharge from chemical and agricultural chemical factories
2,4-D	0.07	0.07	Kidney, liver, or adrenal gland problems	Runoff from herbicide used on row crops
Dalapon	0.2	0.2	Minor kidney changes	Runoff from herbicide used on rights of way
1,2-Dibromo-3-chloropropane (DBCP)	Zero	0.0002	Reproductive difficulties; increased risk of cancer	Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards
o-Dichlorobenzene	0.6	0.6	Liver, kidney, or circulatory system problems	Discharge from industrial chemical factories
p-Dichlorobenzene	0.075	0.075	Anemia; liver, kidney or spleen damage; changes in blood	Discharge from industrial chemical factories
1,2-Dichloroethane	Zero	0.005	Increased risk of cancer	Discharge from industrial chemical factories
1,1-Dichloroethylene	0.007	0.007	Liver problems	Discharge from industrial chemical factories
cis-1,2-Dichloroethylene	0.07	0.07	Liver problems	Discharge from industrial chemical factories
trans-1,2-Dichloroethylene	0.1	0.1	Liver problems	Discharge from industrial chemical factories
Dichloromethane	Zero	0.005	Liver problems; increased risk of cancer	Discharge from pharmaceutical and chemical factories
1,2-Dichloropropane	Zero	0.005	Increased risk of cancer	Discharge from industrial chemical factories
Di(2-ethylhexyl) adipate	0.4	0.4	General toxic effects or reproductive difficulties	Leaching from PVC plumbing systems; discharge from chemical factories
Di(2-ethylhexyl) phthalate	Zero	0.006	Reproductive difficulties; liver problems; increased risk of cancer	Discharge from rubber and chemical factories
Dinoseb	0.007	0.007	Reproductive difficulties	Runoff from herbicide used on soybeans and vegetables
Dioxin (2,3,7,8-TCDD)	Zero	0.00000003	Reproductive difficulties; increased risk of cancer	Emissions from waste incineration and other combustion; discharge from chemical factories
Diquat	0.02	0.02	Cataracts	Runoff from herbicide use
Endothall	0.1	0.1	Stomach and intestinal problems	Runoff from herbicide use
Endrin	0.002	0.002	Nervous system effects	Residue of banned insecticide
Epichlorohydrin	Zero	TT	Stomach problems; reproductive difficulties; increased risk of cancer	Discharge from industrial chemical factories; added to water during treatment process
Ethylbenzene	0.7	0.7	Liver or kidney problems	Discharge from petroleum refineries
Ethylene dibromide	Zero	0.00005	Stomach problems; reproductive difficulties; increased risk of cancer	Discharge from petroleum refineries
Glyphosate	0.7	0.7	Kidney problems; reproductive difficulties	Runoff from herbicide use
Heptachlor	Zero	0.0004	Liver damage; increased risk of cancer	Residue of banned termiticide
Heptachlor epoxide	Zero	0.0002	Liver damage; increased risk of cancer	Breakdown of hepatachlor
Hexachlorobenzene	Zero	0.001	Liver or kidney problems; reproductive difficulties; increased risk of cancer	Discharge from metal refineries and agricultural chemical factories
Hexachlorocyclopentadiene	0.05	0.05	Kidney or stomach problems	Discharge from chemical factories
Lindane	0.0002	0.0002	Liver or kidney problems	Runoff/leaching from insecticide used on catttle, lumber, gardens
Methoxychlor	0.04	0.04	Reproductive difficulties	Runoff/leaching from insecticide used on fruits, vegetables, alfalfa, livestock
Oxamyl (Vydate)	0.2	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes

Polychlorinated biphenyls (PCBs)	Zero	0.0005	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfils; discharge of waste chemicals
Pentachlorophenol	Zero	0.001	Liver or kidney problems; increased risk of cancer	Discharge from wood preserving factories
Picloram	0.5	0.5	Liver problems	Herbicide runoff
Simazine	0.004	0.004	Problems with blood	Herbicide runoff
Styrene	0.1	0.1	Liver, kidney, and circulatory problems	Discharge from rubber and plastic factories; leaching from landfills
Tetrachloroethylene	Zero	0.005	Liver problems; increased risk of cancer	Discharge from factories and dry cleaners
Toluene	1	1	Nervous system, kidney, or liver problems	Discharge from petroleum factories
Toxaphene	Zero	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle
2,4,5-TP (Silvex)	0.05	0.05	Liver problems	Residue of banned herbicide
1,2,4-Trichlorobenzene	0.07	0.07	Changes in adrenal glands	Discharge from textile finishing factories
1,1,1-Trichloroethane	0.20	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories
1,1,2-Trichloroethane	0.003	0.005	Liver, kidney, or immune system problems	Discharge from industrial chemical factories
Trichloroethylene	Zero	0.005	Liver problems; increased risk of cancer	Discharge from petroleum refineries
Vinyl chloride	Zero	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories
Xylenes (total)	10	10	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories
Radionuclides	**MCLG (mg/L)**	**MCL or TT (mg/L)**	**Potential Health Effects from Ingestion of Water**	**Sources of Contaminant in Drinking Water**
Alpha particles	none ---------- as of 12/08/03: zero	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits
Beta particles and photon emitters	none ---------- as of 12/08/03: zero	4 millirems per year	Increased risk of cancer	Decay of natural and man-made deposits
Radium 226 and Radium 228 (combined)	none ---------- as of 12/08/03: zero	5 pCi/L	Increased risk of cancer	Erosion of natural deposits
Uranium	as of 12/08/03: zero	as of 12/08/03: 30 ug/L	Increased risk of cancer, kidney toxicity	Erosion
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