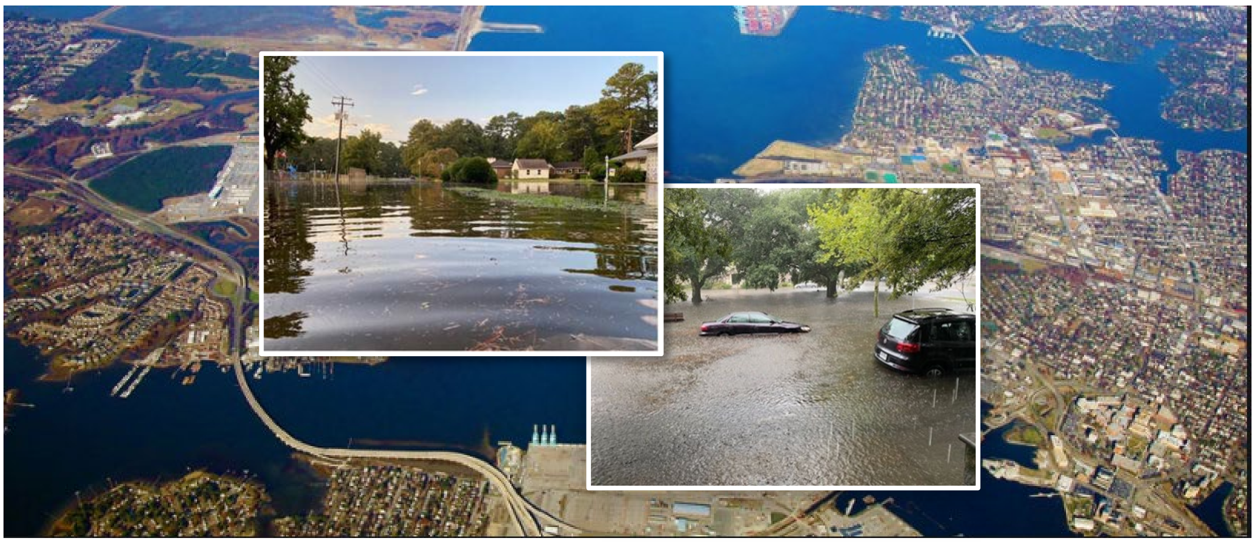
Measuring the Economic Impact of Recurrent Flooding on Workforce Productivity and Property



A Report Prepared for "COCA/SARP – Assessing and Communicating Economic Impacts and Risks Associated with Water Resource Management Challenges Along the Coast" NOAA Award Number NA19OAR4310309

Project Team: Joshua G. Behr, Wie Yusuf, George McLeod, Sarah Stafford, Derek Loftis, Afi Anuar, Rafael Diaz

December 1, 2022

508 Compliance Check

Attention: Program Officer Bhaskaran Subramanian
OAR Climate Program Office (CPO)
Phone: 443-523-7461
bhaskar.subramanian@noaa.gov

Subject: A Report Prepared for "COCA/SARP – Assessing and Communicating Economic Impacts and Risks Associated with Water Resource Management Challenges Along the Coast" NOAA Award Number NA19OAR4310309

Enclosure: Final Report: Measuring the Economic Impact of Recurrent Flooding on Workforce Productivity and

Dr. Subramanian:

The multi-institutional team from Old Dominion University, College of William and Mary, and Virginia Institute of Marine Sciences is pleased to submit the enclosed Final Report titled, "Measuring the Economic Impact of Recurrent Flooding on Workforce Productivity and Property" in accordance with the deliverables for NOAA Award Number NA19OAR4310309

Please direct any questions to Dr. Joshua G Behr (email: jbehr@odu.edu, phone: 757-683-6564).

Regards,

Dr. Joshua Behr
Virginia Modeling, Analysis and Simulation Center (VMASC)
@ Old Dominion University
1030 University Blvd.
Suffolk, VA 23435
757.638.6564 (Office)
757.927.9735 (Cell)
jbehr@odu.edu

Table of Contents

Executive Summary Findings

This research draws upon expertise across multiple disciplines and fields. Leveraged are natural systems data and social-behavioral data. The high-level objective is to advance our understanding of how very recent recurrent flooding has impacted residents within the City of Portsmouth, and then forecast these impacts under projections of sea level rise. While this research draws upon data for the City of Portsmouth, the findings may be generalized to the broader Hampton Roads region. Below are selected non-monetized key findings followed by selected monetized key findings.

Non-monetized Key findings

Non-monetized key findings with the City of Portsmouth are:

- Recurrent flooding is currently impacting households across the City of Portsmouth in terms of property loss, disruption to work (including home-based businesses), and presentment at school. For example:
    - Within the past year, nearly 35 percent of households have had to alter the drive to work or school, such as leaving later or taking a different rout, due to flooding in Portsmouth.
    - Within the past year, nearly 14 percent of households have had a family member unable to get to work for an entire day due to flooding.
    - Within the past year, nearly 16 percent of households report suffering damage to a vehicle due to flooding, and nearly 9 percent a vehicle damaged.
    - Since living in their home, about 13 percent of households report suffering damage to their home due to flooding and more than 54 percent of have missed some days of work due to their home damage.
- Looking ahead through the year 2045, neighborhoods proximate the riverlines will experience more frequent flooding and associated increases in property loss and disruption.
- Inland neighborhoods that have seen relatively little recurrent flooding will begin to experience ponding and recurrent flooding, especially neighborhoods where the water table is high and the elevation is low.
- The northern portion of the City of Portsmouth (separated by the Western Branch of the Elizabeth River) has experienced less disruption and loss relative to the southern portion of the city. These differences are forecasted to widen with the southern portion increasingly suffering more loss relative to the northern portion.
- Actions taken by residents to respond to recurrent flooding, while varied, are not geographically evenly spread; many reporting losses do not report investments to combat potential future loses.

Monetized Key Findings

Monetization of household impacts with the City of Portsmouth are:

- The annual costs associated with households being late or missing work/school due to flooding are estimated from just over one million dollars for the lower bound to more than $14.6 million for the upper bound, with a preferred estimate of around $4.2 million. This equates to a range of $30 to $400 per household per year.
- The annual costs associated with households suffering vehicle and/or property damage due to flooding are estimated from about $4.9 million for the lower bound to more than $22.6 million for the upper bound, with a preferred estimate of around $11.1 million. This equates to a range of $135 to $625 per household per year.
- The annual costs associated with households adapting to flooding -- or perceived risk of future flooding -- are estimated from about $1.7 million for the lower bound to more than $11.9 million for the upper bound, with a preferred estimate of around $3.9 million. This equates to a range of $45 to $330 per household per year.

Part 1 - Introduction

Measuring the Economic Impact of Recurrent Flooding on Workforce Productivity and Property

Objectives

The current consensus is that recurrent flooding already impacts many localities and communities in terms of damage to property and disruption to the workforce. However, the costs of recurrent flooding have not been well studied. Over time, the cumulative totality is consequential (as demonstrated by the findings in this report). The need to study the economic impacts of workforce and property loss will become more pressing, especially given how climate change increases the frequency and severity of flooding.

The logic of this project is to establish, from the household perspective, a baseline of current workforce and property damage stemming from recurrent flooding. Then, based on projected changes in sea level and other climate conditions, estimate the potential increases in workforce disruption and property loss.

This report provides:

1. Comprehensive assessment of household-level experiences with recurrent flooding, private property loss, and disruption to workforce.
2. Development of climate science-based forecasts and models that consider how projected sea level rise and storm surge may impact flooding.
3. Integration of NOAA natural system data (including climate data), spatial data, socio-economic data, and behavioral and experiential data.
4. Development of models and measurement to forecast the economic impacts of property and workforce productivity losses due to flooding.
5. Generation of actionable knowledge to inform ongoing management, planning and policy processes.

Problem Context

Tropical storms, such as hurricanes, and extra-tropical storms, such as nor'easters, contribute to coastal surge flooding and precipitation-induced flooding. The impacts of these storms are exacerbated by climate change and sea level rise. In Virginia, the relative sea level rise rates are the second highest in the nation. In the Hampton Roads region of southeast coastal Virginia, sea level has risen approximately 14 inches since 1930. In combination with the area's low-lying coastal and inland physical geography that is made worse by subsidence, all these factors have led to an increase in recurrent flooding. Climate change, manifested in more severe storms, more extreme precipitation, and higher sea levels, can make flooding worse.

Hampton Roads is also an important geographic center for employment and logistics within the mid-Atlantic region, boasting several critical inter-modal transportation corridors. Recurrent flooding can disrupt the movement of people and goods, and can damage private property, and as such is a significant policy and planning issue for Hampton Roads cities like Portsmouth.

Recurrent flooding is a persistent issue throughout Portsmouth, impacting the city's economic vitality and quality of life, evident in damage or loss to property and disruption to the workforce. The need to study the workforce and economic impacts has become more pressing, especially given the expected increase in the frequency and severity of recurrent flooding. Potential interventions, in the form of adaptation responses and behaviors, may be costly but can reduce the economic impact of recurrent flooding by mitigating personal property loss and lessen disruption in the workforce. However, not all adaptive responses are equal in cost and some responses may have a greater impact than others. Identifying optimal combinations of adaptive measures is an important first step in reducing risk and improving the community capacity to adapt to current and anticipated change in recurrent flooding. Once the property and workforce impacts of recurrent flooding are quantified, potential interventions may be modeled to determine the relative return on investment for adaptation responses. The generation of this knowledge – and its dissemination into the policy and planning processes where information is translated into action – will increase the capacity of communities to adapt.

Adaptation responses and behaviors take place within and across different levels of ecology, such as social ecologies (e.g., individual, household, or social network), geographic ecologies (e.g., neighborhood, city, region, and state), and political ecologies (local, state, regional, and federal governments). Residents, who are already experiencing recurrent flooding, are necessarily already taking adaptive measures. Much of the adaptation decision making throughout the city occurs at the individual or household ecology. However, these responses and behaviors, while deemed household-centric solutions, may be achieved through various paths. For example, the purchase of highwater vehicles, re-locating closer to employment, changing travel routes, installing flood vents or sump pumps, or grading for drainage around the home may be implemented completely independent of coordination with governing authorities. Other adaptive responses, such as increasing elevation of primary living space or retreating from property altogether, may be incentivized by way of government subsidies or tax credits and thus requires coordinated investments across ecologies. Similarly, the relocation of HVAC from crawl space, more stringent set-backs on new construction and additions, or more resilient building materials, may be mandated through policy, codes, or zoning, with the compliance cost largely borne by the individual homeowner. Finally, other household adaptive behaviors in the form of flexible leave or adjusted work hours may be driven by employers both in the government or private sectors.

Therefore, government-driven or government-centric adaptive responses must not be created independently, but rather in conjunction with, household adaptive capacity.

These adaptive responses are expected to mitigate personal property loss and lessen disruption in the workforce, thereby increasing resiliency and decreasing risk. However, not all adaptive responses are equal in cost and effectiveness; some adaption responses are more likely to have a greater impact on mitigating property loss (or workforce disruption) than others. This lack of information frustrates government's ability to assess current resilience, measure progress towards enhancing resilience, and to identify the value of adaptive practices and interventions.

Identification of the most promising government-driven adaptive measures necessitates knowledge of the ongoing adaptive behavior of households and how governments' efforts integrate with them. Government planning practices must also necessarily be responsive to forecasted environmental changes, such as those resulting from climate change, which can affect flooding. Furthermore, adaptive responses do not take place in isolation, and households and governments may pursue combinations of adaptive responses and behaviors.

Portsmouth Regional Context

Figure 1.1 below illustrates the broader extent of the research focus area, Portsmouth, within the broader Hampton Roads region. Near the center of Figure 1.1 are the boundaries for the City of Portsmouth and subareas used in the analyses contained in Part 5 and Part 6 of this report. As discussed in the above Part 1 *Problem Context*, the City of Portsmouth is central to the Hampton Roads region. The facilities and workforce contained within Portsmouth are vital to the region's maritime ecosystem.

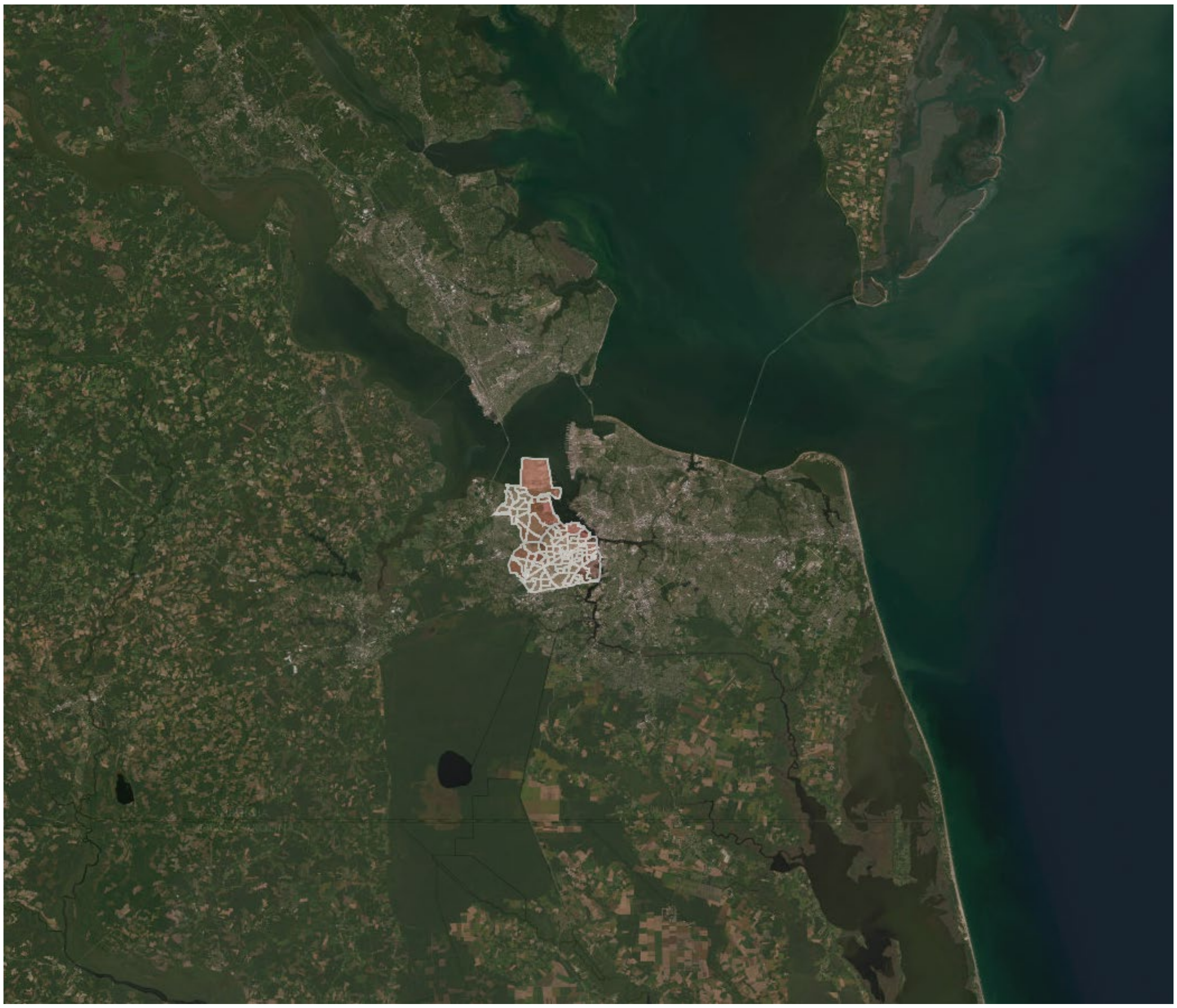


Figure 1.1 Centrality of Portsmouth within the Hampton Roads Region.

Organization of the Report

This report is organized into executive findings, Parts 1-7, and three Appendices:

- **Executive Summery Findings** provides selected key findings organized under Non-monetized Key Findings and Monetized Key Findings.
- **Part 1** provides an introduction, states the high-level objectives, and places the problem into context, essentially stating "why it matters" in a narrative form.
- **Part 2** reports the findings from original data gathered through household interviews relative to recent experiences with flooding vis-à-vis workforce disruptions and property loss.
- **Part 3** draws upon these interview data and American Community Survey data to estimate the current economic impact of flooding.
- **Part 4** provides summary of findings from the several stakeholder engagements with City of Portsmouth staff and Portsmouth residents.
- **Part 5** provides detailed visuals and estimates of the extent and depth of flooding from the Base Scenario (Hurricane Irene 2011) and the Forecast Scenario, which is the similar storm event taking place in 2045 under assumptions of sea level rise and other atmospheric changes (Hurricane Irene 2045).
- **Part 6** provides area specific estimates within the *southside* of Portsmouth, reporting the difference between the Base Scenario and the Forecast Scenario in the number of structures adjacent floodwaters.
- **Part 7** provides area specific estimates within the *northside* of Portsmouth, reporting the difference between the Base Scenario and the Forecast Scenario in the number of structures adjacent floodwaters.
- **Appendix A** provides block group level data used to estimate the economic impacts; these data are organized by strata used in the analyses.
- **Appendix B** provides the survey instrument used in the household interviews to elicit the base data, which is then extrapolated to arrive at non-monetized and monetized impacts.
- **Appendix C** provides a more extensive report of findings from the household interviews, generally providing at least a single chart for each survey question.

Part 2 – Elicited Impacts: Workforce & Property

Elicited Data

This report is in response to a desire to form a better understanding of the impact of recurrent flooding on the Hampton Roads population in general and, more specifically, on the workforce that is integral to a robust maritime ecosystem. This report draws upon original data elicited from residents within the City of Portsmouth. Portsmouth is selected because of its historic ties as a center of maritime activity across the ecosystem. Portsmouth's economic and social wellbeing is closely tied to the shorelines containing substantial maritime industrial activities.

The primary elicited data used for analysis in this repot may be organized into three categories. Elicited at the household level are:

- **Experiential data** related to flooding impact upon the households relative to work and school: 1) late or delayed getting to work or school, 2) missing entire day's work or school 3) losing pay, 4) ability to get in or out of neighborhood, 5) frequency of flooding.
- **Risk perception data** relate to current and future flooding: 1) expected change in flooding, 2) expected flooding of home, 3) probability of catastrophic hurricane event.
- **Car and property damage data** stemming from flooding and disruption to work or school: 1) vehicle damage, 2) days of work or school missed due to vehicle damage, 3) vehicle cost of repair, 4) home damage, 5) days of work or school missed due to home damage, 6) home repair costs.

In addition, since a sizeable portion of the supply chain capacity is found within small businesses, and many small businesses support the needs of the maritime ecosystem, an initial inquiry into business ownership (home-based and otherwise) is made.

These data reflect interviews with 801 households in the Fall, 2020. A random sampling methodology using cell and landlines were used to contact households.

In addition, several of the questions used in the 2020 household interviews were also used in a previous 2015 data gathering effort in the City of Portsmouth. When comparison can be made, the 2020 findings are compared to the 2015 findings. In the Table of Contents, these comparisons are bracketed and noted, "(comparison)".

These elicited data are a sampling and are extrapolated to the entire Portsmouth population to estimate the current workforce and property losses associated with recurrent flooding. A more detailed explanation of the sampling methodology is provided in Part 3 *Estimated Impacts: Workforce & Property* this report.

Last, this Part 2 does not report the entire set of variables gathered from the household elicitation activities. An expanded set of charts is provided in *Appendix C: Extended Survey Results*.

Summary Findings

Provided is a short, bulleted list of selected findings from the household elicitation:

- Within the past year, nearly 35 percent of households have had to alter the drive to work or school, such as leaving later or taking a different rout, due to flooding in Portsmouth.
- Within the past year, nearly 28 percent of households have had a family member late or delayed getting to work due to flooding.
- Within the past year, nearly 14 percent of households have had a family member unable to get to work for an entire day due to flooding.
- Within the past year, nearly 10 percent of the households lost pay due to flooding.
- Within the past year, just over 26 percent of households were unable to either get in or out of their neighborhood due to flooding.
- Nearly 29 percent of households experience flooding a couple time a year or more in front of the house or very near the house.
- Just under 68 percent of households believe flooding will increase in the next 20 years.
- About 25 percent of households believe their home will have flood water come into the living area at least one time in the next 20 years.
- Roughly 40 percent of households report it is more likely than not that Portsmouth will be struck by a catastrophic hurricane within the next 10 years.
- About 35 percent of households report it is more likely than not that damage to their home from this catastrophic event will be so extensive that they will no longer be able to live in their home.
- About 80 percent of households believe that sea level rise and flooding are related in Portsmouth.
- Nearly 74 percent of households believe that sea level rise will negatively impact their economic opportunities.
- Just less than 16 percent of households report suffering damage to a vehicle due to flooding, and nearly 9 percent a vehicle damaged within the past year.
- More than 73 percent of households have missed some days of work and about 71 percent have missed some days at school due to the vehicle suffering flood damage.
- About 13 percent of households report suffering damage to their home due to flooding and more than 54 percent of have missed some days of work due to their home damage.
- Nearly 23 percent of households believe that both flooding and the threat of flooding has negatively impacted the value of their home, and 32 percent believe this decrease has been greater than 20 percent of the value.

Household Characteristics

Residency Tenure

Responding household members were asked how many years they have lived in the current location. Responses are collapsed into five ranges. Nearly a quarter report residing in Portsmouth ten or fewer years. The remainder of the households have lived in the current location over 11 years. Figure 2.1 shows the residency tenure of the respondents.

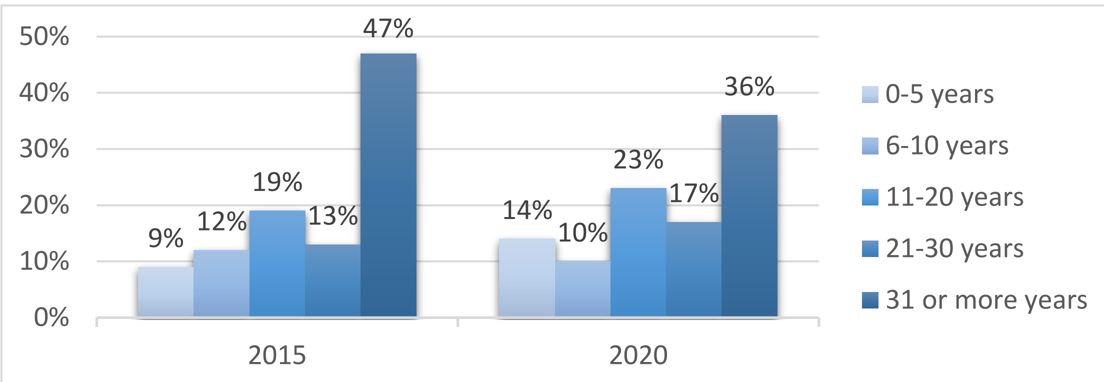


Figure 2.1 Residency Tenure

Members

Among all households, 2.2 shows that slightly over a quarter of households reported being a one-person household, 45 percent were two-person households and 29 percent were households with three or more persons.

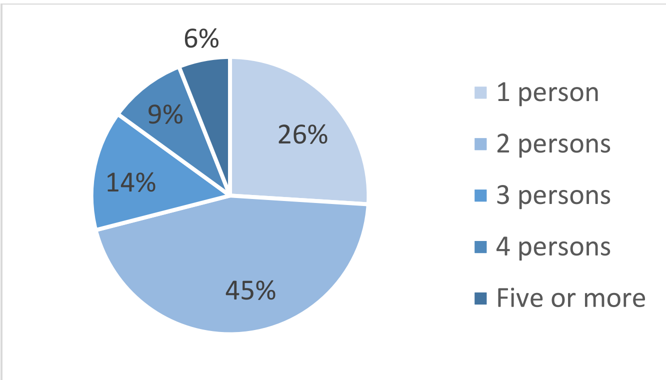


Figure 2.2 Household Size.

Race/Ethnicity

Figure 2.3 shows that fifty eight percent of responding households identify the household as White, thirty eight percent as Black and four percent self-identified as “other.”

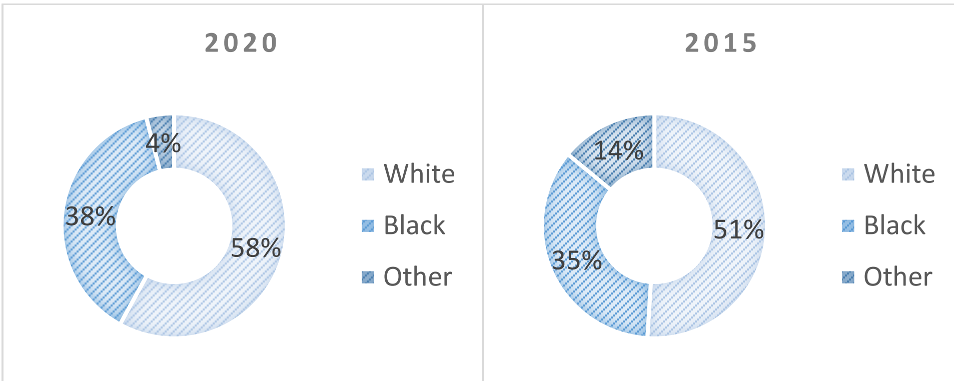


Figure 2.3 Race/Ethnicity.

Income Ranges

Portsmouth households are quired for their household total annual income. Figure 2.4 summarizes annual household income, organized into seven income categories. Twelve percent of responding households report annual income below $25,000 and almost a quarter report annual household income between $25,000 and $45,000. Twenty percent $45000 to $65000, sixteen percent $65000 - $85000 and twelve percent $85000 - $105000. Seventeen percent report over $105,000.

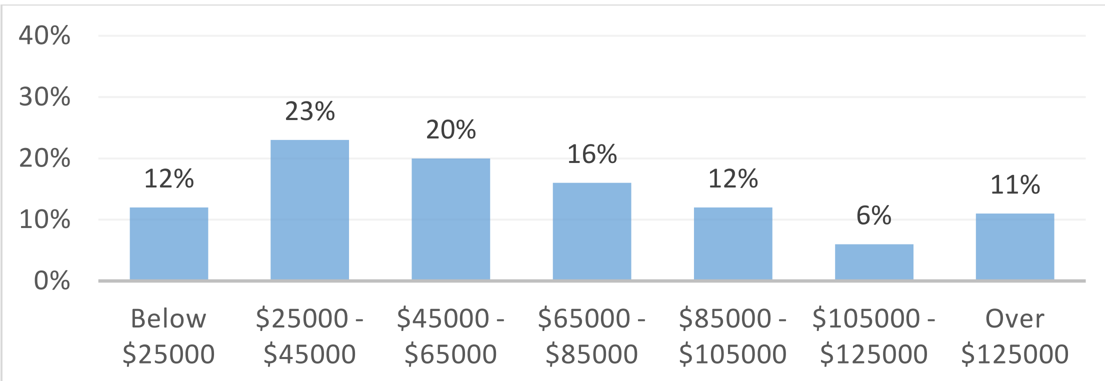


Figure 2.4 Income range.

Income (comparison)

Households can also be organized into four income categories: low-income households (below $25,000), moderate income households ($25,001 to $65,000), moderate-high income households ($65,001 to $105,000), and high-income households (over $105,001). Figure 2.5 below summarizes households according to these four household income categories, and compares 2020 respondents to 2015 respondents.

Thirty five percent of households had a low-level income while twenty percent had a moderate level income. Another twenty eight percent had a moderate-high level income and seventeen percent had a high-level income, as can be seen in Figure 2.5.

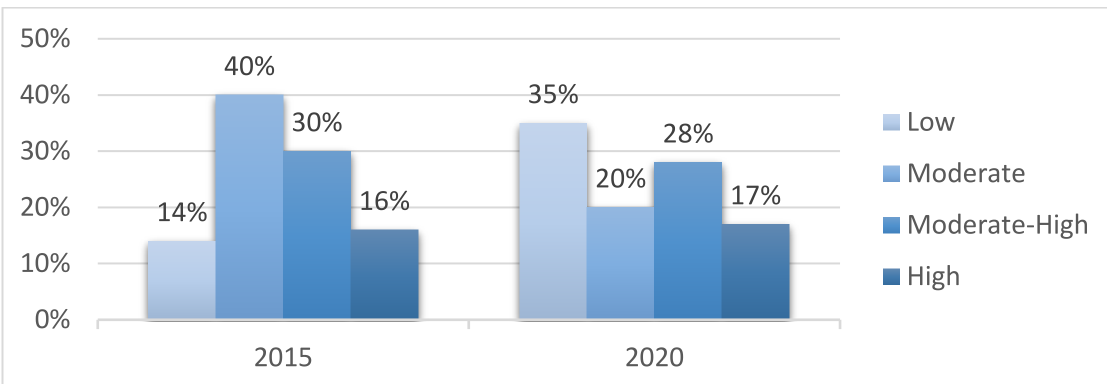


Figure 2.5 Income Categories (2015 and 2020).

Experiences with Flooding

Frequency of Flooding

Responding households were asked to report the frequency of flooding in front of their homes or the streets very near their homes. Reported in Figure 2.6 below, in 2020, 39 percent of households indicated that street flooding occurred rarely if ever and roughly 11 percent reported flooding once every couple of years. Half of the remaining households reported flooding at least once a year. More specifically, 6 percent reported street flooding more than once a month and at just over 7 percent reported flooding about once a month. Further, nearly 29 percent of households reported flooding a couple of times a year. Figure 2.6 shows the results from 2020 and comparing them to the 2015 survey. Households reported less experiences with flooding in 2020 compared to households in 2015.

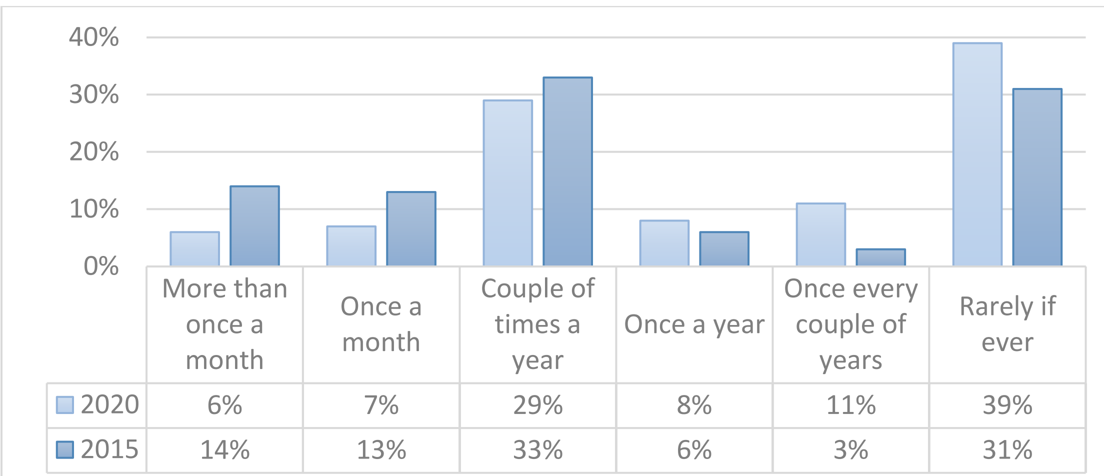


Figure 2.6 Frequency of flooding in front of respondent homes or the streets very near respondent homes (2015 and 2020).

Impacts: School, Work, Pay, & Access

Figure 2.7 illustrates respondent household's experiences with flooding. Respondents were questioned about their recent experiences with flooding. Slightly over a third of the households had to alter their drive (e.g., time, route) when going to work or school. Twenty eight percent were late or delayed getting to work. Nine percent of households indicated that they had experienced lost pay and fourteen percent were unable to travel to work for an entire day. A quarter of the households were unable to get in or out of the neighborhood. In comparison, in the 2015 survey 43 percent of households were unable to get in or out of the neighborhood.

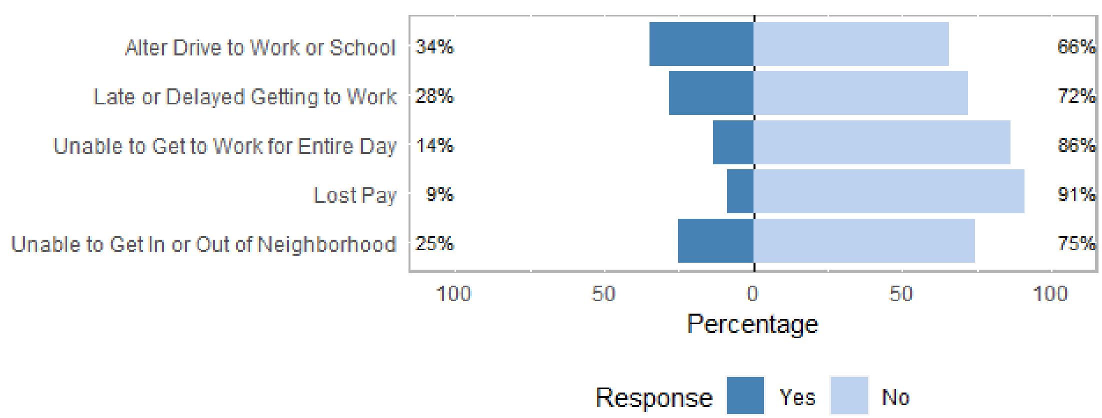


Figure 2.7 Experiences with flooding (2020).

Impacts by Household Size

Figure 2.8 below shows the household size across three types of impact from flooding (lost pay, unable to get to work, late getting to work). Notably, larger households are more likely to suffer impacts. For the households that suffer loss in pay, 51 percent are sized three or more (55 + 6). For households unable to get to work, 51 percent are sized three or more (49 + 2). And for households late getting to work, 50 percent are sized three or more (48 + 2).

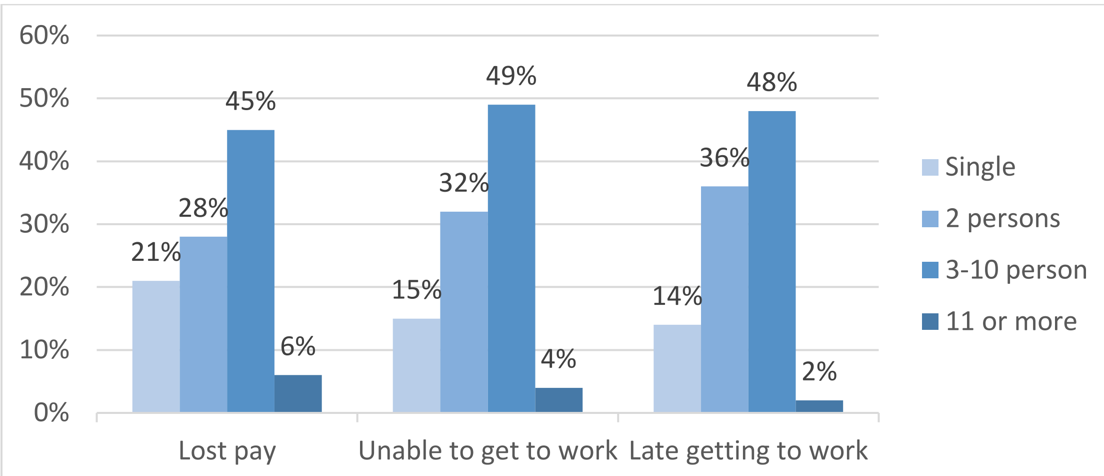


Figure 2.8 Experienced lost pay, unable to get to work or late getting to work due to flooding, by household size.

Impacts by Residency Tenure

Figure 2.9 below shows the household residency tenure across three types of impact from flooding (lost pay, unable to get to work, late getting to work). Roughly 16 to 23 percent of all households report lost pay stemming from flooding, 10 to 27 percent report unable to get to work, and 13 to 25 percent report late getting to work. There does not appear a relationship between length of tenure and either of these three impacts.

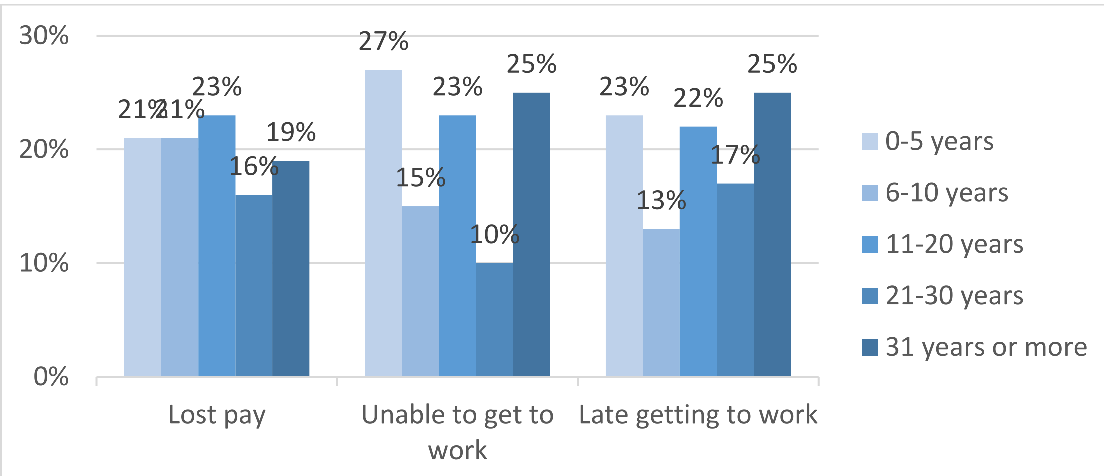


Figure 2.9 Experience with lost pay, unable to get to work or late getting to work due to flooding, by residency tenure.

Impacts by Income

Figure 2.10 shows household income across three types of impact from flooding (lost pay, unable to get to work, late getting to work). Low-income households appear the least impacted by flooding relative to other income groups in terms of late getting to work. Notably, medium income households are markedly more likely relative to the other income groups to suffer impacts from flooding in terms of lost pay, unable to get to work, and late getting to work.

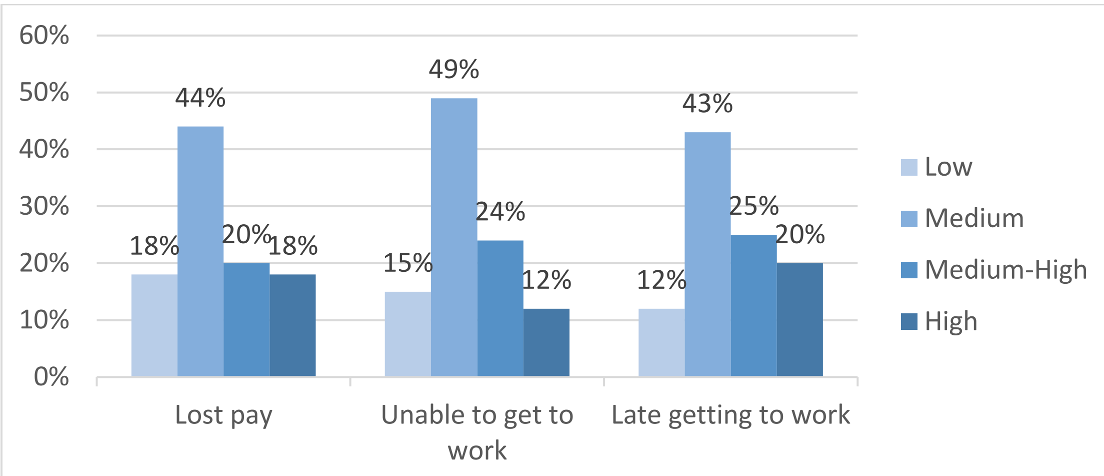


Figure 2.10 Experience with lost pay, unable to get to work, or late getting to work due to flooding, by household income.

Vehicle and Property Damage

Figure 2.11 below summarizes the frequency of vehicle damage due to flooding. Among those Portsmouth households reporting vehicle damage due to flooding, nearly four out of five households (79 percent) report suffering one instance. Eleven percent report two instances of damage due to flooding. The remaining 10 percent had three or more instances where vehicle are damaged due to flooding.

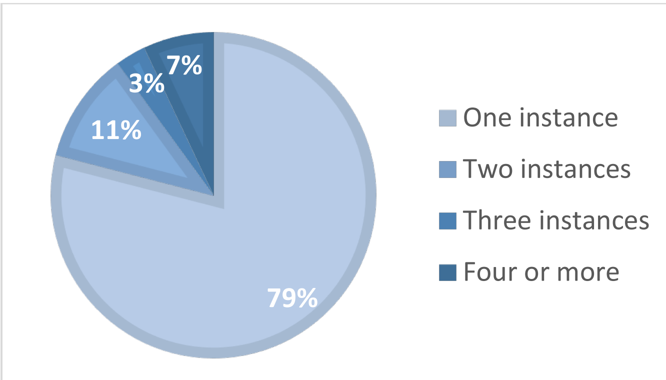


Figure 2.11 Frequency of vehicle damage due to flooding.

Missed Work and School Days

Figure 2.12 illustrates the frequency of missed work and school due to damage to a car stemming from flooding. For the households that reported car damaged due to flooding, 29 percent reported zero missed workdays associated with that damage. However, 31 percent report missing one to two workdays, 23 percent three to five days, and 17 percent six or more days. and under a quarter reported missing three to five workdays. In addition, among the households suffering a damaged car due to flooding, 67 percent did not miss a day at school due to the damaged vehicle. However, 15 percent missed one to two days of school, 9 percent three to five days, and 9 percent six or more days.

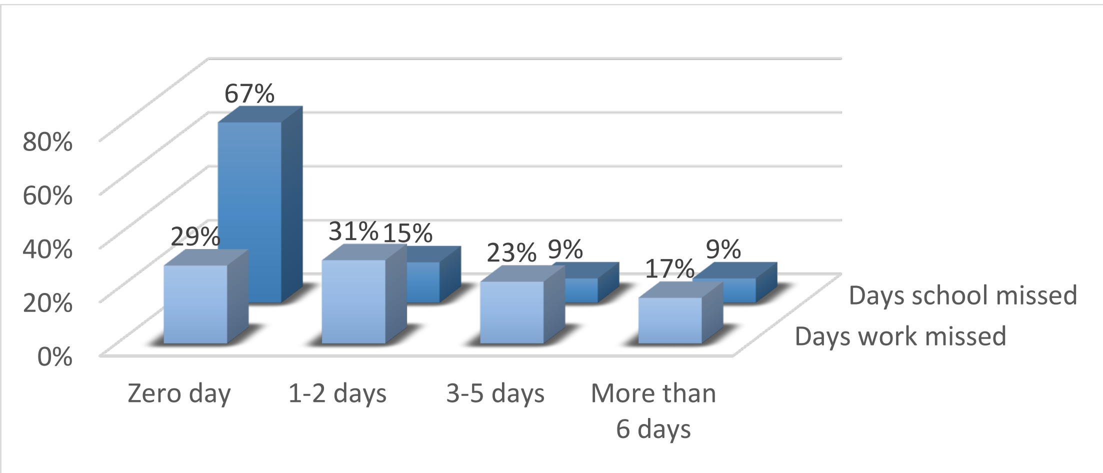


Figure 2.12 Frequency of missed work and school due to car damage from flooding.

Total Car Repair Costs

Figure 2.13 below shows the repair costs for all instances of car damage.For all instances of car damage due to flooding, nearly a quarter of the households reported a total repair cost of up to $500. Thirty seven percent reported a repair cost between $501 and $2000 and slightly over one fifth had repair cost between $2001 and $5000. Eighteen percent reported repair cost of greater than $5001 from car damage due to flooding.

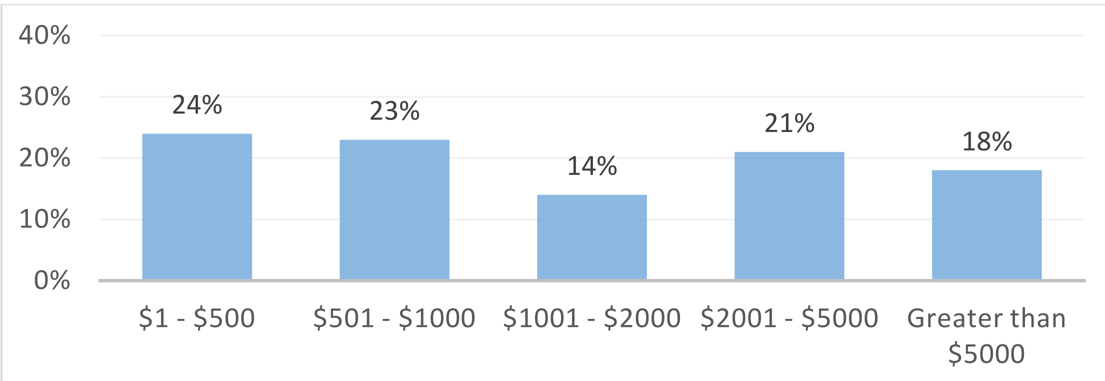


Figure 2.13 Repair costs for all instances of car damage.

Most Recent Car Repair Costs

Figure 2.14 below shows the repair costs for most recent car damage. For the most recent car damaged due to flooding, nearly three out of ten households report a total repair cost of up to $500. Forty six percent report a repair cost between $501 - $2000 and fifteen percent had repair cost between $2001 - $5000. One out of ten households report repair cost of greater than $5000.

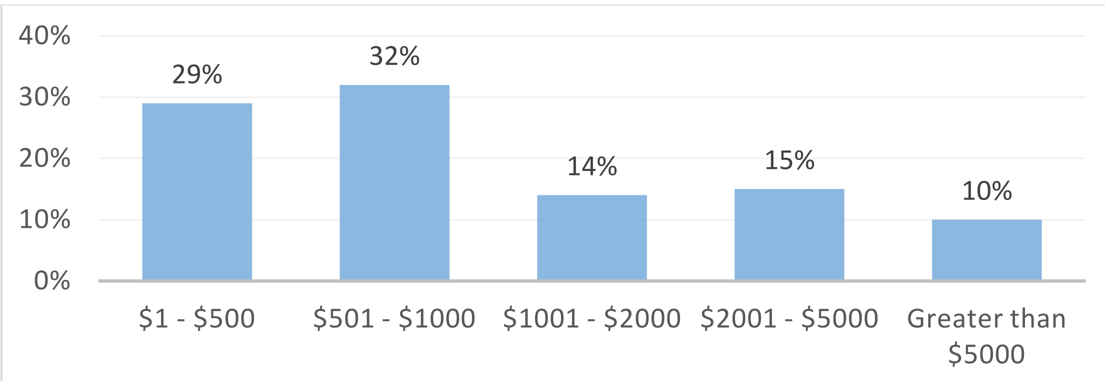


Figure 2.14 Repair costs for most recent car damage.

Recency of Car Damage

Figure 2.15 below shows the timing of the most recent car damage. For the most recent instance of car damage due to flooding, six percent of the household report the event occurring less than one year ago. Near and slightly over two out of ten households report the event occurring between 1-2 years and 3-4 years ago, respectively. Meanwhile slightly over and exactly two out of ten households report the event occurring between 5-9 years and 10-14 years ago, respectively. Thirteen percent reported the car damage occurring 15 years ago or more.

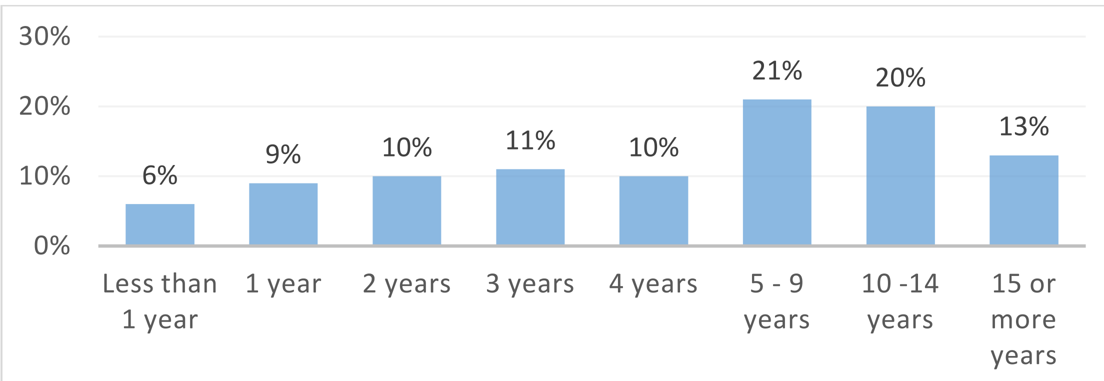


Figure 2.15 Timing for most recent car damage.

Frequency of Home Damage

Figure 2.16 illustrates the frequency of home damage due to flooding. Thirteen percent of households reported damaged to homes or the contents of the homes due to flooding. Among these households, 27 percent of households had one instance of damage to their homes due to flooding while living in Portsmouth. Thirty six percent had two instances of damage to their homes due to flooding. Twenty seven percent had three instances and ten percent reported four or more instances of damage to their homes due to flooding.

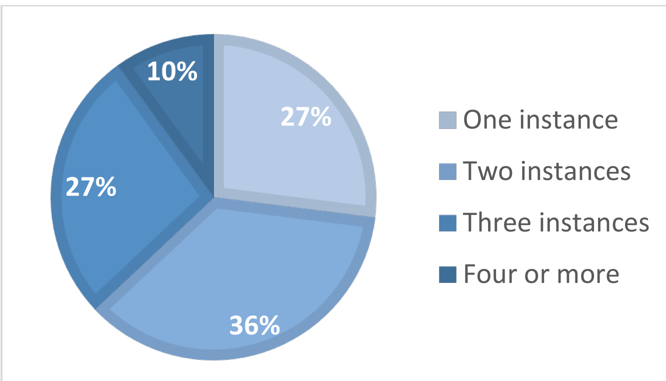


Figure 2.16 Frequency of home damage due to flooding.

Frequency of Missed Work

Figure 2.17 below illustrates the frequency of missed workdays due to home damage stemming from flooding. For the households that report home damages due to flooding 45 percent reported zero missed workdays. Seventeen percent reported missing 1-2 workdays and 14 percent reported missing 3-4 workdays. Eleven percent reported missing 5-9 workdays. Fourteen percent reported missing ten or more workdays. For the same household, seventy percent had zero missed school days. The remaining thirty percent missed one or more workdays.

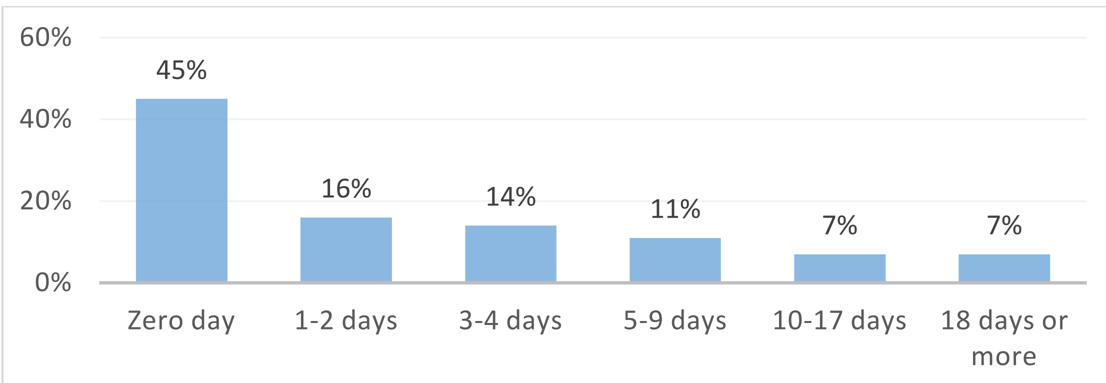


Figure 2.17 Frequency of missed workdays due to home damage from flooding.

Total Home Repair Costs

Figure 2.18 below illustrates the repair costs of home damage due to flooding. For all instances of home damage due to flooding, nearly one out of ten households report a total repair cost of up to $500. Ten percent report a repair cost of $501 - $1,500 and nine percent had repair cost of $1,501 - $3,500. Sixteen percent reported repair cost between $3,501 and $5,000 and slightly under a quarter report repair cost between $5,001 and $10,000. Fourteen percent report repair cost between $10,001 and $20,000 and eighteen percent reported repair cost of greater than $20,001 from home damage due to flooding.

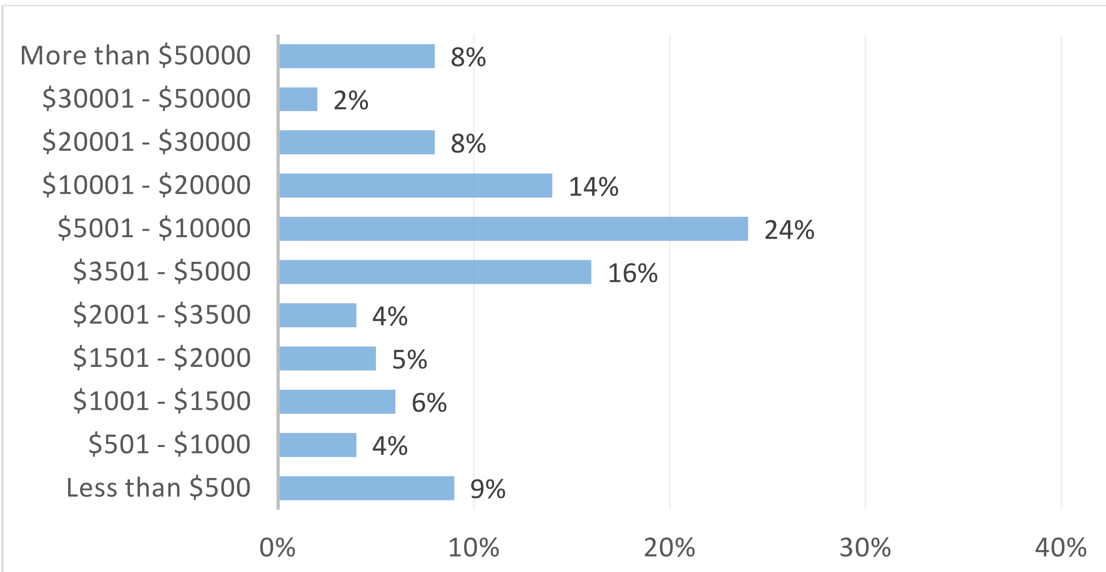


Figure 2.18 Repair costs for all instances of homes from damage due to flooding.

Most Recent Home Repair Costs

Figure 2.19 below illustrates the most recent repair costs of home damage due to flooding. For the most recent home damage due to flooding 18 percent report a total repair cost of up to $500. Slightly over one of ten households reported a repair cost between $501 and $1,500 and between $1,501 and $3,500. Thirty seven percent reported repair cost between $3501 and $5000 and nine percent report repair cost between $5,001 and $10,000. Five percent report repair cost between $10,001 and $20,000 and nine percent reported repair cost of greater than $20001 from home damage due to flooding.

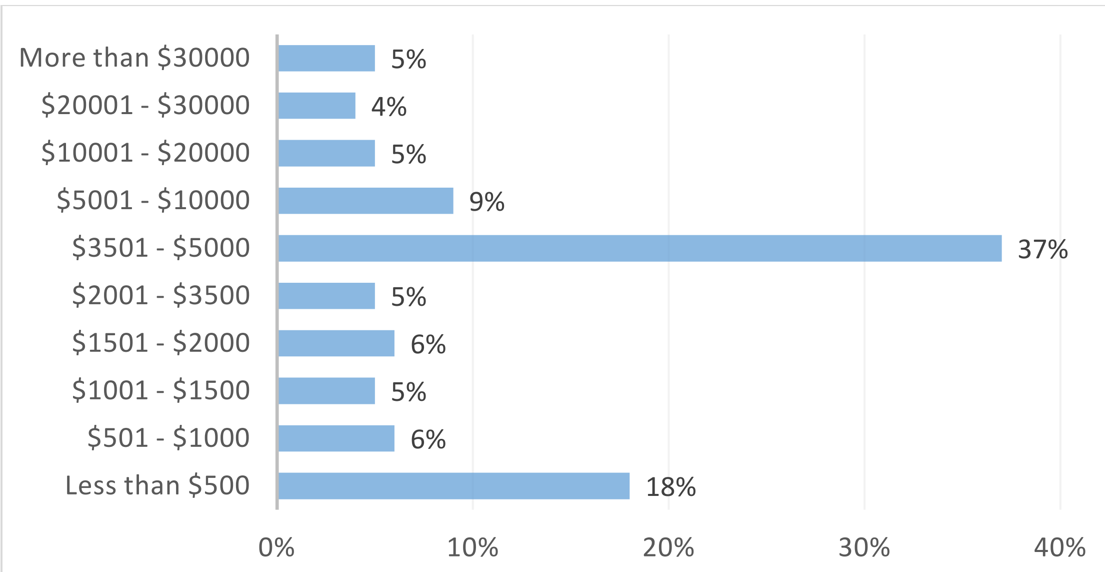


Figure 2.19 Repair costs for homes from most recent damage due to flooding.

Recency of Home Damage

Figure 2.20 below shows the timing of the most recent home damage. For the most recent instance of home damage due to flooding 11 percent of the household report the event occurring less than one year ago. Sixteen percent reported the event occurring 1-2 years ago and fourteen percent report the event occurring 3-4 years ago. Eighteen percent of the households reported the event occurring 5-9 years ago. Seventeen and eleven percent report the event occurring 10-14 years and 15-10 years ago, respectively. Thirteen percent report the home damage occurring 15 years ago or more.

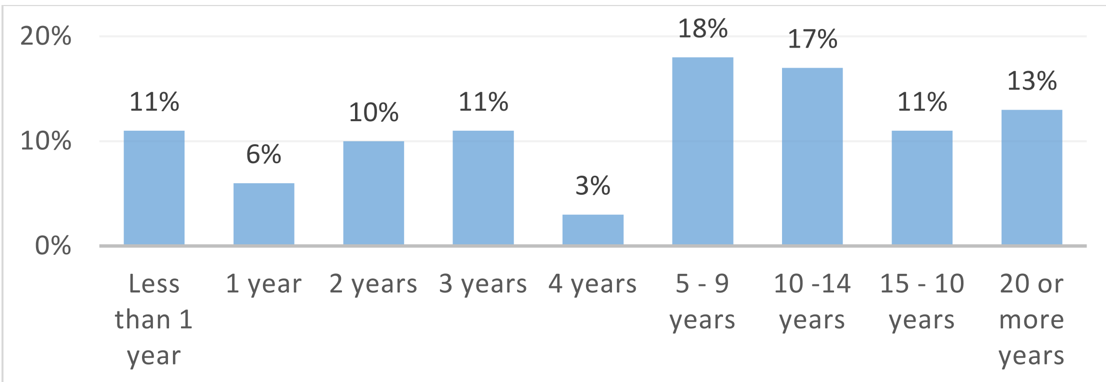


Figure 2.20 Timing for most recent home damage.

Health Impacts from Flooding

Asthma

Figure 2.21 below reports the presence of asthma within the household. Respondents were queried if somebody living in the home has been told by a doctor, nurse, or other health professional that they currently have asthma. Nearly a quarter of the households are identified as having a member who currently has been diagnosed with asthma. Figure 2.21 shows the results from 2020 and comparing them to the 2015 survey.

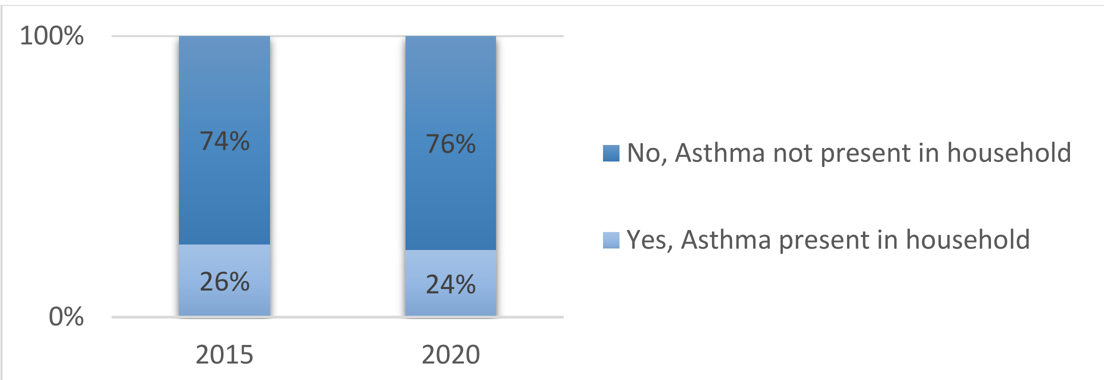


Figure 2.21 Asthma in households.

Asthma by Income

Figure 2.22 below reports the prevalence of asthma within the household by income. Among all households reporting at least a single member suffers from asthma, 14 percent are low-income households, 44 percent medium-income, 23 percent medium-high income, and 19 percent high income.

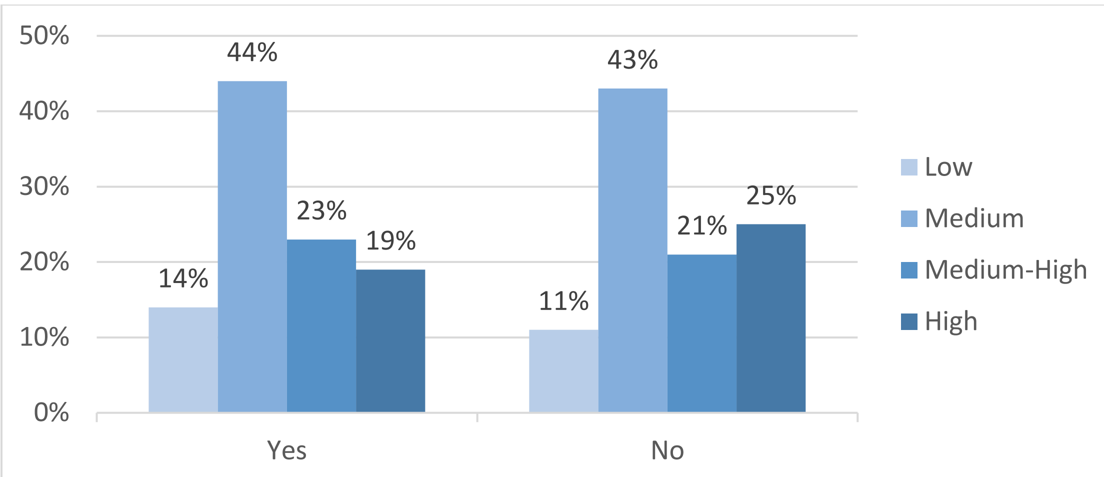


Figure 2.22 Asthma in households by income level.

Asthma Emergency Department Visits

Figure 2.23 below reports household asthma-related emergency department visits. Households with asthmatics were asked how many times within the past year have household members visited an emergency department or urgent care center specifically for asthma. Figure 2.23 illustrates that 14 percent of households report that the Emergency Department (ED) was visited because of the asthma at least a single time.

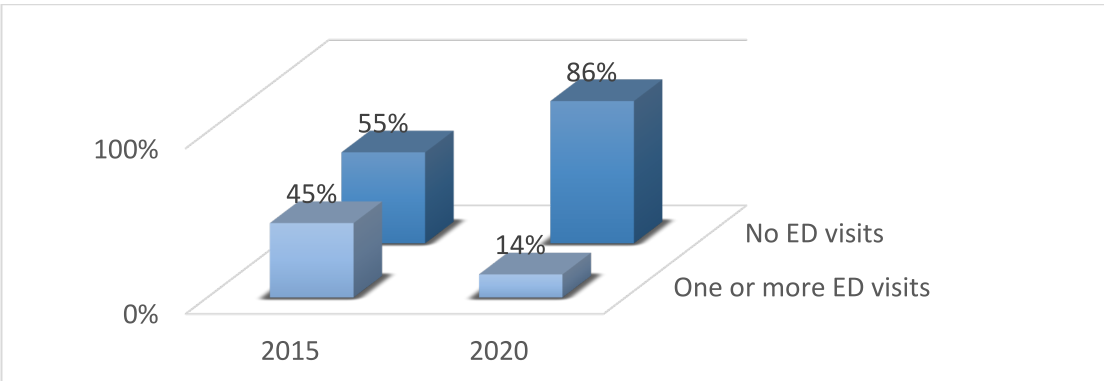


Figure 2.23 Emergency Department visit due to asthma.

Asthma Emergency Department Visits (comparison)

Households with emergency department visits for asthma were asked about their frequency of their visits. Figure 2.24 below illustrates that, among households with at least a single family member currently diagnosed with asthma, 58 percent reported a single visit and 42 percent with multiple visits.

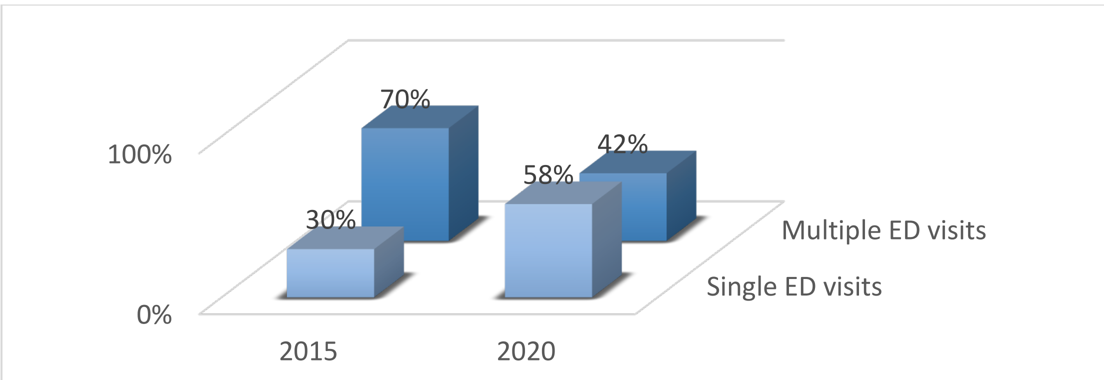


Figure 2.24 Emergency Department number of visits due to asthma.

Risk Perceptions

Flooding Next 20 Years (comparison)

Figure 2.25 below reports the respondents' perceptions of the risk of flooding over the next 20 years. Households were queried about their perception that flooding around the City of Portsmouth will increase, stay the same, or decrease in the next 20 years. In response to this question, slightly over two thirds of the households indicate that flooding will increase, 24 percent indicated that flooding will stay the same and 8 percent indicate that flooding will decrease. Figure 2.25 contrasts results from 2020 with 2015.

