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Insurance Economic Analysis

City of Virginia Beach, Virginia

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Final Report

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EXECUTIVE SUMMARY

Flooding is a major source of economic loss to individuals and homes in Virginia Beach. Between 1977 and 2016, there have been 5,876 flood insurance claims totaling $250.8 million in building damage and $15.9 million in content damage. The highest number of claims in any single year occurred in 2016, with almost 1,500 claims reported in the City. The majority of these claims were associated with the impacts of Hurricane Matthew, and many of them occurred in areas of the City that had never experienced flooding before. Although flood insurance is a legal requirement only for homes with federally backed mortgages situated within the Special Flood Hazard Areas (SFHAs) mapped by the Federal Emergency Management Agency (FEMA), flooding does not always stay within these boundaries. Looking forward, sea level rise and the increasing frequency and intensity of heavy rain and coastal storm events will increase the likelihood of impacts unless significant action is taken to adapt to changing conditions and mitigate risks across the City.

In 2015, the City of Virginia Beach initiated the Comprehensive Sea Level Rise and Recurrent Flooding Study in recognition of increased flood risk and the need for a strategic adaptation strategy. This report contributes to this effort by developing estimates of the proportion of buildings in Virginia Beach that carry a National Flood Insurance Program (NFIP) flood insurance policy today, and by identifying opportunities for, and the potential benefits of, increasing coverage in anticipation of increasing flood hazards.

The analysis found that the overall flood insurance penetration rate across the City of Virginia Beach is approximately 11 percent. Of that coverage, 55 percent of policies are concentrated within the 100-year floodplain, the SFHA on a FEMA Flood Insurance Rate Map. Given that these areas have a 1-in-4 chance of experiencing flood impacts over the life of a typical 30-year mortgage, the remaining 45 percent of homes in the SFHA left unprotected represent a significant risk.

The analysis also revealed substantial variability in penetration rates across different regions of the City. Interestingly, policy penetration rates do not always align with the actual annualized flood losses. Almost all of Virginia Beach's flood risk is not on the open coast, but inside the City's coastal perimeter. However, flood insurance purchasing trends show that residents who live along the oceanfront exhibit the highest uptake of flood insurance. For example, neighborhoods in the Oceanfront Watershed have the highest policy penetration rate within the SFHA, at 85 percent, but actually have the lowest annualized flood losses, only accounting for 2 percent of the overall City-wide flood risk today. In

contrast, neighborhoods in Lynnhaven Watershed have a much lower policy penetration rate, at 54 percent, but make up more than 74 percent of the overall City-wide flood risk today. These discrepancies highlight a potential gap between perceived versus actual risk and demonstrate the need for focused flood risk outreach and education. Residents and businesses of Virginia Beach need to be armored with the knowledge to adequately understand existing and future flood risks and vulnerabilities to increase the likelihood of flood insurance uptake.

Several scenarios of increased policy penetration in Virginia Beach were explored. These scenarios were designed to compare how guiding the uptake of flood insurance, in various areas, or for vulnerable structures, could provide enhanced flood protection to residents and businesses. The various increased policy uptake and future condition scenarios were evaluated through residual risk, which represents the potential loss remaining after applying flood insurance coverage and considering deductible amounts. The top three effective strategies include increasing policy penetration within the SFHA, encouraging uptake of flood insurance for low-lying structures, and increasing policy penetration within the flood risk focus areas that are being used to guide development of sea level rise adaptation strategies in the City. It is important to note that areas subjected to ponding from rainfall/stormwater flooding are often not included in the SFHA. While not part of this analysis, which focuses on coastal flooding, such areas offer opportunities to focus increased policy penetration.

In addition to showing the importance of targeted outreach in areas prone to coastal flooding, the analysis also revealed the importance of maintaining a City-wide flood insurance policy base that reflects changing flood hazards. This outcome can only be achieved through effective messaging on changing flood hazards and regulatory changes to floodplain maps that drive insurance requirements. It will be especially important that the City actively educate residents on how the existing FEMA floodplain mapping and risk rating process may underestimate risk.

