AN ANALYSIS OF IMPERVIOUS AREA INCREASE VS. POPULATION GROWTH IN THE CHESAPEAKE BAY WATERSHED BETWEEN 1990 AND 2000

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AN ANALYSIS OF
IMPERVIOUS AREA INCREASE VS. POPULATION GROWTH
IN THE CHESAPEAKE BAY WATERSHED FROM 1990-2000

INTRODUCTION

Numerous presentations, websites[1], and documents have cited information from the EPA's Chesapeake Bay Program describing a dramatic difference in the increase in impervious cover relative to population growth: "From 1990 to 2000, impervious surfaces increased by 41 percent – a rate five times greater than the 8 percent rate of population growth during that time." This impervious area growth rate is being used as a justification for significant public policy changes in stormwater management policy. The purpose of this document is to examine the veracity of this statement, based upon publicly available information because it is important for the website to contain the most up-to-date, and correct, data.

EXECUTIVE SUMMARY

This analysis examines the statement made on the chesapeakebay.net website that population in the Chesapeake Bay watershed increased by 8% between 1990 and 2000 while impervious area increased by 41%[2]. This claim appears to be erroneous based on U.S. Census data and the information provided in the Phase 5.2 Chesapeake Bay watershed model (a new model, Phase 5.3, is expected to be released soon – and could change the conclusions of this analysis). We also noted that this claim appears to be erroneous based on the previous (Phase 4.3) Chesapeake Bay watershed model data, although we did not analyze that data in-depth. The most current data available at the time of this writing indicates that population within the Chesapeake Bay watershed increased by approximately 10.3% while impervious area increased by 14.2%.

The following table summarizes our findings by state and shows several interesting trends that could be useful for public policy analysts and decision makers:

Jurisdiction (portion within the Chesapeake Bay watershed)	Population Increase (1990-2000) (%)	Impervious Area Increase (1990-2000) (%)
Chesapeake Bay Watershed	10.3%	14.2%
Delaware	23.2%	28.4%
District of Columbia	-5.7%	1.9%
Maryland	10.7%	15.2%
New York	-2.2%	3.7%
Pennsylvania	5.4%	10.6%
Virginia	16.8%	18.0%
West Virginia	18.0%	21.0%

[1] Specifically www.chesapeakebay.net, which disseminates information related to the Chesapeake Bay Community Watershed Model and the Bay Total Maximum Daily Load allowance.

[2] See http://www.chesapeakebay.net/status_population.aspx?menuitem=19842

It is critical for public policy makers to base decisions on the best available data; therefore, we have provided all of the data sources and our methodology in this paper so that these conclusions can be easily verified independently. We understand that errors can be made inadvertantly, and we welcome any corrections to this analysis.

DISTRIBUTION OF THE IMPERVIOUS AREA INCREASE CLAIM

The graph of Chesapeake Bay Watershed Population and Impervious Surface (Figure 1, below) and the website text below the graph (Figure 2, below) indicate that population within the Chesapeake Bay watershed grew by 8% between 1990 and 2000, while impervious surfaces increased by 41% during the same time period. (See Appendix A for a complete screen shot of http://www.chesapeakebay.net/status_population.aspx?menuitem=19842.)

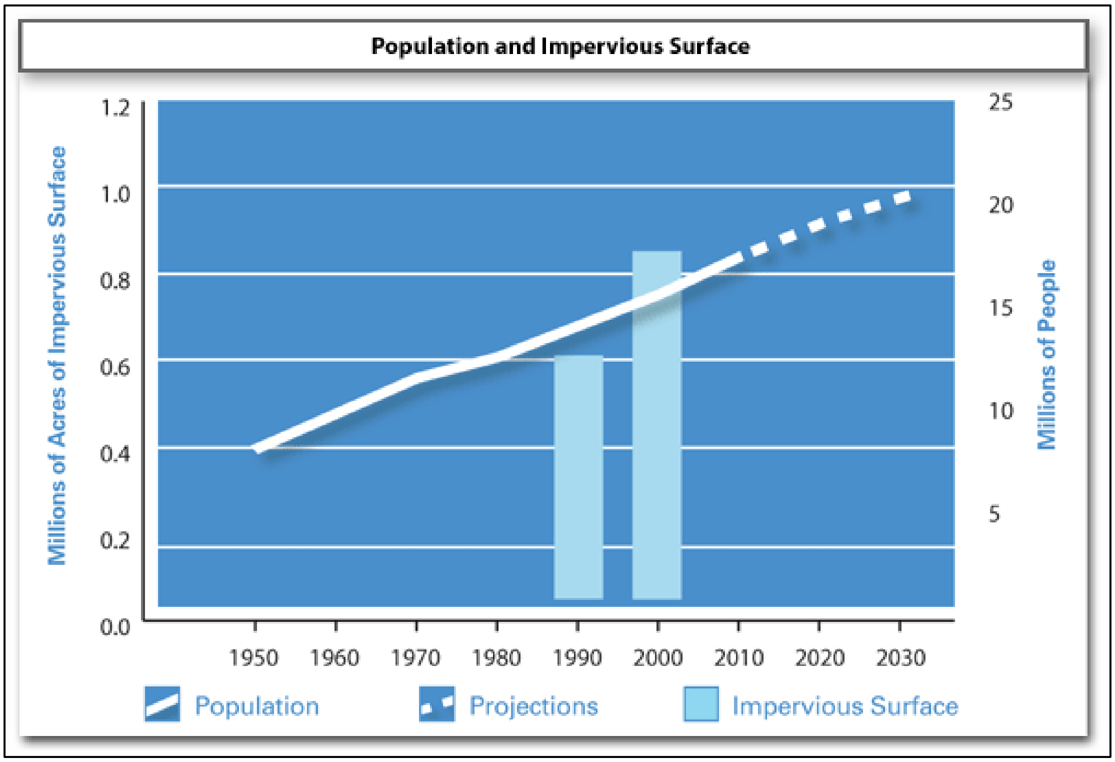
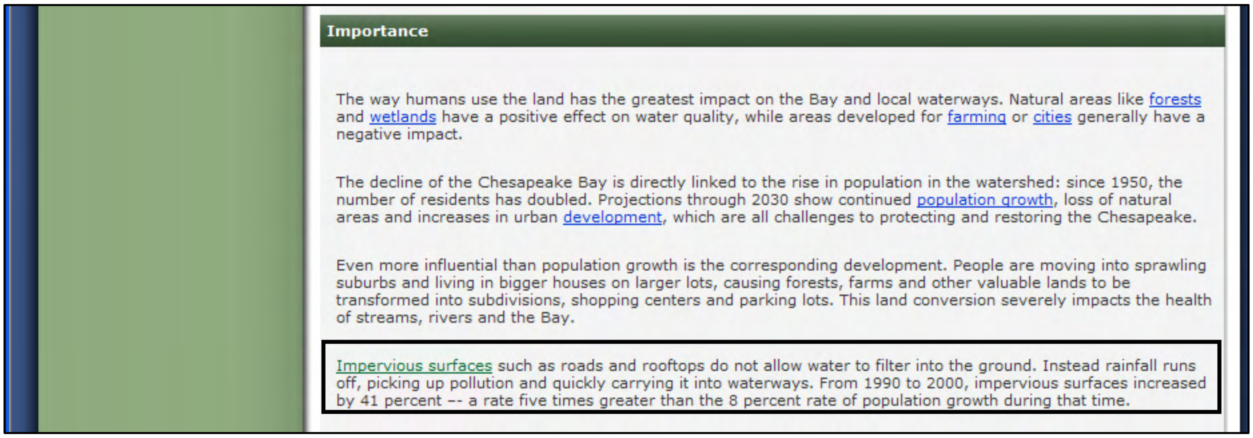


Figure 1. Bay Watershed Population and Impervious Surface.
(Source: http://www.chesapeakebay.net/status_population.aspx?menuitem=19842 Last accessed 2/20/2010)



Importance

The way humans use the land has the greatest impact on the Bay and local waterways. Natural areas like forests and wetlands have a positive effect on water quality, while areas developed for farming or cities generally have a negative impact.

The decline of the Chesapeake Bay is directly linked to the rise in population in the watershed: since 1950, the number of residents has doubled. Projections through 2030 show continued population growth, loss of natural areas and increases in urban development, which are all challenges to protecting and restoring the Chesapeake.

Even more influential than population growth is the corresponding development. People are moving into sprawling suburbs and living in bigger houses on larger lots, causing forests, farms and other valuable lands to be transformed into subdivisions, shopping centers and parking lots. This land conversion severely impacts the health of streams, rivers and the Bay.

Impervious surfaces such as roads and rooftops do not allow water to filter into the ground. Instead rainfall runs off, picking up pollution and quickly carrying it into waterways. From 1990 to 2000, impervious surfaces increased by 41 percent -- a rate five times greater than the 8 percent rate of population growth during that time.

Figure 2. Text from http://www.chesapeakebay.net/status_population.aspx?menuitem=19842.
Last accessed 2/20/2010

This claim has been cited in numerous articles, presentations, discussions, and legislation. A selection of these documents follows (also see Appendix A):

Senate Bill S.1816, *A Bill to Amend the Federal Water Pollution Control Act to Improve and Reauthorize the Chesapeake Bay Program*, submitted by Senator Cardin [D-MD], and H.R.3852, of the same name, submitted by Representative Cummings [D-MD]:

> "(13) during the period beginning in 1990 and ending in 2000, impervious cover, the hardened surfaces through which water cannot penetrate, increased by nearly 250,000 acres, about 41 percent, or the size of 5[3] Districts of Columbia;
> (14) during that period, the watershed population of the Chesapeake Bay grew by just 8 percent."

Testimony of J. Charles Fox, Senior Advisor to Administrator Lisa P. Jackson, U.S. Environmental Protection Agency before the Subcommittee on Water Resources and Environment Committee on Transportation and Infrastructure, U.S. House of Representatives (9/22/2009):

> "Impervious surfaces, such as roads and rooftops, increased by 41% compared to an 8% increase in population from 1990-2000."

National Resources Conservation Service Memorandum (9/25/2009):

> "130,000 new residents per year move into the Bay watershed. For every 8% increase in the population impervious surfaces (roads, parking lots, etc.) increase by 41%."

National Resources Defense Council, *NRDC's Plan to Clean Up the Chesapeake Bay and Its Beaches* (October 2009):

> "Between 1990 and 2000, the population in the Bay watershed increased 8 percent, while developed areas increased by a disproportionate 41 percent."

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[3] U.S. Census Bureau data from http://quickfacts.census.gov/qfd/states/11000.html, last accessed on February 23, 2010, indicates that the land area of the District of Columbia is 61.40 square miles, or 39,296 acres. Based on this information, 250,000 acres is approximately 6.4 times the size of the District of Columbia.

Kim Coble, Maryland Executive Director of the Chesapeake Bay Foundation, *An Op-Ed Response – Chesapeake Bay Foundation: New Stormwater Rules Won't Increase Costs* (*Center Maryland* article posted to its website on February 12, 2010)*:*

> "Between 1990 and 2000 alone, our region's population grew by 8%, but the amount of land paved or covered with buildings and concrete increased by 41%."

REVIEW OF THE POPULATION INCREASE CLAIM

In reviewing the population component of the data used to create Chart 1, WSSI found a discrepancy between the population data file and the Website claim. The file named, "population2008.xls,"[4] indicates that the population of the Chesapeake Bay watershed grew by **10.3%** during the 1990-2000 time period, rather than 8% as stated on the website from which the file was downloaded. (The file indicates that the information was updated 2/2/09.)

We believe this 10.3% estimate is correct based on our analysis of U.S. Census data. WSSI downloaded data from http://www.census.gov[5] for each county within the Chesapeake Bay watershed to determine the population increase from 1985 to 2008. In instances where a county was bisected by the watershed boundary, the population within the county was calculated as the total county population times the ratio of the land within the watershed to the total countywide acreage. WSSI recognizes that this methodology inherently introduces error into the equation, but the resulting population data matches well with the data in the "population2008.xls" file downloaded from the chesapeakebay.net website. Therefore, we concur with the data presented therein (with the aforementioned caveat that the chesapeakebay.net website statement does not match the available downloadable data from the same website.

We also note that we calculated these population figures using county boundaries from Environmental Systems Research Institute, Inc. (ESRI) and checked them against calculations utilizing U.S. Census Topograhically-Integrated Geographic Encoding and Referencing (TIGER) system boundaries from 1990, 2000, and 2008. The variances between the two methods were less than 1% in all cases except for Delaware (which had variances up to 18.5%). Since the overall watershed variation was less than 0.5%, we did not investigate the variances in further detail, and we incorportated the population data that utilized the ESRI boundaries into this analysis.

REVIEW OF THE IMPERVIOUS AREA INCREASE CLAIM

In reviewing the population increase vs. impervious area increase claim, however, it has become apparent that the percent change in impervious area shown in Chart 1 does not match the percent change in impervious area calculated using information from the Phase 5.2 Chesapeake Bay Watershed Model (the "Phase 5.2 model"), which was the latest model available at the time of this review and therefore, presumably, the most accurate. This presumption is corroborated by the data sources used to create the two data sets. The impervious area data used to create Chart

[4] Downloaded from http://www.chesapeakebay.net/status_population.aspx?menuitem=19842 on February 19, 2010.
[5] Specifically, WSSI downloaded the files: http://www.census.gov/popest/archives/1980s/e8089co.xls, http://www.census.gov/popest/archives/1990s/CO-99-08.html, http://www.census.gov/popest/counties/files/CO-EST2008-alldata.pdf, and http://www.census.gov/popest/counties/files/CO-EST2008-ALLDATA.csv

1, above, came from the University of Maryland's Regional Earth Sciences Applications Center (RESAC). However, the impervious area data used within the Phase 5.2 model came from:

- (RESAC) 2000 land cover data;
- USGS's 1992 National Land Cover Dataset (NLCD);
- Agricultural Census data;
- Population and Housing Census data;
- GIS road network overlays (Tele Atlas 2004);
- Maryland construction permit data; and
- National Pollutant Discharge Elimination System (NPDES) permit data.[6]

WSSI IMPERVIOUS AREA INCREASE METHODOLOGY

WSSI used the Phase 5.2 Chesapeake Bay Community Watershed Model (the "Phase 5.2 Model") results from the file, "P52_Loads-Acres_111609.xls," dated January 4, 2010, downloaded from ftp://ftp.chesapeakebay.net/Modeling/phase5/Phase52_Loads-Acres-BMPs/, as the basis for determining the percent increase in impervious area.

The "IU" (impervious urban) category in the Phase 5.2 model is comprised of the "imh" (high-intensity impervious urban) and "iml" (low-intensity impervious urban) categories. WSSI graphed the IU category for the three years simulated with the Phase 5.2 model (1985, 2002, and 2008) to determine the percentage increase in impervious area over the entire Chesapeake Bay watershed between 1985 and 2008:

	1985	2002	2008	Increase 1985-2008
imh	375,013	467,712	512,327	36.6%
iml	260,037	332,505	366,547	40.9%
IU	**635,050**	**800,217**	**878,874**	**38.4%**

Table 1. Impervious area in the Chesapeake Bay watershed based on the Phase 5.2 Chesapeake Bay Model.

WSSI then performed a linear interpolation between 1985 and 2002 to determine the percentage increase between 1990 and 2000 (because the 5.2 Model only provides data for 1985, 2002, and 2008):

Overall Chesapeake Bay Watershed	1985	1990	2000	2002	Increase 1990-2000
IU with Linear Interpolation	635,050	**683,628**	**780,785**	800,217	**14.2%**[7]

Table 2. Linear interpolation of the impervious area in the Chesapeake Bay watershed (based on the Phase 5.2 Chesapeake Bay Model) between 1985 and 2002.

[6] USEPA, (U.S. Environmental Protection Agency). 2008. *Chesapeake Bay Phase 5 Community Watershed Model*. **In preparation** EPA XXX-X-XX-008. U.S. Environmental Protection Agency, Chesapeake Bay Program Office, Annapolis MD. January 2008.

[7] As a verification, a polynomial interpolation of the same data yielded a similar, although slightly higher, increase in impervious area change: 15.1%

WSSI performed the same calculations for the District of Columbia and each state within the Chesapeake Bay watershed.

RESULTS OF IMPERVIOUS AREA ANALYSIS

The results of WSSI's analysis for the individual states, as well as for the Chesapeake Bay watershed as a whole, are shown in the following table and charts (also see Appendix B):

Jurisdiction (portion within the Chesapeake Bay watershed)	1990		2000	
	Population	Impervious Area (acres)	Population	Impervious Area (acres)
Chesapeake Bay Watershed	14,250,226	683,628	15,715,448	780,785
Delaware	138,211	7,952	170,282	10,212
District of Columbia	606,900	17,588	572,059	17,919
Maryland	4,748,709	210,980	5,258,913	242,976
New York	684,310	27,852	669,549	28,874
Pennsylvania	3,395,524	191,390	3,579,049	211,755
Virginia	4,494,087	220,001	5,250,248	259,530
West Virginia	182,486	7,866	215,348	9,519

Table 3. Population and area data for the Chesapeake Bay watershed and individual states (based on the Phase 5.2 Chesapeake Bay model) for 1990 and 2000.

Jurisdiction (portion within the Chesapeake Bay watershed)	Population Increase (1990-2000) (%)	Impervious Area Increase (1990-2000) (%)
Chesapeake Bay Watershed	10.3%	14.2%
Delaware	23.2%	28.4%
District of Columbia	-5.7%	1.9%
Maryland	10.7%	15.2%
New York	-2.2%	3.7%
Pennsylvania	5.4%	10.6%
Virginia	16.8%	18.0%
West Virginia	18.0%	21.0%

Table 4. Population and area increases between 1990 and 2000 (based on a linear interpolation of the Phase 5.2 Chesapeake Bay model results).

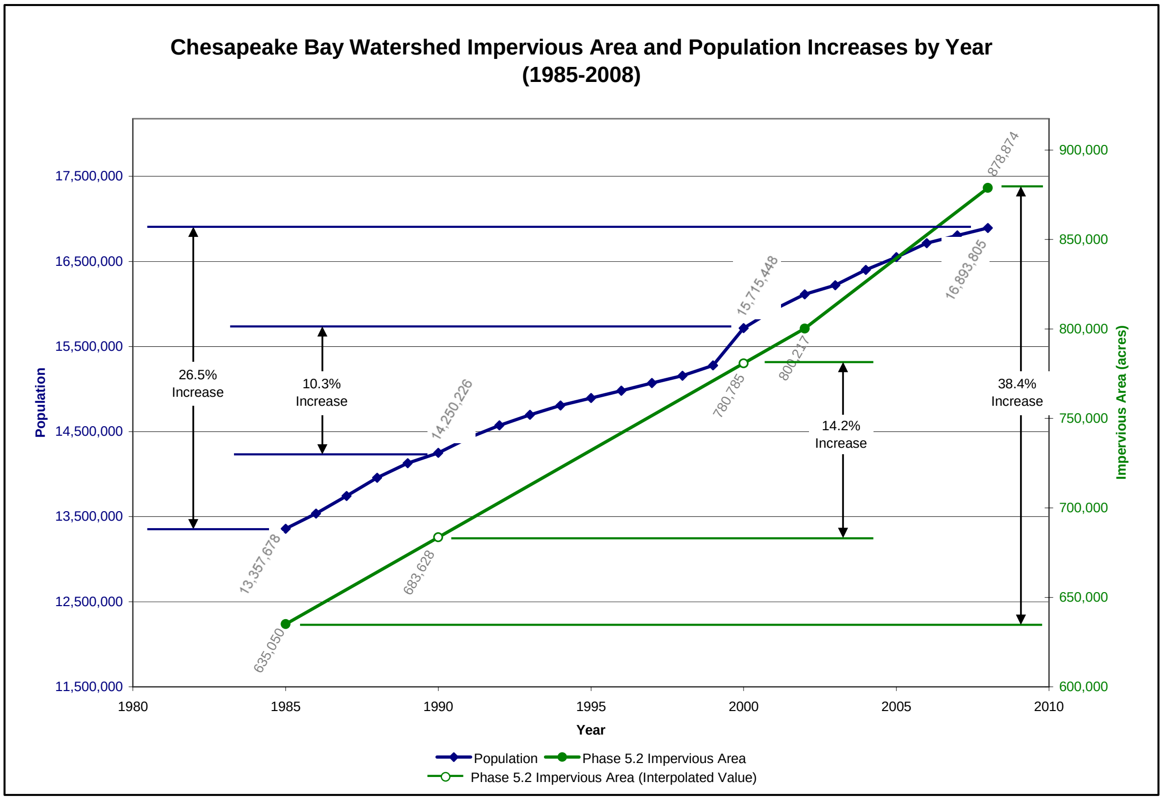

Figure 3. Chesapeake Bay watershed impervious area and population increases by year.

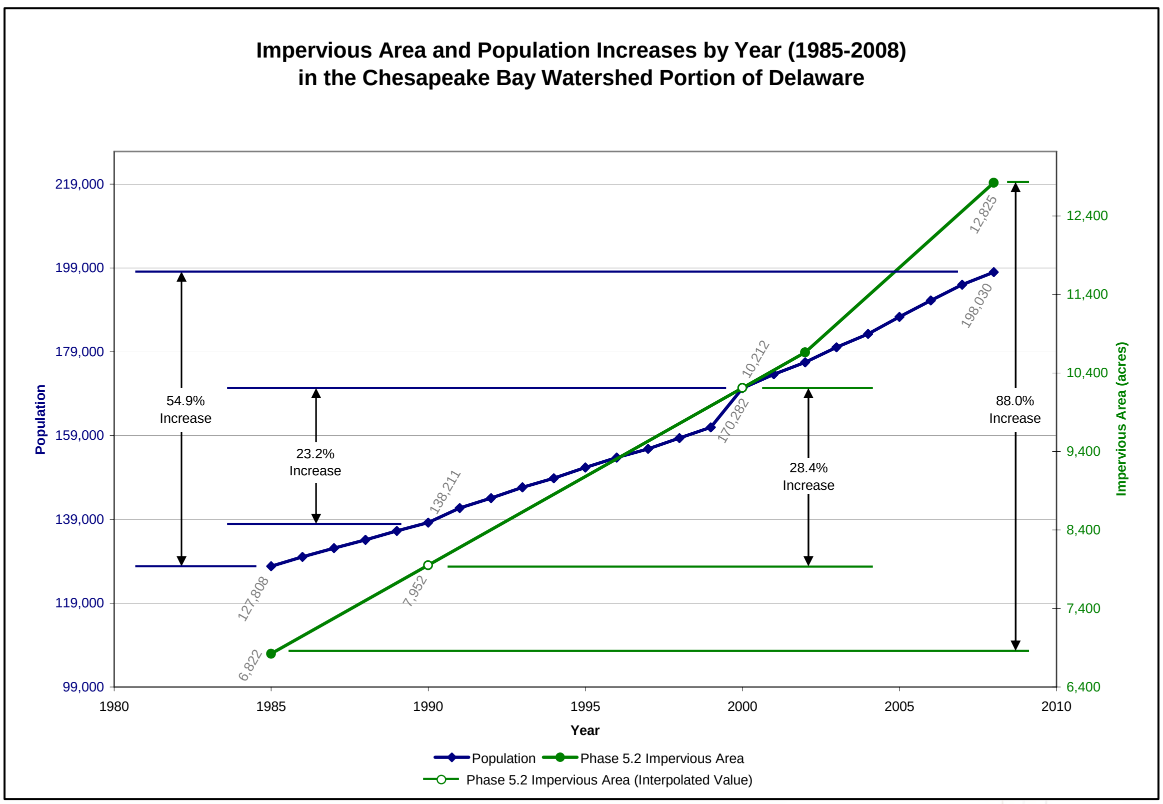

Figure 4. Delaware (within the Chesapeake Bay watershed) impervious area and population increase.

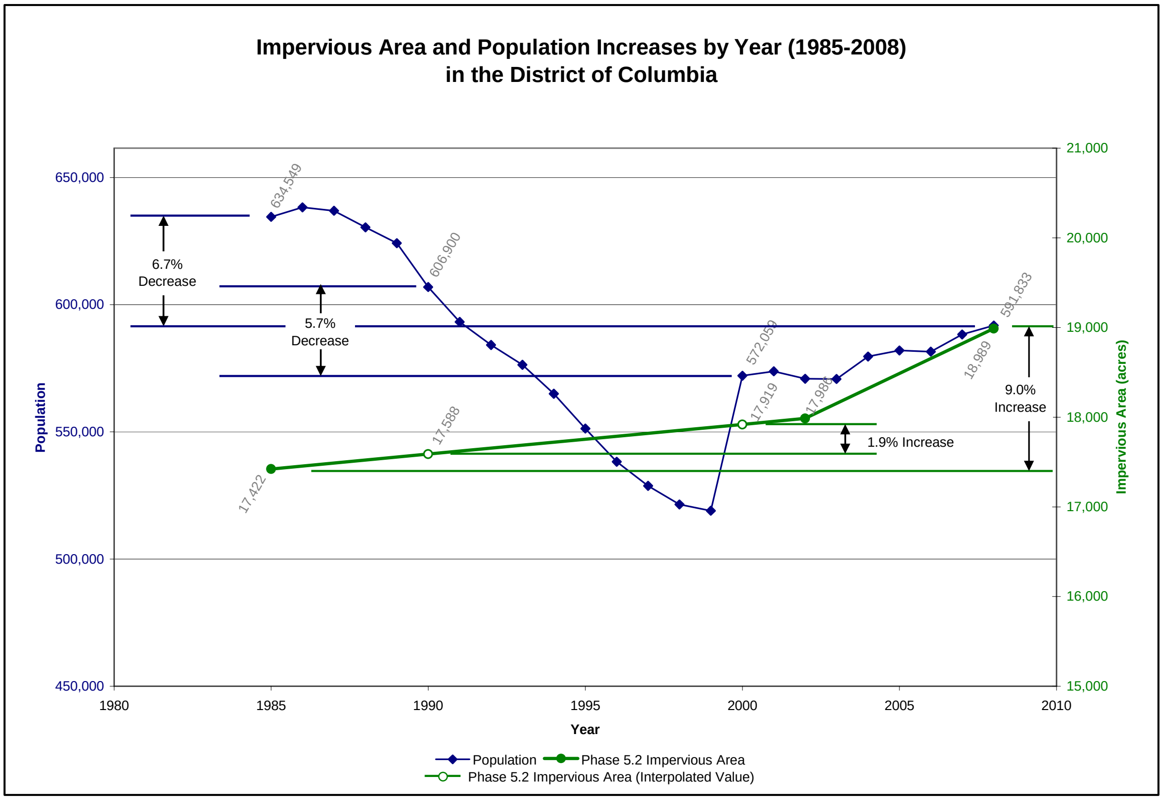

Figure 5. District of Columbia (within the Chesapeake Bay watershed) impervious area and population increase.

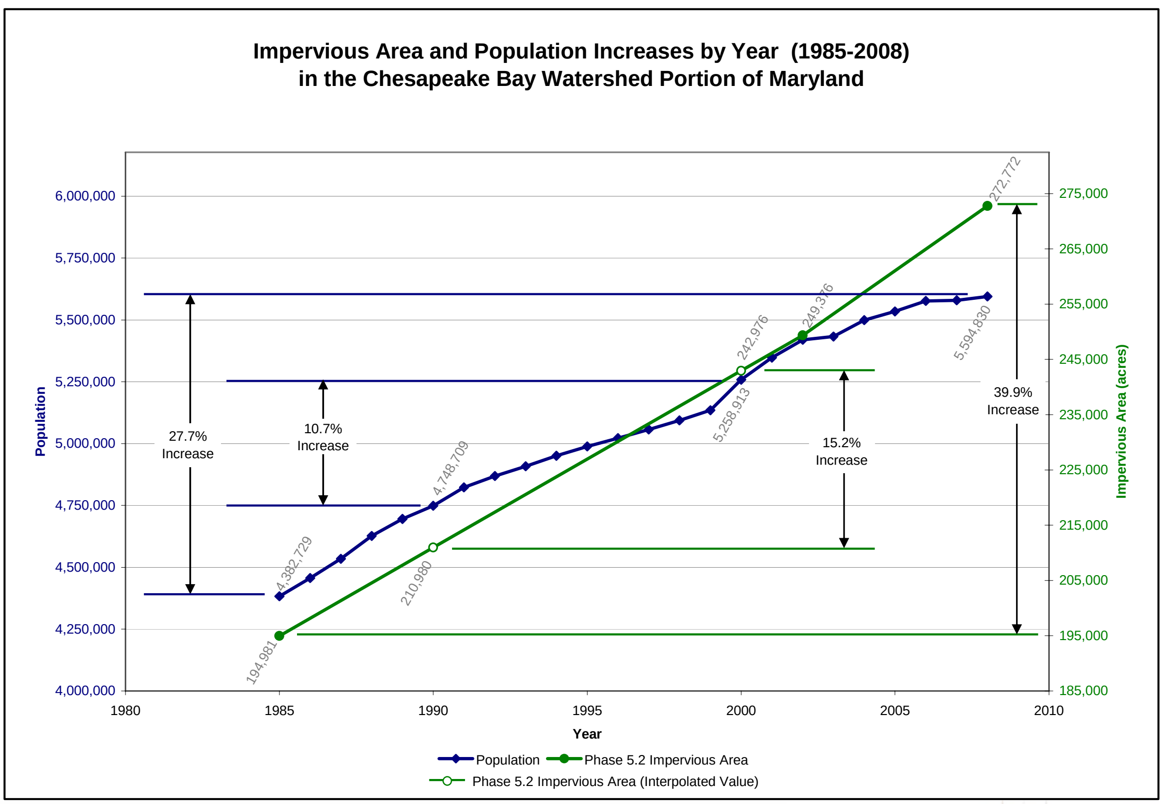

Figure 6. Maryland (within the Chesapeake Bay watershed) impervious area and population increase.

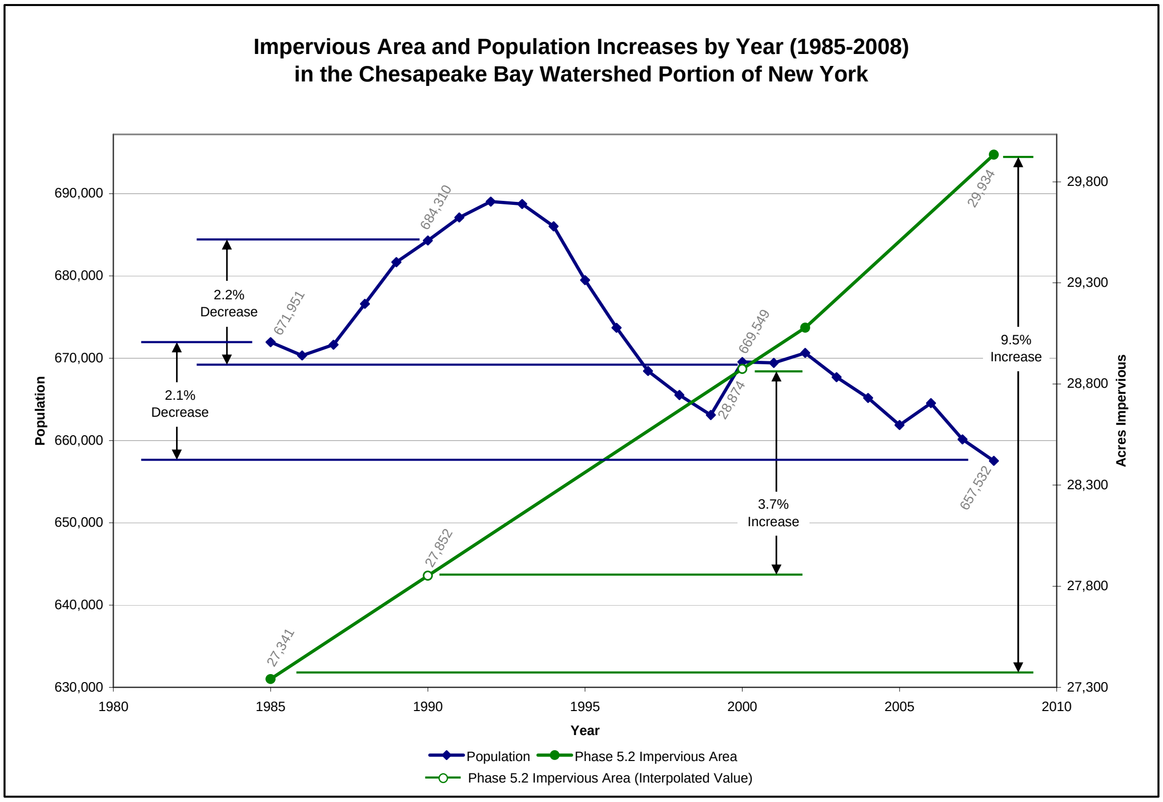

Figure 7. New York (within the Chesapeake Bay watershed) impervious area and population increase.

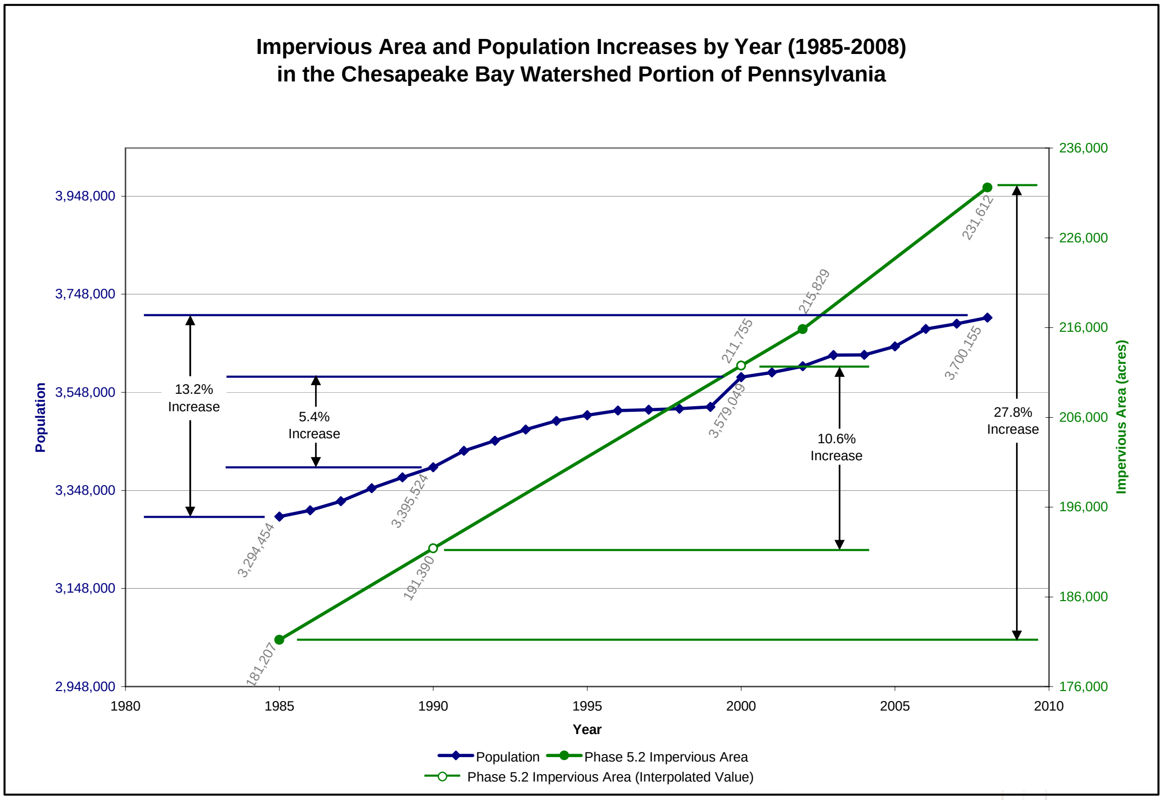

Figure 8. Pennsylvania (within the Chesapeake Bay watershed) impervious area and population increase.