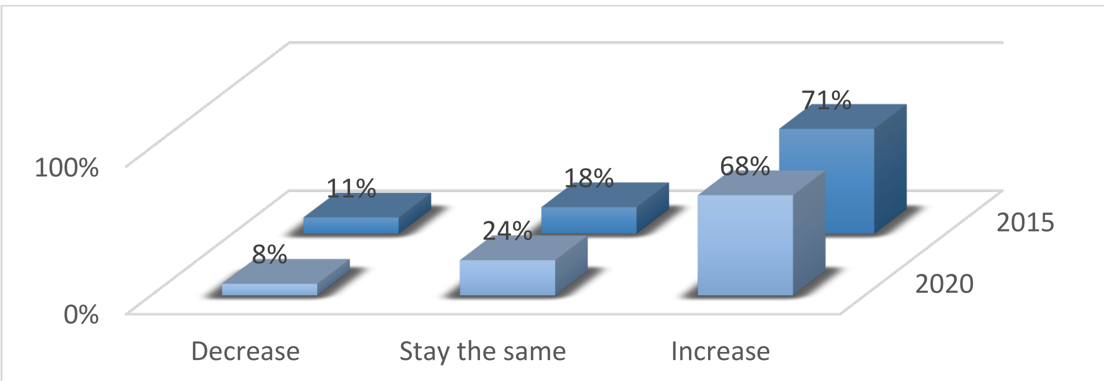


Figure 2.25 Respondent's perception of flooding in the next 20 years (2015 and 2020).

Expect House will Flood Next 20 Years (comparison)

Figure 2.26 below reports respondents' beliefs that floodwaters will enter structure sometime in the next twenty years. Households were asked if they believe that their homes will have floodwater come into the living area at least one time in the next 20 years. A quarter of the households answered affirmatively, and three quarters answered negatively. In 2015, the results were 37 percent yes and 63 percent no. Figure 2.26 contrasts results from 2020 with 2015.

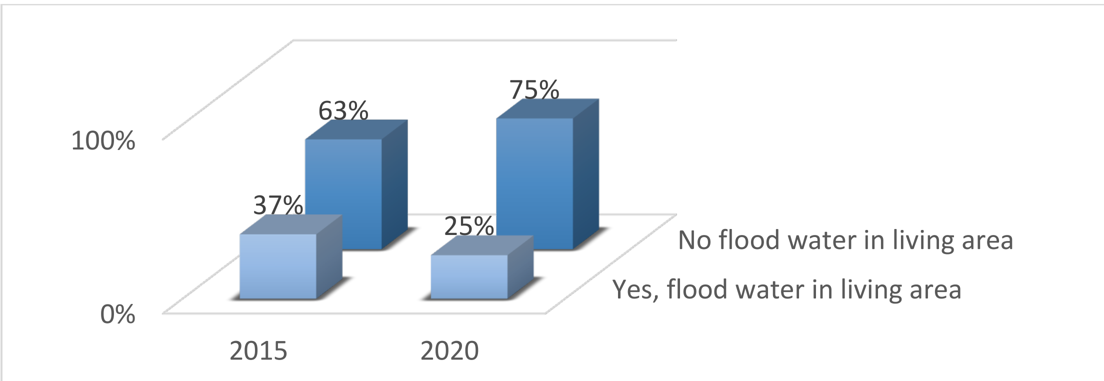


Figure 2.26 Respondent's belief that flood water will come into the living area in the next 20 years (2015 and 2020).

Probability Catastrophic Hurricane Next 10 Years

Figure 2.27 below reports respondents' stated probabilities that Portsmouth homes will be flooded due to catastrophic hurricane within the next ten years. Nearly 88 percent of households express that there is some probability (i.e., one percent of greater) that Portsmouth will witness a catastrophic event within the next ten years. Remarkably, 14 percent express it as a certainly (100 percent probability), and over 60 percent state it as at least a 40 percent probability.

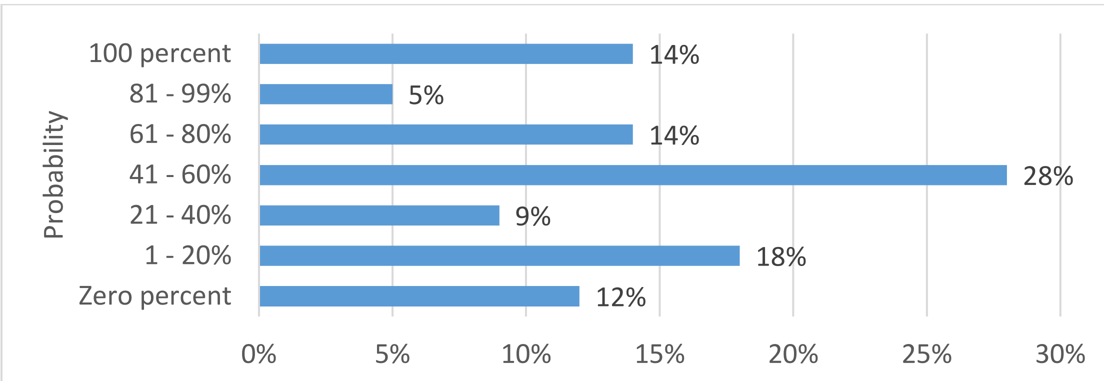


Figure 2.27 Probability of a catastrophic hurricane striking Portsmouth within the next 10 years.

Probability Home will Flood

Figure 2.28 reports respondents' stated probabilities that, should the catastrophic event take place, their home will suffer flooding. Among those households that believe there to be at least some chance of a catastrophic hurricane striking Portsmouth within the next 10 years (i.e., greater than 1 percent probability), these households were next then queried on the probability of their specific home flooding. For the probability of home flooding, the households responded in the following: 27 percent of households responses zero probability, 18 percent responded within the range of 1-20 percent probability, 11 percent responded within the range of 21-40 percent probability, 19 percent responded within the range of 41-60 percent probability, 7 percent responded within the range of 61-80% probability, two percent responded within the range of 81-99 percent probability, and 16 percent stated their home flooding was a certainty (i.e., 100 percent probability). Notable, even though these households believe that a catastrophic hurricane will strike Portsmouth within the next 10 years, over a quarter believed that there is zero chance that their homes will be flooded.

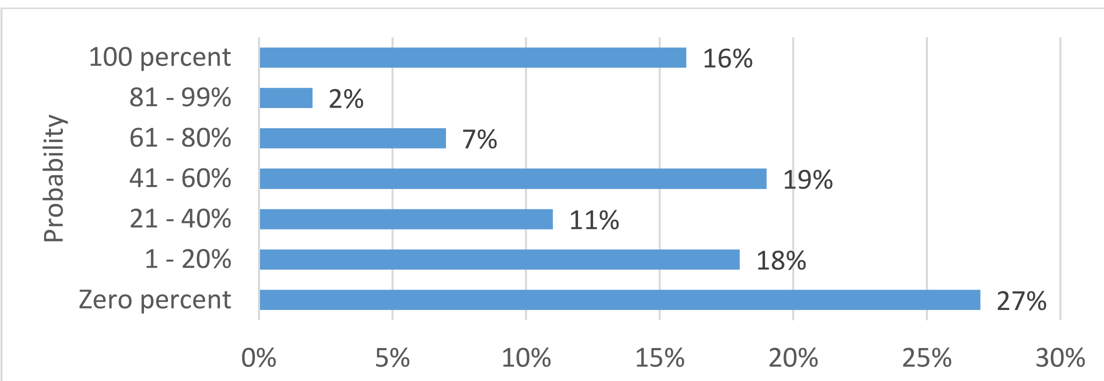


Figure 2.28 Probability of home flooding from catastrophic hurricane.

Probability Home will be Total Loss

Figure 2.29 below reports respondents' stated probabilities that, should the catastrophic event take place and their specific home will be flooded, their home's damage will be extensive and no longer livable. will suffer flooding. Among those households that believe there to be at least some chance of a catastrophic hurricane striking Portsmouth within the next 10 years (i.e., greater than 1 percent probability) were next then queried on probability of their home flooding. For the probability of home no longer livable due to extensive damage, the households answered in the following order: zero probability was 9 percent, 1-20 percent probability was 29 percent, 21-40 percent probability was 14 percent, 41-60 percent probability was 18 percent, 61-80 percent probability was 11 percent, 81-99 percent probability was 4 percent, and 100 percent probability was 15 percent.

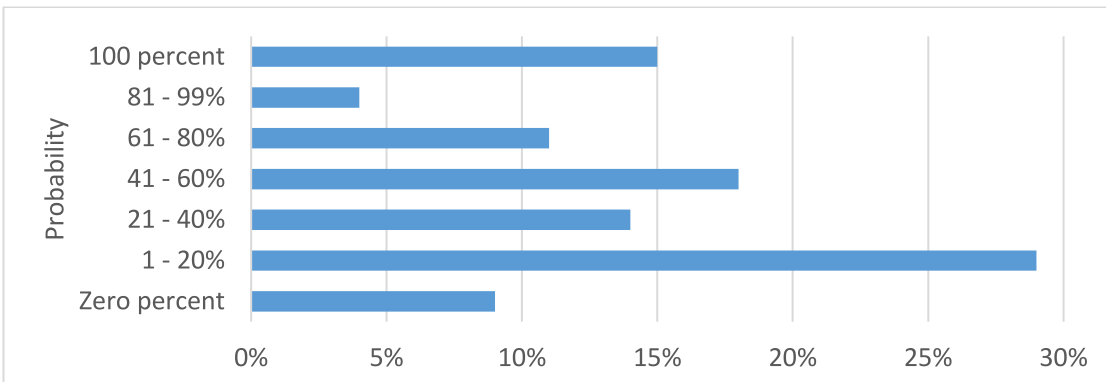


Figure 2.29 Probability of home no longer livable due to extensive damage from catastrophic hurricane.

Business Impacts from Flooding

Business Ownership

Figure 2.30 below shows the reported business ownership among queried households. Households were queried about their household members that own a business. Eleven percent respond that a member of the household owns a business and 89 report no business ownership. Among the households that have a member that owns a business, 59 percent are a business largely run out of the home and 41 percent otherwise.

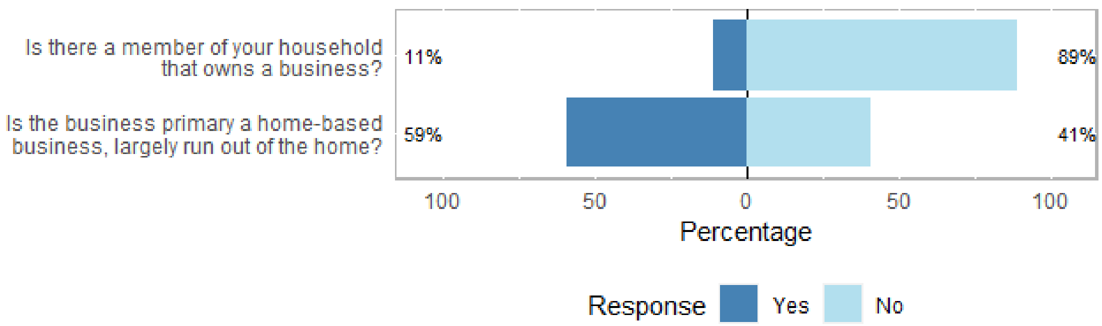


Figure 2.30 Business ownership.

Business Owners and Flood Insurance

Figure 2.31 shows, among those reporting business ownership by a household member, the households that report the business have flood insurance. About 16 percent of all respondents that own a business state they have flood insurance and 84 percent responded that they do not have flood insurance.

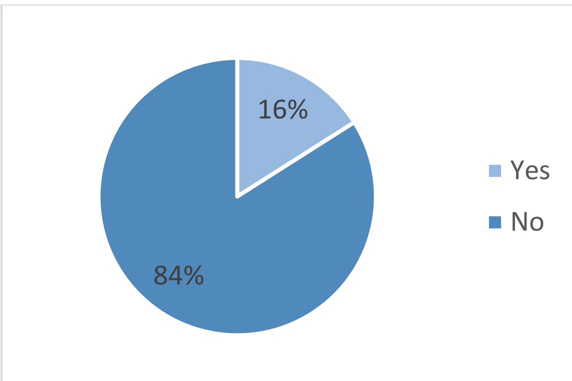


Figure 2.31 Flood insurance for business.

Location of Business and Flood Insurance

Figure 2.32 below shows, the distribution of business with/without flood insurance by the location of the business (home-based or non home-based). For the home-based business, seventeen percent have flood insurance and eighty three percent do not have flood insurance. For the non home-based business, fourteen percent have flood insurance and eighty six percent do not have flood insurance.

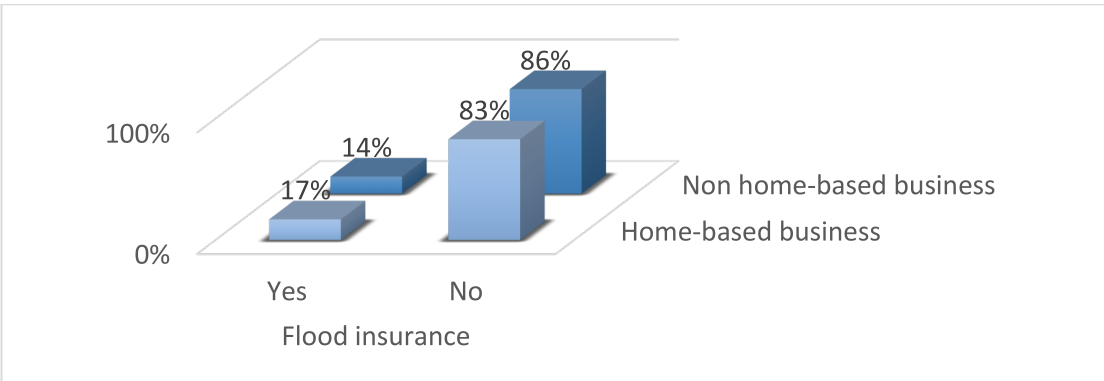


Figure 2.32 Flood insurance for home-based and non -home based business.

Flooding Impact on Business

Figure 2.33 below reports, among households that have a member that owns a business, the impact that flooding is having on that business. Among the respondents that own a business, seventy eight percent indicated that flooding did not impact the business while five percent experienced employees late or missed work. Four percent could not get to customers while six percent could not get customers to come to their businesses. Another four percent lost power and three percent are impacted in other ways.

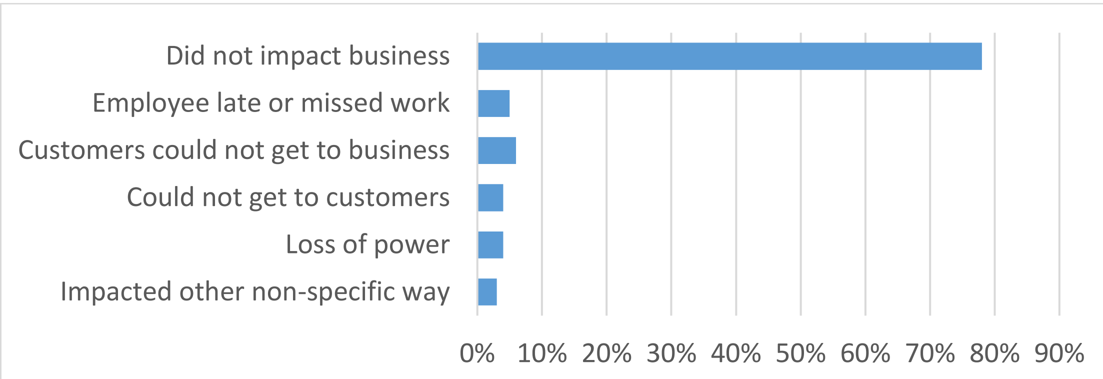


Figure 2.33 Impact to business due to flooding.

Reasons for not Having Flood Insurance

Figure 2.34 below reports, among those households reporting a member owning a business and that business being without flood insurance, the reason for the absence of such insurance. As indicated, slightly over a third indicated that the businesses does not need it, seventeen percent for never flooded before and another seventeen percent for too expensive or can't afford. The remaining fifteen percent were for: (1) not enough risk to justify getting it, (2) too few assets to insure, (3) didn't know the business could get it and (4) didn't know how to get it.

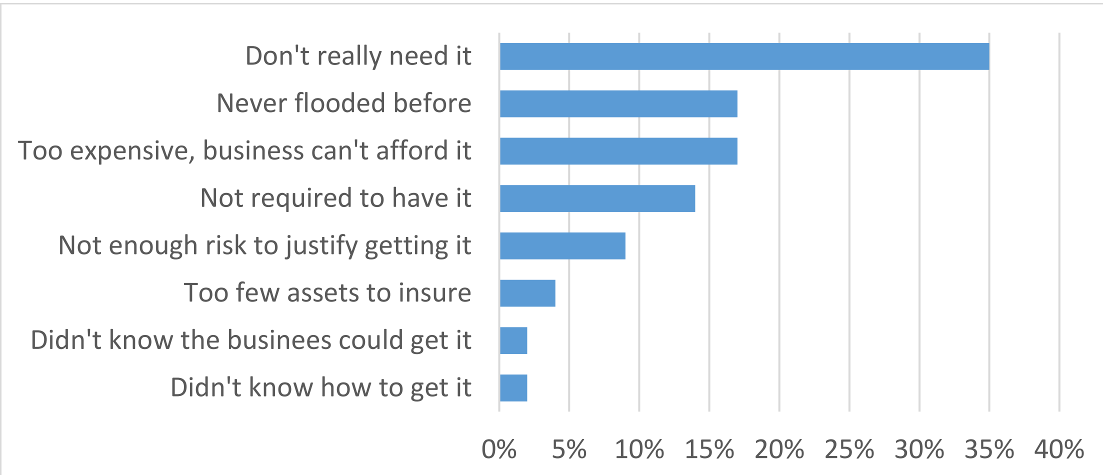


Figure 2.34 Reasons for businesses not having flood insurance.

Perceptions About Sea Level Rise

Sea Level Rise and Flooding are Related (comparison)

Figure 2.35 below reports the issue agreement and compares this agreement between the 2020 and 2015 surveys. Households are queried about their agreement that sea level rise (SLR) and neighborhood flooding in the City of Portsmouth are related issues. About 78 percent of households either agree or strongly agree that SLR and neighborhood flooding in the City of Portsmouth are related issues and 22 percent of households either strongly disagree or disagree that SLR and neighborhood flooding in the City of Portsmouth are related issues.

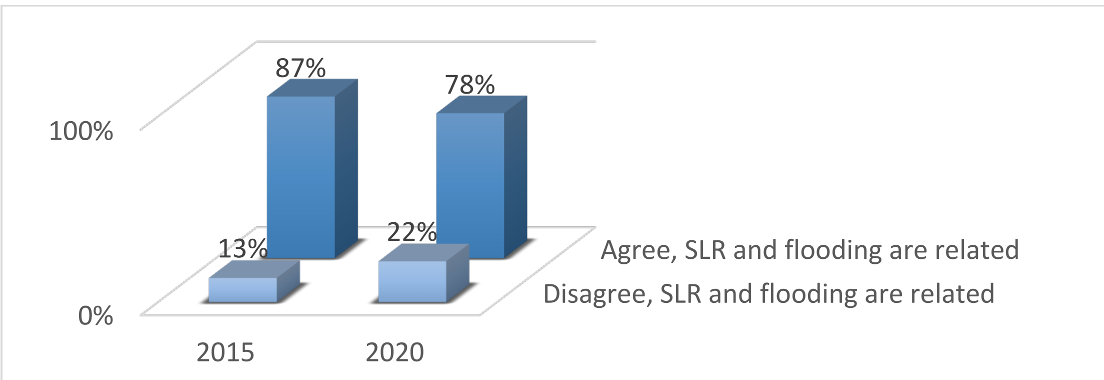


Figure 2.35 Sea level rise and flooding are related (2015 and 2020).

Sea Level Rise will have Negative Economic Impact

Figure 2.36 below reports the percentage of responding households that agree. This agreement is compared across the 2020 and 2015 surveys. Households are asked about their agreement that sea level rise will negatively impact the economic opportunities for citizens of the City of Portsmouth. Seventy three percent of households either strongly agree or agree that SLR will negatively impact the economic opportunities for citizens of the City of Portsmouth while 27 percent of households either strongly disagree or disagree, that SLR will negatively impact the economic opportunities for citizens of the City of Portsmouth.

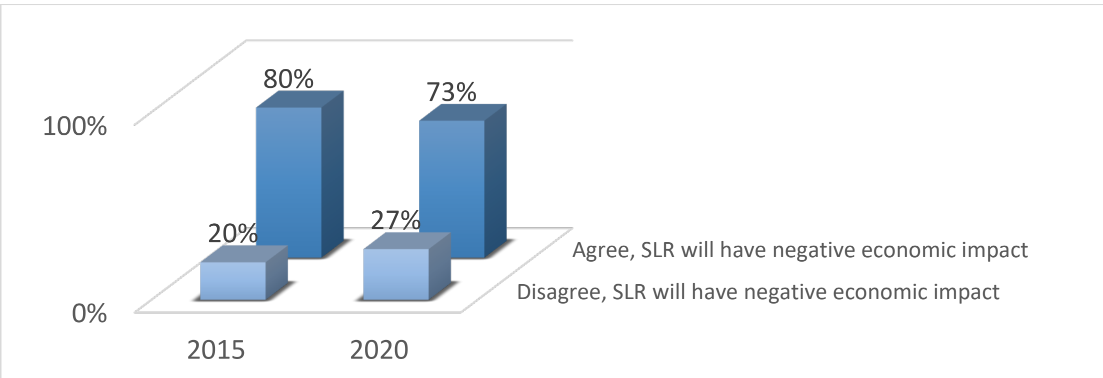


Figure 2.36 Sea level rise will have negative economic impact (2015 and 2020).

Not Enough Information to Invest in Response (comparison)

Figure 2.37 below reports the percentage of responding households that agree. This agreement is compared across the 2020 and 2015 surveys. Households are queried about their agreement that there is not yet enough solid information about sea level rise for the City of Portsmouth to invest money into responding to it. Forty eight percent of households either strongly agree or agree that there is not yet enough solid information about sea level rise for the City of Portsmouth to invest money into responding to it. Fifty two percent of households either strongly disagree or disagree, that there is not enough solid information.

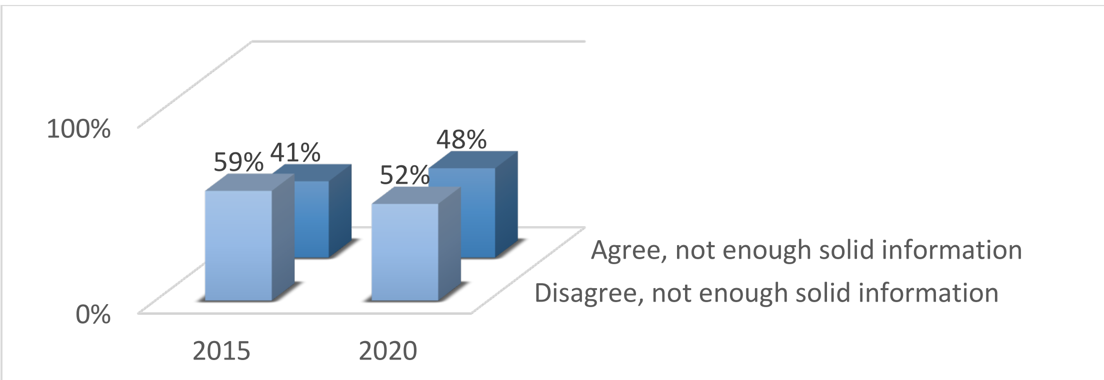


Figure 2.37 Not yet enough solid information about sea level rise for the City of Portsmouth to invest money into responding to it (2015 and 2020).

Flooding Impact on Value of Home (comparison)

Figure 2.38 below reports the perception that flooding has negatively impacted the home's value. Responses are compared across the 2020 and 2015 surveys. The respondents that were identified as non-renting households (inclusive of both those holding a mortgage and those that have paid-off the mortgage) are queried if they believe flooding in the City of Portsmouth had negatively impacted the value of the home. About 77 percent of these households responded that they do not think that flooding has had a negative economic impact on the value of their home, while approximately 23 percent of households did express agreement that flooding has had a negative economic impact on the value of their home.

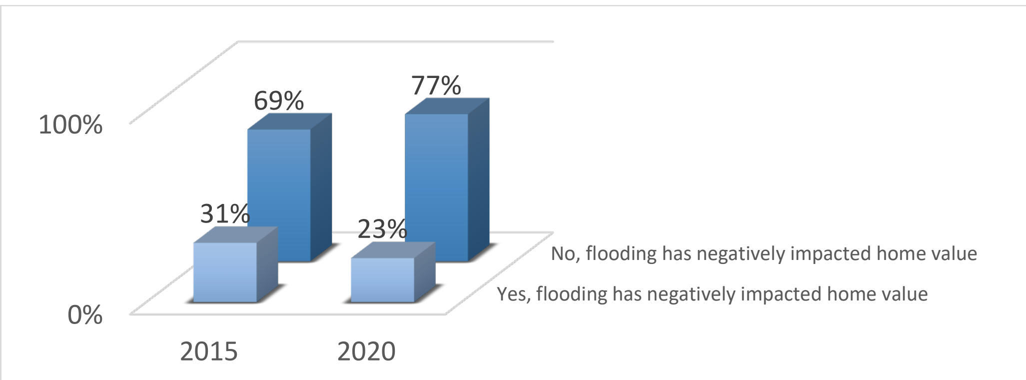


Figure 2.38 Flooding has negatively impacted the value of homes (2015 and 2020).

Percent Value Home has Decreased

Figure 2.39 below illustrates the perceived decrease in home value due to flooding. The households that perceived flooding to have had a negative economic impact on the value of their homes were queried on what percent less is the value of their homes due to flooding and threat of flooding. Slightly over two thirds believed that flooding decreased their home's value by up to 20 percent. A quarter believed that their home value decreased between 15 and 50 percent. Seven percent believed that their home value decreased by greater than 71 percent.

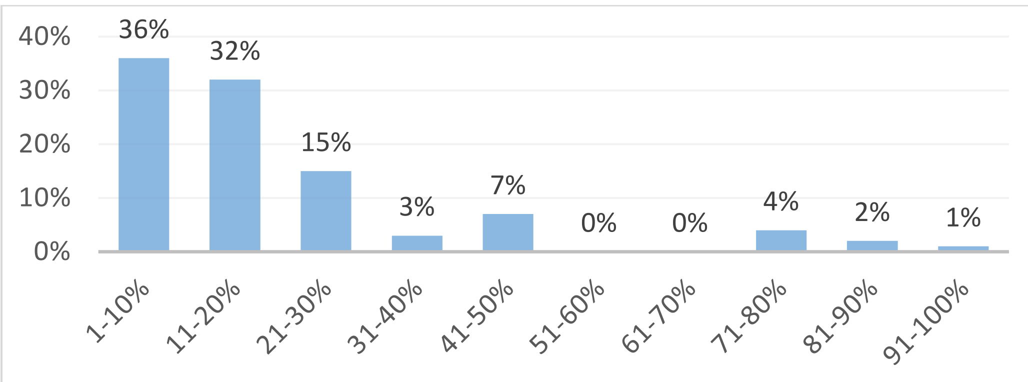


Figure 2.39 Percent value of home decreased due to flooding.

Household Adaptation Actions

Renter: Changes to Property and Insurance

Figure 2.40 below shows the results for rental property flood mitigation and purchase of renters insurance. Seventeen percent of the households were renters and 83 percent were owners. Among the households that were identified as renters, seven out of ten had renters insurance and the remaining 30 percent did not have renters insurance. Among those households that had renters insurance 63 percent had Preferred Risk Policy that covers damage to the content of the homes specifically from storm flooding. Thirty seven percent did not have Preferred Risk Policy. Renters also reported 27 percent of their landlord had taken steps to protect property from flooding. In 2015 renters reported that 20 percent of their landlord had taken steps to protect property from flooding.

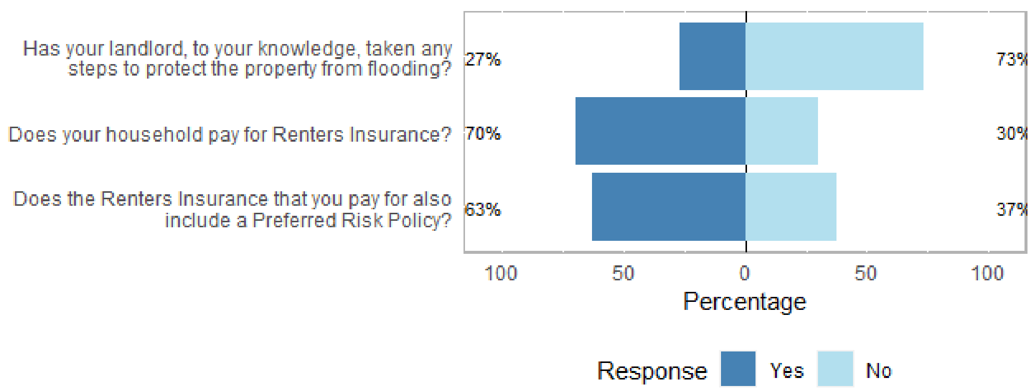


Figure 2.40 Renter: Changes to property and insurance.

Timing of Protective Actions

Figure 2.41 below shows the timing for the most recent flooding protective steps. Eighty seven percent of homeowners had not made any changes to the property in response to flooding. For the thirteen percent of homeowners that had taken protective steps; fifty five percent of them was performed less than five years ago, seventeen percent was performed 6-10 years ago and fourteen percent was performed 11-15 years ago. Ten percent was performed 16-20 years ago and four percent was performed over 20 years ago. For these protective steps eight percent was at no cost and almost a quarter cost $1 - $999. Seventeen percent cost $1,000 - $1,999 and eleven percent cost $2,000 - $4,999. Forty percent cost greater than $5,000.

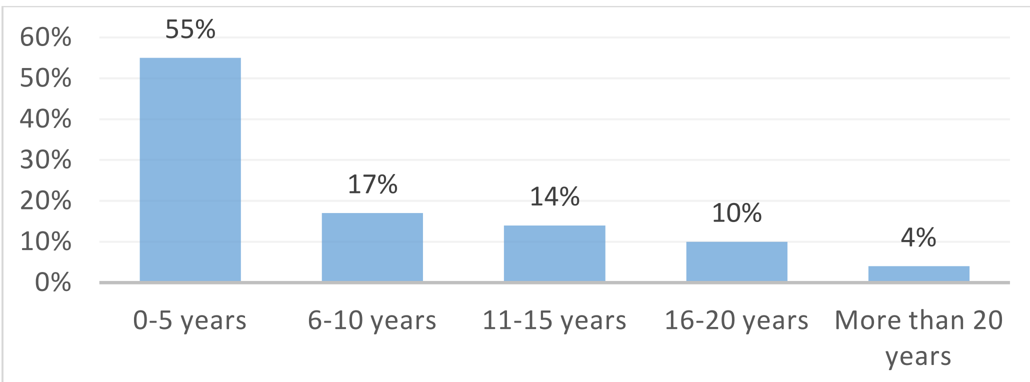


Figure 2.41 Timing of most recent flooding protective steps.

Cost of Most Recent Action

Figure 2.42 below reports, among households that report taking a protectives step to address current and/or potential future flooding, the estimated cost of that action. The figure illustrates that the households are spending a wide range to take action. Roughly 8 percent of households took a preventive action with no cost involved, while 30 percent report the cost above the $100,000 threshold.

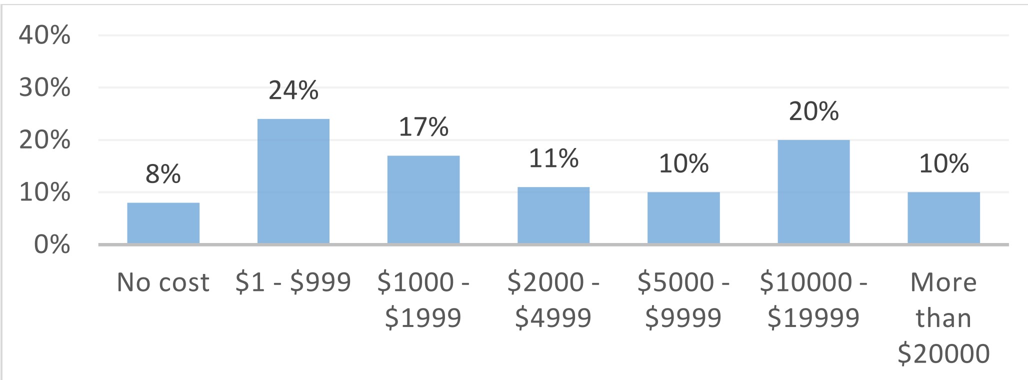


Figure 2.42 Costs for most recent flooding protective steps.

NFIP Prevalence Among Homeowners

NFIP Policyholder (comparison)

Figure 2.44 below show households that report having an NFIP Policy. These results are illustrated across the 2020 and 2015 surveys. Respondents that were identified as non-renting households (inclusive of both those holding a mortgage and those that have paid-off the mortgage) were queried about having a National Flood Insurance Program (NFIP) policy. About 30 percent of these households report having NFIP flood insurance. Figure 2.44 also shows the results for NFIP insurance for the 2015 and 2020 surveys. The percentage of non-renting households with flood insurance is consistent across both surveys.

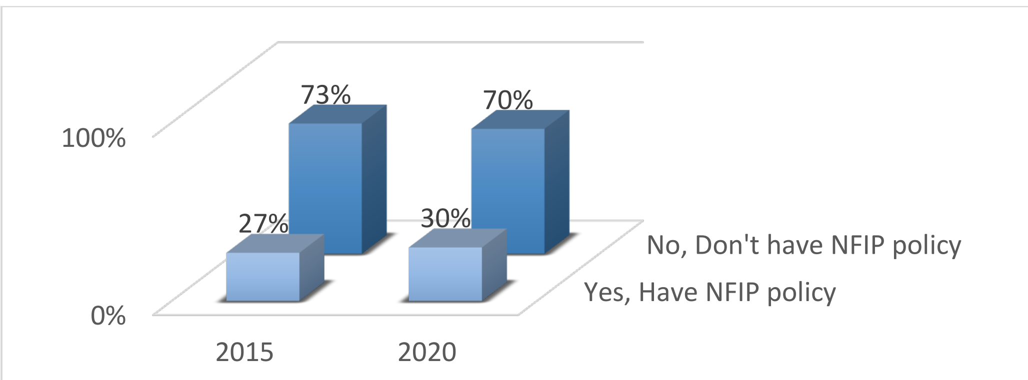


Figure 2.44 Have NFIP flood Insurance policy (2015 and 2020).

NFIP Policyholder by Income

Figure 2.45 below reports the households as NFIP policyholders by income. Respondents that were identified as non-renting households (inclusive of both those holding a mortgage and those that have paid-off the mortgage) were queried about having a National Flood Insurance Program (NFIP) policy. Among policyholders, low-income households are the least likely to report participating in the program.

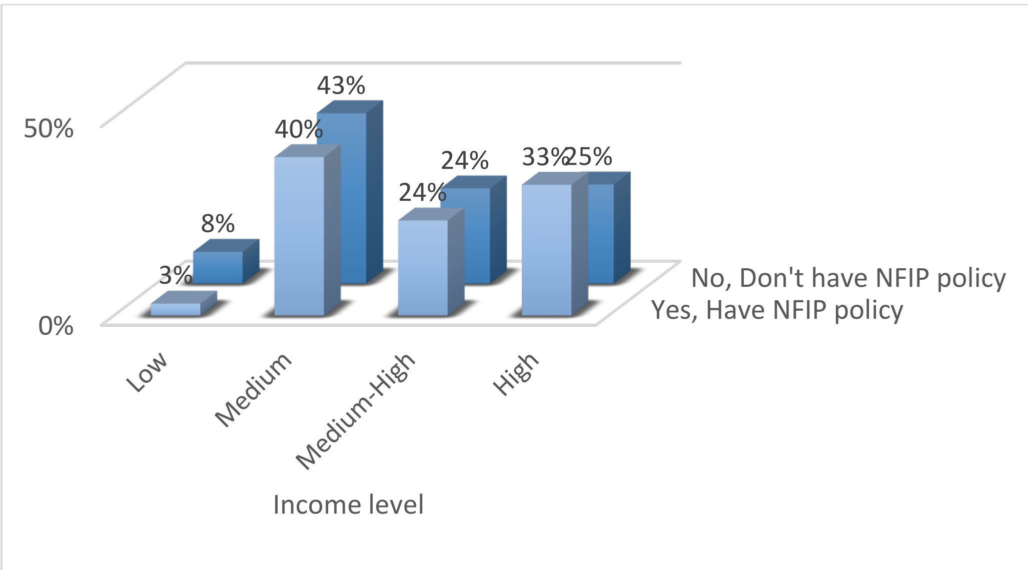


Figure 2.45 Flood insurance policy by income level.

NFIP Policyholder by Protective Action

Figure 2.46 below report non-renting households (inclusive of both those holding a mortgage and those that have paid-off the mortgage) that took at least a single protective step to address current or perceived future flooding, by NFIP participation. Among those that have taken protective steps, the majority are not policyholders.

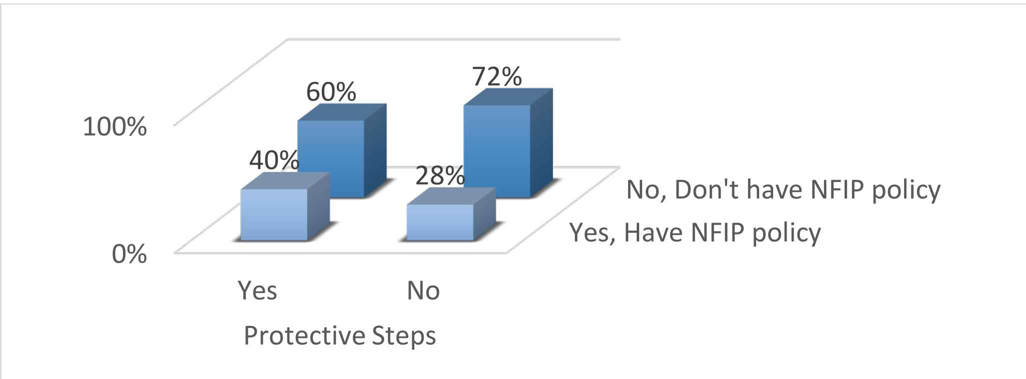


Figure 2.46 Flood protective steps by flood insurance.

Reasons NFIP Policyholder

Table 2.1 below reports the reasons for participating in the NFIP program. Among households that report participating in the NFIP program, forty one percent answer that flood risk is high or near water. Over a quarter respond that they wanted to protect assets/family. Seventeen percent state that mortgage/lender required it and seven percent said it was affordable. Four percent indicate insurance agent recommended it, two percent say that the households does not have enough money for repairs/rebuilds, and two percent are other.

Table 2.1 Reasons for having flood insurance.

Description	Percentage
Flood risk is high	41%
Want to protect my assets	27%
Mortgage/lender requires it	17%
It is affordable	7%
Insurance agent recommended it	4%
Don't have enough money for repairs/rebuild	2%
Other	2%

Reasons not NFIP Policyholder

Table 2.2 below shows the reported reasons, among responding homeowners, for not participating in the NFIP program. For the households that did not have NFIP policy, over a third answered that they are not required to have it, or mortgage does not require it. One fifth respond that they did not know how to get it or stated it was hard to find information. The following responses were reported each by either 6, 7, or 8 percent of households: (1) do not need it, (2) not in flood zone or flood plain, (3) not at risk or not enough to justify it and (4) had flood insurance but dropped it. For each of the following, 1, 2, or 3 percent of households respond: (1) too expensive or cannot afford it, (2) didn’t know could get it, (3) never flooded here before or never needed it before and (4) government will help me if it floods. Thirteen percent responded with something other.

Table 2.2 Reasons not having flood insurance.

Description	Percentage
Not required to have it	34%
Did not know how to get it	20%
Do not need it	8%
Not in flood zone	7%
Not at risk	7%
Dropped flood insurance coverage	6%
Can't afford it	2%
Did not know I could get it	1%
Never flooded before	1%
Government will help me	1%
Other	13%

Part 3 - Estimated Impacts: Workforce & Property

Challenge Context

This research focuses on the identification of the recent (aka 'current') property and workforce costs associated with recurrent flooding. In addition, this research focuses on estimating what these costs may be in the future, thus allowing us to forecast the change in costs over time.

Determining the cost of current recurrent flooding and storm events in terms of property damage and productivity impacts is not an easy task. Currently, there are not publicly available either federal or Virginia databases that provide this information. For large storm events, some property damage information is available for those individuals who receive FEMA assistance, but there is no available data on property damage from non-disaster flooding events, damage that is not covered by FEMA, and impacts on lost productivity from both flooding and storms.

Furthermore, estimating these costs in the future is also challenging. A necessary ingredient in making such estimations is knowledge of future environmental conditions associated with sea level rise, water tables, and wind intensities. There are uncertainties related to these future environmental conditions. Such estimates must be based on assumptions as to how sea level rise and climate change will impact both recurrent flooding and storm events. In Part 5 *Scenario Flood Models* this report provides some indication on the possible future extent of flooding and floodwater contact with structures.

Here in Part 3 *Estimated Impacts: Workforce & Property* this report provides an estimate of the current economic impact of recurrent flooding in Portsmouth Virginia using original data elicited from Portsmouth residents (see Part 2 *Elicited Impacts: Workforce & Property* in this report). Part 3 then reports the extrapolation of these results to the entire population of Portsmouth to estimate the impact of current recurrent flooding within the city in terms of both property damage and lost productivity.

Sampling Approach

As noted above, there are no existing publicly available data sources that track losses from recurrent flooding and storm events. To collect information on households' experiences with recurrent flooding and storm events, we conducted a survey of Portsmouth residents in the summer and fall of 2020. The survey asked households to report on their experiences with flooding and storm events, detailing the types of impacts that they had experienced and the type and amount of damage to cars and property. The survey also asked for information on the respondent's risk perceptions with respect to flooding, flood insurance status, and experience with asthma, although these data that were not used in the analysis described in this report. Additionally, the survey asked for some basic information about the household such as number of household members, race, and income. Survey participation was voluntary and respondents were free to refuse to answer certain questions either because they did not know the answer or they preferred not to answer.

A total of 801 individuals responded to the survey. Using the demographic information that respondents provided, we can compare the respondent population to the overall population of Portsmouth along a number of key socio-economic dimensions as shown in Table 3.1. Overall, homeowners are over-represented in the set of survey respondents and renters are under-represented. Additionally, the average household income of respondents is higher than that of Portsmouth overall. Finally, white households are over-represented among respondents while black households are under-represented.

Table 3.1 Comparison of survey universe to survey respondents.

Socio-Economic Dimension	City of Portsmouth	Survey Respondents
Household Size	2.50	2.35
Home Owner	55.0 %	83.0%
Percent White	39.8%	57.7%
Percent Black	52.9%	38.0%
Income < $25K	24.5%	11.9%
Income $25-45K	20.0%	23.0%
Income $45-75K	25.2%	30.3%
Income $75-125K	21.0%	23.6%
Income > $125K	9.5%	11.2%

Source: City of Portsmouth, 2015-2019 American Community Survey; Respondents, survey responses. Not all respondents answered all demographic questions, percentages based on those who did answer.

Extrapolation Methods

We use the information from the survey respondents to calculate the impact of recurrent flooding and storm surge city-wide, that is we extrapolate from the survey responses to all households in the city under the assumption that the survey responses are representative of the experiences of households in the city overall. One issue in taking this approach is that not all areas of Portsmouth are impacted equally by flooding. This is evident in Part 5 *Scenario Flood Models*.

To ensure that the survey data are being extrapolated to non-respondent households that face similar flooding and storm event experiences to the respondents, we need to break the city into small areas that face relatively similar flooding conditions. Initially we used the U.S. Census Bureau's "Block Group" designation to form our small areas, which are technically referred to as strata. Census Block Groups are the smallest geographical unit for which the Census Bureau publishes sample demographic data (e.g., data collected by the American Community Survey, which we need in order to conduct our extrapolation).

In Portsmouth, there are 81 populated Block Groups which range in area from 0.1 to 5.8 square miles and contain 42 to 2,956 people.[1] We used information provided by survey respondents to determine the Block Group in which each respondent lives. Of the 801 survey respondents, we were able to locate 719 respondents whose responses we use to conduct our analysis. We do not use the responses from the 82 unlocated respondents as we cannot determine their exposure to flood conditions.[2]

The extrapolation method we use to calculate citywide impacts is appropriate as long as the experiences of the survey respondents in a stratum are generally representative of the experiences of the overall population in that stratum. Since not all households in a stratum will share similar experiences, the more survey respondents there are in a stratum, the more likely it is that the survey respondents' answers are generally representative of the stratum as a whole.

For strata with only a few respondents, survey responses may not be representative of overall experiences and thus extrapolation may not provide a valid estimate. For this analysis, any block group that had less than three respondents was merged with the neighboring block group that was most similar in terms of flooding experience according to two measures, the maximum estimated flood depth in the block group and the median estimated flood depth in the block group.[3] These merged block groups became one stratum for the purposes of this analysis. [4]

Another caveat for using the elicited household data to calculate damages is that even controlling for similar flooding and storm event experiences, respondents to the survey may experience different impacts based on demographic and socioeconomic factors. As discussed above, the survey respondents over-represent homeowners and white households and the average household income of respondents is higher than that of the population. A more detailed breakdown of the differences between respondents and the population in each stratum are

---

[1] Table A1 in Appendix A *Data used to Estimate Economic Impacts* provides a list of the 81 populated block groups, their size, population, and the number of survey respondents.

[2] Table A2 in Appendix A *Data used to Estimate Economic Impacts* compares the located respondents to the unlocated respondents. The located respondents are more likely to be homeowners, to be white, and to have higher incomes than the unlocated respondents. These factors should be considered when assessing the results of our analysis.

[3] The maximum estimated flood depth and the median estimated flood depth come from a hydrodynamic urban inundation model that was used to hindcast the flooding from the 2011 Hurricane Irene, the last major Hurricane to significantly impact Portsmouth.

[4] Table A3 in Appendix A *Data used to Estimate Economic Impacts* provides a list of the block groups that were combined for use in the analysis. We omitted two block groups (Census Tract 2130.01, Block Group 1 and 9806, Block Group 1) from the analysis as there are less than 10 households in either of these block groups as the resident population is solely or primarily housed in military base housing.

provided in the appendix.[5] These factors should be considered when assessing the results of our analysis.

Logic for Chosen Estimates

We develop three different sets of estimates of the average household and city-wide impacts from flooding using the survey data: an upper-bound estimate, a lower-bound estimate, and a "preferred" estimate. We do this for a number of reasons. First, some questions ask respondents to provide damages from flooding over an unspecified time period. To calculate the annual cost of damages, we need to annualize these aggregated damages. If we assume a short time period over which the damages have been accumulated, the annual damages are higher than if we assume a longer time period.

For our upper-bound estimate, we assume a 5-year time frame, for our lower-bound estimate we assume a 20-year time frame and for our preferred estimate we assume a 10-year time frame.[6] Additionally, since participating in the survey was voluntary and respondents could decide which questions to answer, in some cases respondents did not supply an answer to a particular question. That is, respondent may have refused to answer the question of stated 'don't know.' In the upper-bound and preferred estimates, we treat this information as missing and use data from respondents who did answer to calculate estimated household impacts. In the lower-bound estimate, however, we interpret no response to mean no impact (this is a conservative approach). If someone does not answer whether their household had a particular impact, we assume that the impact was zero. Taken together, these estimates provide a range for the dollar value of each possible impact as well as a range for the overall impact of recurrent flooding and storm surge in Portsmouth.

[5] Table A4 in Appendix A *Data used to Estimate Economic Impacts* provides comparison of respondents to each stratum's population along these three key demographic dimensions: Percent Owners, Percent White and Median Income Range.

[6] In our discussion of particular impacts, we provide data to support these assumptions.

Impact Estimates

This section of reports how we developed each of the various recurrent flooding and storm surge estimates and assigned a dollar value to those impacts. We consider three different categories of impacts: direct impacts, car and property damage, and adaptation responses.

Direct Flooding Impacts

We consider direct flooding impacts to be situations where individuals must change their plans or actions during a flooding event. For example, one survey question asks households "Within the past year, has anybody in your household had to alter their drive to work or school, such as leaving earlier or later or taking a different route, because of flooding somewhere in Portsmouth?" A related question asks "Has anybody in your household been unable to get either in or out of your neighborhood because of flooding?" In a separate question, the survey asks "How often does either the street in front of your home, or the streets very near your home, flood?" with the response options of more than once a month, once of month, couple times a year, once a year, once every couple of years, or rarely if ever."

We use the response to the question on flooding frequency combined with the responses to the two questions (altering driving, unable to get into/out of the neighborhood) to calculate the number of times each respondent household suffers these in a representative year. If the respondent answered "more than once a month" to the flooding frequency question, we assumed 12 flooding events per year. If the respondent answered "a couple of times a year" we assumed two annual flooding events, if they answered "once every couple of years" we assumed a flooding event every other year and If they answered "rarely if ever" we assumed a flooding event once every ten years.

Of course, flooding may not always result in a driving alteration or neighborhood inaccessibility. Our upper-bound estimate assumes that if the respondent answered yes to either of those two questions, each flooding event resulted in that specified impact. In contrast, the lower-bound estimate caps the number of flooding events resulting in an impact at 1, so that even if the respondent answered that the road in front of their house flooded more than once a month, we assume that they only suffered an impact at most once a year.

We also treat missing information on flooding frequency differently for the two estimates. In the upper-bound estimate, we assume that respondents who stated that they experienced an impact but did not specify the flooding frequency experience that impact once a year. In the lower bound, we assume that if the respondent did not answer the flooding frequency question, there is no impact regardless of how they answered the two impact questions. Additionally, we assume that if the respondent did not answer the impact question there is no impact in the lower bound, while in the upper bound, we treat that as missing information. For both of these impacts (driving alteration, inaccessible neighborhood) our "preferred" estimate the same as the upper-bound estimate.

Types of Impacts

After determining the household frequency of these impacts for each of the three estimates (upper, lower, and preferred), for each stratum we calculated the average number of impacts per respondent household for each scenario. We then extrapolate to the entire stratum by multiplying the average number of accessibility impacts per households to the total number of households in that strata. To determine the number of accessibility impacts across Portsmouth in each estimate, we then aggregate all of the strata impacts. Table 2 presents the results of these calculations. As shown in the first two rows, the number of times households are estimated to have to alter their driving routes ranges from just over 10,000 to almost 56,700 and the number of times that a household's neighborhood is inaccessible ranges from just almost 8,200 to almost 46,300. To put these estimates in context, there are just under 36,400 households in Portsmouth.

Accessibility is just one of the many types of impacts recurrent flooding can have. Using the same basic approach described above, we used survey responses to calculate a number of productivity impacts from flooding which are also reported in Table 3.2. The survey asked three questions about productivity:

- Within the past year, was somebody in your household late or delayed in getting to work due to flooding?
- Within the past year, was somebody in your household unable to get to work for an entire day due to flooding?
- Within the past year, did somebody in your household lose pay due to flooding?

For all three of these impacts (getting to work/school on time, missing school/work, lost pay), our upper-bound estimate assumes that if the respondent answered that flooding had such an impact, each flooding event resulted in the impact and missing answers were not used in computing the average household response. The lower bound estimate caps the number of events resulting in the impact at 1 and assumes a missing answer is the same as no impact. For getting to work/school late, the "preferred" estimate is the average of the upper and lower bound estimates, while for both missing work/school and lost pay, the preferred estimate is the same as the lower bound estimate.

Table 3.2 Estimated occurrence of flooding impacts in Portsmouth.

Impact Type	Upper Bound	Lower Bound	Preferred Est.
Driving alterations required	56,685	10,067	56,685
Neighborhood inaccessible	46,265	8,180	46,265
Late to work/school	48,620	8,844	28,184
Miss work/school	26,960	4,584	4,584
Lost Pay	19,066	3,036	3,036

As one would expect, it is more common for flooding to result in people being late to work or school than it is for them to completely miss work or school, and not all of those that miss work or school lose pay as a result. In the lower bound, less than a tenth of households are estimated to lose pay each year as a result of flooding, although in the upper bound, over half of all households will.

Assigning Monetary Value

The next step is to assign a monetary value to these impacts. The primary monetary consequence for all of these impacts is lost time, the value of which typically varies across individuals depending on what the individual what they would otherwise do with that lost time. Unfortunately, we do not have that information. In cost-benefit analyses, it is standard to assume that the value of lost work time is best measured by the cost of that time to the employer, that is the individual's wage plus the cost of benefits and overhead (EPA 2020). Lost non-work time is typically measured by the value of that time to the individual which in turn is determined by take-home wages, that is wages minus taxes (EPA 2020). While wages, benefits, overhead and taxes vary by individual, employer, industry, region and occupation, for this analysis we only know the general location in which individuals live and work. Thus we use wage data from the US Bureau of Labor Statistics (BLS) for all occupations and all employers for individuals in the Virginia Beach/Norfolk/Newport News MSA to value the lost time.

According to the May 2020 Metropolitan and Nonmetropolitan Area Occupational Employment and Wage Estimates from the BLS, the median hourly wage for all occupations and industries in the Virginia Beach/Norfolk/Newport News MSA is $19.96 and the average hourly wage is $25.08. Following the US EPA's methodology (EPA 2020) we assume that benefits plus overhead costs are equal to 50% of wages, so that the cost of lost work time is equal to the wage rate multiplied by 1.5. To measure the value of leisure or non-work time, following, we use Current Population Survey data on median household in Portsmouth income before and after taxes to calculate the average income tax rate in Portsmouth to be 22 percent, so that the cost of lost non-work time is equal to the wage rate multiplied by 0.78.[7] For our upper-bound estimates, we use the <u>average</u>

[7] According the 2018 Current Population Survey the median pre-tax income in Portsmouth is $72,000 and the median post-tax income is $56,010.

wage rate of $25.08 which results in a value of worktime of $37.62 and a value of non-worktime of $19.56. For both the lower-bound and preferred estimates, we used the median wage rate of $19.96 which results in a value of worktime of $29.94 and a value of non-worktime of $15.57.

For each impact listed in Table , we need to model the average amount of lost work and non-work time per incident for the upper-bound, lower-bound, and preferred estimates. For driving alterations, for all of our estimates we assume that each impact results in 0.5 hours of additional driving and that this driving takes place during work time. We then multiply 0.5 times the number of incidents listed in Table times the appropriate work time value to arrive at the monetary costs of driving alterations under each estimate, as shown in Table 3.3.

Table 1.3 Estimated value of direct flooding impacts in Portsmouth.

Impact Type	Upper Bound	Lower Bound	Preferred Est.
Driving alterations required	$1,066,245	$150,703	$848,574
Neighborhood inaccessible	$3,619,774	$254,725	$1,440,692
Late to work/school	$1,829,084	$132,395	$843,829
Miss work/school	$8,113,882	$548,980	$1,097,960
Lost Pay*	$2,983,448	$189,082	$378,164
Total Direct Flooding Impacts*	$14,628,984	$1,086,803	$4,231,055

*Lost pay is a subset of missed work/school, as not all missed work results in lost pay. Thus, lost pay is not included in the total impacts to avoid double counting.

Other Impacts

For the other impacts, the process is the same although the average amount of time lost varies according to the impact and the estimate in question. For the “neighborhood inaccessible” impact, it the upper bound we assume that when an individual’s neighborhood is inaccessible, it results in 4 lost hours of non-work time while in both the lower bound and the preferred estimates, we assume it results in 2 lost hours of non-work time. When an individual is late to work or school, we assume 1 lost hour of work time for both the upper-bound and preferred estimates and 0.5 lost hours of work time for the lower-bound estimate. When an individual misses work or school, we assume 8 lost hour of work time for both the upper-bound and preferred estimates and 4 lost hours of work time for the lower-bound estimate. Some, but not all of the individuals who miss work will lose pay as a result of the lost time. We assume 8 lost hours of paid work time for both the upper-bound and preferred estimates and 4 lost hours of paid work time for the lower-bound estimate. However, we use the post-tax values for these calculations.

One important caveat in considering these results it that the values of last pay are also included in the calculations for missed work and school. That is, individuals who lose pay due to flooding would also have missed work due to flooding. The difference is that is an individual misses work and doesn't lose pay, the lost productivity accrues to the employer while when the individual does lose pay, the majority (but not all) of the lost pay accrues to the employee. To avoid double counting, the value of lost pay is not included in the total of flooding impacts. However, it is important to track the total amount of lost pay as it impacts the distribution of costs associated with flooding.

Summary Estimates

Overall, we estimate that the annual direct costs of flooding in Portsmouth range from just over one million dollars in the lower bound to more than $14.6 million in the upper bound, with a preferred estimate of around $4.2 million. While these numbers might initially seem quite large, with just under 36,400 households in Portsmouth, these estimates represent a range of direct flooding impacts of approximately $30 to $400 per household per year. Of course, the impacts of flooding are not distributed equally across the population of Portsmouth.

Vehicle and Property Damage Impacts

In addition to the immediate disruptions that flood events cause, such events can also result in damage to both cars and homes. To estimate these impacts, we asked "While living in Portsmouth, has anyone in your household suffered any damage to any cars (home or contents of the home) due to flooding?" in two separate questions. If the respondent answered yes to either of these questions, they were asked the following follow-up questions:

- Thinking back, in total, for all the times your car (home) was damaged due to flooding, how many days, if any, of work would you say were missed due to the car (home) being damaged?
- How many days, if any, in total, of school were missed by household members due to damaged cars (home)?
- Can you recall for me for each time a car (your home) was damaged, about how long ago the damage happened and how much it cost to fix the car (home)?

Calculating Bounds

Using the answers to these questions we determined the percentage of households that had car (home) damage and calculated the annual car (home) damage amount. For our upper-bound estimate, we calculate the percentage of households with car (home) damage as the number of respondents stating that they had such damage divided by the total number of respondents who answered the question. To determine the average annual damage amount for the upper bound, we assumed that all of the damage reported had occurred in the last five years and thus divided the total reported damage amounts by 5 to calculate the average annual cost of damages for those with car (home) damage.[8] Following these assumptions, if someone stated that they had car (home) damage but did not report a total damage amount, we did not use their answer to determine the average damage for households with damage for our upper bound-estimate. To determine the average annual damage across all households, we then multiply the upper-bound percentage of households with car (home) damage by the upper-bound average annual damage amount for those with damage. We treated reports of the number of school and workdays missed due to the car (home) damage similarly, dividing the aggregate number of days missed by 5 to get the annual number of days missed for a household reporting missed days due to car (home) damage and then multiplied it by the total number of households with car (home) damage in the upper bound.

For the lower-bound estimate, we calculate the percentage of households with car (home) damage as the number of respondents stating that they had such damage divided by the total number of respondents in the analysis, including those who did not answer the question. To determine the average annual lower-bound damage amount and days of school/work missed, we assumed that the aggregate numbers reported had occurred in the last twenty years and thus divided the total reported amounts by 20. If someone stated that they had car (home) damages but did not report a total damage amount or days missed, we assumed their total damages were 0. To determine the average annual damage across all households, we then multiply the lower-bound percentage of households with damage by the lower-bound average annual damage amount for those with damage.

For our preferred estimate, we used a 10-year time frame rather than the 5-year time frame assumed in the upper-bound estimate, but otherwise made the same assumptions as in the upper-bound estimate (percentage of households with damage based on only respondents who answered, annual damage and days missed based only on reported amounts). We did not make any inflation adjustments to the damage estimates in any of these three estimates regardless of how long ago the damage occurred, as we assume the damage estimates are somewhat imprecise both in total amount and when the damage occurred and thus any adjustment for inflation would imply false precision for these estimates.

Assigning Monetary Value

Table 3.4presents the estimated current annual car and property damage due to flooding for the City of Portsmouth. To value missed work due to both car and property damage, we used the same assumptions for flooding impacts: in the upper-bound estimate, we assumed 8 hours of missed work-time per day at a rate of $37.62 per hour, and for both the lower-bound and preferred estimates we assumed 8 hours of missed work-time at a rate of $29.94 per hour. For lost school time, the upper-bound estimate assumes 4 hours of lost school time per day at a rate

[8] As shown in Figures A1 and A2 in Appendix A *Data used to Estimate Economic Impacts*, approximately two-thirds of the reported car and property damage took place within the last five years, so we believe that the 5-year time frame is appropriate for our upper bound estimate. Since almost 90 percent of all damage reported happened the last 10 years, we use 10 years for our preferred estimate and the lower bound estimate includes the final 10 percent of all reported damage by using a 20-year time frame.

of $19.56 per hour (the value of non-work time calculated using average wages) while the preferred estimates assume 4 hours of lost school time per day at a rate of $15.57 per hour (the value of non-work time calculated using average wages). For the lower bound, we assume there is no lost value associated with lost school time.

Table 3.4 Estimated annual vehicle and property damage due to flooding in Portsmouth.

Impact Type	Upper Bound	Lower Bound	Preferred Est.
Vehicle damage ($)	$4,151,355	$844,689	$2,075,677
Missed work due to vehicle damage (days)	3,262	752	1,631
Value of missed work	$981,732	$180,119	$390,657
Missed school due to vehicle damage (days)	1,326	262	663
Value of missed school	$103,746	$0	$41,292
Property damage ($)	$16,569,734	$3,739,637	$8,284,867
Missed work due to property damage (days)	2,679	555	1,340
Value of missed work	$806,272	$132,934	$320,957
Missed school due to property damage (days)	981	214	490
Value of missed school	$76,753	$0	$30,517
Total vehicle and property damage impacts	$22,689,592	$4,897,379	$11,143,967

Summary Estimates

To put these figures in context, given the 36,400 households in the city, the upper-bound estimates for car a property damage are about $110 and a $460 per household per year, respectively while the lower-bound estimates are about $60 and $230 per household per year. Overall, combined car and property damage impacts, including productivity losses range from $135 to $625 per household per year with a preferred estimate of about $300 annually per household.

Adaptation Responses Impacts

Flooding events and the threat of future flooding can also prompt both owners and renters to undertake investments in an attempt to minimize or mitigate future flooding impacts. The survey asks homeowners “While living in Portsmouth, has your household made any changes to your property specifically in response to flooding?” and then requests information on the nature and costs of those changes and when the changes were implemented. The survey similarly asks renters “Has your landlord, to your knowledge, taken any steps to protect the property from flooding?" and if the respondent answers yes, follows up by asking what actions have been taken. However, it does not ask the respondent to estimate the value of those actions.

Calculating Bounds

Using the answers to these questions we determined which owners and landlords had made adaptations due to flooding. We then estimated the number of adaptations per year assuming in that all adaptations reported had occurred in the last five years for the upper-bound estimate, in the last 20 years for the lower-bound estimate and in the last 10 years for the preferred estimate.[9] As we did for other impacts, we do not use missing answers in the upper-bound and preferred estimates and in the lower bound assume that respondents who did not answer had no adaptation. We also calculated the annual cost of owner adaptations using these same assumptions. As was the case with car and property damages, we did not make any inflation adjustments to the damage estimates regardless of how long ago the investment occurred.

[9] As shown in Figure A3 in Appendix A *Data used to Estimate Economic Impacts*, approximately half of the reported owner adaptations took place within the last five years, so we felt that the 5-year time frame was appropriate for our upper-bound estimate. Since two thirds of all adaptations happened the last 10 years, we use 10 years for our preferred estimate. The lower-bound estimate assumes a 20-year time frame. Note that we did not have similar information from renters about the time frame in which landlords had made adaptations, but since the average tenancy for respondents who rent is 12 years with a standard deviation of 15, we used the same time frame assumption for rental adaptations.

Summary Estimates

Table 3.5 reports the number of homeowner and landlord adaptations in Portsmouth under each of the three estimates. To put these numbers in perspective, the upper-bound estimates are consistent with roughly two percent of homeowners investing $7,800 in adaptations each year. To value the cost of landlord adaptions, in the upper-bound estimate we assumed that the per adaption cost of landlord adaptions was equal to those of homeowners, that is $7,800. For both the lower-bound and the preferred estimates, we assume landlords spend only 50 percent of what homeowners do for each adaptation, or $3,900. Overall, combined owner and landlord adaptations responses range from about $45 to $330 per household per year with a preferred estimate of about $110 annually per household.

Table 3.5 Estimated adaptation responses to flooding in Portsmouth.

Impact Type	Upper Bound	Lower Bound	Preferred Est.
Annual number of homeowner adaptations	466	114	232
Annual cost of homeowner adaptations ($)	$3,637,995	$897,516	$1,818,997
Annual number of landlord adaptations	1,068	204	533
Annual cost of landlord adaptations	$8,330,400	$795,600	$2,078,700
Total adaptation cost	$11,968,395	$1,693,116	$3,897,697

Home-based Business Impacts

The final flooding impact we asked respondents about was the impact of flooding on any home-based business, i.e., one that is run largely out of the home. Overall, home-based businesses are not very common among respondents with only 6 percent who answered this question indicating that someone in the household owned a home-based business.

Calculating the Bounds

About one out of five of those individuals indicated that their business had been impacted by flooding at some time in the past, either because there was a loss of power, customers could not get to the business (or vice versa), or employees could not get to work. To estimate the number of home-based businesses impacted on an annual basis, we used 5-, 20- and 10-year time-frame assumptions for the upper-bound, lower-bound, and preferred estimates, respectively. Additionally in the upper-bound and the preferred estimates, we determine the percentage of households with impacts to a home-based business using only data from respondents who answered the relevant questions while in the lower bound we assumed that those that did not answer the question do not have a home-based business that was impacted. The resulting estimates are shown in Table 3.6.[10] Because there was no concrete information in the survey that detailed the extent of these impacts, we did not attempt to put a dollar value on these impacts.

Table 3.6 Estimated landlord and homeowner responses to flooding in Portsmouth

Impact Type	Upper Bound	Lower Bound	Preferred Est.
Annual number of home business impacts	55	14	27

Re-cap Summary of Impact Estimates

Table 3.7 presents the total calculated costs associated with responding to, recovering from, and adapting for flooding based on the current level and occurrence of flooding in Portsmouth. Overall, based on the response to the survey, we estimate that total annual impacts of flooding range from $49 million in the upper-bound to $7.6 million in the lower-bound with our preferred estimate resulting in a cost of $19 million per year. On a per household basis, the total impacts range from $210 to $1,350 with a preferred estimate of $530 per household per year.

Table 3.7 Total annual cost of flooding in Portsmouth at current flooding level.

Impact Type	Upper Bound	Lower Bound	Preferred Est.
Direct Flooding Impacts	$14,628,984	$1,086,803	$4,231,055
Vehicle & Property Damage Impacts	$22,689,592	$4,897,379	$11,143,967
Adaptation Costs Impacts	$11,968,395	$1,693,116	$3,897,697
Total Impacts	**$49,286,971**	**$7,677,297**	**$19,272,719**

[10]Respondents were not provided a particular time frame over which they were to report impacts to home businesses.

Coastal Virginia Social Vulnerability Index at the Block Group Level

(Updated August 2021)

Principal Component Analysis

Following other social vulnerability indexes, including the SoVI® developed by the Hazards & Vulnerability Research Institute at the University of South Carolina, this vulnerability index is based on a principal component analysis (PCA). PCA is a statistical technique that takes as its input a matrix of interrelated socioeconomic variables – in this case those considered to measure various dimensions of social vulnerability – and creates a new set of orthogonal principal components that extract the important variation the underlying input data while reducing the noise and redundancy in the data.