The results of this study can be used by the City of Virginia Beach to make strides toward addressing multiple action items identified in the Virginia Beach Sea Level Rise Policy Response Report. The City has recently been accepted into the National Flood Insurance Community Rating System (CRS) program, which was identified as a high-priority action item. Under this program, the City may receive additional CRS credits for providing flood risk data to the public, leading to flood insurance premium discounts for residents and businesses across Virginia Beach. Affordability will be especially important as changing flood hazards increase the cost burden of flood insurance. The outputs of this analysis can be used by the City and its partners to develop targeted outreach to encourage flood insurance uptake

in high risk areas, in advance of future threats. Existing platforms for public outreach could be leveraged, such as the Get Flood Fluent campaign that was recently launched to educate residents of the Hampton Roads region on the benefits of carrying flood insurance.

This analysis could also support several of the floodplain regulation action items. The current conditions analysis revealed that residual risk today and under future conditions could potentially be mitigated by re-defining the "regulatory floodplain" (i.e., the area where there are flood insurance requirements and floodplain regulations). In fact, the newly mapped floodplains that were developed using robust numerical modeling framework demonstrate that the existing Flood Insurance Study for Virginia Beach (effective 2015) underestimates flood risk especially in the southern portion of the City. Strategies, such as these, will help protect the welfare of residents and businesses in Virginia Beach so that they are insured when a flood occurs, able to afford the coverage, and informed about what they can do to reduce the likelihood of flooding impacts.

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Glossary of Commonly Used Terms

Average Annualized Loss	Average Annualized Loss (AAL) represents the average expected loss for any given year as considered within a large series of years. This requires understanding of the frequency and severity of loss events within the series as a whole.
GIS	A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data.
PII	Personally Identifiable Information (PII) includes any information that can be used on its own or with other information to identify, contact, or locate a single person, or to identify an individual in context.
Policy Penetration	A measure of the amount of insurance policies to the amount of insurable assets, typically structures, with a given area. This study uses two ratios primarily to measure policy penetration. The first is a ratio of policies to structures within a given area. The second is a simple percentage of the structures within a given area that have at least 1 associated policy.
Relative Sea Level Increase	Increase in the mean sea level related to a local reference land level, which can result from a combination of land subsidence or actual mean sea level increase.
Residual Risk	Represents potential losses to assets remaining for a given scenario, after applying any applicable flood insurance coverage and deductible amounts.
Special Flood Hazard Areas	The land area covered by the floodwaters of the base flood is the Special Flood Hazard Area (SFHA) on National Flood Insurance Policy (NFIP) maps. The SFHA is the area where the NFIP's floodplain management regulations must be enforced and the area where the mandatory purchase of flood insurance applies.
Under-Insured	For purposes of this study, this refers to structures or assets that have protection in the form of federally provided flood insurance through the NFIP, but not a significant enough amount to overcome modeled loss projects, leaving them at risk.
Uninsured	Refers to structures or assets that lack protection from loss in the form of insurance. For the purpose of is this study, this refers specifically to assets lacking federally provided flood insurance through the NFIP.

1. INTRODUCTION

A major component of preparing a community for increased sea level rise and recurrent flooding is ensuring that residents and businesses have the means to recover from a flood event. Flood insurance is highly recommended for properties located in flood-prone areas and is required for all homes with federally backed mortgages situated within the Special Flood Hazard Area (SFHA). This requirement can be fulfilled through purchasing a flood insurance policy through the Federal Emergency Management Administration's (FEMA's) National Flood Insurance Program (NFIP). Successful adaptation planning necessitates understanding existing policy coverage as well as identifying opportunities for encouraging the uptake of flood insurance in advance of changing flood hazards. Flood insurance will become increasingly important as sea levels continue to rise and rainfall events become more intense and frequent.