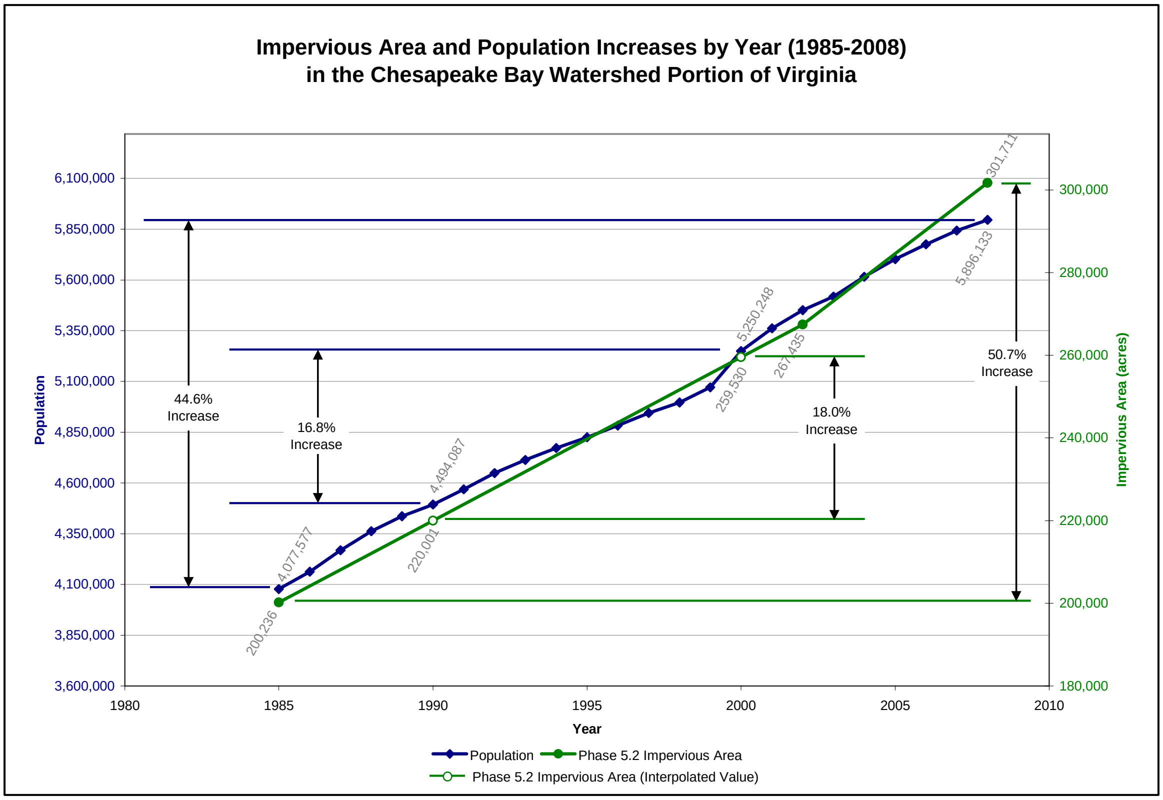

Figure 9. Virginia (within the Chesapeake Bay watershed) impervious area and population increase.

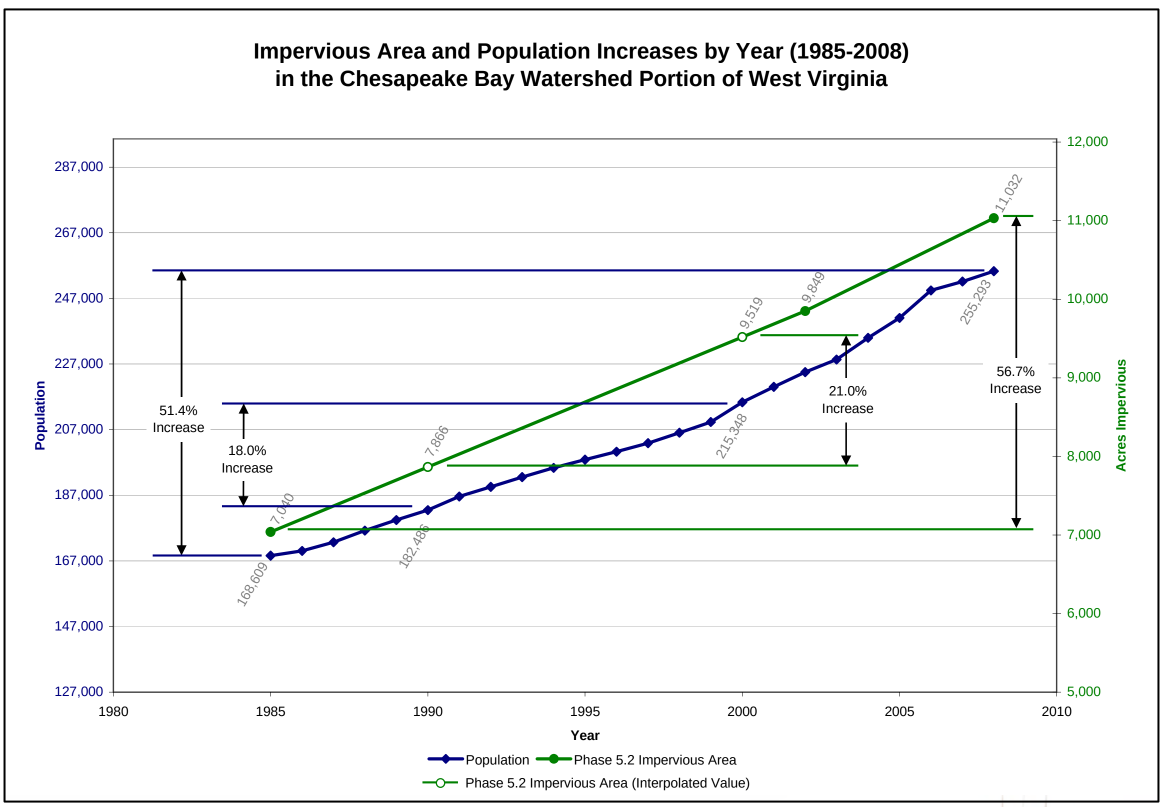

Figure 10. West Virginia (within the Chesapeake Bay watershed) impervious area and population increase.

CONCLUSION

We believe this discrepancy in population increase vs. impervious area increase occurred because the website and background data were not updated with new information as the model was revised. Timestamps on the background data sets used to determine the 41% increase indicate that the calculation was done in or around 2003. Documentation for the Phase 5.2 model indicates that the GIS dataset was updated with information from 2004 and beyond, thus making it more refined than the initial estimate.

Therefore, WSSI respectfully submits that the website should be revised to state that the population of the Chesapeake Bay watershed grew by 10.3% while the impervious area grew by 14.2%. Additionally, because this statistic has been used in so many venues, this new information should be broadcast to the general public, and S.1816/H.R.3852 should be revised to utilize the most up-to-date information:

> (13) during the period beginning in 1990 and ending in 2000, impervious cover, the hardened surfaces through which water cannot penetrate, increased by approximately 97,000 acres, about 14.2 percent, or the size of 2.5 Districts of Columbia;
>
> (14) during that period, the watershed population of the Chesapeake Bay grew by 10.3 percent.

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Appendix A

Sources Citing the Claim of 8% Population Increase and 41% Impervious Area Increase

1. Screen capture of www.chesapeakebay.net (http://www.chesapeakebay.net/status_population.aspx?menuitem=19842)

2. Senate Bill S.1816, *A Bill to Amend the Federal Water Pollution Control Act to Improve and Reauthorize the Chesapeake Bay Program*, submitted by Senator Cardin [D-MD], and H.R.3852, of the same name, submitted by Representative Cummings [D-MD] (pages 1-4 only)

3. Testimony of J. Charles Fox, Senior Advisor to Administrator Lisa P. Jackson, U.S. Environmental Protection Agency before the Subcommittee on Water Resources and Environment Committee on Transportation and Infrastructure, U.S. House of Representatives (9/22/2009)

4. National Resources Conservation Service Memorandum (9/25/2009)

5. National Resources Defense Council, *NRDC's Plan to Clean Up the Chesapeake Bay and Its Beaches* (October 2009)

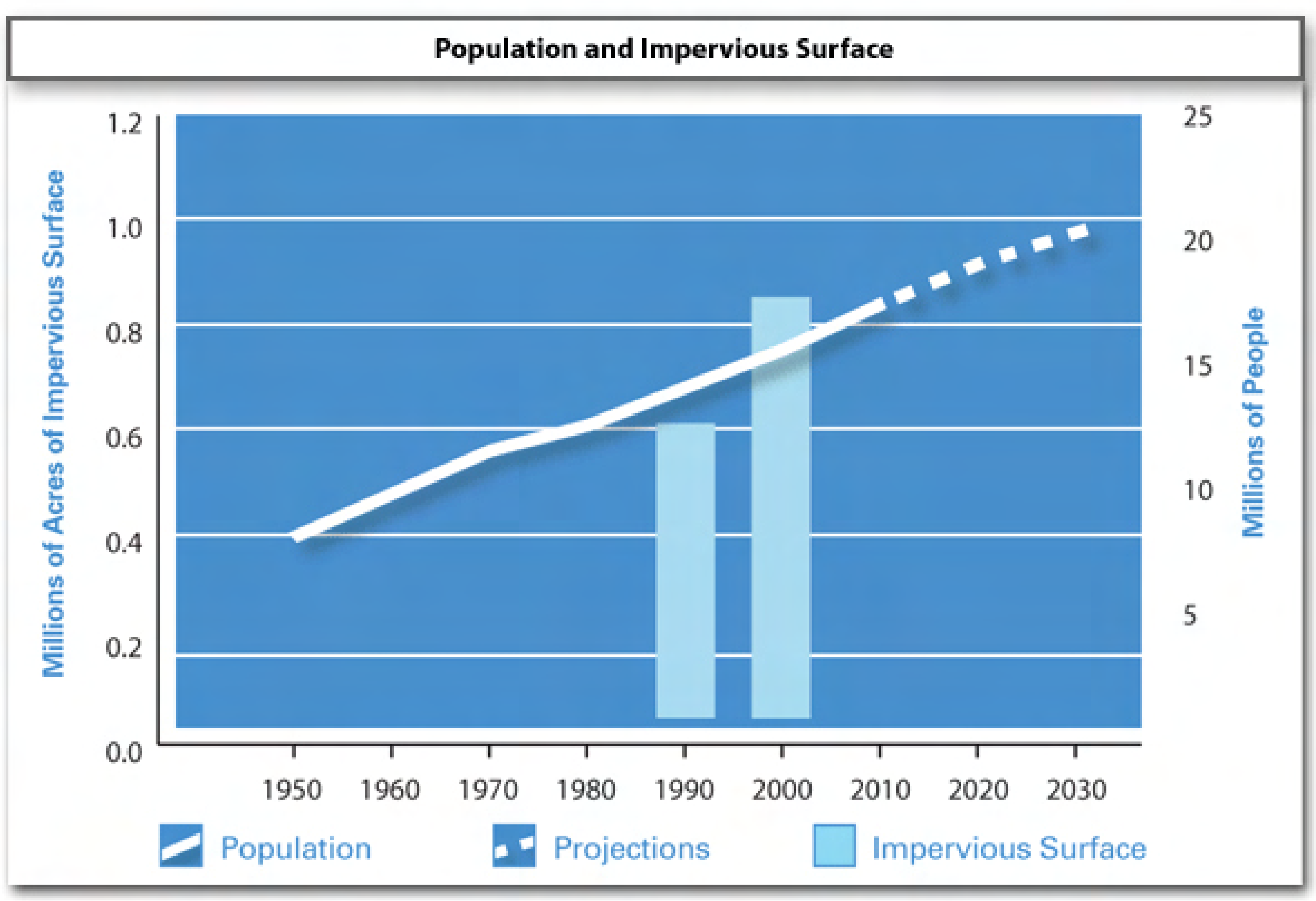
6. Kim Coble, Maryland Executive Director of the Chesapeake Bay Foundation, *An Op-Ed Response – Chesapeake Bay Foundation: New Stormwater Rules Won't Increase Costs* (*Center Maryland* article posted to its website on February 12, 2010)

Bay Watershed Population and Impervious Surface

16,797,132 people live in the watershed.

Assessment

By Chart | By Geography



Download Data File | Download This Slide | Download Analysis & Methods

Importance

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The decline of the Chesapeake Bay is directly linked to the rise in population in the watershed: since 1950, the number of residents has doubled. Projections through 2030 show continued population growth, loss of natural areas and increases in urban development, which are all challenges to protecting and restoring the Chesapeake.

Even more influential than population growth is the corresponding development. People are moving into sprawling suburbs and living in bigger houses on larger lots, causing forests, farms and other valuable lands to be transformed into subdivisions, shopping centers and parking lots. This land conversion severely impacts the health of streams, rivers and the Bay.

Impervious surfaces such as roads and rooftops do not allow water to filter into the ground. Instead rainfall runs off, picking up pollution and quickly carrying it into waterways. From 1990 to 2000, impervious surfaces increased by 41 percent â€"- a rate five times greater than the 8 percent rate of population growth during that time.

Goal

The indicator is not related to a goal at this time.

Trends

Long-term trend (since start of data collection)

From 1950 through 2007, the Bay watershed population increased from 8,385,982 to 16,797,132.

Short-term trend (10-year trend)

The 10-year trend is not available, since the most recent annual data points are 2000 through 2007. During this time, population increased from 15,700,408 to 16,797,132.

Change from previous year (2006-2007)

Population increased from 16,684,893 to 16,797,132.

Additional Information

Future Population Growth and Tracking

Experts predict that the watershedâ€™s population will increase to nearly 20 million by 2030.

In the future, the Bay Program will track change in developed area rather than change in impervious surfaces. Impervious surfaces are a sub-category of developed lands.

Population Growth vs. Impervious Surfaces

Short-term trend (10-year trend)

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Population Growth vs. Impervious Surfaces

The land area of the Chesapeake Bay watershed is 64,000 square miles or ~40.9 million acres. The total acreage of impervious surfaces in the watershed in 1990 was 602,766 acres and in 2000 was 848,727 acres â€"- an increase of 245,961 acres or 40.8 percent.

Variations in Population Growth

While the overall population of the Bay watershed continues to grow, population changes vary from state to state and region to region. Some areas are gaining population at a high rate, while populations in other areas are leveling out or declining.

Contact

For more information contact: Peter Claggett at 800-968-7229 ext. 771

Source of Data

Chesapeake Bay Program

For more information, contact the Chesapeake Bay Program Office:
410 Severn Avenue / Suite 109 / Annapolis, Maryland 21403
Tel: (800) YOUR-BAY / Fax: (410) 267-5777 | Directions to the Bay Program Office

II

111TH CONGRESS
1ST SESSION

S. 1816

To amend the Federal Water Pollution Control Act to improve and reauthorize the Chesapeake Bay Program.

IN THE SENATE OF THE UNITED STATES

OCTOBER 20, 2009

Mr. CARDIN (for himself, Ms. MIKULSKI, Mr. CARPER, and Mr. KAUFMAN) introduced the following bill; which was read twice and referred to the Committee on Environment and Public Works

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A BILL

To amend the Federal Water Pollution Control Act to improve and reauthorize the Chesapeake Bay Program.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the ''Chesapeake Clean Water and Ecosystem Restoration Act of 2009''.

SEC. 2. FINDINGS.

Congress finds that—

(1) the Chesapeake Bay and the tributary waters of the Chesapeake Bay are natural resources of

outstanding ecological, economic, and cultural importance to the United States;

(2) for more than 20 years, the Federal Government and the States of the Chesapeake Bay Watershed, the Chesapeake Bay Commission, and various local government, scientific, and citizen advisory boards have worked through the Chesapeake Bay Program of the Environmental Protection Agency to develop an unparalleled body of scientific information and cooperative partnerships to advance the Chesapeake Bay restoration effort;

(3) despite significant efforts by Federal, State, and local governments and other interested parties, water pollution in the Chesapeake Bay prevents the attainment of existing State water quality standards and the ecological goals of the Federal Water Pollution Control Act (33 U.S.C. 1251 et seq.);

(4) the Chesapeake Bay Program partnership has developed a rich body of environmental data based on an extensive network of monitors, which provide a critical measure of success in attainment of the goals of the restoration effort;

(5) the Chesapeake Bay Program partnership has also developed some of the world's foremost

water quality and ecosystem computer models, which are invaluable planning tools for resource managers;

(6) the major pollutants affecting the water quality of the Chesapeake Bay and related tidal waters are nitrogen, phosphorus, and sediment;

(7) the largest developed land use in the Chesapeake Bay watershed, and the largest single-sector source of nitrogen, phosphorus, and sediment pollution, is agriculture;

(8) conservation practices have resulted in significant reductions in pollution loads from the agricultural sector;

(9) to speed continued progress in the agricultural sector, the Federal Government and State governments have initiated a number of agricultural conservation programs, including the Chesapeake Bay watershed initiative under section 1240Q of the Food Security Act of 1985 (16 U.S.C. 3839bb–4);

(10) atmospheric deposition of nitrogen oxides and ammonia on the Chesapeake Bay watershed contributes as much as ⅓ of the nitrogen pollution in the Chesapeake Bay;

(11) for years, a steady stream of technology development and increasingly stringent permit requirements have resulted in a steady decline in the

nitrogen and phosphorus pollution derived from wastewater treatment plants in the Chesapeake Bay watershed;

(12) suburban and urban development is the fastest growing land use sector in the Chesapeake Bay watershed, and stormwater runoff from that sector is the only major source of pollution in the watershed that is increasing;

(13) during the period beginning in 1990 and ending in 2000, impervious cover, the hardened surfaces through which water cannot penetrate, increased by nearly 250,000 acres, about 41 percent, or the size of 5 Districts of Columbia;

(14) during that period, the watershed population of the Chesapeake Bay grew by just 8 percent;

(15) the population of the watershed is estimated to be growing by about 157,000 people per year;

(16) continuing at that rate, the population will increase to nearly 20,000,000 by 2030;

(17) about 58 percent of the watershed of the Chesapeake Bay is undeveloped and mostly forested, but as many as 100 acres of forest are lost to development each day;

111TH CONGRESS
1ST SESSION

H. R. 3852

To amend the Federal Water Pollution Control Act to improve and reauthorize the Chesapeake Bay Program.

IN THE HOUSE OF REPRESENTATIVES

OCTOBER 20, 2009

Mr. CUMMINGS (for himself, Mr. CONNOLLY of Virginia, Mr. VAN HOLLEN, Mr. SARBANES, Mr. MORAN of Virginia, Ms. EDWARDS of Maryland, Ms. NORTON, Mr. SCOTT of Virginia, Mr. HOYER, Mr. OBERSTAR, and Ms. EDDIE BERNICE JOHNSON of Texas) introduced the following bill; which was referred to the Committee on Transportation and Infrastructure

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(3) despite significant efforts by Federal, State, and local governments and other interested parties, water pollution in the Chesapeake Bay prevents the attainment of existing State water quality standards and the ecological goals of the Federal Water Pollution Control Act (33 U.S.C. 1251 et seq.);

(4) the Chesapeake Bay Program partnership has developed a rich body of environmental data based on an extensive network of monitors, which provide a critical measure of success in attainment of the goals of the restoration effort;

(5) the Chesapeake Bay Program partnership has also developed some of the world's foremost

water quality and ecosystem computer models, which are invaluable planning tools for resource managers;

(6) the major pollutants affecting the water quality of the Chesapeake Bay and related tidal waters are nitrogen, phosphorus, and sediment;

(7) the largest developed land use in the Chesapeake Bay watershed, and the largest single-sector source of nitrogen, phosphorus, and sediment pollution, is agriculture;

(8) successful implementation of conservation practices have resulted in significant reductions in pollutant loads from the agricultural sector;

(9) to speed continued progress in the agricultural sector, the Federal Government and State governments have initiated a number of agricultural conservation programs, including the Chesapeake Bay watershed initiative under section 1240Q of the Food Security Act of 1985 (16 U.S.C. 3839bb–4);

(10) atmospheric deposition of nitrogen oxides and ammonia on the Chesapeake Bay watershed contributes as much as ⅓ of the nitrogen pollution in the Chesapeake Bay;

(11) for years, a steady stream of technology development and increasingly stringent permit requirements have resulted in a steady decline in the

nitrogen and phosphorus pollution derived from wastewater treatment plants in the Chesapeake Bay watershed;

(12) suburban and urban development is the fastest growing land use sector in the Chesapeake Bay watershed, and stormwater runoff from that sector is the only major source of pollution in the watershed that is increasing;

(13) during the period beginning in 1990 and ending in 2000, impervious cover, the hardened surfaces through which water cannot penetrate, increased by nearly 250,000 acres, about 41 percent, or the size of 5 Districts of Columbia;

(14) during that period, the population of the Chesapeake Bay watershed grew by just 8 percent;

(15) the population of the watershed is estimated to be growing by about 157,000 people per year;

(16) continuing at that rate, the population will increase to nearly 20,000,000 by 2030;

(17) about 58 percent of the watershed of the Chesapeake Bay is undeveloped and mostly forested, but as many as 100 hundred acres of forest are lost to development each day;

TESTIMONY OF J. CHARLES FOX
SENIOR ADVISOR TO ADMINISTRATOR LISA P. JACKSON
U.S. ENVIRONMENTAL PROTECTION AGENCY
BEFORE THE
SUBCOMMITTEE ON WATER RESOURCES AND ENVIRONMENT
COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE
U.S. HOUSE OF REPRESENTATIVES

September 22, 2009

Madame Chairwoman and members of the Subcommittee, I am J. Charles Fox, Senior Advisor to Administrator Lisa P. Jackson at the U.S. Environmental Protection Agency (EPA). Thank you for the invitation to speak today on reauthorizing the Chesapeake Bay Program. We appreciate greatly the leadership of this Subcommittee on the Chesapeake and we look forward to working closely with you in the weeks and months ahead.

Our testimony will describe the actions of EPA and other federal agencies in implementing President Obama's Executive Order on Chesapeake Bay Protection and Restoration. Collectively, the federal family is committed to a new generation of federal leadership which is characterized by new levels of accountability, performance, partnership and innovation to help protect and restore the Bay and its tributaries to a healthy condition.

<u>The Scope and Complexity of the Watershed and Bay</u>

The Chesapeake Bay watershed encompasses 64,000 square miles, parts of six States and the District of Columbia. Nearly 17 million people live in the watershed. The land mass of the Bay watershed is sixteen times the size of the Bay, a ratio higher than any other estuary in the world. This means that our actions on the land have a profound impact on our local streams, rivers and, ultimately the Bay.

The Chesapeake Bay is the largest estuary in North America and is ecologically, economically and culturally critical to the region and the country. It is home to more than 3,600 species of fish, plants and animals. For more than 300 years, the Bay and its tributaries have sustained the region's economy and defined its traditions and culture. The economic value of the Bay is estimated at more than $1 trillion[1] and two of the five largest Atlantic ports (Baltimore and Norfolk) are located in the Bay.

<u>The Health of the Bay</u>

In March 2009, the Chesapeake Bay Program issued its annual Health and Restoration Assessment of the Chesapeake Bay and Watershed, also referred to as the "Bay Barometer." A copy of the Executive Summary has been provided to the Chair and Members of the Subcommittee.

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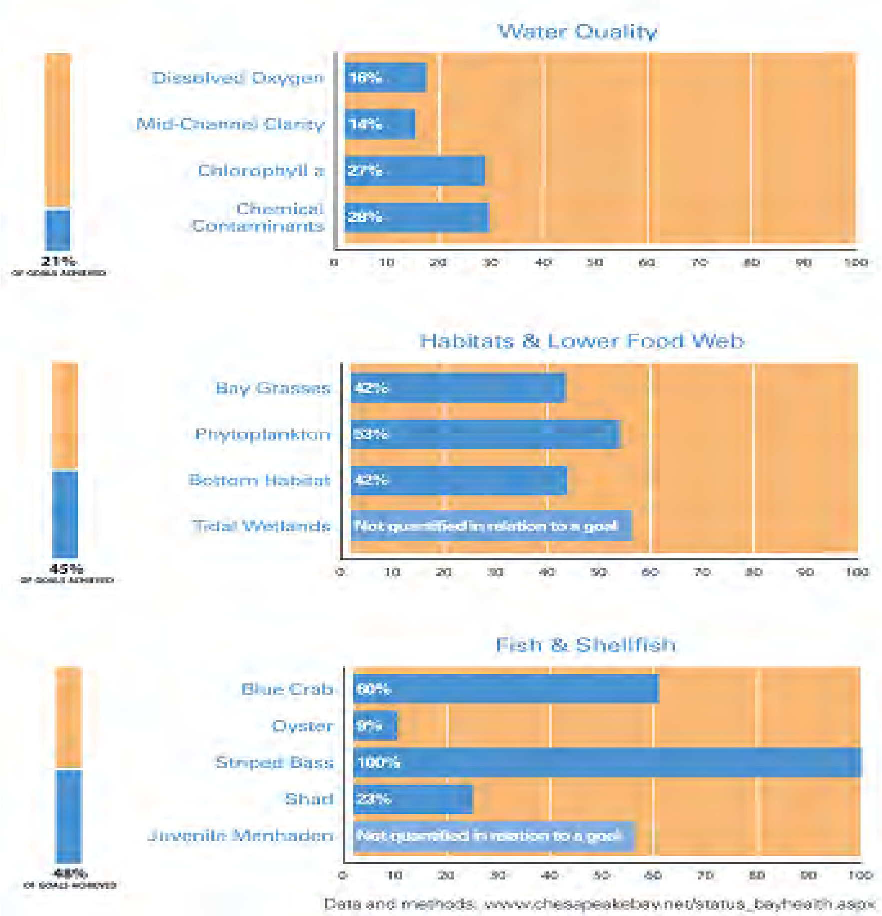
[1] *Saving a National Treasure: Financing the Cleanup of the Chesapeake Bay*, A Report to the Chesapeake Bay Executive Council, Chesapeake Bay Blue Ribbon Finance Panel, October 27, 2004

The Bay Barometer affirms what we all know. Despite the impressive restoration work done by the array of partners, the health of the Bay and watershed remains severely degraded. The data included in this report are sobering. Virtually all of the 13 measures which comprise Bay health show very limited progress (water quality, habitats and lower food web and fish and shellfish) (see Figure 1). There have been positive improvements in the population of striped bass, which is generally attributed to the actions by Maryland, Virginia and other east coast states to limit harvest pressure years ago, although this population has been stressed in recent years by a high incidence of mycobacteriosis.

Figure 1. Chesapeake Bay Measures of Health Progress (2008)



In general, the Bay Program partners have made some important – but not sufficient -- progress to reduce nutrient pollution from agriculture and wastewater treatment plants. Agriculture is the single largest source of nutrient and sediment pollution to the Bay, with about half of that load directly related to animal manure. However, the pollution from urban and suburban stormwater has an increasingly large impact on the Bay's water quality.

The negative trend in nutrient and sediment pollution from stormwater is directly linked to the rise in population and land use patterns in the watershed. Since 1950, the number of residents has doubled. Experts predict that population will continue to rise through the next three decades, topping 19 million in 2020.

Impervious surfaces, such as roads and rooftops, increased by 41% compared to an 8% increase in population from 1990-2000. Low density, disconnected development -- commonly referred to as sprawl -- has been the predominant form of development in the Bay watershed for the past several decades. New development that is spread-out, far from existing communities, schools, wastewater treatment facilities, shopping, and jobs explains the disparity between the rate of population growth and the increase in impervious surfaces.

Impervious surfaces do not allow water to filter into the ground. Instead, rainfall runs off, picking up pollution and quickly carrying it into waterways. Projections through

2030 show continued population growth, which could result in the loss of natural areas if we continue the development patterns of recent decades. People are coming to the Chesapeake Bay watershed. Where and how these people are accommodated will have a profound influence on the health of the Bay.

Executive Order 13508

On May 12, 2009, President Obama presented all citizens who cherish the Chesapeake with an historic opportunity when he signed an Executive Order on Chesapeake Bay Protection and Restoration, directing a new era of federal leadership on the Chesapeake Bay. The Executive Order acknowledged that the efforts of the past 25 years to reduce pollution and clean up the Bay and its tributaries have yielded some progress. However, it concluded that the poor health of the Chesapeake remains one of our nation's most significant environmental challenges. Indeed, Administrator Jackson has emphasized repeatedly that communities in the Chesapeake Bay watershed expect and deserve rivers and streams that are healthy and thriving.

The Executive Order created a Federal Leadership Committee, chaired by EPA, to strengthen the role of the federal government in the Bay restoration and align the capabilities of EPA, and Departments of the Interior, Commerce, Agricultural, Defense, Homeland Security, and Transportation. The Order directed federal agencies to prepare seven draft reports within 120 days addressing key challenges to the Chesapeake Bay, ranging from improving water quality to expanding public access to the Bay and its tributaries. Last week, the Federal Leadership Committee received the seven draft reports for review. The draft reports focus on a number of recommendations that include:

- **Define the next generation of tools and actions to restore water quality** in the Chesapeake Bay and describe changes to be made to regulations, programs and policies to implement these actions (led by EPA).
- **Target resources** to better protect the Chesapeake Bay and its rivers (led by USDA).
- **Strengthen storm water management practices** at federal facilities and on federal lands within the Chesapeake Bay watershed and develop storm water best practices guidance (led by DOD).
- **Assess the impacts of climate change** and develop a strategy for adapting to those impacts on water quality and living resources (led by DOI and NOAA).
- **Expand public access** to waters and open spaces of the Bay and its tributaries (led by DOI).
- **Strengthen monitoring** and decision support for ecosystem management (led by DOI and NOAA).
- Focus and coordinate habitat and research activities that **protect and restore living resources** and water quality (led by DOI and NOAA).

The draft reports are available online at: http://executiveorder.chesapeakebay.net

The reports outline four broad tenets of new federal leadership:

1. Increasing accountability and performance from pollution control, habitat protection and land conservation programs at all levels of government;
2. Expanding use of regulatory authorities to assure reductions in nitrogen, phosphorus and sediment pollution to the Bay and its tributaries;
3. Expanding targeting of technical and financial resources to improve efficiency and secure better outcomes; and,

4. Harnessing technological innovations and making these tools accessible and meaningful to the states, D.C. and local communities whose decisions are fundamental to protection and restoration of the Bay.

<u>Draft 202(a) Report on Water Quality</u>

The Executive Order's draft report on water quality, which was prepared by EPA, defined three principal mechanisms to achieving water quality objectives in Chesapeake Bay and its tributaries:

1. Create a new accountability program to guide federal and state water quality efforts;
2. Initiate new federal rulemakings and other actions under the Clean Water Act and other authorities; and,
3. Establish an enhanced partnership between USDA and EPA to implement a "Healthy Bay – Thriving Agriculture" Initiative.

The proposed new accountability framework builds on Sections 117(g) and the "Total Maximum Daily Load" (TMDL) provisions under section 303(d) of the Clean Water Act to set new expectations to guide state and federal efforts for reducing nutrient and sediment pollution. Specifically, EPA proposes to define more precisely the criteria it would use to approve implementation strategies, including its intention to rely heavily upon enforceable or otherwise binding programs.

The proposed accountability framework also proposes that EPA would identify a number of potential consequences that it may use in the event that jurisdictions do not commit to establish and implement effective restoration programs or do not achieve interim milestones. These consequences would include, but are not limited to:

- Revising the draft or final pollutant reduction allocations in the Bay TMDL that EPA will establish in December 2010 to assign more stringent pollutant reduction responsibilities to point and non-point sources of nutrient and sediment pollution;
- Objecting to state-issued CWA National Pollutant Discharge Elimination System (NPDES) permits;
- Acting to limit or prohibit new or expanded discharges of nutrients and sediments;
- Withholding, conditioning, or reallocating federal grant funds; and,
- Taking other actions as appropriate.

The draft water quality report also cites potential changes in regulations under the Clean Water Act to reduce pollution from concentrated animal feeding operations (CAFOs), stormwater, and new or expanding discharges of nutrients and sediment. With these rulemakings, EPA would significantly strengthen or clarify federal requirements that would further limit nutrient and sediment discharges to the Bay.

In a rulemaking for CAFOs, EPA would consider a number of potential changes including regulating more animal feeding operations as CAFOs. EPA would also consider revising minimum nutrient management planning elements in the current CAFO rule to better define agricultural practices essential for load reductions based on sound science and adaptive management principles.

To deal with storm water – a growing and urgent issue – EPA would consider revising its stormwater regulations to include additional high-growth areas and establish stronger minimum performance standards in stormwater permits.

EPA would also consider a rulemaking to clarify, at a minimum, how permitting authorities can authorize new or increased discharges related to population growth and development in the context of managing overall pollutant loads into impaired waters. Such a rule could address how high priority point source load increases can be managed so that the resultant load will be protective of water quality standards and achieve the goals of the President's Chesapeake Bay Executive Order.

In addition to rulemakings, the draft water quality report contains recommendations for implementing a compliance and enforcement strategy focusing on four key sectors: concentrated animal feeding operations, stormwater discharges, wastewater treatment plants and air deposition sources of nitrogen regulated under the CAA, including power plants. Further, we will address pollutants from Superfund sites and RCRA facilities that are impacting the Bay where we are performing removal, remedial and corrective action activities. EPA would also ensure that states adhere to their schedules for installing nutrient removal technology at significant wastewater treatment plants throughout the watershed; develop and promote model state septic tank control programs and ensure states meet their commitment to reduce septic tank loadings to the Bay; and pursue an ambitious regulatory agenda that would significantly reduce atmospheric deposition of nitrogen to the Bay.

EPA and USDA would also develop and implement a "Healthy Bay-Thriving Agriculture Initiative" that would include:

- An intensive and strategic effort to expand the use of key conservation practices in the high priority watersheds in the Bay
- Coordination with other federal and state partners on the development of next generation nutrient management planning tools;
- Establishment of centerpiece projects in each of the Bay states to demonstrate benefits of significant and innovative conservation approaches to addressing key issues in the region; and
- Implementation of a targeted, collaborative initiative using USDA and EPA funds to support development of critically needed tools and technologies that can create new market and revenue streams that support the adoption of conservation measures.

All of these recommendations are part of new leadership on the Bay. Working closely with our partner agencies, we will fulfill President Obama's goal to restore this unique ecological, economic, and cultural resource.

Key Challenge Reports and Coordinated Strategy

The other reports called for under Section 202 of the Order provide the lead agencies' recommendations to address the additional key challenges identified in the Order:

- Targeting conservation practices
- Strengthening storm water management at Federal facilities
- Adapting to impacts of a changing climate
- Conserving landscapes
- Strengthening science for decision making
- Conducting habitat and research activities to improve outcomes for living resources.

In the next 60 days, the Federal Leadership Committee will evaluate the recommendations and consult with states and the District of Columbia. The Committee will revise, refine, and prioritize the recommendations, and develop the best plan for meeting key challenges. Later this fall, the Federal Leadership Committee will release, for public comment, a draft strategy that integrates the seven reports. All of this will culminate in a final strategy targeted for release on May 12, 2010 – one year after the President issued the Executive Order.

Let me stress that this is not the beginning and the end of our work on the Chesapeake. We will not just be reviewing reports for the next eight months. Federal agencies are continuing to implement important actions for restoration and protection and will continue to look for ways to move forward in implementing policies and programs before the strategy becomes final.

<u>Chesapeake Bay Program Reauthorization</u>

We applaud the Committee's leadership and look forward to offering you technical assistance to improve the performance and accountability of the Chesapeake Bay Program. EPA strongly supports reauthorization of the Chesapeake Bay Program and the opportunity to work with the Committee to make restoration and protection of the Bay happen more effectively and efficiently.

The Clean Water Act, Section 117, the Chesapeake Bay, was last authorized in 2000. It expired in 2005. This action by Congress was helpful in supporting the Chesapeake Bay Program and the Agreement adopted by the partners in 2000. But as we know now, the 2010 goals of that Agreement are not going to be achieved. Indeed, the goals of the original 1983 Agreement, which was the basis for the 1987 inclusion of Section 117, have not yet been achieved. We are hopeful that any reauthorization of the program will be supportive of and consistent with steps taken to date through our work to address the goals of the EO, and can put within our reach the goals of these agreements. This may necessitate significant changes to the program.

As noted earlier, the fundamental challenge for the Bay's water quality is reducing runoff pollution from urban, suburban and agricultural lands. In fact, urban and suburban runoff pollution to the Chesapeake is increasing, while agricultural pollution is not declining nearly enough as needed to restore the Bay. Presently, we have a range of tools that we are implementing to tackle these problems, and through our work to address the goals of the EO we have found potential ways to increase the number and effectiveness of the tools available to us. However, as we continue to think about Bay restoration and protection, we are also examining changes to our program's authorization that may provide even better results.

Our nation's modern history includes several successful models of pollution control. The Clean Air Act (CAA), for example, has produced significant improvements in air quality, despite sizable growth in population, energy consumption, and vehicle miles travelled. As we think about ways to further protect the bay, we are looking at a range of accountability mechanisms including provisions similar to those available in the Clean Air Act.

We look forward to working with the Subcommittee and other Members of Congress to explore these issues in the months ahead. A reauthorization of the Chesapeake Bay Program presents all of us with a unique opportunity to redefine our future, and we greatly appreciate the Subcommittee's leadership in this regard.

Closing

Across the Chesapeake Bay watershed, there have been important actions over the past 25 years - by farmers to implement nutrient management practices and install buffer strips and fences; by homeowners to reduce energy consumption and runoff pollution; by localities to upgrade wastewater treatment plants and to reduce stormwater pollution; by developers to implement sediment and erosion control plans and implement smart growth practices; by states to expand land conservation and strengthen their water quality protection programs. However these good efforts are simply not sufficient.

The straightforward conclusion is that the Chesapeake Bay ecosystem remains severely degraded, despite the concerted efforts by many for more than 25 years. However, all of these challenging conclusions are tempered by a strong sense of optimism we all share for the future. Scientists have learned much about the Bay and that knowledge is being used by managers to help plan and evaluate new policies and practices. Our region's elected officials are engaged as never before. At EPA and partner federal agencies, we have clear direction from the President to provide the leadership necessary to protect and restore the Bay.

Thank you again Chairwoman Johnson, and Members of the Subcommittee, for the opportunity to appear before you today. In the coming months, we look forward to working with you on reauthorization amendments for the Chesapeake Bay Program that meet our shared goals for protecting and restoring this national treasure.