After conducting the PCA, the researcher combines the newly created component variables into a composite index that provides a single value for each observation in the dataset, in this case a social vulnerability score. The utility of a PCA-based index is that it encapsulates a lot of information in an easily consumed form and individual observations can be ranked relative to each other.

This update uses data from the 2015-2019 American Community Survey at the census block group level where available and at the census tract level where block group data is not available. It is an update of the Social Vulnerability Index on the Adapt VA Portal and uses the same or similar variables to the ones used in that analysis. These variables, shown in the next table, are those that we consider to be the most direct determinants of social vulnerability.

Variable	Description	Block Group or Tract Level
Income	Per capita income	Block Group
Black	Percent of population that is Black or African American	Block Group
Hispanic	Percent of population that is Hispanic	Block Group
Native	Percent of population that is Native American	Block Group
Over 65	Percent of population that is over 65 years of age	Block Group
Unemployed	Percent of civilian labor force 16 and over that is unemployed	Block Group
Poverty	Percent of population for whom poverty status is established that is living in poverty	Tract
No High School	Percent of population 25 and older with no high school degree or equivalent	Block Group
Group Quarters	Percent of population in group quarters including nursing homes and prisons	Tract
Female Labor Force	Percent of females 16 and over in civilian labor force	Tract
Female Households	Percent of households with female head, no spouse	Block Group
Social Security	Percent of households with social security income	Block Group

Before conducting the PCA, the variables were first standardized to z-scores with zero means and unit variances to avoid any confounding effects that might arise from using variables of different magnitudes in the analysis. We then conducted a PCA, keeping those components with eigenvalues greater than 1 (the Kaiser selection criterion). As a next step, we conducted a Varimax rotation of the components to facilitate interpretation of each component because – as is the case with all PCA-based indices – the researcher must determine the directionality of each retained component, that is whether higher values of the component increase the level of social vulnerability (positive directionality) or decrease the level of social vulnerability (negative directionality). Where the directionality of the component was clearly negative, we scaled the component by a factor of -1 before including it in the composite index so that higher values of the scaled component would increase the overall vulnerability index.

As is common in the literature, in instances when the effect of the component on vulnerability is ambiguous (as is the case when the different variables that make up the component work in opposite ways), we assume a positive directionality. Each component is then multiplied by the variance it captures from the total input matrix and the weighted components are added together to form the index. To ensure that the index can be compared to other indices, the resulting aggregated values to z-scores with zero means and unit variances. Since all values of the index are relative, it can be used to rank observations relative to each other in terms of vulnerability. However, many studies also identify a group of "highly vulnerable" observations – that is those observations whose standardized index score exceeds a threshold value of 1 (i.e., whose value is one standard deviation above the mean value of the index). We note that vulnerability indices depend on the variables included in the PCA as well as the geographic area of the study and the component selection and weighting criteria. Thus, our vulnerability index will not necessarily match the vulnerability indices created by other researchers.

Statement on Inability to Estimate Future Impacts & Model Return on Investments

The proposed methodology for estimating the future impacts of recurrent flooding in Portsmouth Virginia was based on the assumption that we would be able to model a relationship between current flooding levels and estimated direct and indirect impacts on property damage and productivity and could use that model to project future impacts based on estimates of future flooding levels. Our estimates of current direct and indirect impacts on property damage and productivity were developed from the results of a survey of Portsmouth residents conducted in the summer and fall of 2020 which asked households to report on their current and past experiences with flooding and storm events, detailing the types of impacts that they had experienced. Survey participation was voluntary and respondents did provide sufficient information to provide approximate geo-locations for the household (e.g., closest intersection). Our estimate of current flooding levels was based on a hydrodynamic urban inundation model that was used to hindcast the flooding from the 2011 Hurricane Irene, the last major Hurricane to significantly impact Portsmouth.

Unfortunately, we were unable to find any clear relationship between current flooding levels and reported direct and indirect impacts. There are several possible explanations for the lack of clear relationship. First, the survey asked residents to recall past impacts of flooding and to provide estimates of property damage and productivity impacts, and it has been shown that such answers may be subject to errors that occurs when participants do not remember previous events or experiences accurately which can vary across participants based on age, education, socioeconomic status, and experiences. Second, the response rate for the survey was relatively low and certain types of households were under-represented, particularly renters, lower-income households, and minority households. Third, survey households and flooding levels were matched at the U.S. census block group level, which can range from 0.1 square miles in area to over 5 square miles in area. Since flooding levels can vary dramatically over relatively short distances, it could be the case that we do not have a close enough match between our flooding estimates and our impact estimates to discern any underlying relationship.

Without a clear relationship between flooding levels and direct and indirect impacts, we cannot credibly provide estimates of how these impacts would be expected to increase in the future with sea level rise. In addition, without firmly establishing this relationship, it is impossible to model with any reasonable certainly the return on investment stemming from particular houeh9olds adaptive interventions.

However, it is reasonable to suggest that impacts will not likely decrease under the current state of investments in adaptation measures or programs. The current estimates of annual impacts can be used as a conservative estimate of future annual impacts in the absence of any new adaptation investments or programs.

In addition, as demonstrated in Part 5 Scenario Flood Models, the modeling clealr8y shows increased areas likely to flood relative to the validated Base Scenario. Part 5 documents significant increases in the number of structures that will be adjacent floodwaters. We document that there are existing impacts across the city, and we expect that as flooding increases, so will the impacts.

While it is disappointing not to find the expected relationship, and therefore model the return on investment for adaptation interventions, nonetheless this research makes valuable contributions to the general body of knowledge and make contributions that may actually inform policy and practice in the region. For example, this report's monetization of the impacts illustrate the large over-all costs to residents and, by way of presenting costs per households, allows officials to better understand the magnitude of the impacts of recurrent flooding on individual households. These 'current' dollar figures are not insignificant given the population size and economy of the city. The scenario flood modeling, while not conclusive, show marked increases in the number of structures adjacent floodwaters and leads readers to expect that the costs of these impacts are likely to increase in no small measure over the coming two decades.

Part 4 - Stakeholder Engagement

Locality Engagement

Focus Group with City of Portsmouth Staff (November 26, 2019)

The following presents a summation of key findings organized under four broad themes:

1. Storm and flooding scenarios to model
2. Residents' and property owners' coping strategies
3. Business owners
4. City priorities for coping with flooding

1. Storm and flooding scenarios to model
    - No specific Saffir-Simpson Hurricane Scale Storm category to be used.
        i. Modeled Category 2 and 4 for comprehensive planning process, Category 2 for public utilities.
        ii. More concerned about rain events. Arcadis is doing some modeling for Portsmouth that includes rain events.
    - Historic storm to model: Would like us to model Isabel (2003) and Nor'Ida (2009). If can only model 1, prefer Nor'Ida in terms of windspeed, 3-day duration
    - Using NOAA's intermediate curve in 2050 for most of the planning
    - SLR: 1.5ft, 3 ft, 4ft. Need to follow-up re: what level beyond 4ft
2. Residents' and property owners' coping strategies
    - They don't see a ton of adaptation strategies undertaken by residents and property owners.
    - Common adaptations:
        i. Elevate HVAC and other mechanical equipment
        ii. Flood vents not common unless doing substantial modifications/improvements that make flood vents necessary
        iii. Elevate home – not common. Some property owners ask if there is funding to elevate their property.
        iv. Living shoreline – people do experience erosion and undertake shoreline restoration. But haven't seen living shorelines.
        v. Abandoned structures – Not seeing people abandon property/structures yet.
    - Challenges and issues faced by property owners: fixing drainage, grade issues, erosion control, riprap, bulkhead replacement, flooding due to roads being at higher grade (water in ROW drains to property)
    - Very few are voluntary. Largely triggered by permitting requirements, e.g. if make substantial improvements or demo/rebuilding in flood zones. New construction must be elevated.

- City staff are not seeing any flood retrofitting at this point. People are not doing flood vents on their own
- Drainage is a problem. (See notes about city priorities).

3. Business owners
    - City staff recommend we survey business owners as well.
        i. How many days closed due to flooding?
        ii. Lost business?
        iii. Employees not coming to work?
        iv. Flood damage to property?
    - More adaptations being undertaken by business owners. Example: Apartment complex across the street from City Hall. Also, the 7-11 built their site up (they are in the flood plain).
    - Developers are still building new projects. Example: Chestnut St. project must build to 11' BFE, so putting in garages and building up.
    - Individual developers are making these accommodations, not property owners.
    - Developers are still building and selling homes in flood plain

4. City priorities for coping with flooding
    - Data gathering and benchmarking. City staff want to use our models and results as data for their planning processes. They definitely welcome information on economic impact, workforce productivity.
    - Specific comments/feedback re: our survey of residents/homeowners:
        i. It is important to know what residents think is causing the flooding
        ii. The Health Dept. is doing door-to-door survey of residents in spring & summer, about mold, asthma, etc. There may be a chance to collaborate. Lauren James can connect us.
        iii. Tolerance for flooding – are residents okay with current nuisance flooding levels?
        iv. They are interested in social resilience and behavioral impacts. How is this affecting you daily? Are you thinking about changing neighborhoods, or even leaving the city? Are you experiencing losses in productivity, getting the kids to school? What did this [event] cost you in lost wages, in additional day care? Trouble selling your home – taking longer or lower sale price (vs. estimated price)?
        v. Want us to include renters in the survey. Do renters have renters' insurance? If they move, are they moving to other units in the same area? Moving outside of the city?
        vi. They would like to get information about broader vulnerabilities, not just flooding. And linkages to social resilience.
        vii. For demographics, want to be able to link back to health status, income, employment, age, race.

- Looking at 50-year planning horizon, especially in downtown Portsmouth area. City is trying to move City Hall out of the downtown area and change downtown into residential and commercial.
- City would like to look into more stringent development standards (similar to Virginia Beach). City staff feel it would be beneficial to understand the economic/financial impact of having such stringent development standards.
- City staff not actively encouraging people to make improvements. They can make suggestions and talk homeowners through possibilities.
- Stormwater and drainage are major city priority.
    - i. More than $500M in infrastructure needs for adequately address drainage issues – from a 20+ year-old report done for Portsmouth
    - ii. They are rotating around neighborhoods and doing improvements per the ~2005 drainage assessment.
    - iii.
- There are specific city priorities for developers; it is very piecemeal.

Focus Groups with Portsmouth Residents

(December 3 and December 9, 2019)

The following presents a summation of key findings organized under ten broad themes:

1. Experiences with property damage
2. Flood impact on ability to travel
3. Structural changes to properties or modifications to property
4. Nature-based features
5. Areas where people have avoided building or have abandoned structures
6. Changes homeowners would like to make and barriers
7. What homeowners should do
8. What city is doing to cope with flooding
9. What city should do to help residents and businesses
10. Other issues

1. Experiences with property damage
    - Damaged cars, flooded out cars – from driving through flooded water and from when parked in street
    - Damage to homes from wakes
    - Flooding in basements – heaters, boilers all damaged
    - Home sales are affected by flooding
    - Need to know where not to park. Or need to move vehicles into city parking garages. Appreciate that city provides access to park in city garages, but it takes time and is inconvenient.
    - Water breeds mosquitoes
    - Flood insurance rates
    - Utilities are often impacted by floods, i.e. transformers and tower/receptacle for WIFI too.
    - Impervious surfaces make run-off worse
    - Shop owners and homeowners need to sandbag
    - Real estate property values are impacted, especially in Olde Towne, because of flooding problems.
2. Flood impact on ability to travel
    - Choose different routes
    - Need to consider timing, e.g. high tide at rush hour, morning rain affecting commute to work
    - Stormwater system makes things worse
    - Heavy rain vs. tidal flooding

- Gate to the shipyard floods. Causes delays getting to work.
- Bus stops are flooded.
- Can't take ferry to work when dock (on Norfolk side) is underwater
- Portsmouth Naval Shipyard had to be shut down due to the massive restriction of movement to the base due to heavy downpour and flooding. This posed a security risk, necessitating the base's closure.
- Ambulances have been rerouted (in Olde Towne)

3. Structural changes to properties or modifications to property
    - Damage (or potential damage) to property during flooding events have necessitated some adaptation to be in compliance with codes
        i. Elevating home
        ii. Install flood vents
        iii. Bringing homes up to code costs more, and homeowners generally compare this cost to the cost of flood insurance
    - Water heaters are being elevated
    - Residents put up sandbags and gates to prevent drivers from entering restricted roads; to ensure that the sandbags are able to keep flood waters low.
    - House built on berm
    - Install drains in basement
    - French drains
    - Fill in basement with concrete
    - There can be a ripple effect from standalone adaptation – what one homeowner does can have an effect on other homes
    - For older homes, modifications are very expensive and may not work for the property (e.g., may affect structural integrity). Particularly a challenge for historic buildings
    - Newer homes are built higher
    - In yard, put in raised walkways (like a boardwalk)
    - Bought generator. But needs to be elevated by 5ft – aesthetics and sound/noise issues

4. Nature-based features
    - Some people use rain barrels to collect rain
    - There have been discussions within the community about green initiatives (Green Portsmouth), e.g., the planting of trees that can withstand high winds, green street initiative which features permeable sidewalks.
    - Permeable pavers, permeable surfaces

5. Areas where people have avoided building or have abandoned structures
    - Homes on Dinwiddie St. are condemned
    - Holiday Inn project next to the marina has been abandoned due to a flooding problem
    - In Olde Towne, most areas are already built up.

6. Changes homeowners would like to make and barriers
    - Regrade yard to fix slope
    - Get flood elevation certificate
    - Work with flood mitigation expert (Mike Vernon)
    - Elevate utility systems (HVAC, boiler, electric panels, generator) – knows that this is cost effective, but still pricey
    - Cost is a limiting factor preventing further structural changes to current homes and properties.
    - Want to know what the return is for different adaptations
7. What homeowners should do
    - Don't have basements or fill in basements (but there are lots of basements in Olde Towne)
    - Should property owners be required to mitigate flooding?
        i. No.
        ii. Homeowners cannot be forced to do what the city itself cannot do.
        iii. Homeowners already have limited resources.
        iv. Already pay a lot for flood insurance
        v. Requiring will force people to move
        vi. Encourage but do not require.
    - Because required by code, the Wawa on Effingham decreased its green space
    - Inflatable barriers
8. What city is doing to cope with flooding
    - Paving projects use better material
    - Dealing with the stormwater system
    - What city should be doing:
        i. Big projects (e.g., casino, apartment buildings) need to look at flood mitigation and make sure flood impact is assessed
        ii. Assess evacuation and sheltering plan – Some shelters are inaccessible when it floods
        iii. Wetlands
        iv. Spend more on maintenance, keep ditches and drains cleared
9. What city should do to help residents and businesses
    - City could offer specific sites/location for research and testing of different mitigation solutions
    - Flood insurance rates are not affordable – offer program to offset flood insurance rates
    - Offer grants like from ERP for homeowners to install rain gardens, drains, etc.
    - No interest small loans for homeowners to undertake adaptations
    - Provide more information - Have a staff member available to provide information; residents don't know what assistance is available; how do residents learn about resources? Getting information to residents is a big challenge for the city. Need to

overcome the information dam. There is an education element that is missing – need to push information to residents.

- Many residents lack basic preparedness.
- Homeowners need to keep their trees trimmed and drains cleared.
- A properly developed and efficient emergency management transportation system would be helpful during periods of heavy flooding. Need to make sure first responders can do their job.
- City has invested in fixing some storm drainage issues, but some projects (like Court St) have been put on hold
- Building codes guide property owners in their installation and elevation of their property (for major/substantial modifications). But there is lack of enforcement in this area
- Lack of funding is a major restriction to the city in its ability to do more.

10. Other issues

- Flood insurance is expensive
- Flooding has affected farmers' market operations.
- FEMA re-drew flood maps. Some homes now in different flood zones.
- Parking and zoning codes force people to remove green space and put in parking spaces.
- Zoning ordinances are inflexible
- Concerns about Super Fund sites. Heavy flooding can cause problems – What happens and what will be done?

Part 5 - Scenario Flood Models

Analysis Approach

This Part 5 and the subsequent Part 6 provide an overview of two central scenarios, the Hurricane Irene 2011 Base Scenario and the Hurricane Irene 2045 Forecast Scenario. These scenarios provide new insights beyond that provided by simple bathtub models. Parameterized in the approach are differences in sea level rise-driven changes in the water table and how these may increase ponding and recurrent flooding. And, by extension, may be associated with loss and disruption. Both these scenarios are reported for the two broad areas encompassing the southern and northern portions of the City of Portsmouth.

Imagery and Inundation Thresholds

The figures provided in both Part 5 and Part 6 show satellite imagery for the city overlayed with footprints of the built structures, which are shaded in grey (typically, grey geometric shapes). The imagery is overlayed with a blue color gradient that indicates the maximum extent and depth of flooding.

The footprints of buildings that are adjacent to two inundation thresholds (i.e., >1ft and >2ft) receive bright-color shading. Buildings that are expected to come into contact with (i.e., be adjacent to) one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow. Thus, “>1ft” is the first inundation level threshold. Buildings adjacent to two or more feet of inundation are shaded in orange-red. Thus, “>2ft” is the second inundation level threshold.

Impacted Structures

These yellow and orange-red colors assigned to the water-contacted building footprints are selected to visually set apart the water-contacted buildings from the surroundings. This colorization readily communicates to the reader the number and location of the potentially impacted structures.

Interpretation

Caution should be used when interpreting color-indicated structures as structures that suffer flooding. More precisely, these colors represent structures that may be expected to come into contact with rising or ponding water. Unknown are the actual elevations for the floors of the spaces within these structures used for living, commerce, institutional, or industrial activities. It cannot be assumed that the first-floor elevation is at grade. Therefore, many of the color highlighted structures, while coming into contact with water, will not necessarily experience inundation into the human-used spaces of the structure. Of course, many stem-wall homes, for example, have finished floor elevations that are above the exterior grade and therefore also likely to have utilities and HVAC systems under the floor joists, often within a crawl space. Structures contacted by water, even if not necessarily experiencing flooded interiors, can expect to suffer damage.

Insights

Within either scenario, the number of structures shown to be adjacent flood waters is insightful. First and foremost, this study is interested in flood-related property loss and disruption. The extent and depth of neighborhood flooding are good indications of damaged and total-loss vehicles as well as disruptions in terms of delays to work and school. While there is uncertainty whether these colored structures experience flooding within the interior spaces, it is reasonable to assert that for many structures the systems associated with the structure may be compromised due to the flooding. In addition, repeated flooding around the exterior of a structure will alter the soil compression resulting in foundation cracks and settling structures. Further, inundation around the structure and possibly within the neighborhood itself is certain to correlate with damaged vehicles and inability to get to and from the home or business. While water may not be adjacent to a particular home, the household may still suffer delays or loss associated with traversing flooded streets within the neighborhood or enroute to shopping, medical appointments, work, or school.

The expected *change* in the number of structures between 2011 and 2045 (also an important part of this analysis) is also insightful. The measured change is an indication of which neighborhoods can be expected to experience greater change in water-contact relative to other neighborhoods and, therefore, which neighborhoods may be expected to suffer higher rates of property damage and disruption. In Part 5 *Scenario Flood Models* this report provides some indication on the possible future extent of flooding and floodwater contact with structures.

Hurricane Irene Year 2011 Base Scenario

This Hurricane Irene 2011 Base Scenario was validated by using eleven sets of high-water mark data from gauges rapidly deployed by the USGS and the subsequent field report. Geospatial forecasts at 9KLM winds are modeled (from this setpoint, increases in wind are modeled for the Hurricane Irene 2045 Forecast Scenario).

Inundation Portsmouth Citywide Irene 2011

Figure 5.1 below is the Base Scenario illustrating flooding inundation for the modeled 2011 Hurricane Irene Base Scenario. The image shows satellite imagery for the city overlayed with footprints of the built structures, shaded in grey (typically, grey geometric shapes). Figure 5.2 provides a blue color gradient that indicates the maximum extent and depth of flooding, also overlayed on Figure 5.1.

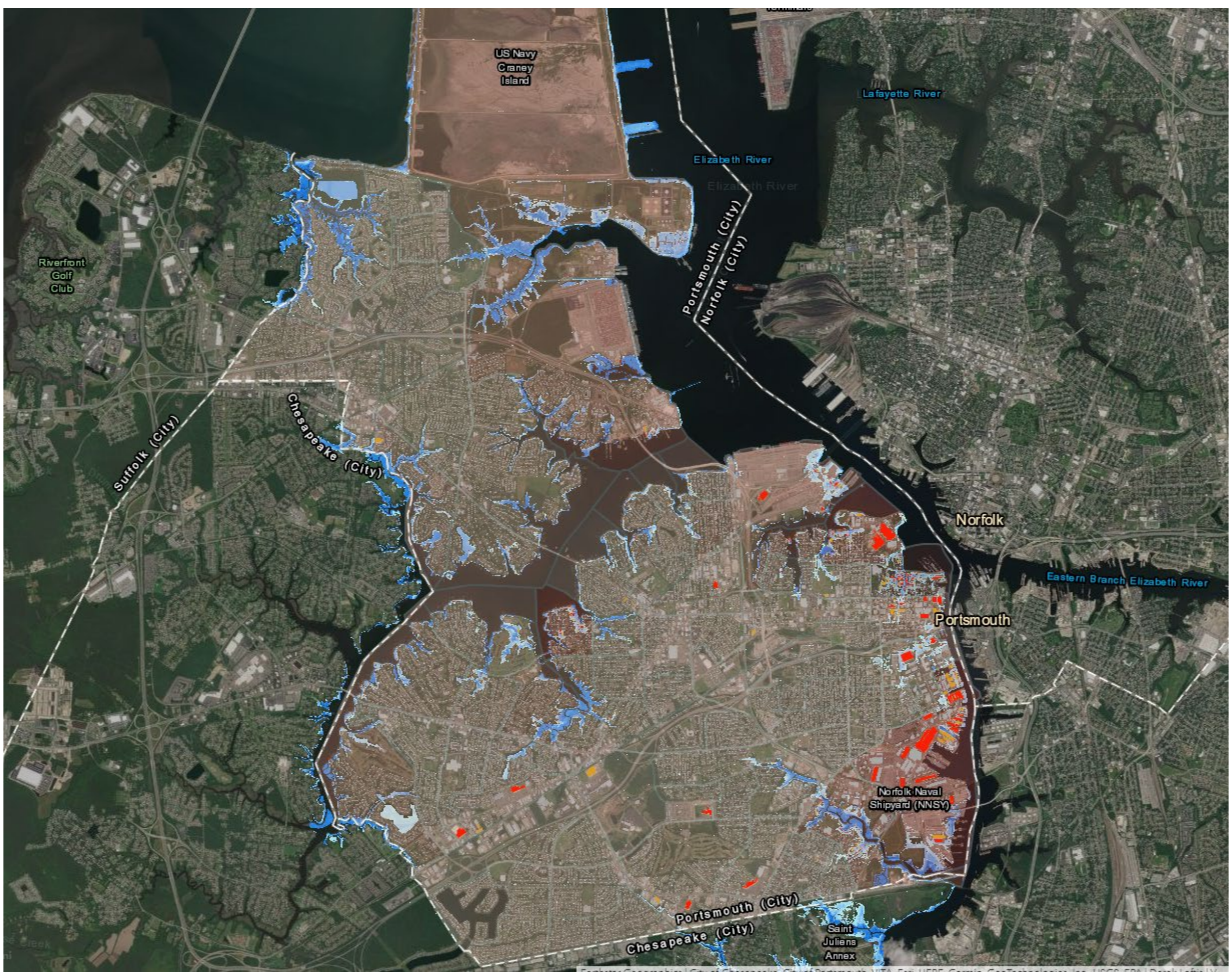


Figure 5.1 Inundation Portsmouth Citywide Irene 2011.

Figure 5.2 below displays the color gradient that illustrates the maximum extent and depth of flooding for the Base Scenario, Hurricane Irene 2011.

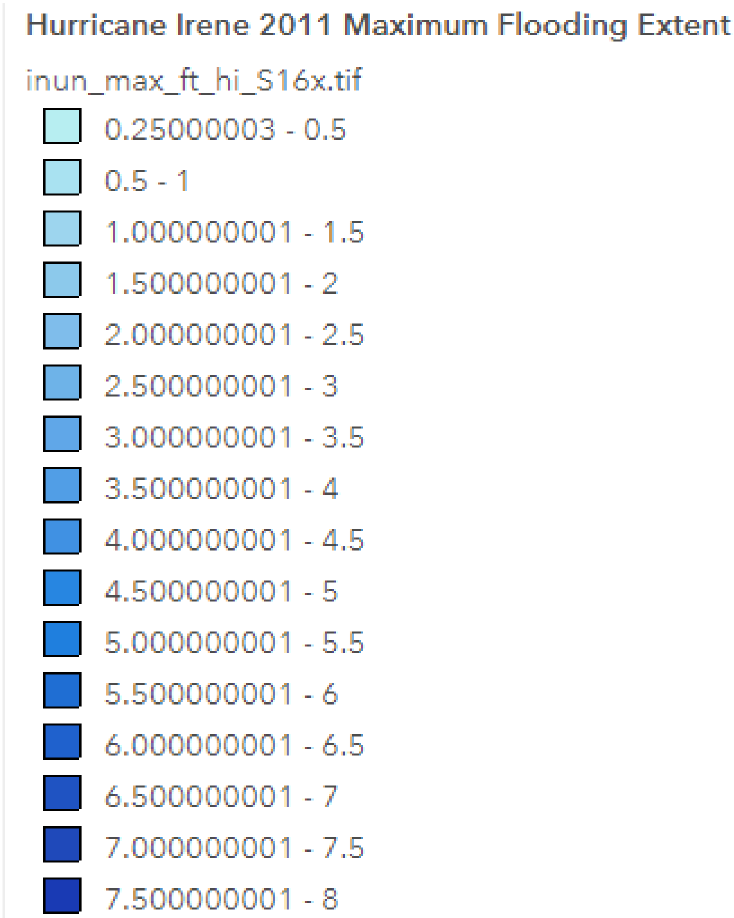


Figure 5.2 Inundation Portsmouth Citywide Irene 2011.

Southern Portion of Portsmouth Irene 2011

Figure 5.3 below illustrates the southern portion of Portsmouth, separated from the northern portion by the Western Branch of the Elizabeth River. The location of the concentrated structural contact with inundation waters proximate the riverline is heaviest along the eastern riverline side of Portsmouth. While inundation nis shown along creeks and waterways extending into the interior of Portsmouth, few structures suffer flooding relative to the area most proximate the branches of the Elizabeth River.

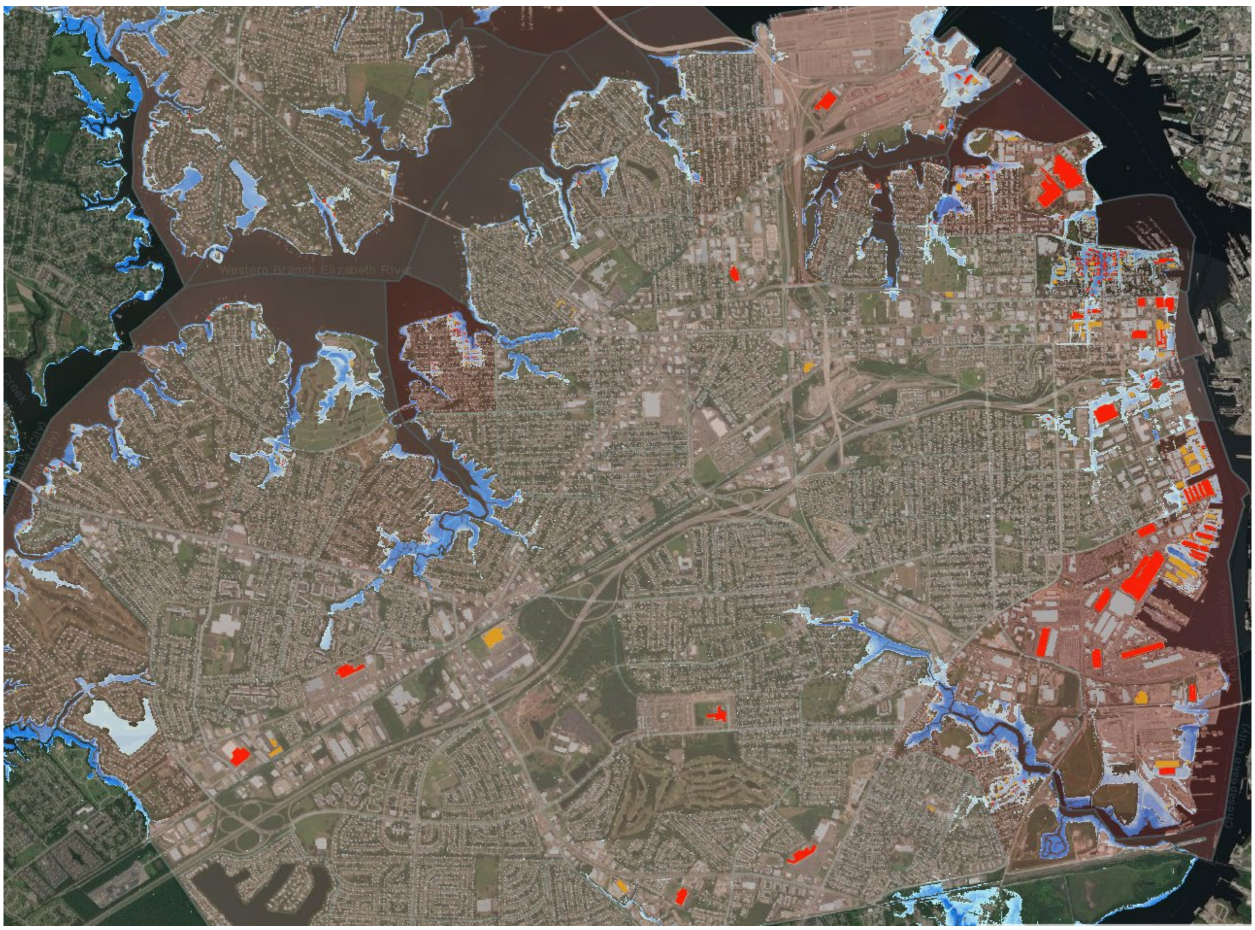


Figure 5.3 Southern Portion of Portsmouth Irene 2011.

Northern Portion of Portsmouth Irene 2011

Figure 5.4 below illustrates the northern portion of Portsmouth, separated from the northern portion by the Western Branch of the Elizabeth River. The northern portion of Portsmouth does not immediately illustrate extensive, concentrated numbers of structures coming into contact with flood waters proximate the riverline and relatively few structures distant from the riverline. The northern portion of Portsmouth suffers less flooding and contacted structures relative to the southern portion.

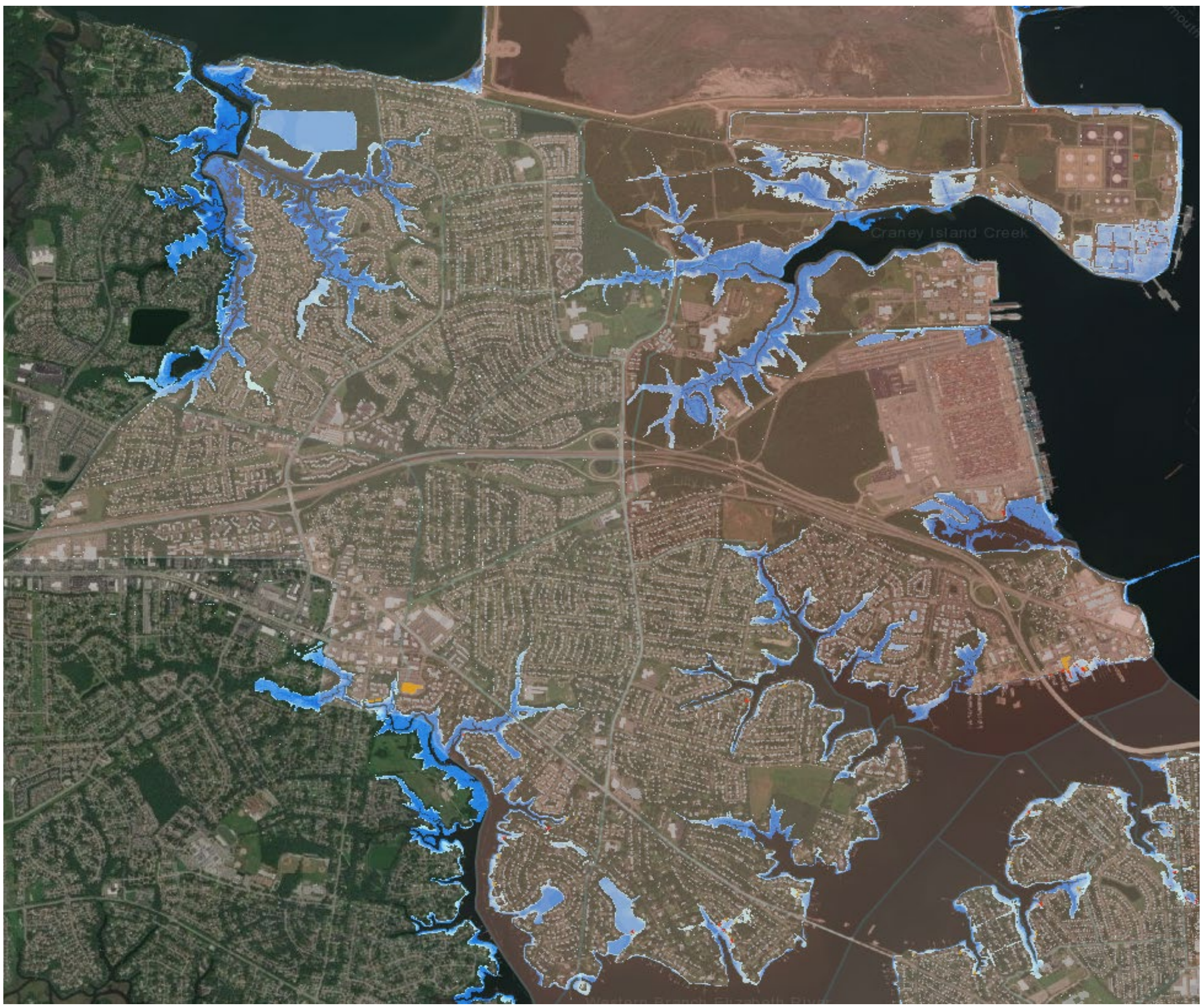


Figure 5.4 Northern Portion of Portsmouth Irene 2011.

Hurricane Irene Year 2045 Forecast Scenario

The parameters for the Hurricane Irene 2045 Forecast Scenario includes 30 percent amplified wind and sea level rise using the 2011 Base Scenario as the setpoint. Three-hour temporal interpolation of the Base Scenario 9KLM winds are applied.

Inundation Portsmouth Citywide Irene 2045

Figure 5.5 below is the Forecast Scenario illustrating flooding inundation for the 2045 Hurricane Irene. The image shows satellite imagery of the city with footprints of the built structures shaded in grey (typically, grey geometric shapes). Figure 5.6 provides a blue color gradient that indicates the maximum extent and depth of flooding on Figure 5.5.

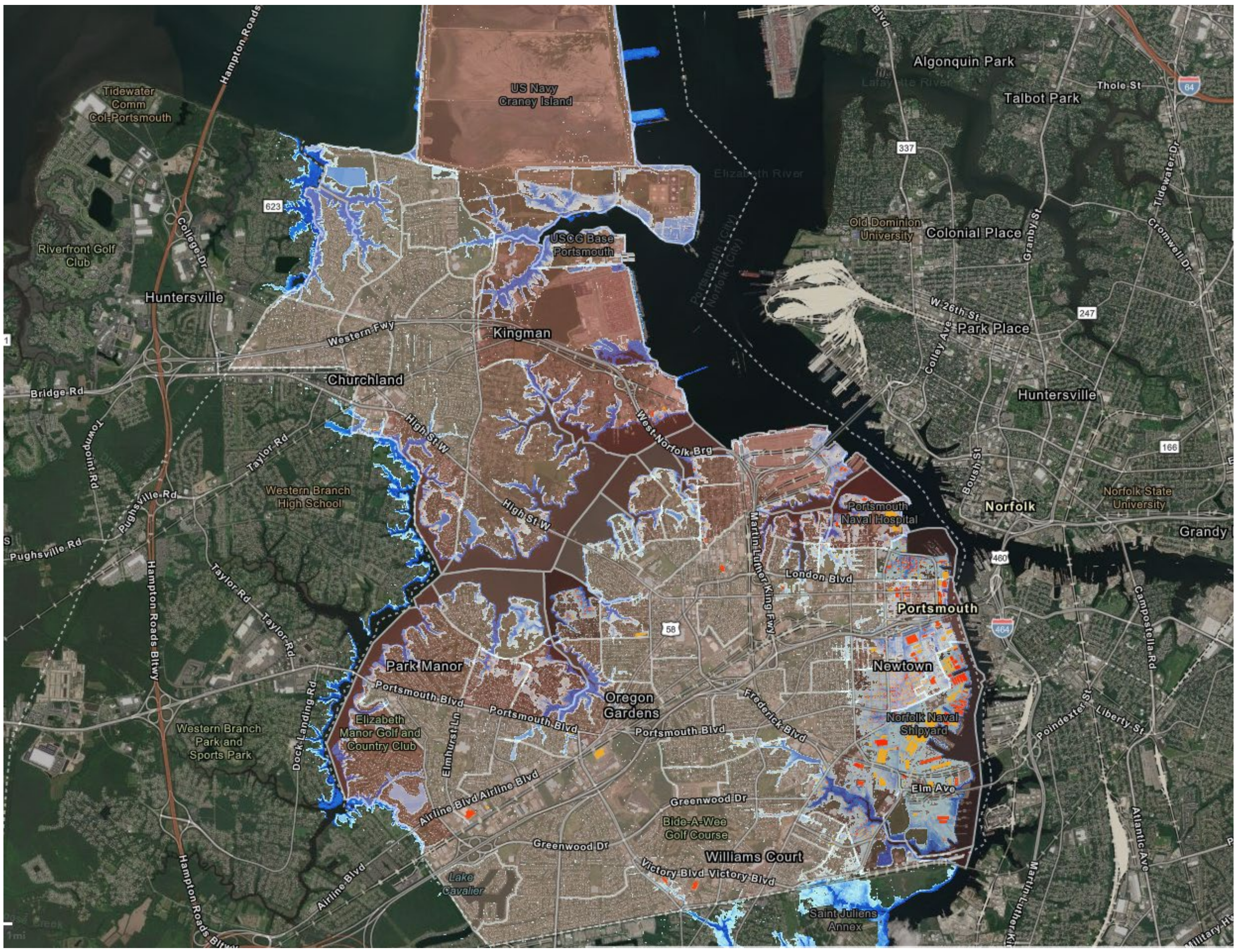


Figure 5.5 Inundation Portsmouth Citywide Irene 2045.

Figure 5.6 shows color gradient illustrating the maximum extent and depth of flooding for the Forecast Scenario, Hurricane Irene 2045.

Figure 5.6 Inundation Portsmouth Citywide Irene 2045.

Southern Portion of Portsmouth Irene 2045

Figure 5.7 below illustrates the southern portion of Portsmouth, separated from the northern portion by the Western Branch of the Elizabeth River. The 2045 Scenario shows the location of the concentrated structural contact with inundation to be proximate the riverline, the heaviest contact along the eastern riverline of Portsmouth. The extent of flooding and the number of contacted structures is greater relative to the 2011 Base Scenario. The 2045 Forecast Scenario also shows increased inundation along creeks and waterways extending into the interior of Portsmouth. Relative to the 2011 Base Scenario, there appears, although modest in interior areas, an increase in the number of structures contacted with inundation.

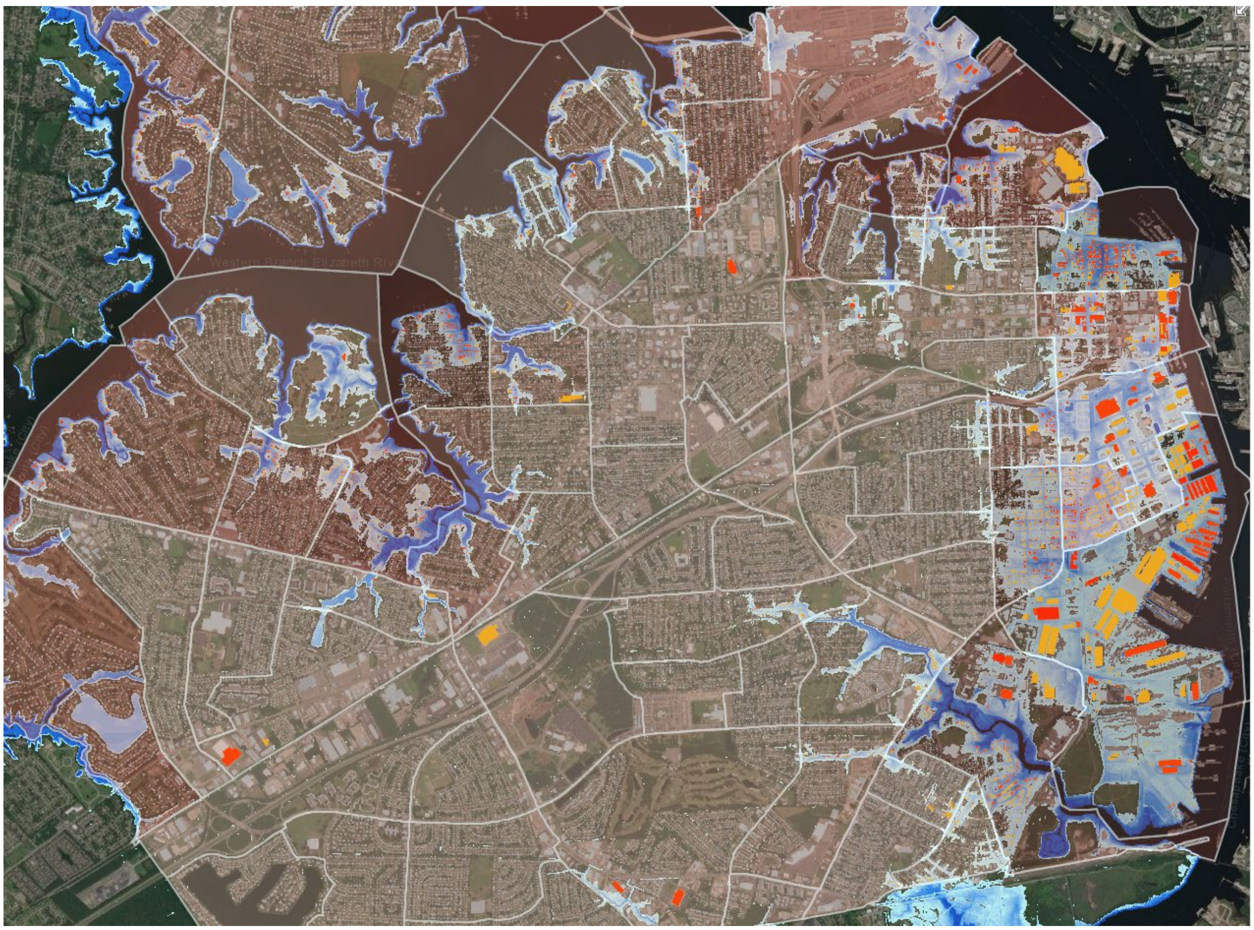


Figure 5.7 Southern Portion of Portsmouth Irene 2045.

Northern Portion of Portsmouth Irene 2045

Figure 5.8 below illustrates the northern portion of Portsmouth, separated by the Western Branch of the Elizabeth River. Relative to the Base Scenario, the northern portion of Portsmouth illustrates an increase in extent and depth of inundation as well as an increase in the number of structures contacting with floodwaters. However, the number of structures does not immediately illustrate extensive, concentrated structural contact proximate riverlines. There appears relatively few contacted structures distant the riverline. In the 2045 Scenario, the northern portion of Portsmouth suffers less inundation and contact of structures with flood waters relative to the southern portion.

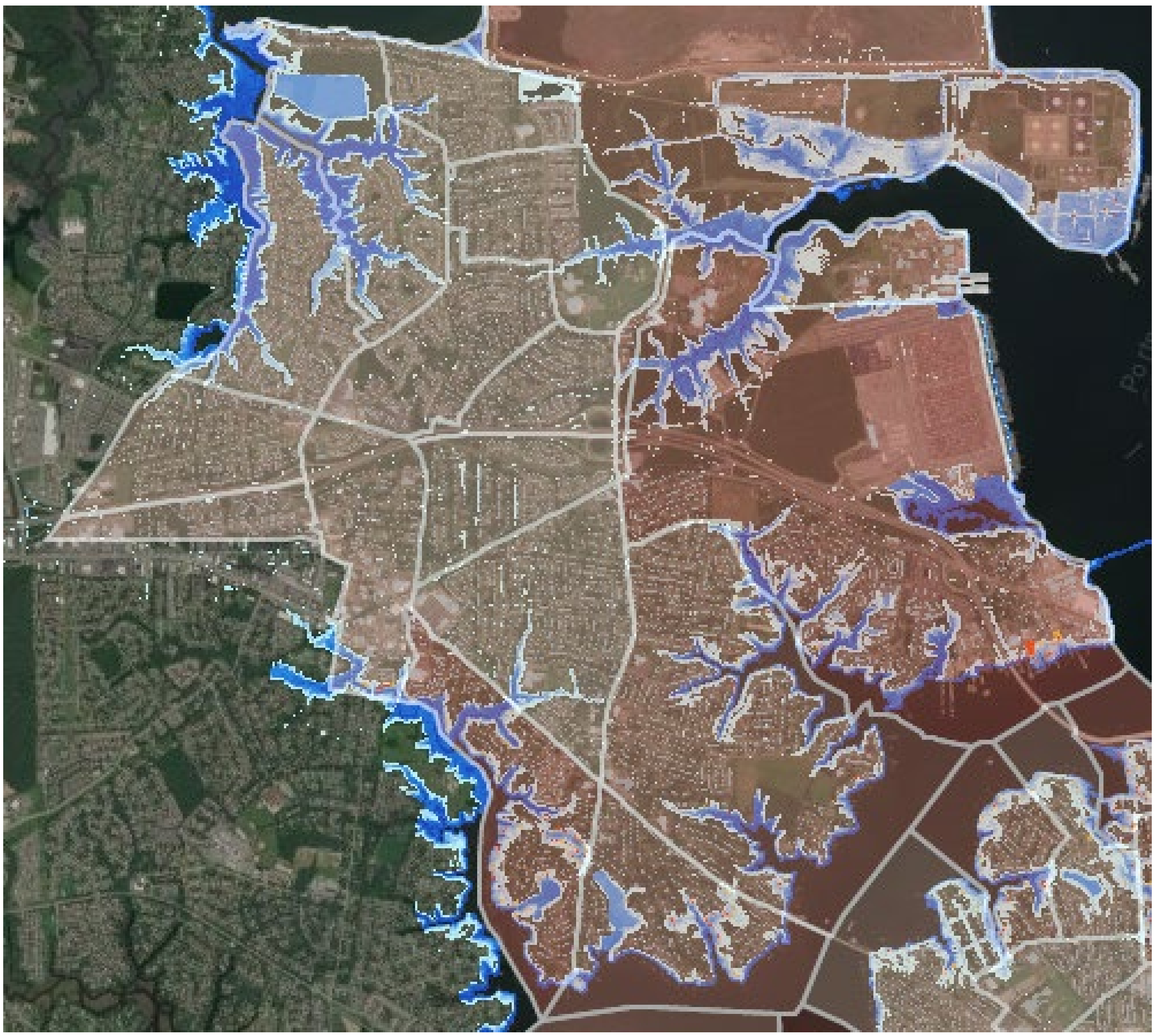


Figure 5.8 Northern Portion of Portsmouth Irene 2045.

Part 6 - Area-Specific Flooding: Southern Portion of Portsmouth

The following series of figures and tables focuses on eighteen areas within the southern portion of Portsmouth. These areas are purposively selected, representing areas where inundations are prominent relative to other southern portion areas. The logic is to provide for each selected Area two figures: Base Scenario (Irene 2011) and Forecast Scenario (Irene 2045). For each Area, next provide a simple table that reports the increases in number of structures contacted by flood waters, by both the 1 ft and 2 ft thresholds.

Area 1 Impact Irene 2011

The below Figure 6.1a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

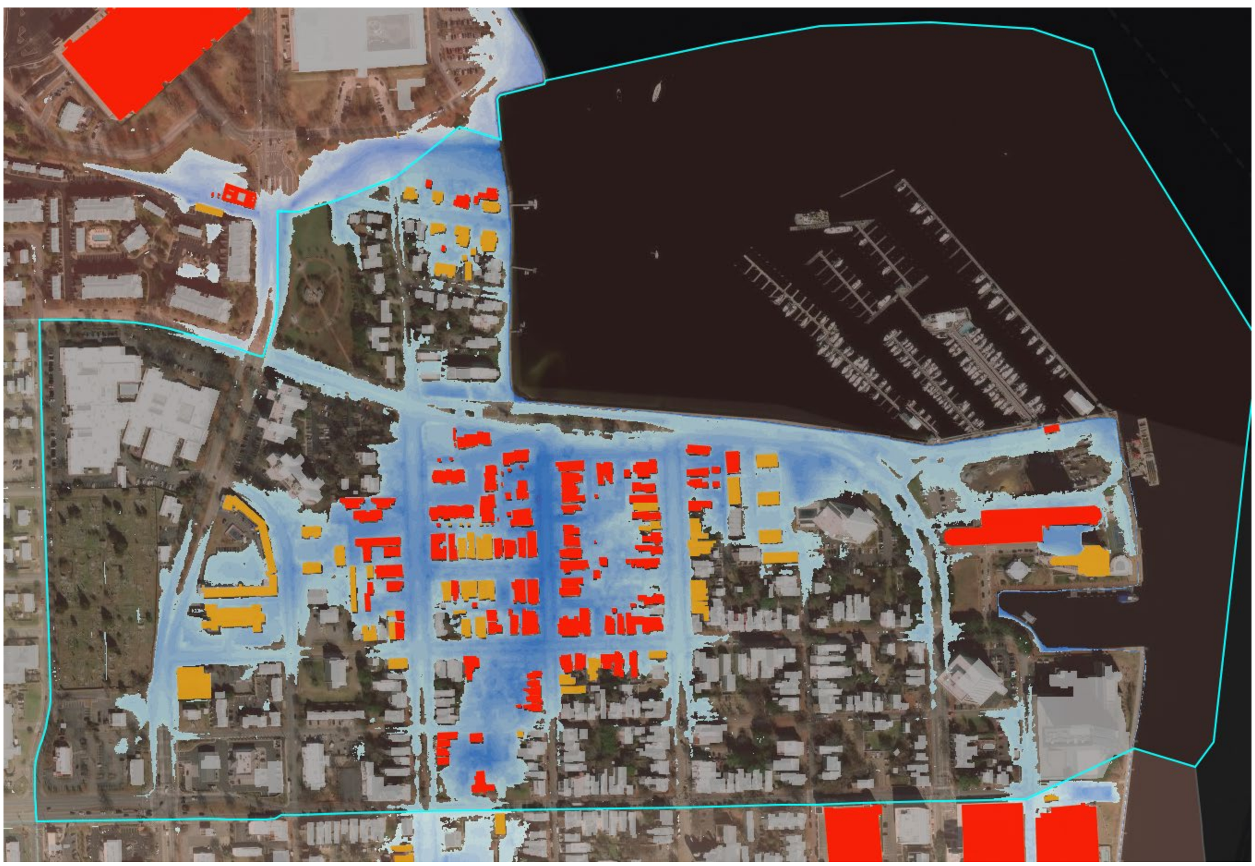


Figure 6.1a Area 1 Southern Portion of Portsmouth Irene 2011.

Area 1 Impact Irene 2045

The below Figure 6.1b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

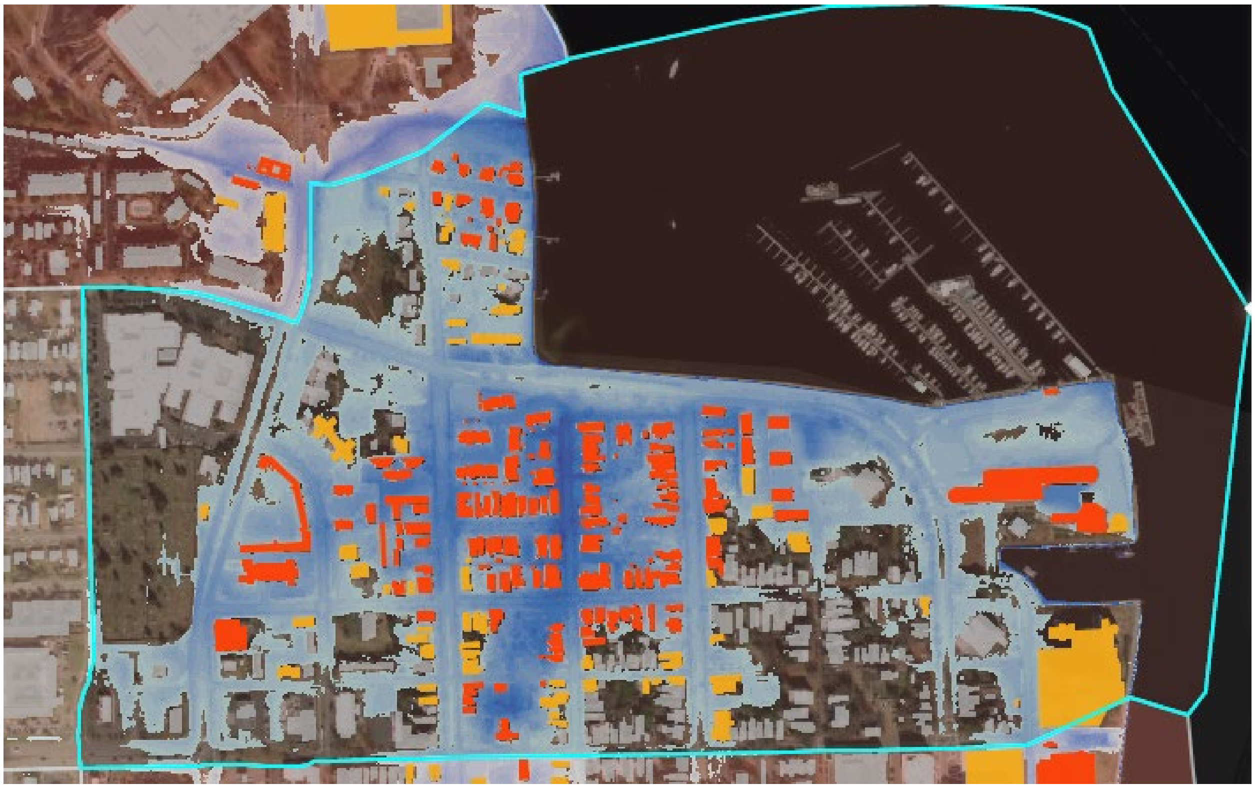


Figure 6.1b Area 1 Southern Portion of Portsmouth Irene 2045.

Area 1 Differences

Table 6.1 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 6.1 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	1.75	2.04	.26
Flood Std Dev (ft)	1.19	1.37	.18
Flood Adjacent Bldgs >1ft	168	235	(40%) 67
Flood Adjacent Bldgs >2ft	111	171	(54%) 60

2011

Census Block 517402109002	
POPULATION	1,780
POP/SQMI	5,393.90
SQMI	0.33
Flood_Area (ft^2)	174,680.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.40
Flood_Range (ft)	6.15
Flood_Mean (ft)	1.75
Flood_StdDev (ft)	1.19
Flood_SumVol (ft^3)	305,218.17
Flood_Variety (ft)	6.15
Flood_Majority (ft)	0.28
Flood_Minority (ft)	5.94
Flood_Median (ft)	1.45
Flooded Buildings >1ft	168
Flooded Buildings >2ft	111

2045

Census Block 517402109002	
POPULATION	1,780
POP/SQMI	5,393.90
SQMI	0.33
Flood_Area (ft^2)	277,172.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.44
Flood_Range (ft)	7.19
Flood_Mean (ft)	2.04
Flood_StdDev (ft)	1.37
Flood_SumVol (ft^3)	565,460.19
Flood_Variety (ft)	7.19
Flood_Majority (ft)	0.66
Flood_Minority (ft)	7.36
Flood_Median (ft)	1.73
Flooded Buildings >1ft	235
Flooded Buildings >2ft	171

Area 2 Impact Irene 2011

The below Figure 6.2a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

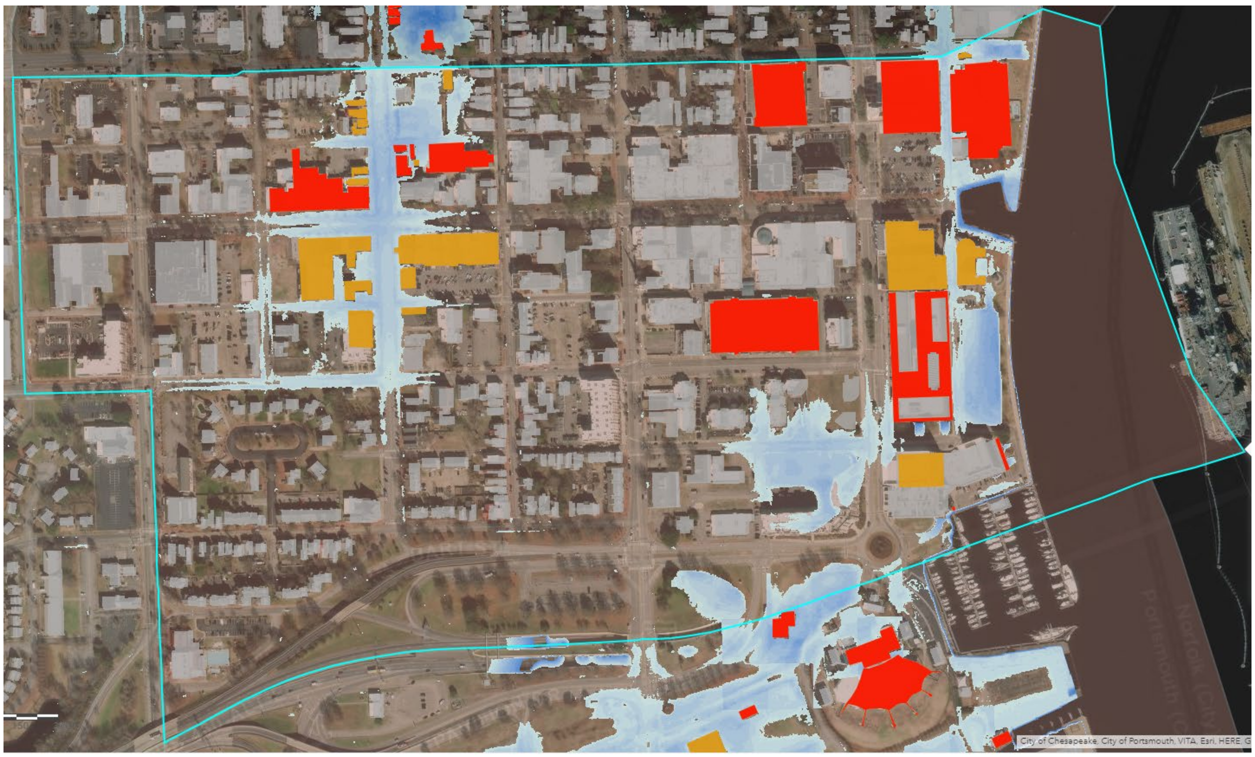


Figure 6.2a Area 2 Southern Portion of Portsmouth Irene 2011.

Area 2 Impact Irene 2045

The below Figure 6.2b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

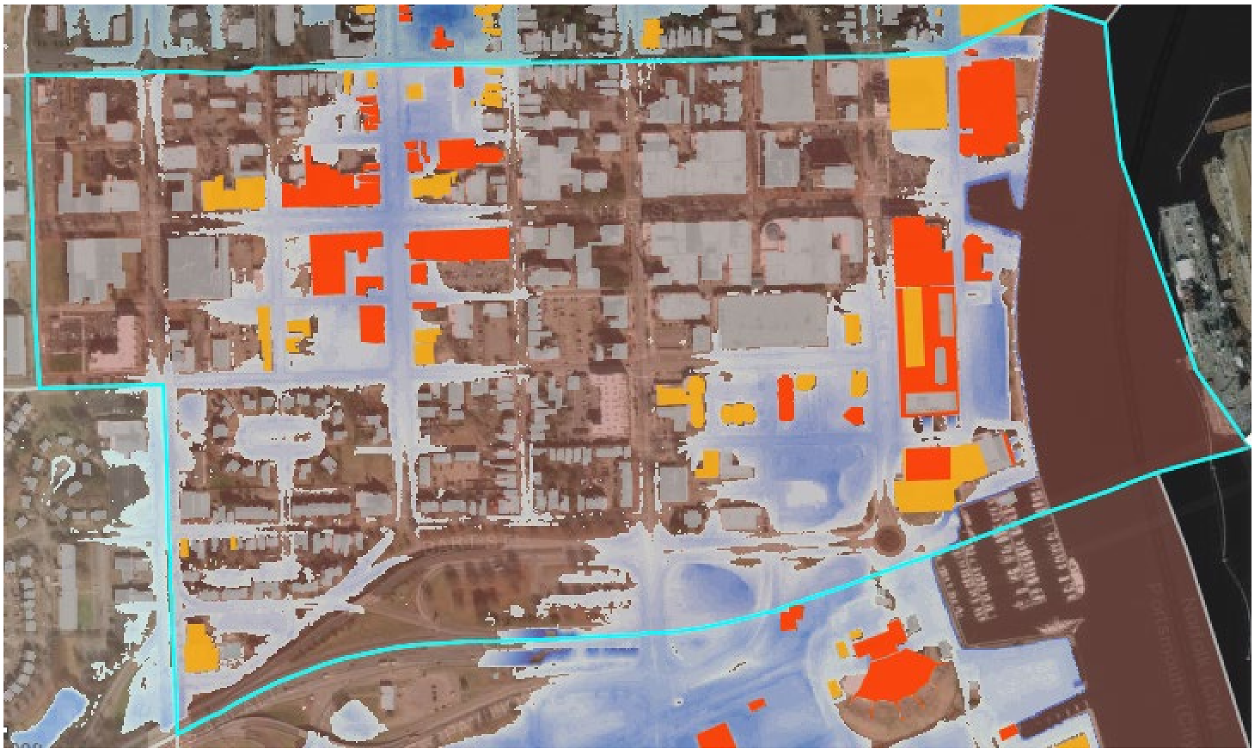


Figure 6.2b Area 2 Southern Portion of Portsmouth Irene 2045.

Area 2 Differences

Table 6.2 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 6.2 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	1.29	1.51	.22
Flood Std Dev (ft)	.9	1.06	.16
Flood Adjacent Bldgs >1ft	31	62	(100%) 31
Flood Adjacent Bldgs >2ft	13	30	(131%) 17

2011

Census Block 517402109001	
POPULATION	1,520
POP/SQMI	5,428.60
SQMI	0.28
Flood_Area (ft^2)	71,278.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.40
Flood_Range (ft)	6.15
Flood_Mean (ft)	1.29
Flood_StdDev (ft)	0.90
Flood_SumVol (ft^3)	92,040.75
Flood_Variety (ft)	6.11
Flood_Majority (ft)	0.27
Flood_Minority (ft)	4.29
Flood_Median (ft)	1.09
Flooded Buildings >1ft	31
Flooded Buildings >2ft	13

2045

Census Block 517402109001	
POPULATION	1,520
POP/SQMI	5,428.60
SQMI	0.28
Flood_Area (ft^2)	190,974.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.45
Flood_Range (ft)	7.20
Flood_Mean (ft)	1.51
Flood_StdDev (ft)	1.06
Flood_SumVol (ft^3)	289,098.54
Flood_Variety (ft)	7.18
Flood_Majority (ft)	0.26
Flood_Minority (ft)	5.98
Flood_Median (ft)	1.23
Flooded Buildings >1ft	62
Flooded Buildings >2ft	30

Area 3 Impact Irene 2011

The below Figure 6.3a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

Figure 6.3a Area 3 Southern Portion of Portsmouth Irene 2011.

Area 3 Impact Irene 2045

The below Figure 6.3b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

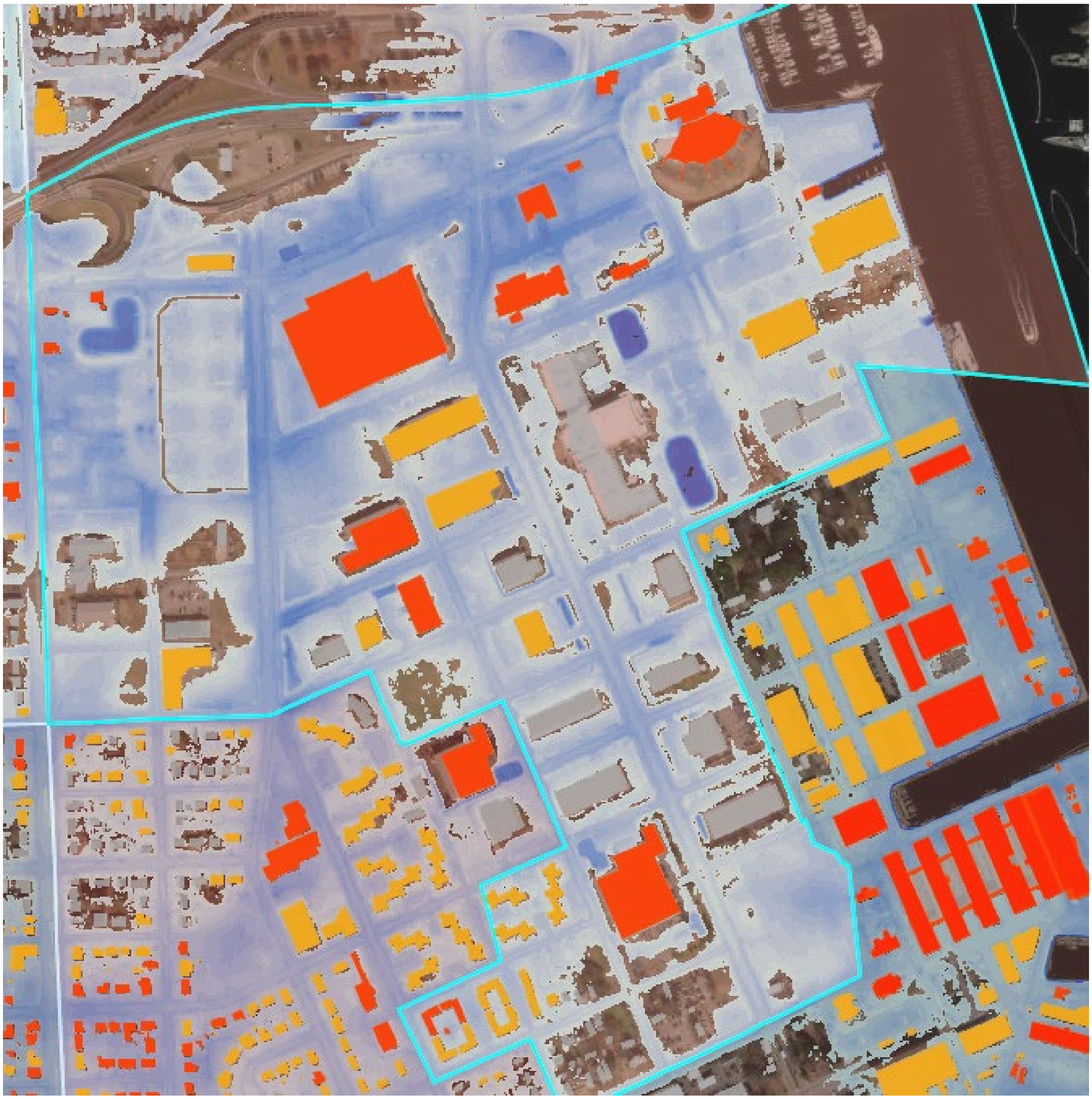


Figure 6.3b Area 3 Southern Portion of Portsmouth Irene 2045.