In 2015, the City of Virginia Beach initiated the Comprehensive Sea Level Rise and Recurrent Flooding (CSLRRF) study to produce information and strategies to enable the City of Virginia Beach to establish long-term resilience to sea level rise (SLR) and associated recurrent flooding. The study was phased over three key elements consisting of an Impact Assessment, Adaptation Strategy Development, and Implementation (Figure 1). As part of the impact phase of the study, the City of Virginia Beach, supported by Dewberry and sub-consultant Syndeste LLC, conducted an economic analysis of flood insurance under current and future flood conditions and regulatory change scenarios. The purpose of this analysis was to equip the City of Virginia Beach with planning and flood risk communication tools to encourage flood insurance uptake in advance of changing flood conditions.

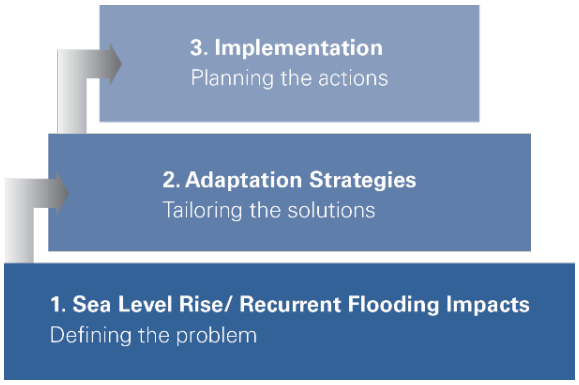

Figure 1: Three elements of the CSLRRF.

The City's recent acceptance into the National Flood Insurance Community Rating System (CRS) program provides flood insurance premium discounts for residents and businesses across Virginia Beach. This program provides additional opportunities to focus on flood risk outreach and education. The City may receive additional CRS credits for providing flood risk data to the public. Through this educational outreach, the City has the chance to increase its CRS score and further reduce insurance

premiums for all NFIP insurance holders within the City. It is recommended that the results of this analysis be leveraged to enable focused educational outreach and risk communication within specific neighborhoods in Virginia Beach.

2. APPROACH AND OUTCOMES

This effort was carried out in the four primary tasks outlined in Figure 2. Together, these tasks will support development of long-term strategies to increase flood insurance policy penetration throughout the City to reduce loss exposure and enable better recovery following damaging flood events.

Data Management Plan

- **Approach:** Develop a data management plan for transfer and storage of flood insurance policy and claims data.
- **Outcome**: Ensure proper management of any Personal Identifiable Information associated with FEMA flood insurance policy data.

Current Conditions Analysis

- **Approach:** Analyze current flood insurance policy penetration in Virginia Beach.
- **Outcome:** Understand the current adoption rates of flood insurance offered by the NFIP, both inside and outside the FEMA SFHA. Also allow for identification of concentration of claims and under-insured areas.

Future Conditions and Regulatory Change Analysis

- **Approach:** Evaluate various flood insurance uptake scenarios to help identify areas that could benefit from increased flood insurance policy penetration today and under future conditions.
- **Outcome**: Provide a community planning tool for testing strategies for encouraging flood insurance uptake, especially for properties outside of the current SFHA that are estimated to be located in "future floodplains."

Flood Insurance Affordability Analysis

- **Approach**: Leverage the socio-economic data to analyze flood insurance affordability across Virginia Beach.
- **Outcome**: Identify areas that are likely to be impacted by increased cost burdens of flood insurance.

Figure 2: Key tasks for the flood insurance economic analysis for the City of Virginia Beach.

3. DATA MANAGEMENT ACTIVITIES

Given that this effort involves analysis of sensitive FEMA flood insurance policy datasets, a data transfer, management, and infrastructure strategy was completed in the initial stages of this effort to ensure proper management of any Personally Identifiable Information (PII). See Appendix A for more information.

3.1. Data Management Plan

Subsequent to general contract setup and coordination, a PII Data Management Plan was established to support transfer of the following datasets:

- Existing Policies in Force (PIF) database
- Historical flood insurance claims database

PII data received was set up in a secure infrastructure in Syndeste's private cloud, and user roles were assigned for data access as approved in the PII Data Management Plan.