United States Department of Agriculture
NRCS Natural Resources Conservation Service

Memorandum

Updated 09/25/2009

To: Interested Parties

From: Ann Mills, Deputy Under Secretary
Natural Resources & Environment
U.S. Department of Agriculture

Re: Release of USDA Report on Chesapeake Bay Executive Order

Date: September 10, 2009

The Chesapeake Bay is a national treasure with great historical, cultural and economic significance.

USDA is committed to taking action to aggressively implement voluntary measures and market-based solutions in the Chesapeake Bay.

On May 12, President Obama issued Executive Order 13508 on Chesapeake Bay Restoration and Protection, the first-ever presidential directive on the Bay. The Executive Order called on the Federal Government to exercise greater leadership and Federal action to restore this great resource.

Today, USDA and other Federal agencies are providing insights into our earliest thinking about possible Federal actions to improve the health of the Bay. This is the beginning of a deliberate and transparent process.

In addition to an annual investment of $90 million and additional $188 million over five years for voluntary conservation programs under the 2008 Farm Bill, under Secretary Vilsack's leadership, USDA is going further by elevating water quality as an important national priority.

Through the 202(b) Report being made available today, USDA recommends a series of important new actions to improve Bay water quality including the following:

- USDA will invest financial resources in watersheds that have demonstrated the highest levels of nutrient loadings, primarily nitrogen and phosphorus. This represents a clear departure from past policy.
- USDA will work with Federal and State partners to focus on high impact practices that show the greatest water quality improvement per dollar invested.
- USDA will accelerate adoption of conservation practices by increasing incentives and coordinating outreach and marketing efforts in order to reach the most critical agricultural areas and generate interest in conservation practice implementation.
- USDA will use emerging markets for ecosystems services to promote new opportunities for actions

such as carbon sequestration, water quality, wetland protection, and habitat development.

- USDA will accelerate development of new conservation technologies through public-private research partnerships and by promoting innovation.
- USDA will implement a sound system of accountability by establishing environmental outcome measures, monitoring and assessing water quality, and using science to adapt the strategy.

As USDA takes these broad steps to improve the health of the Bay, the Department is very concerned about the loss of agriculture and forestry lands in the watershed.

- About 25% of the Chesapeake Bay Watershed produces a diverse array of fresh vegetables, fruits, grain, dairy, beef, poultry and other products. Agricultural lands also anchor rural communities and provide important open space, wildlife habitat and other benefits important to the fabric of this unique watershed.
- The Chesapeake Bay Watershed is currently losing 100 acres of forestland everyday. These forests prevent millions of pounds of nutrients and sediment from reaching the Bay each year.
- 130,000 new residents per year move into the Bay watershed. For every 8% increase in the population impervious surfaces (roads, parking lots etc.) increase by 41%.
- A one-acre parking lot produces about 16 times the volume of runoff that comes from a one-acre meadow.

Agriculture and Forestry are preferred land uses in the Bay watershed. While agriculture has been making positive reductions in nutrients and sediment to the Bay, urban and developed lands have increased pollution levels in recent years.

If you have any questions, contact the USDA press office at 202-720-4623.

To view the Executive Summary of USDA's report, go to http://executiveorder.chesapeakebay.net/file.axd?file=2009%2f9%2f202(b)+Targeting+Resources+Draft+Report+Executive+Summary.pdf

To view the full report, go to http://executiveorder.chesapeakebay.net/post/202(b)-Targeting-Resources-Draft-Report.aspx

To learn more about the President's Executive Order and the process for developing the Administration's recommendations for the Chesapeake Bay, go to http://executiveorder.chesapeakebay.net

NRDC Issue Paper
OCTOBER 2009

Seizing a Watershed Opportunity

NRDC's Plan to Clean Up the Chesapeake Bay and Its Beaches

Author

Janine Harris

Project Manager

Nancy Stoner

NRDC
THE EARTH'S BEST DEFENSE

About NRDC

The Natural Resources Defense Council (NRDC) is an international nonprofit environmental organization with more than 1.3 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC has offices in New York City, Washington, D.C., Los Angeles, San Francisco, Chicago, Montana, and Beijing. Visit us at www.nrdc.org.

Acknowledgments

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NRDC Publications Manager: Lisa Goffredi
NRDC Publications Editor: Anthony Clark

The report is also available online at www.nrdc.org/policy.
This report is printed on paper that is 100 percent post-consumer recycled fiber, processed chlorine free.

Table of Contents

Executive Summary

Following NRDC's annual nationwide beachwater quality report this summer, *Testing the Waters*, this issue paper zooms in on the Chesapeake Bay. On the heels of reports from seven federal agencies commissioned by President Obama to clean up this national treasure, this issue paper delves into the sources of pollution that are undermining the health of the Bay and provides the solutions that Congress must take up to bolster the important work being carried out by the other branches of government. From dangerous algal blooms, to harmful bacteria at our beaches, plastic bags clogging tributaries, and economic hardships for the crabbing industry, the Chesapeake watershed and those who rely on it are in need of help. By acting on our recommendations, Congress can enact the comprehensive policies needed to make a lasting difference in improving the health of the nation's largest estuary.

A Treasure Worth Protecting

The Chesapeake Bay is the largest estuary in the United States and the third largest estuary in the world. Considered a national treasure, the Bay drains an immense 64,000 square miles in six states: New York, Pennsylvania, West Virginia, Delaware, Maryland, and Virginia, as well as Washington, D.C. (Figure 1). Two of these states, Maryland and Virginia, have 83 beaches along the shoreline of the Bay that are analyzed in this paper.

The Chesapeake Bay watershed is not only large in landscape, but also in population. The population of the area is growing by more than 170,000 residents annually. Development within the watershed that is associated with this increasing population affects the local water resources that eventually reach the shoreline and beaches of the Chesapeake Bay. Between 1990 and 2000, the population in the Bay watershed increased 8 percent, while developed areas increased by a disproportionate 41 percent.[1]

Measuring the Health of the Bay

The University of Maryland Center for Environmental Science and the National Oceanic and Atmospheric Administration (NOAA) create an annual Chesapeake Bay report card evaluating the health of the Bay. This comprehensive report card analyzes indicators of the Bay's health, such as chlorophyll a, aquatic grasses, dissolved oxygen, benthic organisms, water clarity, and phytoplankton.[2] The Bay received a grade of a C- in 2008. The Chesapeake Bay Foundation also rates the health of the Chesapeake Bay in the "State of the Bay Report," and assigned the Bay a low 28 points out of 100 in the 2008 report.[3] In May 2009, President Obama expressed his concern about the health of the Chesapeake Bay in an Executive Order to the Environmental Protection Agency. In this Executive Order, President Obama established a Federal Leadership Committee for the Chesapeake Bay to coordinate protection and restoration efforts for the Bay. The President also asked the EPA to publish guidance for federal

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Center Maryland

An Op-Ed Response — Chesapeake Bay Foundation: New stormwater rules won't increase costs

Editor's Note: The Chesapeake Bay Federation contacted Center Maryland and asked for an opportunity to respond to recent opinion pieces published on the state's proposed new stormwater regulations.

By Kim Coble

We interrupt the sky-is-falling rhetoric on the state's new stormwater regulations for a few facts.

The new rules will most likely reduce costs for many builders. The U.S. Environmental Protection Agency estimates 15-80 percent lower capital costs when builders use low-impact stormwater strategies similar to those required in the new state regulations. The agency arrived at those figures after evaluating 17 different case studies. Even in redevelopment settings, stormwater management does not have to raise costs, especially when several options are included as alternatives for meeting the state's requirement in the regulations as they currently exist.

It is incorrect to say these regulations will cause costs to go up. Everyone needs to keep this fact in mind when they hear unsubstantiated cost estimates for stormwater management quoted by builders – who are attempting to weaken the state's new rules through the legislative process.

An equally important fact: if builders don't properly treat stormwater from their development and redevelopment sites, taxpayers will have to pick up the tab of treating it as it heads into their local rivers. New federal initiatives will require states to reduce Bay pollution, and the fact is that if one group shirks its responsibilities, others will have to shoulder that debt.

The fact of the matter is that development has been dramatically changing our landscape for decades. Between 1990 and 2000 alone, our region's population grew by 8%, but the amount of land paved or covered with buildings and concrete increased by 41%. All those hard surfaces have created the stormwater pollution problem we face today. In fact, according to the Environmental Protection Agency Chesapeake Bay Program, urban and suburban development is the ONLY source of nutrient and sediment pollution that is increasing. There is no doubt that the development industry has profited from growth in Maryland, but there is also no doubt development has harmed local creeks, rivers and the Bay.

Some developers have tried to blame other types of pollution as culprits in the Bay's pollution, arguing that their own impact is minimal. Their logic: the amount of land paved over each year pales in comparison to the entire 64,000 square mile watershed. This is a specious argument and is not unlike trying to minimize the impact of agriculture over the years by only looking at the new farms that started production in one year alone.

Here are some other facts often overlooked in the rhetorical debate:

• Other jurisdictions, including Montgomery County and Philadelphia, have been meeting similar standards for stormwater management with no ill effects to builders or localities. Even in high density urban areas, higher standards of treatment have not created an exodus of development to the farm fields.
• All regulations require implementation flexibility; we stand firm with the development community in demanding clarity, flexibility, and attention to site-specific details especially in these first several months of implementation. But we should NOT and can NOT preempt regulatory improvements out of fear, or uncertainty.
• These new rules can help create jobs. These regulations follow a national trend – using "green infrastructure" technologies, instead of outdated structural practices. Requiring these practices in Maryland will boost employment of landscape architects, site designers, engineers and others.

The new rules benefit everyone – builders and the real estate industry, and everyone who is tired of stinky fish kills, endangered crab populations, and concrete dead zones stretching for miles over our landscape.

Legislators should not allow themselves to be scared by unsubstantiated predictions of doom. The Stormwater Management Act of 2007 they passed is the basis of these regulations, and reflects a necessary, yet modest improvement from the status quo. It is not a radical departure and in fact, was supported by the development community.

We must put the rhetoric aside and think about the dollars we will continue to hemorrhage in the Chesapeake region from decimated fisheries, lost tourism dollars, property flooding, sediment-clogged waterways, and the toll of continued finger-pointing for the Chesapeake's water quality shortcomings. Everyone, including the development community – needs to acknowledge their decades of free passes and step up to the plate to help correct the course.

Kim Coble is Maryland Executive Director of the Chesapeake Bay Foundation.

Here are opinion pieces on stormwater regulations previously published by Center Maryland:

Builders: Are Jobs Really a Priority?

VIDEO: Jim Smith on stormwater regulations

A threat to Smart Growth

This entry was posted on Friday, February 12th, 2010 at 2:38 am. You can follow any responses to this entry through the RSS 2.0 feed. Both comments and pings are currently closed.

-
    - The Video Lottery Commission's Letter to the Governor

      Maryland's Video Lottery Commission is attracting some headlines for its recent recommendations to Governor Martin O'Malley and the General Assembly leadership on

Appendix B

Tables and Graphs Showing Impervious Area and Population Increases by Year (1985-2008) in the Chesapeake Bay Watershed and the Portion of Each Jurisdiction Within the Watershed

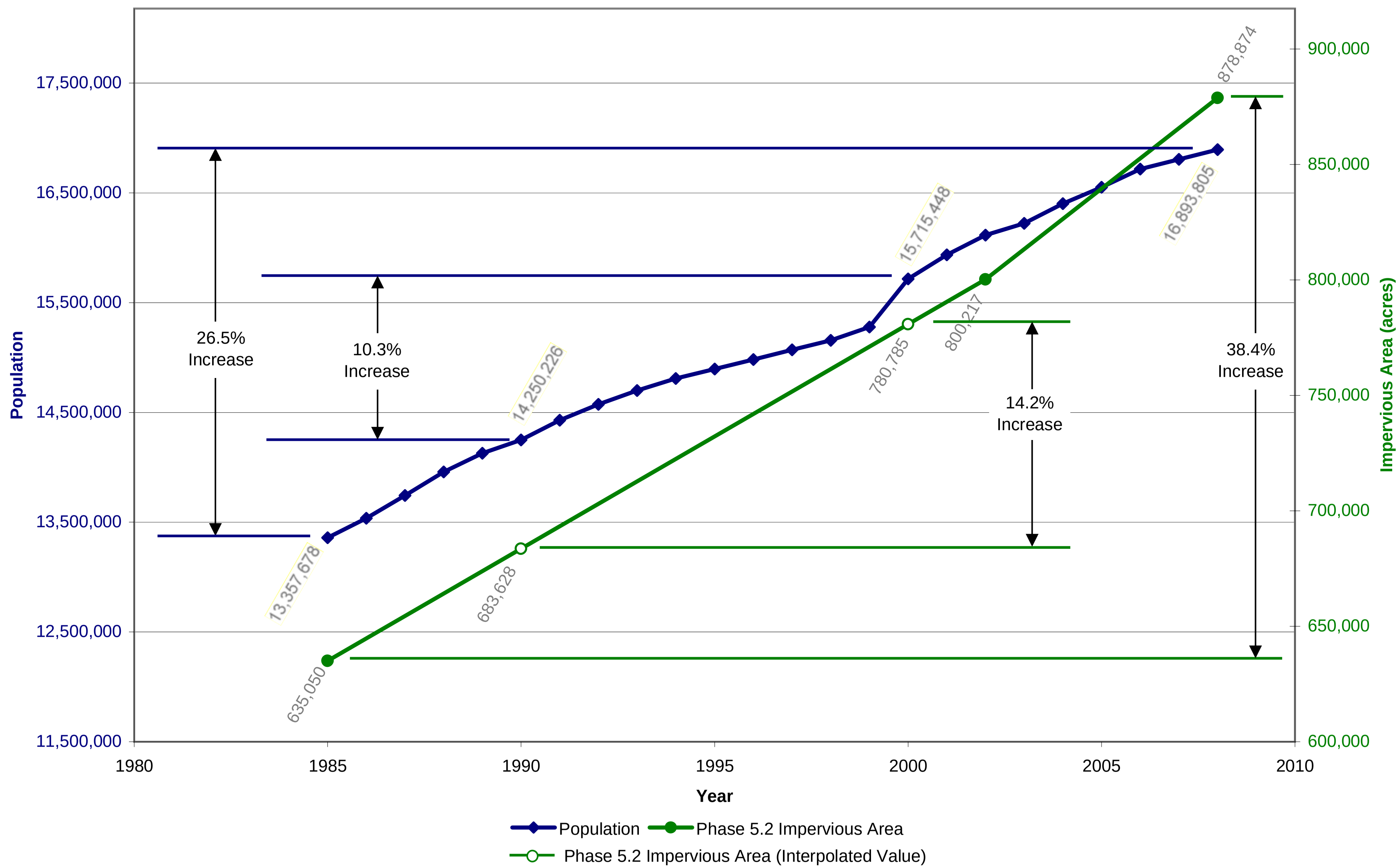
Impervious Area and Population by Year (1985-2008) in the Chesapeake Bay Watershed and the Portion of Each Jurisdiction Within the Watershed

	Chesapeake Bay Watershed		Delaware		District of Columbia		Maryland		New York		Pennsylvania		Virginia		West Virginia	
	Population	Impervious Area	Population	Impervious Area	Population	Impervious Area	Population	Impervious Area	Population	Impervious Area	Population	Impervious Area	Population	Impervious Area	Population	Impervious Area
	(# people)	(acres)	(# people)	(acres)	(# people)	(acres)	(# people)	(acres)	(# people)	(acres)	(# people)	(acres)	(# people)	(acres)	(# people)	(acres)
1985	13,357,678	635,050	127,808	6,822	634,549	17,422	4,382,729	194,981	671,951	27,341	3,294,454	181,207	4,077,577	200,236	168,609	7,040
1986	13,535,553	*644,765*	130,060	*7,048*	638,269	*17,456*	4,456,369	*198,181*	670,339	*27,443*	3,307,306	*183,243*	4,163,162	*204,189*	170,050	*7,205*
1987	13,743,105	*654,481*	132,161	*7,274*	636,930	*17,489*	4,534,707	*201,381*	671,639	*27,546*	3,325,935	*185,280*	4,269,056	*208,142*	172,678	*7,370*
1988	13,958,515	*664,197*	134,104	*7,500*	630,432	*17,522*	4,626,693	*204,580*	676,613	*27,648*	3,352,266	*187,316*	4,362,165	*212,095*	176,242	*7,535*
1989	14,128,263	*673,912*	136,260	*7,726*	624,168	*17,555*	4,695,621	*207,780*	681,678	*27,750*	3,374,660	*189,353*	4,436,414	*216,048*	179,460	*7,701*
1990	14,250,226	*683,628*	138,211	*7,952*	606,900	*17,588*	4,748,709	*210,980*	684,310	*27,852*	3,395,524	*191,390*	4,494,087	*220,001*	182,486	*7,866*
1991	14,429,413	*693,344*	141,701	*8,178*	593,239	*17,621*	4,823,271	*214,179*	687,103	*27,954*	3,428,656	*193,426*	4,568,811	*223,954*	186,632	*8,031*
1992	14,574,362	*703,060*	144,098	*8,404*	584,183	*17,654*	4,869,117	*217,379*	689,042	*28,057*	3,449,538	*195,463*	4,648,802	*227,906*	189,583	*8,196*
1993	14,698,459	*712,775*	146,656	*8,630*	576,358	*17,687*	4,908,589	*220,579*	688,741	*28,159*	3,472,137	*197,499*	4,713,426	*231,859*	192,551	*8,362*
1994	14,808,418	*722,491*	148,850	*8,856*	564,982	*17,721*	4,951,060	*223,778*	686,037	*28,261*	3,489,857	*199,536*	4,772,257	*235,812*	195,375	*8,527*
1995	14,895,221	*732,207*	151,371	*9,082*	551,273	*17,754*	4,988,862	*226,978*	679,494	*28,363*	3,501,256	*201,572*	4,825,099	*239,765*	197,865	*8,692*
1996	14,981,360	*741,922*	153,741	*9,308*	538,273	*17,787*	5,021,982	*230,178*	673,709	*28,465*	3,510,707	*203,609*	4,882,656	*243,718*	200,292	*8,858*
1997	15,070,311	*751,638*	155,829	*9,534*	528,752	*17,820*	5,057,299	*233,377*	668,454	*28,568*	3,512,574	*205,646*	4,944,514	*247,671*	202,890	*9,023*
1998	15,157,174	*761,354*	158,390	*9,760*	521,426	*17,853*	5,094,291	*236,577*	665,535	*28,670*	3,514,618	*207,682*	4,996,856	*251,624*	206,057	*9,188*
1999	15,277,482	*771,070*	160,945	*9,986*	519,000	*17,886*	5,135,416	*239,777*	663,106	*28,772*	3,518,532	*209,719*	5,071,143	*255,577*	209,339	*9,353*
2000	15,715,448	*780,785*	170,282	*10,212*	572,059	*17,919*	5,258,913	*242,976*	669,549	*28,874*	3,579,049	*211,755*	5,250,248	*259,530*	215,348	*9,519*
2001	15,935,573	*790,501*	173,646	*10,438*	573,822	*17,952*	5,348,073	*246,176*	669,436	*28,976*	3,588,659	*213,792*	5,361,908	*263,482*	220,029	*9,684*
2002	16,114,588	800,217	176,511	10,664	570,898	17,986	5,419,700	249,376	670,644	29,079	3,601,143	215,829	5,451,178	267,435	224,514	9,849
2003	16,221,773	*813,326*	180,087	*11,024*	570,803	*18,153*	5,432,852	*253,275*	667,704	*29,221*	3,624,101	*218,459*	5,517,868	*273,148*	228,358	*10,046*
2004	16,401,706	*826,436*	183,256	*11,384*	579,621	*18,320*	5,499,060	*257,175*	665,175	*29,364*	3,624,493	*221,090*	5,615,131	*278,860*	234,971	*10,243*
2005	16,550,533	*839,545*	187,329	*11,745*	582,049	*18,487*	5,534,637	*261,074*	661,874	*29,506*	3,641,600	*223,720*	5,701,990	*284,573*	241,053	*10,440*
2006	16,716,069	*852,655*	191,273	*12,105*	581,530	*18,654*	5,577,013	*264,973*	664,545	*29,649*	3,677,337	*226,351*	5,774,945	*290,286*	249,425	*10,637*
2007	16,806,038	*865,765*	195,031	*12,465*	588,292	*18,822*	5,579,592	*268,873*	660,143	*29,791*	3,687,833	*228,981*	5,843,005	*295,998*	252,141	*10,835*
2008	16,893,805	878,874	198,030	12,825	591,833	18,989	5,594,830	272,772	657,532	29,934	3,700,155	231,612	5,896,133	301,711	255,293	11,032

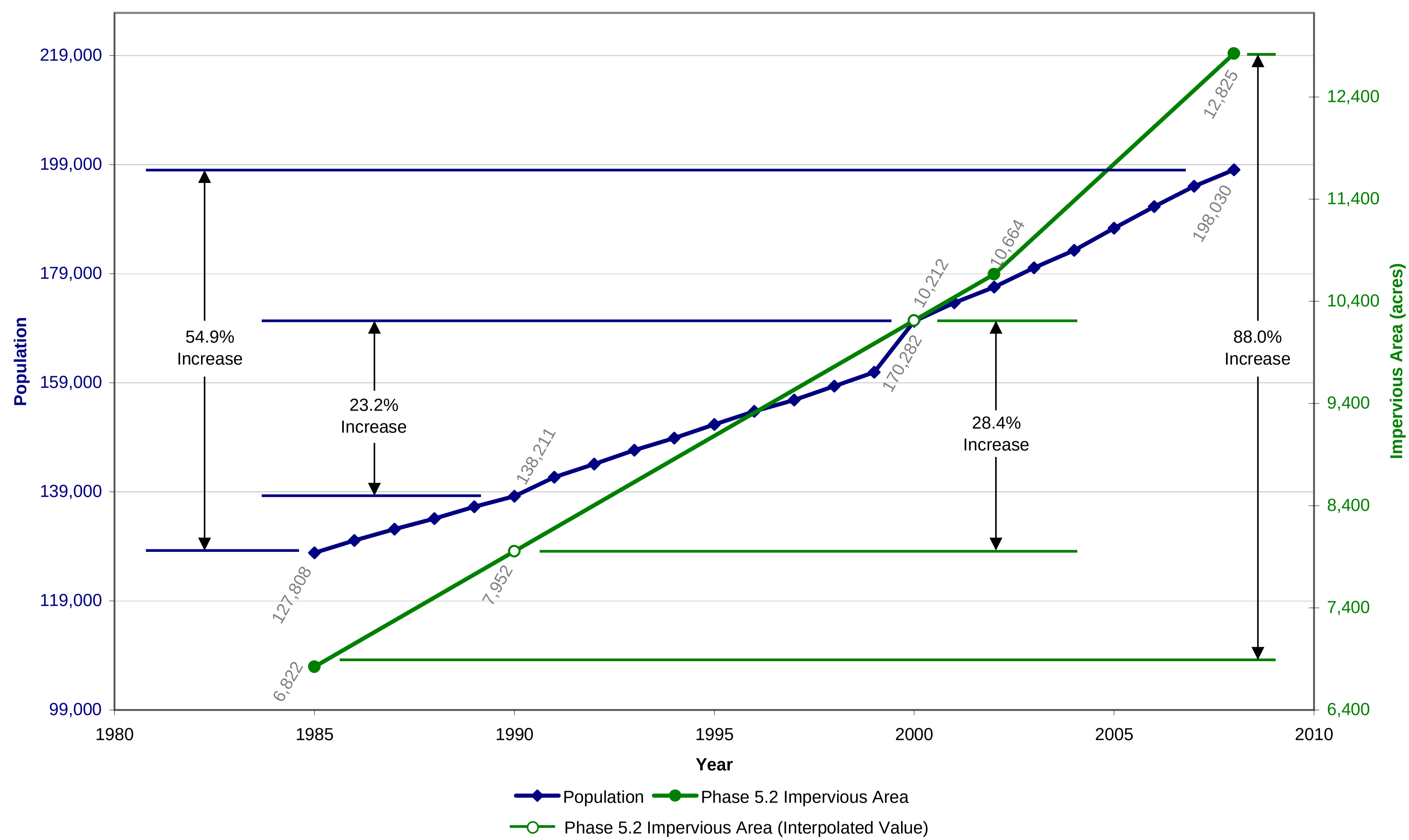
Legend:

Indicates Values from U.S. Census
Indicates Values from Phase 5.2 Chesapeake Bay Community Watershed Model
Indicates Interpolated Values (based on Phase 5.2 model data)

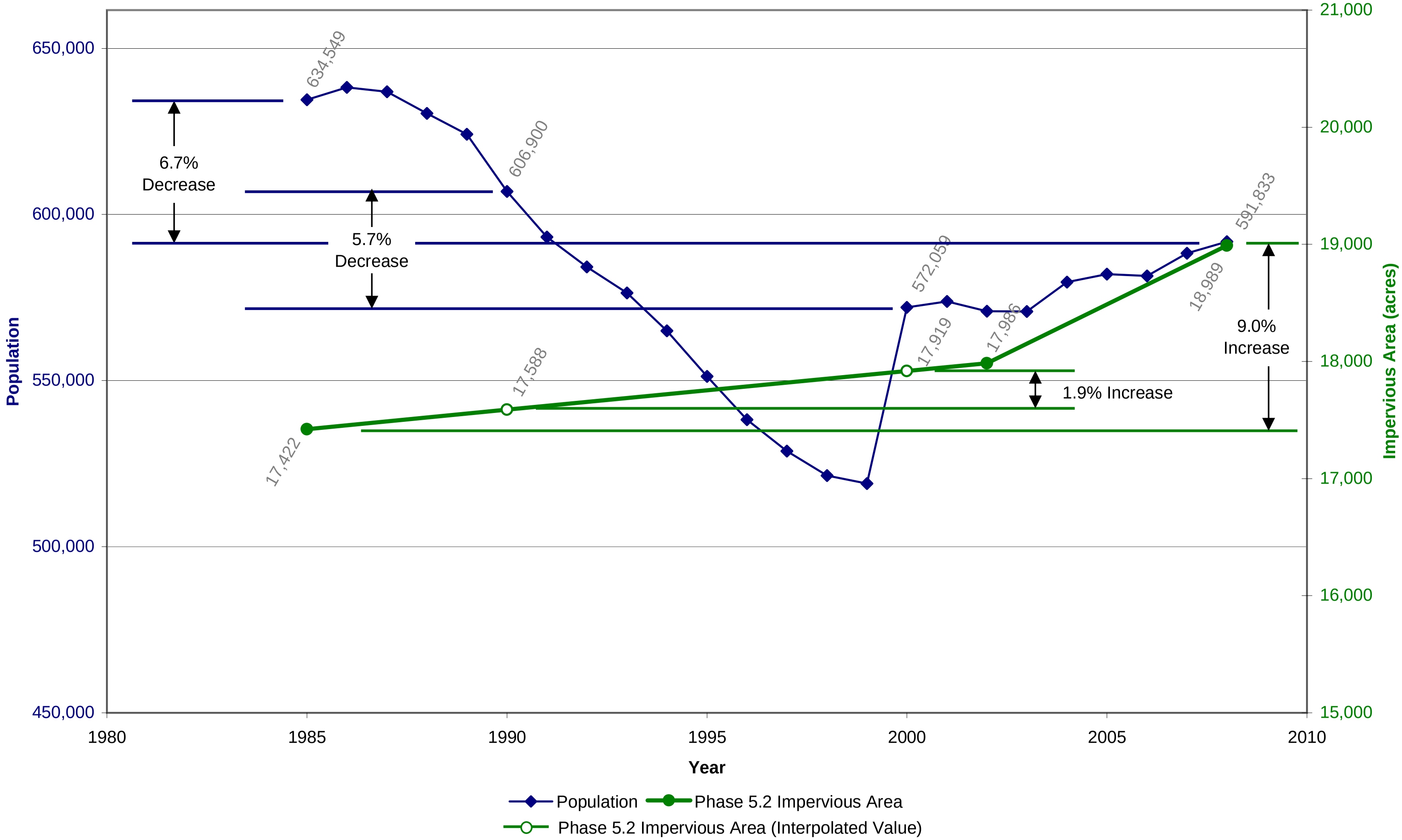
Chesapeake Bay Watershed Impervious Area and Population Increases by Year (1985-2008)



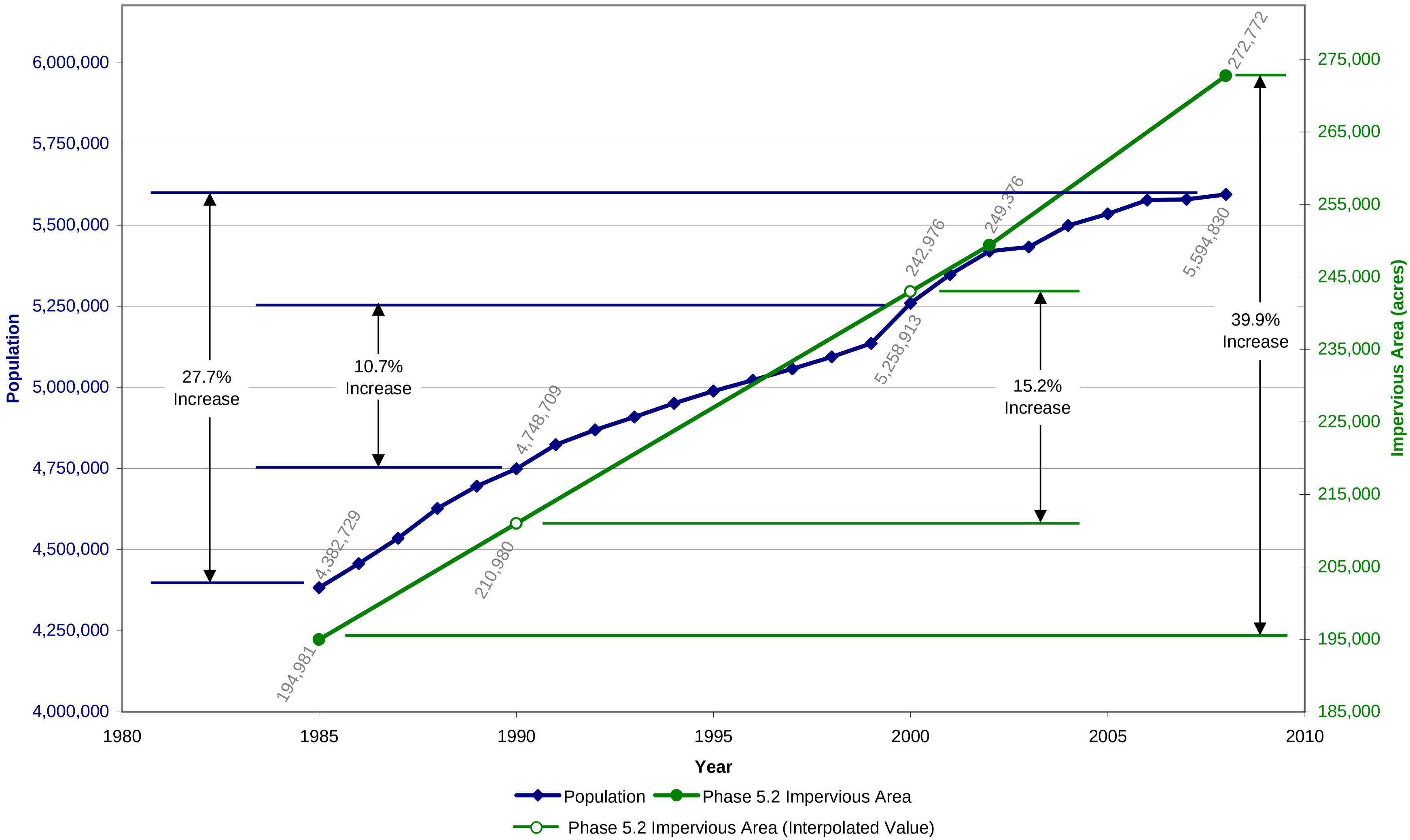
Impervious Area and Population Increases by Year (1985-2008) in the Chesapeake Bay Watershed Portion of Delaware



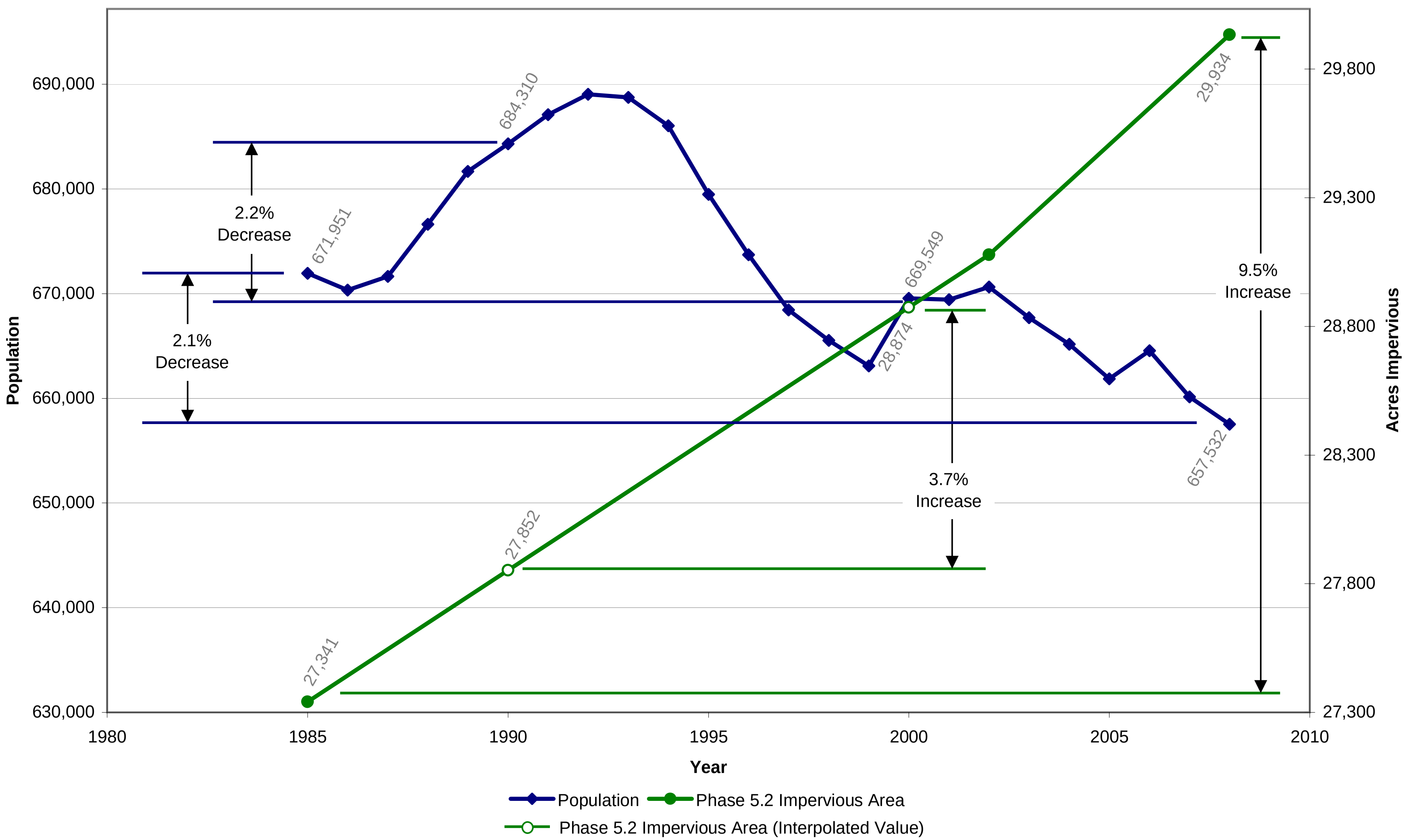
Impervious Area and Population Increases by Year (1985-2008) in the District of Columbia