Area 3 Differences

Table 6.3 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 6.3 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	1.21	1.95	.74
Flood Std Dev (ft)	.91	1.22	.31
Flood Adjacent Bldgs >1ft	9	43	(378%) 34
Flood Adjacent Bldgs >2ft	7	21	(200%) 14

2011

Census Block 517402121001

POPULATION	289
POP/SQMI	825.70
SQMI	0.35
Flood_Area (ft^2)	176,247.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.39
Flood_Range (ft)	6.14
Flood_Mean (ft)	1.21
Flood_StdDev (ft)	0.91
Flood_SumVol (ft^3)	213,109.32
Flood_Variety (ft)	6.01
Flood_Majority (ft)	0.27
Flood_Minority (ft)	5.17
Flood_Median (ft)	0.95
Flooded Buildings >1ft	9
Flooded Buildings >2ft	7

2045

Census Block 517402121001

POPULATION	289
POP/SQMI	825.70
SQMI	0.35
Flood_Area (ft^2)	568,453.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.45
Flood_Range (ft)	7.20
Flood_Mean (ft)	1.95
Flood_StdDev (ft)	1.22
Flood_SumVol (ft^3)	1,108,195.89
Flood_Variety (ft)	7.21
Flood_Majority (ft)	1.42
Flood_Minority (ft)	6.58
Flood_Median (ft)	1.71
Flooded Buildings >1ft	43
Flooded Buildings >2ft	21

Area 4 Impact Irene 2011

The below Figure 6.4a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

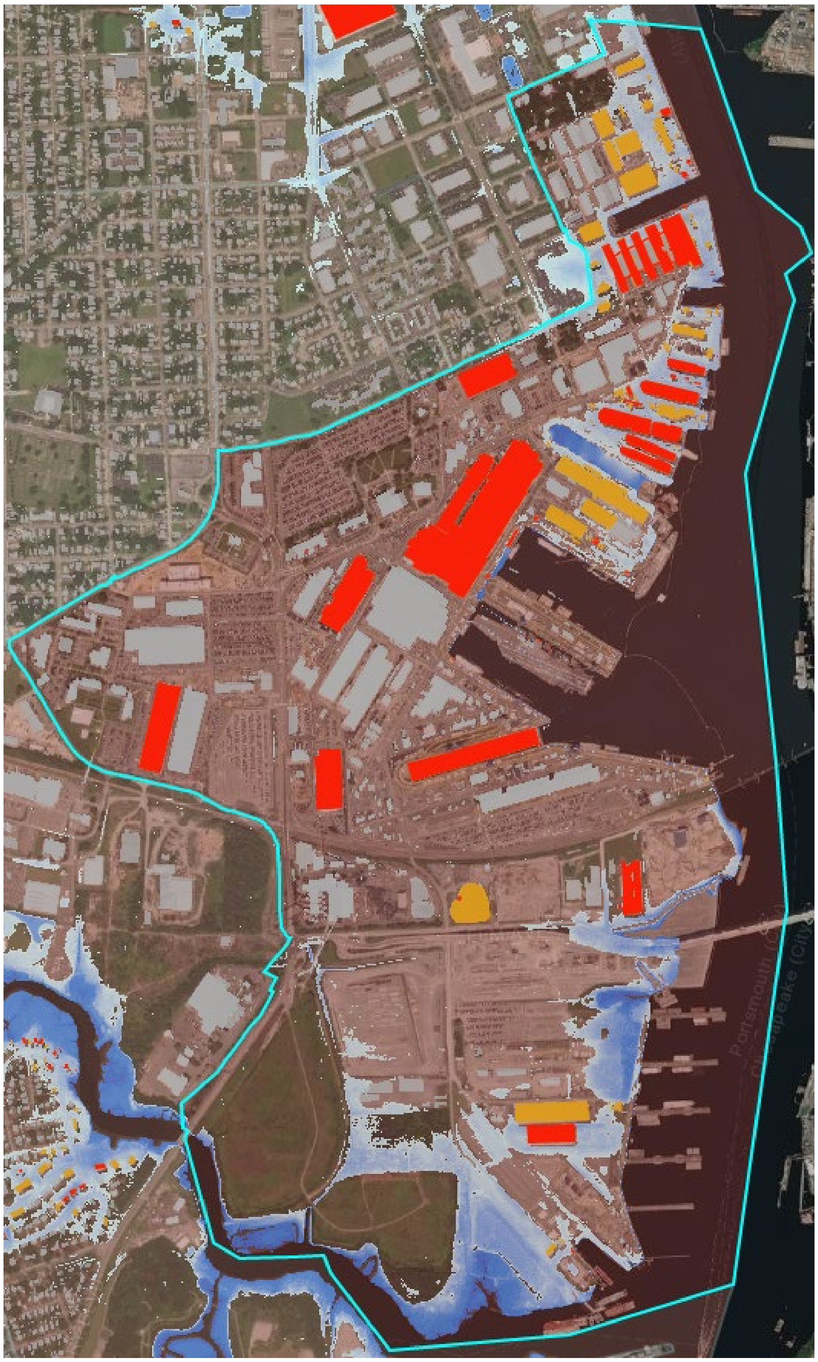


Figure 6.4a Area 4 Southern Portion of Portsmouth Irene 2011.

Area 4 Impact Irene 2045

The below Figure 6.4b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

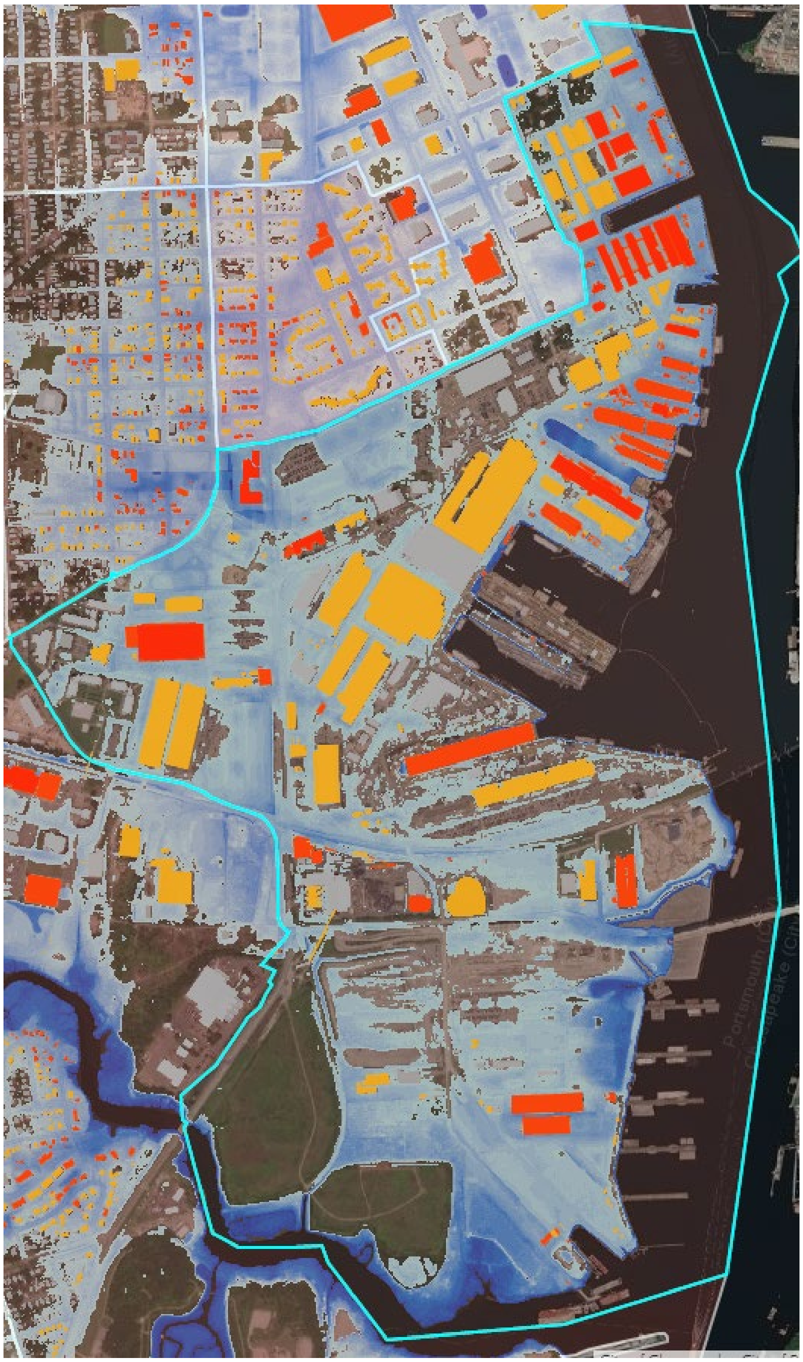


Figure 6.4b Area 4 Southern Portion of Portsmouth Irene 2045.

Area 4 Differences

Table 6.4 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 6.4 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	2.02	1.70	.32
Flood Std Dev (ft)	1.63	1.48	.15
Flood Adjacent Bldgs >1ft	188	446	(137%) 258
Flood Adjacent Bldgs >2ft	73	207	(184%) 134

2011

Census Block 517409801001

POPULATION	70
POP/SQMI	48.60
SQMI	1.44
Flood_Area (ft^2)	442,988.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.47
Flood_Range (ft)	6.22
Flood_Mean (ft)	2.02
Flood_StdDev (ft)	1.63
Flood_SumVol (ft^3)	894,202.11
Flood_Variety (ft)	6.23
Flood_Majority (ft)	0.25
Flood_Minority (ft)	6.47
Flood_Median (ft)	1.46
Flooded Buildings >1ft	188
Flooded Buildings >2ft	73

2045

Census Block 517409801001

POPULATION	70
POP/SQMI	48.60
SQMI	1.44
Flood_Area (ft^2)	1,277,329.00
Flood_Min (ft)	0.25
Flood_Max (ft)	8.25
Flood_Range (ft)	8.00
Flood_Mean (ft)	1.70
Flood_StdDev (ft)	1.48
Flood_SumVol (ft^3)	2,165,497.78
Flood_Variety (ft)	7.85
Flood_Majority (ft)	0.43
Flood_Minority (ft)	7.53
Flood_Median (ft)	1.20
Flooded Buildings >1ft	446
Flooded Buildings >2ft	207

Area 5 Impact Irene 2011

The below Figure 6.5a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

Figure 6.5a Area 5 Southern Portion of Portsmouth Irene 2011.

Area 5 Impact Irene 2045

The below Figure 6.5b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

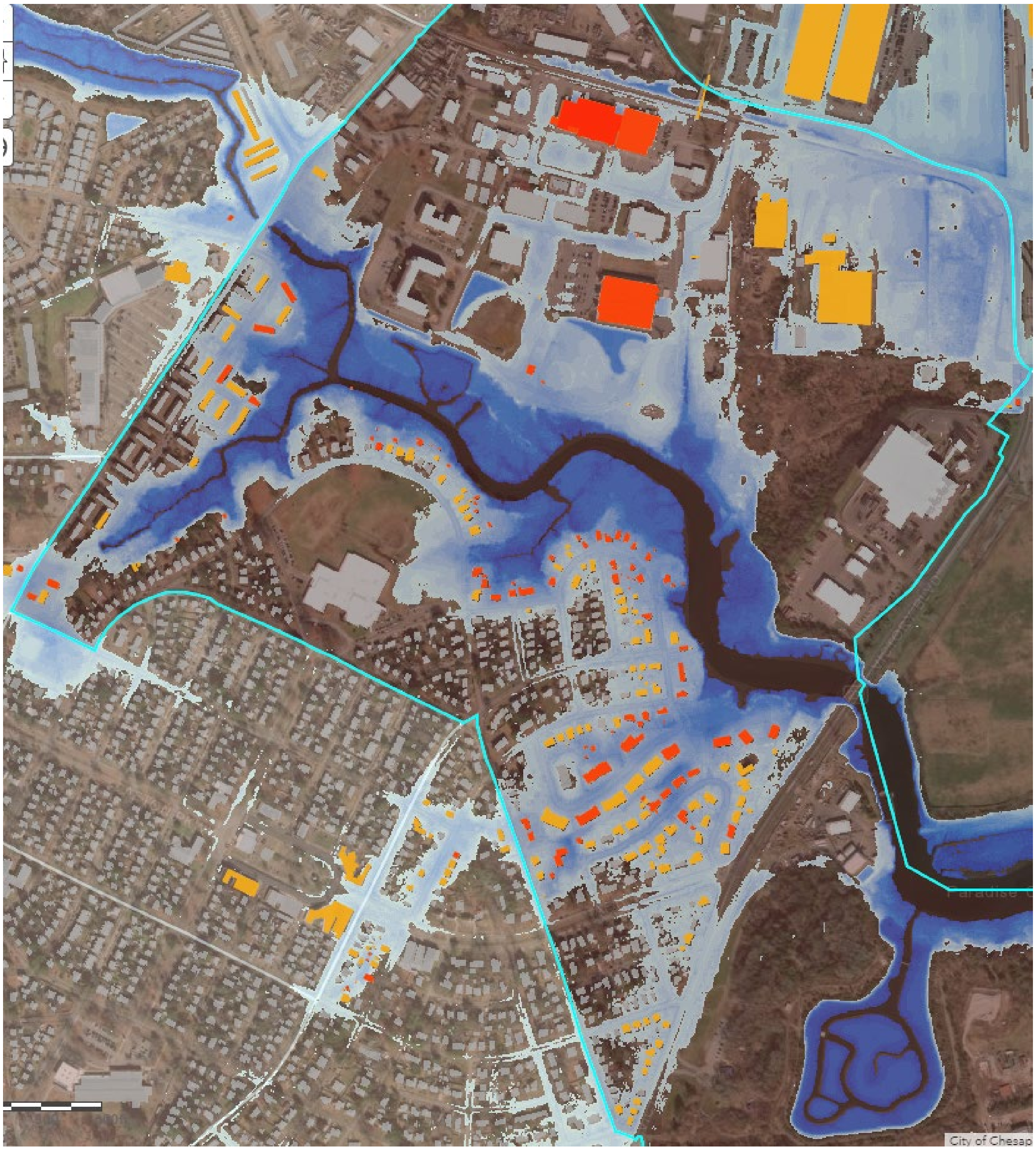


Figure 6.5b Area 5 Southern Portion of Portsmouth Irene 2045.

Area 5 Differences

Table 6.5 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 6.5 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	3.15	2.81	.44
Flood Std Dev (ft)	1.99	2.21	.22
Flood Adjacent Bldgs >1ft	81	217	(168%) 36
Flood Adjacent Bldgs >2ft	30	93	(210%) 63

2011

Census Block 517402123001	
POPULATION	1,521
POP/SQMI	2,142.30
SQMI	0.71
Flood_Area (ft^2)	402,356.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.50
Flood_Range (ft)	6.25
Flood_Mean (ft)	3.15
Flood_StdDev (ft)	1.99
Flood_SumVol (ft^3)	1,266,687.61
Flood_Variety (ft)	6.26
Flood_Majority (ft)	0.25
Flood_Minority (ft)	6.50
Flood_Median (ft)	3.36
Flooded Buildings >1ft	81
Flooded Buildings >2ft	30

2045

Census Block 517402123001	
POPULATION	1,521
POP/SQMI	2,142.30
SQMI	0.71
Flood_Area (ft^2)	718,539.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.54
Flood_Range (ft)	7.29
Flood_Mean (ft)	2.81
Flood_StdDev (ft)	2.21
Flood_SumVol (ft^3)	2,017,869.48
Flood_Variety (ft)	7.30
Flood_Majority (ft)	0.29
Flood_Minority (ft)	7.54
Flood_Median (ft)	1.93
Flooded Buildings >1ft	217
Flooded Buildings >2ft	93

Area 6 Impact Irene 2011

The below Figure 6.6a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

Figure 6.6a Area 6 Southern Portion of Portsmouth Irene 2011.

Area 6 Impact Irene 2045

The below Figure 6.6b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

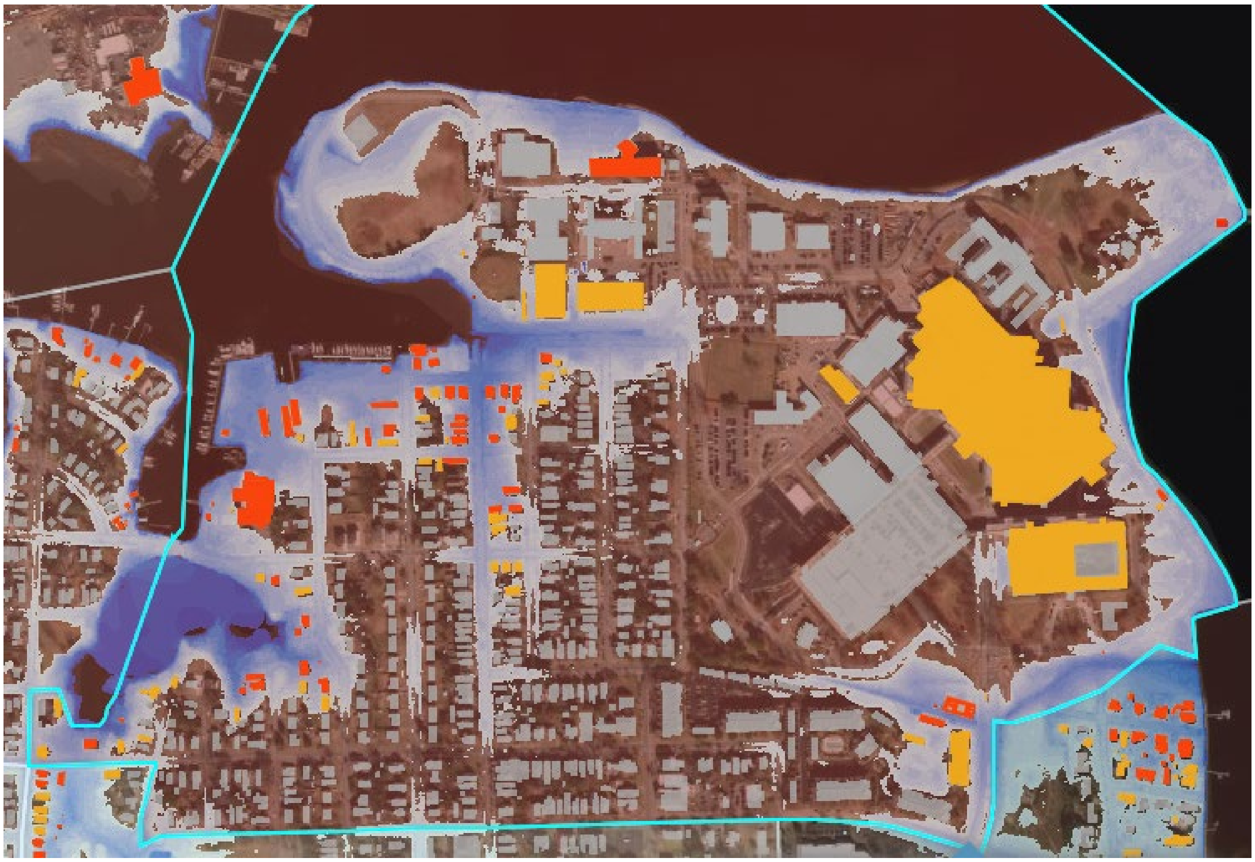


Figure 6.6b Area 6 Southern Portion of Portsmouth Irene 2045.

Area 6 Differences

Table 6.6 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 6.6 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	2.13	2.21	.08
Flood Std Dev (ft)	1.64	1.77	.13
Flood Adjacent Bldgs >1ft	65	112	(72%) 47
Flood Adjacent Bldgs >2ft	39	61	(56%) 22

2011

Census Block 517402132001	
POPULATION	1,431
POP/SQMI	3,180.00
SQMI	0.45
Flood_Area (ft^2)	152,599.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.39
Flood_Range (ft)	6.14
Flood_Mean (ft)	2.13
Flood_StdDev (ft)	1.64
Flood_SumVol (ft^3)	324,785.08
Flood_Variety (ft)	6.15
Flood_Majority (ft)	0.27
Flood_Minority (ft)	6.39
Flood_Median (ft)	1.66
Flooded Buildings >1ft	65
Flooded Buildings >2ft	39

2045

Census Block 517402132001	
POPULATION	1,431
POP/SQMI	3,180.00
SQMI	0.45
Flood_Area (ft^2)	250,322.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.43
Flood_Range (ft)	7.18
Flood_Mean (ft)	2.21
Flood_StdDev (ft)	1.77
Flood_SumVol (ft^3)	552,232.00
Flood_Variety (ft)	7.19
Flood_Majority (ft)	0.26
Flood_Minority (ft)	7.43
Flood_Median (ft)	1.70
Flooded Buildings >1ft	112
Flooded Buildings >2ft	62

Area 7 Impact Irene 2011

The below Figure 6.aa illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

Figure 6.7a Area 7 Southern Portion of Portsmouth Irene 2011.

Area 7 Impact Irene 2045

The below Figure 6.7b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

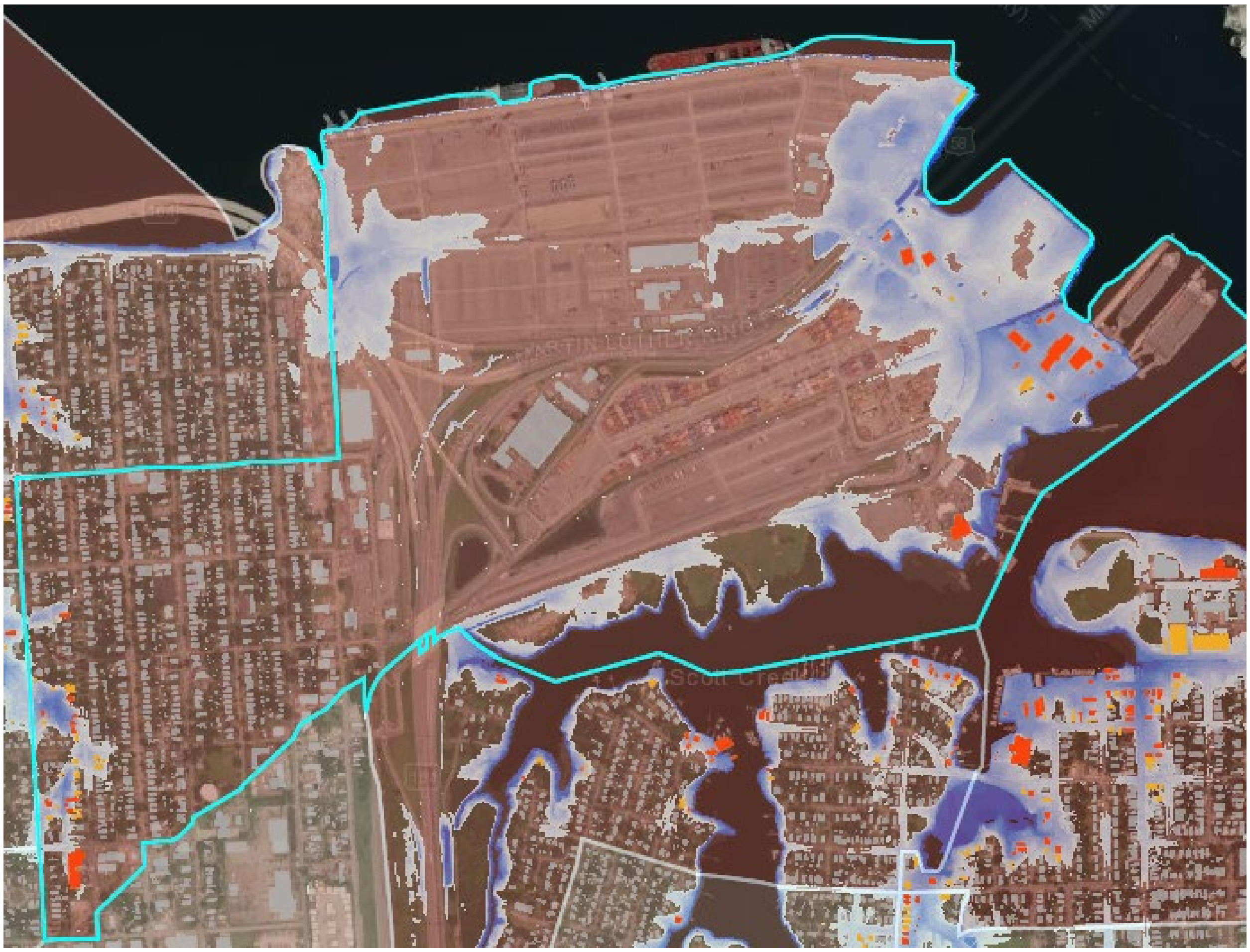


Figure 6.7b Area 7 Southern Portion of Portsmouth Irene 2045.

Area 7 Differences

Table 6.7 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 6.7 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	1.62	1.84	.24
Flood Std Dev (ft)	1.27	1.36	.09
Flood Adjacent Bldgs >1ft	30	62	(107%) 32
Flood Adjacent Bldgs >2ft	18	36	(100%) 18

2011

Census Block 517402102002	
POPULATION	1,352
POP/SQMI	1,408.30
SQMI	0.96
Flood_Area (ft^2)	244,668.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.38
Flood_Range (ft)	6.13
Flood_Mean (ft)	1.62
Flood_StdDev (ft)	1.27
Flood_SumVol (ft^3)	395,598.74
Flood_Variety (ft)	6.14
Flood_Majority (ft)	0.34
Flood_Minority (ft)	6.38
Flood_Median (ft)	1.28
Flooded Buildings >1ft	30
Flooded Buildings >2ft	18

2045

Census Block 517402102002	
POPULATION	1,352
POP/SQMI	1,408.30
SQMI	0.96
Flood_Area (ft^2)	447,137.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.42
Flood_Range (ft)	7.17
Flood_Mean (ft)	1.84
Flood_StdDev (ft)	1.36
Flood_SumVol (ft^3)	824,420.88
Flood_Variety (ft)	7.18
Flood_Majority (ft)	0.53
Flood_Minority (ft)	7.42
Flood_Median (ft)	1.55
Flooded Buildings >1ft	62
Flooded Buildings >2ft	36

Area 8 Impact Irene 2011

The below Figure 6.8a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

Figure 6.8a Area81 Southern Portion of Portsmouth Irene 2011.

Area 8 Impact Irene 2045

The below Figure 6.8b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

Figure 6.8b Area 8 Southern Portion of Portsmouth Irene 2045.

Area 8 Differences

Table 6.8 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 6.8 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	2.61	2.62	.01
Flood Std Dev (ft)	1.74	2.00	1.74
Flood Adjacent Bldgs >1ft	27	52	(93%) 25
Flood Adjacent Bldgs >2ft	7	29	(314%) 22

2011

Census Block 517402102001

POPULATION	941
POP/SQMI	3,035.50
SQMI	0.31
Flood_Area (ft^2)	57,886.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.34
Flood_Range (ft)	6.09
Flood_Mean (ft)	2.61
Flood_StdDev (ft)	1.74
Flood_SumVol (ft^3)	151,054.73
Flood_Variety (ft)	6.10
Flood_Majority (ft)	0.26
Flood_Minority (ft)	5.83
Flood_Median (ft)	2.30
Flooded Buildings >1ft	27
Flooded Buildings >2ft	7

2045

Census Block 517402102001

POPULATION	941
POP/SQMI	3,035.50
SQMI	0.31
Flood_Area (ft^2)	90,088.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.42
Flood_Range (ft)	7.17
Flood_Mean (ft)	2.62
Flood_StdDev (ft)	2.00
Flood_SumVol (ft^3)	235,894.26
Flood_Variety (ft)	7.18
Flood_Majority (ft)	0.25
Flood_Minority (ft)	7.42
Flood_Median (ft)	2.02
Flooded Buildings >1ft	52
Flooded Buildings >2ft	29

Area 9 Impact Irene 2011

The below Figure 6.9a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

Figure 6.9a Area 9 Southern Portion of Portsmouth Irene 2011.

Area 9 Impact Irene 2045

The below Figure 6.9b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

Figure 6.9b Area 9 Southern Portion of Portsmouth Irene 2045.

Area 9 Differences

Table 6.9 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 6.9 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	1.82	2.14	.32
Flood Std Dev (ft)	1.37	1.65	.28
Flood Adjacent Bldgs >1ft	10	30	(200%) 20
Flood Adjacent Bldgs >2ft	5	10	(100%) 5

2011

Census Block 517402103001	
POPULATION	899
POP/SQMI	3,210.70
SQMI	0.28
Flood_Area (ft^2)	48,596.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.34
Flood_Range (ft)	6.09
Flood_Mean (ft)	1.82
Flood_StdDev (ft)	1.37
Flood_SumVol (ft^3)	88,577.43
Flood_Variety (ft)	6.10
Flood_Majority (ft)	0.45
Flood_Minority (ft)	4.12
Flood_Median (ft)	1.47
Flooded Buildings >1ft	10
Flooded Buildings >2ft	5

2045

Census Block 517402103001	
POPULATION	899
POP/SQMI	3,210.70
SQMI	0.28
Flood_Area (ft^2)	117,681.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.42
Flood_Range (ft)	7.17
Flood_Mean (ft)	2.14
Flood_StdDev (ft)	1.65
Flood_SumVol (ft^3)	252,350.81
Flood_Variety (ft)	7.18
Flood_Majority (ft)	4.62
Flood_Minority (ft)	7.42
Flood_Median (ft)	1.59
Flooded Buildings >1ft	30
Flooded Buildings >2ft	10

Area 10 Impact Irene 2011

The below Figure 6.10a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

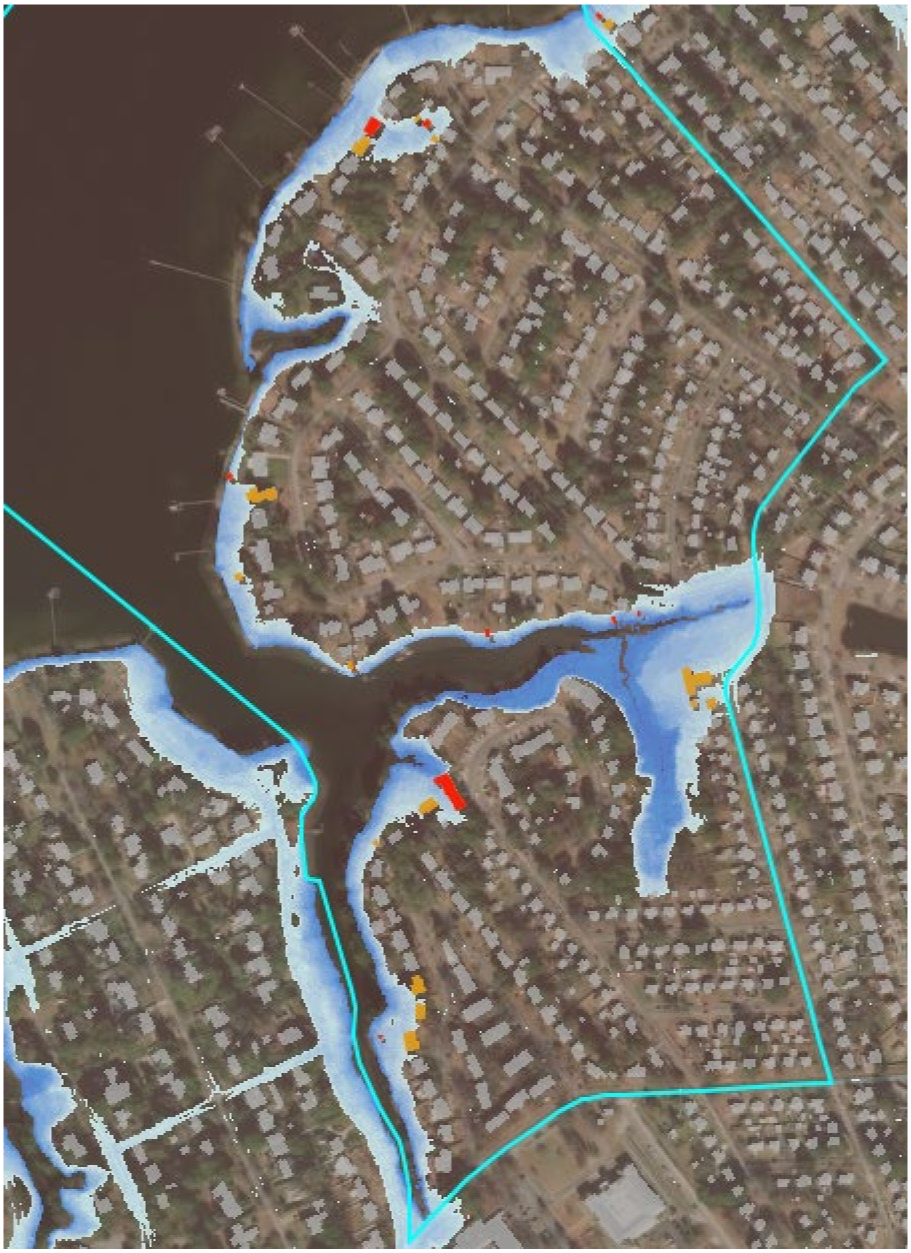


Figure 6.10a Area 10 Southern Portion of Portsmouth Irene 2011.

Area 10 Impact Irene 2045

The below Figure 6.10b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

Figure 6.10b Area 10 Southern Portion of Portsmouth Irene 2045.

Area 10 Differences

Table 6.10 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 6.10 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	2.69	2.89	.20
Flood Std Dev (ft)	1.77	2.05	.28
Flood Adjacent Bldgs >1ft	23	44	(91%) 21
Flood Adjacent Bldgs >2ft	9	22	(144%) 13

2011

Census Block 517402103003

POPULATION	789
POP/SQMI	2,630.00
SQMI	0.30
Flood_Area (ft^2)	69,905.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.34
Flood_Range (ft)	6.09
Flood_Mean (ft)	2.69
Flood_StdDev (ft)	1.77
Flood_SumVol (ft^3)	188,117.59
Flood_Variety (ft)	6.10
Flood_Majority (ft)	0.27
Flood_Minority (ft)	6.34
Flood_Median (ft)	2.28
Flooded Buildings >1ft	23
Flooded Buildings >2ft	9

2045

Census Block 517402103003

POPULATION	789
POP/SQMI	2,630.00
SQMI	0.30
Flood_Area (ft^2)	98,824.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.45
Flood_Range (ft)	7.20
Flood_Mean (ft)	2.89
Flood_StdDev (ft)	2.05
Flood_SumVol (ft^3)	285,877.93
Flood_Variety (ft)	7.21
Flood_Majority (ft)	0.26
Flood_Minority (ft)	7.45
Flood_Median (ft)	2.48
Flooded Buildings >1ft	44
Flooded Buildings >2ft	22

Area 11 Impact Irene 2011

The below Figure 6.11a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

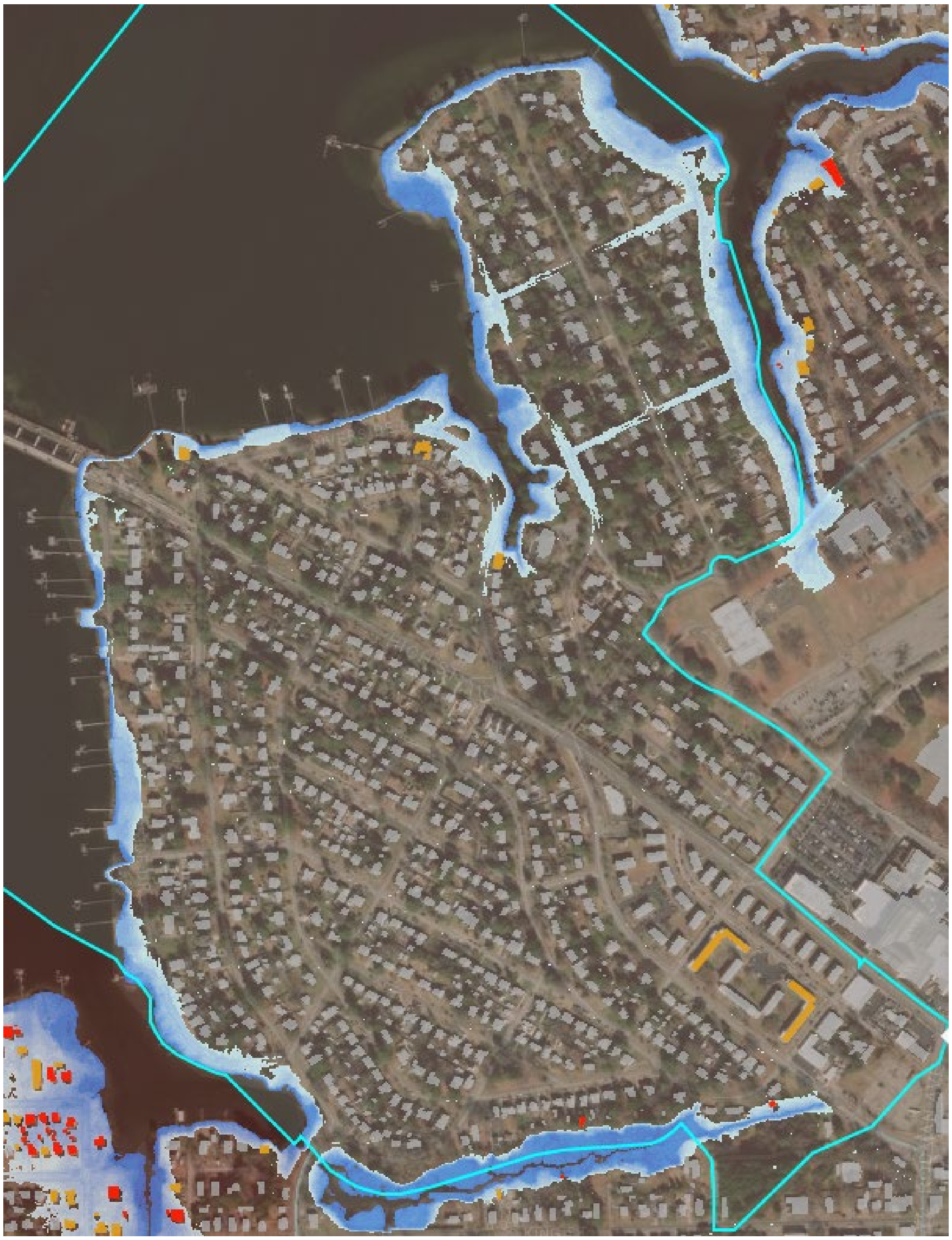


Figure 6.11a Area 11 Southern Portion of Portsmouth Irene 2011.

Area 11 Impact Irene 2045

The below Figure 6.11b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

Figure 6.11b Area 11 Southern Portion of Portsmouth Irene 2045.

Area 11 Differences

Table 6.11 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 6.11 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	2.67	2.70	.03
Flood Std Dev (ft)	1.83	2.08	25
Flood Adjacent Bldgs >1ft	8	20	(150%) 12
Flood Adjacent Bldgs >2ft	2	6	(200%) 4

2011

Census Block 517402104001

POPULATION	1,553
POP/SQMI	2,724.60
SQMI	0.57
Flood_Area (ft^2)	91,966.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.36
Flood_Range (ft)	6.11
Flood_Mean (ft)	2.67
Flood_StdDev (ft)	1.83
Flood_SumVol (ft^3)	245,123.67
Flood_Variety (ft)	6.12
Flood_Majority (ft)	0.26
Flood_Minority (ft)	6.36
Flood_Median (ft)	2.25
Flooded Buildings >1ft	8
Flooded Buildings >2ft	2

2045

Census Block 517402104001

POPULATION	1,553
POP/SQMI	2,724.60
SQMI	0.57
Flood_Area (ft^2)	141,667.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.48
Flood_Range (ft)	7.23
Flood_Mean (ft)	2.70
Flood_StdDev (ft)	2.08
Flood_SumVol (ft^3)	382,503.99
Flood_Variety (ft)	7.24
Flood_Majority (ft)	0.29
Flood_Minority (ft)	7.48
Flood_Median (ft)	2.07
Flooded Buildings >1ft	20
Flooded Buildings >2ft	6

Area 12 Impact Irene 2011

The below Figure 6.12a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

Figure 6.12a Area 12 Southern Portion of Portsmouth Irene 2011.

Area 12 Impact Irene 2045

The below Figure 6.12b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

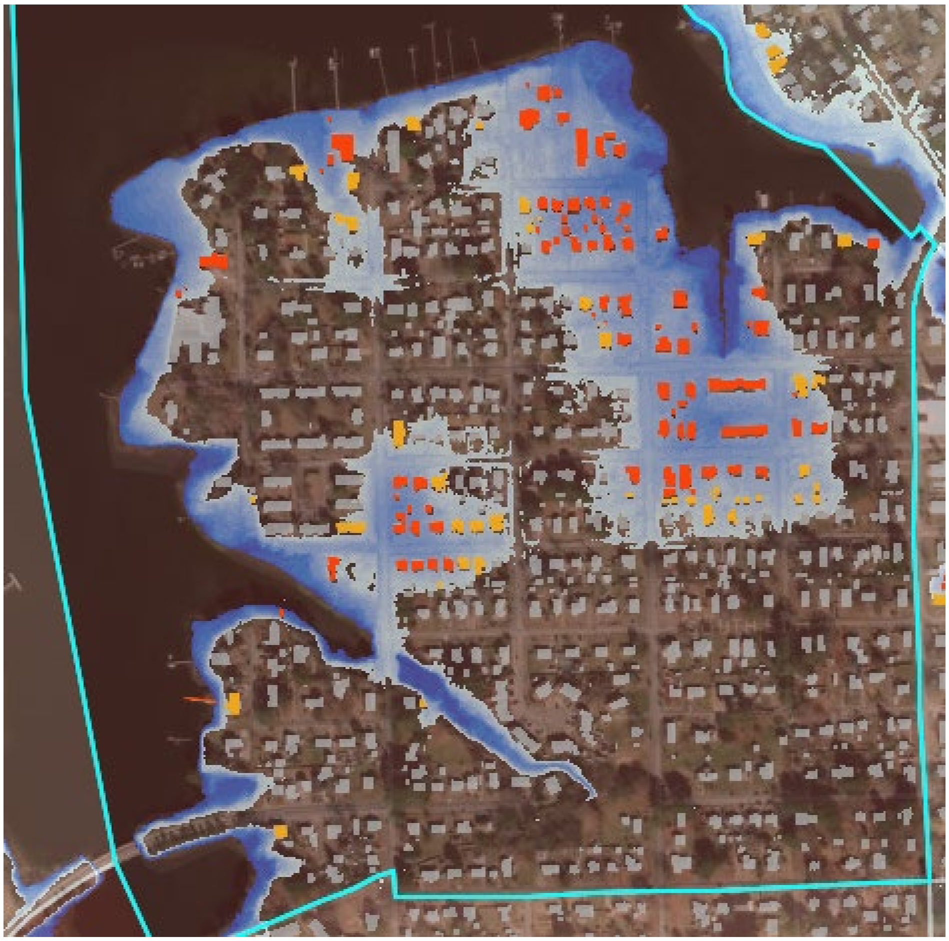


Figure 6.12b Area 12 Southern Portion of Portsmouth Irene 2045.

Area 12 Differences

Table 6.12 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 6.12 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	2.43	2.80	.37
Flood Std Dev (ft)	1.61	1.86	.25
Flood Adjacent Bldgs >1ft	84	138	(64%) 54
Flood Adjacent Bldgs >2ft	44	90	(105%) 46

2011

Census Block 517402116005

POPULATION	985
POP/SQMI	3,283.30
SQMI	0.30
Flood_Area (ft^2)	108,678.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.37
Flood_Range (ft)	6.12
Flood_Mean (ft)	2.43
Flood_StdDev (ft)	1.61
Flood_SumVol (ft^3)	263,898.60
Flood_Variety (ft)	6.13
Flood_Majority (ft)	0.31
Flood_Minority (ft)	6.37
Flood_Median (ft)	2.02
Flooded Buildings >1ft	84
Flooded Buildings >2ft	44

2045

Census Block 517402116005

POPULATION	985
POP/SQMI	3,283.30
SQMI	0.30
Flood_Area (ft^2)	148,740.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.48
Flood_Range (ft)	7.23
Flood_Mean (ft)	2.80
Flood_StdDev (ft)	1.86
Flood_SumVol (ft^3)	415,883.21
Flood_Variety (ft)	7.24
Flood_Majority (ft)	0.56
Flood_Minority (ft)	7.48
Flood_Median (ft)	2.48
Flooded Buildings >1ft	138
Flooded Buildings >2ft	90

Area 13 Impact Irene 2011

The below Figure 6.13a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

Figure 6.13a Area 13 Southern Portion of Portsmouth Irene 2011.

Area 13 Impact Irene 2045

The below Figure 6.13b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

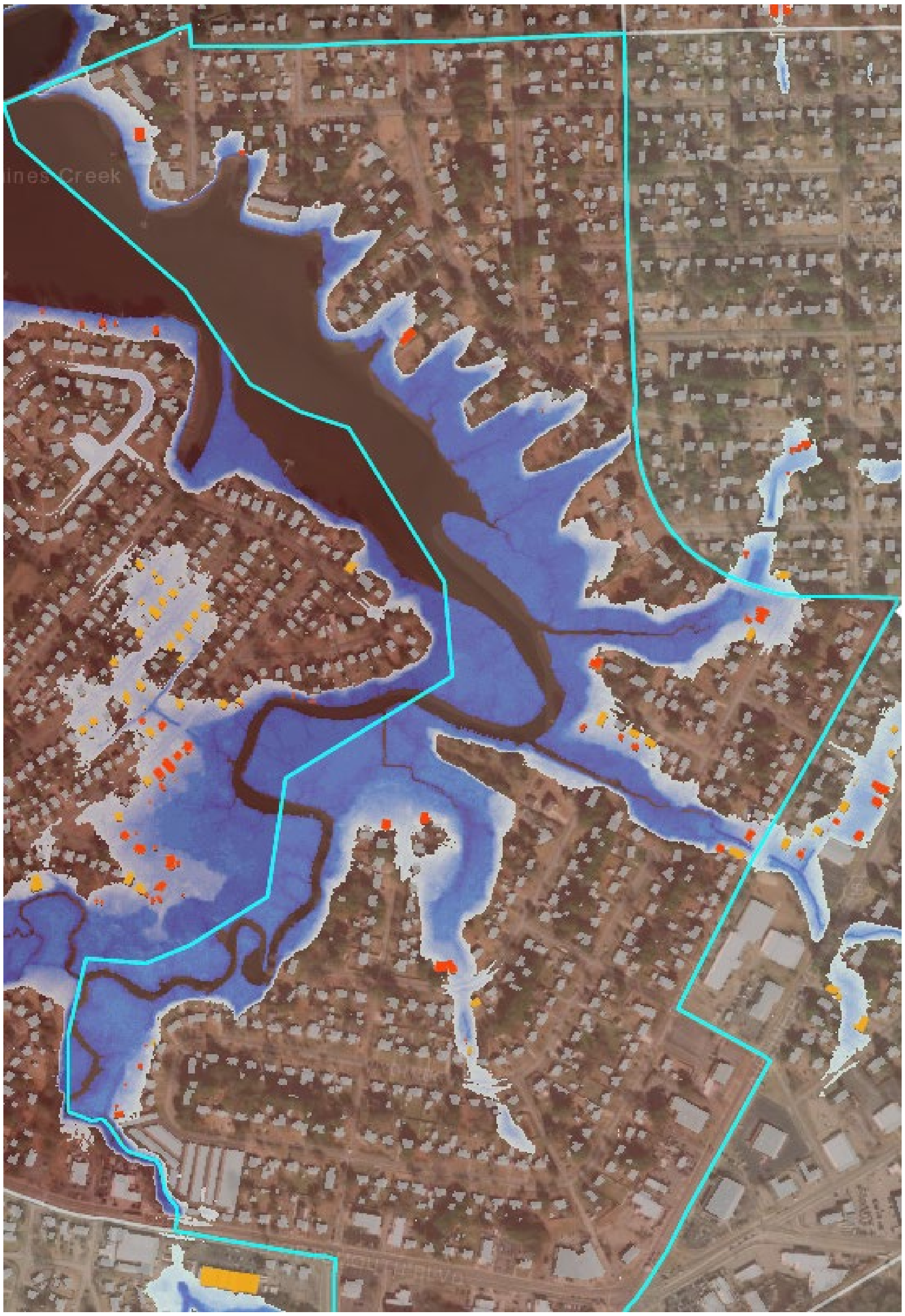


Figure 6.13b Area 13 Southern Portion of Portsmouth Irene 2045.

Area 13 Differences

Table 6.13 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 6.13 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	4.12	4.58	.46
Flood Std Dev (ft)	1.59	2.16	.45
Flood Adjacent Bldgs >1ft	23	31	(35%) 8
Flood Adjacent Bldgs >2ft	8	23	(188%) 15

2011

Census Block 517402116004	
POPULATION	928
POP/SQMI	2,729.40
SQMI	0.34
Flood_Area (ft^2)	156,765.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.39
Flood_Range (ft)	6.14
Flood_Mean (ft)	4.12
Flood_StdDev (ft)	1.59
Flood_SumVol (ft^3)	645,220.88
Flood_Variety (ft)	6.15
Flood_Majority (ft)	4.95
Flood_Minority (ft)	6.39
Flood_Median (ft)	4.76
Flooded Buildings >1ft	23
Flooded Buildings >2ft	8

2045

Census Block 517402116004	
POPULATION	928
POP/SQMI	2,729.40
SQMI	0.34
Flood_Area (ft^2)	184,201.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.50
Flood_Range (ft)	7.25
Flood_Mean (ft)	4.58
Flood_StdDev (ft)	2.16
Flood_SumVol (ft^3)	842,844.17
Flood_Variety (ft)	7.26
Flood_Majority (ft)	6.10
Flood_Minority (ft)	7.50
Flood_Median (ft)	5.68
Flooded Buildings >1ft	31
Flooded Buildings >2ft	23

Area 14 Impact Irene 2011

The below Figure 6.14a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

Figure 6.14a Area 14 Southern Portion of Portsmouth Irene 2011.

Area 14 Impact Irene 2045

The below Figure 6.14b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

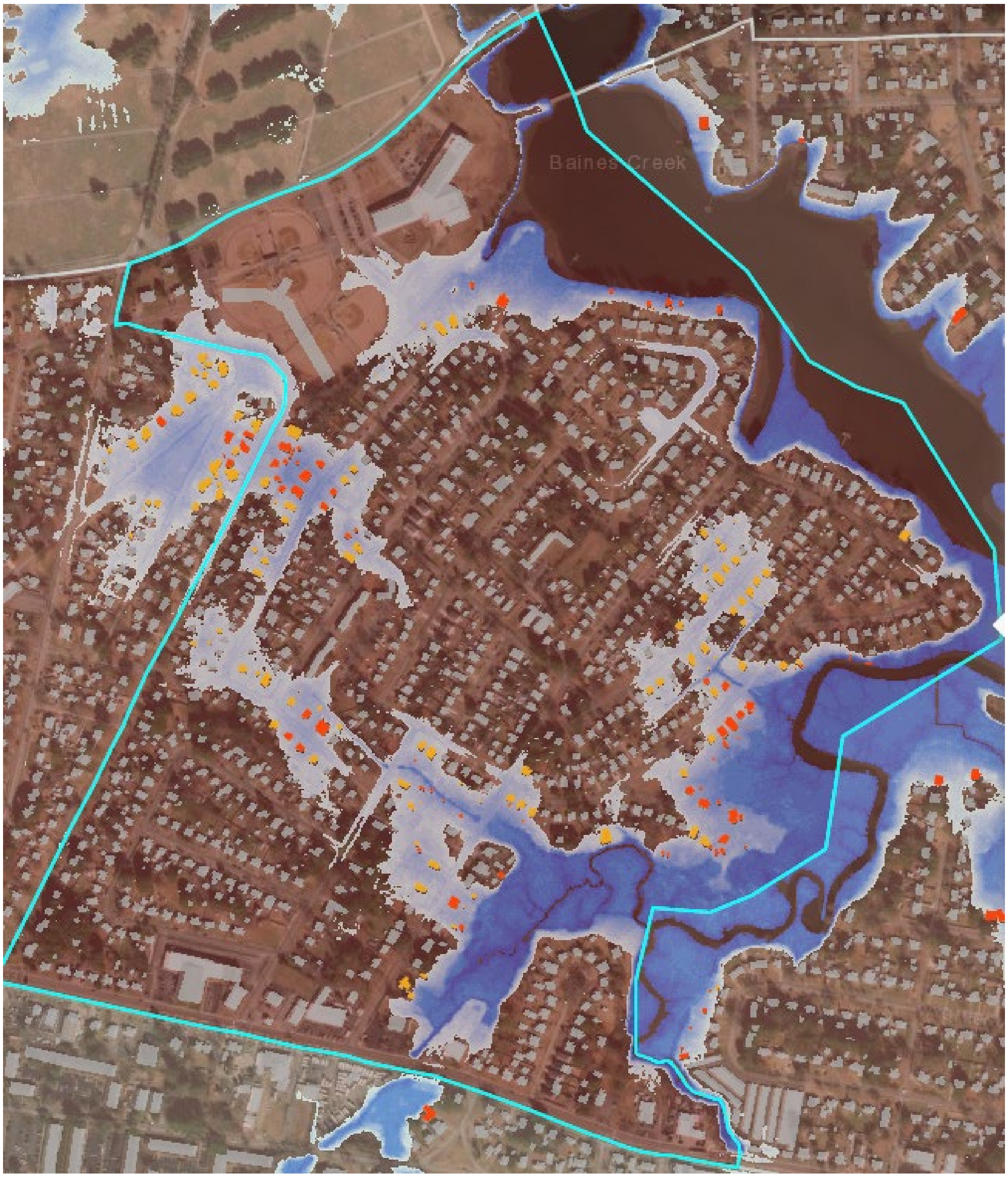


Figure 6.14b Area 14 Southern Portion of Portsmouth Irene 2045.

Area 14 Differences

Table 6.14 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 6.14 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	3.45	3.05	<.40>
Flood Std Dev (ft)	1.79	2.28	.49
Flood Adjacent Bldgs >1ft	45	151	(235%) 106
Flood Adjacent Bldgs >2ft	17	66	(288%) 49

2011

Census Block 517402129002	
POPULATION	1,372
POP/SQMI	3,708.10
SQMI	0.37
Flood_Area (ft^2)	139,115.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.39
Flood_Range (ft)	6.14
Flood_Mean (ft)	3.45
Flood_StdDev (ft)	1.79
Flood_SumVol (ft^3)	479,687.11
Flood_Variety (ft)	6.15
Flood_Majority (ft)	4.60
Flood_Minority (ft)	6.39
Flood_Median (ft)	4.20
Flooded Buildings >1ft	45
Flooded Buildings >2ft	17

2045

Census Block 517402129002	
POPULATION	1,372
POP/SQMI	3,708.10
SQMI	0.37
Flood_Area (ft^2)	239,249.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.50
Flood_Range (ft)	7.25
Flood_Mean (ft)	3.05
Flood_StdDev (ft)	2.28
Flood_SumVol (ft^3)	729,652.37
Flood_Variety (ft)	7.26
Flood_Majority (ft)	0.26
Flood_Minority (ft)	7.50
Flood_Median (ft)	2.19
Flooded Buildings >1ft	151
Flooded Buildings >2ft	66

Area 15 Impact Irene 2011

The below Figure 6.15a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

Figure 6.15a Area 15 Southern Portion of Portsmouth Irene 2011.

Area 15 Impact Irene 2045

The below Figure 6.15b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

Figure 6.15b Area 15 Southern Portion of Portsmouth Irene 2045.

Area 15 Differences

Table 6.15 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 6.15 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	2.36	2.10	.26
Flood Std Dev (ft)	1.51	1.60	.09
Flood Adjacent Bldgs >1ft	28	101	(261%) 73
Flood Adjacent Bldgs >2ft	8	39	(387%) 31

2011

Census Block 517402129003	
POPULATION	1,332
POP/SQMI	4,933.30
SQMI	0.27
Flood_Area (ft^2)	43,706.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.37
Flood_Range (ft)	6.12
Flood_Mean (ft)	2.36
Flood_StdDev (ft)	1.51
Flood_SumVol (ft^3)	103,110.09
Flood_Variety (ft)	6.13
Flood_Majority (ft)	0.32
Flood_Minority (ft)	6.31
Flood_Median (ft)	2.04
Flooded Buildings >1ft	28
Flooded Buildings >2ft	8

2045

Census Block 517402129003	
POPULATION	1,332
POP/SQMI	4,933.30
SQMI	0.27
Flood_Area (ft^2)	106,766.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.49
Flood_Range (ft)	7.24
Flood_Mean (ft)	2.10
Flood_StdDev (ft)	1.60
Flood_SumVol (ft^3)	224,707.94
Flood_Variety (ft)	7.25
Flood_Majority (ft)	0.29
Flood_Minority (ft)	7.41
Flood_Median (ft)	1.63
Flooded Buildings >1ft	101
Flooded Buildings >2ft	39

Area 16 Impact Irene 2011

The below Figure 6.16a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

Figure 6.16a Area 16 Southern Portion of Portsmouth Irene 2011.

Area 16 Impact Irene 2045

The below Figure 6.16b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

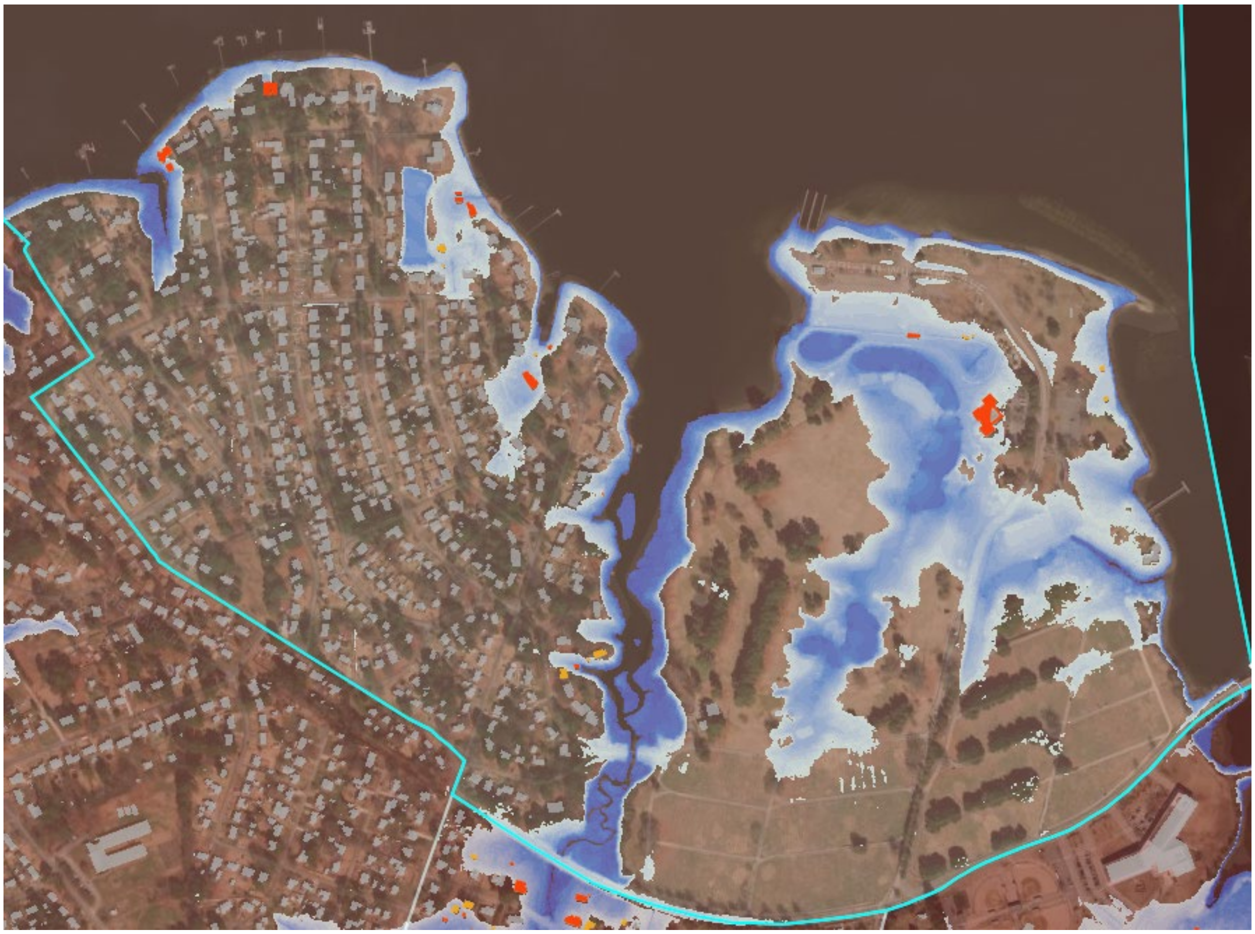


Figure 6.16b Area 16 Southern Portion of Portsmouth Irene 2045.

Area 16 Differences

Table 6.16 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 6.16 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	2.83	3.02	.19
Flood Std Dev (ft)	1.79	2.10	.32
Flood Adjacent Bldgs >1ft	13	24	(85%) 11
Flood Adjacent Bldgs >2ft	6	13	(116%) 7

2011

Census Block 517402129001

POPULATION	787
POP/SQMI	1,093.10
SQMI	0.72
Flood_Area (ft^2)	199,369.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.39
Flood_Range (ft)	6.14
Flood_Mean (ft)	2.83
Flood_StdDev (ft)	1.79
Flood_SumVol (ft^3)	564,305.94
Flood_Variety (ft)	6.15
Flood_Majority (ft)	0.25
Flood_Minority (ft)	6.39
Flood_Median (ft)	2.52
Flooded Buildings >1ft	13
Flooded Buildings >2ft	6

2045

Census Block 517402129001

POPULATION	787
POP/SQMI	1,093.10
SQMI	0.72
Flood_Area (ft^2)	281,036.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.50
Flood_Range (ft)	7.25
Flood_Mean (ft)	3.02
Flood_StdDev (ft)	2.10
Flood_SumVol (ft^3)	849,050.43
Flood_Variety (ft)	7.26
Flood_Majority (ft)	0.27
Flood_Minority (ft)	7.50
Flood_Median (ft)	2.57
Flooded Buildings >1ft	24
Flooded Buildings >2ft	13

Area 17 Impact Irene 2011

The below Figure 6.17a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

Figure 6.17a Area 17 Southern Portion of Portsmouth Irene 2011.

Area 17 Impact Irene 2045

The below Figure 6.17b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

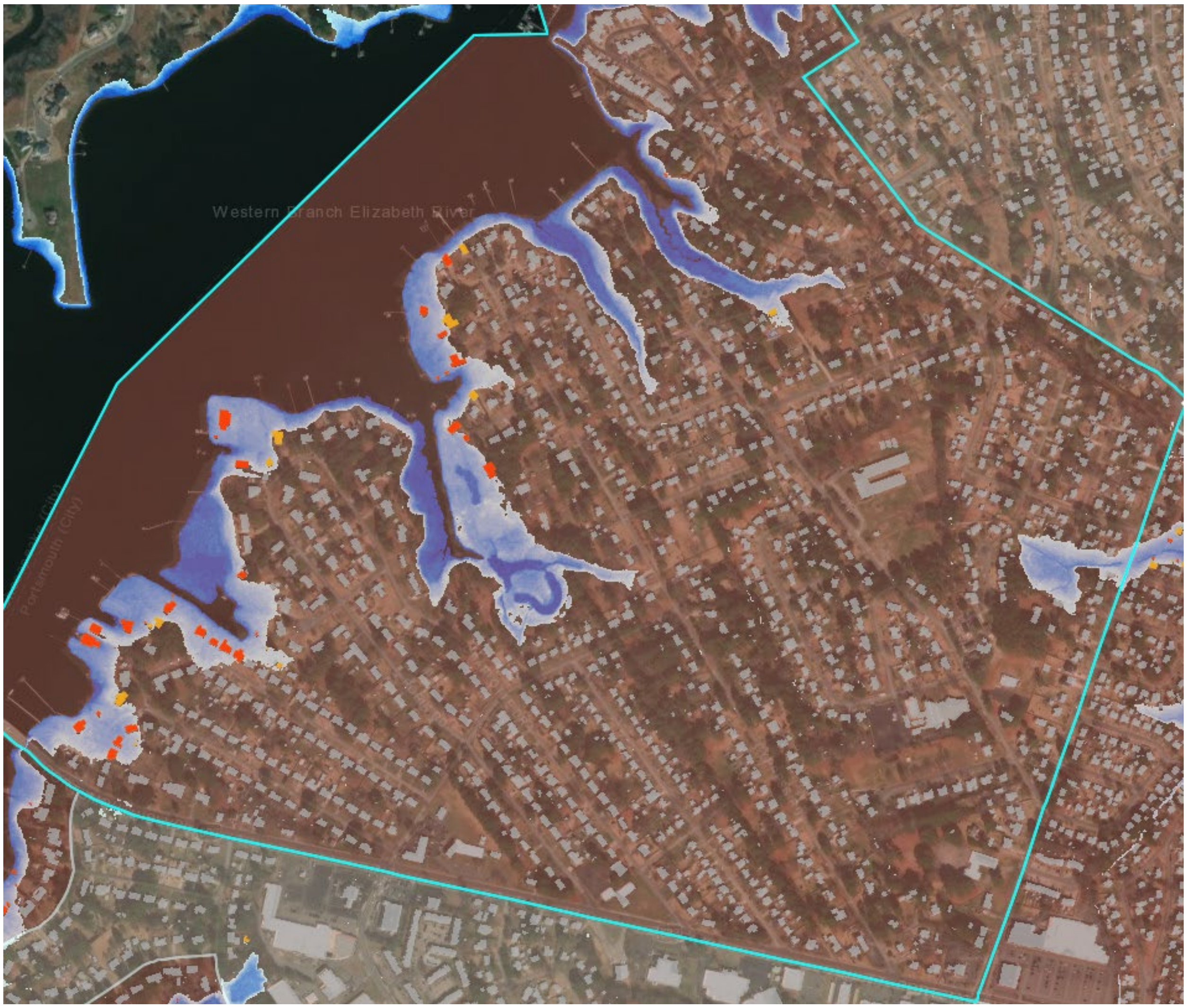


Figure 6.17b Area 17 Southern Portion of Portsmouth Irene 2045.