3.2. Data Collection

In parallel, Syndeste worked with Dewberry to establish additional data needs for the analysis, including conducting geospatial layer quality assurance and ensuring that all data attributes needed were present for the following datasets:

- Building Footprints
- Reporting Geographies
- Land Parcels
- 5-Foot Resolution Digital Elevation Model (DEM)
- Multi-Frequency and Future SLR Scenario Estimated Flooding Extents
- Multi-Frequency and Future SLR Scenario Estimated Flooding Depth Grids
- Structure Specific Multi-Frequency and Future SLR Scenario Estimated Structure and Content Loss Estimates
- Average Annualized Loss (AAL) Estimates

3.2.1. Building Footprints

This effort leveraged a common set of building footprints and land parcels developed under the CSLRRF study, including 147,726 structures and 134,631 parcels. This dataset represents all building footprints that are considered "valid"—meaning that those buildings are considered to be occupied structures. Therefore, buildings such as detached garages, sheds, or other various outbuildings were not included in the analysis. Military buildings were also excluded.

3.2.2. Reporting Geographies

Reporting geographies allow for the building and address-specific flood insurance policy information to be summarized to various geographies areas listed below:

Planning Subdivisions	Strategic Growth Areas	Stormwater Drainage Basins	Watersheds
Census Blocks	Census Block Groups	1,500 ft Grid	500 ft Grid

These reporting entities allow the study team, as well as the City of Virginia Beach, to create visualizations for a variety of audiences and stakeholders. It should be noted that several of the reporting entities do not cover the entire City. This means that the roll-up totals of any metric for each set of reporting entities will be dissimilar by a small order of magnitude.

3.2.3. Policy and Claims Data

This analysis leveraged the latest FEMA NFIP policy and claims datasets available at the time of the analysis, which included:

- Policy Database – December, 2016.
- Claims Database – August, 2017.

3.2.4. Flood Loss Estimates

The economic flood loss data, developed using FEMA's HAZUS software as part of the economic flood risk analysis under the CSLRRF study, was leveraged to calculate residual risk (i.e., the economic loss remaining after an insurance payout is made following a flood insurance claim). These modeled losses include building and content damage estimates for the 10-, 25-, 50-, 100-, and 500-year frequency events as well as average annualized losses (AAL) attributed to building footprints. The modeled loss values represent dollars of damage projected to be experienced at different flood depths for each structure, assuming certain flood depths correspond to particular modeled flood frequency events.

4. CURRENT CONDITIONS ANALYSIS

4.1. Introduction

The analysis of current conditions will enable the City of Virginia Beach to understand the current adoption rates of flood insurance offered by the NFIP, both inside and outside the SFHA. The analytical and mapping outputs will identify areas of policy and claims concentration, compared against residual risk estimates.

Residual risk estimates represent potential loss remaining for a given scenario after applying flood insurance coverage and deductible amounts. These scenarios can be specific to particular flood frequencies or annualized to represent expected average loss per year across a large time frame. Residual risk estimates provide a window into liabilities remaining after insurance has played its role in a loss scenario.

Together with examining current policy adoption at a structure-level, the current conditions analysis identifies specific under-insurance issues across the City of Virginia Beach. This analysis may also be used for obtaining CRS credits by leveraging the outputs for risk communication within specific neighborhoods in the community, while honoring the privacy of PII data.

4.2. Methods

The subsections below provide an overview of the various steps involved in the analysis of current flood insurance penetration rates within the City of Virginia Beach.

4.2.1. Setup for Computations Based on Current Conditions

A geocoding engine was developed to match the individual addresses provided in the NFIP policy and claims datasets to specific building footprints. The geocoding was performed using the Texas A&M Geocoder, with some manual clean-up of geocoder outputs. Out of 17,532 policy records and 5,982 claim records, 17,429 and 5,876 could be reasonably located, respectively. The result was a comprehensive dataset where existing policies were matched to individual structures/parcels.

Subsequently, building footprints were mapped to each of the parcels in which they were located. Several deficiencies were found between the footprints and parcels, which were corrected where feasible. Only 54 building footprints remained unassociated with parcels.