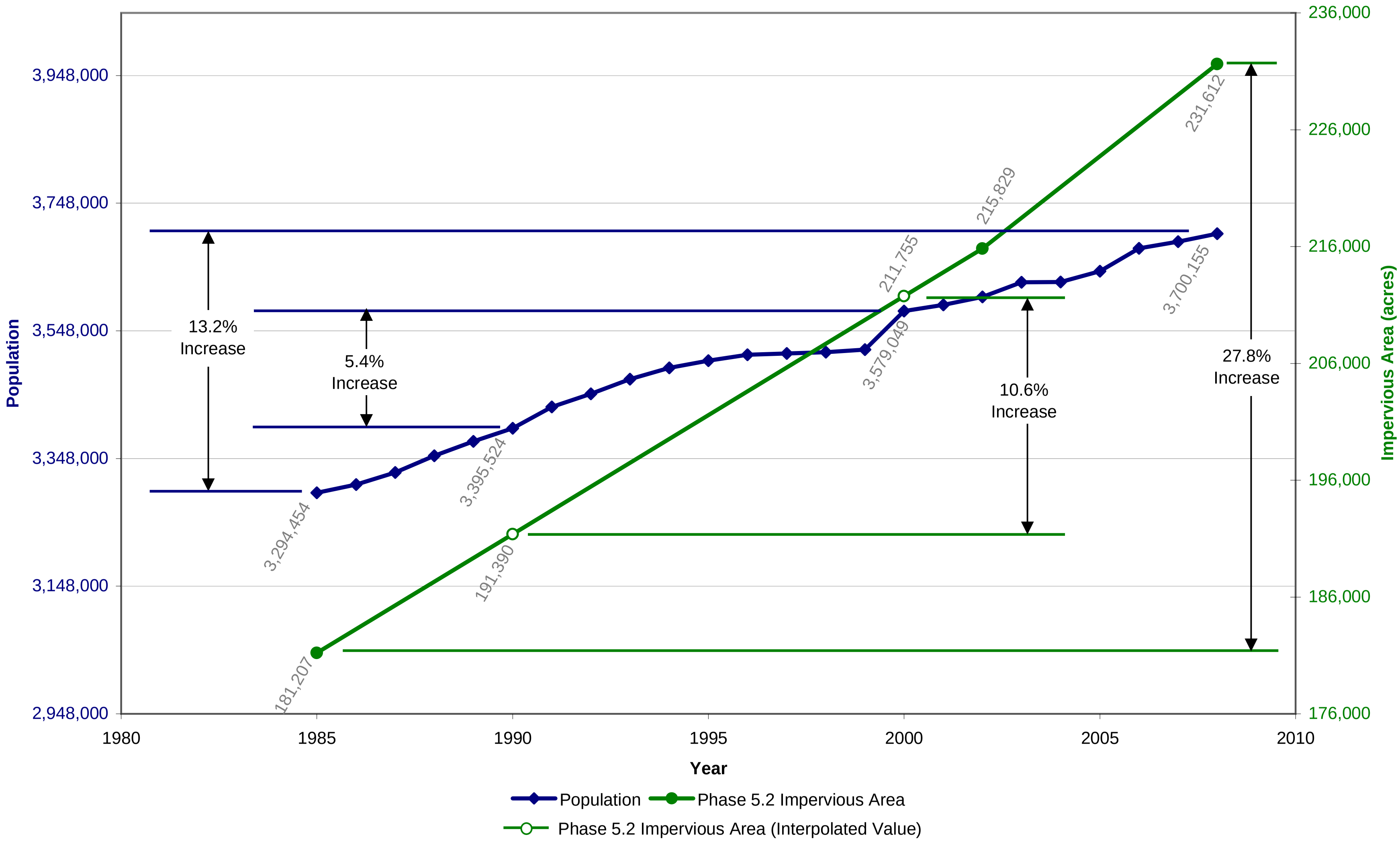
Impervious Area and Population Increases by Year (1985-2008) in the Chesapeake Bay Watershed Portion of Maryland



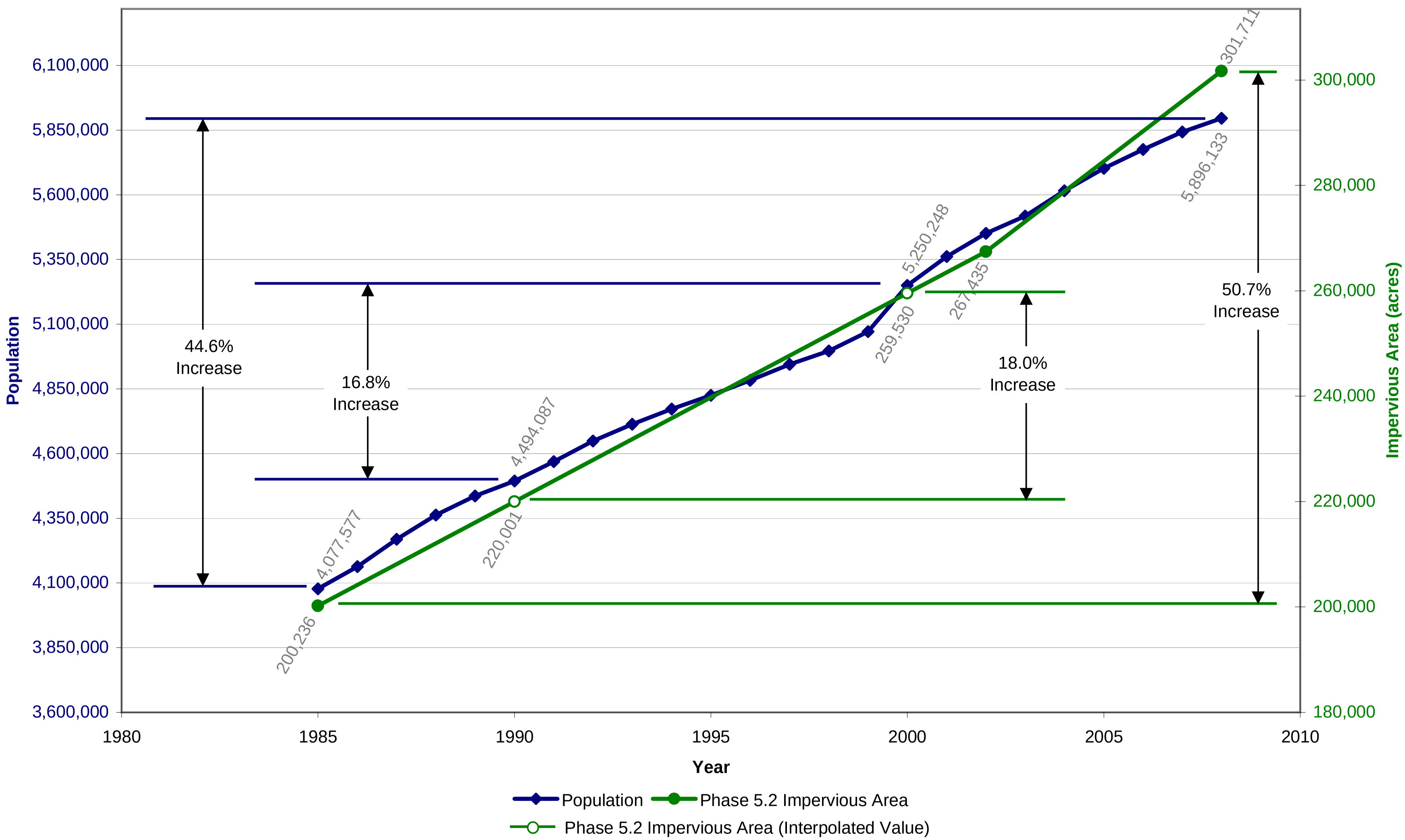
Impervious Area and Population Increases by Year (1985-2008) in the Chesapeake Bay Watershed Portion of New York



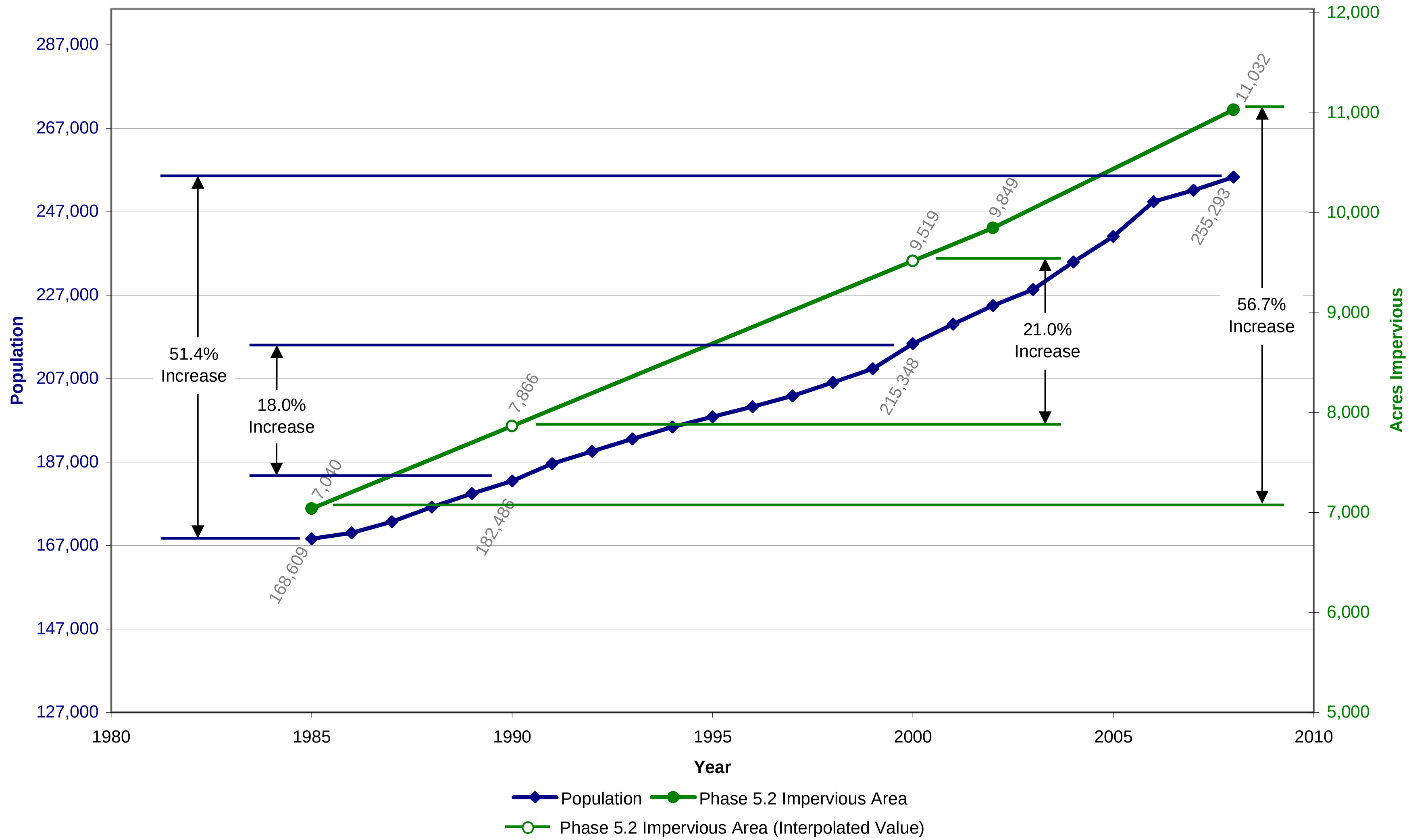
Impervious Area and Population Increases by Year (1985-2008) in the Chesapeake Bay Watershed Portion of Pennsylvania



Impervious Area and Population Increases by Year (1985-2008) in the Chesapeake Bay Watershed Portion of Virginia



Impervious Area and Population Increases by Year (1985-2008) in the Chesapeake Bay Watershed Portion of West Virginia



AN ANALYSIS OF IMPERVIOUS AREA INCREASE VS. POPULATION GROWTH IN THE CHESAPEAKE BAY WATERSHED BETWEEN 1990 AND 2000

ADDENDUM #1

MARCH 9, 2010
WSSI #21859.01

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AN ANALYSIS OF
IMPERVIOUS AREA INCREASE VS. POPULATION GROWTH
IN THE CHESAPEAKE BAY WATERSHED FROM 1990-2000

ADDENDUM #1

INTRODUCTION

This report outlines additional efforts we have undertaken to try to explain our observations regarding the impervious area increase vs the population increase in the Chesapeake Bay watershed. It is an addendum to the white paper of the same name, dated February 23, 2010.

EXECUTIVE SUMMARY

While we have been unable to reach a definitive conclusion regarding our results (except that the Phase 5.2 model does *not* corroborate the claim that impervious surfaces in the watershed increased by 41% between 1990 and 2000), our additional research below has uncovered three points of interest. Specifically, it appears that:

1. The variation between the RESAC data (the basis of the 41% impervious area increase claim) and the Phase 5.2 model data increases with population density. 1990 RESAC data is consistently lower than the Phase 5.2 model data, and 2000 data is consistently higher. This means that, in more populous areas, the perceived percent change is higher (on average) than in less populous areas.

2. The RESAC layers show impervious areas artificially increasing, or "bleeding," between 1990 and 2000, in locations which showed no physical change in imperviousness based on aerial photos.

3. All RESAC cells showing impervious area in 1990 show the same impervious area in 2000, which indicates that all impervious area increases come from greenfield development, rather than redevelopment.

ADDITIONAL IMPERVIOUS AREA RESEARCH

To begin this effort, we downloaded the following files (imperviousness data from the University of Maryland's Regional Earth Sciences Applications Center (RESAC)) from the project FTP site at ftp://ftp.chesapeakebay.net/Modeling/GIS/landuse/all_landcov.zip:

- umdimp90_v131;
- umdimp2k_v131; and
- UMD-Imperv-Version 1.3 Changes.doc**.**

Our understanding[1] is that these two files (and documentation) represent the 1990 and 2000 impervious area coverage for the Chesapeake Bay watershed and were used to initially calculate

[1] "All_landcov.zip" also includes metadata text files showing that these layers match the description in Goetz, et al, 2004, Integrated analysis of ecosystem interactions with land use change: the Chesapeake Bay watershed (http://www.geog.umd.edu/resac/lc2.html), which is cited as the reference for the chart showing the 41% impervious area increase (http://www.chesapeakebay.net/status_population.aspx?menuitem=19842, Analysis and Methods).

the impervious area increase. In an effort to replicate this calculation to use as a starting point, we calculated the average percent imperviousness for each cell within the watershed and multiplied it by the area of the watershed. We arrived at an impervious area increase of 44.8%, which is approximately 10% higher than the 41% claimed for the Bay-wide watershed, as shown in Table 1, below, but is close enough (considering the scale of the study) to suggest that we are using the same data source as the original claim.

Data Source	Watershed Area (acres)	Impervious Acres (1990)	Percent Impervious (1990)	Impervious Acres (2000)	Percent Impervious (2000)	Increase (1990-2000)
chesapeakebay.net[2]	±40,900,000	602,766	---	848,727	---	41%
RESAC	41,168,527	624,226	1.5%	903,970	2.2%	44.8%
Phase 5.2 Model		683,629	1.7%	780,785	1.9%	14.2%

Table 1. Impervious area analysis

Because our overall impervious area calculation above resulted in a similar percent increase as the website claim, we chose several (26) counties and cities in Virginia and Maryland to analyze more closely to see if there is a pattern in the increases that isn't readily apparent at the overall watershed scale. We calculated the impervious surface acreages for 1990 and 2000 based on the RESAC data for individual land-river segments[3] using the same methodology described above. We also extracted model input values[4] for IMH (high-density impervious) and IML (low-density impervious) from 1987, 1992, 1997, and 2002 for each land-river segment, and used those values to calculate IMH and IML values for 1990 and 2000[5]. The results of this comparison are shown in Appendix A, which consists of an individual chart and table for each county/city showing impervious area growth (based on RESAC data and Phase 5.2 model data) and population growth between 1985 and 2008. We also included recent (2005-2008) GIS vector data for jurisdictions where such data was readily available (the counties of Arlington, Fairfax, James City, and Loudoun and the City of Alexandria)[6] to see if the RESAC and Phase 5.2 impervious surfaces correlate with current GIS information. Appendix A also includes a summary table showing the RESAC and Phase 5.2 model impervious area increases for the selected counties, along with the ratio of impervious area increase to population increase.

In the majority of counties that we looked at, the 1990 RESAC estimate is lower than the Phase 5.2 model estimate, while the 2000 RESAC estimate is higher than the Phase 5.2 model estimate. (This observation is consistent with the overall RESAC impervious area increase estimate that is 5 times greater than the Phase 5.2 model estimates.) To determine if there is a watershed-wide pattern between the RESAC data and the Phase 5.2 model data, we graphed population density (in people per acre) against the difference in percent impervious surface between the two data sources for each of the 203 jurisdictions (cities and counties) throughout the Bay watershed. In cases where a jurisdiction is only partially contained within the Bay watershed, the entire county (including the portion outside the watershed) was used for the calculations. Water bodies (as

[2] http://www.chesapeakebay.net/impervioussurfaces.aspx
[3] ftp://ftp.chesapeakebay.net/Modeling/GIS/model_gis_segs/GIS_GISOWNER_P5_RiverSegs_July07.shp.zip
ftp://ftp.chesapeakebay.net/Modeling/GIS/model_gis_segs/GIS_GISOWNER_P5_LandSegs_July07.zip
[4] ftp://ftp.chesapeakebay.net/Modeling/phase5/data/model_inputs/landuse
[5] Using simple linear interpolation.
[6] GIS vector data was obtained directly from the individual counties listed here.

defined in the 2000 land-use GIS layer) were subtracted from the total acreage of each jurisdiction so the results would not be skewed by jurisdictions containing large bodies of water. See Chart 1, below.

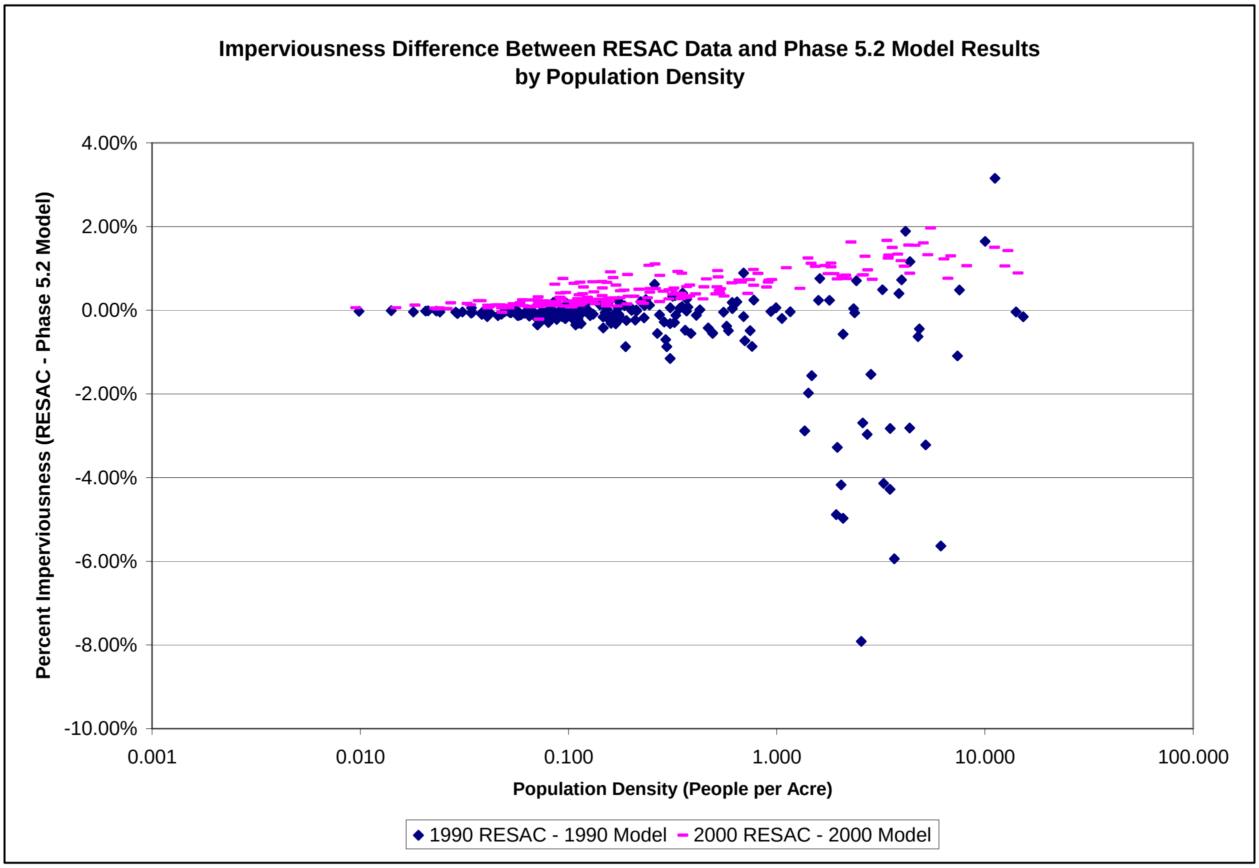

Chart 1. Imperviousness Differences Between RESAC Data and Phase 5.2 Model Results

Chart 1 shows that, throughout the Chesapeake Bay watershed, 1990 RESAC data is almost consistently lower than the Phase 5.2 model results, while the 2000 data is consistently higher. The 1990 difference is also greater in magnitude than the 2000 difference, especially in areas of high population density. In fact, the chart indicates that the discrepancies between the RESAC data and the Phase 5.2 model results tend to increase with increased density. (This is opposite of one suggestion that was posed to us that the impervious area in the Phase 5.2 model simply does not include imperviousness in non-urban land uses.)

We also looked to correlate the impervious area variation with population, population growth, percent impervious area, and impervious area growth, but we did not see a trend based on casual observation. Among the data we gathered, the only trend appears to correlate impervious area variation with population density, as seen above in Chart 1.

Our GIS vector data analysis indicates that the Phase 5.2 impervious areas are within approximately 10% of the GIS vector data in all cases except for James City County (in which case the Phase 5.2 model imperviousness is 50% lower than the current GIS imperviousness calculation.) The RESAC data is harder to correlate with the GIS data because of the time between the last RESAC data point and the GIS vector data, but they also seem to correlate fairly well, at least visually. This general precision between methods is good to note, because it appears that the RESAC and model estimates are at least reasonably accurate based on up-to-date GIS information. The GIS vector data does not, however, give us any indication of which growth trend (RESAC vs. Phase 5.2 model) is more accurate because the available GIS data does not extend far enough into the past.

Finally, to try to understand the trend observed in Chart 1, we looked at land-river segments where the RESAC data indicates a large increase in impervious surface but the model inputs indicate little or no change. Richmond, Virginia, shows such a trend, so we chose three study areas to analyze in the Richmond area. We overlaid the 1990 and 2000 RESAC layers on 1981, 1994, and 2004 aerial photographs[7] to give us a baseline for each area. The photos help us generally interpret the impervious surfaces of each RESAC layer and give us an idea about what impervious areas may or may not have changed during the 1990-2000 time period. (See Appendix B).

Appendix B1: Richmond, Virginia (Overall)

The Richmond, Virginia, region shows significant increases in impervious area according to the RESAC layers but very little increase in the 5.2 model. This region also shows little to no population growth from 1990 to 2000.

We chose to focus on the portion of Richmond that intersects River Segment JL7_7070_0001. Most of this area appears to consist of residential and urban developments that were established prior to 1990. This assumption is corroborated by a photo dated March 11, 1994, which shows the presence of large trees and a dense rectangular road network in the residential areas. Areas which have high impervious surface coverage according to the 1990 RESAC data appear to be shopping centers and urban downtown centers. Comparing the 1994 and 2004 photos for this area (not shown in Appendix B1 for clarity due to the size of the study area) shows very little obvious change, with the exception of one new shopping center (approximately 40 acres). However, the RESAC impervious layers indicate an overall increase of 25% in impervious surface for this area.

	Impervious Area (acres)		Increase	
	1990	2000	Acres	Percent
Phase 5.2 Model	2,738	2,765	26	1.0%
RESAC	2,395	3,000	605	25.3%

Table 2. Summary of Richmond, VA, JL7_7070_0001

Appendices B2-B4 (explained more fully below) show examples of impervious surfaces (based on the RESAC impervious layers) appearing to "bleed" into pervious surfaces between 1990 and 2000, when they should theoretically show no change.

[7] Because this is an unfunded analysis, we used readily-available photographs rather than expending the time and money to obtain 1990 and 2000 images.

Appendix B2: Richmond, Virginia (Study Area 1)

Study Area 1 consists of residential neighborhoods in Richmond in the western portion of the study area and a large cemetery in the eastern portion of the study area. Images 1 and 2 (impervious data in 1990 and 2000) show similar patterns of imperviousness within the residential neighborhoods, but Image 3 (showing the change in imperviousness between 1990 and 2000) reveals a pattern of increased imperviousness along the boundary between the residential section and within the cemetery. The 1981 aerial photo in Image 1 shows that many of the roads and houses along the edge of the development were in place prior to 1990, indicating that the there should be no "bleed" in imperviousness; it also indicates that the 1990 RESAC data may have "missed" impervious areas along the edges of existing development.

Appendix B3: Richmond, Virginia (Study Area 2)

Study Area 2 is centered on the Powhite Parkway Bridge over the James River in Richmond. The 1990 RESAC layer[8] shows the bridge as a line of cells with high values for impervious surface (as expected). However, the bridge appears wider based on the 2000 RESAC layer. According to the Richmond Metropolitan Authority website[9], the bridge was widened in 1987-1988 and resurfaced in 1996 without widening[10]. (The bridge was, however, restriped in 1996 with narrower lanes to add one more lane of capacity.) Thus, the area of impervious surface for this feature should remain constant from 1990 to 2000, rather than increasing (significantly) as the RESAC layers indicate.

Appendix B4: Richmond, Virginia (Study Area 3)

Study Area 3 is just northeast of Study Area 2 and centers on a large rectangular structure (which is indicated on the Wikimapia.org website to be a reservoir, although there is some conjecture regarding its actual use.) Regardless, the 1981, 1994, and 2004 aerial photos indicates that the size and shape of the structure's impervious area have remained constant. The 1990 RESAC layer, however, appears to only show the structure's core as impervious, while the 2000 RESAC layer encompasses the entire structure. This again appears to be a "bleed" of imperviousness increase on the fringe of existing impervious cells, rather than a physical increase in impervious area.

This pattern seems to occur often throughout the RESAC dataset in locations with an abrupt transition from an area of high imperviousness to an area of low or no imperviousness. This could be an error with the RESAC dataset that results in an overestimation of the increase in impervious surfaces throughout the watershed. (This is not meant to imply that the higher impervious surface value from the 2000 data is

[8] The 1990 RESAC layer is overlain on a 1994 aerial photo, rather than a photo from 1981. This is because we know that the bridge did not change size between 1990 and 2000 and chose to use a photo with a closer date.
[9] http://www.rmaonline.org/facilities/powhite.html
[10] We also confirmed with VDOT and the Richmond Metropolitan Authority (via e-mail on March 4, 2010) that the bridge width did not increase between 1990 and 2000.

incorrect, just that the perceived *increase* is higher than it should be. Since the increase has been quoted extensively, it should be as accurate as possible.)

During the analysis of the 1990 and 2000 RESAC layers, we also noted a trend that can be described as "odd" at best, at least statistically. In the files we downloaded from the FTP site, every RESAC cell that has an impervious surface value greater than 0 in 1990 shows the exact same value in 2000. This would indicate that, throughout the Chesapeake Bay watershed, no surface[11] increased or decreased in impervious area between 1990 and 2000 and that all imperviousness increases came from greenfield development. Physically, this is unlikely (since redevelopment typically changes impervious area one way or the other), and statistically, it is nearly impossible. Even without physical changes in impervious area, a portion of the cells should show some sort of variation based on the inexact nature of the satellite imagery and reflectance analysis.

We have been unable to reach a definitive conclusion regarding our results, although we have noted three points of interest. Specifically, it appears that:

1. The variation between the RESAC data (the basis of the 41% impervious area increase claim) and the Phase 5.2 model data increases with population density. 1990 RESAC data is consistently lower than the Phase 5.2 model data, and 2000 data is consistently higher. This means that, in more populous areas, the perceived percent change is higher (on average) than in less populous areas.

2. The RESAC layers show impervious areas artificially increasing, or "bleeding," between 1990 and 2000, in locations which showed no physical change in imperviousness based on aerial photos.

3. All RESAC cells showing impervious area in 1990 show the same impervious area in 2000, which indicates that all impervious area increases come from greenfield development, rather than redevelopment.

We welcome further discussion on this topic; we understand that our analysis could be in error and we believe it is important to base claims (including our own) on the most accurate data.

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[11] Each cell is 30 meters by 30 meters, or approximately 970 square feet.

Appendix A: Impervious Area and Population Increase Comparison for Selected Counties and Cities in Virginia and Maryland

Summary Table
A1: Albemarle County, Virginia
A2: City of Alexandria, Virginia*
A3: Allegany County, Virginia
A4: Anne Arundel County, Maryland
A5: Arlington County, Virginia*
A6: Baltimore County, Maryland
A7: City of Charlottesville, Virginia
A8: Charles City County, Virginia
A9: Chesterfield County, Virginia
A10: Fairfax County, Virginia*
A11: Fauquier County, Virginia
A12: Frederick County, Maryland
A13: City of Hampton, Virginia
A14: Hanover County, Virginia
A15: Henrico County, Virginia
A16: James City County, Virginia*
A17: Loudoun County, Virginia*
A18: Montgomery County, Maryland
A19: City of Newport News, Virginia
A20: Northumberland County, Virginia
A21: Prince Georges County, Maryland
A22: Prince William County, Virginia
A23: City of Richmond, Virginia
A24: Stafford County, Virginia
A25: Westmoreland County, Virginia
A26: City of Williamsburg, Virginia

(* - indicates jurisdiction with GIS vector data used for comparison)

Appendix A: Impervious Area and Population Increase Comparison for Selected Counties and Cities in Virginia and Maryland

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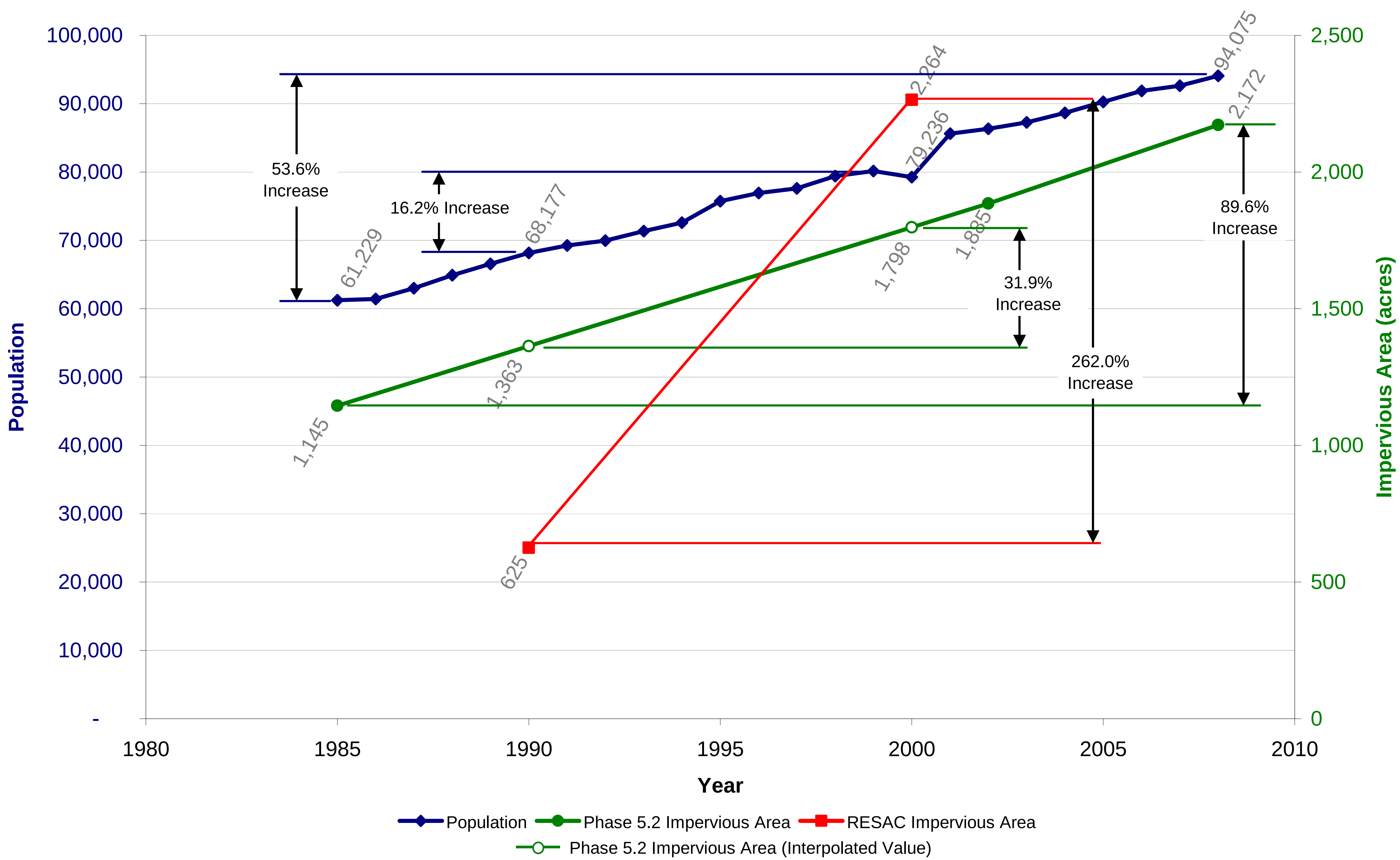
A26: City of Williamsburg, Virginia

(* - indicates jurisdiction with GIS vector data used for comparison)

		1990 - 2000			1985 - 2008		
		Impervious Area Increase (%)	Population Increase (%)	Impervious Area Increase / Population Increase	Impervious Area Increase (%)	Population Increase (%)	Impervious Area Increase / Population Increase
Cheasapeake Bay Watershed	RESAC / Woods Hole Model	41.0	8.0	**5.1**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	14.2	10.3	**1.4**	38.4	26.5	**1.4**
Albemarle County, VA	RESAC / Woods Hole Model	262.0	16.2	**16.2**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	31.9	16.2	**2.0**	89.6	53.6	**1.7**
Alexandria City, VA	RESAC / Woods Hole Model	5.7	15.4	**0.4**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	10.5	15.4	**0.7**	27.1	29.2	**0.9**
Allegany County, MD	RESAC / Woods Hole Model	32.2	-0.02	**-1610.0**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	3.0	-0.02	**-150.0**	7.7	-5.3	**-1.5**
Anne Arundel County, MD	RESAC / Woods Hole Model	29.1	14.6	**2.0**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	18.9	14.6	**1.3**	47.9	29.5	**1.6**
Arlington County, VA	RESAC / Woods Hole Model	5.0	10.9	**0.5**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	5.9	10.9	**0.5**	11.1	27.0	**0.4**
Baltimore County, MD	RESAC / Woods Hole Model	16.9	9.0	**1.9**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	11.3	9.0	**1.3**	28.7	18.2	**1.6**
Charlottesville City, VA	RESAC / Woods Hole Model	63.3	11.3	**5.6**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	4.1	11.3	**0.4**	7.6	3.0	**2.5**
Charles City County, VA	RESAC / Woods Hole Model	520.0	10.3	**50.5**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	27.5	10.3	**2.7**	78.2	10.4	**7.5**
Chesterfield County, VA	RESAC / Woods Hole Model	101.6	24.0	**4.2**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	25.5	24.0	**1.1**	72.5	82.2	**0.9**
Fairfax County, VA	RESAC / Woods Hole Model	25.6	18.5	**1.4**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	19.2	18.5	**1.0**	50.7	42.0	**1.2**
Fauquier County, VA	RESAC / Woods Hole Model	117.4	13.2	**8.9**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	23.9	13.2	**1.8**	83.8	63.8	**1.3**
Frederick County, MD	RESAC / Woods Hole Model	43.0	30.0	**1.4**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	35.0	30.0	**1.2**	103.1	75.7	**1.4**
Hampton County, VA	RESAC / Woods Hole Model	8.7	9.5	**0.9**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	8.2	9.5	**0.9**	29.0	14.9	**1.9**
Hanover County, VA	RESAC / Woods Hole Model	109.5	36.4	**3.0**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	31.5	36.4	**0.9**	87.5	87.7	**1.0**
Henrico County, VA	RESAC / Woods Hole Model	71.6	20.4	**3.5**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	18.2	20.4	**0.9**	49.0	48.0	**1.0**
James City County, VA	RESAC / Woods Hole Model	73.5	38.3	**1.9**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	43.0	38.3	**1.1**	136.0	125.4	**1.1**
Loudoun County, VA	RESAC / Woods Hole Model	68.7	96.8	**0.7**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	105.4	96.8	**1.1**	577.1	331.4	**1.7**
Montgomery County, MD	RESAC / Woods Hole Model	27.5	14.5	**1.9**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	13.8	14.5	**1.0**	35.9	45.6	**0.8**
Newport News City, VA	RESAC / Woods Hole Model	13.7	5.1	**2.7**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	10.4	5.1	**2.0**	35.0	14.5	**2.4**
Northumberland County, VA	RESAC / Woods Hole Model	165.0	16.5	**10.0**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	16.1	16.5	**1.0**	41.5	29.9	**1.4**
Prince George's County, MD	RESAC / Woods Hole Model	22.5	10.9	**2.1**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	14.6	10.9	**1.3**	37.9	20.1	**1.9**
Prince William County, VA	RESAC / Woods Hole Model	50.4	30.6	**1.6**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	37.2	30.6	**1.2**	126.4	109.6	**1.2**
Richmond City, VA	RESAC / Woods Hole Model	18.6	-2.4	**-7.8**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	0.3	-2.4	**-0.1**	0.6	-5.0	**-0.1**
Stafford County, VA	RESAC / Woods Hole Model	81.8	48.5	**1.7**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	53.8	48.5	**1.1**	186.2	154.8	**1.2**
Westmoreland County, VA	RESAC / Woods Hole Model	49.7	8.0	**6.2**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	10.2	8.0	**1.3**	26.5	21.2	**1.3**
Williamsburg City, VA	RESAC / Woods Hole Model	18.5	3.4	**5.4**	-	-	**-**
	Phase 5.2 Model (WSSI Analysis)	3.1	3.4	**0.9**	21.5	19.4	**1.1**