Area 17 Differences

Table 6.17 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 6.17 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	3.07	3.63	.56
Flood Std Dev (ft)	1.80	2.07	.47
Flood Adjacent Bldgs >1ft	30	45	(50%) 15
Flood Adjacent Bldgs >2ft	11	32	(190%) 21

2011

Census Block 517402129004

POPULATION	1,842
POP/SQMI	2,423.70
SQMI	0.76
Flood_Area (ft^2)	151,251.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.43
Flood_Range (ft)	6.18
Flood_Mean (ft)	3.07
Flood_StdDev (ft)	1.80
Flood_SumVol (ft^3)	464,024.66
Flood_Variety (ft)	6.19
Flood_Majority (ft)	5.60
Flood_Minority (ft)	6.43
Flood_Median (ft)	2.80
Flooded Buildings >1ft	30
Flooded Buildings >2ft	11

2045

Census Block 517402129004

POPULATION	1,842
POP/SQMI	2,423.70
SQMI	0.76
Flood_Area (ft^2)	179,579.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.52
Flood_Range (ft)	7.27
Flood_Mean (ft)	3.63
Flood_StdDev (ft)	2.07
Flood_SumVol (ft^3)	651,493.02
Flood_Variety (ft)	7.28
Flood_Majority (ft)	6.67
Flood_Minority (ft)	7.52
Flood_Median (ft)	3.37
Flooded Buildings >1ft	45
Flooded Buildings >2ft	32

Area 18 Impact Irene 2011

The below Figure 6.18a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

Figure 6.18a Area 18 Southern Portion of Portsmouth Irene 2011.

Area 18 Impact Irene 2045

The below Figure 6.18b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

Figure 6.18b Area 18 Southern Portion of Portsmouth Irene 2045.

Area 18 Differences

Table 6.18 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 6.18 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	2.22	3.17	.95
Flood Std Dev (ft)	1.78	1.76	<.01>
Flood Adjacent Bldgs >1ft	30	49	(63%) 19
Flood Adjacent Bldgs >2ft	17	40	(135%) 23

2011

Census Block 517402128022	
POPULATION	1,112
POP/SQMI	1,222.00
SQMI	0.91
Flood_Area (ft^2)	331,773.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.48
Flood_Range (ft)	6.23
Flood_Mean (ft)	2.22
Flood_StdDev (ft)	1.78
Flood_SumVol (ft^3)	737,092.00
Flood_Variety (ft)	6.24
Flood_Majority (ft)	0.53
Flood_Minority (ft)	6.48
Flood_Median (ft)	1.39
Flooded Buildings >1ft	30
Flooded Buildings >2ft	17

2045

Census Block 517402128022	
POPULATION	1,112
POP/SQMI	1,222.00
SQMI	0.91
Flood_Area (ft^2)	374,734.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.55
Flood_Range (ft)	7.30
Flood_Mean (ft)	3.17
Flood_StdDev (ft)	1.76
Flood_SumVol (ft^3)	1,187,801.84
Flood_Variety (ft)	7.31
Flood_Majority (ft)	2.08
Flood_Minority (ft)	7.55
Flood_Median (ft)	2.49
Flooded Buildings >1ft	49
Flooded Buildings >2ft	40

Part 7 - Area-Specific Flooding: Northern Portion of Portsmouth

The following series of figures and tables focus on six purposively selected areas within the northern portion of Portsmouth where there is prominent inundation contacts with structures relative to other areas in the northern portion of Portsmouth.

Area 1 Impact Irene 2011

The below Figure 7.1a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

Figure 7.1a Area 1 Northern Portion of Portsmouth Irene 2011.

Area 1 Impact Irene 2045

The below Figure 7.1b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

Figure 7.1b Area 1 Northern Portion of Portsmouth Irene 2011.

Area 1 Differences

Table 7.1 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 7.1 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	3.68	4.08	.40
Flood Std Dev (ft)	1.67	2.13	.46
Flood Adjacent Bldgs >1ft	40	67	(68%) 27
Flood Adjacent Bldgs >2ft	25	41	(24%) 16

2011

Census Block 517402130013

POPULATION	2,978
POP/SQMI	1,172.40
SQMI	2.54
Flood_Area (ft^2)	658,197.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.37
Flood_Range (ft)	6.12
Flood_Mean (ft)	3.68
Flood_StdDev (ft)	1.67
Flood_SumVol (ft^3)	2,419,685.41
Flood_Variety (ft)	6.13
Flood_Majority (ft)	4.85
Flood_Minority (ft)	6.37
Flood_Median (ft)	4.22
Flooded Buildings >1ft	40
Flooded Buildings >2ft	25

2045

Census Block 517402130013

POPULATION	2,978
POP/SQMI	1,172.40
SQMI	2.54
Flood_Area (ft^2)	786,364.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.44
Flood_Range (ft)	7.19
Flood_Mean (ft)	4.08
Flood_StdDev (ft)	2.13
Flood_SumVol (ft^3)	3,208,215.73
Flood_Variety (ft)	7.20
Flood_Majority (ft)	5.91
Flood_Minority (ft)	7.44
Flood_Median (ft)	4.68
Flooded Buildings >1ft	67
Flooded Buildings >2ft	41

Area 2 Impact Irene 2011

The below Figure 7.2a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

Figure 7.2a Area 2 Northern Portion of Portsmouth Irene 2011.

Area 2 Impact Irene 2045

The below Figure 7.2b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

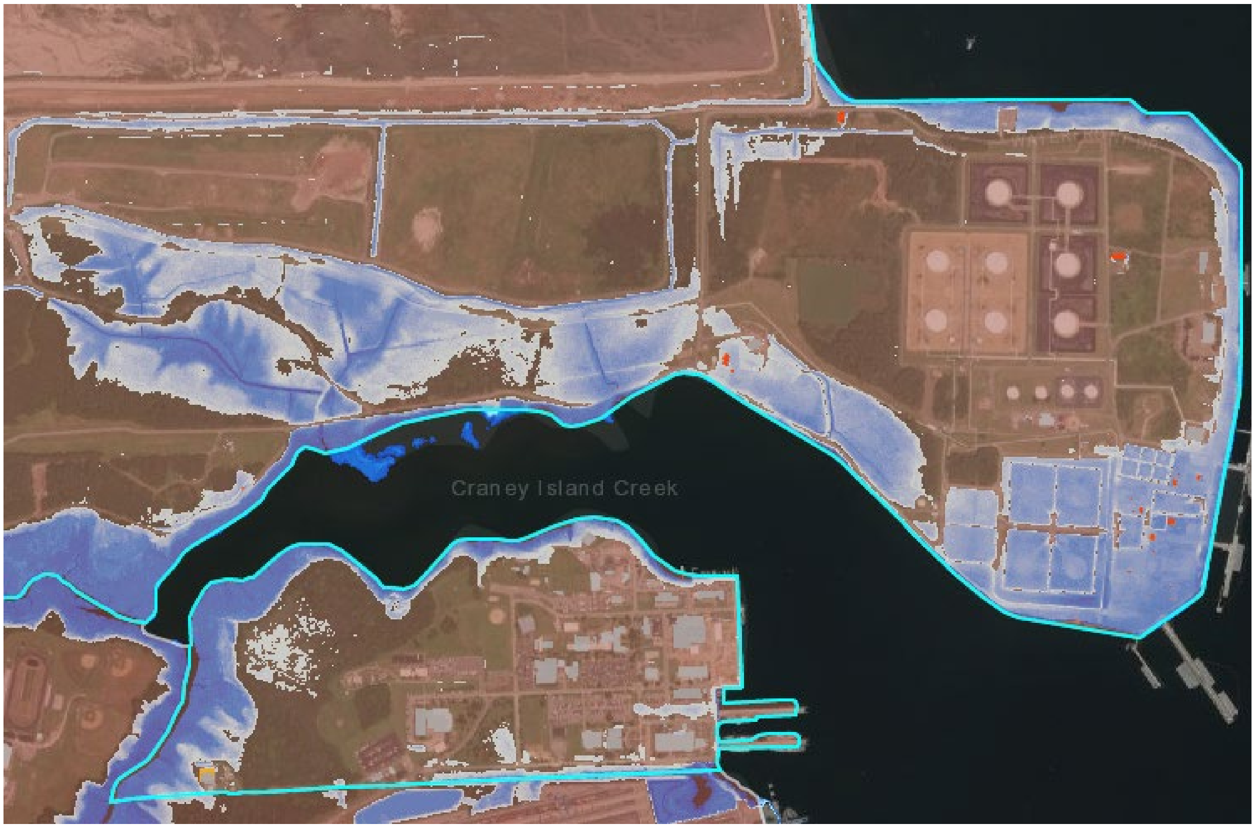


Figure 7.2b Area 2 Northern Portion of Portsmouth Irene 2011.

Area 2 Differences

Table 7.2 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 7.2 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	2.77	3.17	.30
Flood Std Dev (ft)	1.56	1.88	.32
Flood Adjacent Bldgs >1ft	27	30	(11%)3
Flood Adjacent Bldgs >2ft	25	27	(8%)2

2011

Census Block 517402130011

POPULATION	340
POP/SQMI	60.30
SQMI	5.64
Flood_Area (ft^2)	1,111,585.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.45
Flood_Range (ft)	6.20
Flood_Mean (ft)	2.77
Flood_StdDev (ft)	1.56
Flood_SumVol (ft^3)	3,074,344.90
Flood_Variety (ft)	6.13
Flood_Majority (ft)	0.27
Flood_Minority (ft)	6.45
Flood_Median (ft)	2.61
Flooded Buildings >1ft	27
Flooded Buildings >2ft	25

2045

Census Block 517402130011

POPULATION	340
POP/SQMI	60.30
SQMI	5.64
Flood_Area (ft^2)	1,414,204.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.39
Flood_Range (ft)	7.14
Flood_Mean (ft)	3.17
Flood_StdDev (ft)	1.88
Flood_SumVol (ft^3)	4,488,737.40
Flood_Variety (ft)	7.15
Flood_Majority (ft)	0.25
Flood_Minority (ft)	7.39
Flood_Median (ft)	3.10
Flooded Buildings >1ft	30
Flooded Buildings >2ft	27

Area 3 Impact Irene 2011

The below Figure 7.3a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

Figure 7.3a Area 3 Northern Portion of Portsmouth Irene 2011.

Area 3 Impact Irene 2045

The below Figure 7.3b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

Figure 7.3b Area 3 Northern Portion of Portsmouth Irene 2011.

Area 3 Differences

Table 7.3 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 7.3 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	3.27	3.55	.28
Flood Std Dev (ft)	1.74	2.12	.38
Flood Adjacent Bldgs >1ft	18	73	(305%) 55
Flood Adjacent Bldgs >2ft	10	34	(240%) 24

2011

Census Block 517402130022

POPULATION	1,293
POP/SQMI	2,308.90
SQMI	0.56
Flood_Area (ft^2)	189,490.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.42
Flood_Range (ft)	6.17
Flood_Mean (ft)	3.27
Flood_StdDev (ft)	1.74
Flood_SumVol (ft^3)	619,164.66
Flood_Variety (ft)	6.18
Flood_Majority (ft)	4.71
Flood_Minority (ft)	6.42
Flood_Median (ft)	3.64
Flooded Buildings >1ft	18
Flooded Buildings >2ft	10

2045

Census Block 517402130022

POPULATION	1,293
POP/SQMI	2,308.90
SQMI	0.56
Flood_Area (ft^2)	258,510.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.53
Flood_Range (ft)	7.28
Flood_Mean (ft)	3.55
Flood_StdDev (ft)	2.12
Flood_SumVol (ft^3)	917,962.87
Flood_Variety (ft)	7.29
Flood_Majority (ft)	5.81
Flood_Minority (ft)	7.53
Flood_Median (ft)	3.50
Flooded Buildings >1ft	73
Flooded Buildings >2ft	34

Area 4 Impact Irene 2011

The below Figure 7.4a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

Figure 7.4a Area 4 Northern Portion of Portsmouth Irene 2011.

Area 4 Impact Irene 2045

The below Figure 7.4b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

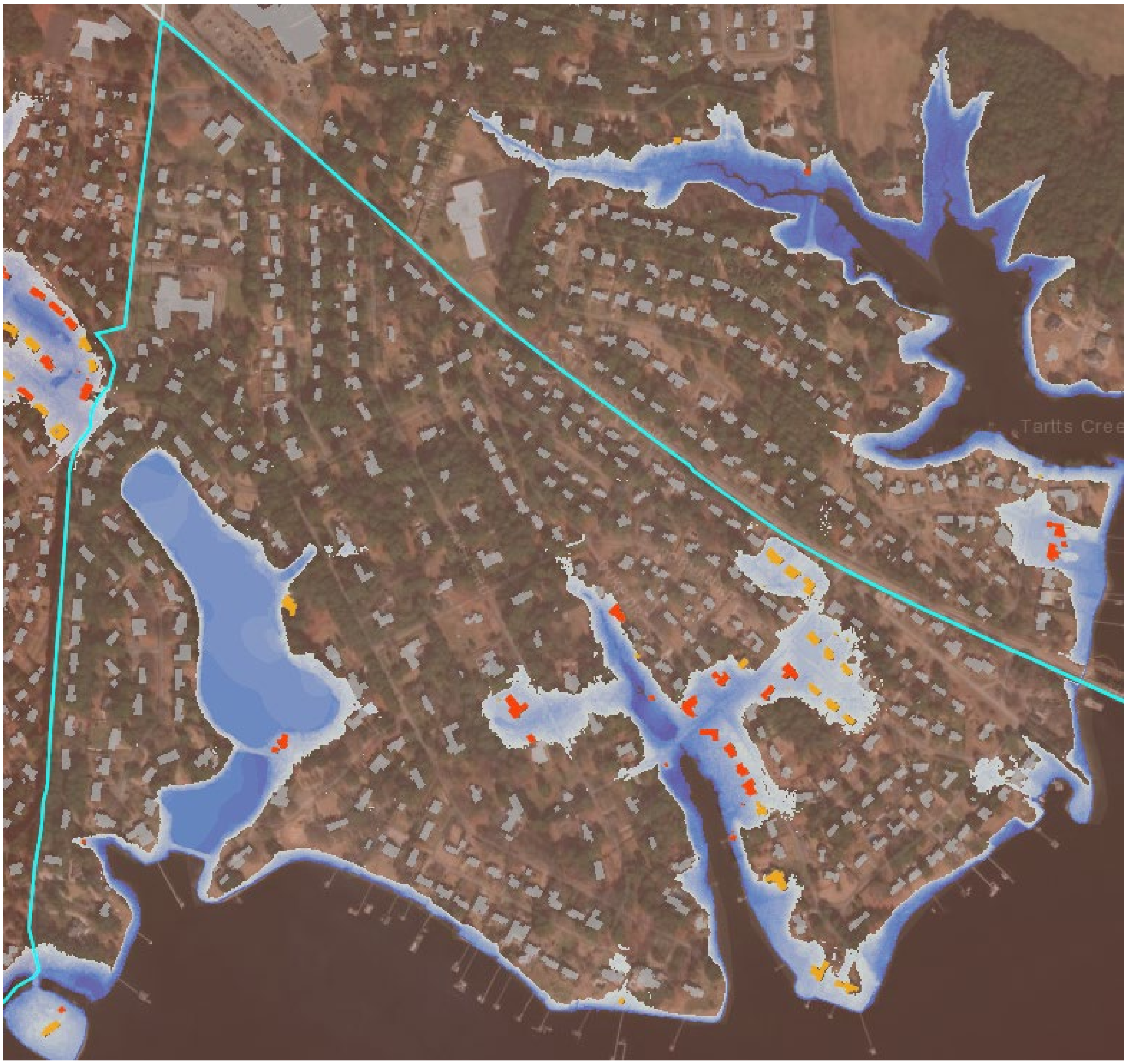


Figure 7.4b Area 4 Northern Portion of Portsmouth Irene 2011.

Area 4 Differences

Table 7.4 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 7.4 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	2.71	3.01	.30
Flood Std Dev (ft)	1.43	1.81	.38
Flood Adjacent Bldgs >1ft	16	43	(168%) 27
Flood Adjacent Bldgs >2ft	8	20	(150%) 12

2011

Census Block 517402130021	
POPULATION	780
POP/SQMI	1,278.70
SQMI	0.61
Flood_Area (ft^2)	135,644.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.38
Flood_Range (ft)	6.13
Flood_Mean (ft)	2.71
Flood_StdDev (ft)	1.43
Flood_SumVol (ft^3)	367,397.32
Flood_Variety (ft)	6.14
Flood_Majority (ft)	3.18
Flood_Minority (ft)	6.38
Flood_Median (ft)	2.94
Flooded Buildings >1ft	16
Flooded Buildings >2ft	8

2045

Census Block 517402130021	
POPULATION	780
POP/SQMI	1,278.70
SQMI	0.61
Flood_Area (ft^2)	187,742.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.50
Flood_Range (ft)	7.25
Flood_Mean (ft)	3.01
Flood_StdDev (ft)	1.81
Flood_SumVol (ft^3)	565,645.60
Flood_Variety (ft)	7.26
Flood_Majority (ft)	4.29
Flood_Minority (ft)	7.50
Flood_Median (ft)	3.03
Flooded Buildings >1ft	43
Flooded Buildings >2ft	20

Area 5 Impact Irene 2011

The below Figure 7.5a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the “>1ft” inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the “>2ft” inundation threshold).

Figure 7.5a Area 5 Northern Portion of Portsmouth Irene 2011.

Area 5 Impact Irene 2045

The below Figure 7.5b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

Figure 7.5b Area 5 Northern Portion of Portsmouth Irene 2011.

Area 5 Differences

Table 7.5 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 7.5 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	3.01	3.29	.28
Flood Std Dev (ft)	1.80	2.14	.34
Flood Adjacent Bldgs >1ft	20	44	(120%) 24
Flood Adjacent Bldgs >2ft	8	21	(163%) 13

2011

Census Block 517402130012	
POPULATION	2,800
POP/SQMI	2,014.40
SQMI	1.39
Flood_Area (ft^2)	201,391.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.35
Flood_Range (ft)	6.10
Flood_Mean (ft)	3.01
Flood_StdDev (ft)	1.80
Flood_SumVol (ft^3)	606,523.74
Flood_Variety (ft)	6.11
Flood_Majority (ft)	0.25
Flood_Minority (ft)	6.35
Flood_Median (ft)	2.89
Flooded Buildings >1ft	20
Flooded Buildings >2ft	8

2045

Census Block 517402130012	
POPULATION	2,800
POP/SQMI	2,014.40
SQMI	1.39
Flood_Area (ft^2)	265,438.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.46
Flood_Range (ft)	7.21
Flood_Mean (ft)	3.29
Flood_StdDev (ft)	2.14
Flood_SumVol (ft^3)	873,593.65
Flood_Variety (ft)	7.22
Flood_Majority (ft)	0.25
Flood_Minority (ft)	7.46
Flood_Median (ft)	2.98
Flooded Buildings >1ft	44
Flooded Buildings >2ft	21

Area 6 Impact Irene 2011

The below Figure 7.6a illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

Figure 7.6a Area 6 Northern Portion of Portsmouth Irene 2011.

Area 6 Impact Irene 2045

The below Figure 7.6b illustrates the extent and depth of flooding within the blue perimeter boundary. Building footprints are shown in shaded grey. Buildings that are expected to come into contact with one or more feet of flood water, but less than two feet of flood water, are shown shaded in yellow (meeting the ">1ft" inundation threshold). Buildings adjacent to two or more feet of inundation are shaded in orange-red (meeting the ">2ft" inundation threshold).

Figure 7.6b Area 6 Northern Portion of Portsmouth Irene 2011.

Area 6 Differences

Table 7.6 below reports an increase in the mean depth of floodng and an increase in the number of structures adjacent floodwaters.

Table 7.6 Change in Flooding and Contact with Adjacent Structures.

	2011 Base Scenario	2045 Forecast Scenario	(%) # Change
Flood Mean (ft)	3.49	4.10	.61
Flood Std Dev (ft)	1.81	2.45	.64
Flood Adjacent Bldgs >1ft	3	2	(-50%) 1
Flood Adjacent Bldgs >2ft	0*	4	(*) 4

2011

Census Block 517402131011	
POPULATION	1,269
POP/SQMI	3,021.40
SQMI	0.42
Flood_Area (ft^2)	47,233.00
Flood_Min (ft)	0.25
Flood_Max (ft)	6.43
Flood_Range (ft)	6.18
Flood_Mean (ft)	3.49
Flood_StdDev (ft)	1.81
Flood_SumVol (ft^3)	164,625.14
Flood_Variety (ft)	6.19
Flood_Majority (ft)	0.26
Flood_Minority (ft)	6.43
Flood_Median (ft)	3.86
Flooded Buildings >1ft	3
Flooded Buildings >2ft	0

2045

Census Block 517402131011	
POPULATION	1,269
POP/SQMI	3,021.40
SQMI	0.42
Flood_Area (ft^2)	53,890.00
Flood_Min (ft)	0.25
Flood_Max (ft)	7.54
Flood_Range (ft)	7.29
Flood_Mean (ft)	4.10
Flood_StdDev (ft)	2.15
Flood_SumVol (ft^3)	221,012.92
Flood_Variety (ft)	7.30
Flood_Majority (ft)	5.77
Flood_Minority (ft)	2.71
Flood_Median (ft)	4.60
Flooded Buildings >1ft	4
Flooded Buildings >2ft	2

APPENDIX A: Data Used to Estimate Economic Impacts

Table A1. Portsmouth Block Groups

Block Group Identifier	Total Population	Area (Sq. miles)	Households	Number of Respondents
Block Group 1, Census Tract 2102	811	0.18	422	9
Block Group 2, Census Tract 2102	1623	0.85	592	11
Block Group 1, Census Tract 2103	673	0.20	328	5
Block Group 2, Census Tract 2103	651	0.20	232	4
Block Group 3, Census Tract 2103	776	0.19	377	7
Block Group 1, Census Tract 2104	1202	0.37	723	11
Block Group 1, Census Tract 2105	2122	0.39	705	6
Block Group 1, Census Tract 2106	1074	0.23	385	4
Block Group 2, Census Tract 2106	574	0.12	322	7
Block Group 1, Census Tract 2109	1285	0.26	654	7
Block Group 2, Census Tract 2109	1594	0.22	934	27
Block Group 1, Census Tract 2111	770	0.15	317	3
Block Group 2, Census Tract 2111	1081	0.48	441	5
Block Group 1, Census Tract 2114	1020	0.18	454	9
Block Group 2, Census Tract 2114	894	0.15	107	2
Block Group 1, Census Tract 2115	646	0.27	248	0
Block Group 2, Census Tract 2115	1248	0.17	339	4
Block Group 1, Census Tract 2116	863	0.17	262	1
Block Group 2, Census Tract 2116	796	0.20	341	2
Block Group 3, Census Tract 2116	663	0.20	281	3
Block Group 4, Census Tract 2116	585	0.26	377	7
Block Group 5, Census Tract 2116	1023	0.19	442	7
Block Group 1, Census Tract 2117	1093	0.27	413	7
Block Group 2, Census Tract 2117	775	0.32	438	4
Block Group 3, Census Tract 2117	700	0.27	374	6
Block Group 1, Census Tract 2118	940	0.15	237	1
Block Group 2, Census Tract 2118	845	0.23	382	6
Block Group 3, Census Tract 2118	1191	0.12	323	5
Block Group 4, Census Tract 2118	799	0.11	387	4
Block Group 1, Census Tract 2119	521	0.14	283	4
Block Group 2, Census Tract 2119	730	0.20	284	3
Block Group 1, Census Tract 2120	558	0.12	298	5
Block Group 2, Census Tract 2120	879	0.20	410	7
Block Group 1, Census Tract 2121	365	0.32	128	0
Block Group 2, Census Tract 2121	1146	0.12	476	6

Block Group Identifier	Total Population	Area (Sq. miles)	Households	Number of Respondents
Block Group 1, Census Tract 2123	1213	0.62	634	8
Block Group 2, Census Tract 2123	782	0.12	361	2
Block Group 3, Census Tract 2123	1271	0.19	473	9
Block Group 4, Census Tract 2123	692	0.12	339	2
Block Group 1, Census Tract 2124	1622	0.36	358	1
Block Group 2, Census Tract 2124	661	0.33	511	5
Block Group 3, Census Tract 2124	1275	0.09	489	4
Block Group 1, Census Tract 2125	2011	0.84	829	17
Block Group 1, Census Tract 2126	42	0.58	11	0
Block Group 2, Census Tract 2126	597	0.17	130	3
Block Group 3, Census Tract 2126	817	0.15	289	5
Block Group 1, Census Tract 2127.01	1795	0.66	361	5
Block Group 2, Census Tract 2127.01	1081	0.23	284	6
Block Group 3, Census Tract 2127.01	2410	0.50	814	23
Block Group 4, Census Tract 2127.01	540	0.25	286	12
Block Group 1, Census Tract 2127.02	1703	0.32	595	14
Block Group 2, Census Tract 2127.02	1502	0.36	712	15
Block Group 1, Census Tract 2128.01	1174	0.30	574	9
Block Group 2, Census Tract 2128.01	1835	0.20	605	5
Block Group 3, Census Tract 2128.01	1902	0.42	817	7
Block Group 1, Census Tract 2128.02	1521	0.47	683	15
Block Group 2, Census Tract 2128.02	1049	0.77	530	21
Block Group 1, Census Tract 2129	1004	0.45	329	12
Block Group 2, Census Tract 2129	1107	0.33	599	3
Block Group 3, Census Tract 2129	1417	0.27	517	10
Block Group 4, Census Tract 2129	1615	0.63	770	30
Block Group 1, Census Tract 2130.01*	445	5.76	7	0
Block Group 2, Census Tract 2130.01	2956	1.06	1148	51
Block Group 3, Census Tract 2130.01	2921	2.24	1081	35
Block Group 1, Census Tract 2130.02	763	0.36	303	17
Block Group 2, Census Tract 2130.02	1319	0.48	693	26
Block Group 3, Census Tract 2130.02	2113	0.60	852	18
Block Group 1, Census Tract 2131.01	1416	0.42	528	7
Block Group 2, Census Tract 2131.01	1456	0.17	611	3
Block Group 3, Census Tract 2131.01	1822	0.35	796	19
Block Group 1, Census Tract 2131.03	459	0.32	297	9
Block Group 2, Census Tract 2131.03	651	0.24	292	16
Block Group 3, Census Tract 2131.03	2107	0.40	838	16
Block Group 4, Census Tract 2131.03	2071	0.44	642	8
Block Group 5, Census Tract 2131.03	1621	0.28	514	8

Block Group Identifier	Total Population	Area (Sq. miles)	Households	Number of Respondents
Block Group 1, Census Tract 2131.04	2881	0.46	908	25
Block Group 2, Census Tract 2131.04	1654	0.58	462	13
Block Group 1, Census Tract 2132	1868	0.32	553	3
Block Group 2, Census Tract 2132	734	0.18	183	3
Block Group 1, Census Tract 9801*	686	1.06	0	0

*Residents are solely or primarily housed in military base housing.
Source: Population and area data from 2015-2019 American Community Survey.

Table A2. Comparison of Survey Universe to Survey Respondents

Socio-Economic Dimension	City of Portsmouth	Located Respondents	Unlocated Respondents
Household Size	2.50	2.25	3.15
Home Owner	55.0 %	86.1%	55.0%
Percent White	39.8%	58.1%	54.1%
Percent Black	52.9%	37.2%	44.6%
Income < $25K	24.5%	9.7%	26.4%
Income $25-45K	20.0%	23.0%	23.6%
Income $45-75K	25.2%	30.0%	31.9%
Income $75-125K	21.0%	25.1%	13.8%
Income > $125K	9.5%	12.2%	4.2%

Source: City of Portsmouth, 2015-2019 American Community Survey; Respondents, survey responses. Not all respondents answered all demographic questions, percentages based on those who did answer.

Table A3. Strata Block Group Combinations

Strata Name	Number of Respondents	Block Groups Included in Strata
Group 1	9	T2111 BG1, T2118 BG1, T2120 BG1, T2121 BG1
Group 2	12	T2104 BG1, T2116 BG1
Group 3	15	T2114 BG1, T2114 BG2, T2115 BG1, T2115 BG2
Group 4	9	T2123 BG1, T2124 BG1
Group 5	10	T2106 BG2, T2132 BG1
Group 6	8	T2111 BG2, T2132 BG2
Group 7	10	T2116 BG4, T2129 BG2
Group 2116	5	T2116 BG2, T2116 BG3
Group 2119	7	T2119 BG1, T2119 BG2
Group 2123	4	T2123 BG2, T2123 BG4
Group 2126	8	T2126 BG1, T2126 BG2, T2126 BG3
Group 21311	22	T2131.01 BG2, T2131.01 BG3

Table A4. Key Demographic Measures for Strata Used in the Analysis

	Overall Strata			Survey Respondents*		
Strata ID	Pct. Owners	Pct. White	Median Income	Pct. Owners	Pct. White	Median Income
2102_1	0.48	0.83	45-75K	0.89	0.89	45-75K
2102_2	0.56	0.74	45-75K	0.91	0.90	75-125K
2103_1	0.83	0.40	75-125K	1.00	0.75	75-125K
2103_2	0.68	0.77	25-45K	1.00	1.00	GT125K
2103_3	0.42	0.91	45-75K	0.57	1.00	25-45K
2105_1	0.15	0.02	LT25K	0.50	0.25	25-45K
2106_1	0.67	0.67	75-125K	1.00	1.00	45-75K
2109_1	0.22	0.45	25-45K	0.86	0.57	45-75K
2109_2	0.35	0.74	25-45K	0.78	0.87	75-125K
2116_5	0.42	0.84	25-45K	0.86	1.00	25-45K
2117_1	0.64	0.02	25-45K	1.00	0.17	45-75K
2117_2	0.72	0.29	25-45K	0.75	0.25	LT25K
2117_3	0.24	0.02	25-45K	0.33	0.40	25-45K
2118_2	0.65	0.15	25-45K	0.67	0.25	45-75K
2118_3	0.63	0.03	25-45K	0.60	0.00	45-75K
2118_4	0.10	0.00	LT25K	0.25	0.25	25-45K
2120_2	0.47	0.02	25-45K	0.71	0.00	25-45K
2121_2	0.25	0.04	25-45K	0.67	0.00	25-45K
2123_1	0.41	0.56	45-75K	1.00	0.88	25-45K
2124_2	0.48	0.40	45-75K	0.60	0.80	45-75K
2124_3	0.00	0.01	LT25K	0.25	0.33	45-75K
2125_1	0.76	0.59	45-75K	0.82	0.69	25-45K
21271_1	0.50	0.08	25-45K	1.00	0.00	25-45K
21271_2	0.77	0.00	45-75K	0.67	0.00	45-75K
21271_3	0.90	0.10	45-75K	0.91	0.05	45-75K
21271_4	0.91	0.02	45-75K	1.00	0.09	45-75K
21272_1	0.80	0.00	45-75K	0.79	0.00	25-45K
21272_2	0.67	0.03	45-75K	0.93	0.00	45-75K
21281_1	0.63	0.58	45-75K	0.78	0.75	25-45K
21281_2	0.28	0.32	25-45K	0.60	0.75	GT125K
21281_3	0.41	0.48	25-45K	0.86	0.60	25-45K
21282_1	0.79	0.70	45-75K	0.93	0.62	45-75K
21282_2	0.86	0.71	75-125K	0.81	0.78	45-75K
2129_1	0.92	0.85	75-125K	0.92	0.91	45-75K
2129_3	0.70	0.84	45-75K	0.90	0.78	45-75K
2129_3	0.74	0.75	45-75K	0.97	0.96	45-75K

Strata ID	Overall Strata Pct. Owners	Overall Strata Pct. White	Overall Strata Median Income	Survey Respondents* Pct. Owners	Survey Respondents* Pct. White	Survey Respondents* Median Income
21301_2	0.92	0.73	75-125K	1.00	0.86	45-75K
21301_3	0.95	0.52	75-125K	0.97	0.54	45-75K
21302_1	1.00	1.00	75-125K	1.00	0.94	75-125K
21302_2	0.75	0.83	45-75K	0.88	0.75	75-125K
21302_3	0.80	0.58	45-75K	1.00	0.83	75-125K
21311_1	0.35	0.10	25-45K	0.57	0.33	75-125K
21313_1	0.90	0.75	75-125K	1.00	0.83	75-125K
21313_2	0.76	0.49	75-125K	0.88	0.67	45-75K
21313_3	0.40	0.36	45-75K	0.94	0.58	45-75K
21313_4	0.29	0.18	45-75K	0.88	0.71	25-45K
21313_5	0.79	0.37	45-75K	1.00	0.29	75-125K
21314_1	0.79	0.16	75-125K	0.92	0.22	75-125K
21314_2	0.92	0.39	75-125K	0.92	0.50	75-125K
Group1	0.21	0.02	25-45K	0.44	0.13	25-45K
Group2	0.57	0.67	45-75K	0.92	0.91	45-75K
Group3	0.38	0.23	25-45K	0.73	0.30	45-75K
Group4	0.25	0.37	25-45K	0.67	0.50	25-45K
Group5	0.41	0.46	45-75K	1.00	0.60	75-125K
Group6	0.21	0.22	25-45K	0.50	0.29	45-75K
Group7	0.65	0.76	45-75K	0.80	0.86	45-75K
Group2116	0.66	0.69	45-75K	1.00	1.00	45-75K
Group2119	0.61	0.12	25-45K	0.86	0.14	45-75K
Group2123	0.51	0.42	25-45K	0.50	0.00	45-75K
Group2126	0.66	0.58	45-75K	0.50	0.57	45-75K
Group21311	0.32	0.31	45-75K	0.82	0.35	45-75K

Source: Strata demographics from 2015-2019 American Community Survey, Respondent demographics from survey responses.

*Not all survey respondents provided demographic information.

Figure A1. Timing of Reported Car Damage Occurrences

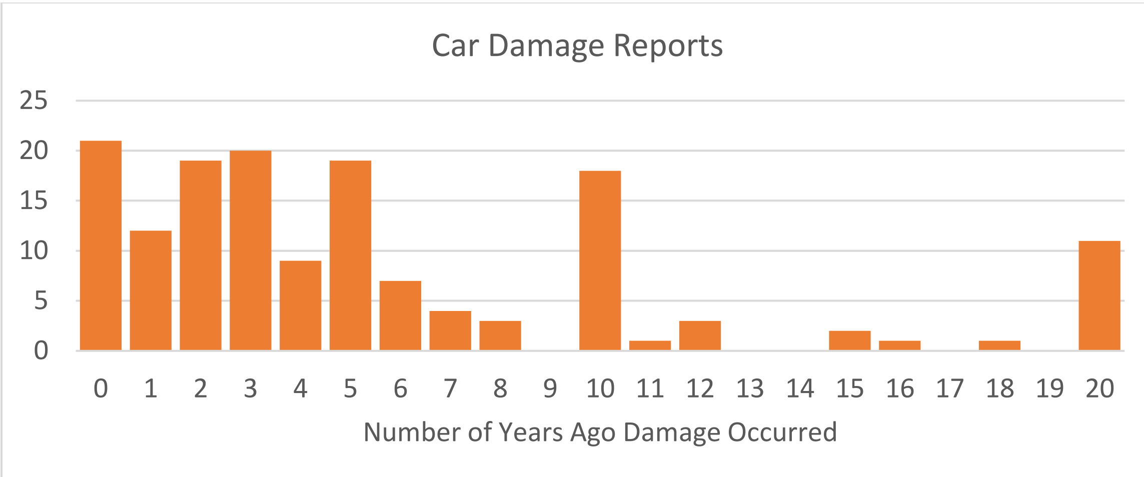


Figure A2. Timing of Reported Property Damage Occurrences

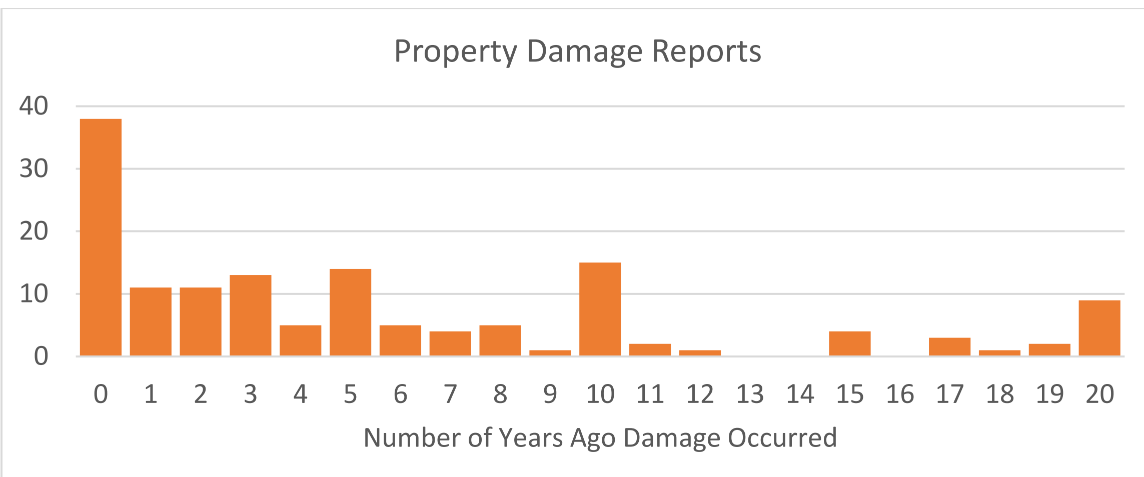
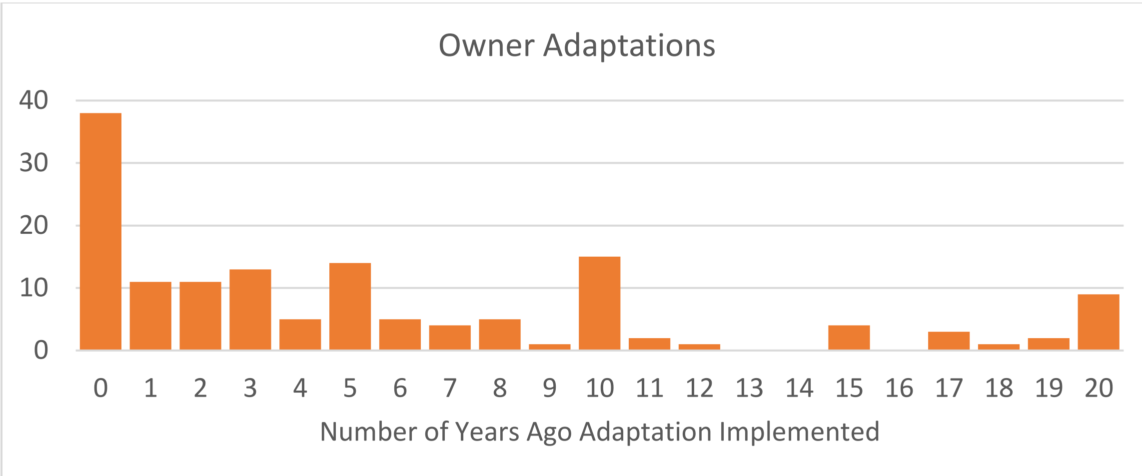


Figure A3. Timing of Reported Owner Adaptations



APPENDIX B: Survey Instrument

Hello, my name is <?> and I'm calling on behalf of Old Dominion University. We are calling to interview you about flooding in Portsmouth and how it has impacted your household. Any experiences you share with us will remain completely confidential and your participation is voluntary.

It should only take 7 minutes. Do you have time to complete the interview with me now? Great! To check, you are 18 years old, correct?

Let's begin by talking about your recent experiences with flooding.

Experiences with Flooding

Q1
Within the past year, has anybody in your households had to alter their drive to work or school, such as leaving earlier or later or taking a different route, because of flooding somewhere in Portsmouth?
Yes..01
No...02
Don't Know 88
Refuse 99

Q2
Within the past year, somebody in my household was late or delayed in getting to work due to flooding.
Yes..01
No...02
Don't Know 88
Refuse 99

Q3
Within the past year, somebody in my household was unable to get to work for an entire day due to flooding?
Yes..01
No...02
Don't Know 88
Refuse 99

Q4
Within the past year, somebody in my household lost pay due to flooding?
Yes..01
No...02
Don't Know 88
Refuse 99

Q5
Has anybody in your household been unable to get either in or out of your neighborhood because of flooding?

Yes 01
No 02
Don't Know 88
Refuse 99

Q6

How often does either the street in front of your home, or the streets very near your home, flood? Would you say, more than once a month, once of month, couple times a year, once a year, once every couple of years, or rarely if ever?

More than once a month 01
Once a month..02
Couple times a year 03
Once a year 04
Once every couple of years...05
Rarely if ever 06
Don't Know 88
Refuse 99

Risk Perceptions

Q7

Looking ahead, do you think flooding in the City of Portsmouth in general will increase, stay the same, or decrease in the next 20 years?

Increase..01
Stay the same..02
Decease...03
Don't Know 88
Refuse 99

Q8

Thinking ahead in about 20 years, do you believe your home specifically will have flood water come into the living area at least one time?

Yes 01
No 02
Don't Know 88
Refuse 99

Q9

What would you say is the probability between 0 and 100 that Portsmouth will be struck by a catastrophic hurricane within the next 10 years? 0 percent means it absolutely will not happen, and 100 percent means it absolutely will happen.

0 Percent ....01 SKIP TO Q12
1-100 Percent ....02 open
Don't Know 88
Refuse 99

Q10

If such hurricane hit Portsmouth, what would you say is the probability that your home would flood, 0 percent means it absolutely will not flood, and 100 percent means it absolutely will flood.

0 Percent .... 01 SKIP TO Q12
1-100 Percent .... 01 open
Don't Know 88
Refuse 99

Q11

What is the percent chance, 0 to a 100, that the damage to your home would be so extensive that you would no longer be able to live in it?

Percent .... 01 open
Don't Know 88
Refuse 99

Q12

For the following three statements, please tell me if you Strongly Agree, Agree, Disagree, or Strongly Disagree. Okay, here is the first one: Sea level rise and neighborhood flooding in the City of Portsmouth are related issues.

Strongly Agree 01
Agree 02
Disagree 02
Strongly Disagree 02
Don't Know 88
Refuse 99

Q13

Here is the second one: Sea level rise will negatively impact the economic opportunities for Portsmouth citizens.

Strongly Agree 01
Agree 02
Disagree 02
Strongly Disagree 02
Don't Know 88
Refuse 99

Q14

And here is the third one: There is not yet enough solid information about sea level rise for the City of Portsmouth to invest money into responding to it.

Strongly Agree 01
Agree 02
Disagree 02
Strongly Disagree 02
Don't Know 88
Refuse 99

Car & Property Damage

Q15

While living in Portsmouth, has anyone in your household suffered any damage to any CARS due to flooding?

Yes 01
No..02 SKIP TO Q19
Don't Know ....88 SKIP TO Q19
Refuse ....99 SKIP TO Q19

Q16

Thinking back, in total, for all the times a car was damaged due to flooding, how many days, if any, of work would you say were missed due to the car being damaged?

Total # days of missed work...01 open
Don't Know 88
Refuse 99

Q17

How many days, if any, in total, of school were missed by household members due to damaged cars?

Total # days of missed school ....01 open
Don't Know 88
Refuse 99

Q18

Can you recall for me for each time a car was damaged about how long ago the damage happened and how much it cost to fix the car?

Car 1: # years ago and $ damage cost ....01 open
Car 2: # years ago and $ damage cost ....02 open
Car 3: # years ago and $ damage cost ....03 open
Car 4: # years ago and $ damage cost ....04 open
Car 5: # years ago and $ damage cost ....05 open
Car 6: # years ago and $ damage cost ....06 open
Car 7: # years ago and $ damage cost ....07 open
No, cannot recall/Don't Know 88
Refuse 99

Q19

While living in Portsmouth, has your household suffered any property damage to a HOME OR THE CONTENTS OF THE HOME due to flooding?

Yes 01
No..02 SKIP TO Q23
Don't know..88 SKIP TO Q23
Refuse ....99 SKIP TO Q23

Q20

Thinking back, in total, for all the times a home was damaged due to flooding, how many days, if any, of work would you say were missed due to the home damage?

Total # days of missed work..01 open
Don't know...88
Refuse 99

Q21
How many days, if any, in total, of school were missed due to home damages?
Total # days of missed school ....01 open
Don't know...88
Refuse 99

Q22
Can you recall for me for each time the home was damaged, about how long ago it happened and how much it cost?
Home/contents 1: # years ago and $ damage cost ....01 open
Home/contents 1: # years ago and $ damage cost ....02 open
Home/contents 1: # years ago and $ damage cost ....03 open
Home/contents 1: # years ago and $ damage cost ....04 open
Home/contents 1: # years ago and $ damage cost ....05 open
Home/contents 1: # years ago and $ damage cost ....06 open
Home/contents 1: # years ago and $ damage cost ....07 open
No, cannot recall/Don't Know 88
Refuse 99

Renter: Changes to Property

Q23
Does your household rent or own the place where you are now?
Rent/lease 01
Own/mortgage...02 SKIP TO Q28
Don't Know ....88 SKIP TO Q36
Refuse ....99 SKIP TO Q36

Q24
Has your landlord, to your knowledge, taken any steps to protect the property from flooding?
Yes 01
Done nothing/has not taken steps ....02 SKIP TO Q26
Don't Know ....88 SKIP TO Q26
Refuse ....99 SKIP TO Q26

Q25
Please describe what the landlord has done to protect the property from flooding.
Protective step 1 ....01 open
Protective step 2 ....02 open
Protective step 3 ....03 open
Protective step 4 ....04 open
Don't Know/Not my problem 88

Refuse 99

Renter: Insurance

Q26

Does your household pay for Renters Insurance?

Yes 01
No ....02 SKIP TO Q36
Don't know ....88 SKIP TO Q36
Refuse ....99 SKIP TO Q36

Q27

Does the Renters Insurance that you pay for also include a Preferred Risk Policy that covers damage to the contents of your home specifically from storm flooding?

Yes ....01 SKIP TO Q36
No ....02 SKIP TO Q36
Don't know ....88 SKIP TO Q36
Refuse ....99 SKIP TO Q36

Homeowner: Changes to Property

Q28

Is your home paid off or do you still have a mortgage?

Paid off/no mortgage 01
Not paid off/still have a mortgage 02
Other ....03 open
Don't Know 88
Refuse 99

Q29

Do you think the flooding as well as the threat of flooding in the City of Portsmouth has negatively impacted the value of your home?

Yes 01
No/not really ....02 SKIP TO Q31
Don't Know ....88 SKIP TO Q31
Refuse ....99 SKIP TO Q31

Q30

In your opinion, roughly what percent less is the value of your home due to this flooding and the threat of flooding?

Percent ....01 open
Don't Know 88
Refuse 99

Q31

While living in Portsmouth, has your household made any changes to your property specifically in response to flooding?

Yes..01
No..02 SKIP TO Q33
Don't Know ....88 SKIP TO Q33
Refuse ....99 SKIP TO Q33

Q32

Please tell me the changes you made to your property, about how long ago it was, and about how much each cost you.

Change 1: description, #years, and $ cost ....01 open
Change 2: description, #years, and $ cost ....02 open
Change 3: description, #years, and $ cost ....03 open
Change 4: description, #years, and $ cost ....04 open
Change 5: description, #years, and $ cost ....05 open
Change 6: description, #years, and $ cost ....06 open
Change 7: description, #years, and $ cost ....07 open
Don't Know 88
Refuse 99

Homeowner: Insurance

Q33

Standard homeowner's insurance is different than flood insurance which is offered through the Federal government. Does your home have an insurance policy with the government's National Flood Insurance Program?

Yes..01 SKIP TO Q35
No..02
Don't Know ....88 SKIP TO Q36
Refuse ....99 SKIP TO Q36

Q34

What do you think are some of the reasons why your household does not have flood insurance?

DO NOT READ RESPONSE OPTIONS; CHECK ALL THAT APPLY

Other:..01 open, SKIP TO Q36
Too expensive, can't afford it ....02 SKIP TO Q36
Didn't know I could get it...03 SKIP TO Q36
Didn't know *how* I could get it/hard to find info ....04 SKIP TO Q36
Don't need it ....05 SKIP TO Q36
Not required to have it, mortgage doesn't require it................06 SKIP TO Q36
Not in flood zone, flood plain ....07 SKIP TO Q36
Not at risk, not enough risk to justify getting it.........................08 SKIP TO Q36
Never flooded here before, never needed it before ....09 SKIP TO Q36
Not my job/responsibility, somebody else manages that ....10 SKIP TO Q36
Government will help me if it floods ....11 SKIP TO Q36
I had flood insurance but I dropped it ....12 SKIP TO Q36

Not sure/Don't Know ....88 SKIP TO Q36
Refuse ....99 SKIP TO Q36

Q35
Could you tell me some of the reasons your household has flood insurance?
DO NOT READ THE RESPONSE OPTION; CHECK ALL THAT APPLY
Other: ....01 open
Mortgage/lender requires it 02
It is affordable 03
Flood risk is high...04
Want to protect my assets/family 05
Insurance agent recommended it...06
Don't have enough money for repairs/rebuild....................................07
Don't Know 88
Refuse 99

Information Sources

Q36
When you want to find out if roads are flooding, where do you usually turn to get information?
DO NOT READ THE RESPONSE OPTIONS; CHECK ALL THAT APPLY
Other: ....01 open
Call 511 for road info 02
My social media 03
Street/route/driving app..04
Flooding app..05
Local news/TV/radio 06
VDOT road cameras 07
Text message alerts...08
Word of mouth friends, neighbors, family 09
Don't Know 88
Refuse 99

Asthma

Q37
What are the ages of any members of your household that have been told by a doctor, nurse, or other health professional that they currently have asthma, if any?
Person 1 with asthma: Age ....01 open
Person 2 with asthma: Age ....02 open
Person 3 with asthma: Age ....03 open
Person 4 with asthma: Age ....04 open
Person 5 with asthma: Age ....05 open
Person 6 with asthma: Age ....06 open
Person 7 with asthma: Age ....07 open
Person 8 with asthma: Age ....08 open
Person 9 with asthma: Age ....09 open

No persons in household with Asthma .... 10 SKIP TO Q40
Don't Know .... 88 SKIP TO Q40
Refuse .... 99 SKIP TO Q40

Q38
Has anybody in your household with asthma been to the Emergency Department or Urgent Care within the past year because of that asthma?
Yes 01
No .... 02 SKIP TO Q40
Don't Know .... 88 SKIP TO Q40
Refuse .... 99 SKIP TO Q40

Q39
If you could, please tell me the age of each person that went to either the Emergency Department or Urgent Care and the total number of times they went
Person 1: Age and number of total visits .... 01 open
Person 2: Age and number of total visits .... 02 open
Person 3: Age and number of total visits .... 03 open
Person 4: Age and number of total visits .... 04 open
Person 5: Age and number of total visits .... 05 open
Person 6: Age and number of total visits .... 06 open
Person 7: Age and number of total visits .... 07 open
Person 8: Age and number of total visits .... 08 open
Person 9: Age and number of total visits .... 09 open
Don't Know 88
Refuse 99

Q40
Thinking about the inside of your home, have you noticed any mold, mildew, or fungus on any surfaces such as walls, floors, ceilings, or around windows?
Yes 01
No .... 02 SKIP TO Q46
Don't Know .... 88 SKIP TO Q46
Refuse .... 99 SKIP TO Q46

Business: Impacts, Flood Insurance

Q41
Is there a member of your household that is owns a business?
Yes 01
No 02
Don't Know 88
Refuse 99

Q42

Is the business primary a home-based business, largely run out of the home?
Yes 01
No 02
Don't Know 88
Refuse 99

Q43
Can you tell me some of the ways, if any, that flooding has impacted the business?
Other ....01 open
Loss of power 02
Could not get to customers 03
Customers could not get to the business 04
Employees late/missed work 05
Supplies/suppliers/supply chain disrupted..............................06
Don't Know 88
Refuse 99

Q44
Does the business have flood insurance?
Yes 01
No ....02 SKIP TO Q46
Don't Know ....88 SKIP TO Q46
Refuse ....99 SKIP TO Q46

Q45
Why do you think the business does not have flood insurance?
Too few assts to insure, small business 01
Not enough risk to justify getting it 07
Too expensive, business can't afford it.....................................01
Didn't know the business could get it.......................................02
Didn't know *how* the business could get it/hard to find info 03
Not required to have it, so business does not have it 05
Never flooded before, never needed it before..........................08
Don't really need it 04
Government will help business if it floods................................10
Business had flood insurance at one time, but dropped it.........11
Other ....12 open
Not sure/Don't Know 88
Refuse 99

Household Characteristics

Q46
Are there members of your household that work in the City of Portsmouth?
Yes 01
No 02
Don't Know 88

Refuse 99

Q47
How many years has your household lived in the current location?
Years...01 open
Don’t Know 88
Refuse 99

Q48
How many people, including yourself, live in your household?
Number ....01 open
Don't know..88
Refuse 99

Q49
How would you characterize the overall race or ethnicity of your household?
DO NOT READ RESPONSE OPTIONS; CHECK ALL THAT APPLY
White..01
Anglo 02
European..03
Caucasian 04
North African...05
Middle Eastern 06
African American...07
Black 08
Saharan or Sub-Saharan African 09
Caribbean 10
Islands 11
American Indian 12
Central American 13
Alaskan Native...14
Asian..15
Far Eastern 16
Southeastern Asian 17
Subcontinent Indian..18
Filipino...19
Native Hawaiian 20
Pacific Islander 21
Hispanic...22
Latino 23
Latina...24
Latinx...25
Other ....26 open
Don’t Know 88
Refuse 99

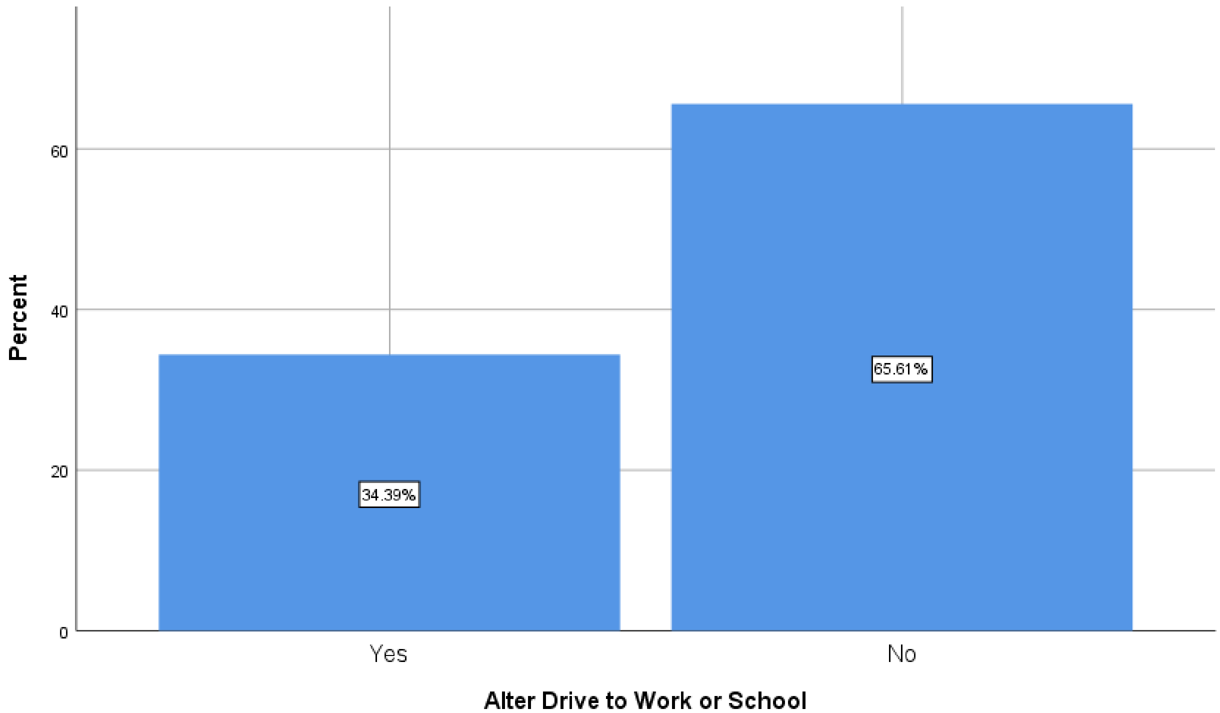
Q50

What is your annual household income? I will read a list and you can stop me when I get to the category that includes your household income.