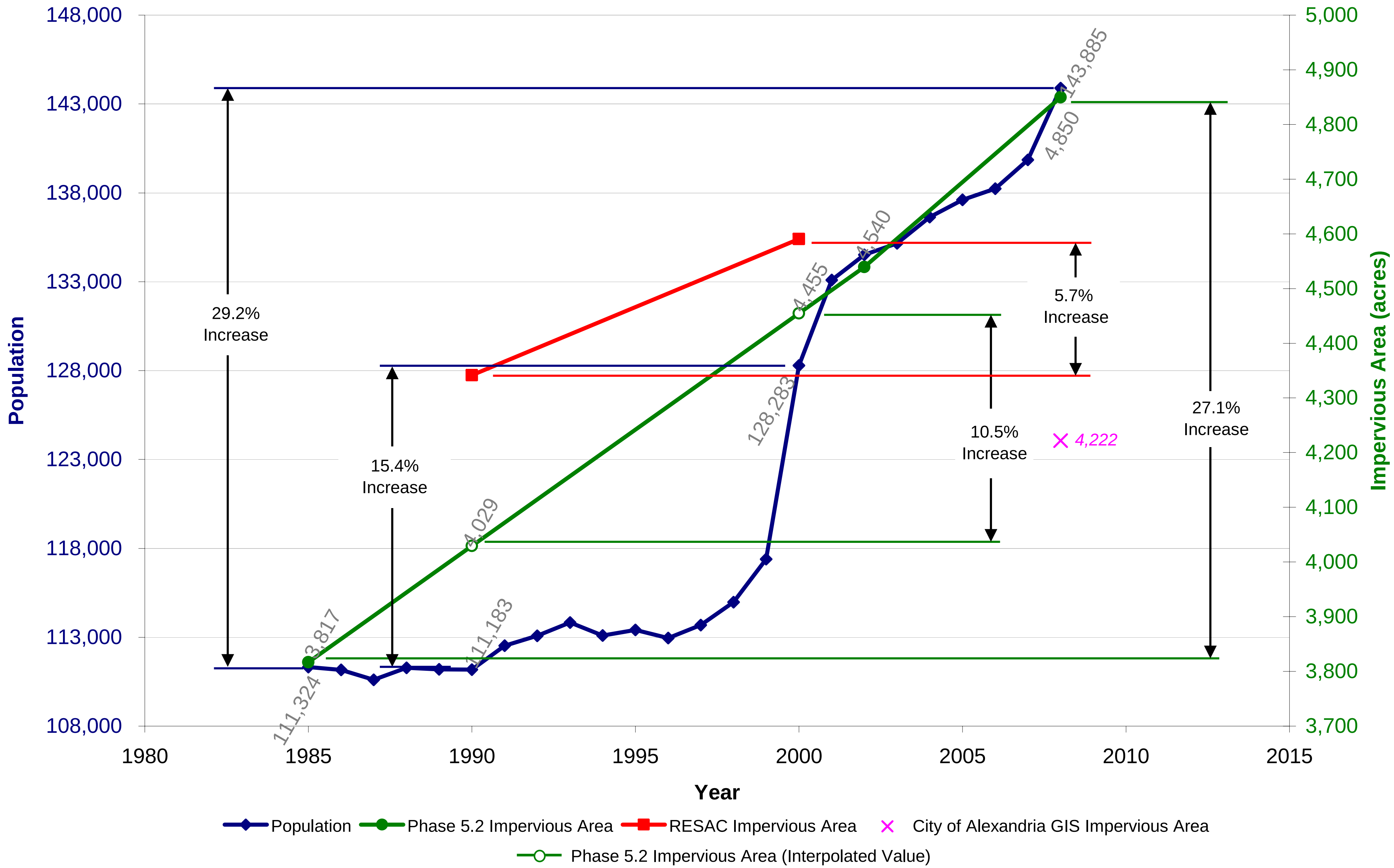
Impervious Area and Population Increases by Year (1985-2008) in Albemarle County, Virginia



Albemarle County

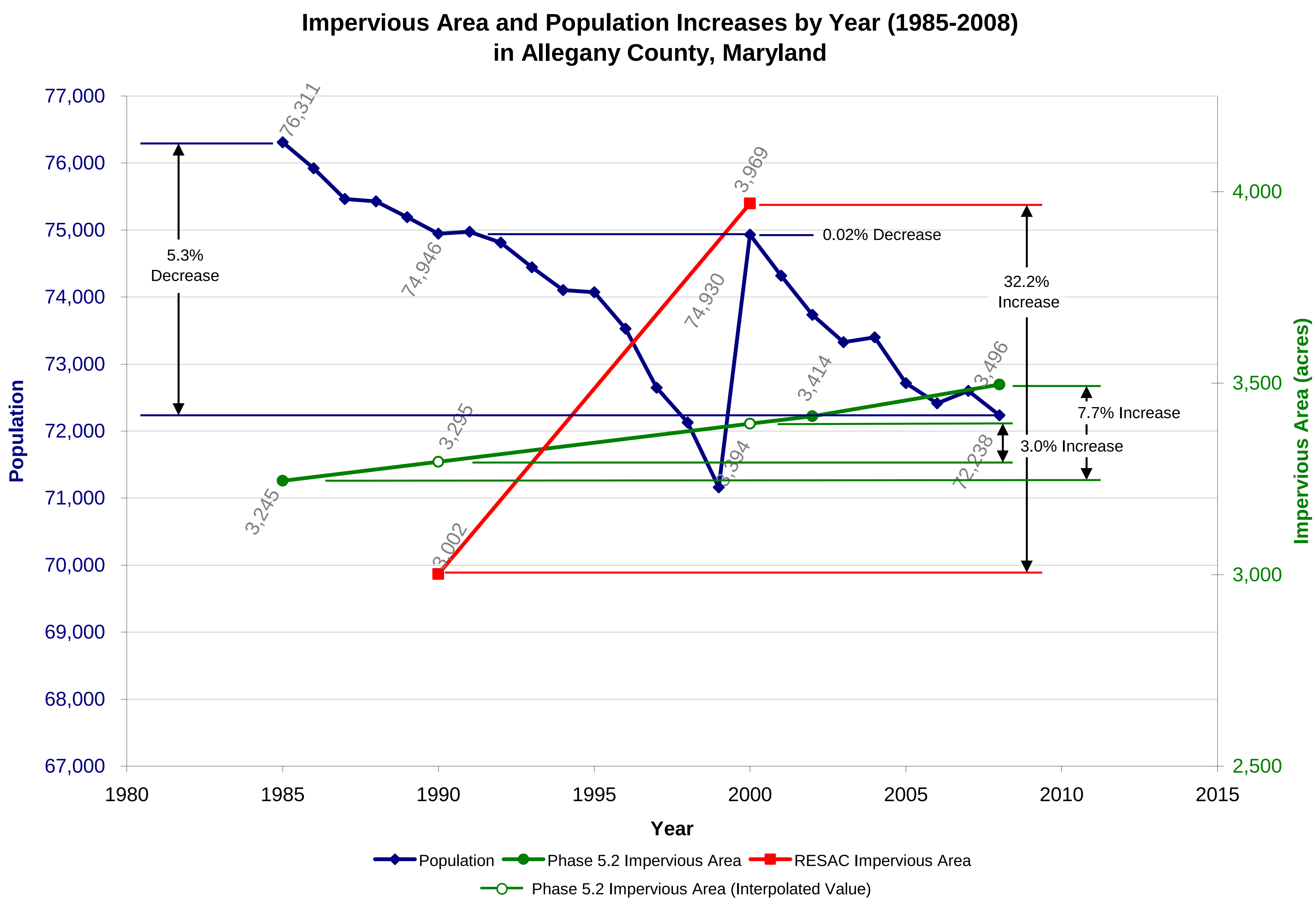
Year	RESAC / Woods Hole	Phase 5.2 Model	Population
1985		1,145	61,229
1986		*1,189*	61,423
1987		*1,232*	63,004
1988		*1,276*	64,918
1989		*1,319*	66,538
1990	625	*1,363*	68,177
1991		*1,407*	69,240
1992		*1,450*	69,977
1993		*1,494*	71,340
1994		*1,537*	72,569
1995		*1,581*	75,744
1996		*1,624*	76,935
1997		*1,668*	77,615
1998		*1,711*	79,417
1999		*1,755*	80,145
2000	2264	*1,798*	79,236
2001		*1,842*	85,628
2002		1,885	86,320
2003			87,277
2004			88,650
2005			90,266
2006			91,870
2007			92,639
2008		2,172	94,075
% Change 1990-2000	262.0%	31.9%	16.2%

Impervious Area and Population Increases by Year (1985-2008)
in the City of Alexandria, Virginia



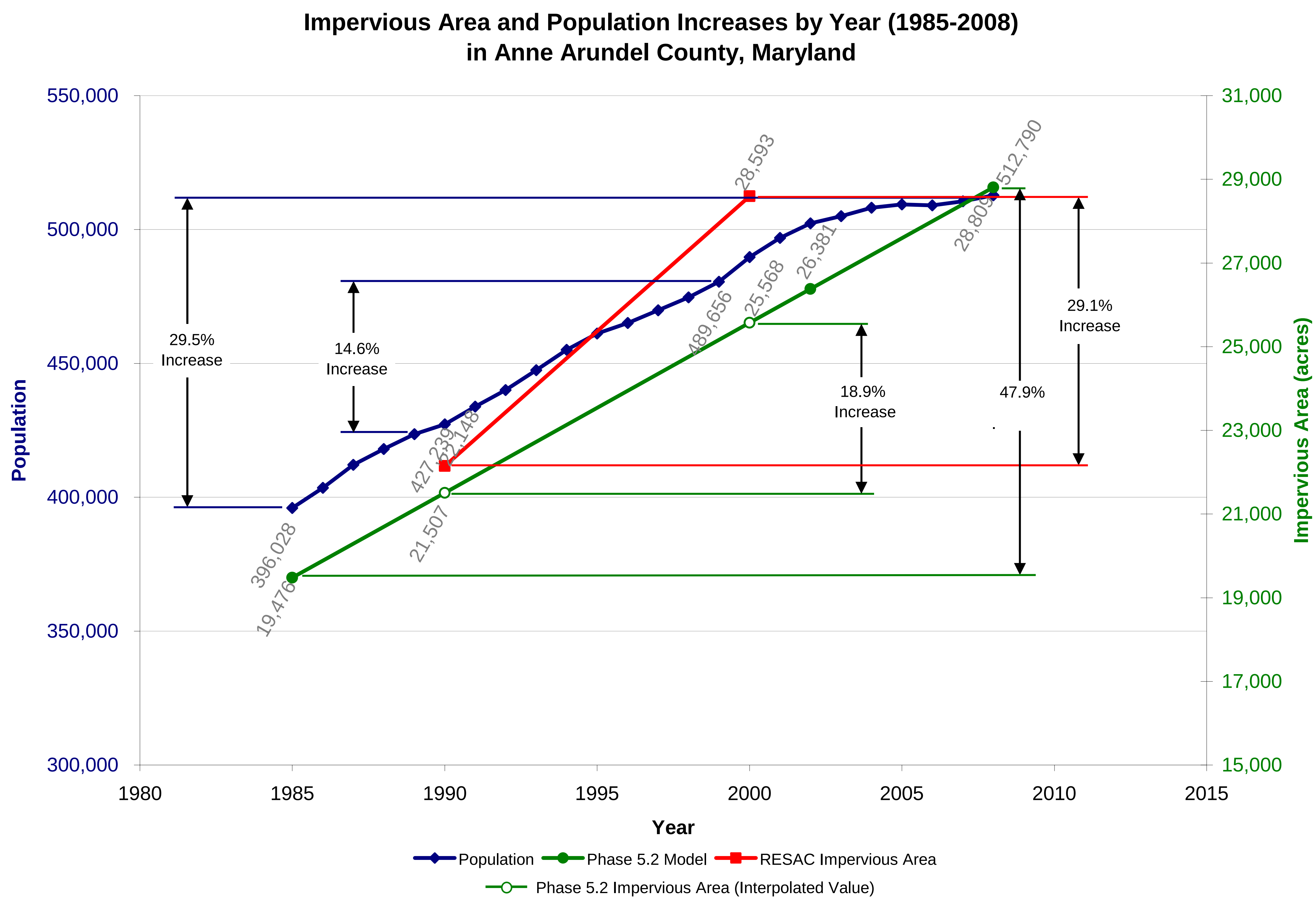
Alexandria City

Year	RESAC / Woods	Phase 5.2 Model	Vector Data	Population
1985		3,817		111,324
1986		*3,859*		111,165
1987		*3,902*		110,611
1988		*3,944*		111,273
1989		*3,987*		111,198
1990	4,342	*4,029*		111,183
1991		*4,072*		112,523
1992		*4,114*		113,079
1993		*4,157*		113,821
1994		*4,199*		113,103
1995		*4,242*		113,418
1996		*4,284*		112,947
1997		*4,327*		113,688
1998		*4,370*		114,978
1999		*4,412*		117,390
2000	4,591	*4,455*		128,283
2001		*4,497*		133,090
2002		4,540		134,516
2003				135,162
2004				136,635
2005				137,602
2006				138,237
2007				139,848
2008		4,850	4,222	143,885
% Change 1990-2000	5.7%	10.5%	-	15.4%



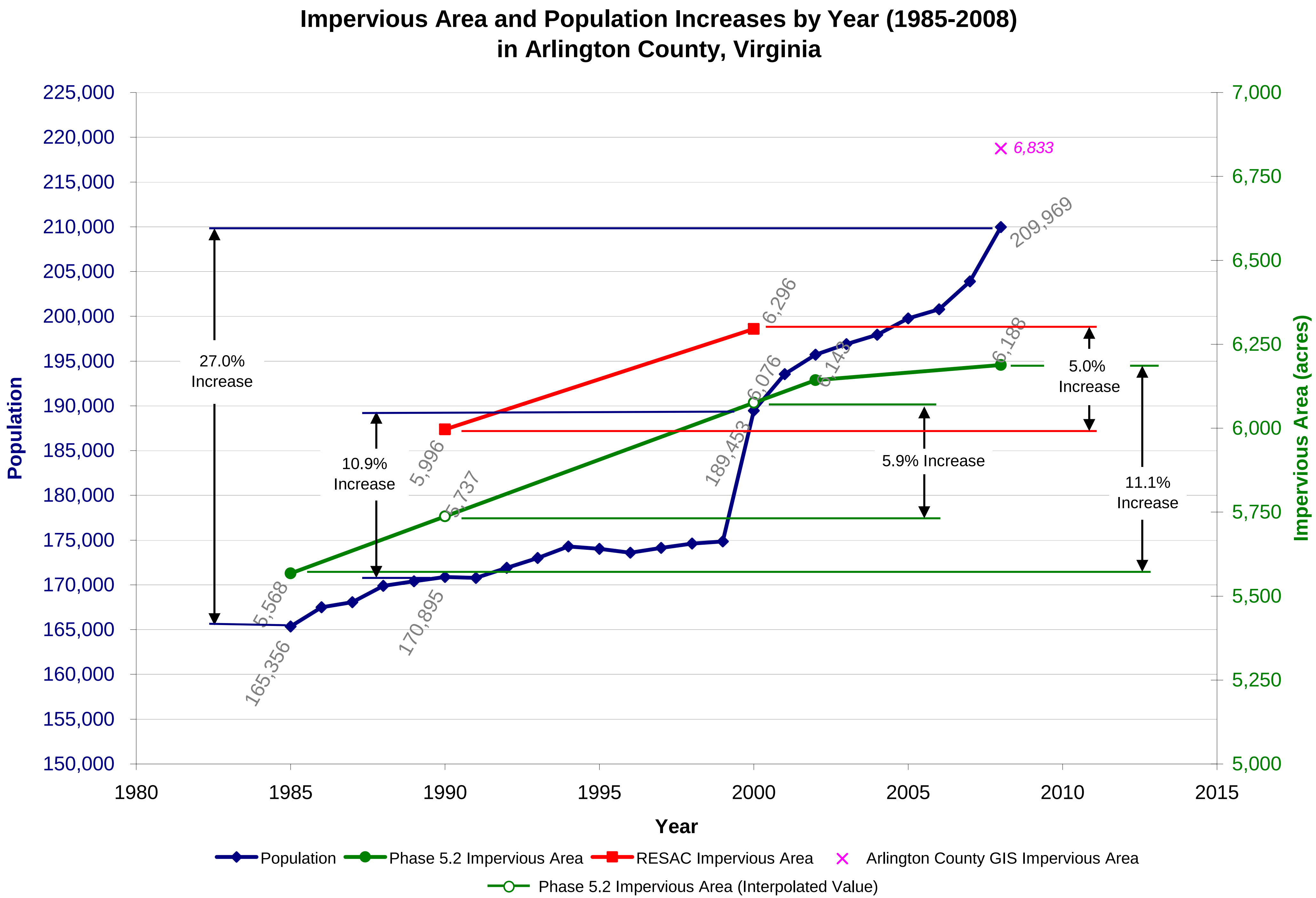
Allegany County

Year	RESAC / Woods Hole	Phase 5.2 Model	Popu-lation
1985		3,245	76,311
1986		*3,255*	75,922
1987		*3,265*	75,466
1988		*3,275*	75,428
1989		*3,285*	75,193
1990	3,002	*3,295*	74,946
1991		*3,305*	74,974
1992		*3,315*	74,813
1993		*3,325*	74,445
1994		*3,335*	74,103
1995		*3,344*	74,073
1996		*3,354*	73,528
1997		*3,364*	72,649
1998		*3,374*	72,130
1999		*3,384*	71,162
2000	3,969	*3,394*	74,930
2001		*3,404*	74,320
2002		3,414	73,737
2003			73,327
2004			73,398
2005			72,716
2006			72,415
2007			72,603
2008		3,496	72,238
% Change 1990-2000	32.2%	3.0%	0.0%



Anne Arundel County

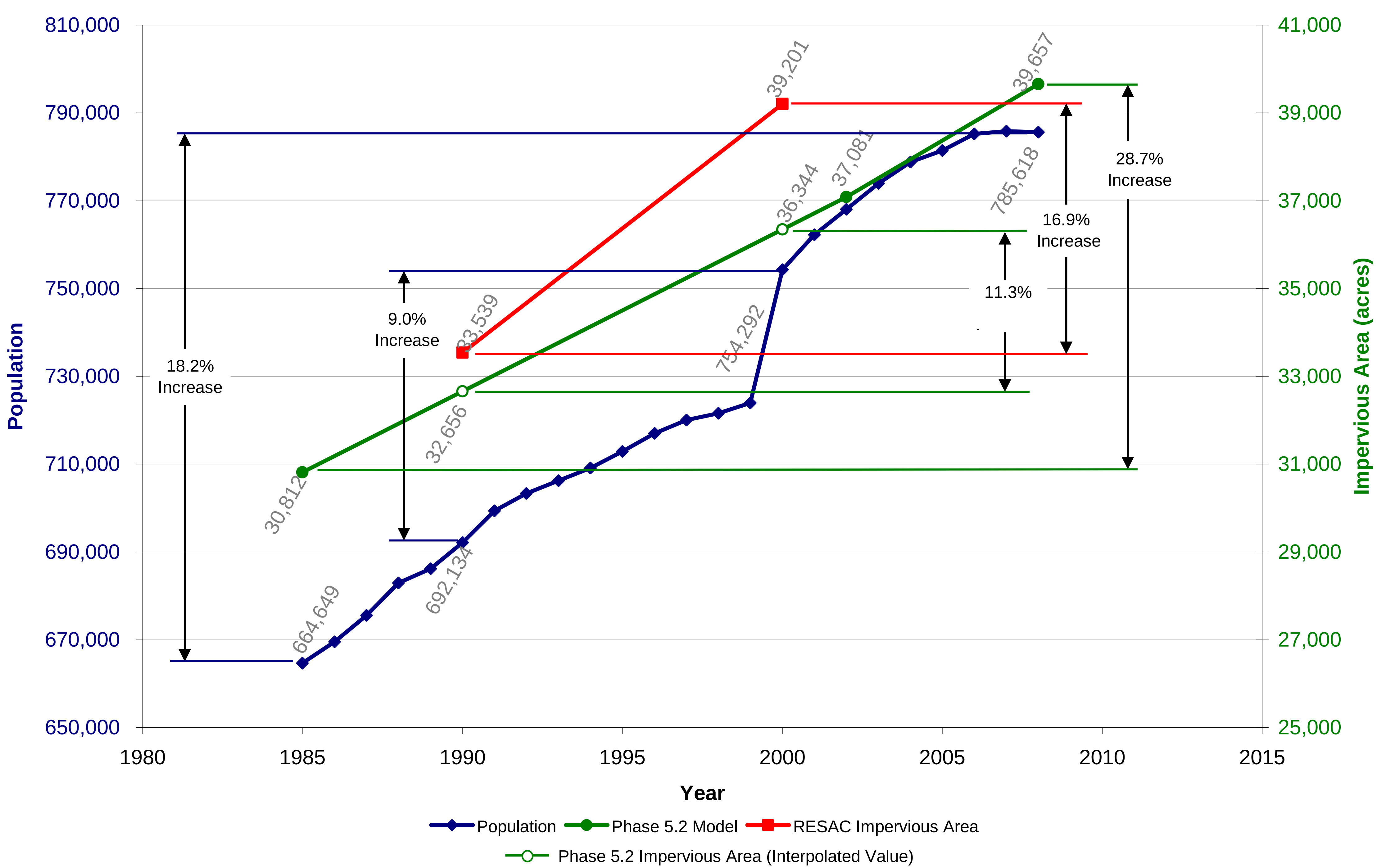
Year	RESAC / Woods Hole	Phase 5.2 Model	Population
1985		19,476	396,028
1986		*19,883*	403,532
1987		*20,289*	412,139
1988		*20,695*	418,047
1989		*21,101*	423,564
1990	22,148	*21,507*	427,239
1991		*21,913*	433,895
1992		*22,319*	440,020
1993		*22,725*	447,450
1994		*23,132*	455,038
1995		*23,538*	461,159
1996		*23,944*	465,087
1997		*24,350*	469,815
1998		*24,756*	474,682
1999		*25,162*	480,483
2000	28,593	*25,568*	489,656
2001		*25,975*	496,881
2002		26,381	502,267
2003			505,000
2004			508,132
2005			509,414
2006			509,037
2007			510,507
2008		28,809	512,790
% Change 1990-2000	29.1%	18.9%	14.6%



Arlington County

Year	RESAC / Woods Hole	Phase 5.2 Model	Vector Data	Population
1985		5,568		165,356
1986		*5,602*		167,502
1987		*5,635*		168,060
1988		*5,669*		169,903
1989		*5,703*		170,391
1990	5,996	*5,737*		170,895
1991		*5,771*		170,774
1992		*5,805*		171,911
1993		*5,839*		173,009
1994		*5,872*		174,298
1995		*5,906*		174,038
1996		*5,940*		173,591
1997		*5,974*		174,130
1998		*6,008*		174,607
1999		*6,042*		174,848
2000	6,296	*6,076*		189,453
2001		*6,110*		193,550
2002		6,143		195,724
2003				196,890
2004				197,955
2005				199,761
2006				200,789
2007				203,909
2008		6,188	6,833	209,969
% Change 1990-2000	5.0%	5.9%	-	10.9%

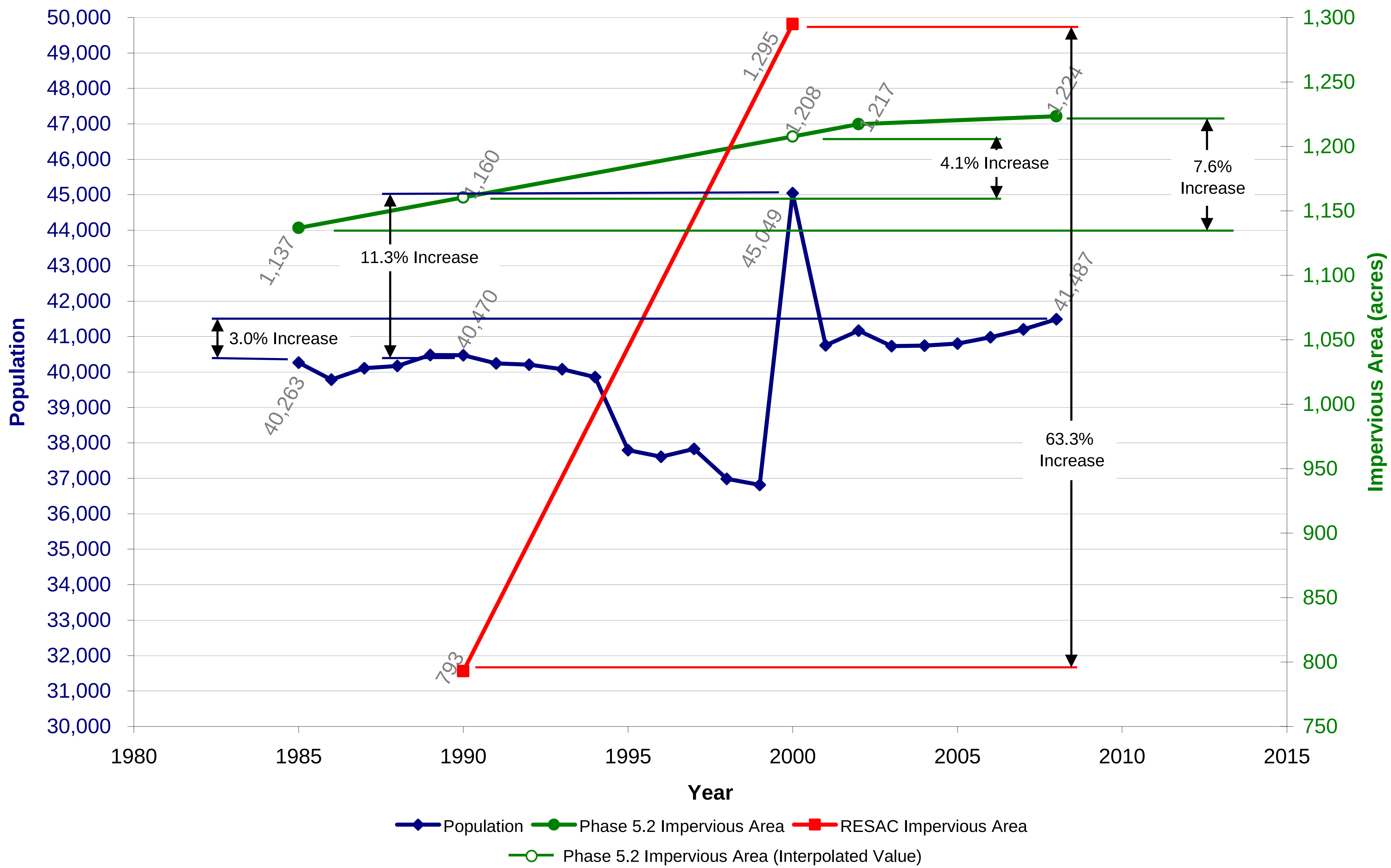
Impervious Area and Population Increases by Year (1985-2008) in Baltimore County, Maryland



Baltimore County

Year	RESAC / Woods Hole	Phase 5.2 Model	Population
1985		30,812	664,649
1986		*31,181*	669,544
1987		*31,550*	675,514
1988		*31,919*	682,941
1989		*32,287*	686,188
1990	33,539	*32,656*	692,134
1991		*33,025*	699,337
1992		*33,394*	703,337
1993		*33,762*	706,225
1994		*34,131*	709,104
1995		*34,500*	712,904
1996		*34,869*	716,974
1997		*35,237*	720,043
1998		*35,606*	721,556
1999		*35,975*	723,914
2000	39,201	*36,344*	754,292
2001		*36,712*	762,269
2002		37,081	768,047
2003			773,921
2004			778,810
2005			781,452
2006			785,200
2007			785,830
2008		39,657	785,618
% Change 1990-2000	16.9%	11.3%	9.0%

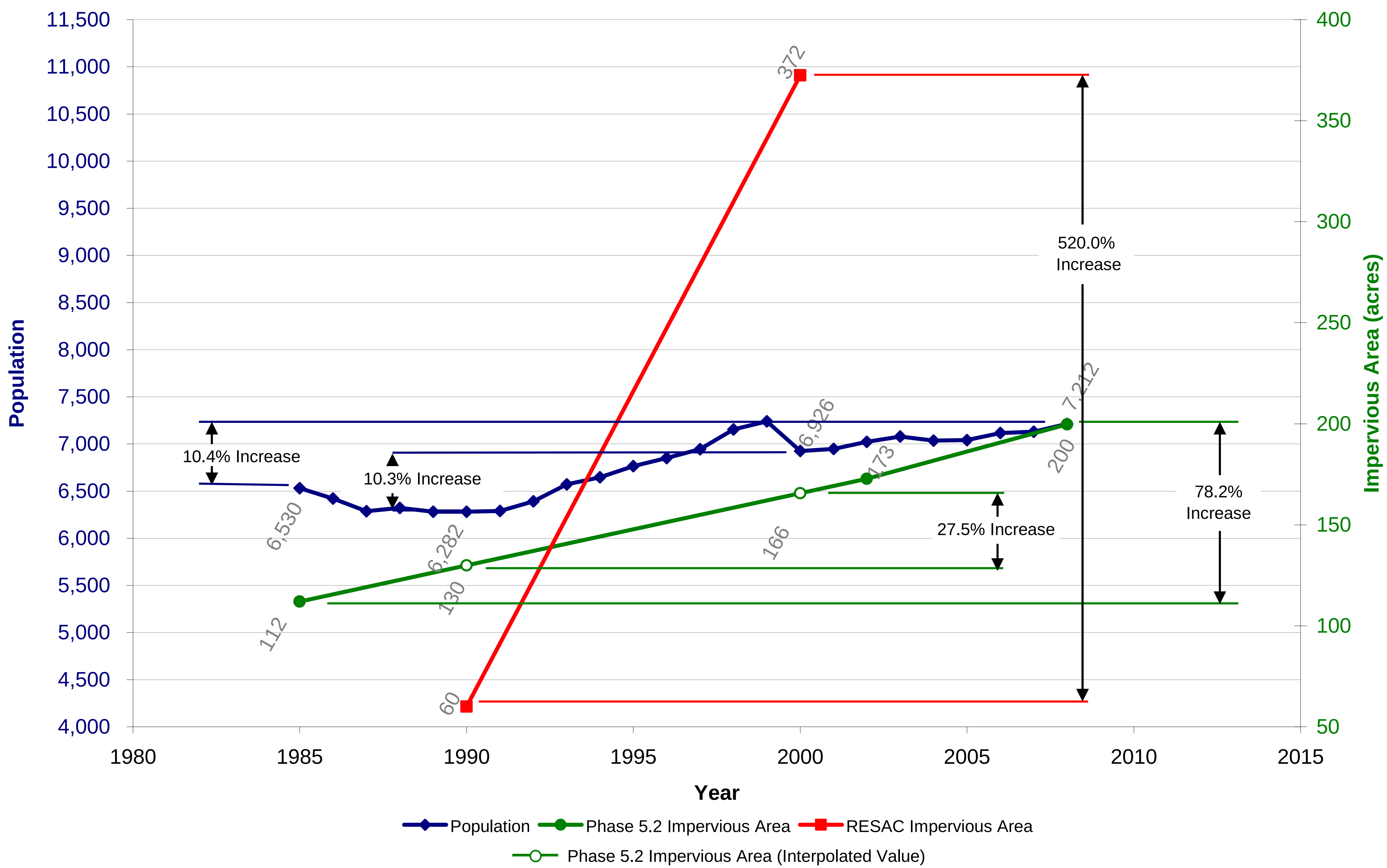
Impervious Area and Population Increases by Year (1985-2008) in the City of Charlottesville, Virginia



Charlottesville City

Year	RESAC / Woods Hole	Phase 5.2 Model	Population
1985		1137	40263
1986		*1142*	39784
1987		*1146*	40107
1988		*1151*	40173
1989		*1156*	40482
1990	793	*1160*	40470
1991		*1165*	40246
1992		*1170*	40208
1993		*1175*	40079
1994		*1179*	39856
1995		*1184*	37794
1996		*1189*	37609
1997		*1194*	37830
1998		*1198*	36988
1999		*1203*	36815
2000	1295	*1208*	45049
2001		*1212*	40750
2002		1217	41169
2003			40730
2004			40745
2005			40805
2006			40982
2007			41206
2008		1224	41487
% Change 1990-2000	63.3%	4.1%	11.3%

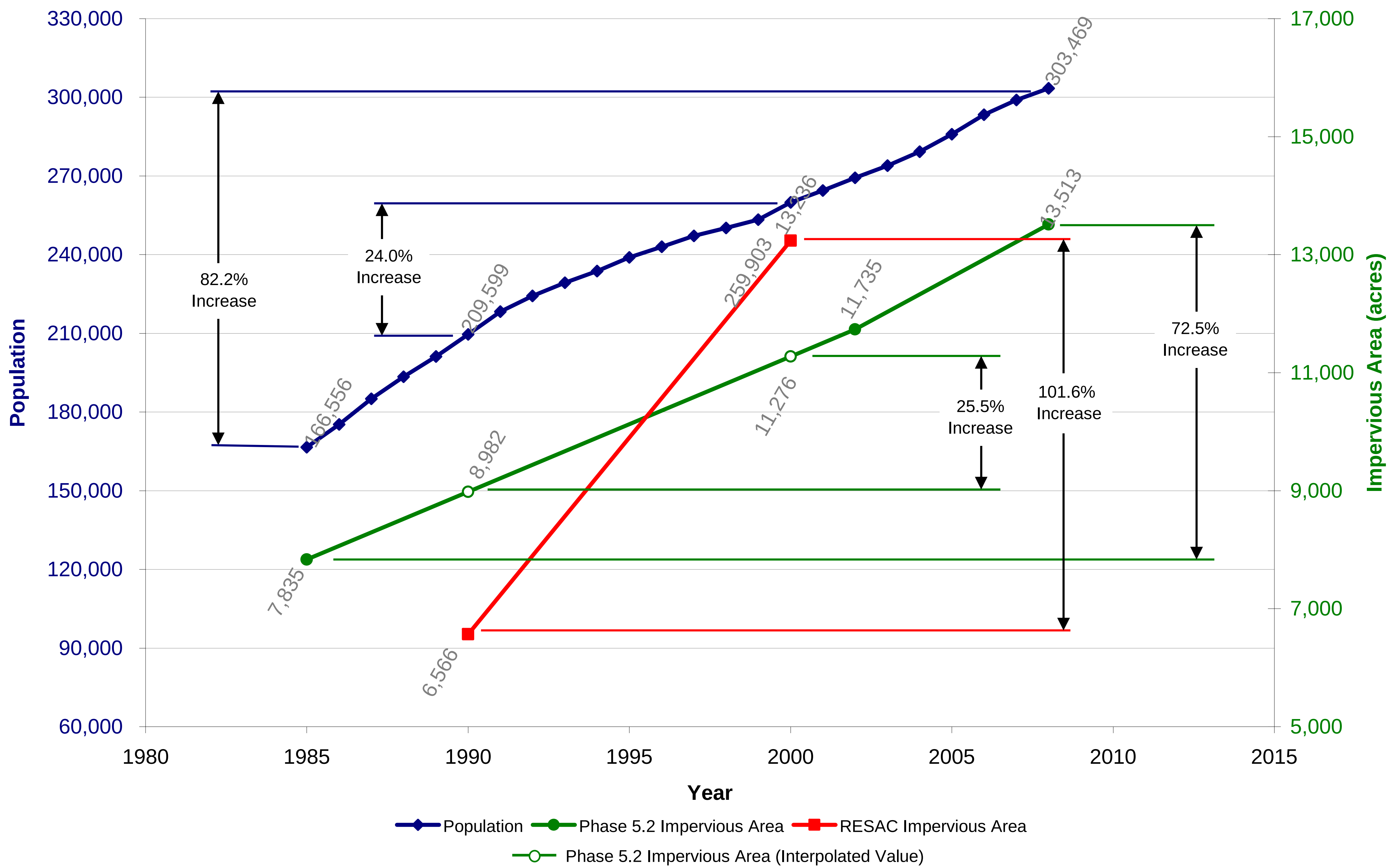
Impervious Area and Population Increases by Year (1985-2008) in Charles City County, Virginia



Charles City County

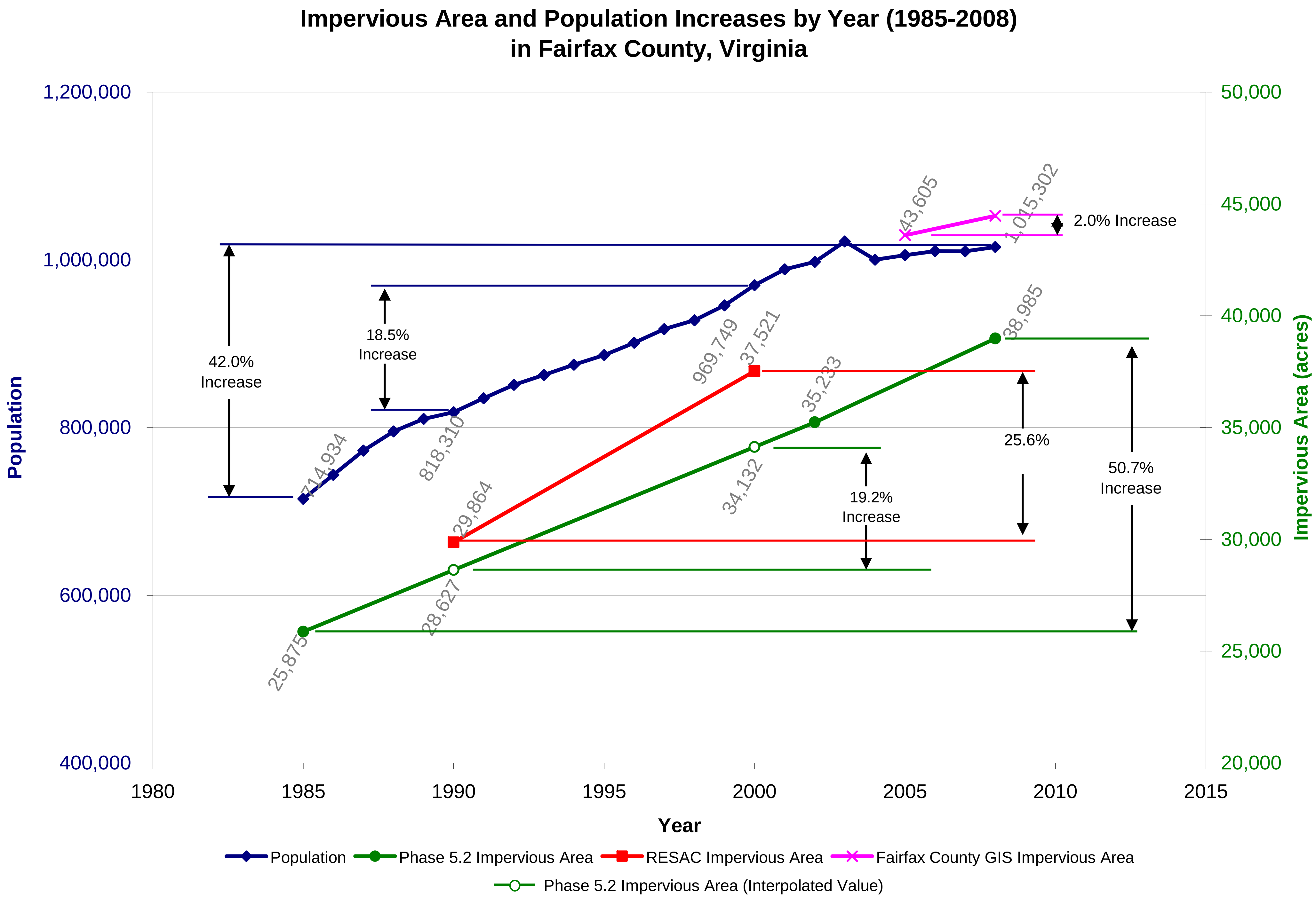
Year	RESAC / Woods Hole	Phase 5.2 Model	Population
1985		112	6,530
1986		*116*	6,422
1987		*119*	6,287
1988		*123*	6,321
1989		*126*	6,282
1990	60	*130*	6,282
1991		*133*	6,290
1992		*137*	6,393
1993		*141*	6,572
1994		*144*	6,646
1995		*148*	6,764
1996		*151*	6,852
1997		*155*	6,946
1998		*158*	7,153
1999		*162*	7,240
2000	372	*166*	6,926
2001		*169*	6,947
2002		173	7,023
2003			7,079
2004			7,037
2005			7,041
2006			7,116
2007			7,130
2008		200	7,212
% Change 1990-2000	520.0%	27.5%	10.3%

Impervious Area and Population Increases by Year (1985-2008) in Chesterfield County, Virginia



Chesterfield County

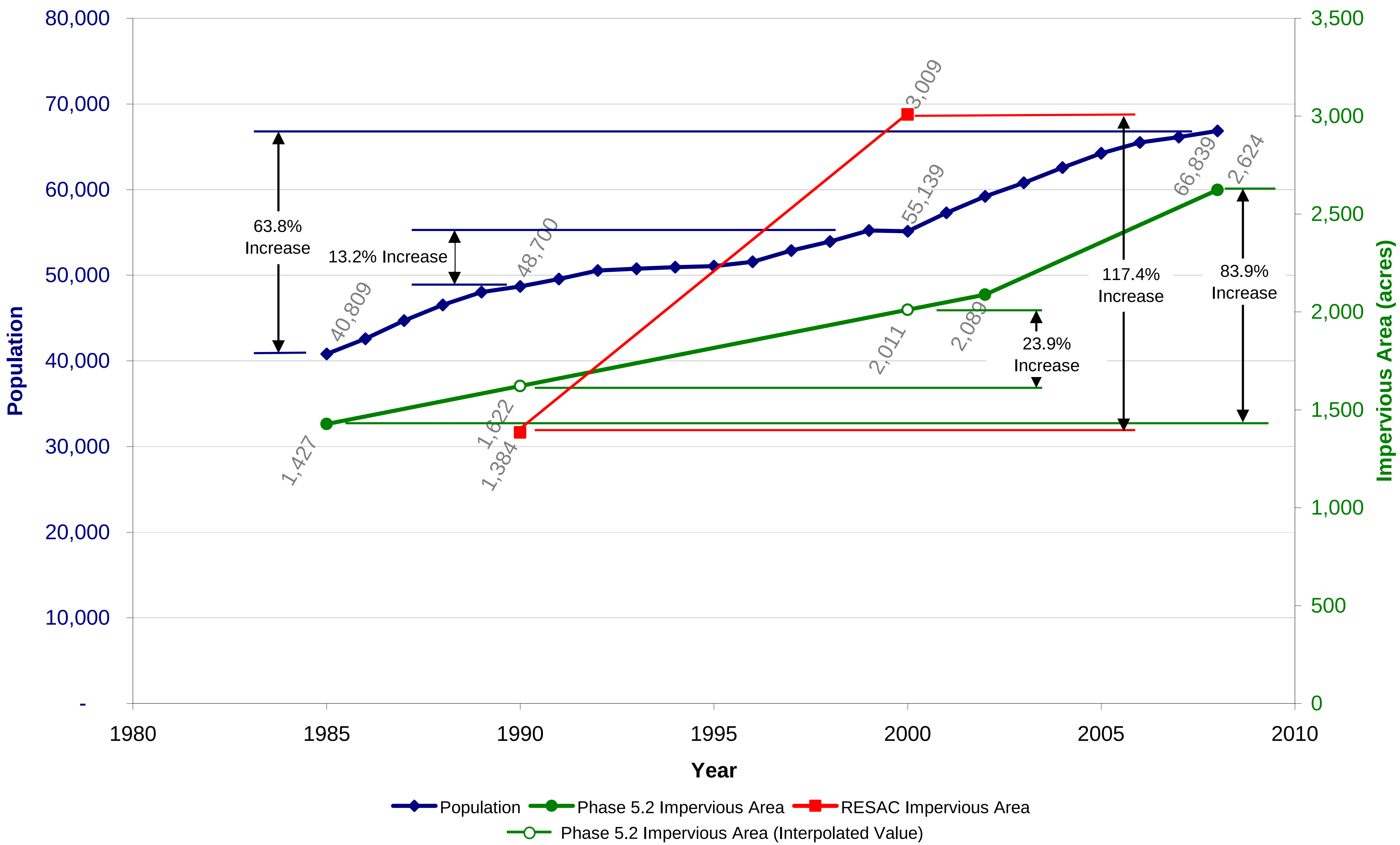
Year	RESAC / Woods Hole	Phase 5.2 Model	Population
1985		7,835	166,556
1986		*8,064*	175,256
1987		*8,294*	185,053
1988		*8,523*	193,417
1989		*8,753*	201,200
1990	6,566	*8,982*	209,599
1991		*9,211*	218,316
1992		*9,441*	224,307
1993		*9,670*	229,287
1994		*9,900*	233,721
1995		*10,129*	238,932
1996		*10,359*	243,030
1997		*10,588*	247,155
1998		*10,817*	250,161
1999		*11,047*	253,365
2000	13,236	*11,276*	259,903
2001		*11,506*	264,469
2002		11,735	269,266
2003			273,909
2004			279,243
2005			285,891
2006			293,361
2007			299,022
2008		13,513	303,469
% Change 1990-2000	101.6%	25.5%	24.0%



Fairfax County

Year	RESAC / Woods Hole	Phase 5.2 Model	Vector Data	Population
1985		25,875		714,934
1986		*26,426*		743,504
1987		*26,976*		772,555
1988		*27,527*		795,374
1989		*28,077*		810,406
1990	29,864	*28,627*		818,310
1991		*29,178*		835,010
1992		*29,728*		851,021
1993		*30,279*		862,658
1994		*30,829*		875,059
1995		*31,380*		886,379
1996		*31,930*		901,092
1997		*32,481*		917,488
1998		*33,031*		927,895
1999		*33,581*		945,717
2000	37,521	*34,132*		969,749
2001		*34,682*		988,714
2002		35,233		997,580
2003				1,021,838
2004				1,000,046
2005			43,605	1,005,616
2006				1,010,443
2007				1,010,241
2008		38,985	44,474	1,015,302
% Change 1990-2000	25.6%	19.2%	-	18.5%

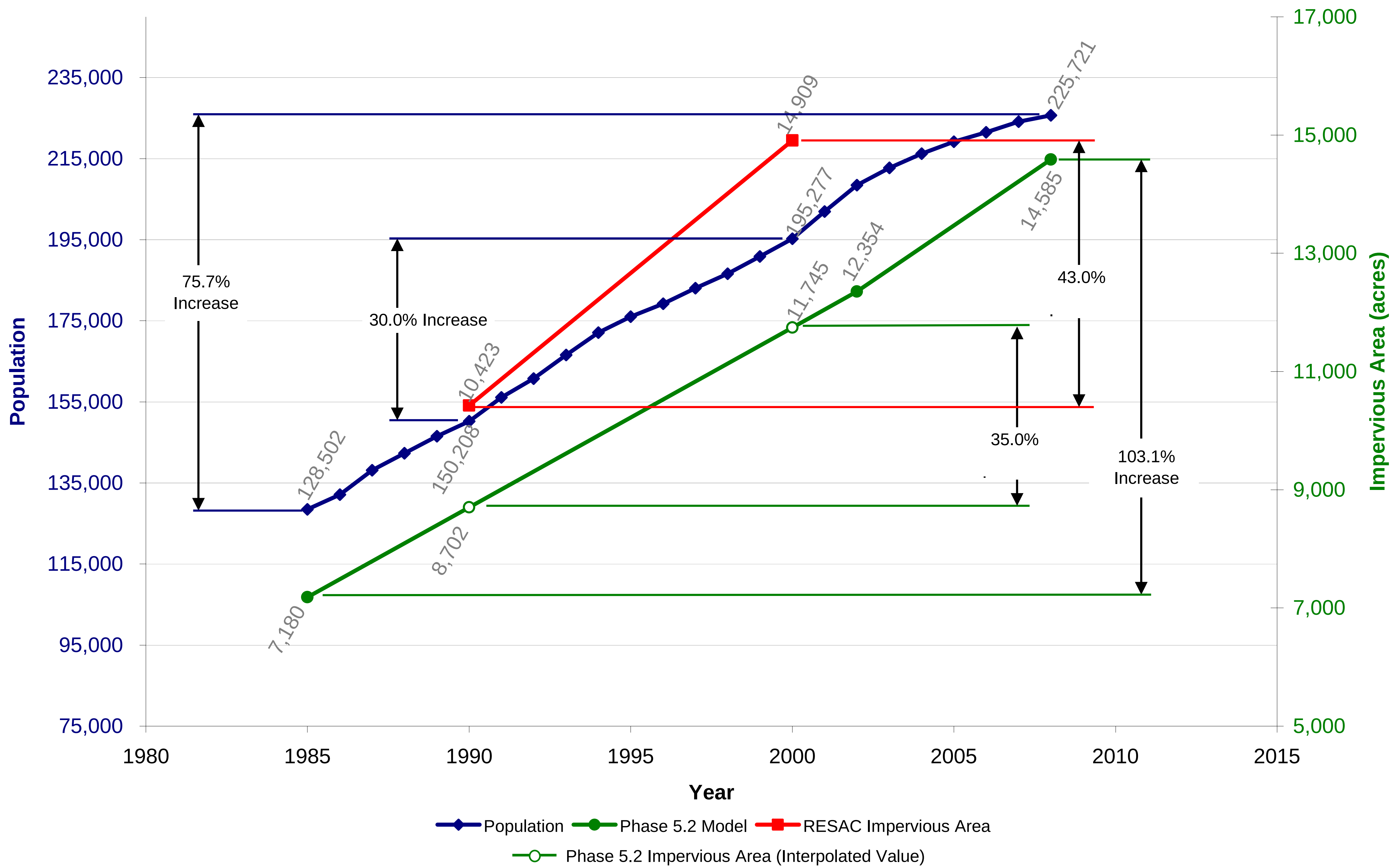
Impervious Area and Population Increases by Year (1985-2008)
in Fauquier County, Virginia



Fauquier County

Year	RESAC / Woods Hole	Phase 5.2 Model	Population
1985		1,427	40,809
1986		*1,466*	42,576
1987		*1,505*	44,716
1988		*1,544*	46,545
1989		*1,583*	48,044
1990	1,384	*1,622*	48,700
1991		*1,661*	49,563
1992		*1,699*	50,547
1993		*1,738*	50,742
1994		*1,777*	50,927
1995		*1,816*	51,057
1996		*1,855*	51,573
1997		*1,894*	52,881
1998		*1,933*	53,939
1999		*1,972*	55,206
2000	3,009	*2,011*	55,139
2001		*2,050*	57,280
2002		2,089	59,195
2003			60,797
2004			62,561
2005			64,225
2006			65,512
2007			66,122
2008		2,624	66,839
% Change 1990-2000	117.5%	24.0%	13.2%

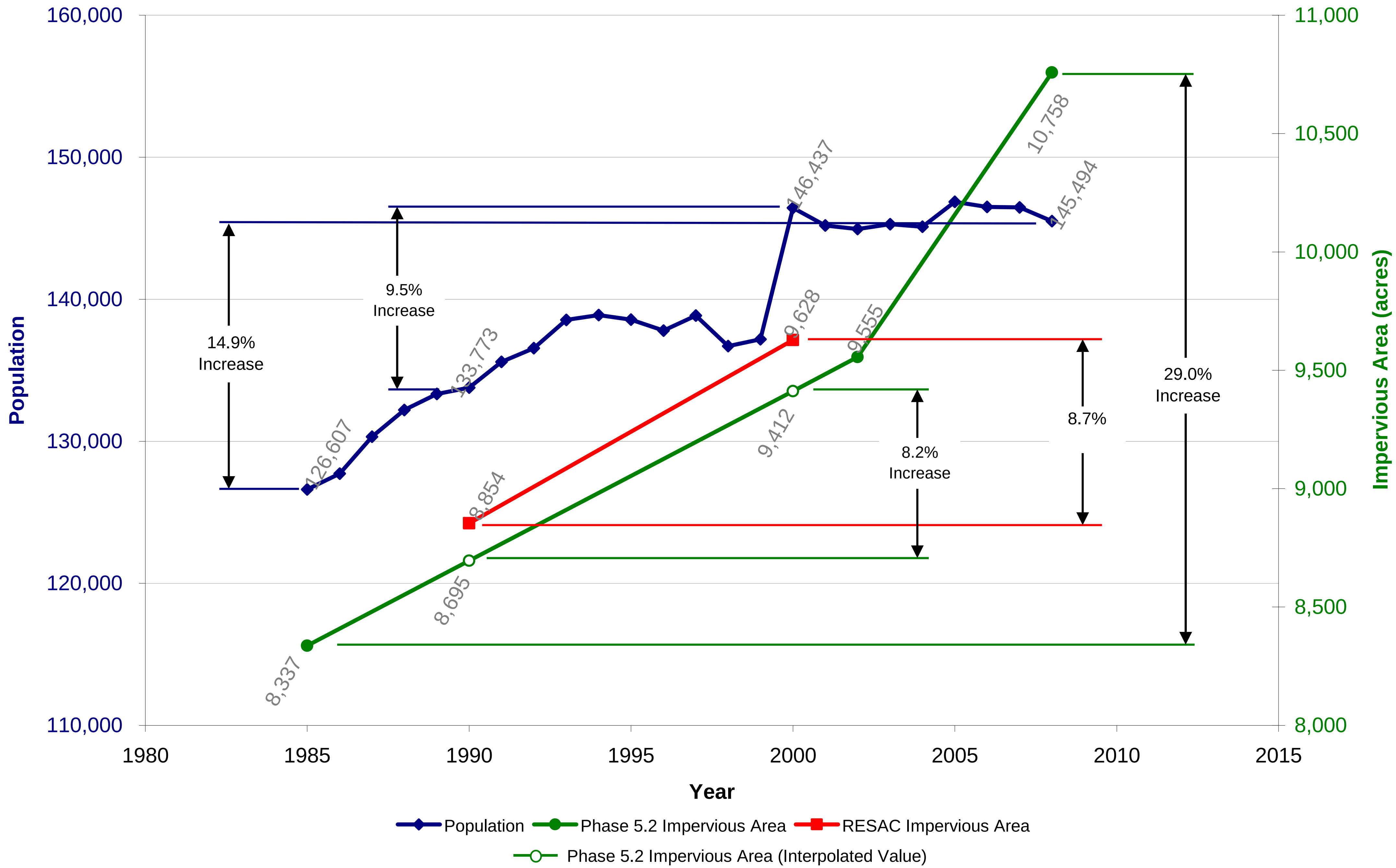
Impervious Area and Population Increases by Year (1985-2008) in Frederick County, Maryland



Frederick County

Year	RESAC / Woods Hole	Phase 5.2 Model	Popu-lation
1985		7,180	128,502
1986		*7,484*	132,124
1987		*7,789*	138,113
1988		*8,093*	142,328
1989		*8,397*	146,517
1990	10,423	*8,702*	150,208
1991		*9,006*	156,133
1992		*9,310*	160,723
1993		*9,615*	166,572
1994		*9,919*	172,082
1995		*10,223*	176,044
1996		*10,528*	179,223
1997		*10,832*	183,042
1998		*11,136*	186,621
1999		*11,441*	190,869
2000	14,909	*11,745*	195,277
2001		*12,049*	201,942
2002		12,354	208,498
2003			212,735
2004			216,232
2005			219,178
2006			221,492
2007			224,147
2008		14,585	225,721
% Change 1990-2000	43.0%	35.0%	30.0%

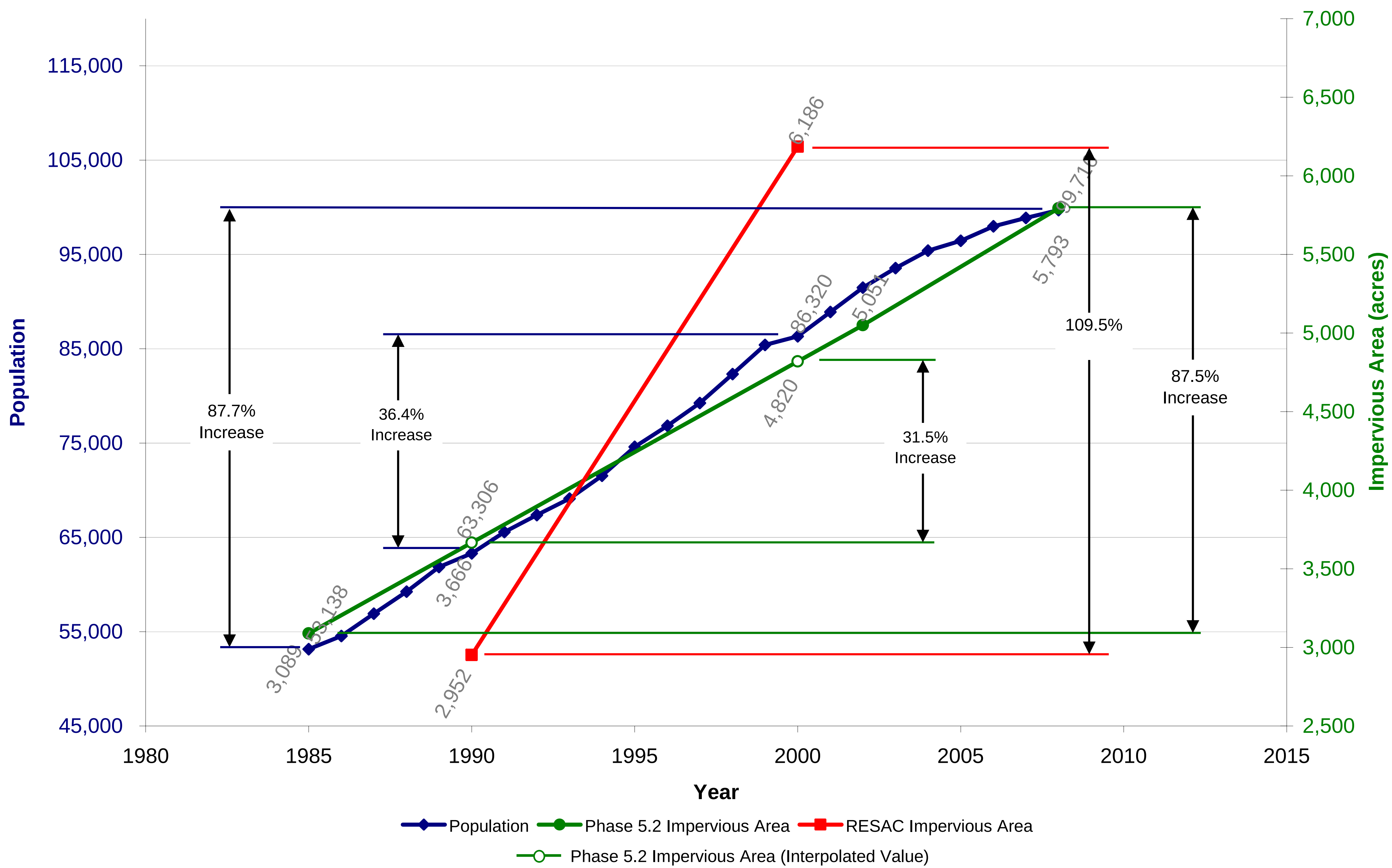
Impervious Area and Population Increases by Year (1985-2008) in the City of Hampton, Virginia



Hampton City

Year	RESAC / Woods Hole	Phase 5.2 Model	Population
1985		8,337	126,607
1986		*8,408*	127,730
1987		*8,480*	130,319
1988		*8,552*	132,200
1989		*8,624*	133,327
1990	8,854	*8,695*	133,773
1991		*8,767*	135,589
1992		*8,839*	136,561
1993		*8,910*	138,545
1994		*8,982*	138,885
1995		*9,054*	138,575
1996		*9,125*	137,795
1997		*9,197*	138,846
1998		*9,269*	136,706
1999		*9,340*	137,193
2000	9,628	*9,412*	146,437
2001		*9,484*	145,196
2002		9,555	144,939
2003			145,288
2004			145,105
2005			146,859
2006			146,503
2007			146,466
2008		10,758	145,494
% Change 1990-2000	8.7%	8.2%	9.5%

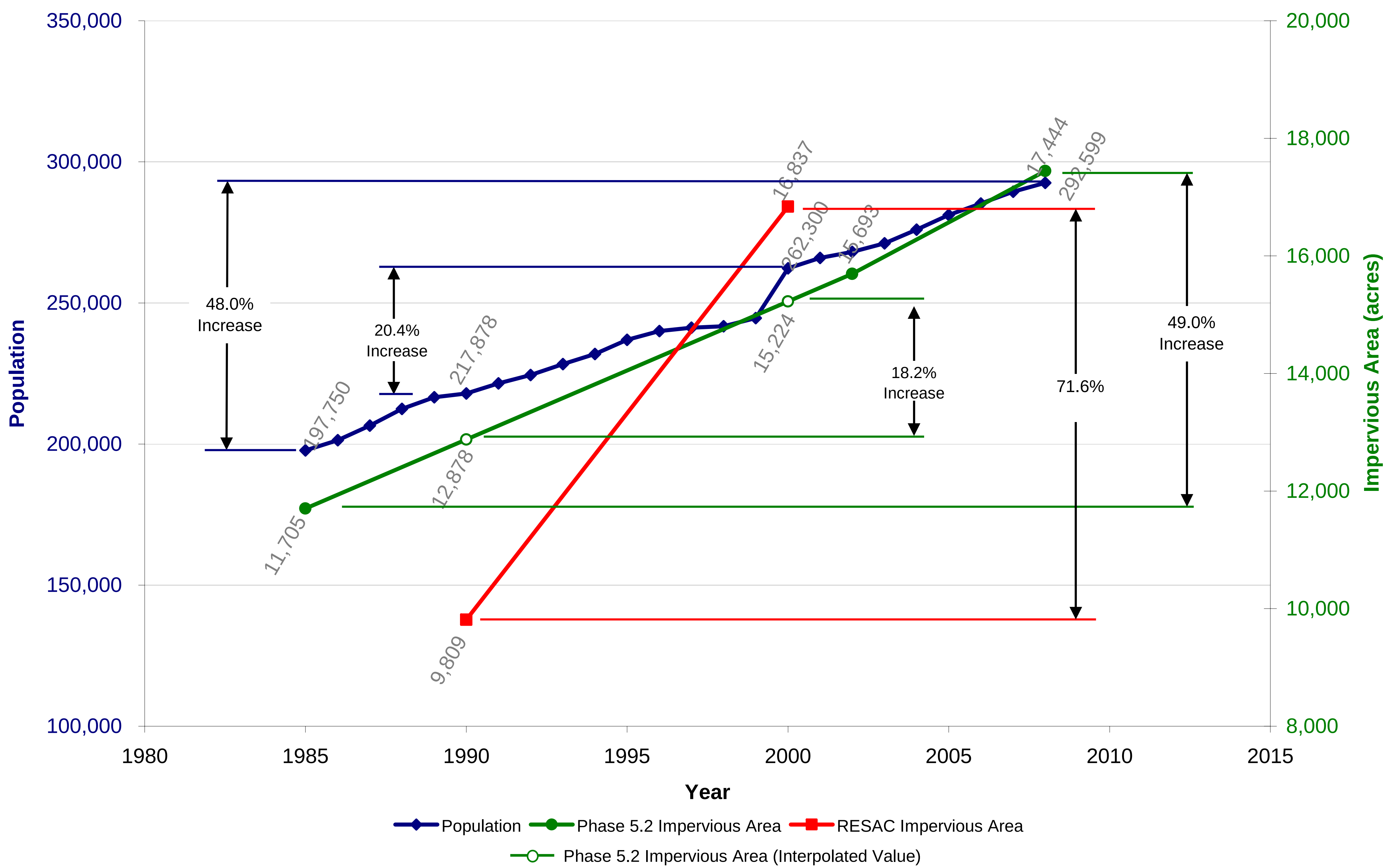
Impervious Area and Population Increases by Year (1985-2008) in Hanover County, Virginia



Hanover County

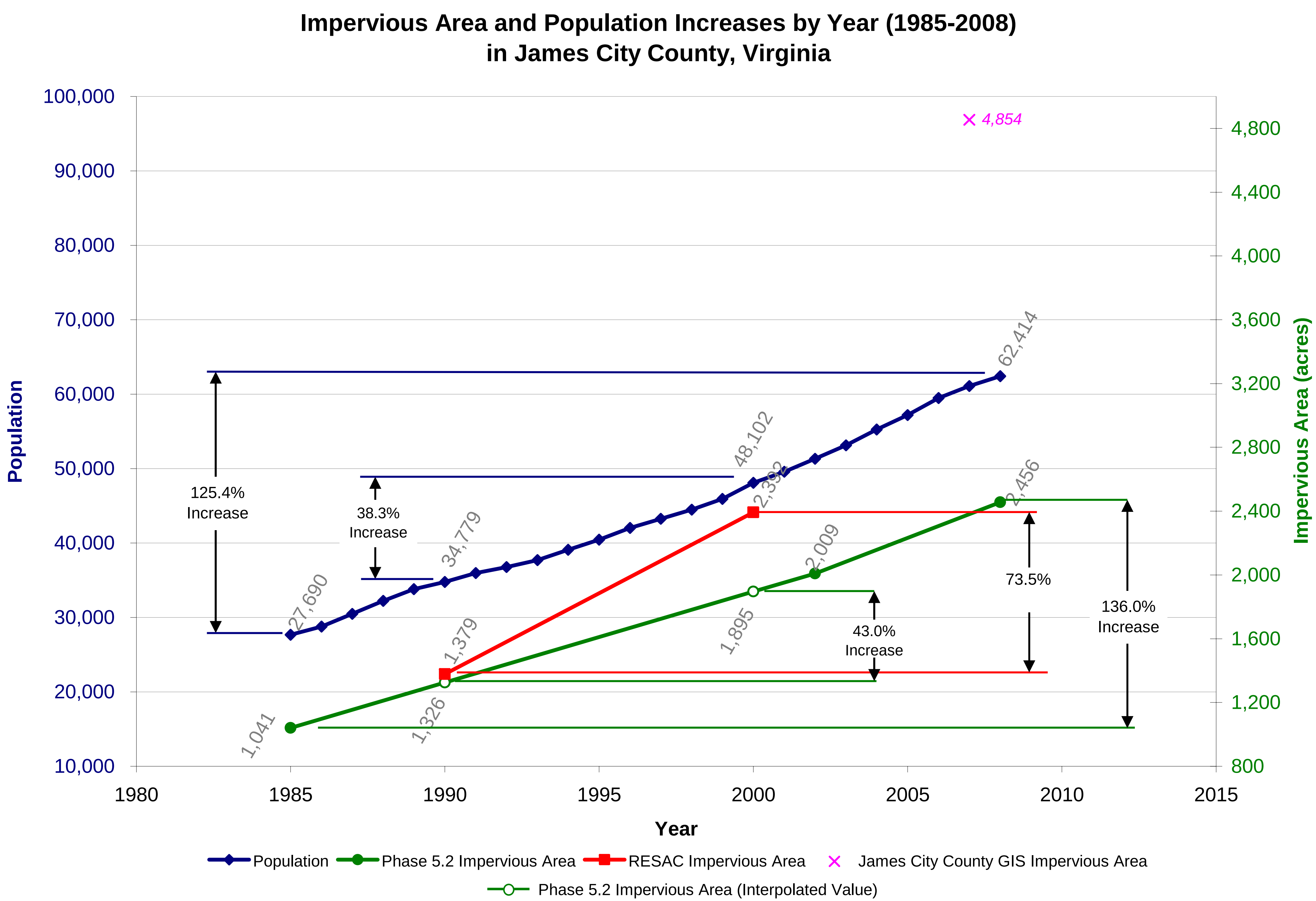
Year	RESAC / Woods Hole	Phase 5.2 Model	Population
1985		3,089	53,138
1986		*3,205*	54,551
1987		*3,320*	56,897
1988		*3,436*	59,254
1989		*3,551*	61,864
1990	2,952	*3,666*	63,306
1991		*3,782*	65,558
1992		*3,897*	67,360
1993		*4,012*	69,108
1994		*4,128*	71,539
1995		*4,243*	74,586
1996		*4,359*	76,823
1997		*4,474*	79,253
1998		*4,589*	82,302
1999		*4,705*	85,410
2000	6,186	*4,820*	86,320
2001		*4,935*	88,895
2002		5,051	91,485
2003			93,548
2004			95,414
2005			96,458
2006			97,992
2007			98,862
2008		5,793	99,716
% Change 1990-2000	109.5%	31.5%	36.4%

Impervious Area and Population Increases by Year (1985-2008) in Henrico County, Virginia



Henrico County

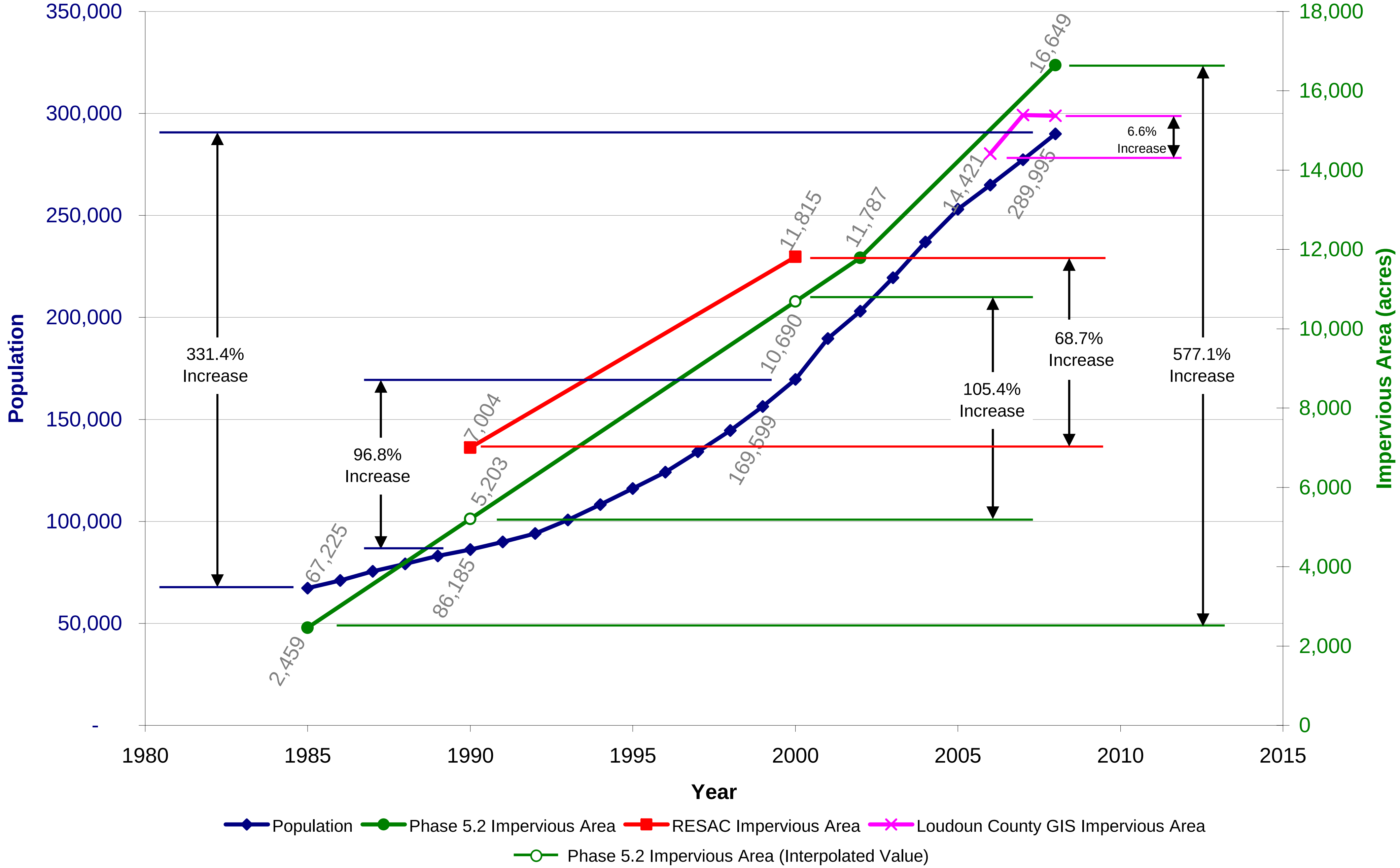
Year	RESAC / Woods Hole	Phase 5.2 Model	Population
1985		11,705	197,750
1986		*11,940*	201,376
1987		*12,174*	206,524
1988		*12,409*	212,486
1989		*12,644*	216,547
1990	9,809	*12,878*	217,878
1991		*13,113*	221,520
1992		*13,347*	224,425
1993		*13,582*	228,353
1994		*13,816*	231,942
1995		*14,051*	236,936
1996		*14,286*	240,056
1997		*14,520*	241,245
1998		*14,755*	241,766
1999		*14,989*	244,652
2000	16,837	*15,224*	262,300
2001		*15,458*	265,957
2002		15,693	268,099
2003			271,104
2004			275,996
2005			281,169
2006			285,187
2007			289,460
2008		17,444	292,599
% Change 1990-2000	71.6%	18.2%	20.4%



James City County

Year	RESAC / Woods Hole	Phase 5.2 Model	Vector Data	Popu-lation
1985		1,041		27,690
1986		*1,098*		28,774
1987		*1,155*		30,485
1988		*1,212*		32,212
1989		*1,269*		33,811
1990	1,379	*1,326*		34,779
1991		*1,383*		35,966
1992		*1,440*		36,764
1993		*1,496*		37,716
1994		*1,553*		39,088
1995		*1,610*		40,439
1996		*1,667*		42,040
1997		*1,724*		43,254
1998		*1,781*		44,488
1999		*1,838*		45,945
2000	2,392	*1,895*		48,102
2001		*1,952*		49,570
2002		2,009		51,313
2003				53,113
2004				55,246
2005				57,187
2006				59,484
2007			4,854	61,094
2008		2,456		62,414
% Change 1990-2000	73.5%	43.0%	-	38.3%