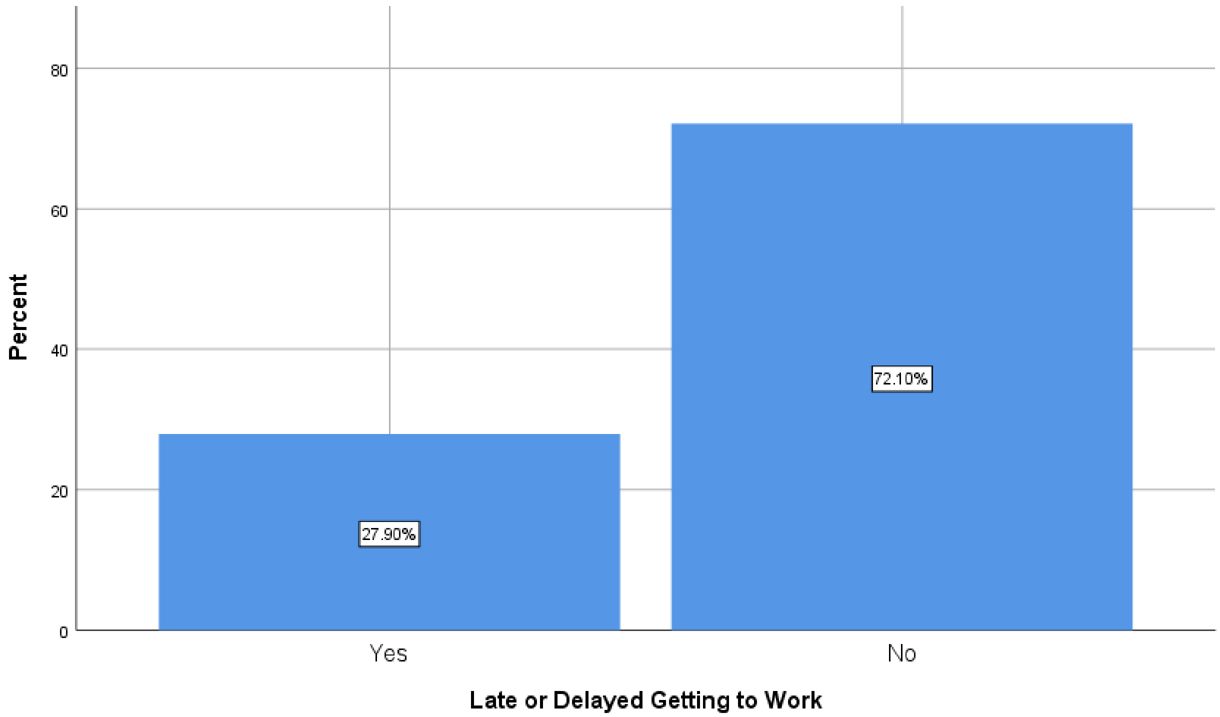
Would you say, less than $10,000 01
$10,001 up to $25,000...02
$25,001 up to $35,000...03
$35,001 up to $45,000...04
$45,001 up to $55,000...05
$55,001 up to $65,000...06
$65,001 up to $75,000...07
$75,001 up to $85,000...08
$85,001 up to $95,000...09
$95,001 up to $105,000...10
$105,001 up to $115,000...11
$115,001 up to $125,000...12
More than $125,000 13
Don't know..88
Refuse 99

APPENDIX C: Extended Survey Results

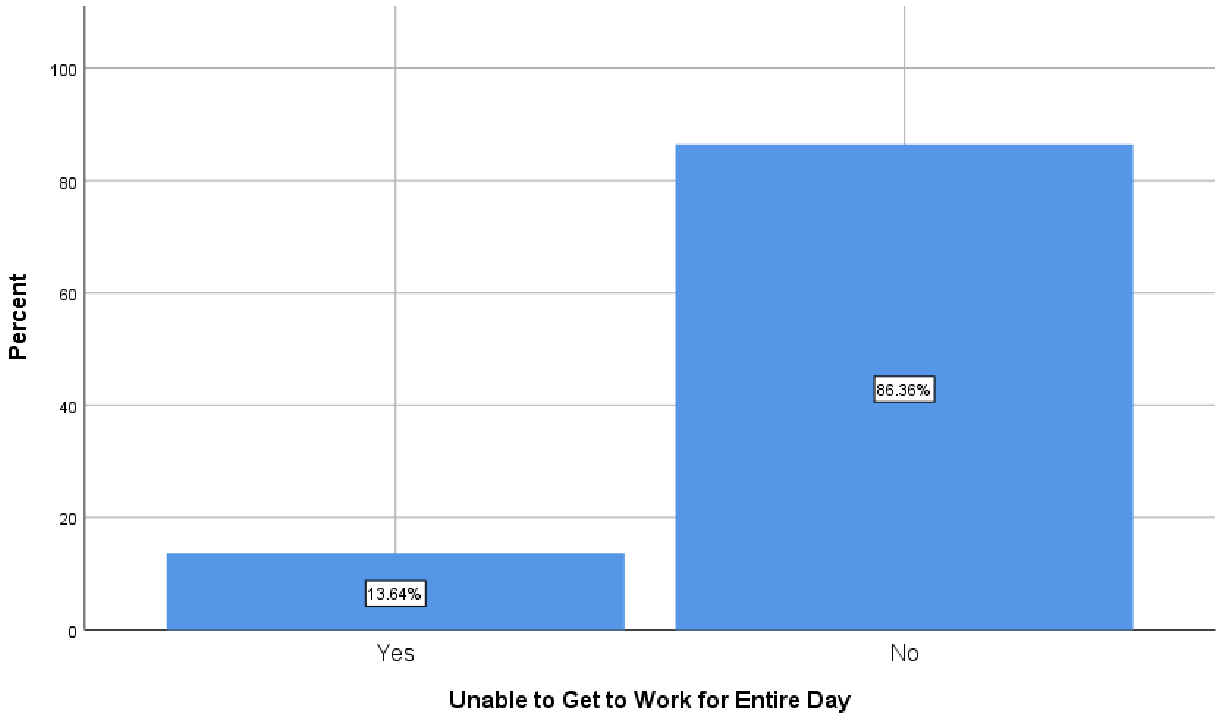
Alter Drive to Work or School



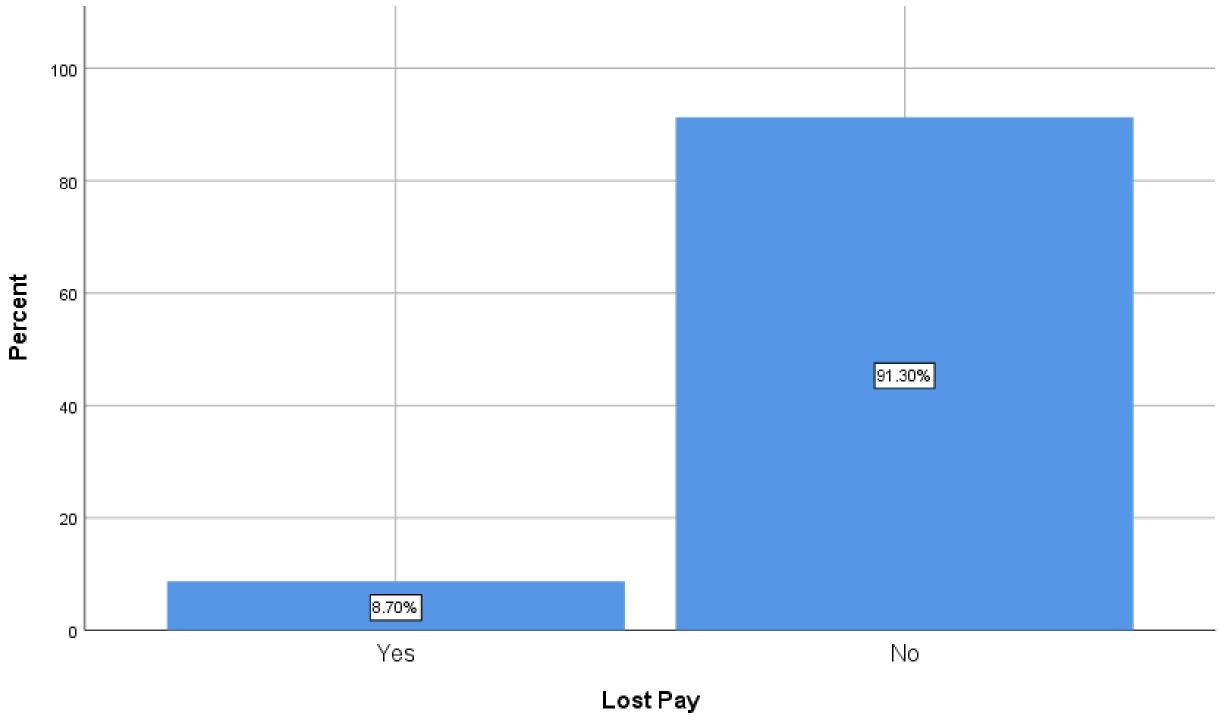
Late or Delayed Getting to Work



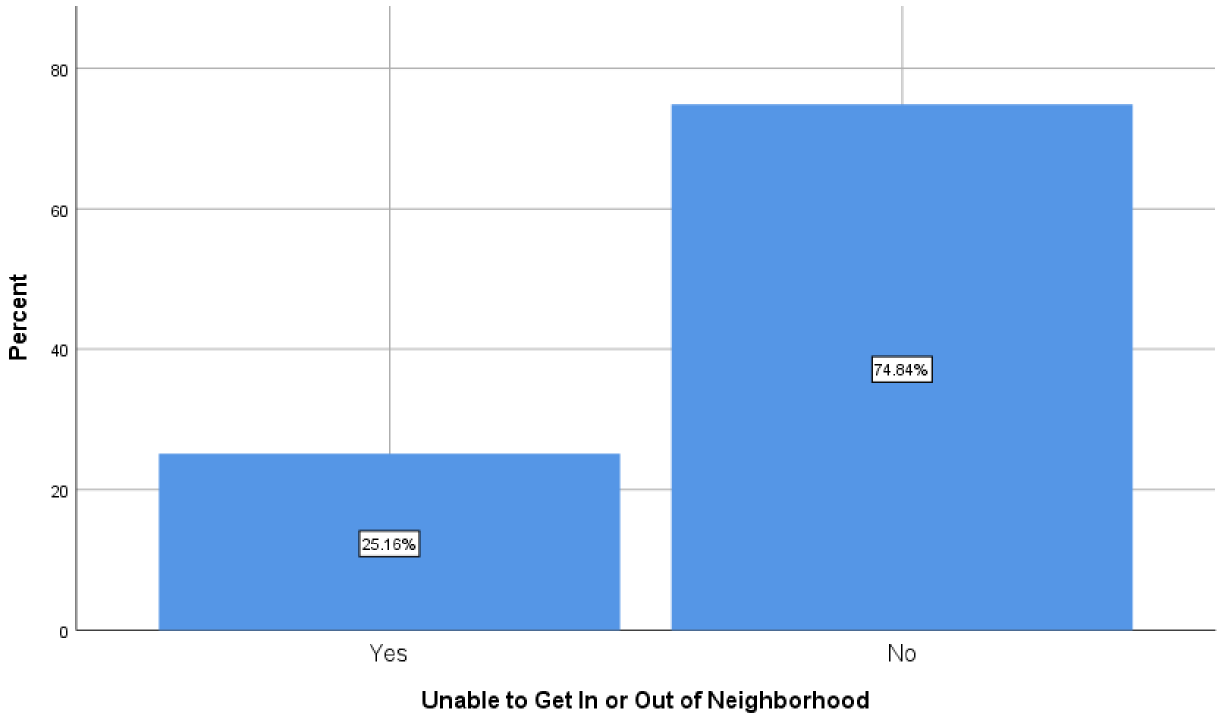
Unable to Get to Work for Entire Day



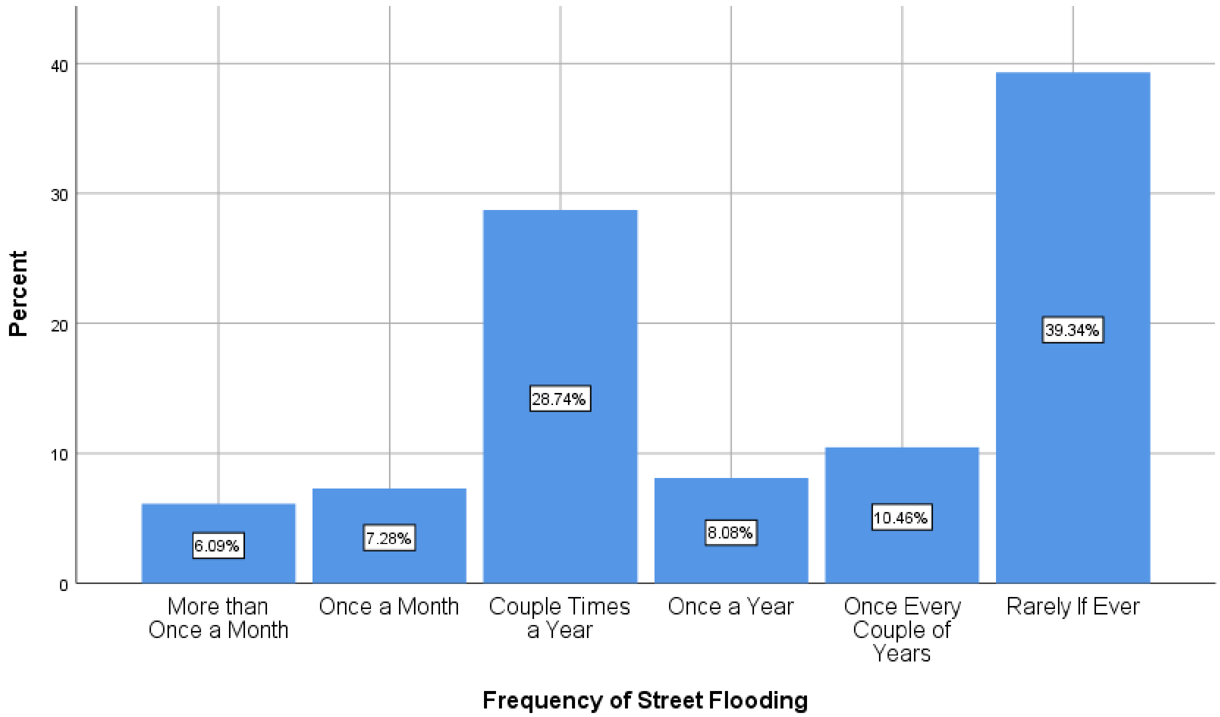
Lost Pay



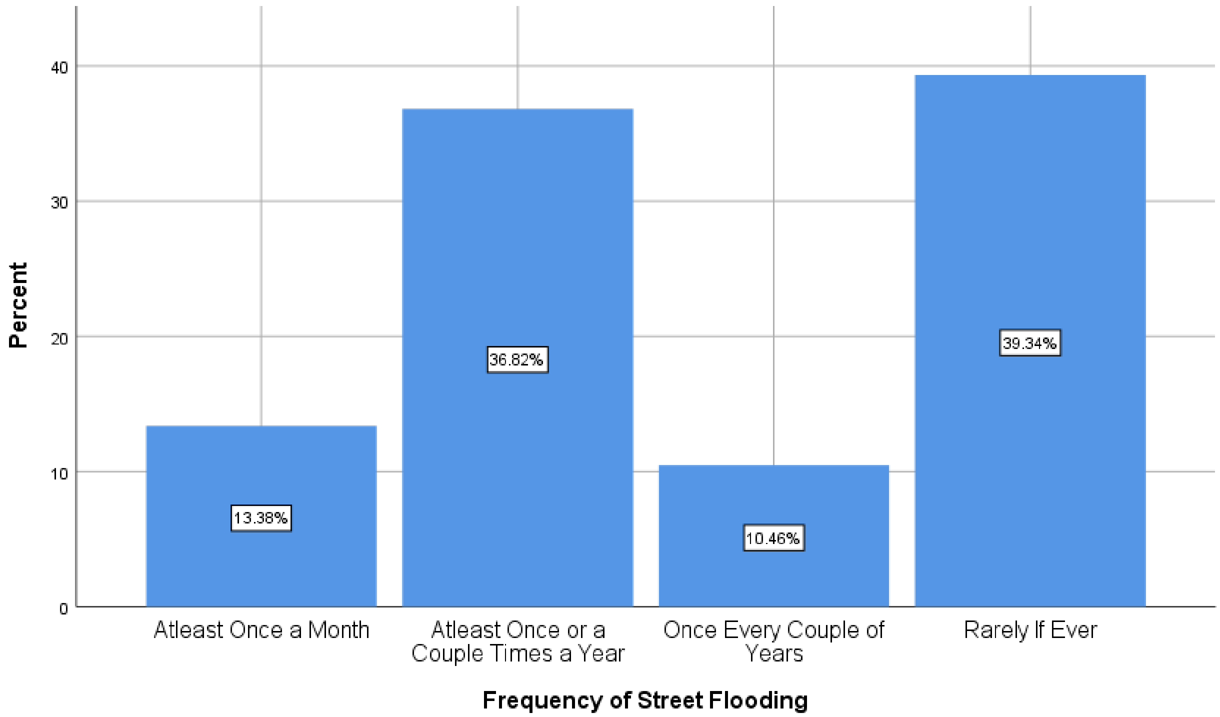
Unable to Get In or Out of Neighborhood



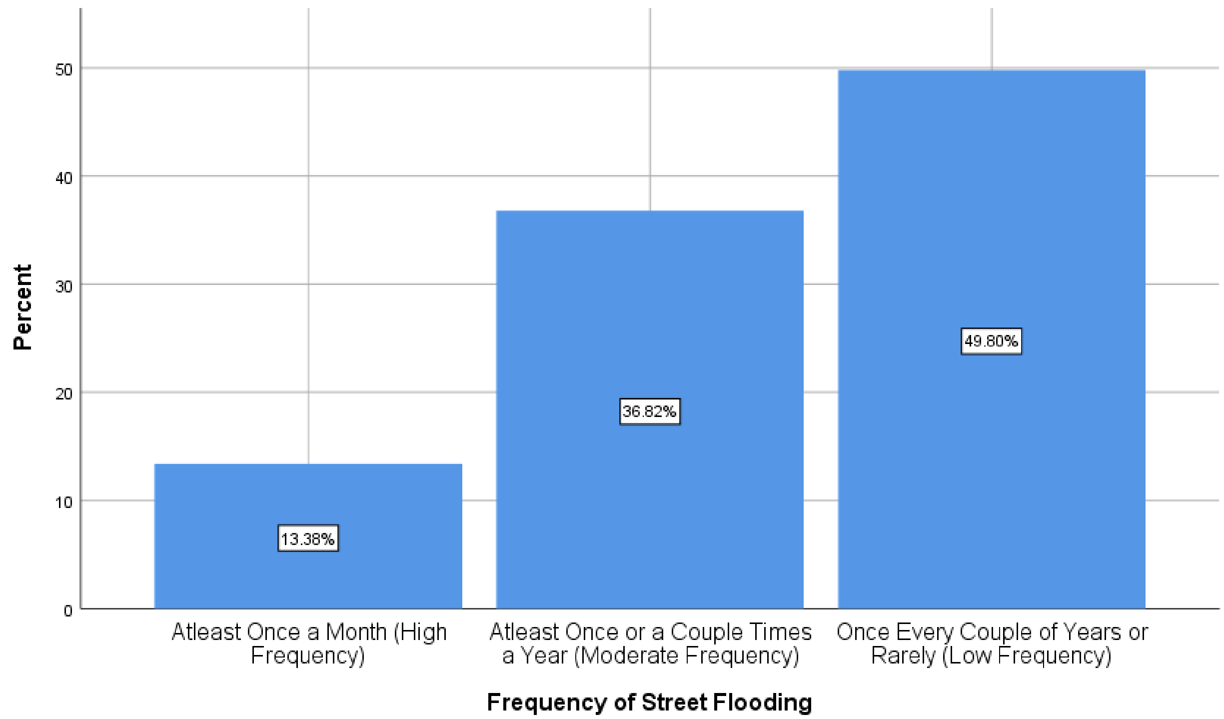
Frequency of Street Flooding (6 attributes)



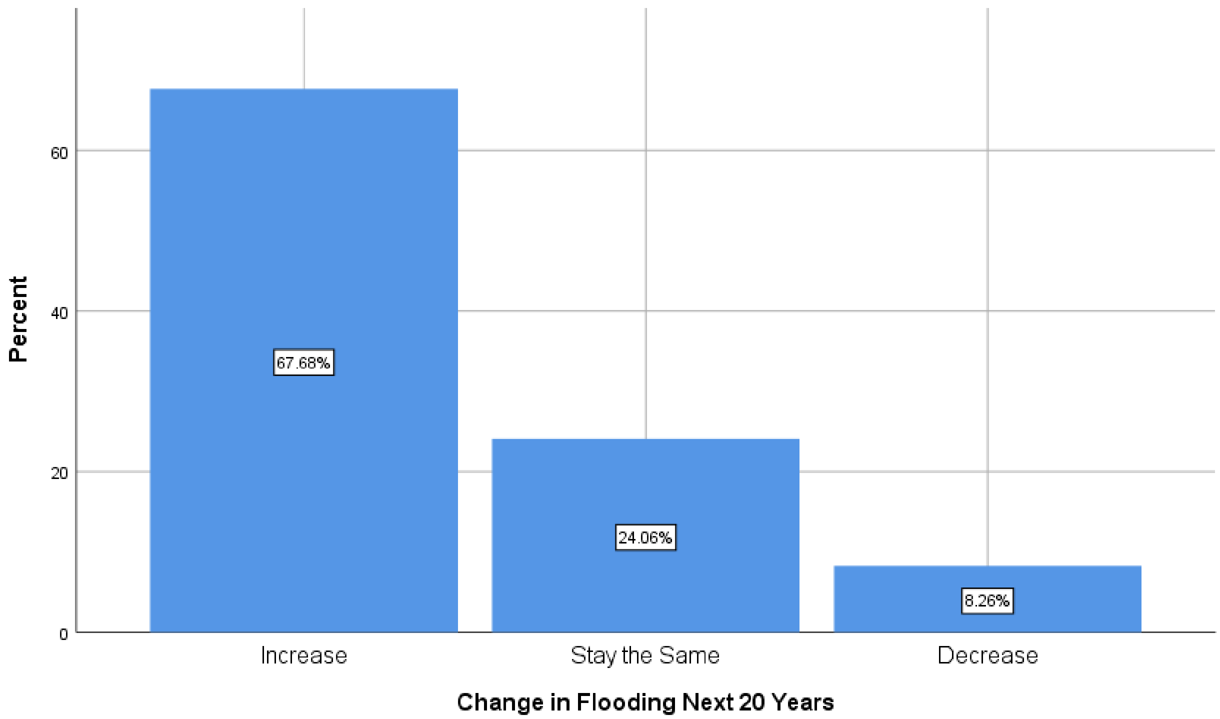
Frequency of Street Flooding (4 attributes)



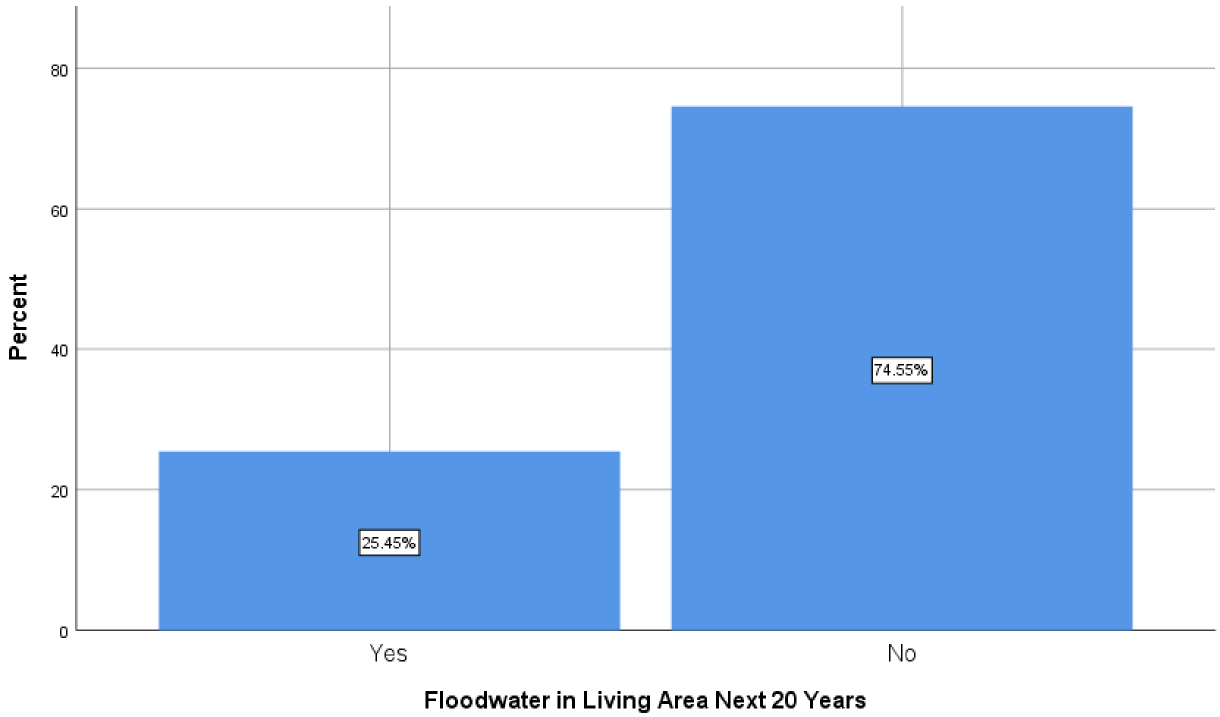
Frequency of Street Flooding (3 attributes)



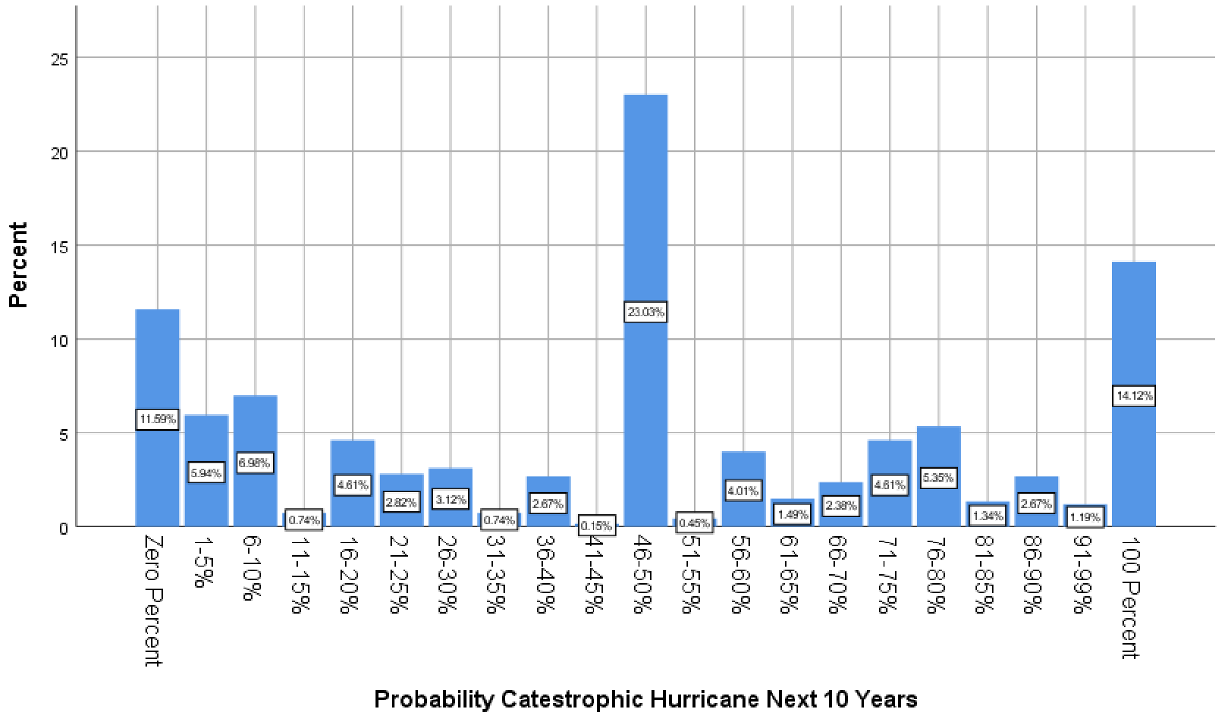
Change in Flooding Next 20 Years



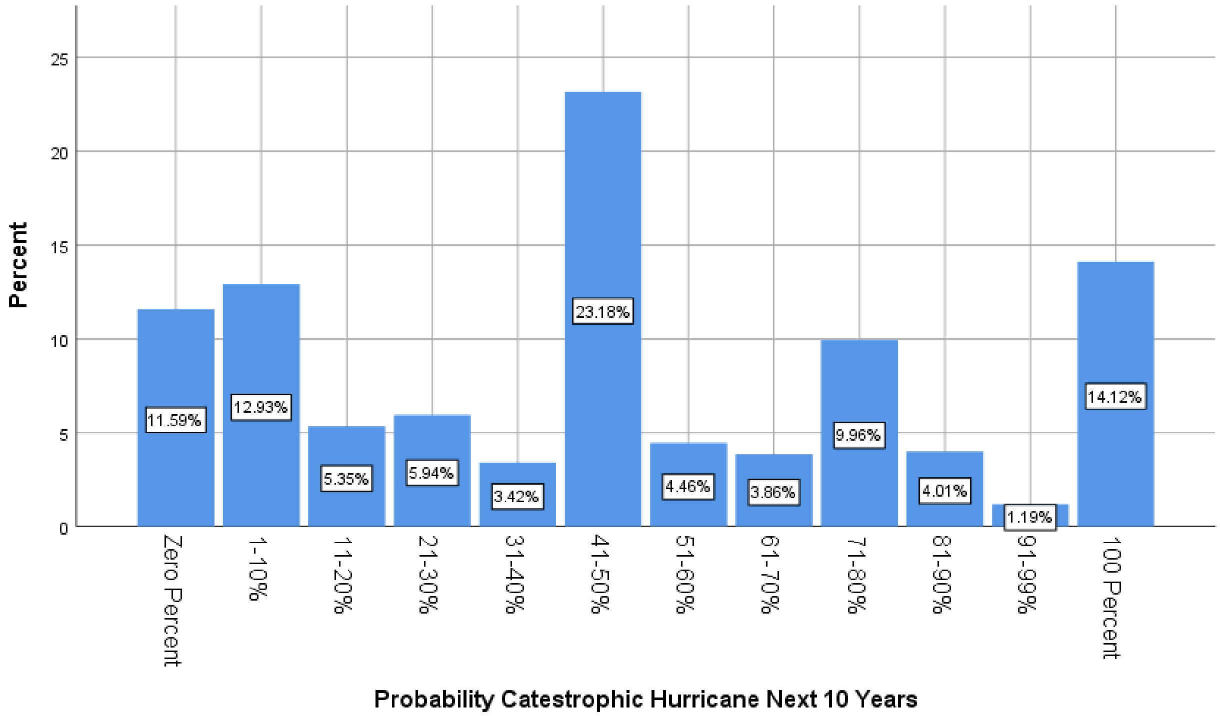
Floodwater in Living Area Next 20 Years



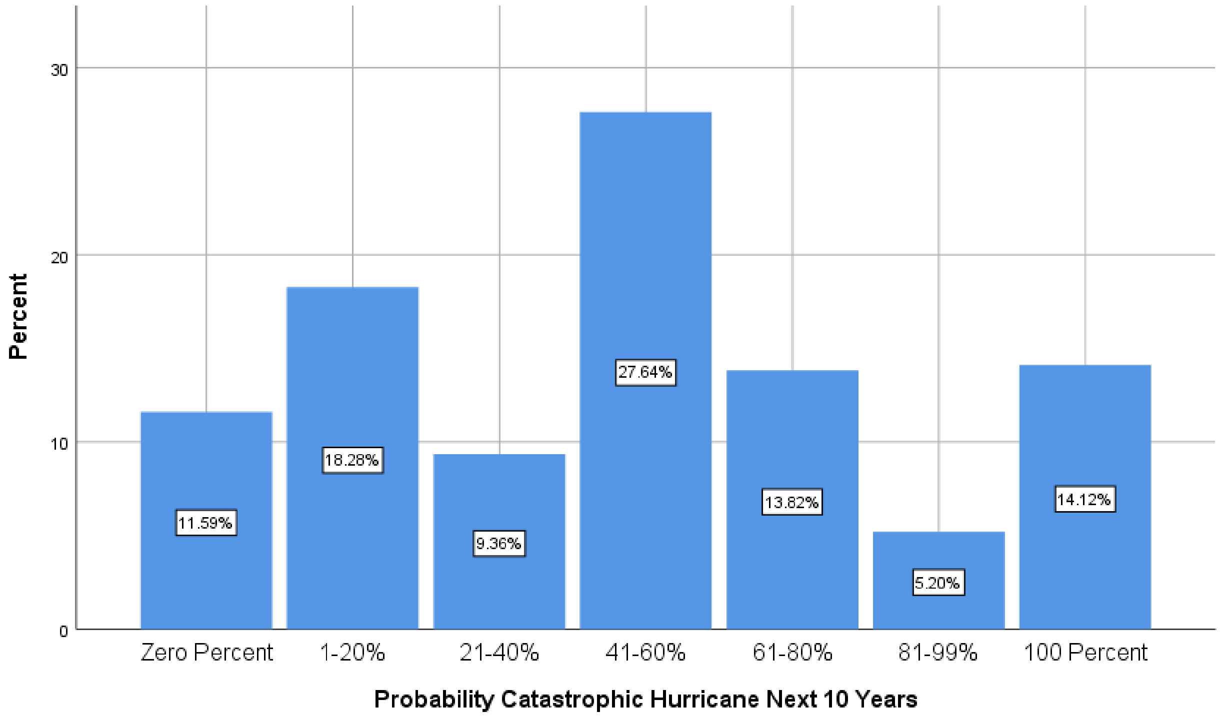
Probability Catastrophic Hurricane Next 10 Years (21 attributes)



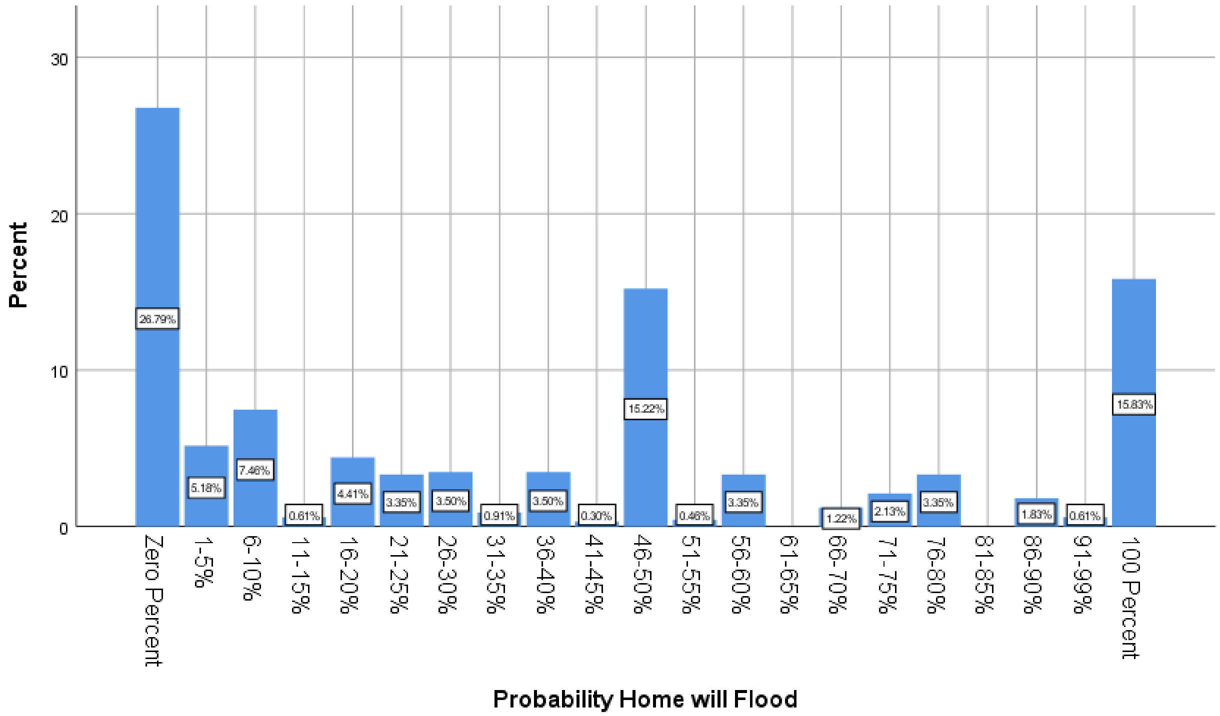
Probability Catastrophic Hurricane Next 10 Years (11 attributes)



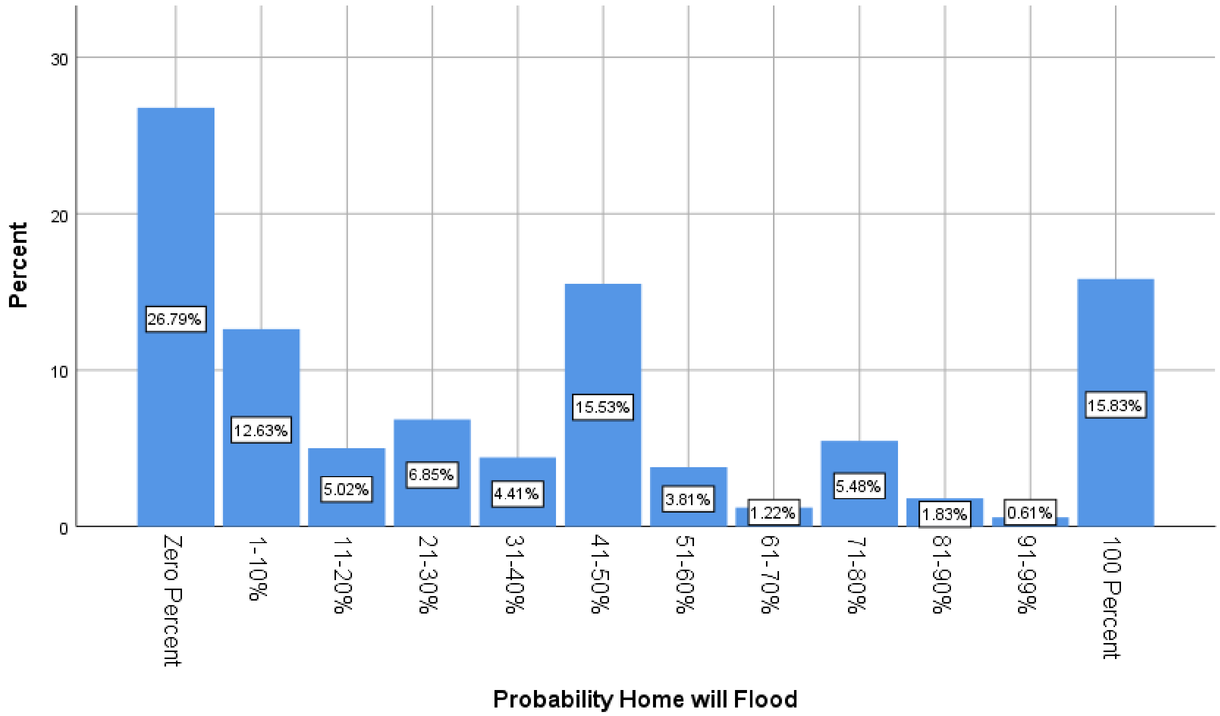
Probability Catastrophic Hurricane Next 10 Years (7 attributes)



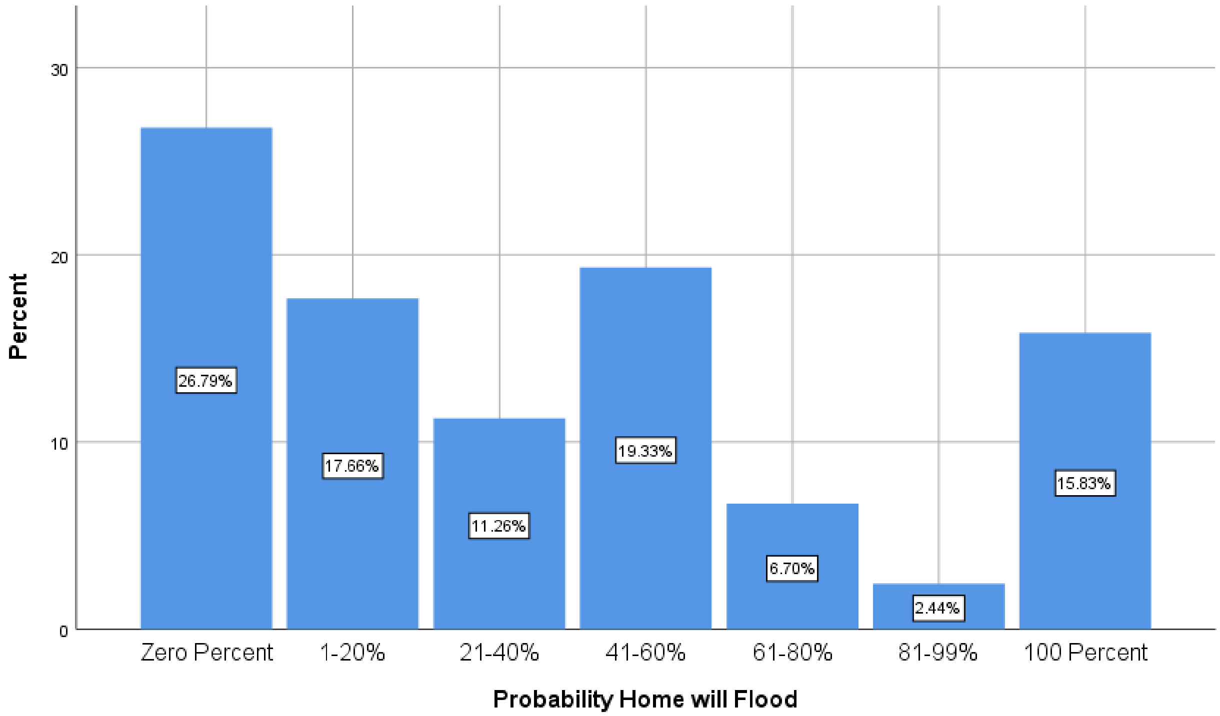
Probability Home will Flood (21 attributes)



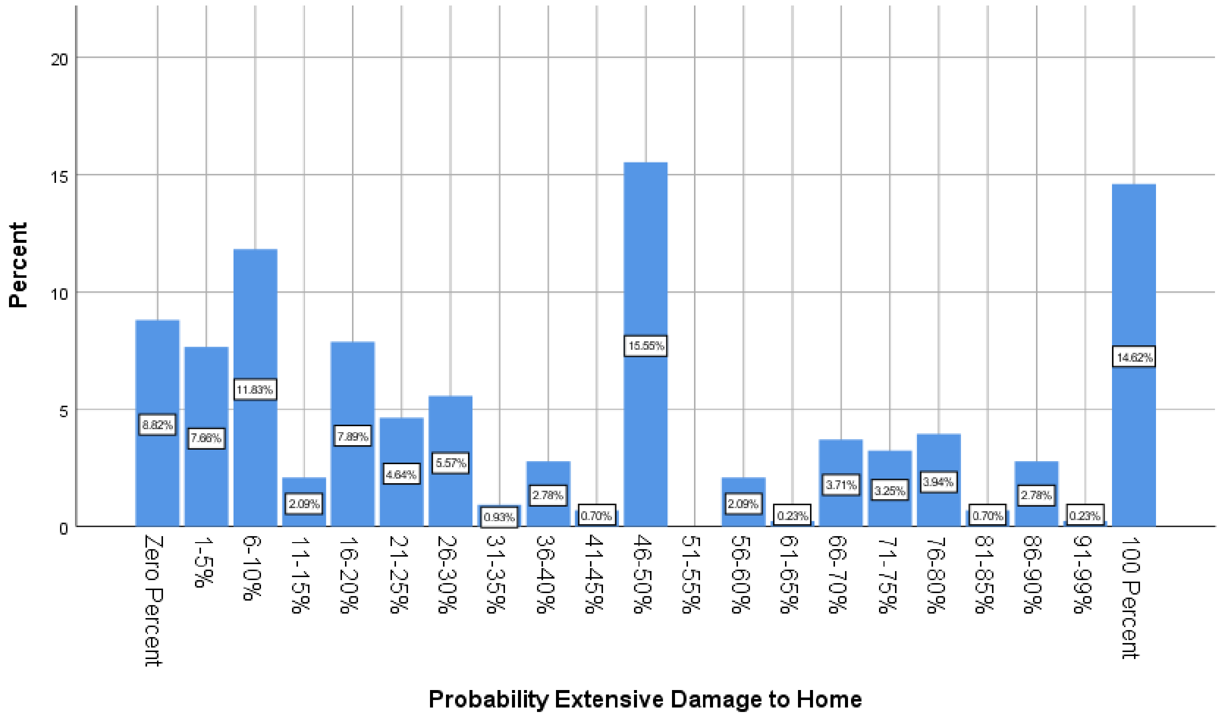
Probability Home will Flood (11 attributes)



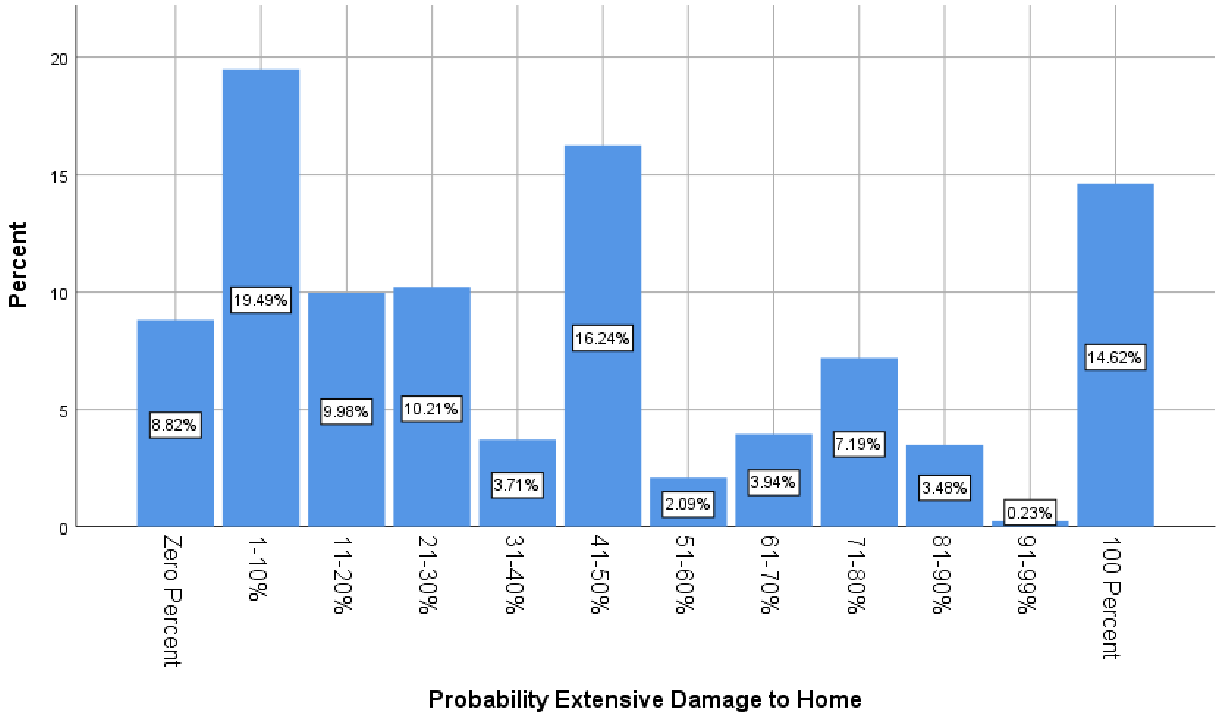
Probability Home will Flood (7 attributes)



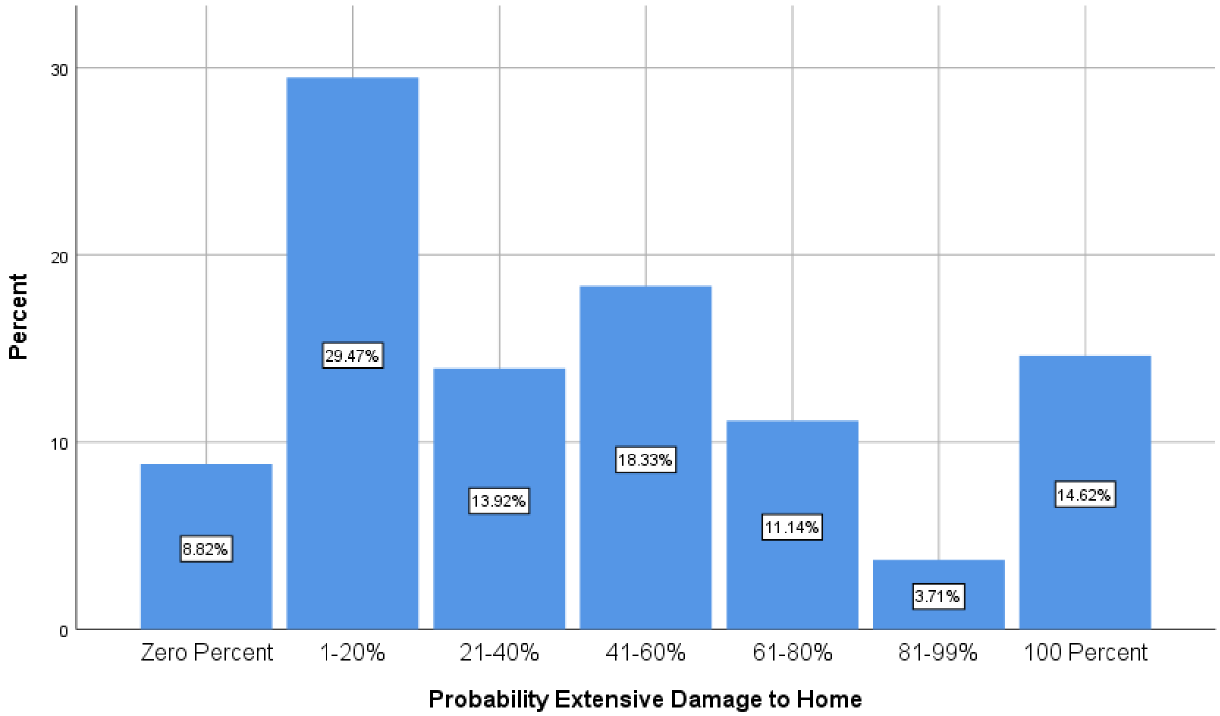
Probability Extensive Damage to Home (21 attributes)



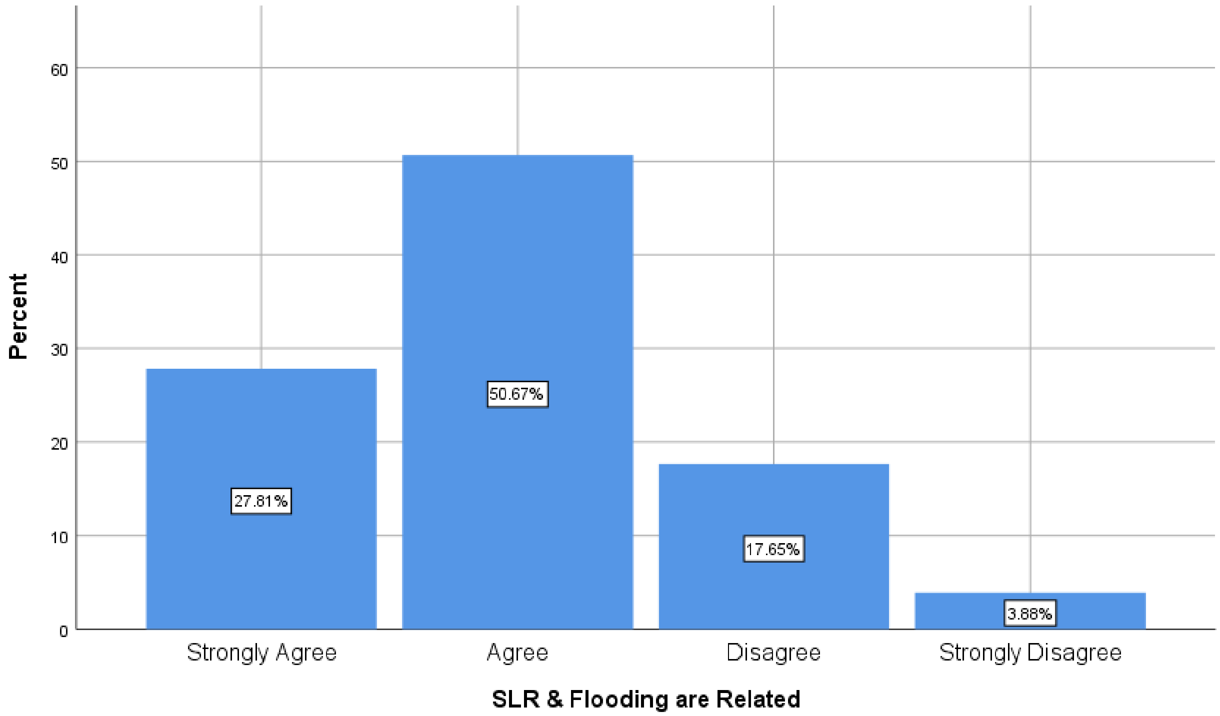
Probability Extensive Damage to Home (11 attributes)



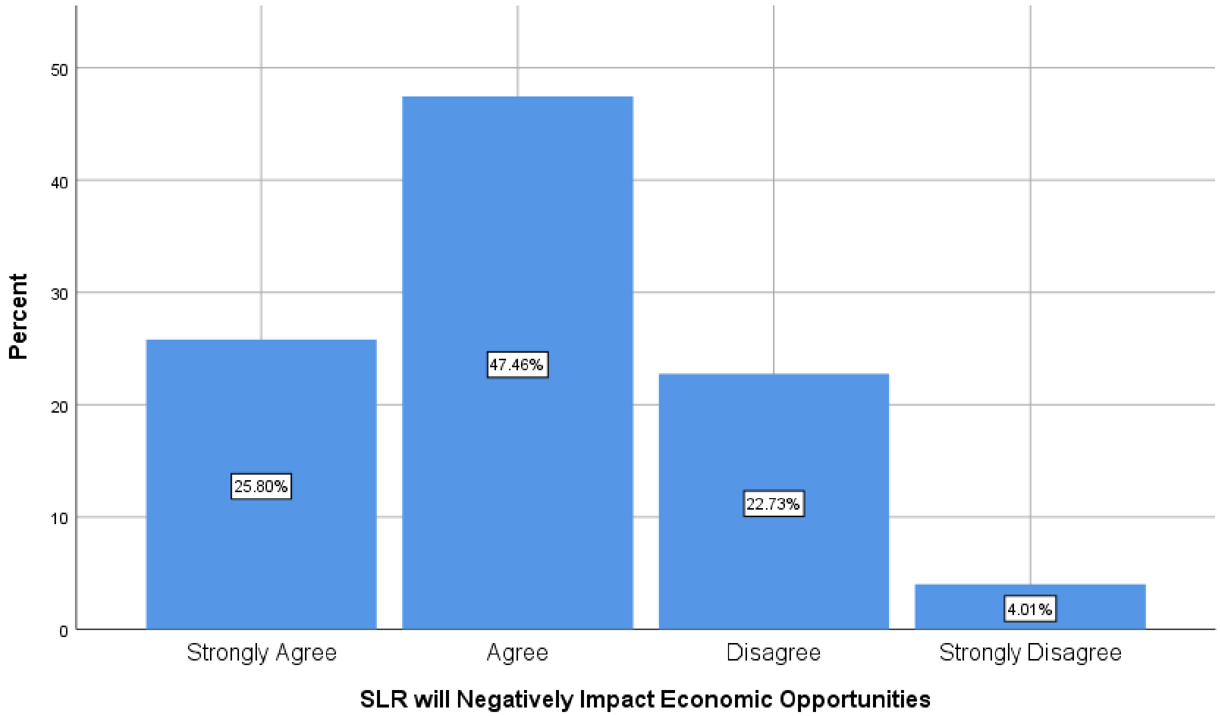
Probability Extensive Damage to Home (7 attributes)



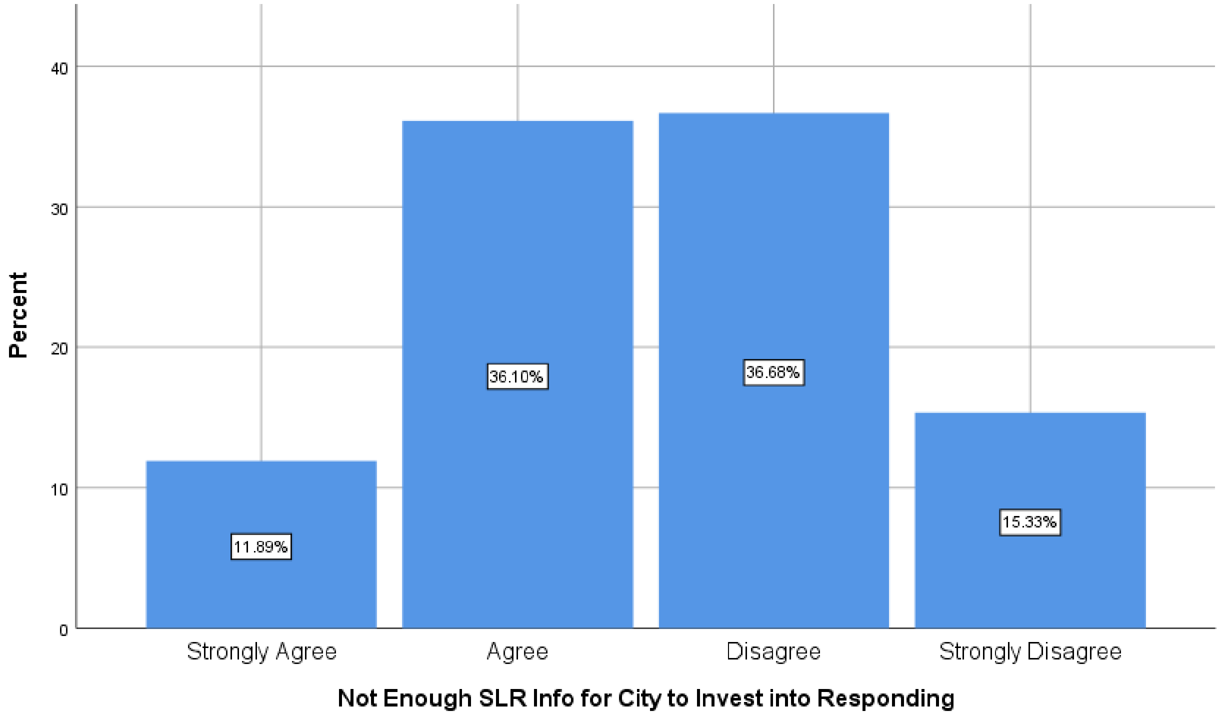
SLR & Flooding are Related



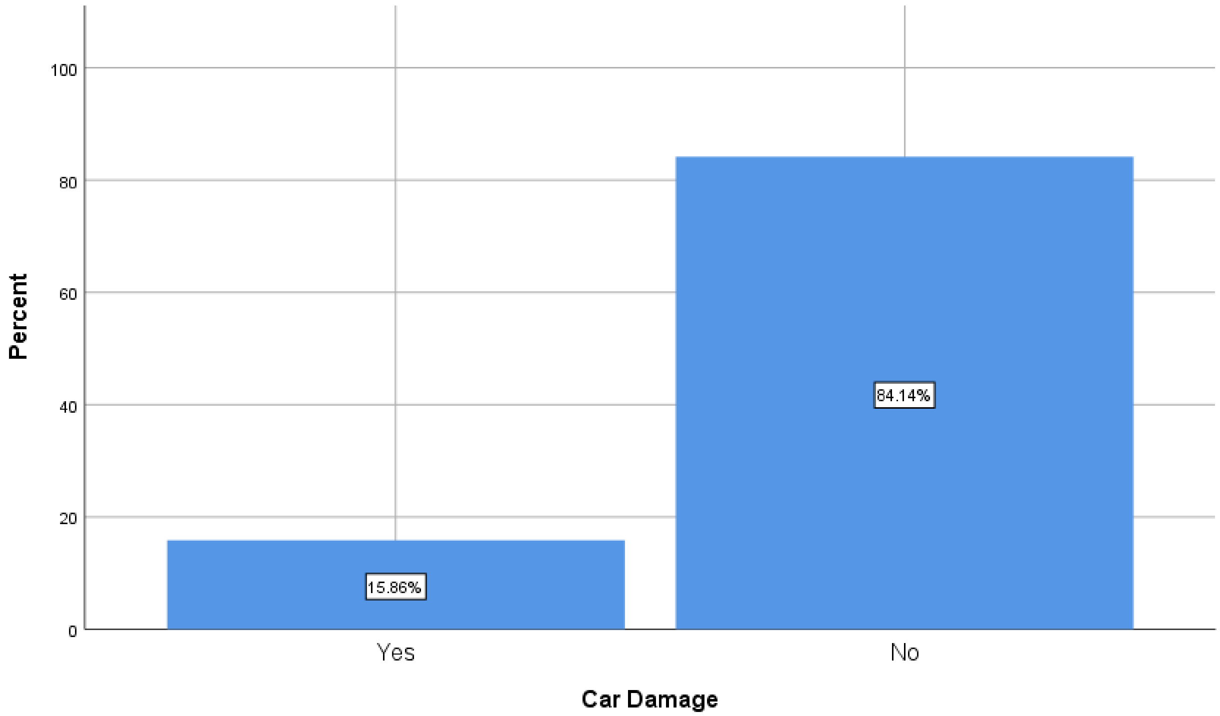
SLR will Negatively Impact Economic Opportunities



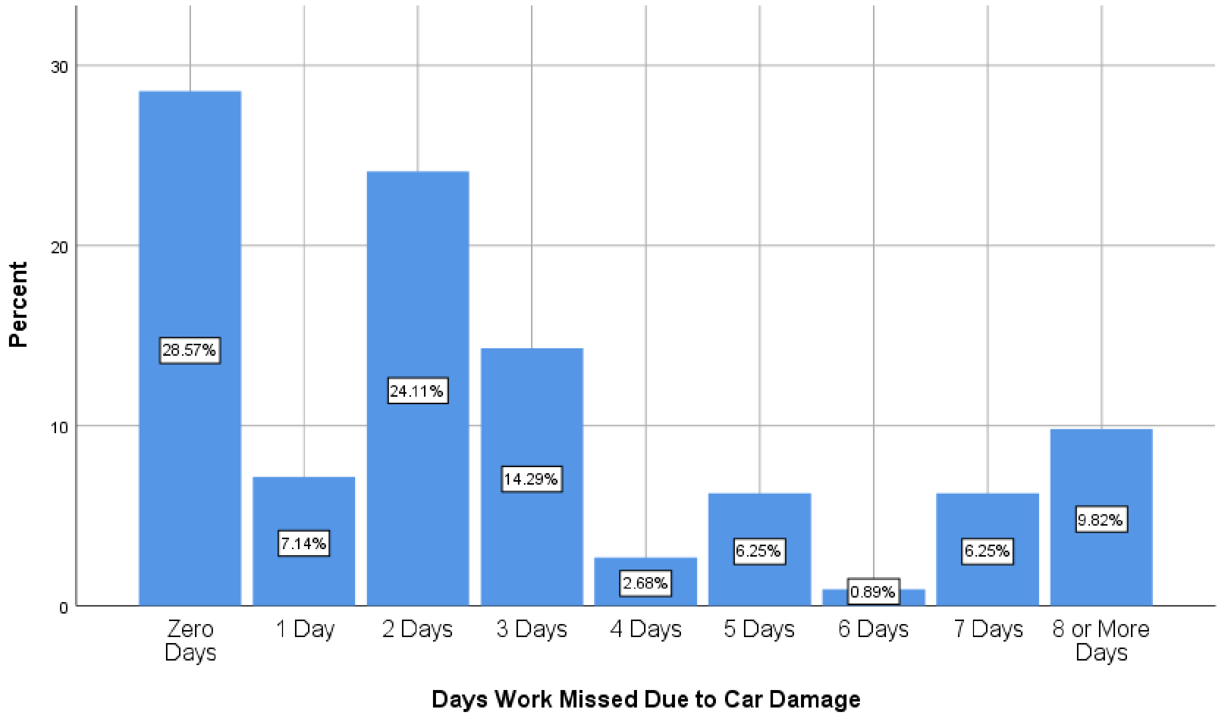
Not Enough SLR Info for City to Invest into Responding



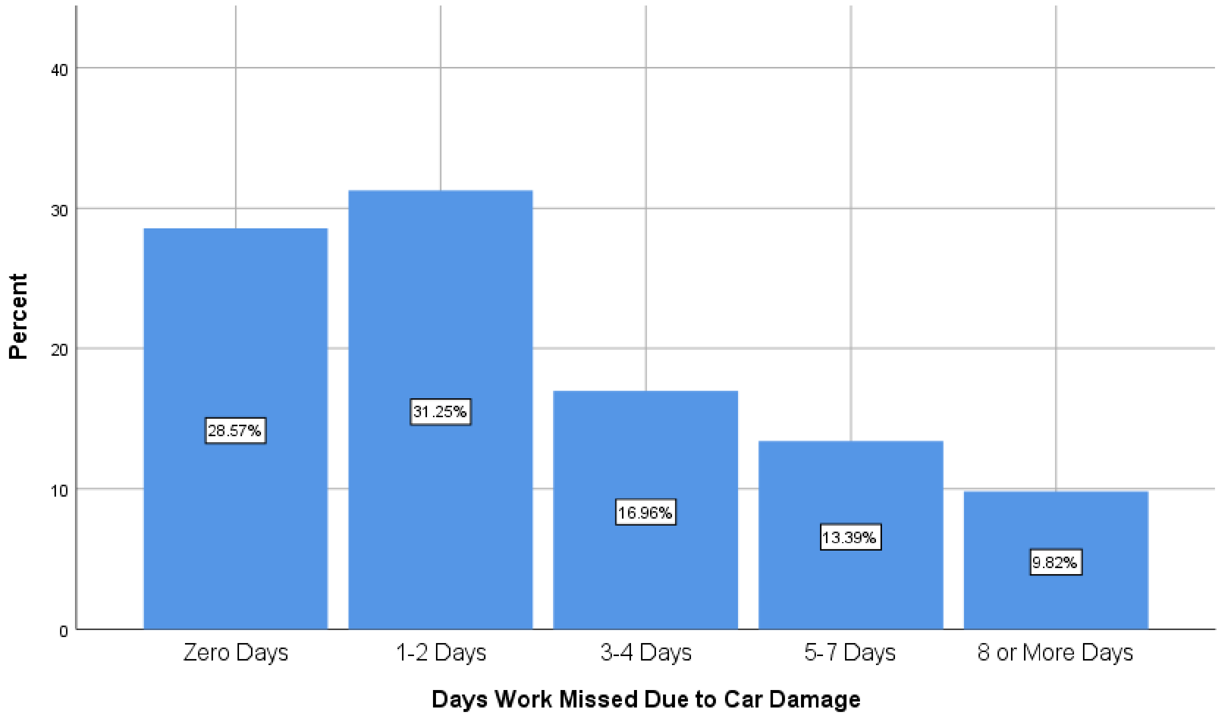
Car Damage



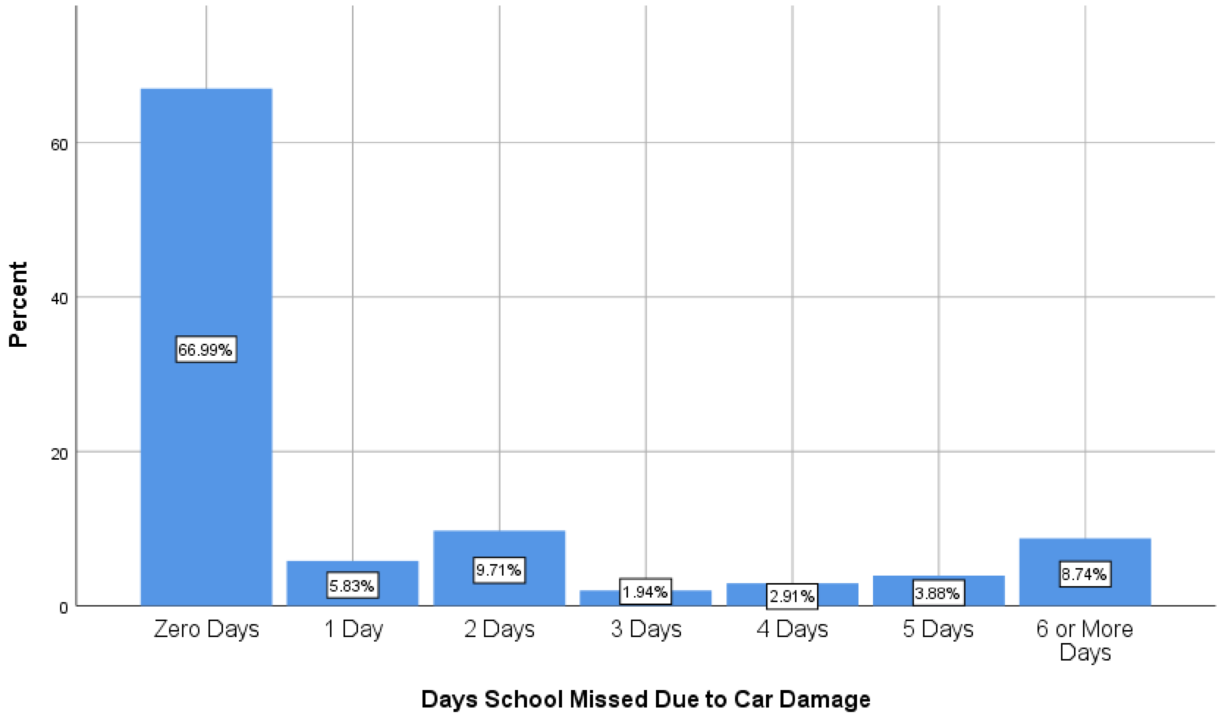
Days Work Missed Due to Car Damage (9 attributes)



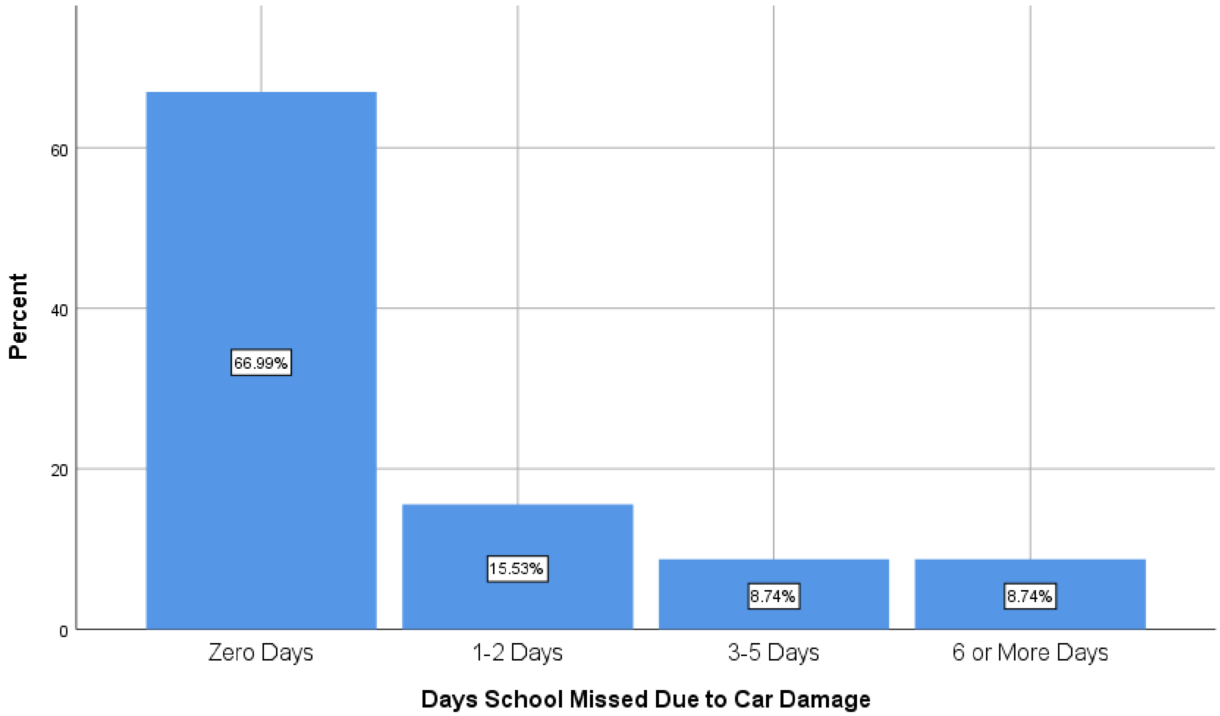
Days Work Missed Due to Car Damage (5 attributes)



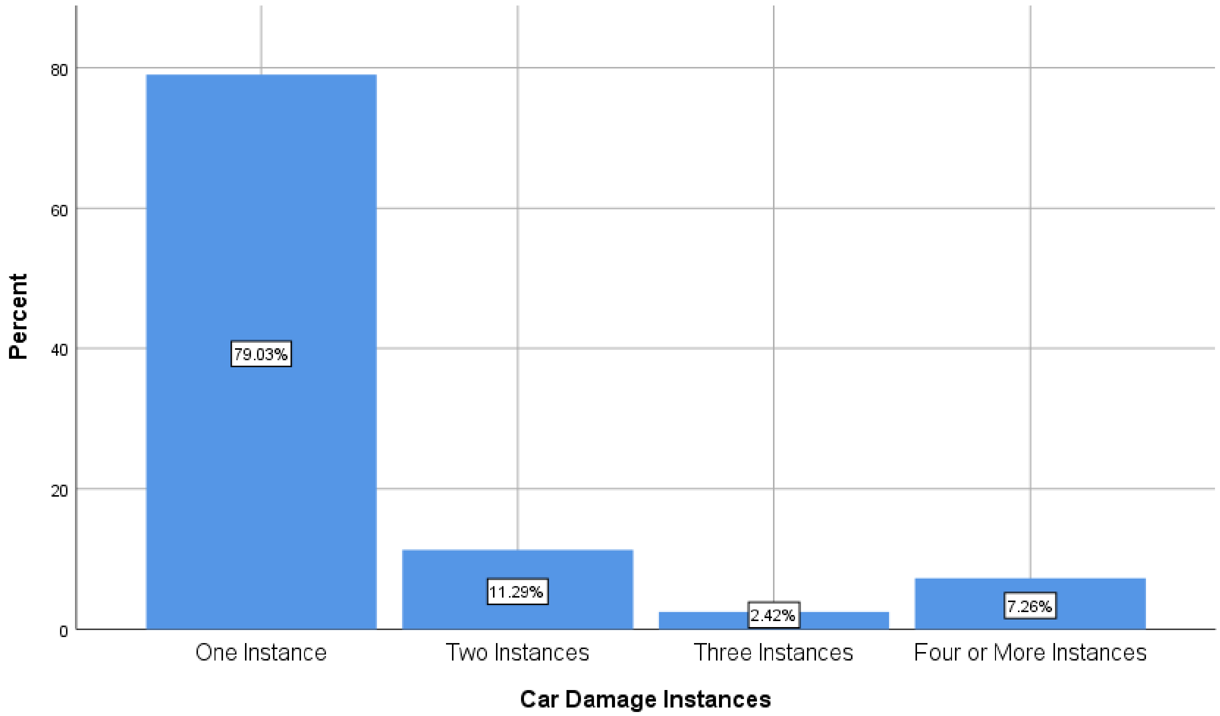
Days School Missed Due to Car Damage (7 attributes)