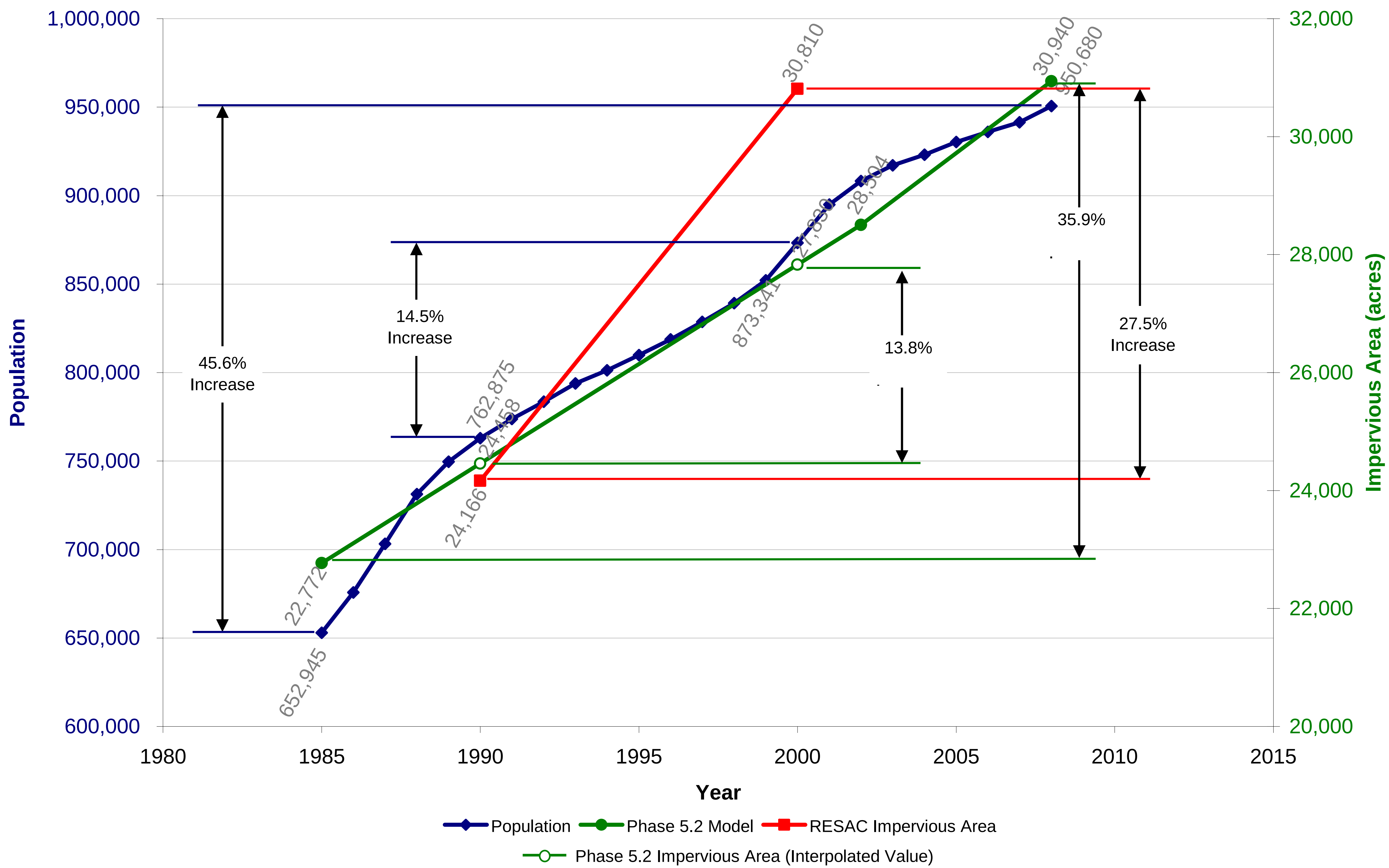
Impervious Area and Population Increases by Year (1985-2008) in Loudoun County, Virginia



Loudoun County

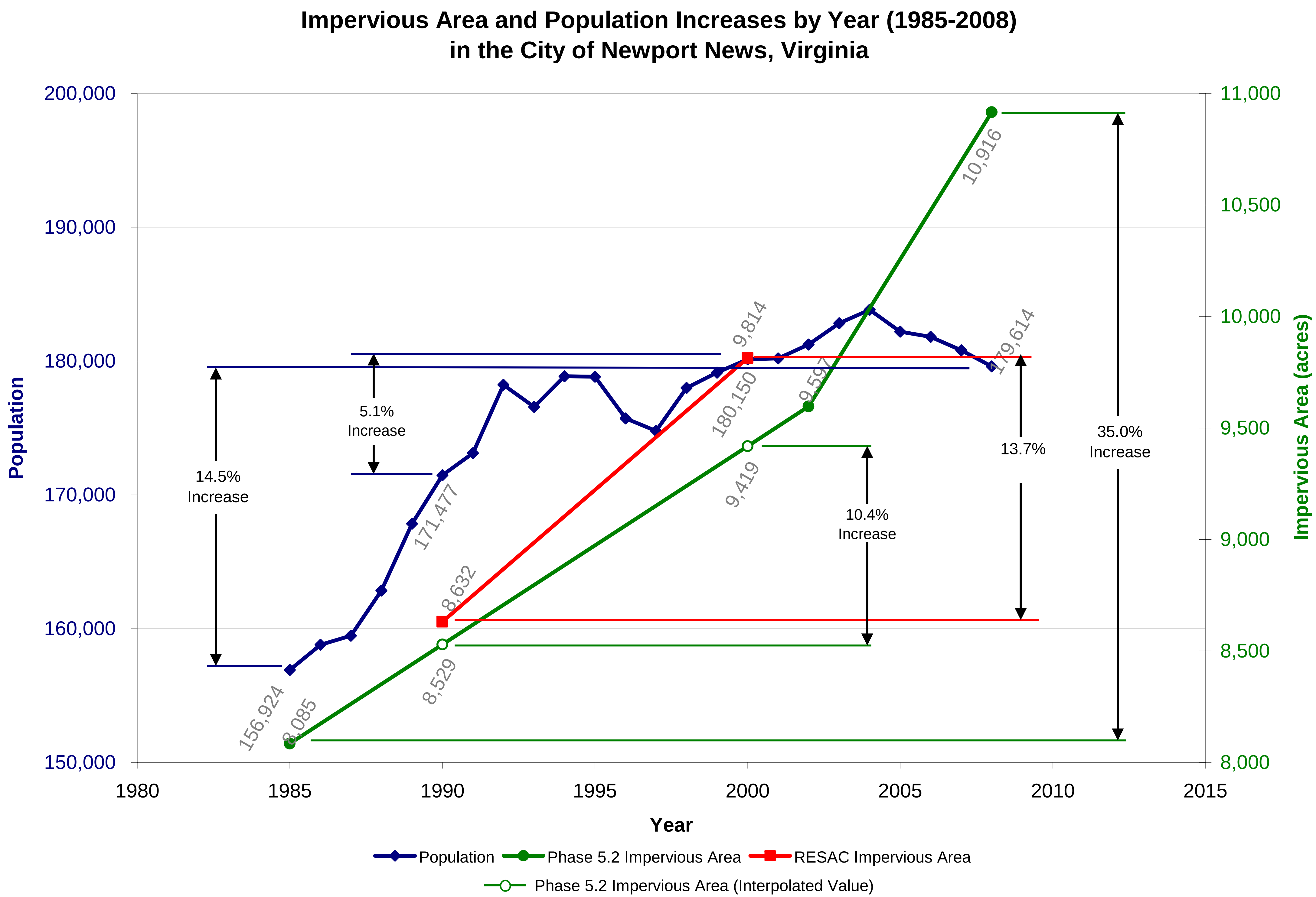
Year	RESAC / Woods Hole	Phase 5.2 Model	Vector Data	Population
1985		2,459		67,225
1986		*3,008*		71,026
1987		*3,557*		75,578
1988		*4,106*		79,117
1989		*4,654*		83,084
1990	7,004	*5,203*		86,185
1991		*5,752*		89,971
1992		*6,300*		94,047
1993		*6,849*		100,723
1994		*7,398*		108,187
1995		*7,946*		116,140
1996		*8,495*		124,114
1997		*9,044*		134,170
1998		*9,592*		144,514
1999		*10,141*		156,284
2000	11,815	*10,690*		169,599
2001		*11,239*		189,649
2002		11,787		203,007
2003				219,423
2004				236,965
2005				253,053
2006			14,421	264,958
2007			15,389	277,346
2008		16,649	15,371	289,995
% Change 1990-2000	68.7%	105.5%	-	96.8%

Impervious Area and Population Increases by Year (1985-2008) in Montgomery County, Maryland



Montgomery County

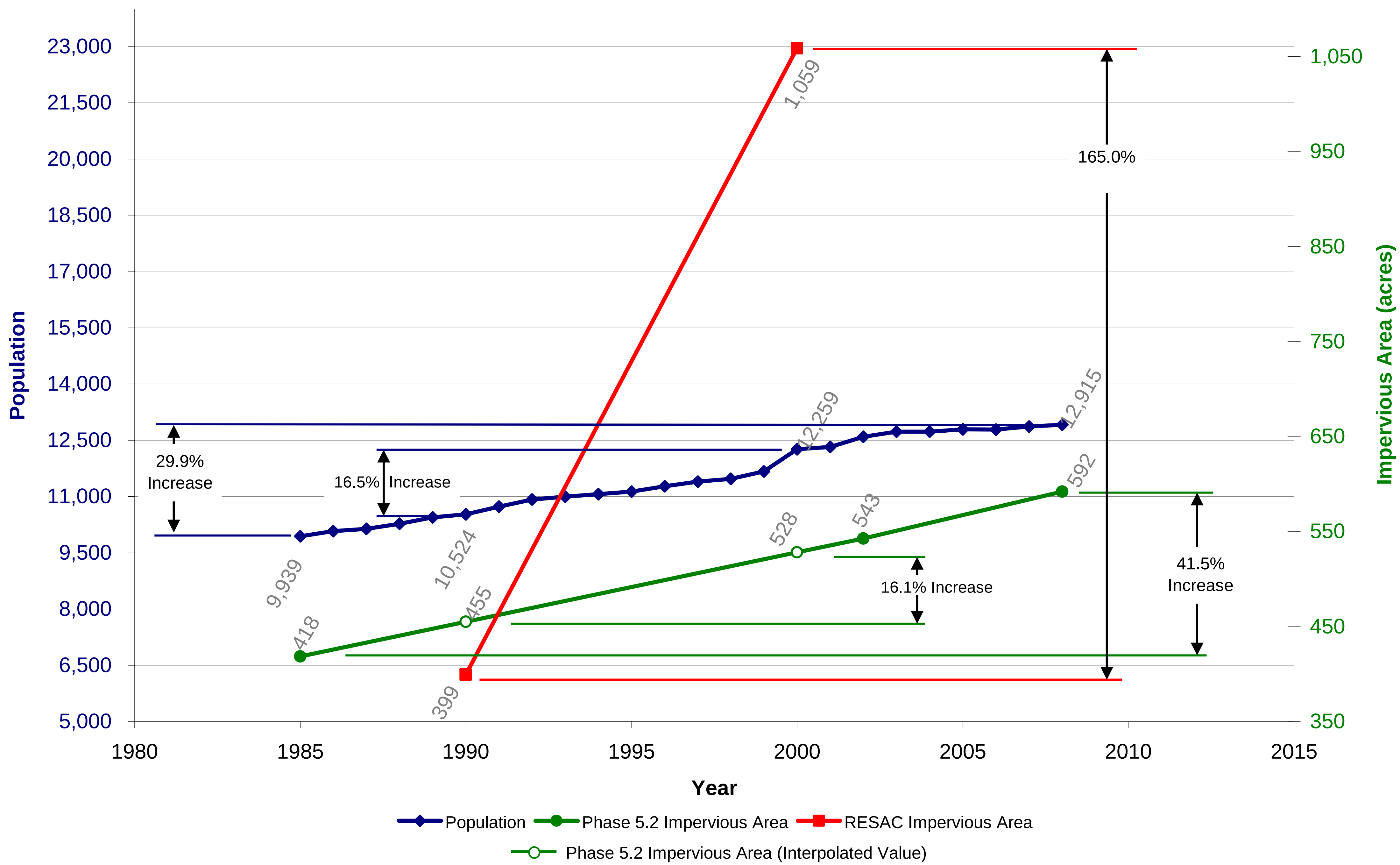
Year	RESAC / Woods Hole	Phase 5.2 Model	Population
1985		22,772	652,945
1986		*23,109*	675,784
1987		*23,446*	703,273
1988		*23,783*	731,351
1989		*24,120*	749,638
1990	24,166	*24,458*	762,875
1991		*24,795*	773,755
1992		*25,132*	783,567
1993		*25,469*	793,903
1994		*25,806*	801,356
1995		*26,144*	809,814
1996		*26,481*	818,753
1997		*26,818*	828,617
1998		*27,155*	839,158
1999		*27,492*	852,174
2000	30,810	*27,830*	873,341
2001		*28,167*	894,878
2002		28,504	908,233
2003			917,160
2004			923,094
2005			930,286
2006			936,070
2007			941,491
2008		30,940	950,680
% Change 1990-2000	27.5%	13.8%	14.5%



Newport News City

Year	RESAC / Woods Hole	Phase 5.2 Model	Population
1985		8,085	156,924
1986		*8,174*	158,808
1987		*8,263*	159,484
1988		*8,352*	162,854
1989		*8,441*	167,851
1990	8,632	*8,529*	171,477
1991		*8,618*	173,113
1992		*8,707*	178,233
1993		*8,796*	176,580
1994		*8,885*	178,874
1995		*8,974*	178,837
1996		*9,063*	175,720
1997		*9,152*	174,792
1998		*9,241*	178,001
1999		*9,330*	179,138
2000	9,814	*9,419*	180,150
2001		*9,508*	180,192
2002		9,597	181,230
2003			182,826
2004			183,832
2005			182,213
2006			181,812
2007			180,810
2008		10,916	179,614
% Change 1990-2000	13.7%	10.4%	5.1%

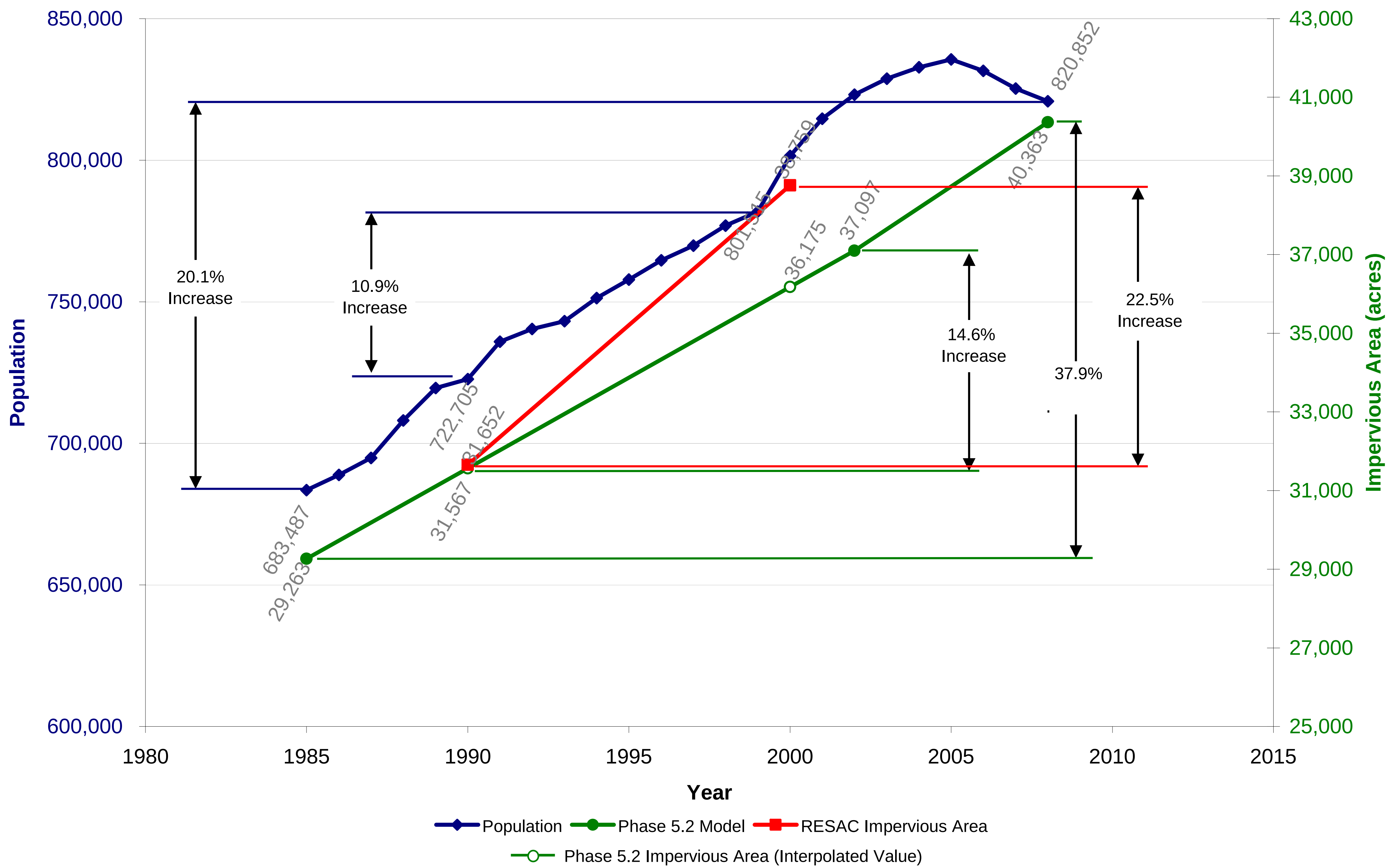
Impervious Area and Population Increases by Year (1985-2008) in Northumberland County, Virginia



Northumberland County

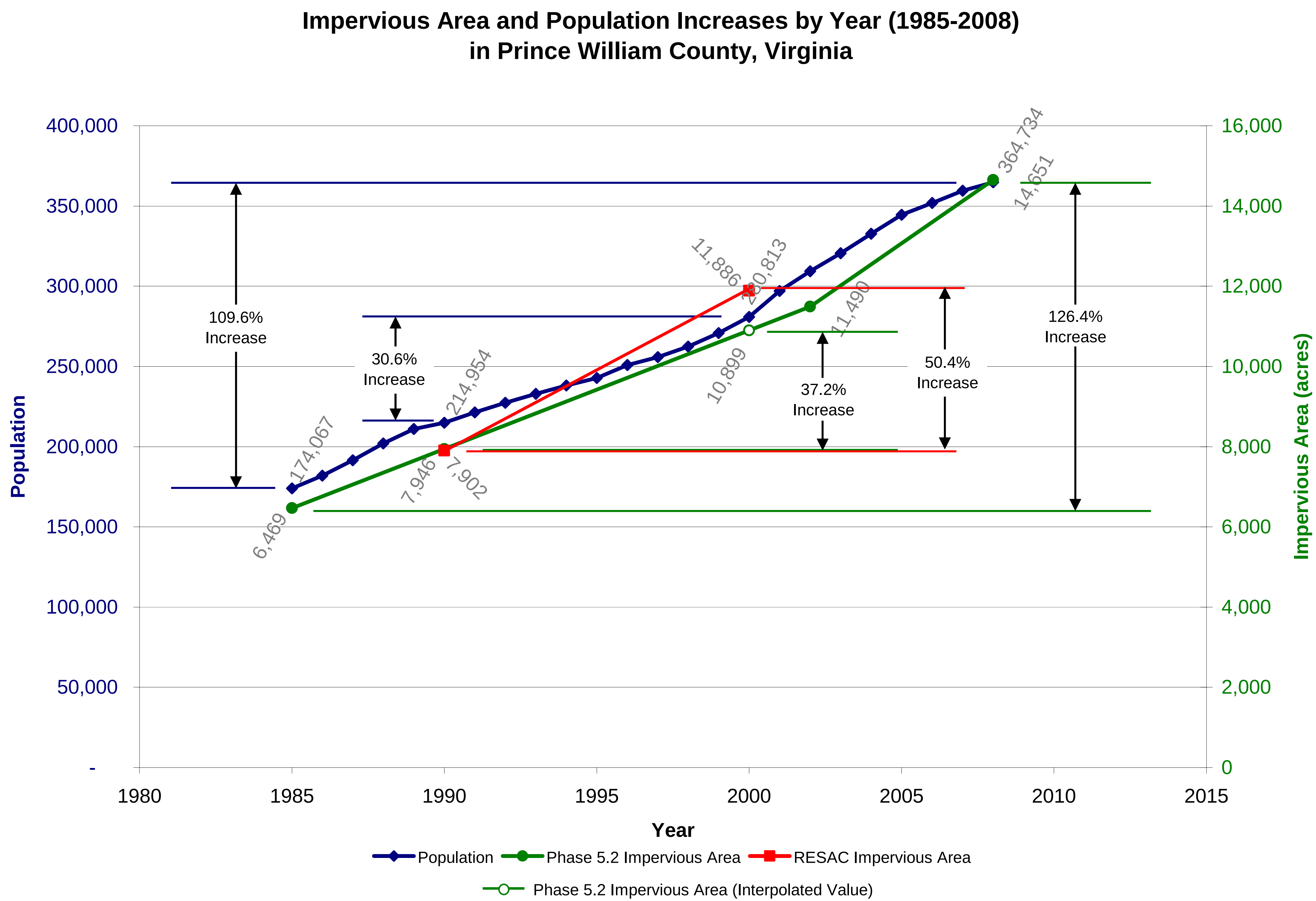
Year	RESAC / Woods Hole	Phase 5.2 Model	Population
1985		418	9,939
1986		*426*	10,079
1987		*433*	10,136
1988		*440*	10,275
1989		*448*	10,447
1990	399	*455*	10,524
1991		*462*	10,728
1992		*470*	10,920
1993		*477*	10,993
1994		*484*	11,061
1995		*492*	11,134
1996		*499*	11,271
1997		*506*	11,396
1998		*513*	11,473
1999		*521*	11,668
2000	1,059	*528*	12,259
2001		*535*	12,325
2002		543	12,592
2003			12,733
2004			12,732
2005			12,795
2006			12,788
2007			12,867
2008		592	12,915
% Change 1990-2000	165.0%	16.1%	16.5%

Impervious Area and Population Increases by Year (1985-2008) in Prince George's County, Maryland



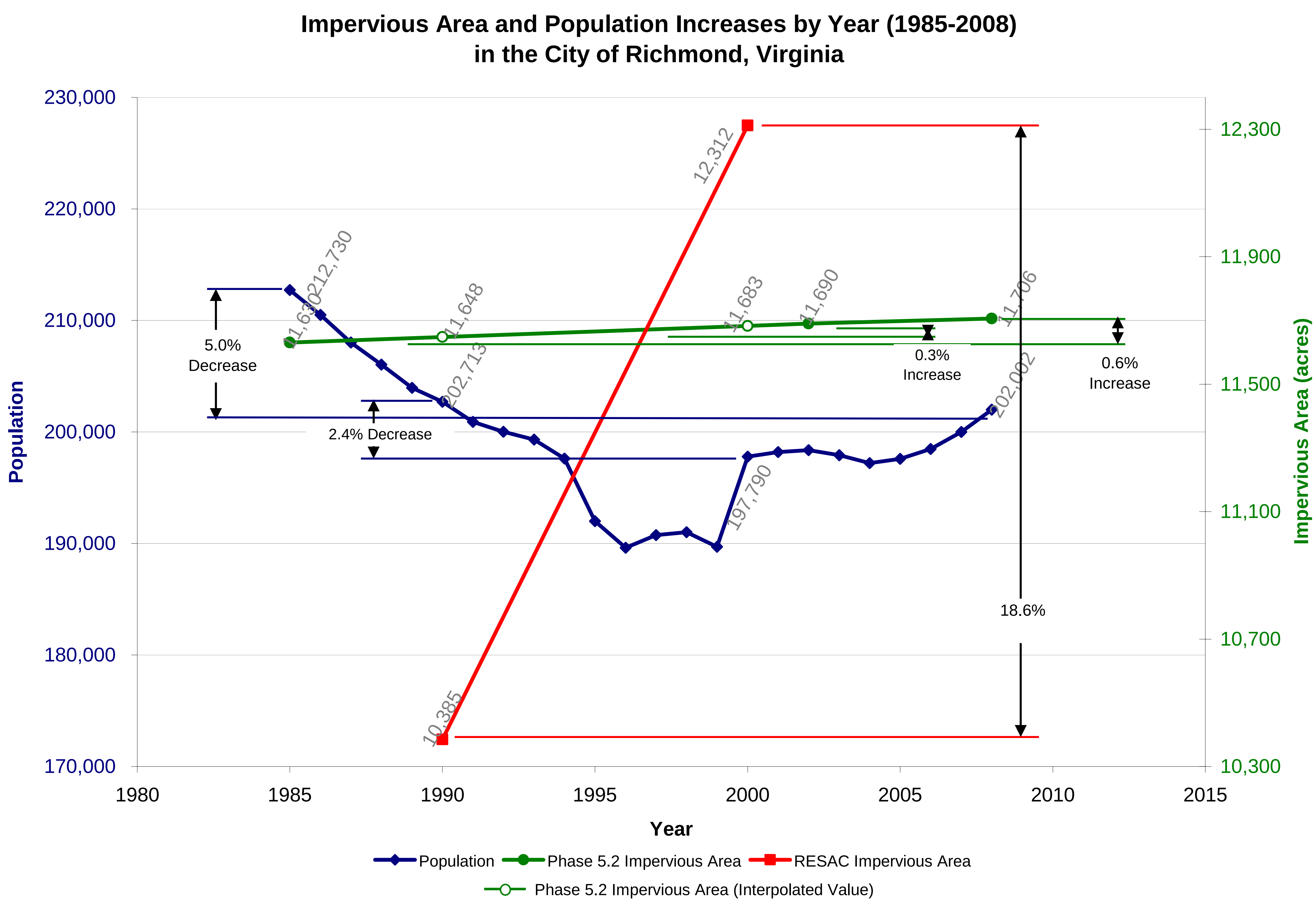
Prince George's County

Year	RESAC / Woods Hole	Phase 5.2 Model	Popu-lation
1985		29,263	683,487
1986		*29,723*	688,863
1987		*30,184*	694,845
1988		*30,645*	708,095
1989		*31,106*	719,550
1990	31,652	*31,567*	722,705
1991		*32,028*	735,915
1992		*32,488*	740,390
1993		*32,949*	743,156
1994		*33,410*	751,282
1995		*33,871*	757,795
1996		*34,332*	764,644
1997		*34,792*	769,840
1998		*35,253*	776,907
1999		*35,714*	781,781
2000	38,759	*36,175*	801,515
2001		*36,636*	814,689
2002		37,097	823,186
2003			828,822
2004			832,806
2005			835,588
2006			831,602
2007			825,318
2008		40,363	820,852
% Change 1990-2000	22.5%	14.6%	10.9%



Prince William County

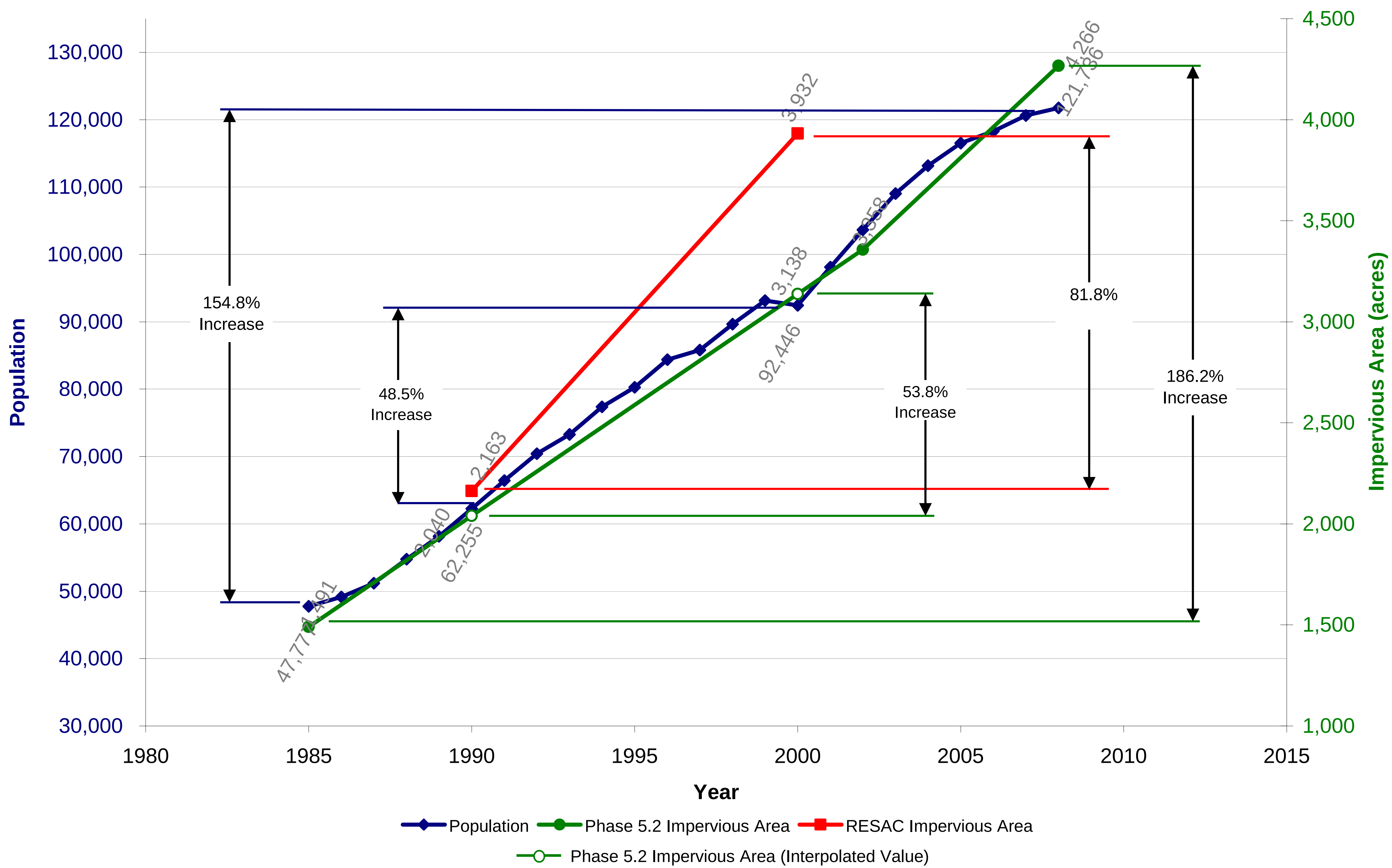
Year	RESAC / Woods Hole	Phase 5.2 Model	Population
1985		6,469	174,067
1986		*6,764*	181,935
1987		*7,060*	191,570
1988		*7,355*	202,079
1989		*7,650*	211,064
1990	7,902	*7,946*	214,954
1991		*8,241*	221,284
1992		*8,537*	227,384
1993		*8,832*	232,900
1994		*9,127*	238,215
1995		*9,423*	242,718
1996		*9,718*	250,892
1997		*10,013*	255,786
1998		*10,309*	262,414
1999		*10,604*	270,841
2000	11,886	*10,899*	280,813
2001		*11,195*	297,080
2002		11,490	309,312
2003			320,618
2004			332,689
2005			344,572
2006			351,835
2007			359,588
2008		14,651	364,734
% Change 1990-2000	50.4%	37.2%	30.6%



City of Richmond

Year	RESAC / Woods Hole	Phase 5.2 Model	Population
1985		11,630	212,730
1986		*11,634*	210,497
1987		*11,637*	208,018
1988		*11,641*	206,050
1989		*11,644*	203,963
1990	10,385	*11,648*	202,713
1991		*11,651*	200,900
1992		*11,655*	200,024
1993		*11,658*	199,303
1994		*11,662*	197,610
1995		*11,665*	192,003
1996		*11,669*	189,608
1997		*11,672*	190,757
1998		*11,676*	191,001
1999		*11,679*	189,700
2000	12,312	*11,683*	197,790
2001		*11,686*	198,204
2002		11,690	198,356
2003			197,924
2004			197,194
2005			197,586
2006			198,480
2007			199,991
2008		11,706	202,002
% Change 1990-2000	18.6%	0.3%	-2.4%

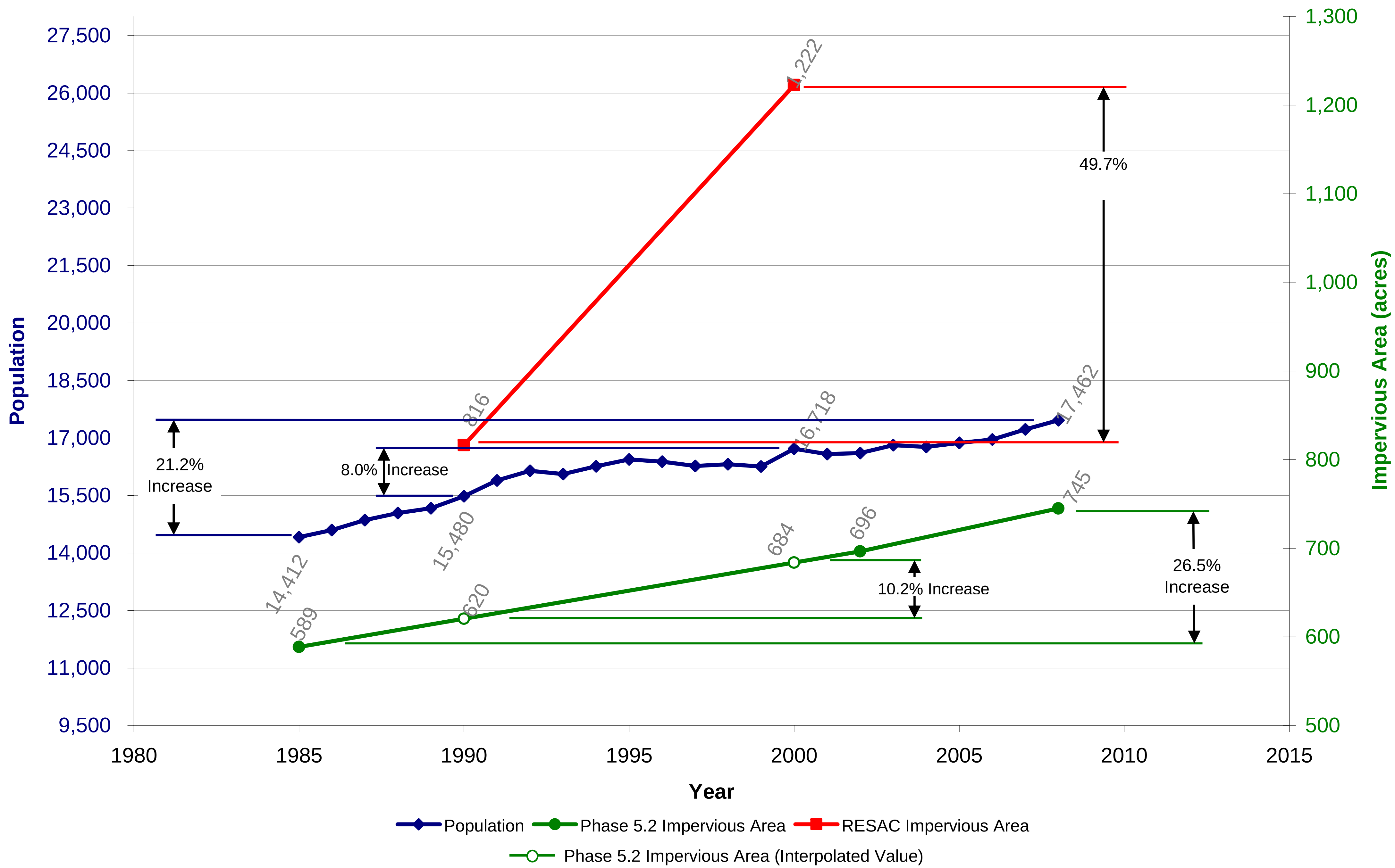
Impervious Area and Population Increases by Year (1985-2008) in Stafford County, Virginia