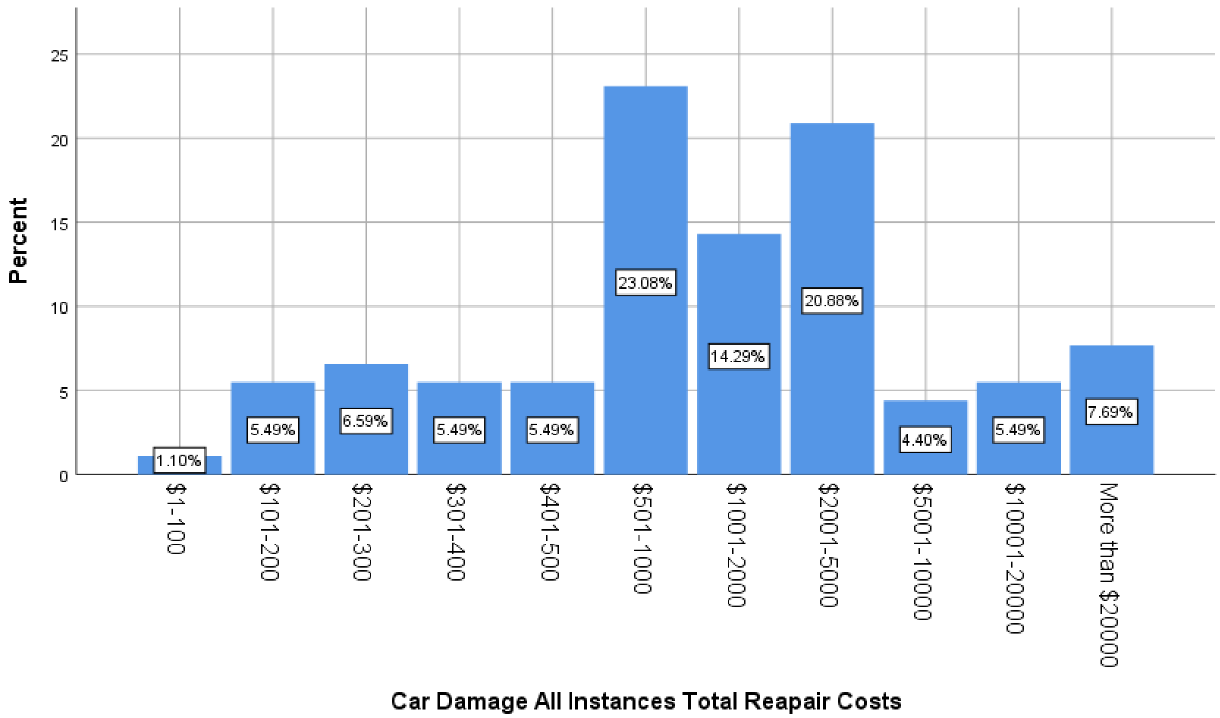
Days School Missed Due to Car Damage (4 attributes)



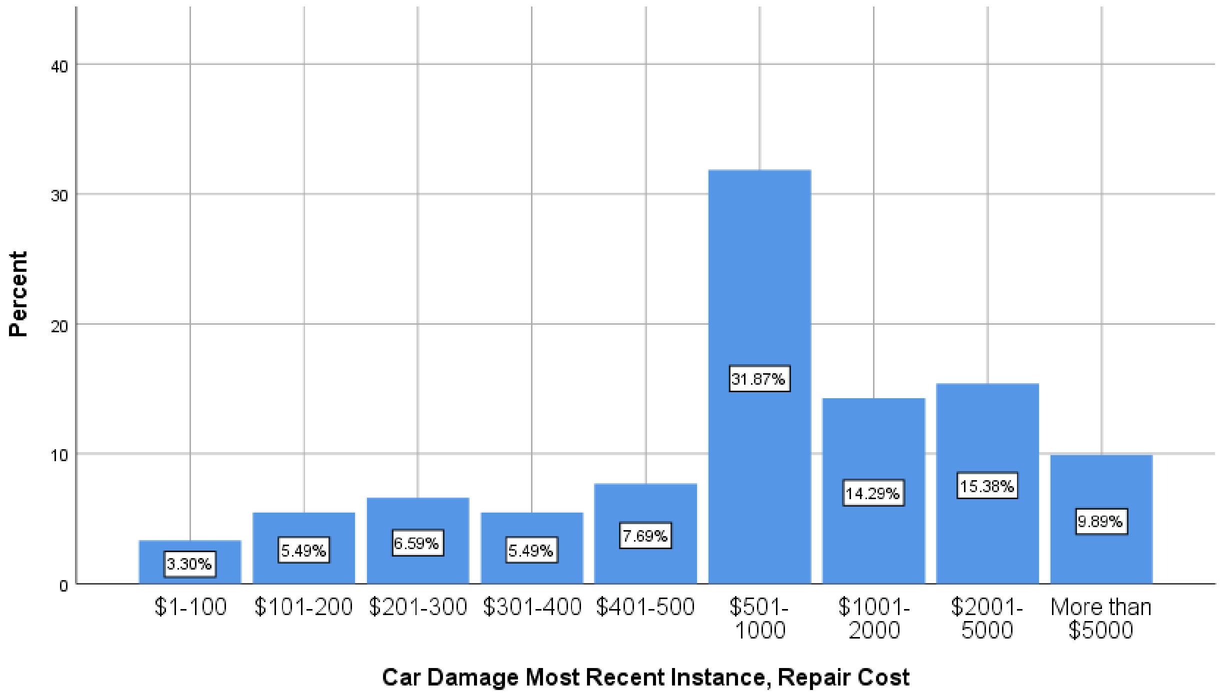
Car Damage Instances



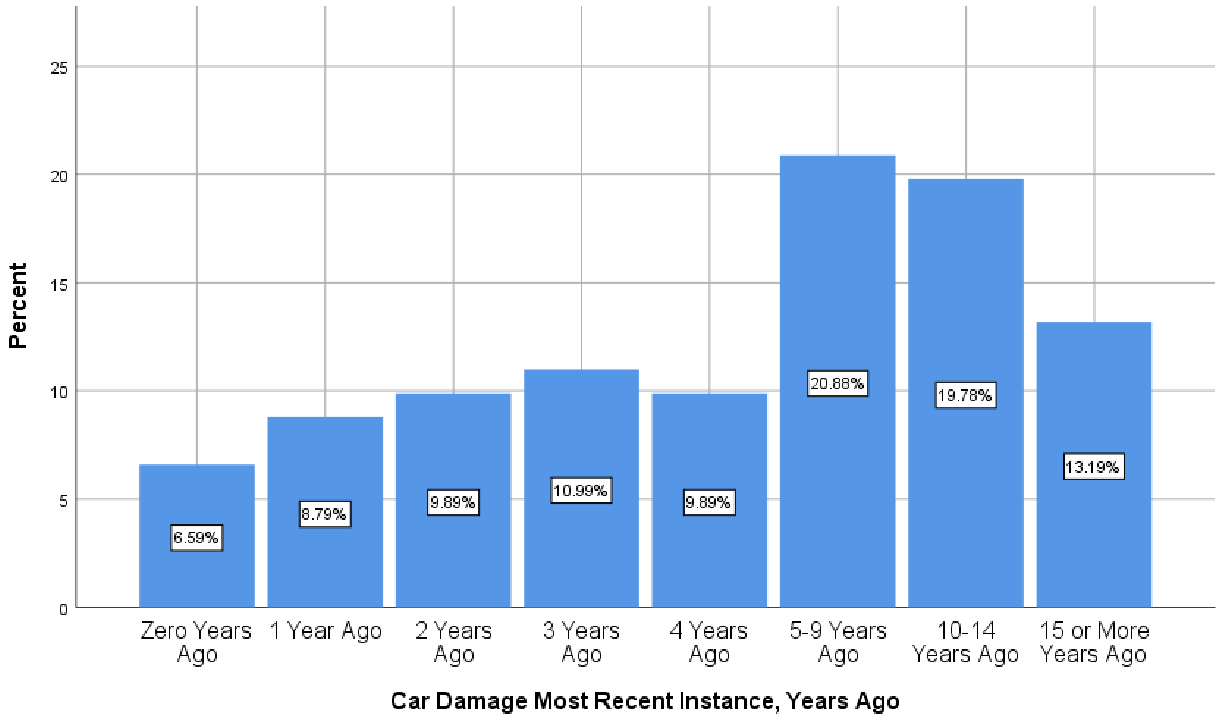
Car Damage All Instances Total Repair Costs



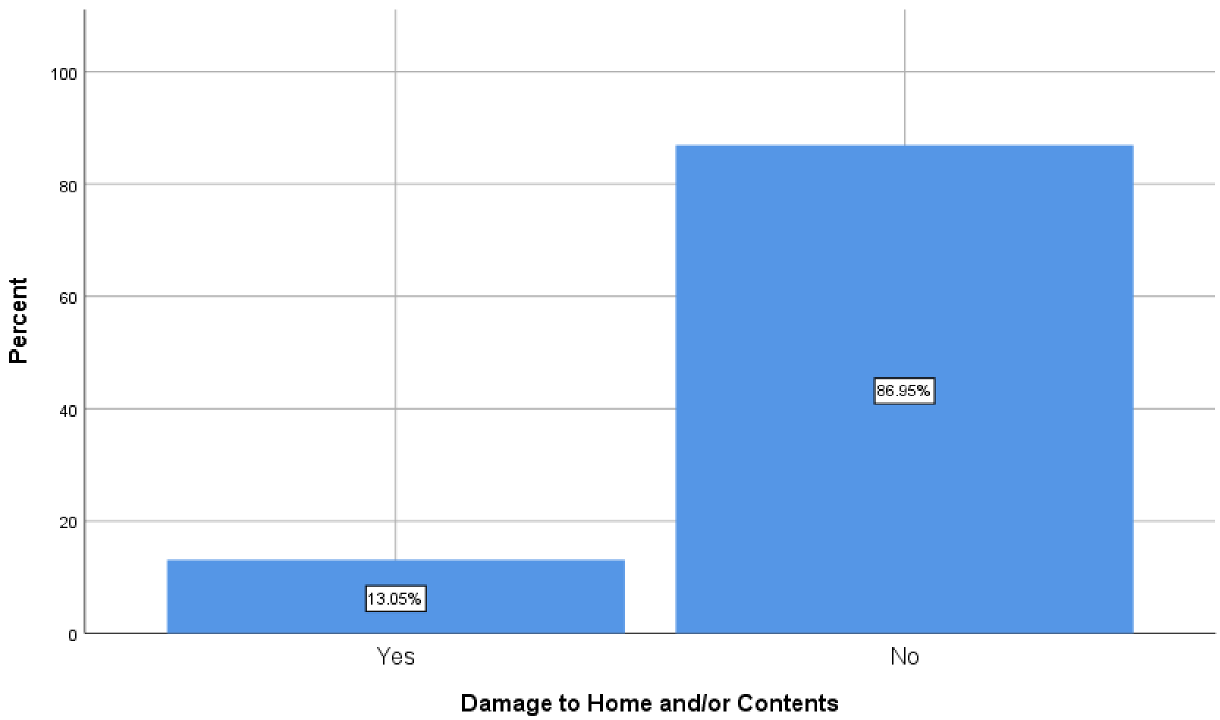
Car Damage Most Recent Instance, Repair Cost



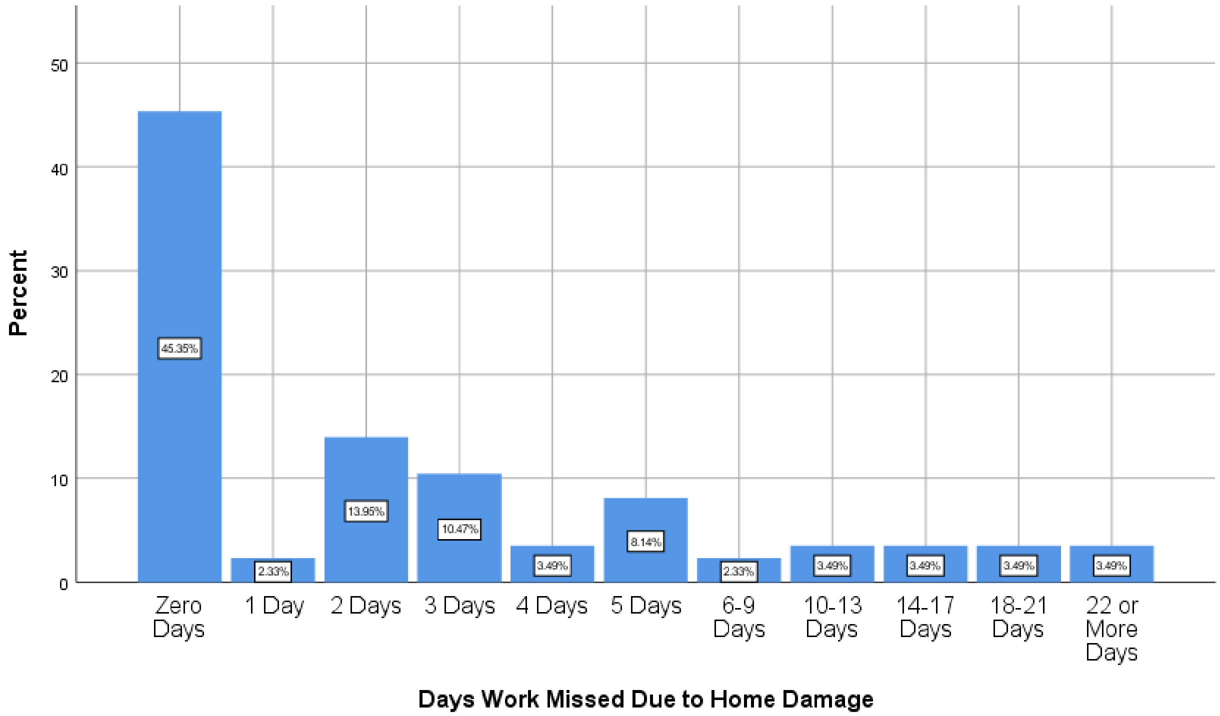
Car Damage Most Recent Instance, Years Ago



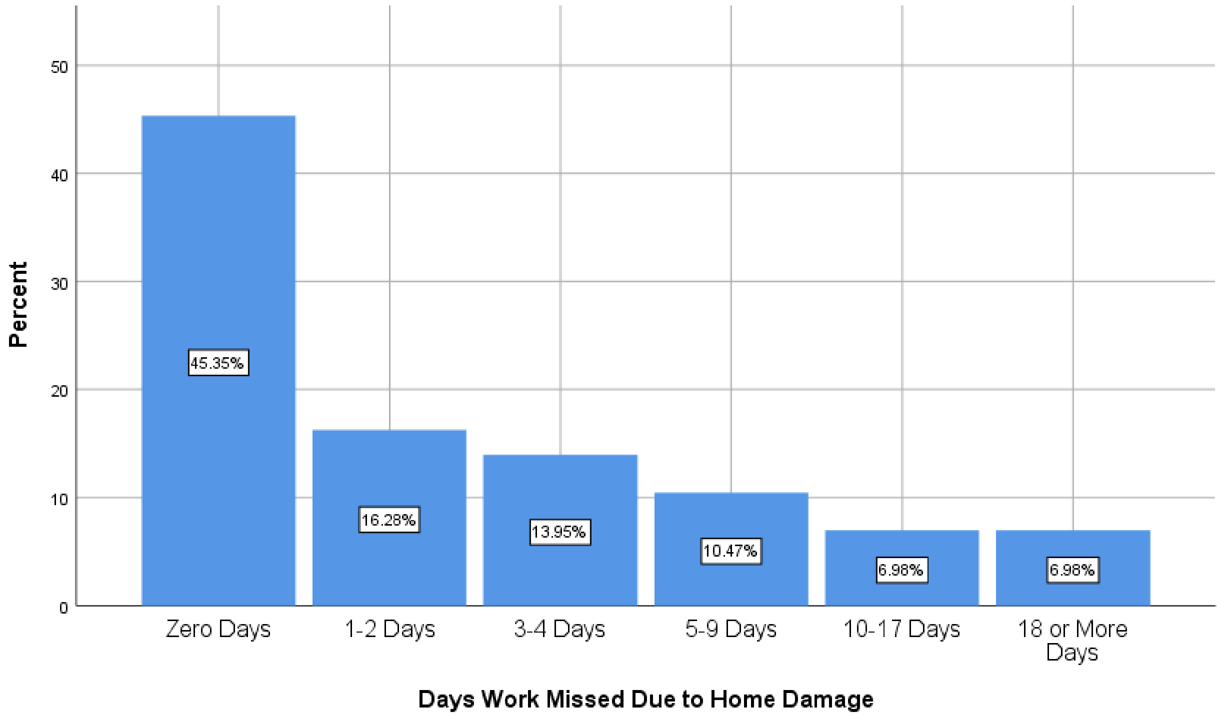
Damage to Home and/or Contents



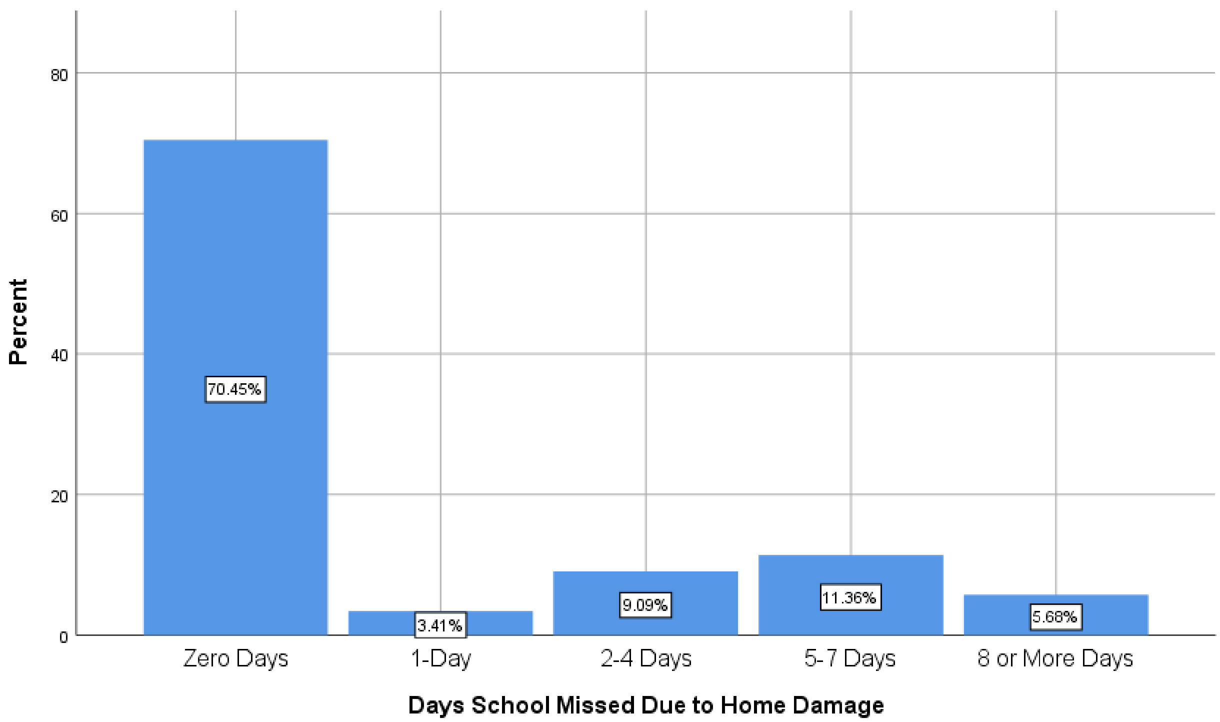
Days Work Missed Due to Home Damage (11 attributes)



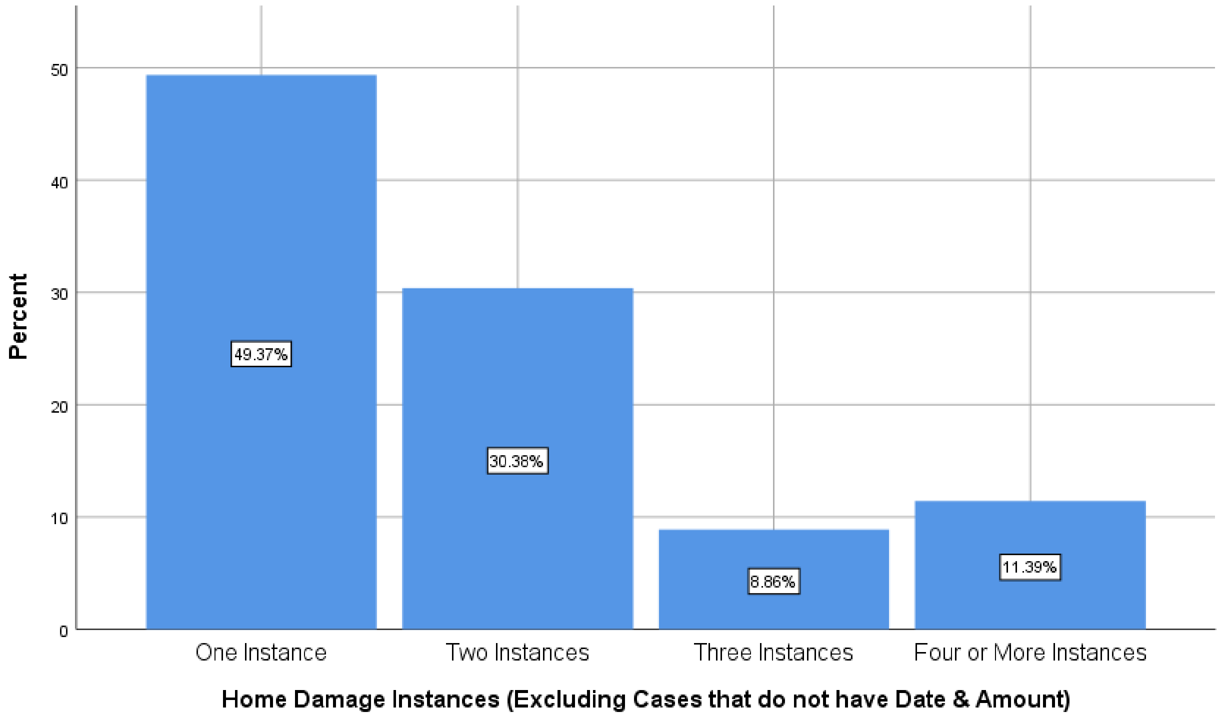
Days Work Missed Due to Home Damage (6 attributes)



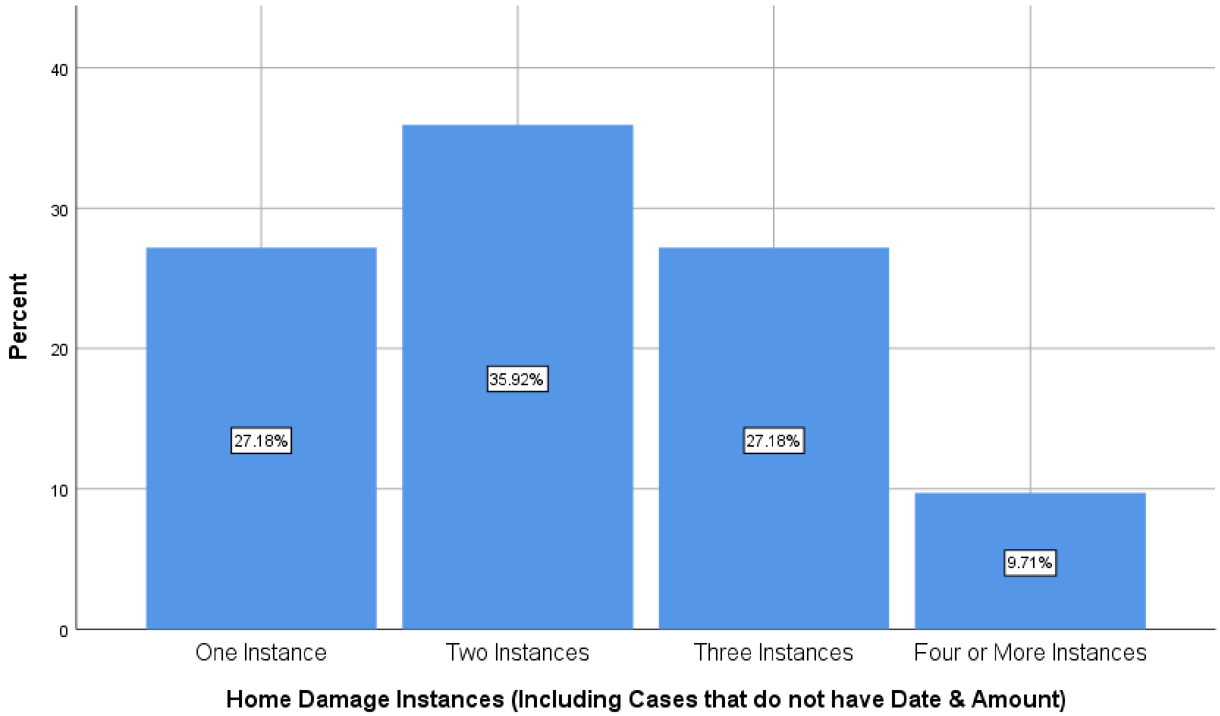
Days School Missed Due to Home Damage



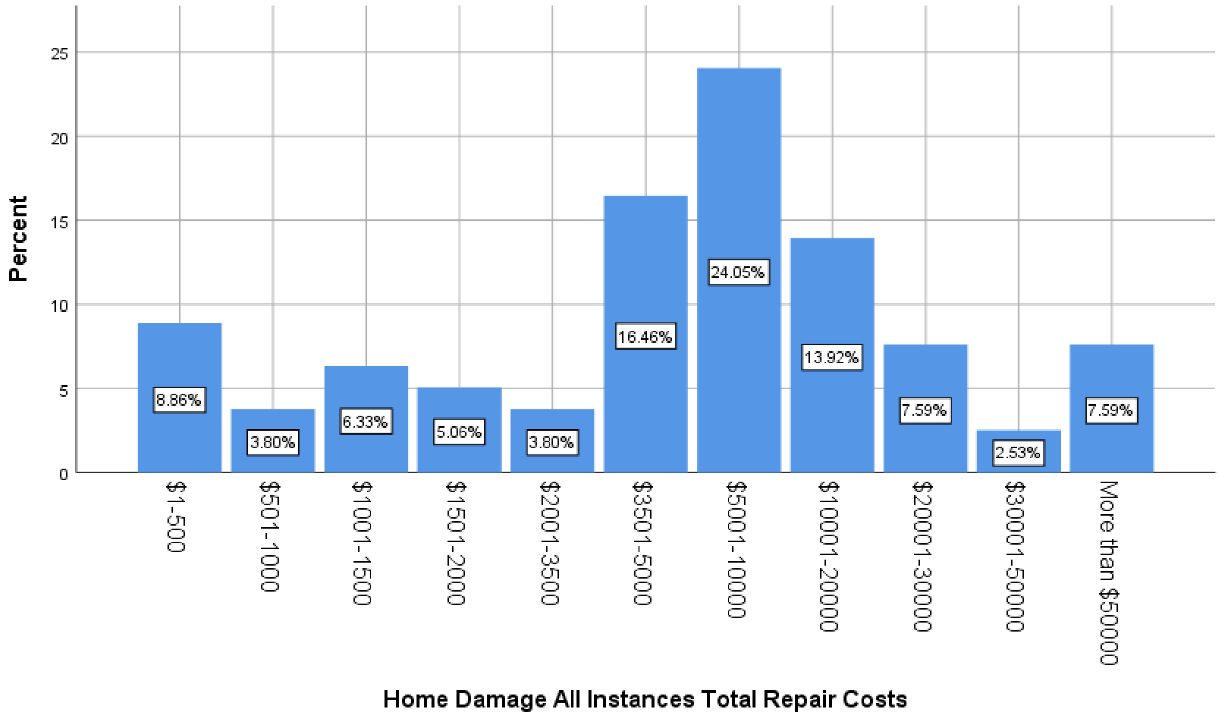
Home Damage Instances (Excluding Cases that do not have Date & Amount)



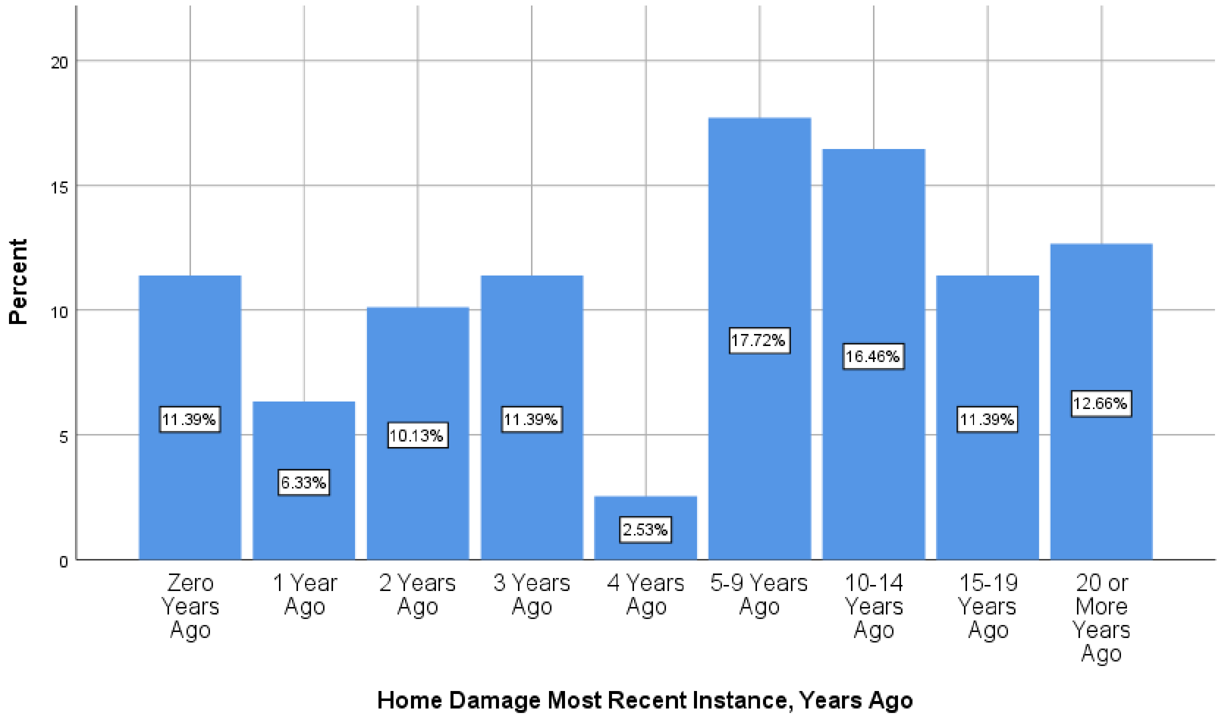
Home Damage Instances (Including Cases that do not have Date & Amount)



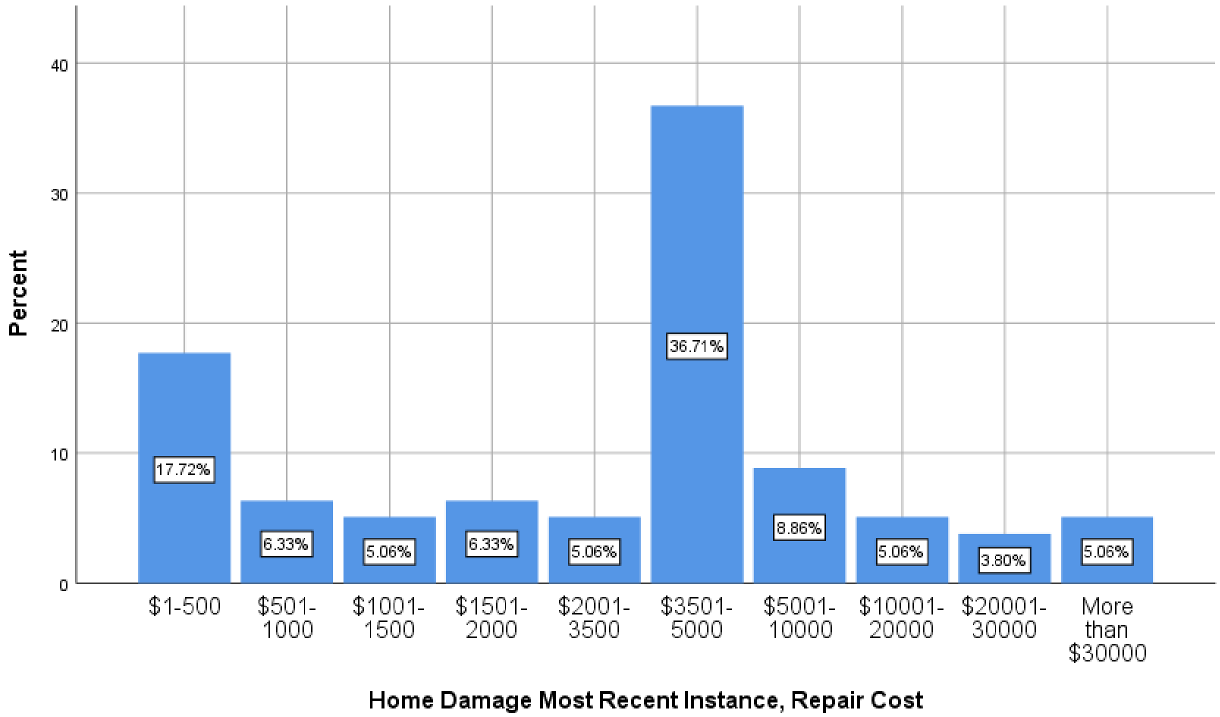
Home Damage All Instances Total Repair Costs



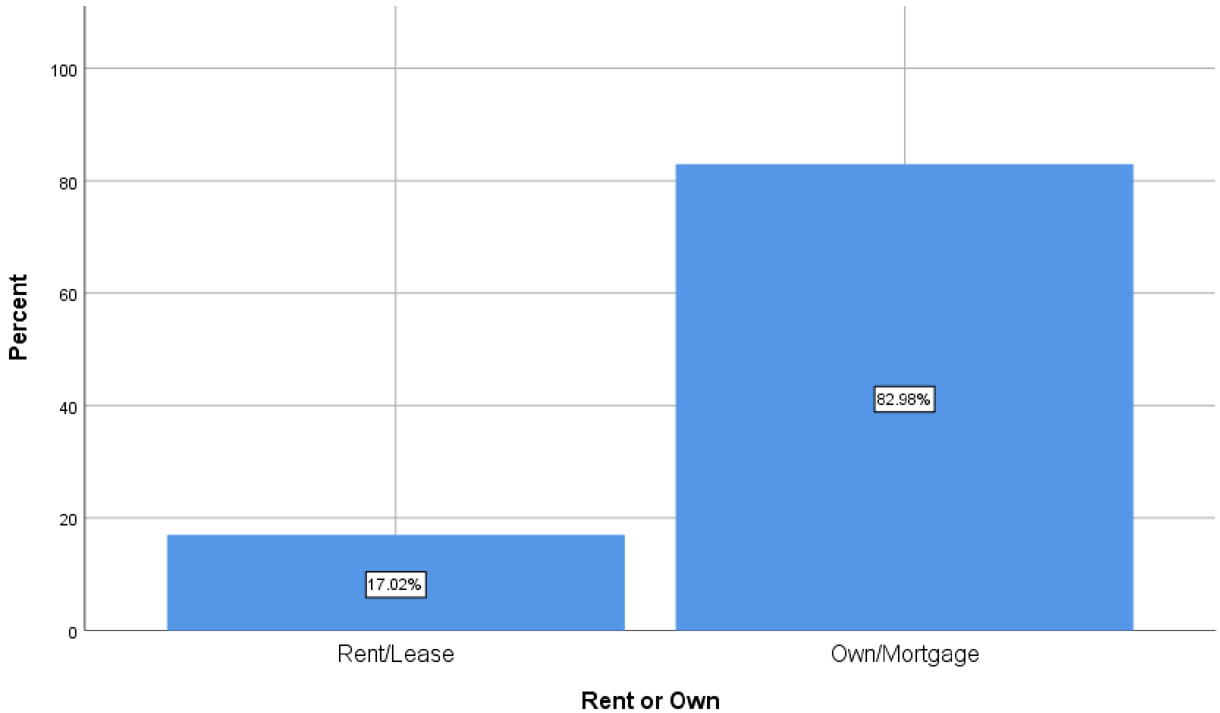
Home Damage Most Recent Instance, Years Ago



Home Damage Most Recent Instance, Repair Cost

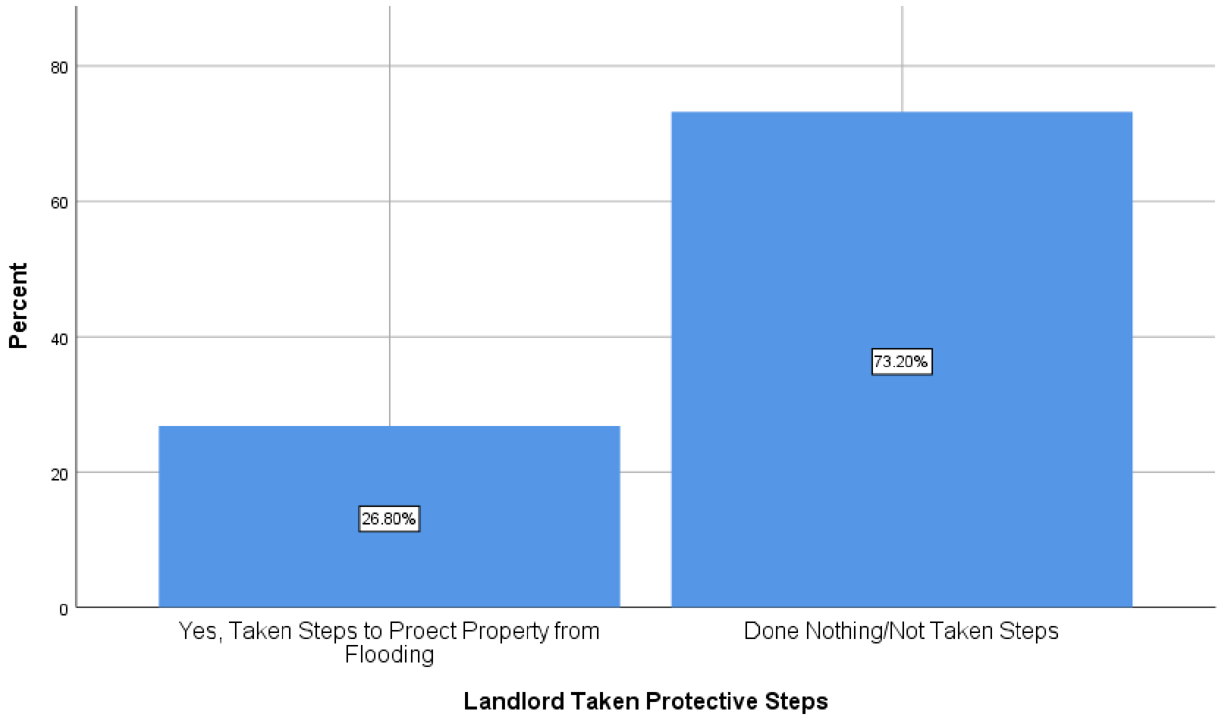


Rent or Own

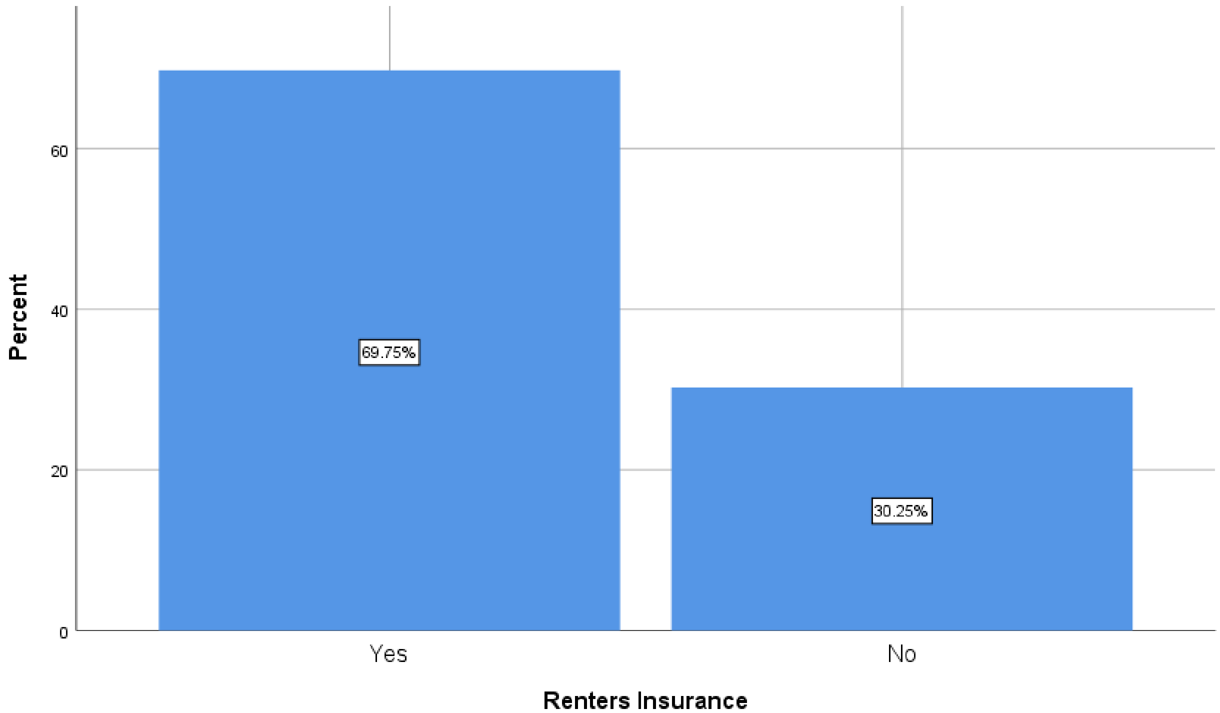


100
80
60
40
20
0
Percent
17.02%
82.98%
Rent/Lease
Own/Mortgage
Rent or Own

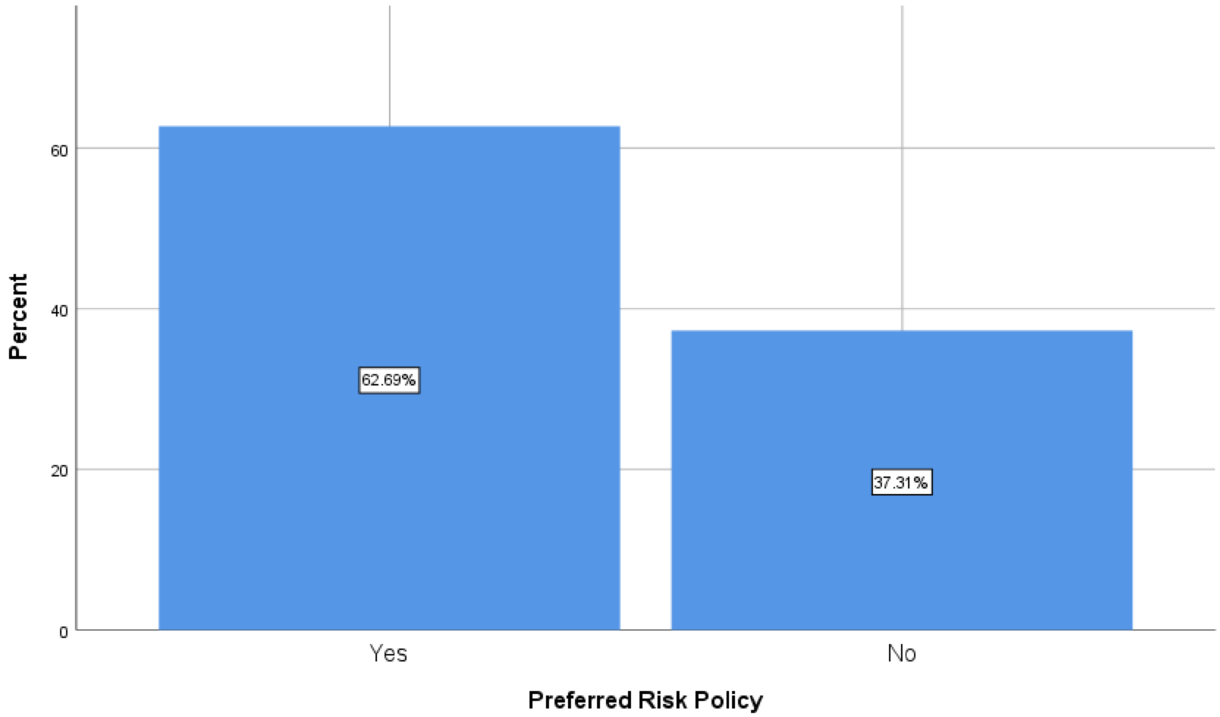
Landlord Taken Protective Steps



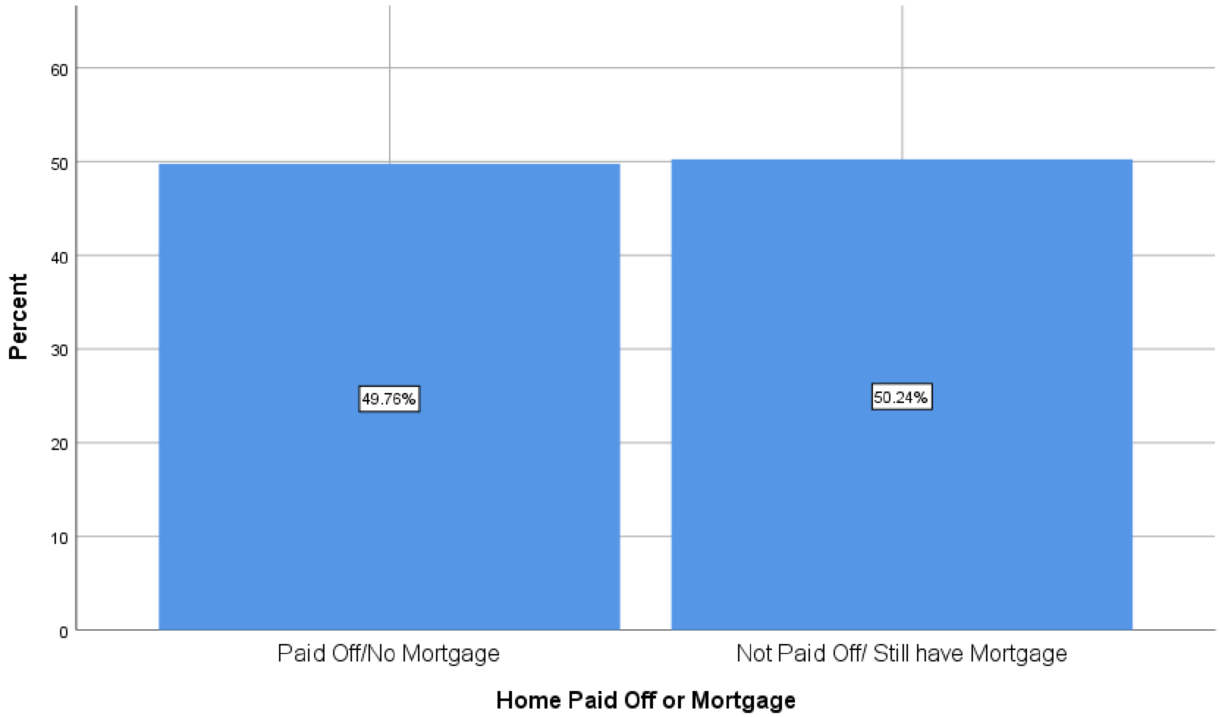
Renters Insurance



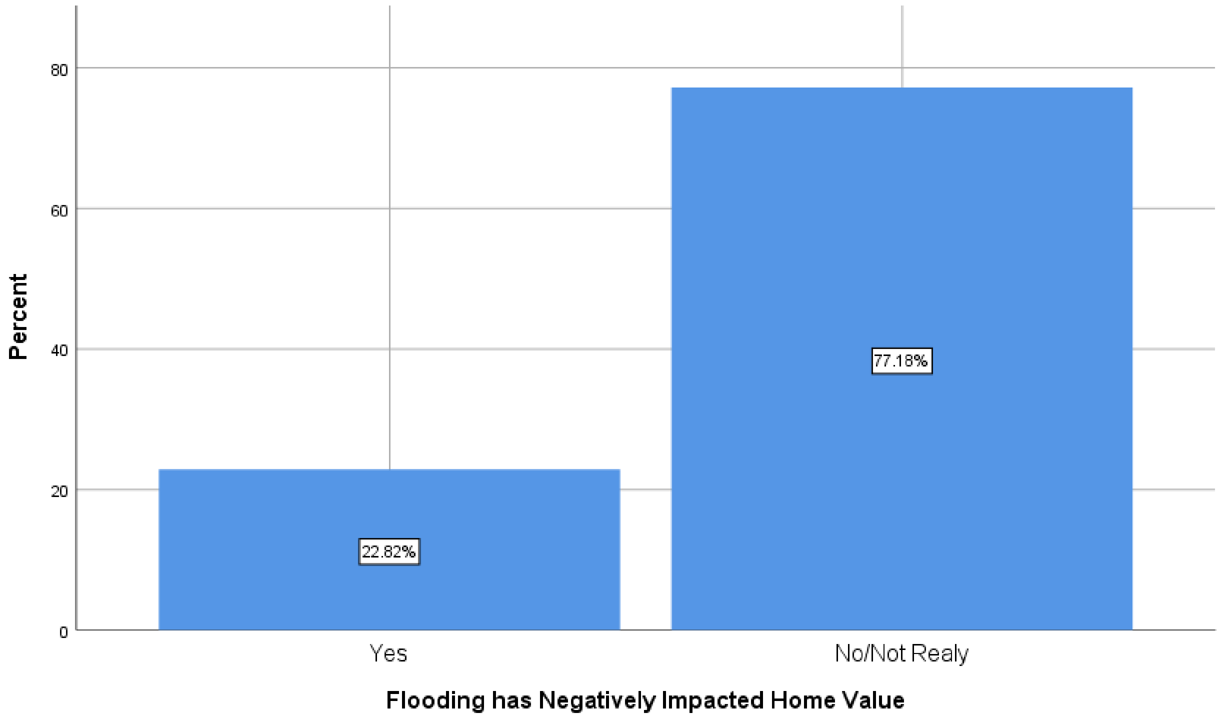
Preferred Risk Policy



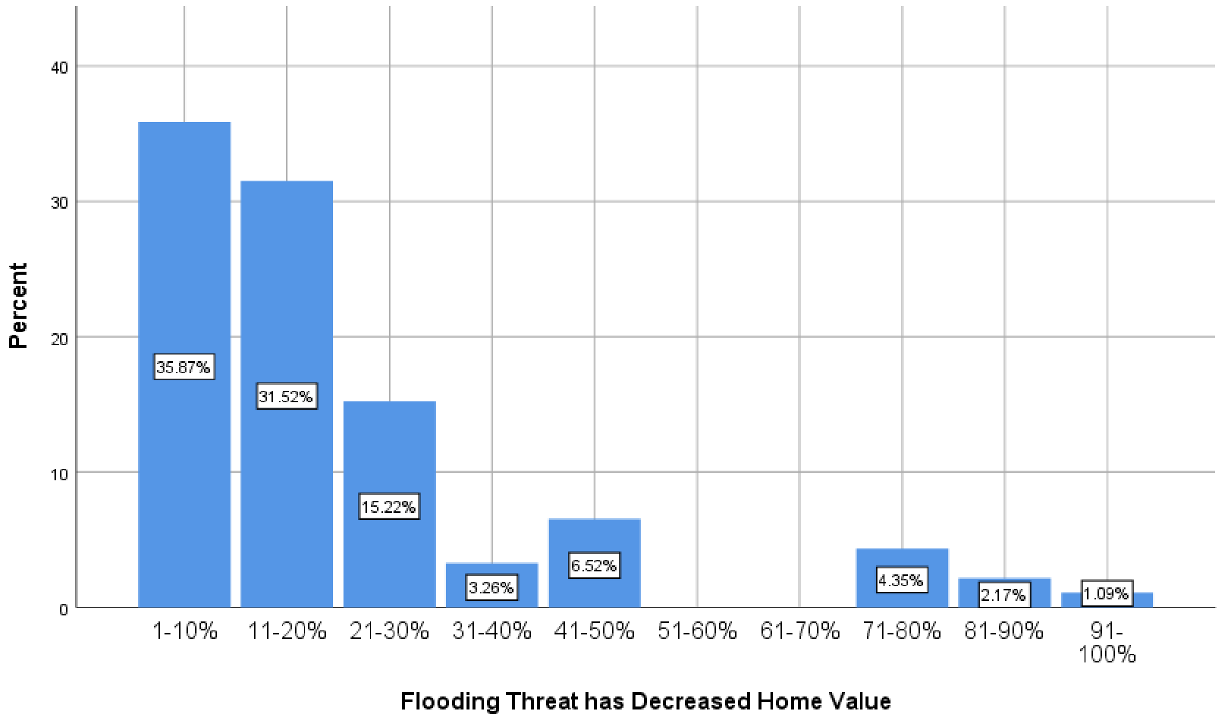
Home Paid Off or Mortgage



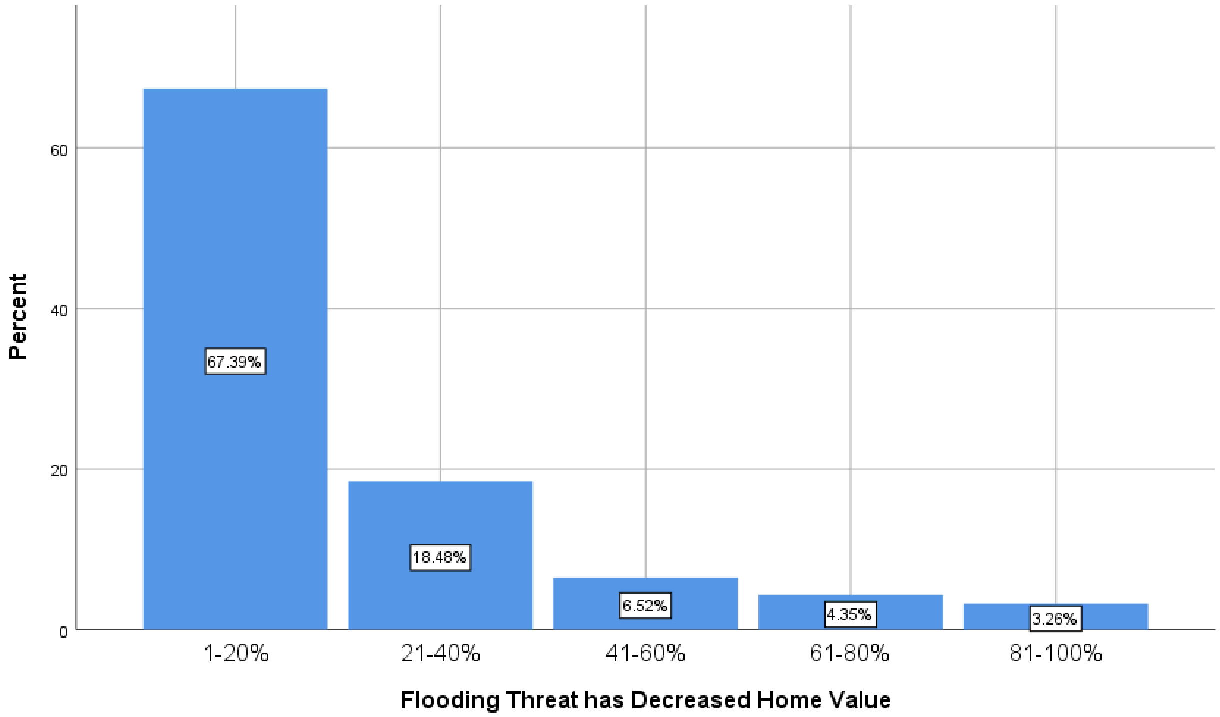
Flooding has Negatively Impacted Home Value



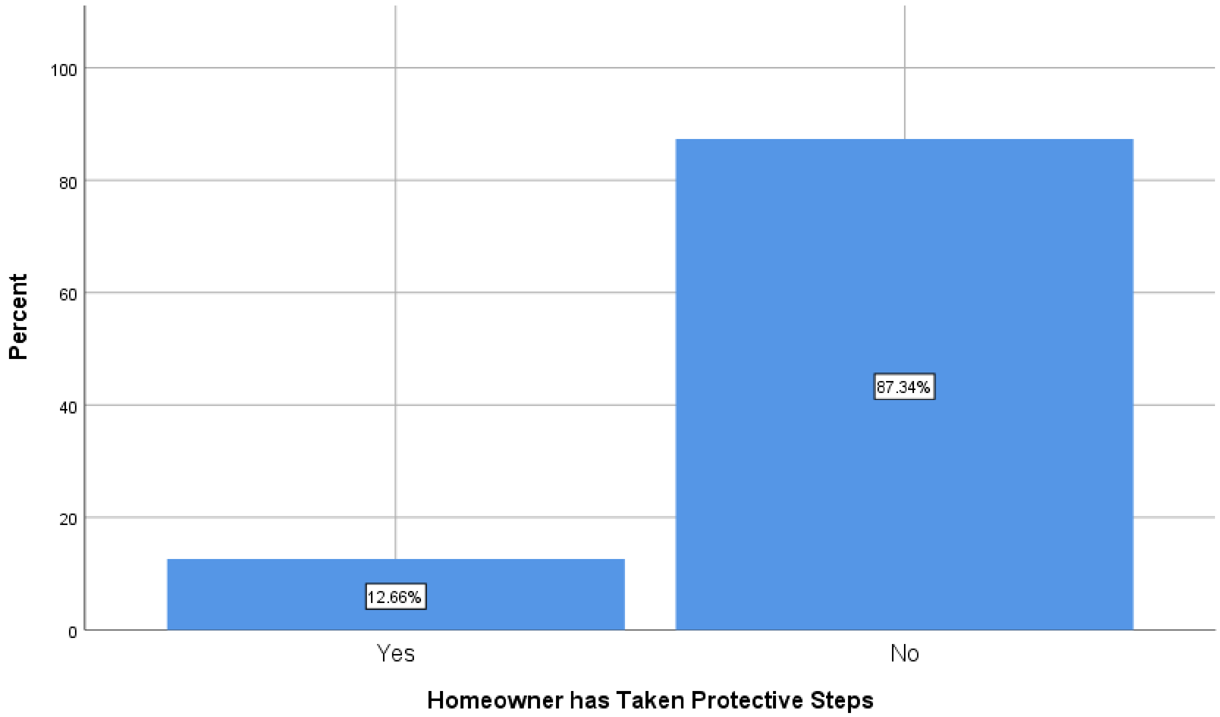
Flooding Threat has Decreased Home Value (10 attributes)



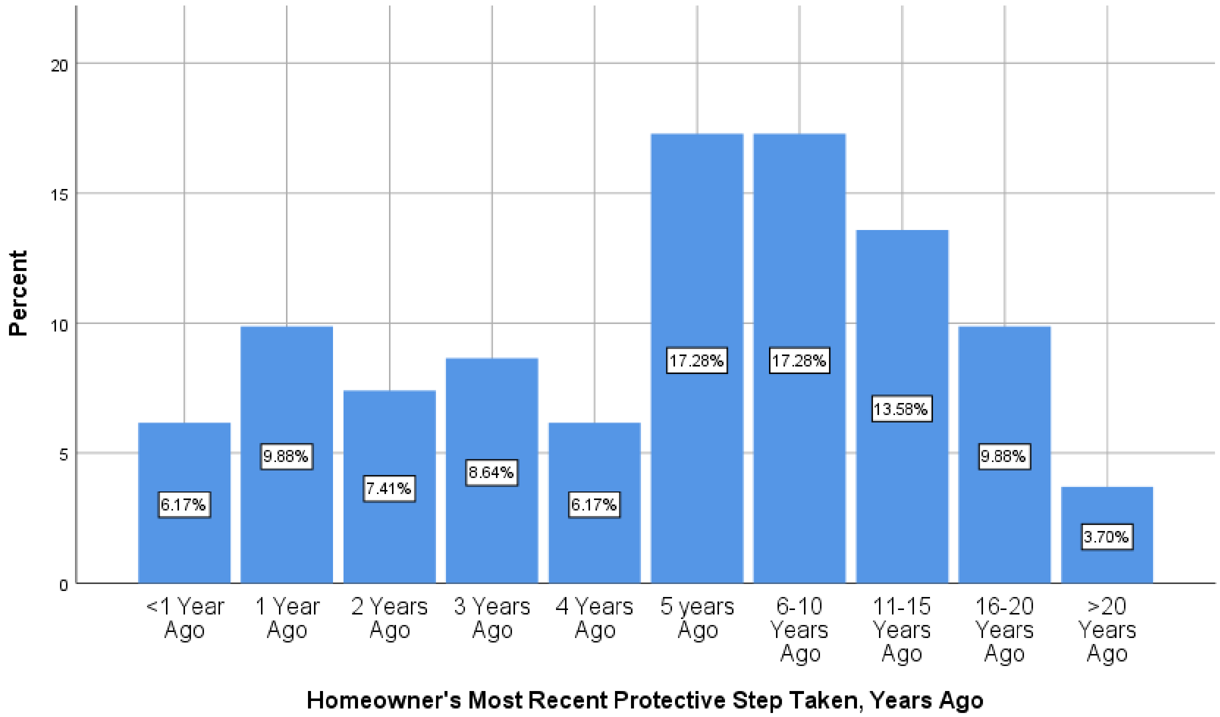
Flooding Threat has Decreased Home Value (5 attributes)



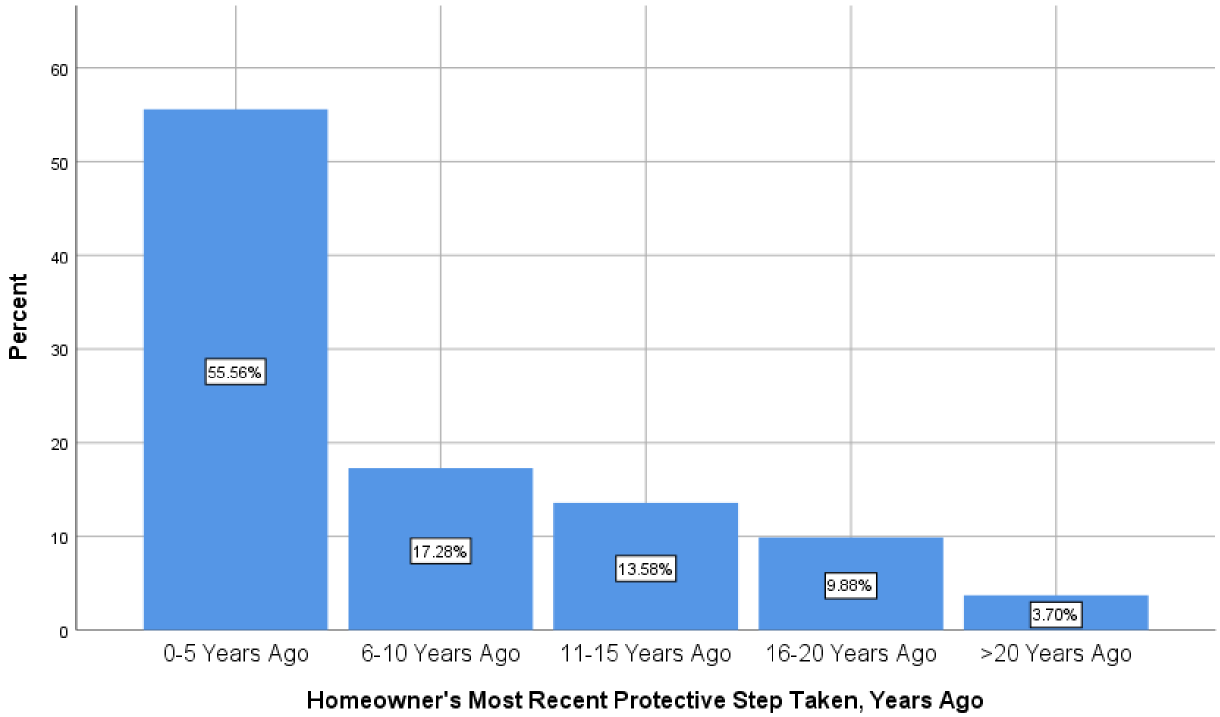
Homeowner has Taken Protective Steps



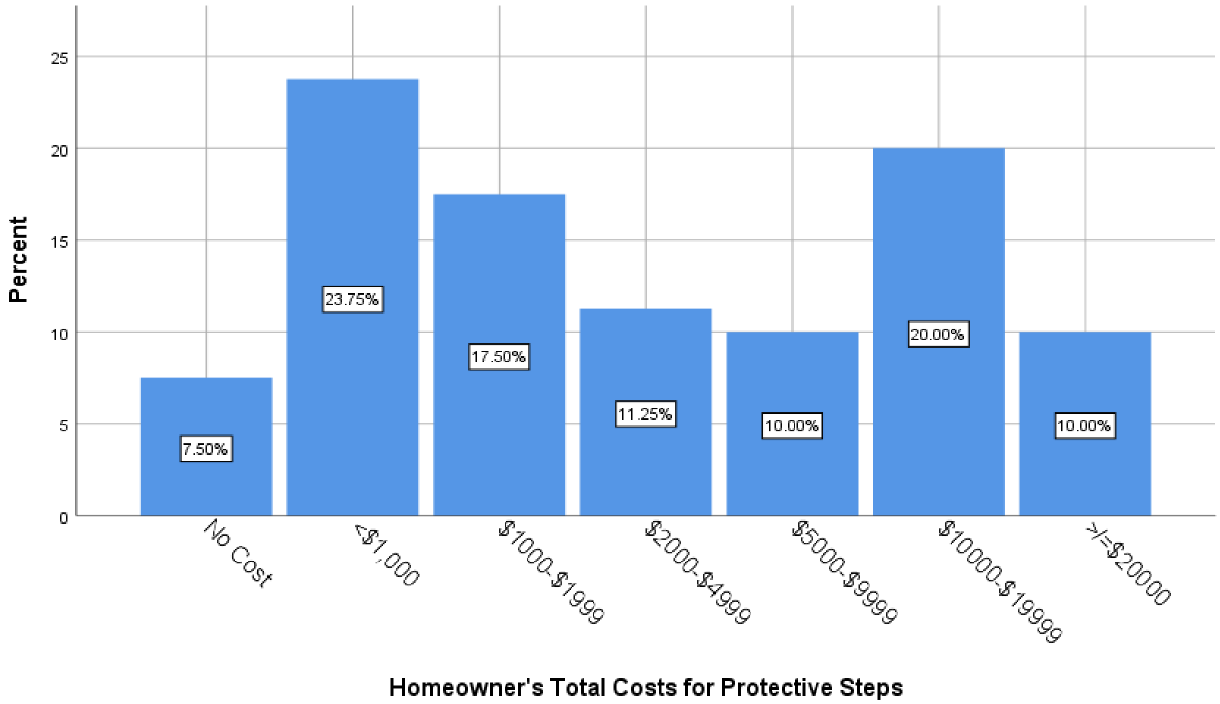
Homeowner's Most Recent Protective Step Taken, Years Ago (10 attributes)