Stafford County

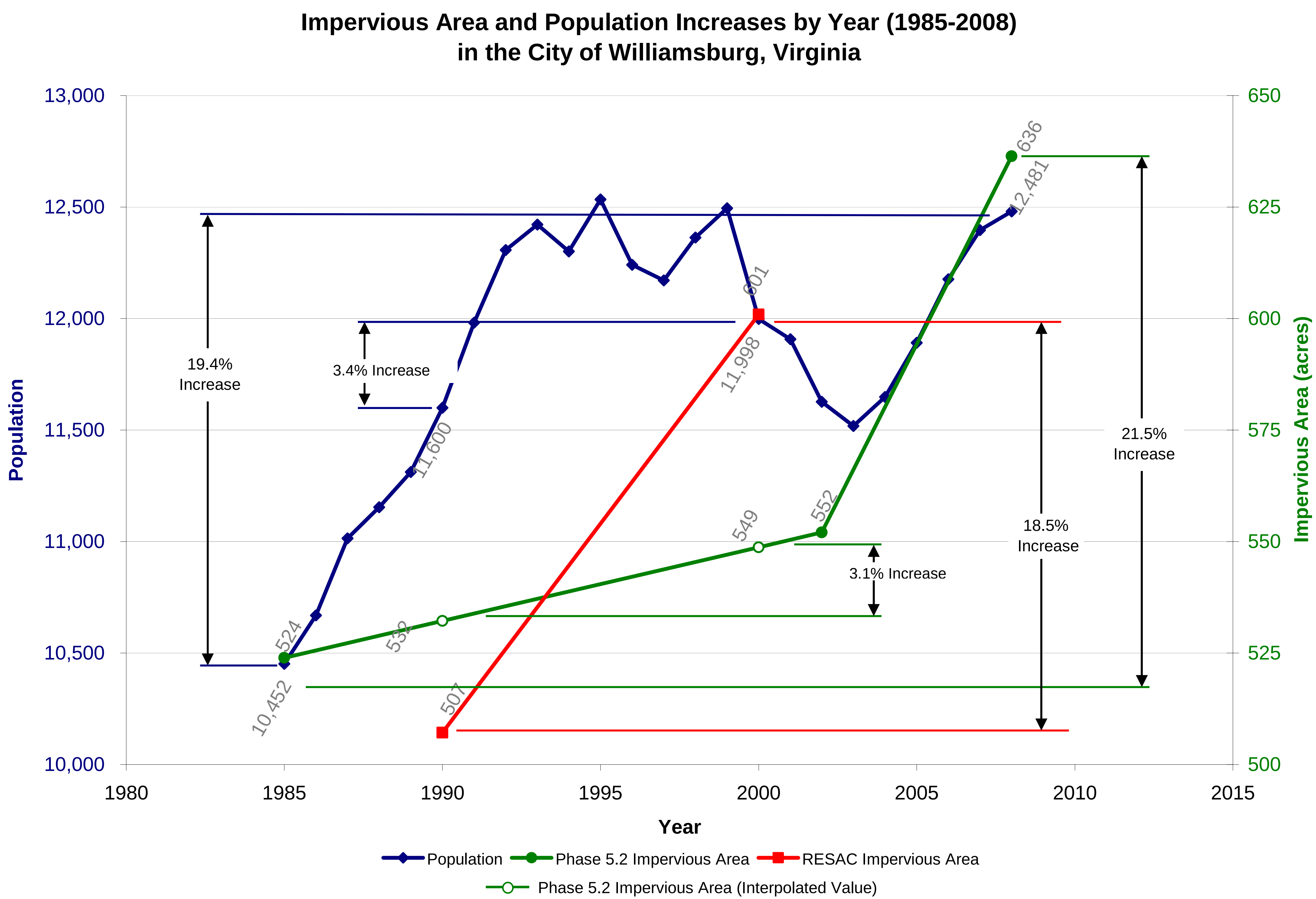
Year	RESAC / Woods Hole	Phase 5.2 Model	Population
1985		1,491	47,777
1986		*1,600*	49,143
1987		*1,710*	51,193
1988		*1,820*	54,749
1989		*1,930*	58,139
1990	2,163	*2,040*	62,255
1991		*2,150*	66,444
1992		*2,259*	70,409
1993		*2,369*	73,261
1994		*2,479*	77,379
1995		*2,589*	80,275
1996		*2,699*	84,382
1997		*2,809*	85,799
1998		*2,918*	89,668
1999		*3,028*	93,160
2000	3,932	*3,138*	92,446
2001		*3,248*	98,101
2002		3,358	103,645
2003			109,035
2004			113,164
2005			116,536
2006			118,299
2007			120,621
2008		4,266	121,736
% Change 1990-2000	81.8%	53.8%	48.5%

Impervious Area and Population Increases by Year (1985-2008) in Westmoreland County, Virginia



Westmoreland County

Year	RESAC / Woods Hole	Phase 5.2 Model	Population
1985		589	14,412
1986		*595*	14,596
1987		*601*	14,861
1988		*608*	15,044
1989		*614*	15,169
1990	816	*620*	15,480
1991		*627*	15,889
1992		*633*	16,143
1993		*639*	16,060
1994		*646*	16,262
1995		*652*	16,442
1996		*658*	16,380
1997		*665*	16,267
1998		*671*	16,319
1999		*677*	16,259
2000	1,222	*684*	16,718
2001		*690*	16,583
2002		696	16,611
2003			16,815
2004			16,769
2005			16,875
2006			16,962
2007			17,225
2008		745	17,462
% Change 1990-2000	49.7%	10.2%	8.0%



Williamsburg City

Year	RESAC / Woods Hole	Phase 5.2 Model	Popu-lation
1985		524	10,452
1986		*526*	10,669
1987		*527*	11,014
1988		*529*	11,154
1989		*531*	11,312
1990	507	*532*	11,600
1991		*534*	11,982
1992		*535*	12,307
1993		*537*	12,422
1994		*539*	12,301
1995		*540*	12,534
1996		*542*	12,241
1997		*544*	12,171
1998		*545*	12,363
1999		*547*	12,495
2000	601	*549*	11,998
2001		*550*	11,908
2002		552	11,627
2003			11,518
2004			11,648
2005			11,891
2006			12,176
2007			12,397
2008		636	12,481
% Change 1990-2000	18.5%	3.1%	3.4%

Appendix B: Analysis of RESAC Data Changes Between 1990 and 2000

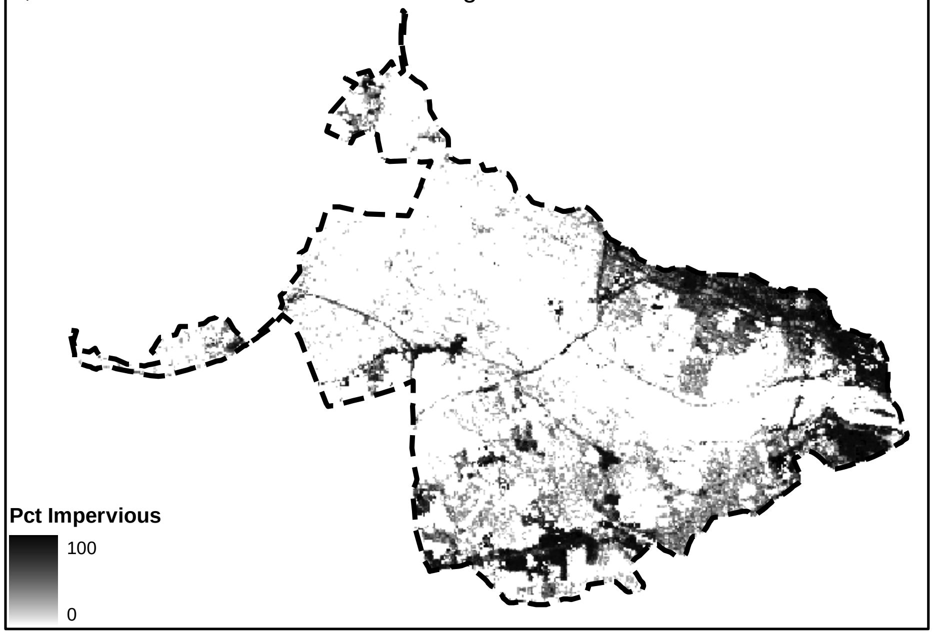
B1: City of Richmond, Virginia
B2: Study Area 1, City of Richmond, Virginia (Residential Development and Cemetery)
B3: Study Area 2, City of Richmond, Virginia (Powhite Parkway Bridge)
B4: Study Area 2, City of Richmond, Virginia (Reservoir Structure)

Appendix B: Analysis of RESAC Data Changes Between 1990 and 2000

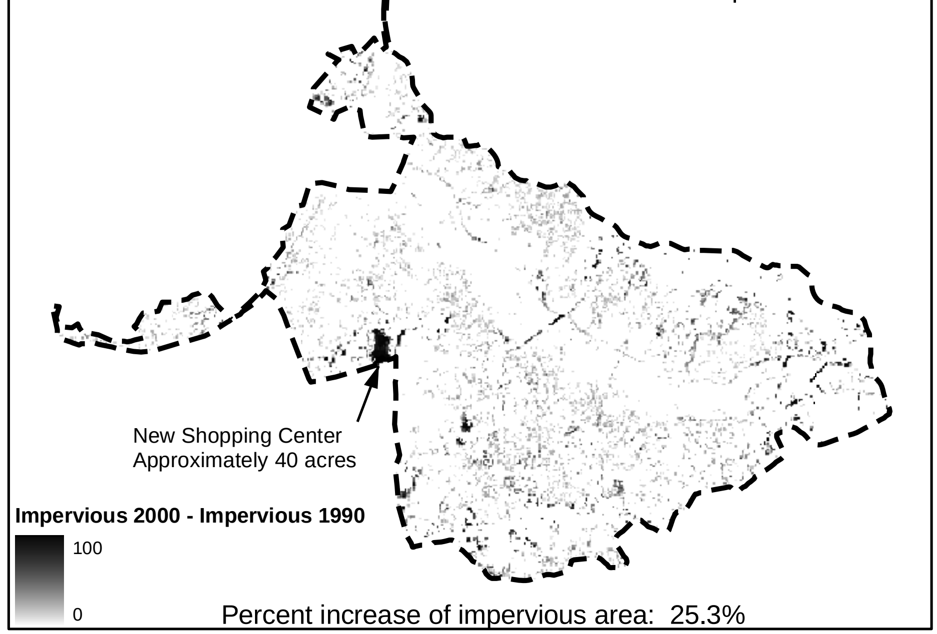
B1: City of Richmond, Virginia
B2: Study Area 1, City of Richmond, Virginia (Residential Development and Cemetery)
B3: Study Area 2, City of Richmond, Virginia (Powhite Parkway Bridge)
B4: Study Area 2, City of Richmond, Virginia (Reservoir Structure)

Appendix B1
Land Segment: 51760 (Richmond, VA)
River Segment: JL7_7070_0001 (James River)

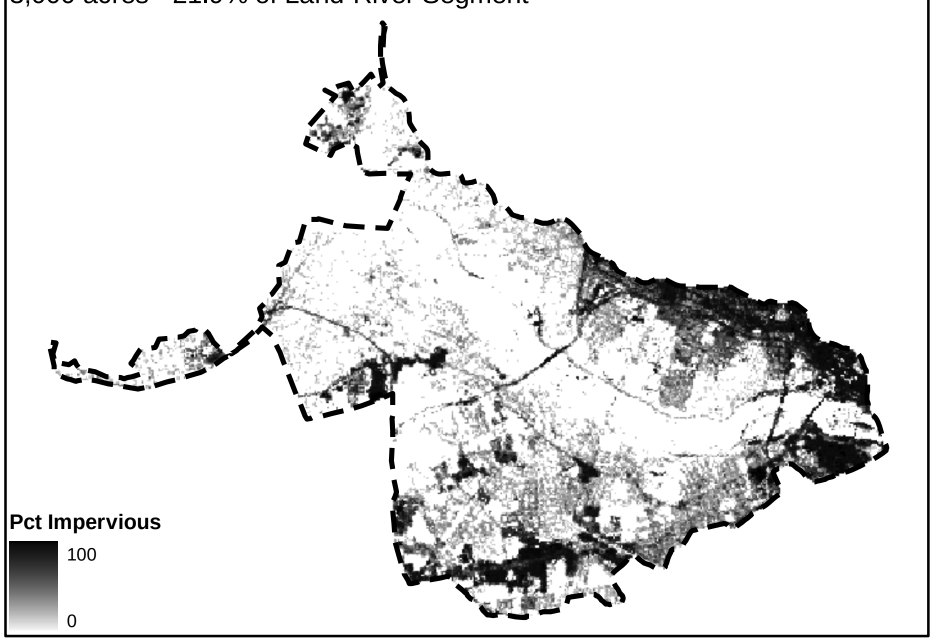
1990 Impervious Surface
2,395 acres - 17.5 % of Land-River Segment

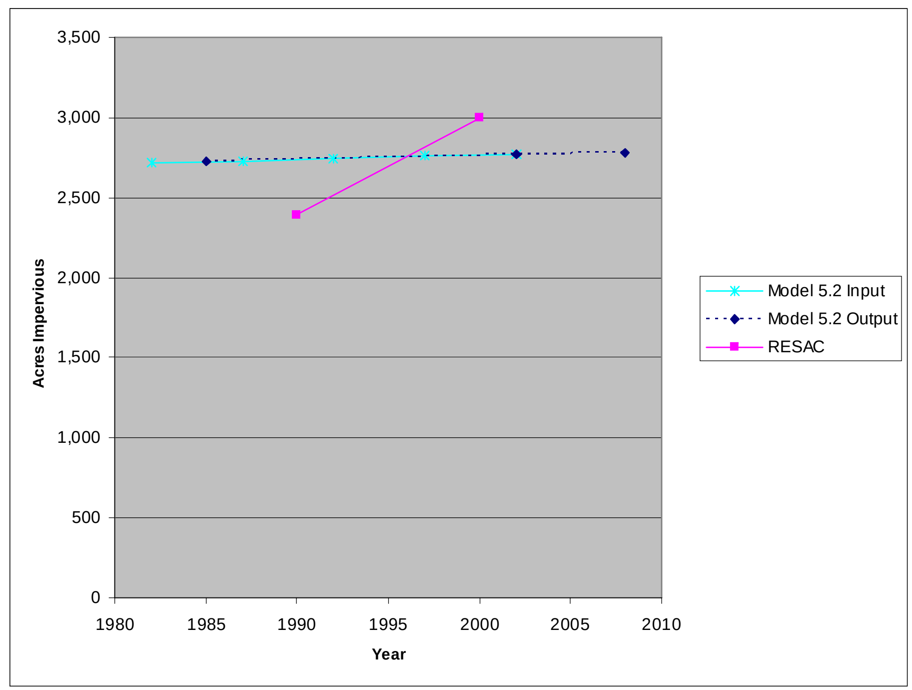


Impervious Surface Change
605 acres of new impervious surface



2000 Impervious Surface
3,000 acres - 21.9% of Land-River Segment





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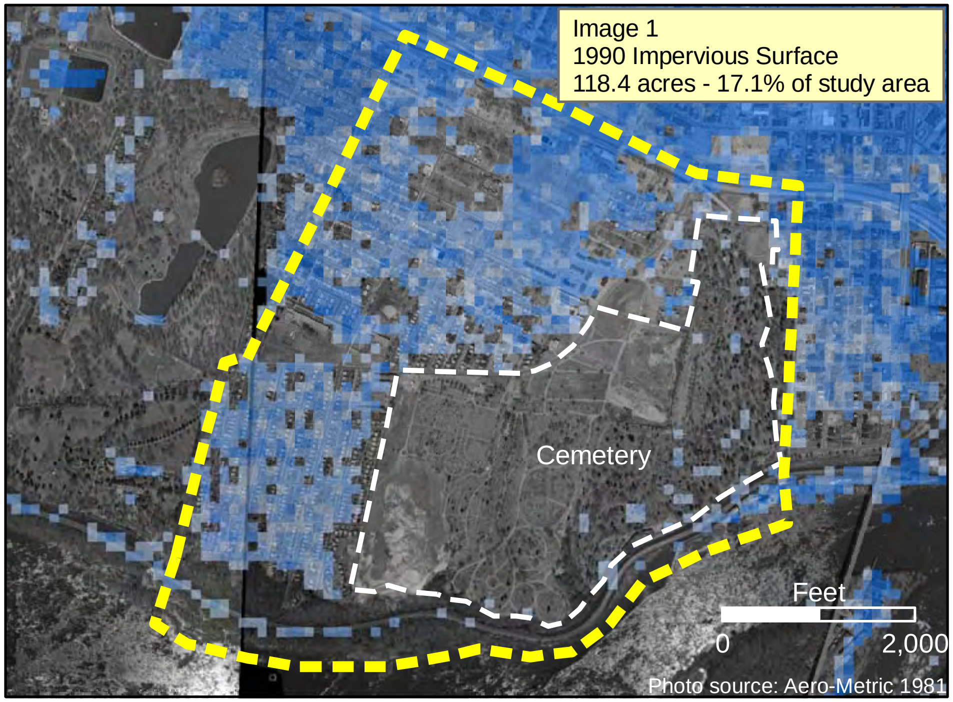
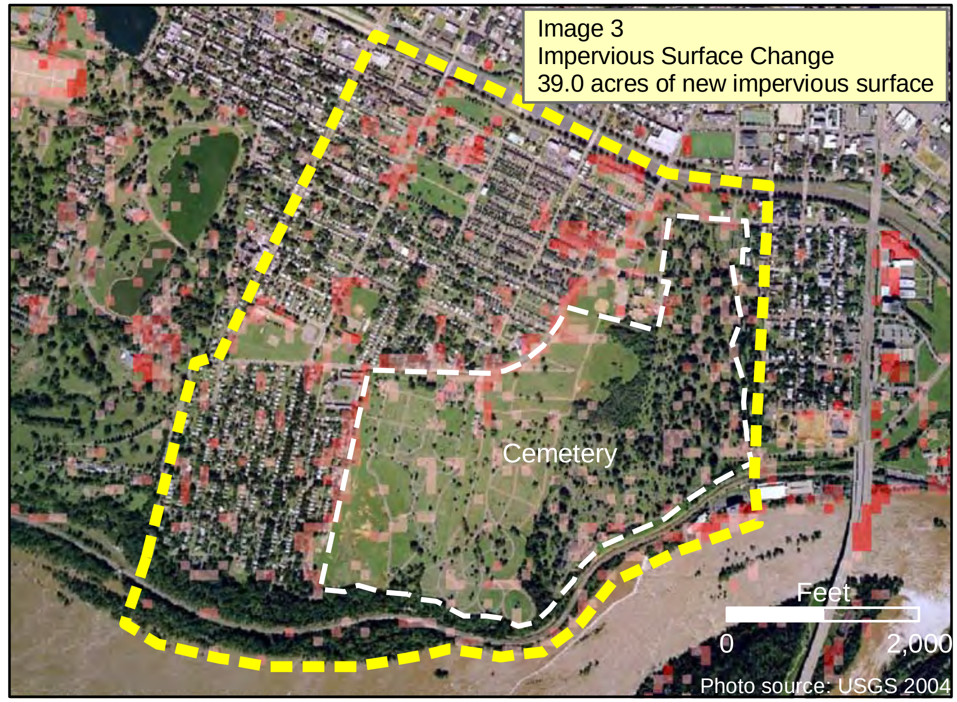
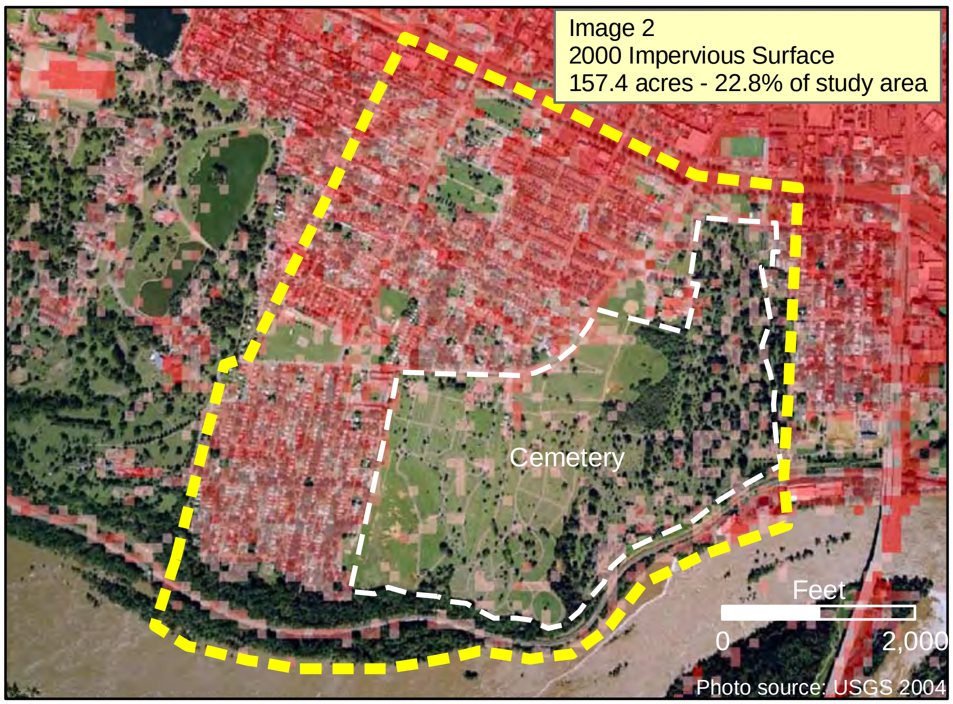
Appendix B2
Study Area 1 - Section of Richmond, VA





Percent increase of impervious area: 32.9%



Year	Acres Impervious	Percent of Study Area
1990	118.4	17.1%
2000	157.4	22.8%
Change	39.0	5.6%

Total Study Area (acres): 691.6

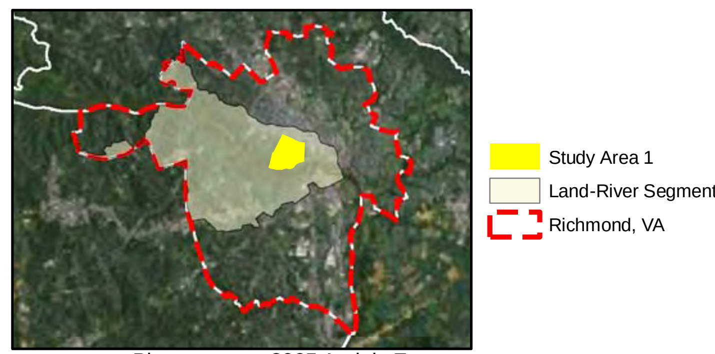


Photo source: 2005 Aerials Express

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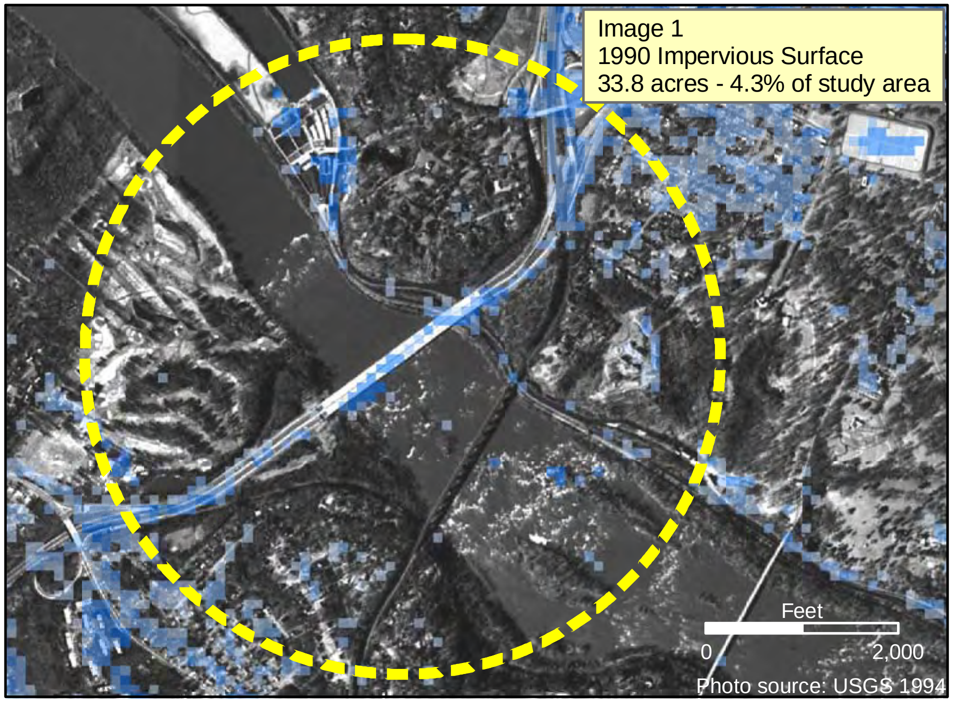
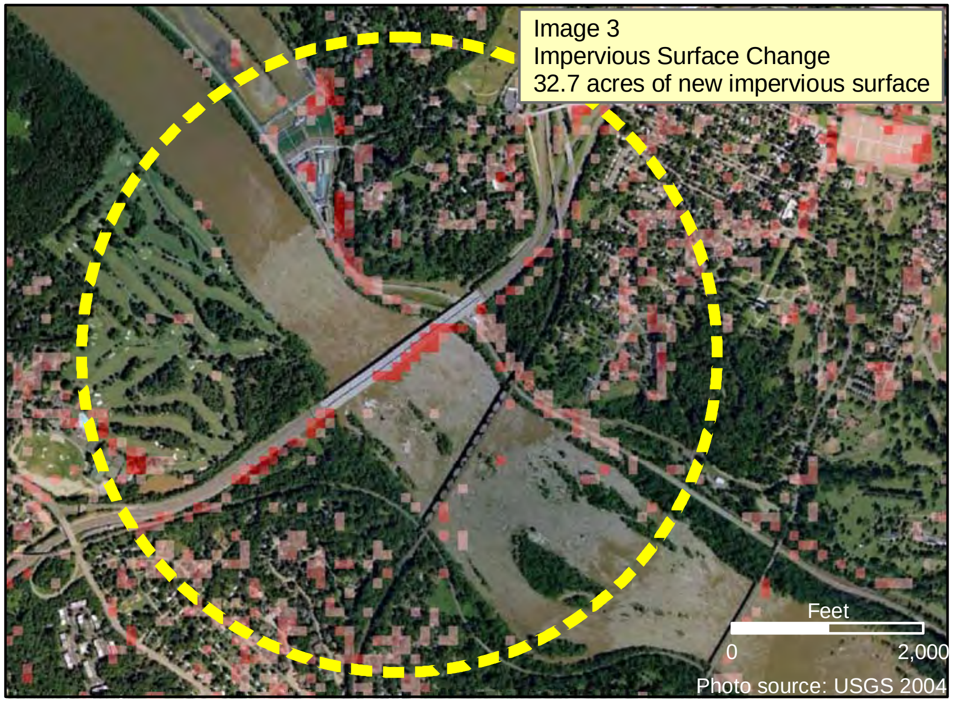
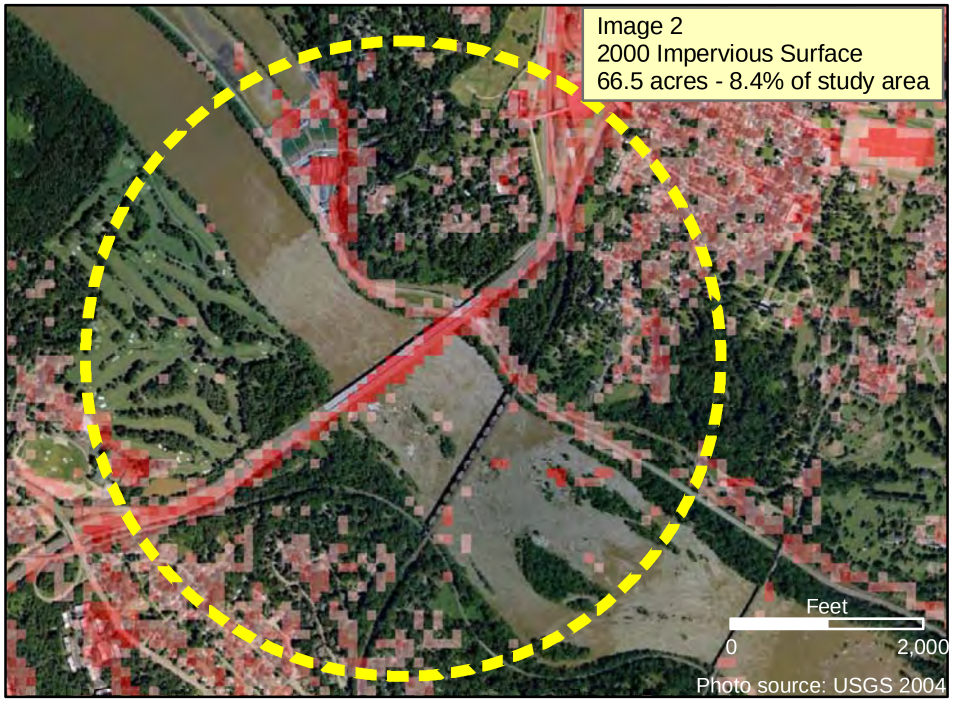
Appendix B3

Study Area 2 - Section of Richmond, VA (Powhite Parkway Bridge)





Percent increase of impervious area: 96.6%



Year	Acres Impervious	Percent of Study Area
1990	33.8	4.3%
2000	66.5	8.4%
Change	32.7	4.1%

Total Study Area (acres): 788.2

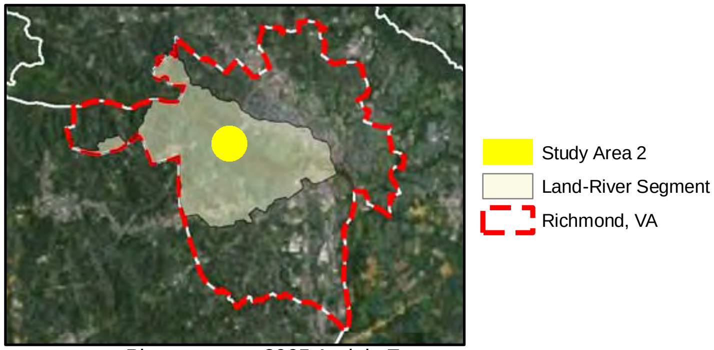


Photo source: 2005 Aerials Express

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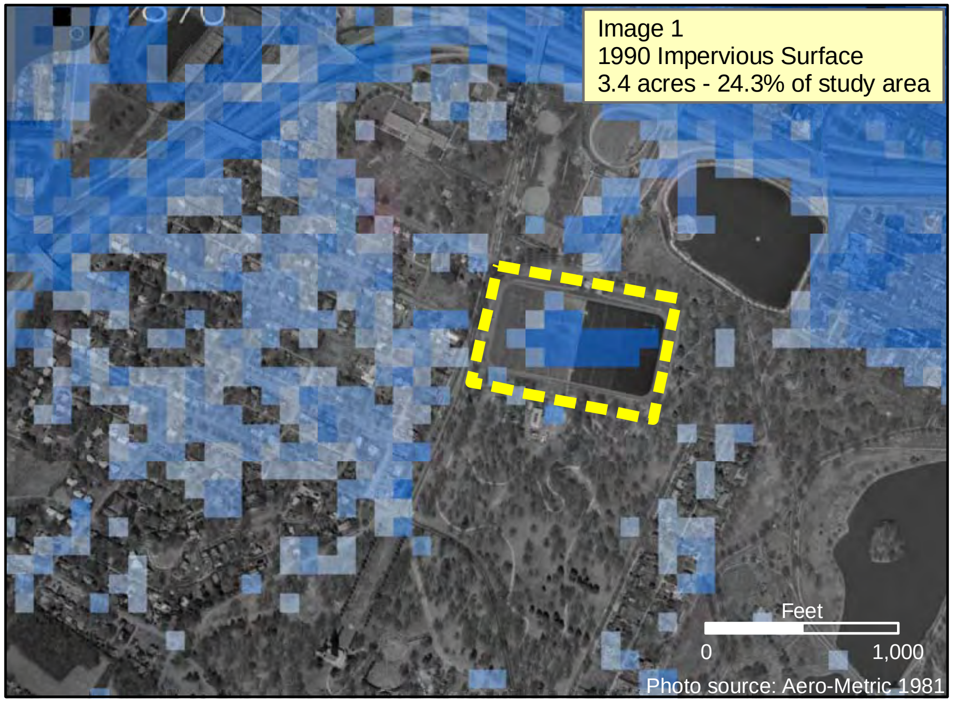
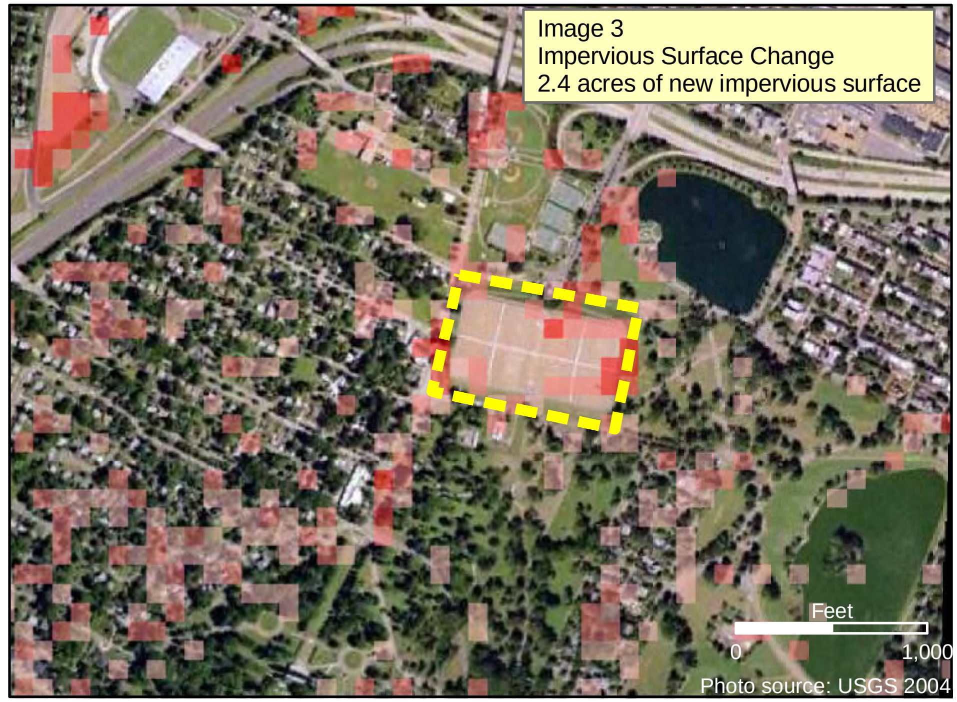
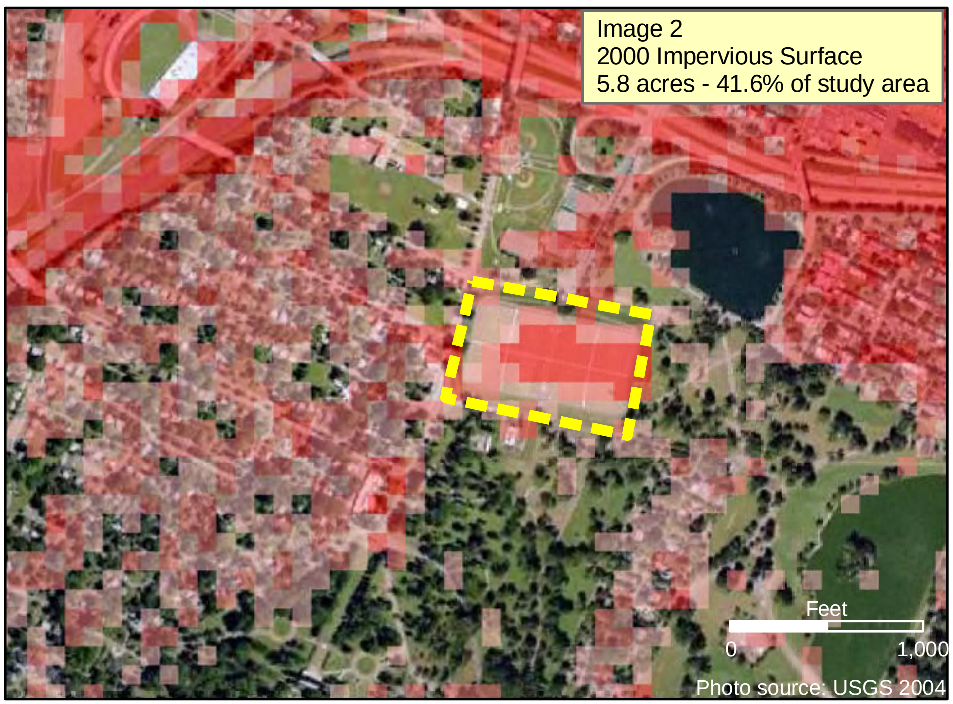
Appendix B4
Study Area 3 - Section of Richmond, VA





Percent increase of impervious area: 71.6



Year	Acres Impervious	Percent of Study Area
1990	3.4	24.3%
2000	5.8	41.6%
Change	2.4	17.4%

Total Study Area (acres): 13.9

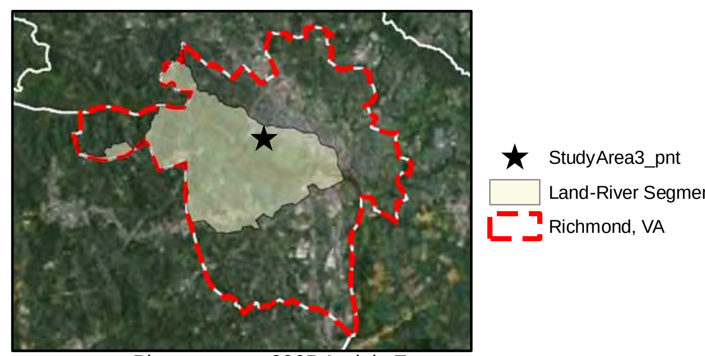


Photo source: 2005 Aerials Express

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