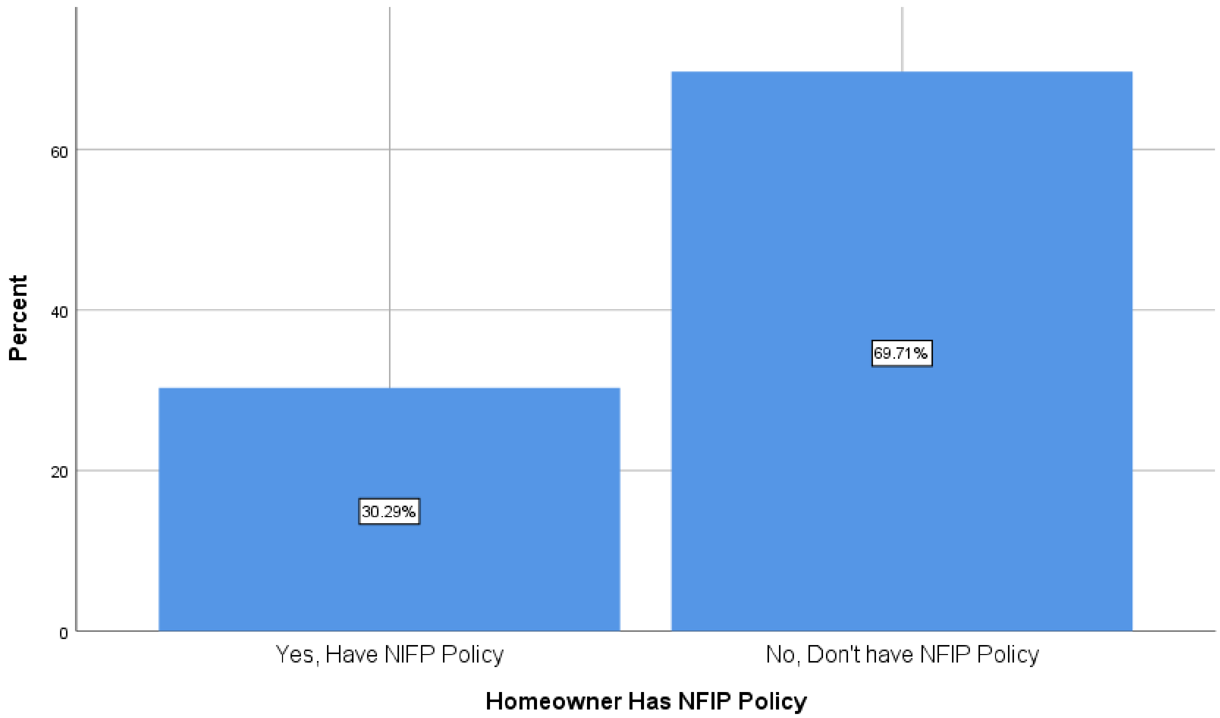
Homeowner's Most Recent Protective Step Taken, Years Ago (5 attributes)



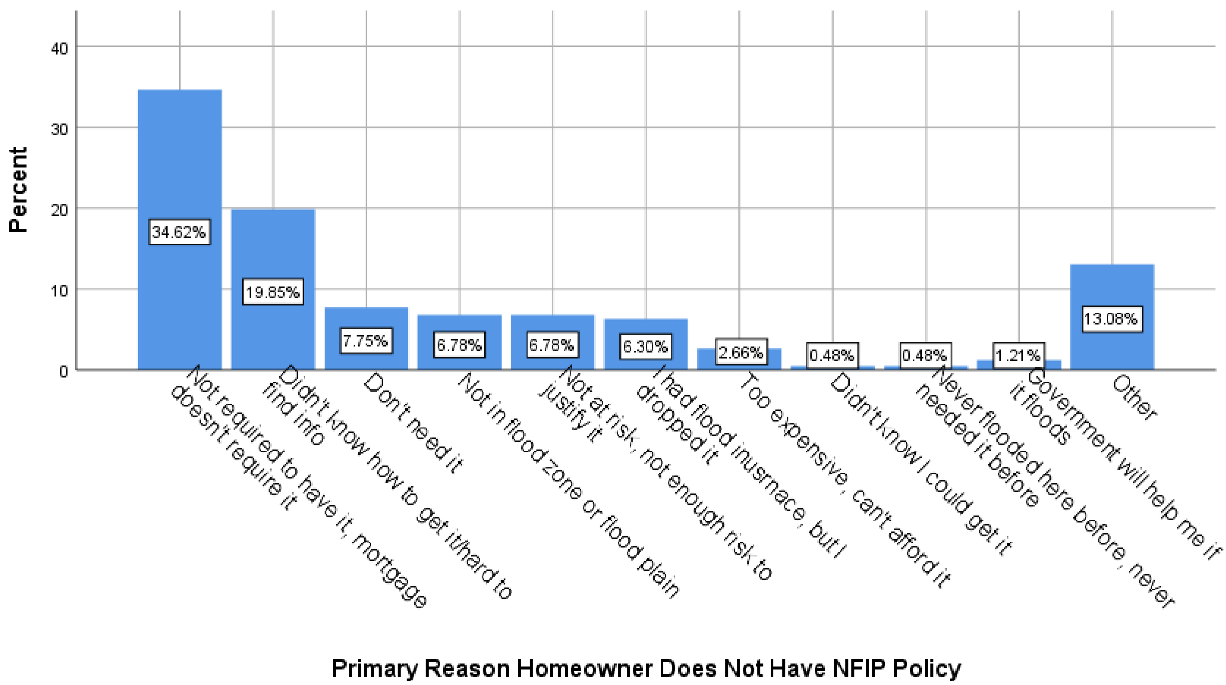
Homeowner's Total Costs for Protective Steps



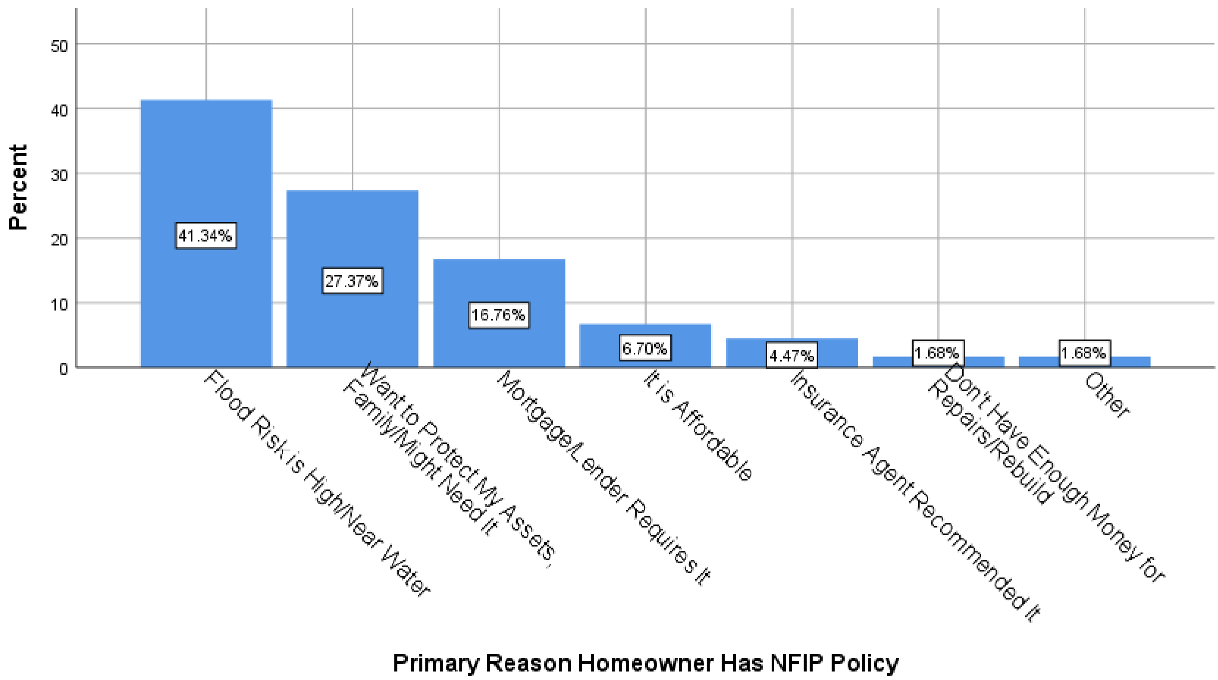
Homeowner Has NFIP Policy



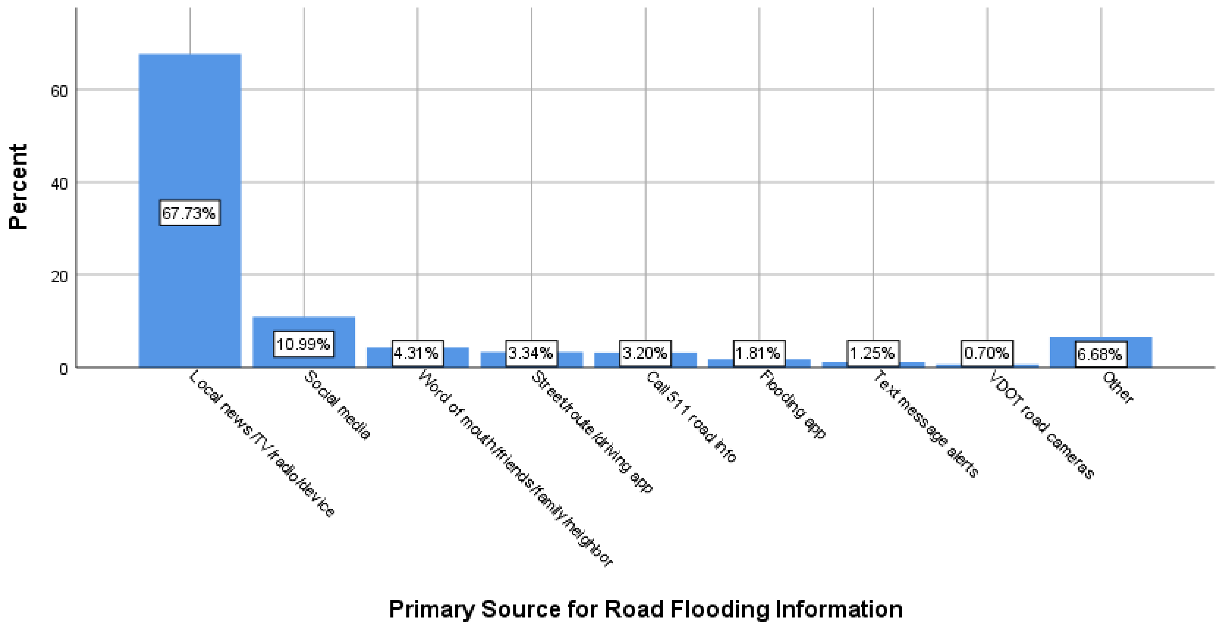
Primary Reason Homeowner Does Not Have NFIP Policy



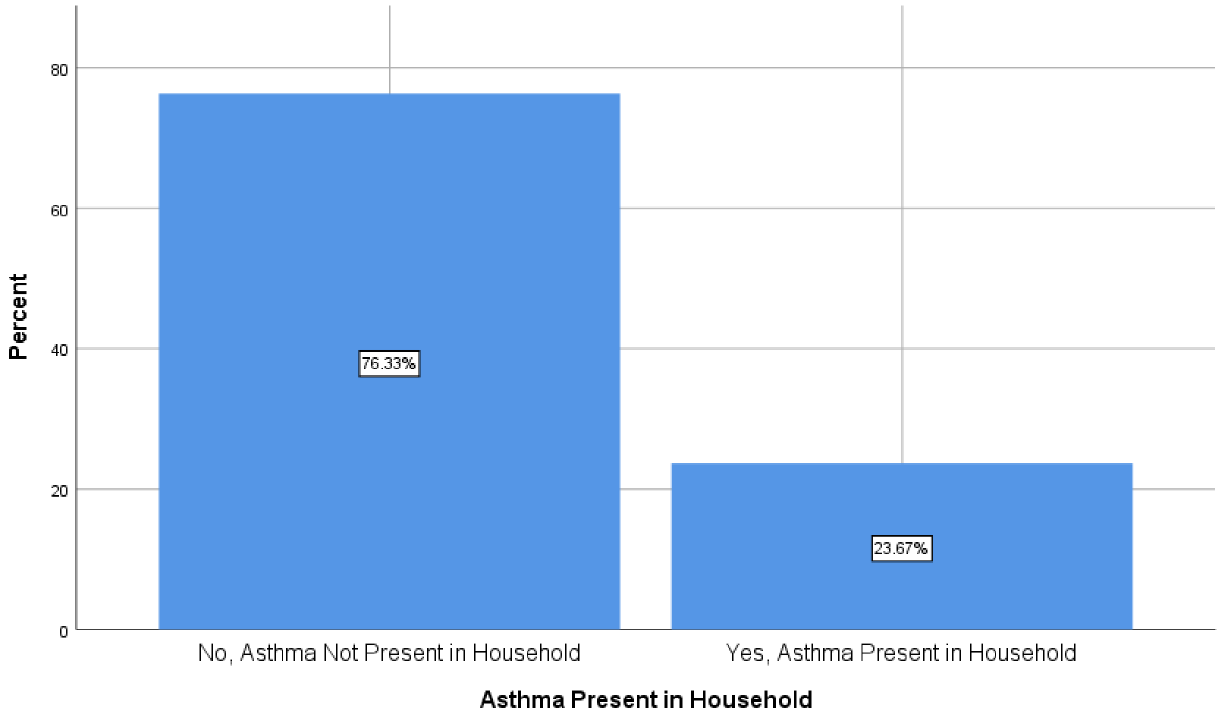
Primary Reason Homeowner Has NFIP Policy



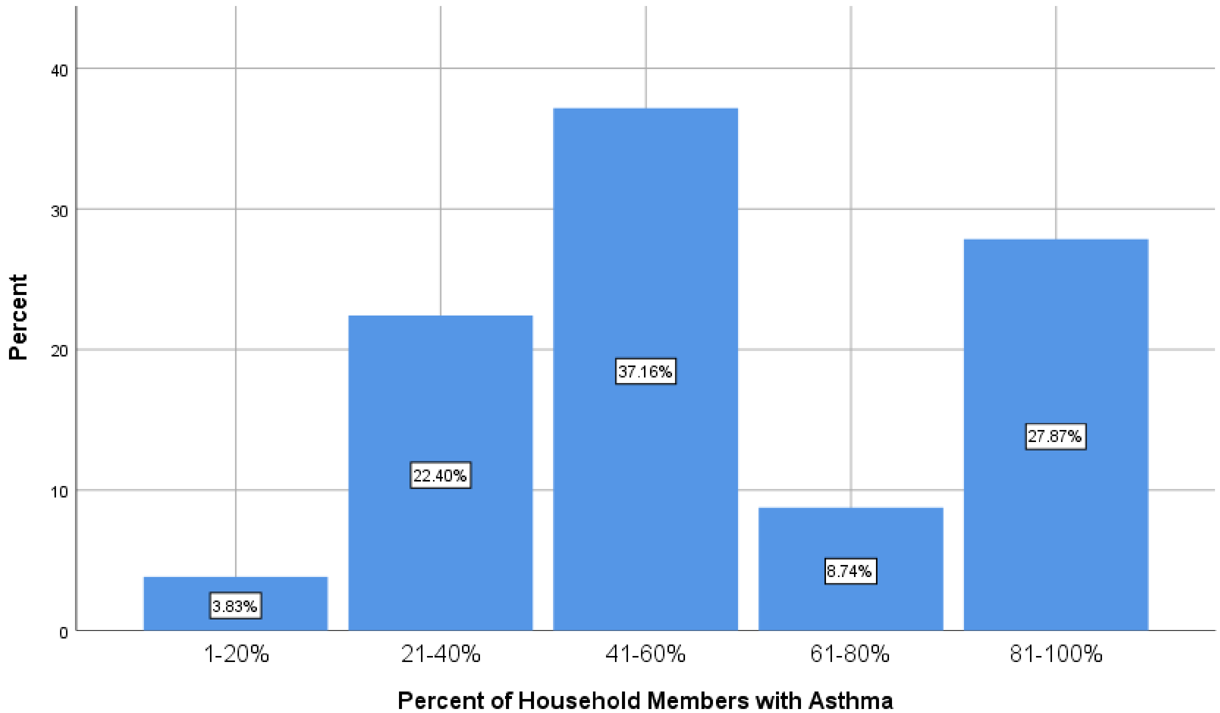
Primary Source for Road Flooding Information



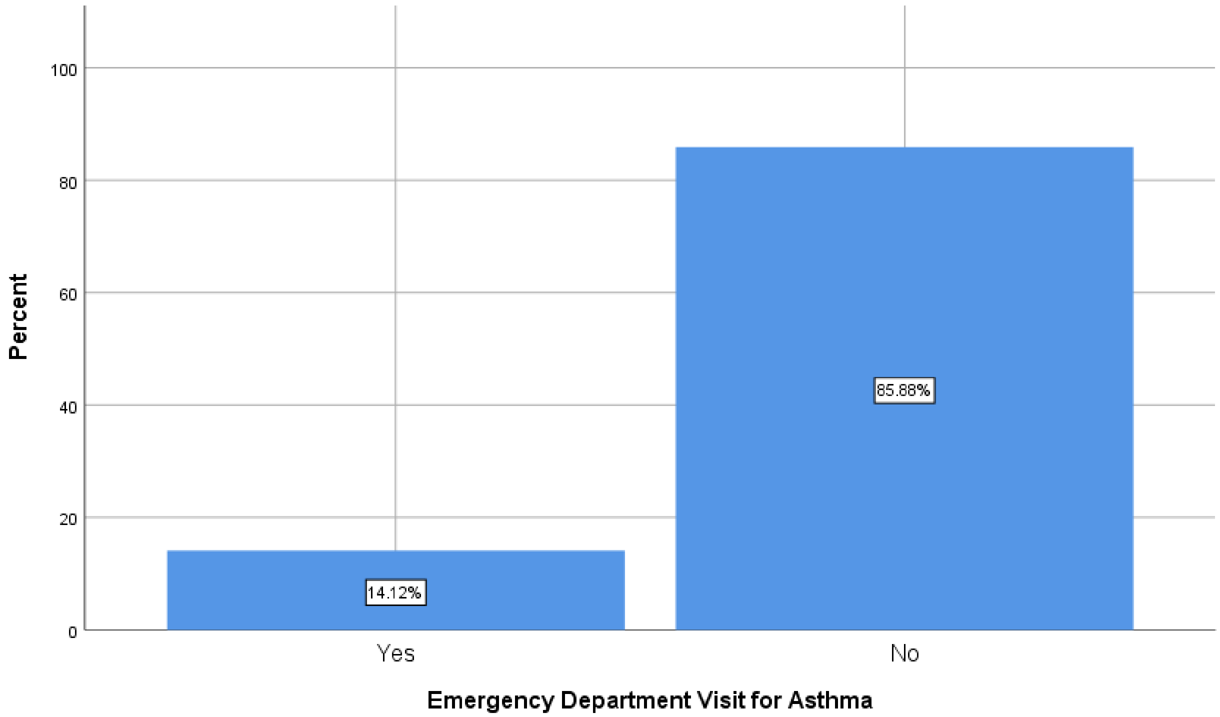
Asthma Present in the Household



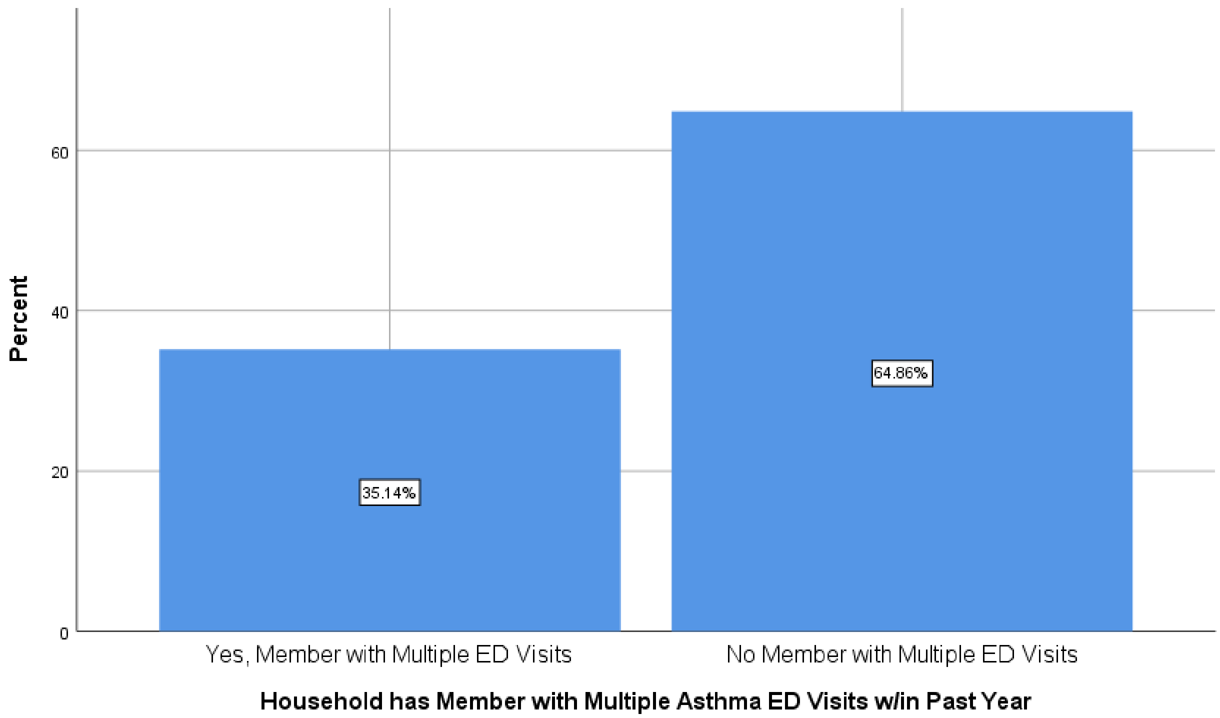
Percent of Household Members with Asthma (5 attributes)



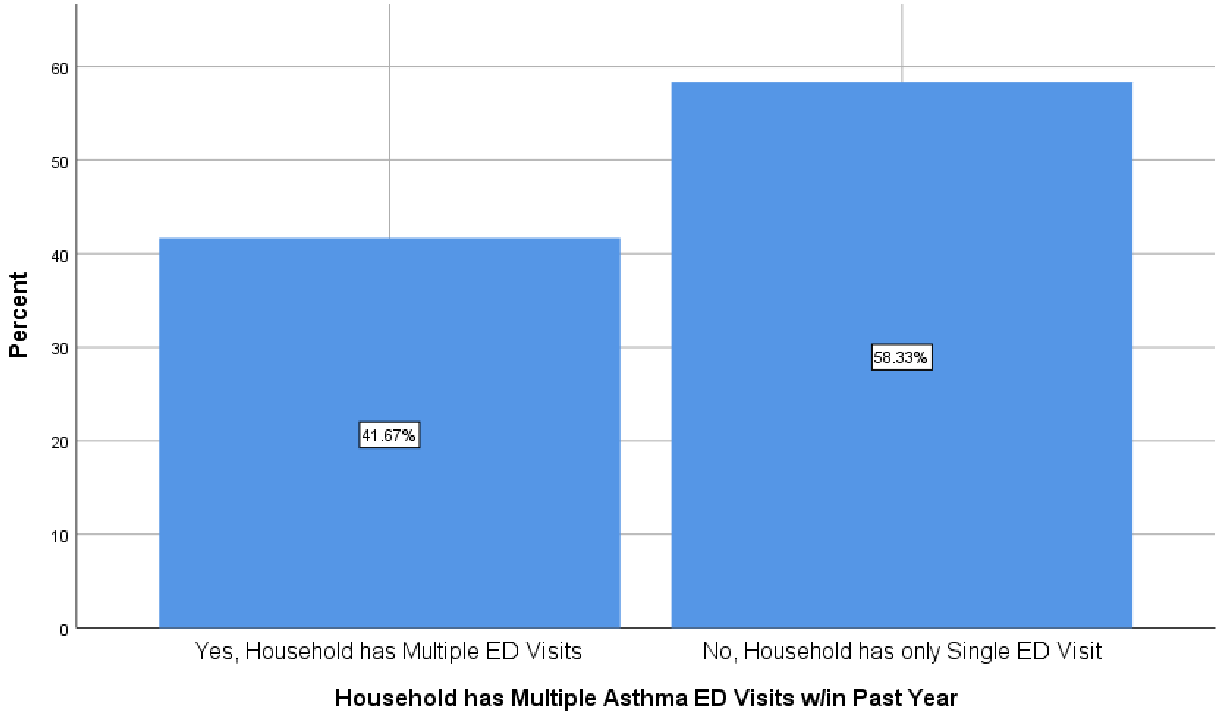
Emergency Department Visit within Past Year for Asthma



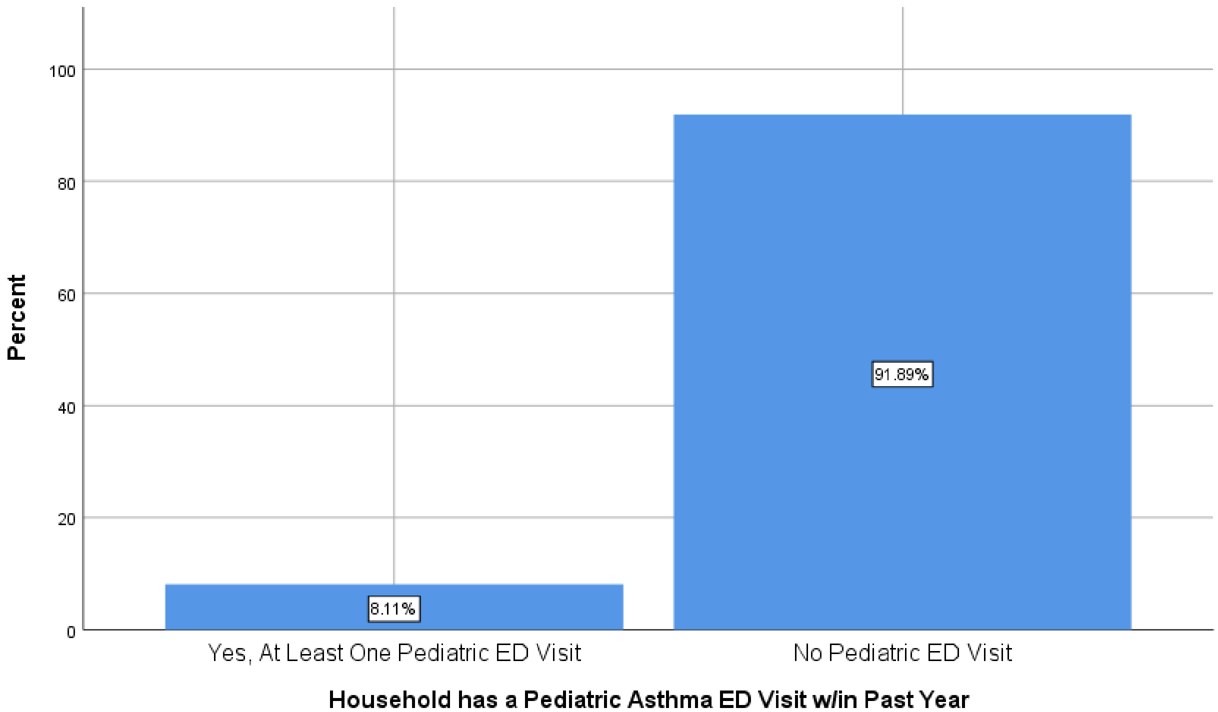
Member with Multiple Asthma ED Visits w/in Past Year



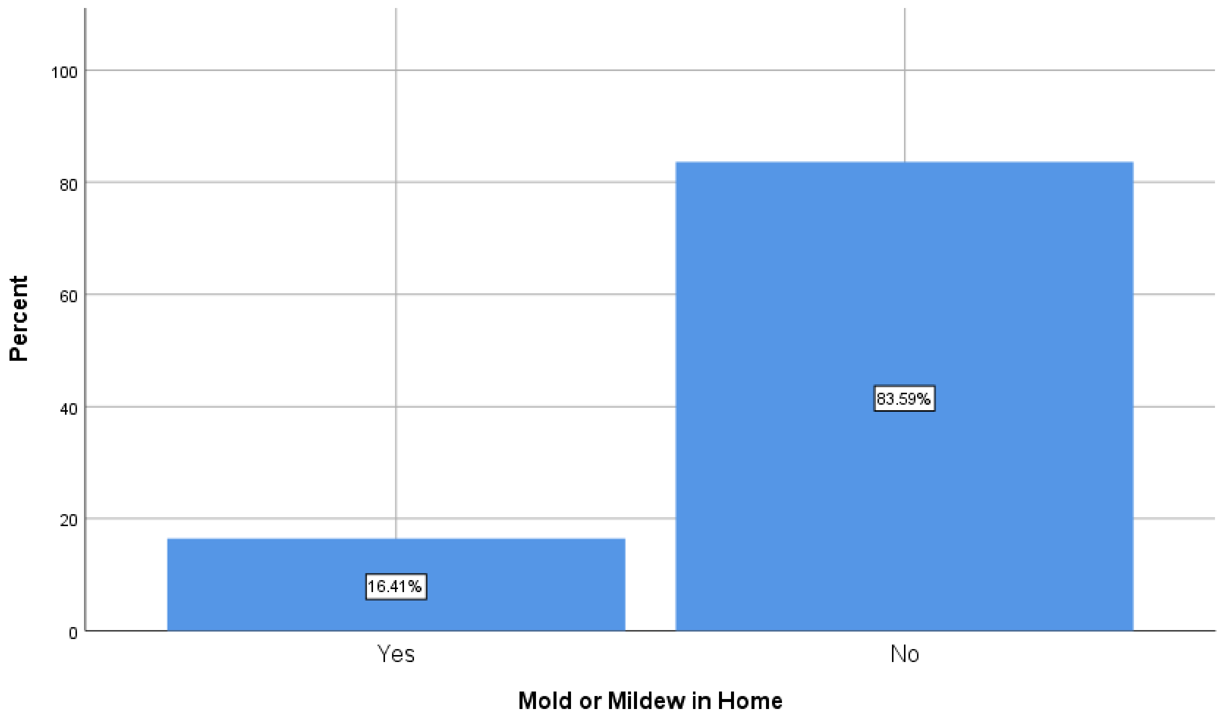
Household with Multiple Asthma ED Visits w/in Past Year



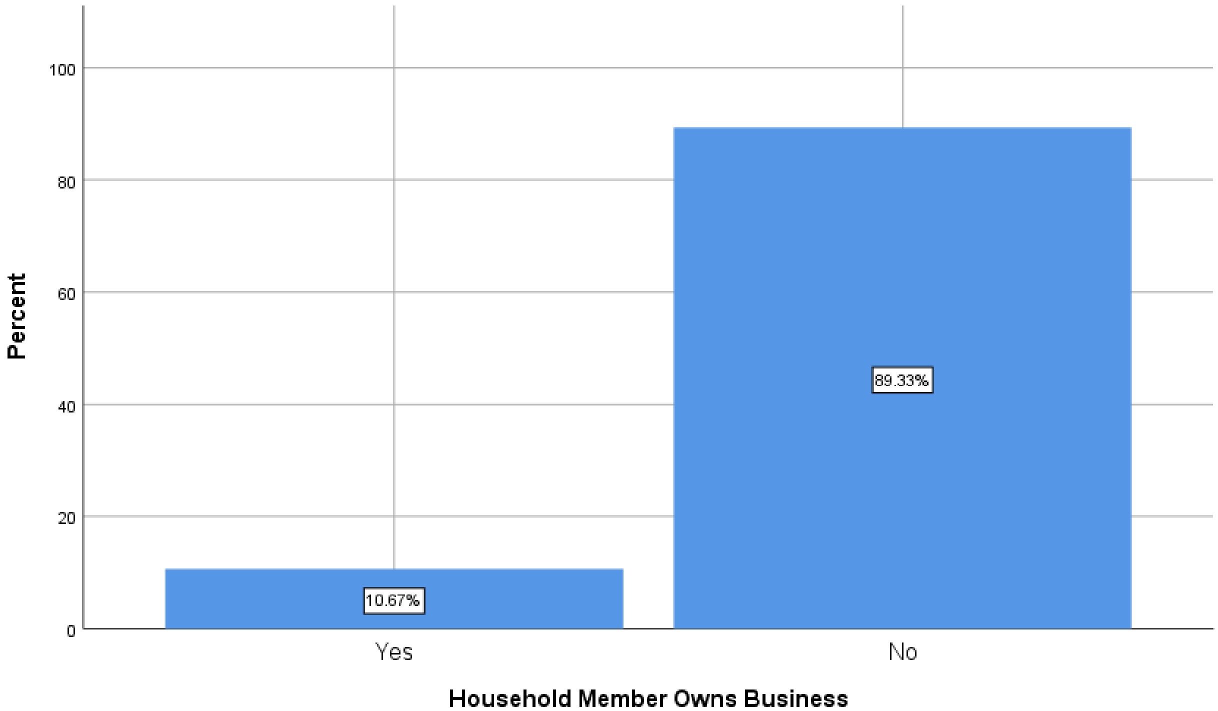
Pediatric Asthma ED Visit



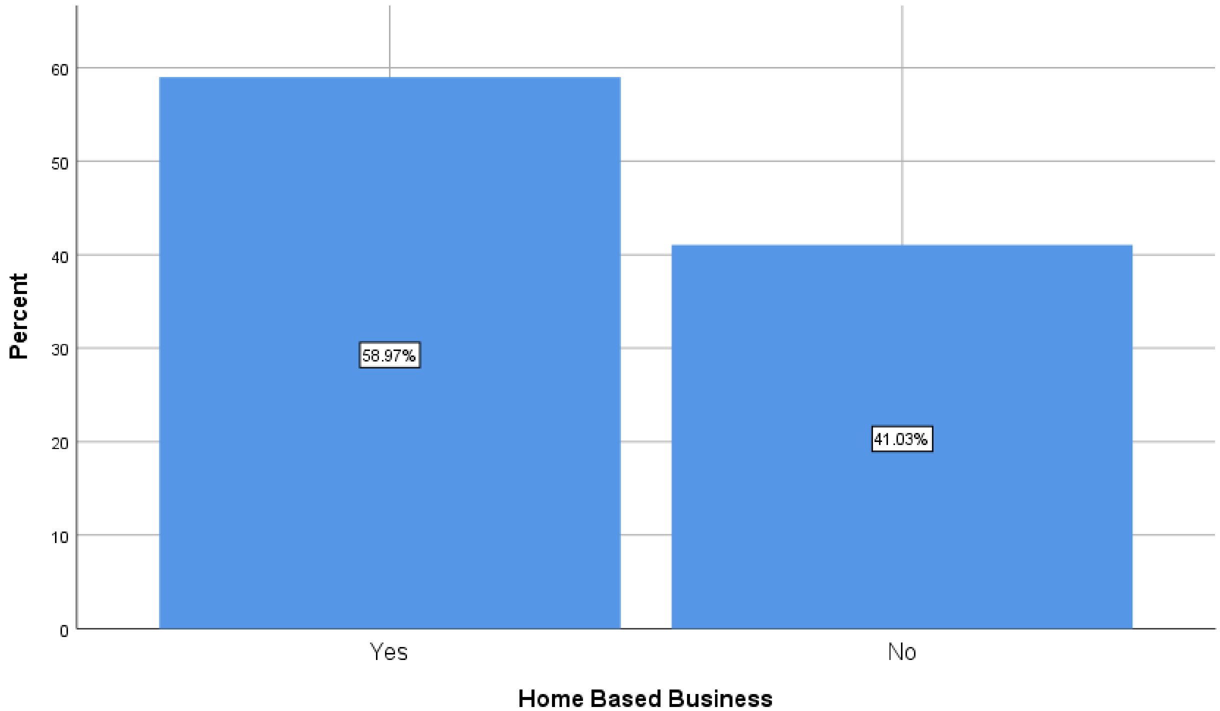
Mold or Mildew in Home



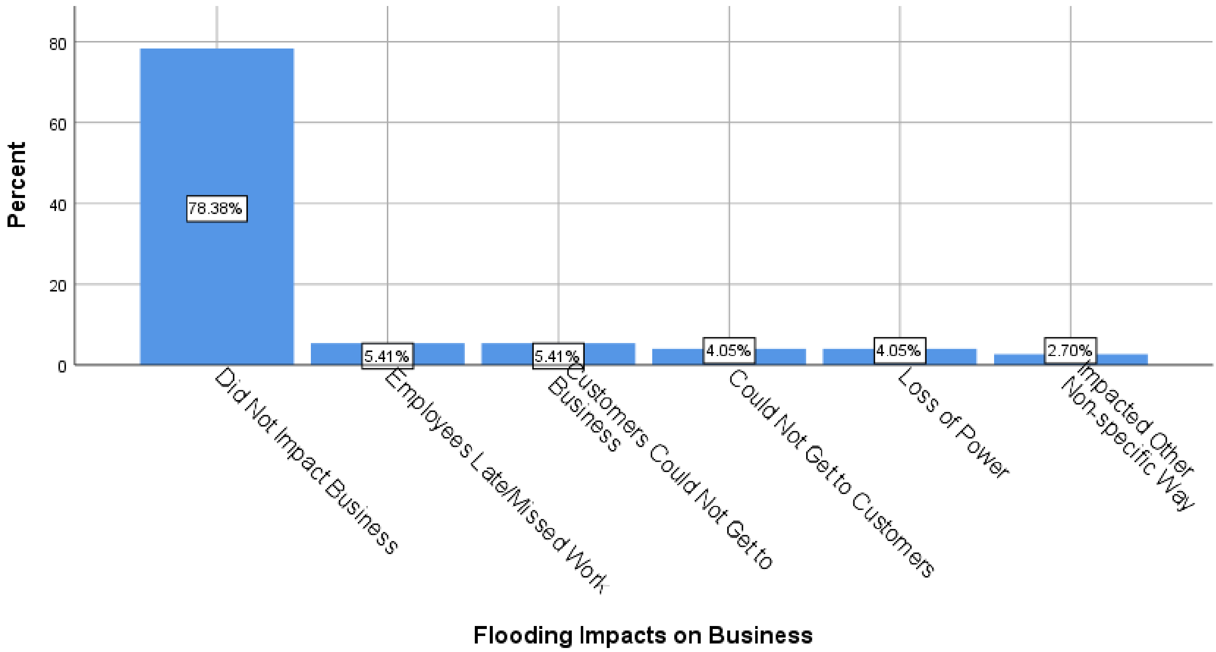
Household Member owns Business



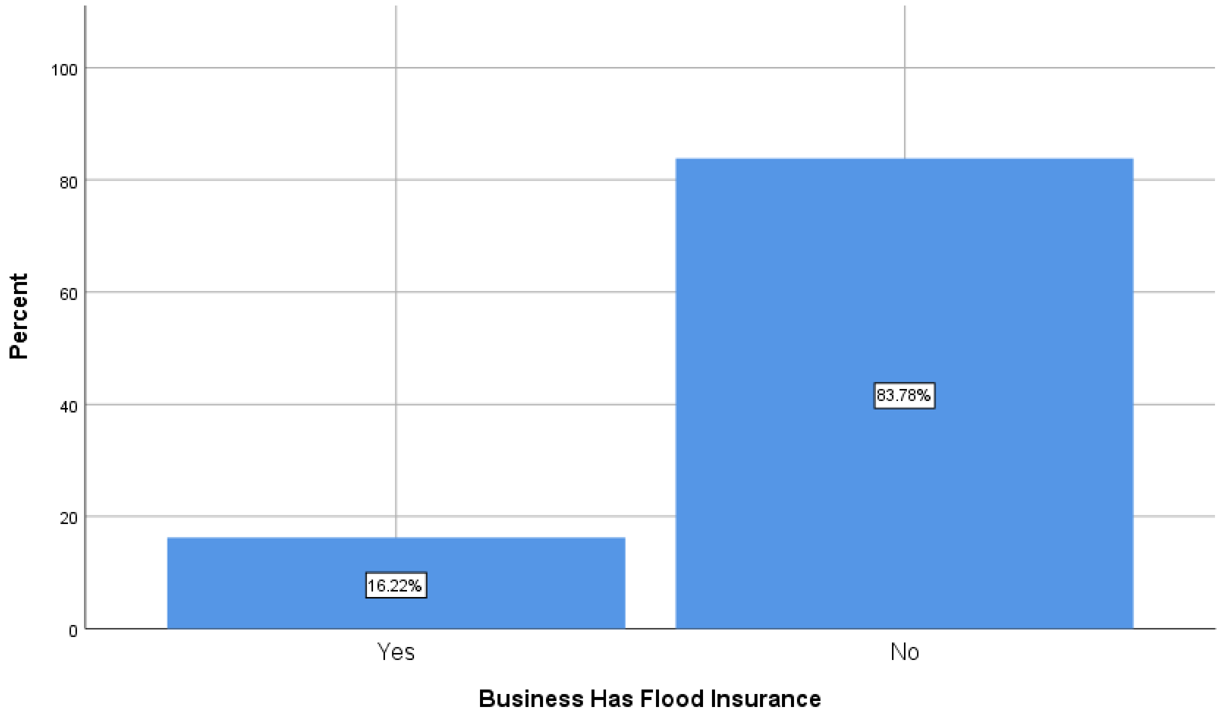
Home Based Business



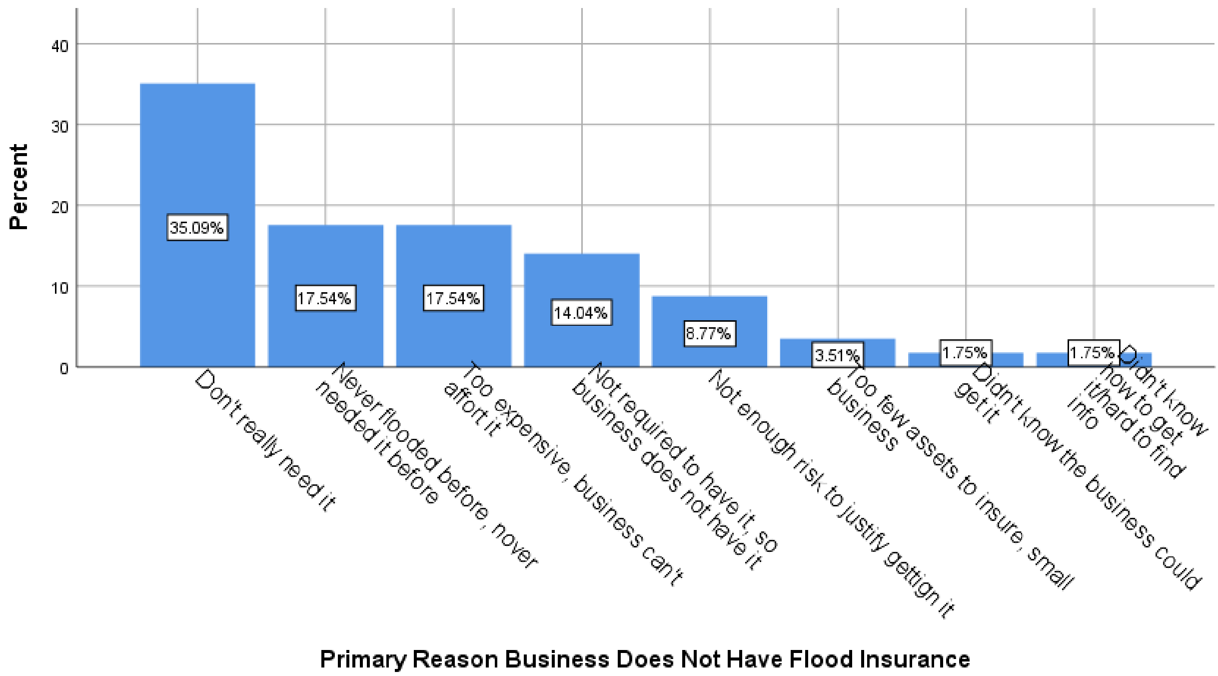
Flooding Impacts on Business



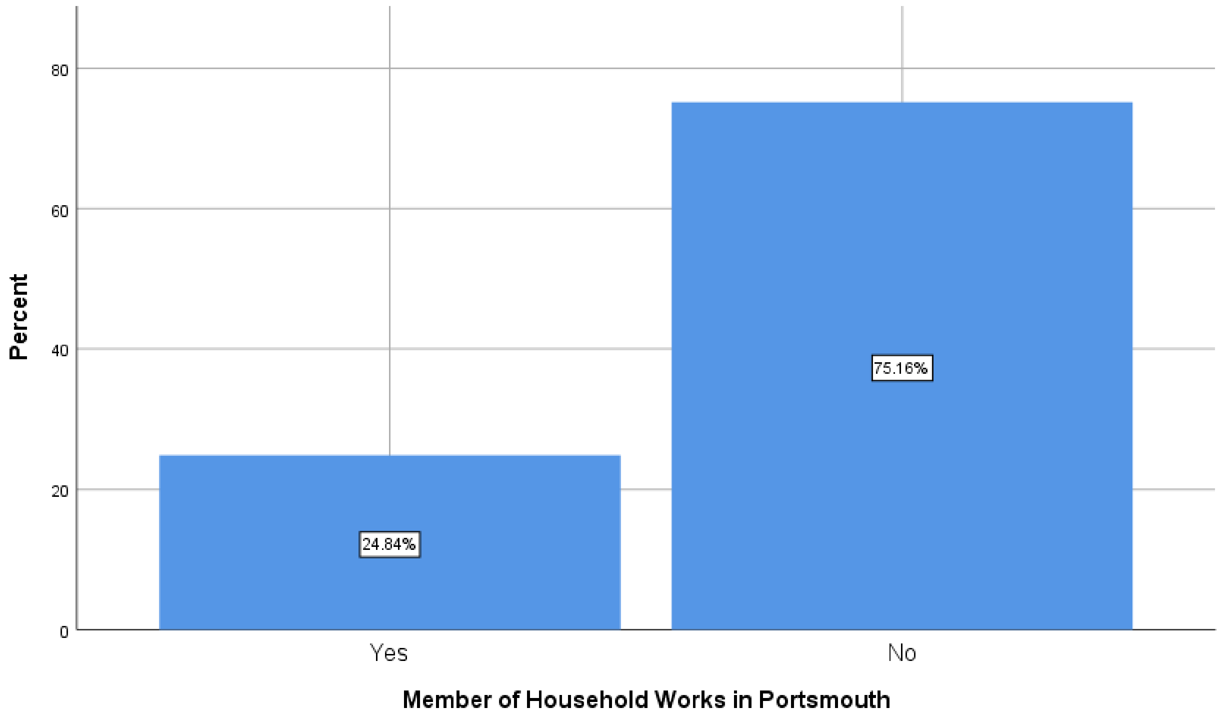
Business has Flood Insurance



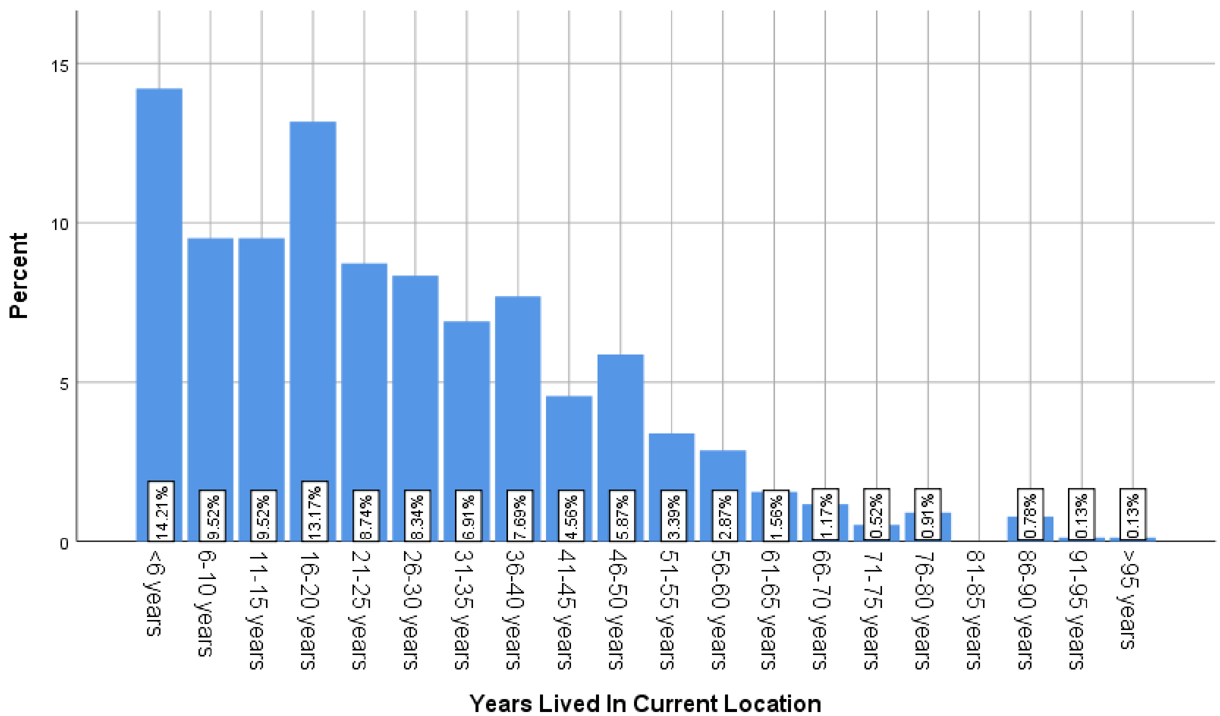
Primary Reason Business Does Not Have Flood Insurance



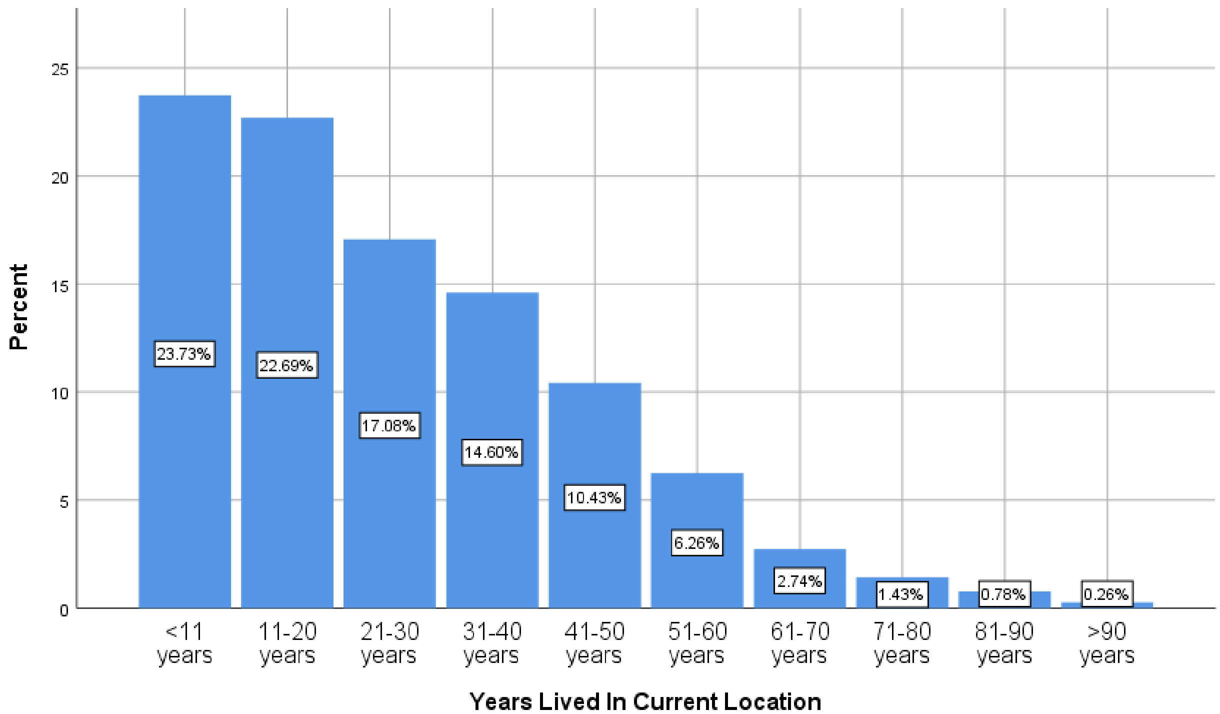
Member of Household Works in Portsmouth



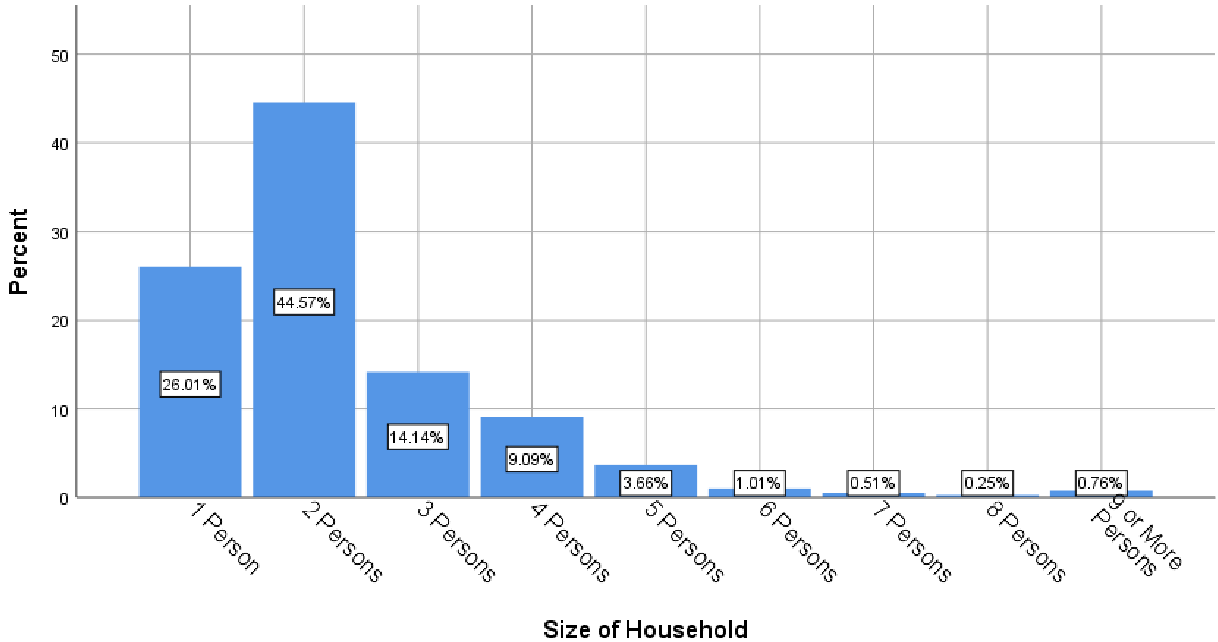
Years in Current Location (20 attributes)



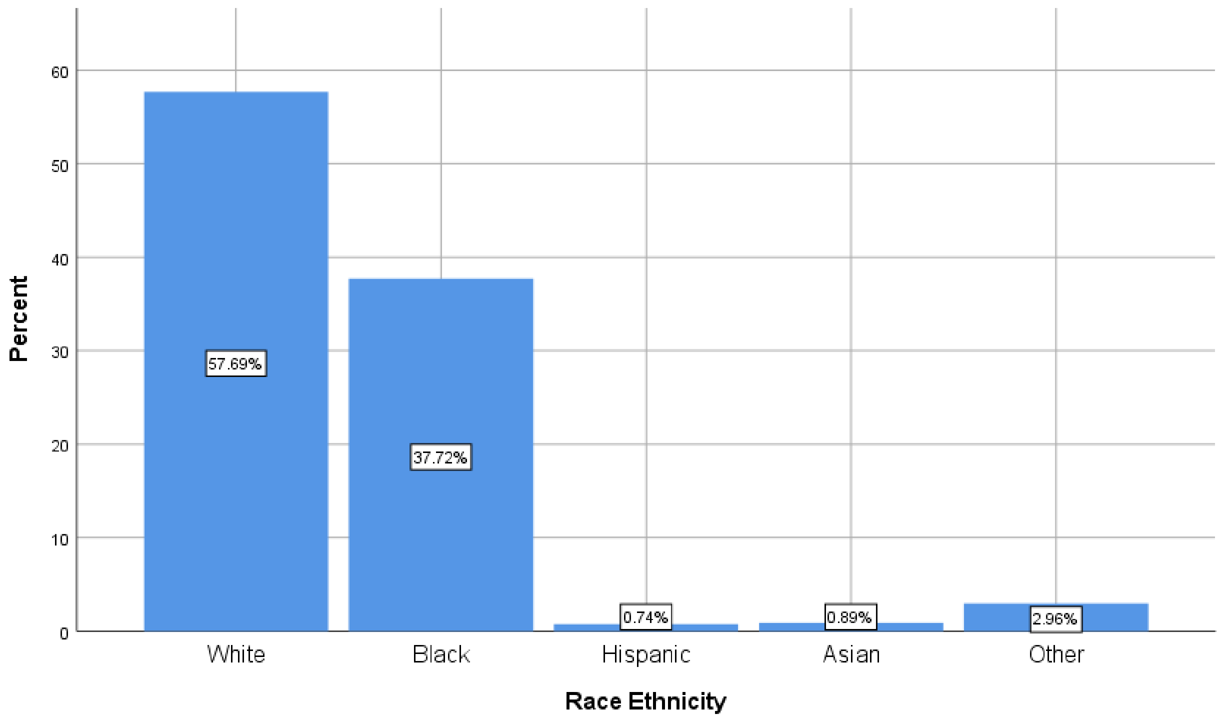
Years in Current Location (10 attributes)



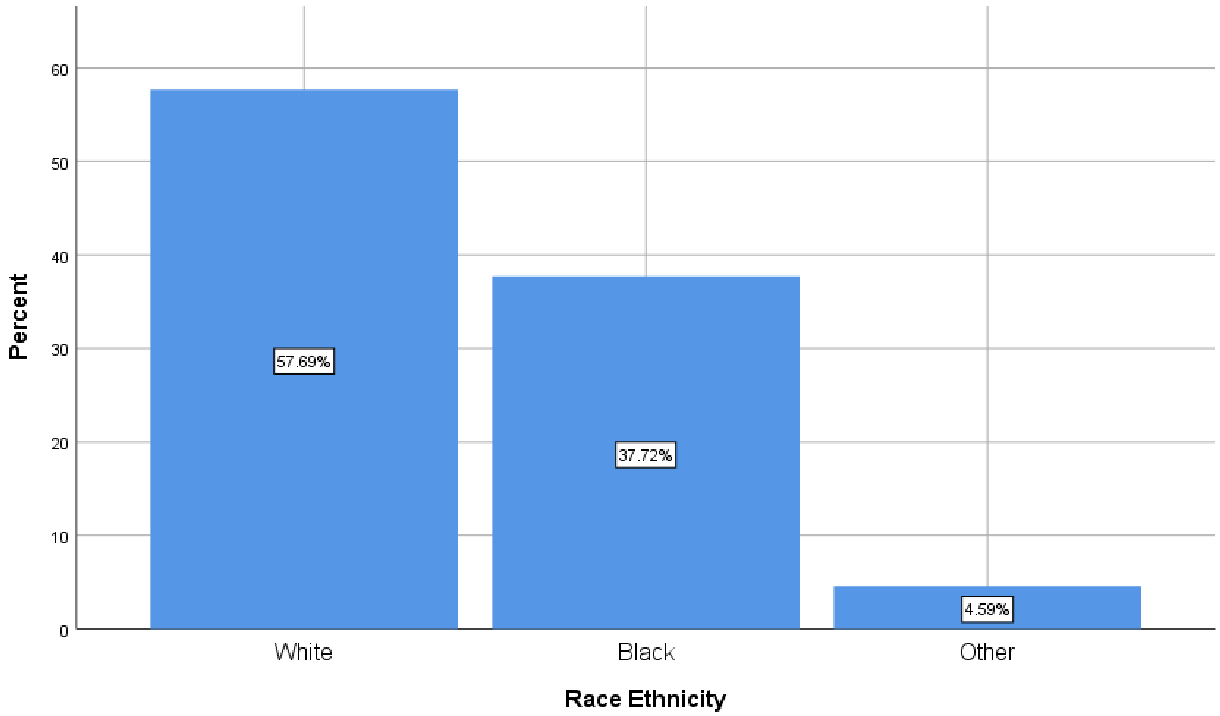
Size of Household



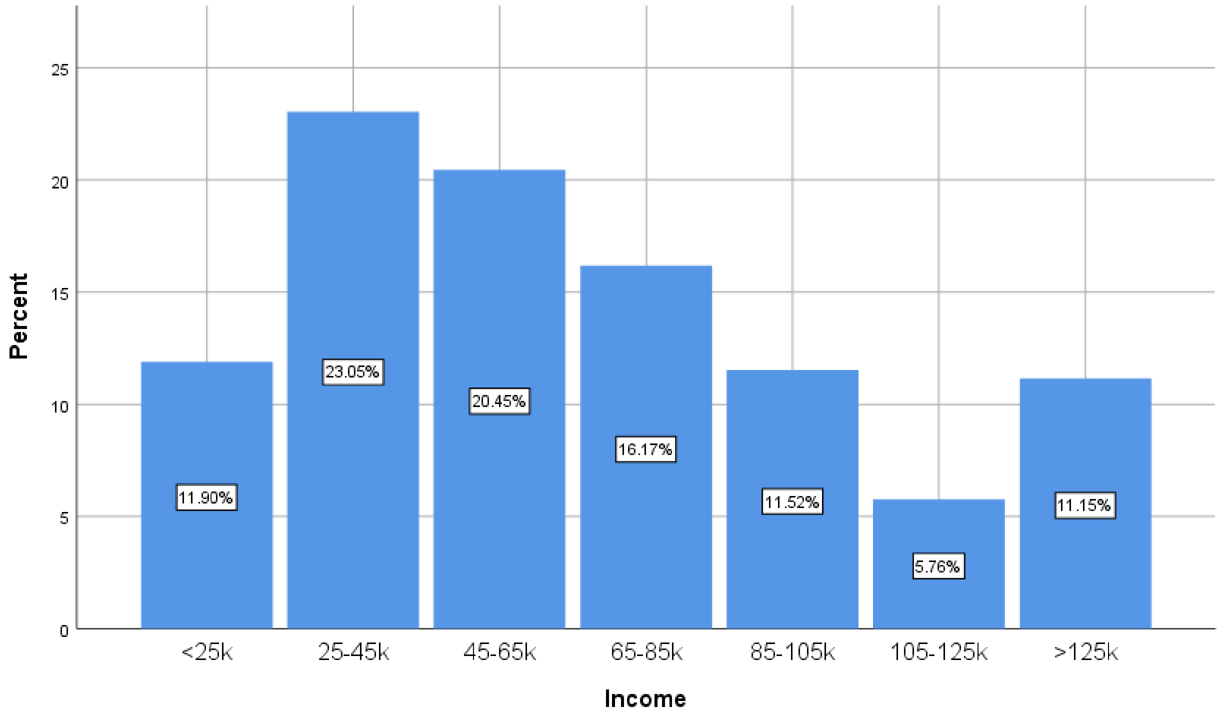
Race Ethnicity (5 attributes)



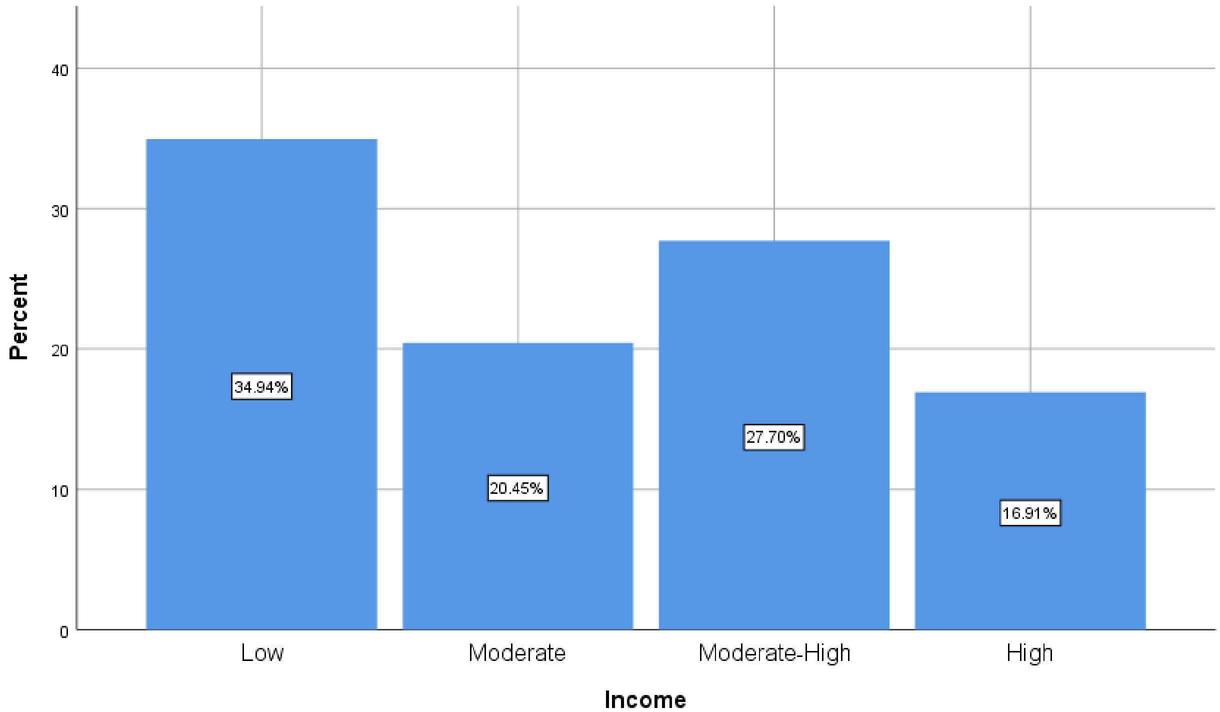
Race Ethnicity (3 attributes)



Income (7 attributes)



Income (4 attributes)



Income (2 attributes)