A key assumption in this analysis is that all policies assigned to a given individual structure act in aggregate in the case of a modeled loss. Deficiencies in the attributes of input data on NFIP policies prevented the study team from distinguishing multiple policies tied to the same individual structure or parcel. As a result, the analyses were conducted by treating multiple policies mapped to a single building or parcel in aggregate. As an extension of this concept, it is important to note that all calculations within the analysis have been conducted at the highest possible resolution, which is always either a structure or parcel. Care was taken to avoid aggregation of liabilities that would have resulted in coverage or losses being incorrectly shared between any multiple structures or parcels.

Not all of the existing policies could be tied to structures, even where the address on the policy received a reasonable geocoding result. In the interest of allowing these records to be included in the analysis, they were classified as “orphans.” Orphan policies here refer to those that could not be mapped to a structure, even after manual cleanup. Out of 17,429 policies successfully mapped, 1,145 were found to be orphan. Likewise, orphan buildings are those that have no associated policies, although they have been included in the analysis and could have associated modeled losses. These policies and buildings are accounted for in the study results, although the methods differ as to how they are rolled up. Specific details of these roll-up steps are presented below.

4.2.2. Calculation of Policy Penetration

Policy penetration can be calculated using either of two primary methods:

1. A **ratio** measure of the number of policies within a given area to the number of structures or housing units, or
2. A **percentage** of structures within a given area that have one or more associated policies.

The appropriate choice of methods depends on the land use and structure occupancy characteristics of given areas. For example, in reporting areas containing both single family and multi-family homes, a higher policy count to structures ratio may look favorable on the surface, even though, if those policies are concentrated in multi-family homes, the single family homes may actually be unprotected. In such a case, a percentage of structures with at least one policy may be a more telling metric. Conversely, a high percentage of structures with at least one policy may conceal a lack of policies associated with structures that have multiple housing units that perhaps should each have an associated policy. Summary tables presented in this report will include metrics calculated in both ways for comparison.

4.2.3. Calculation of Residual Risks

The modeled losses, along with the policy coverage amounts and deductibles associated with individual structures, provide the input needed to calculate residual risks. The modeled losses, broken down across the four major watersheds in the City of Virginia Beach, are presented in Table 1. The percentage of total City-wide annualized flood losses for the current condition scenario are shown in Figure 3. Residual risk for this analysis was calculated for building and content loss values separately and then combined to obtain a total. The computations were first performed for building-level residual risk, followed by a composite parcel-level residual risk analysis.

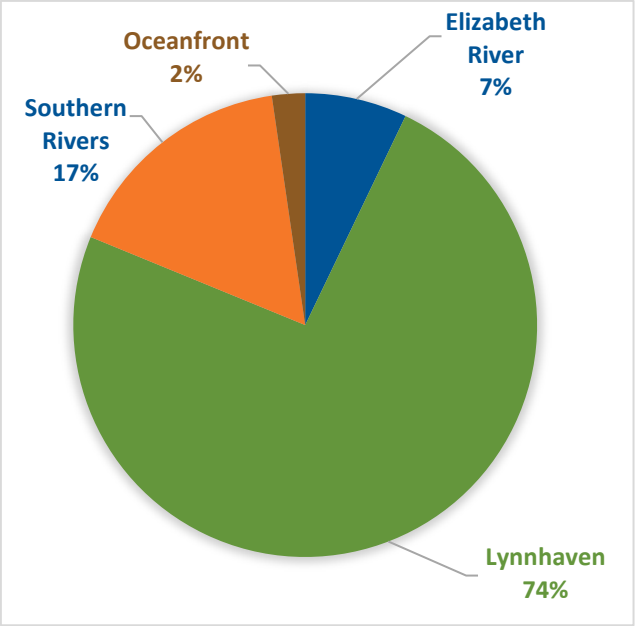

Figure 3: Concentration of annualized flood losses today within the City's four major watersheds.

Table 1: Aggregate modeled losses as an input for the residual risk calculation, broken down by watershed for the 100- and 500-year events, as well as for Average Annualized Loss (AAL) for existing conditions.

Watershed	Location (In/Out SFHA)	100-Year Event Modeled Loss		500-Year Event Modeled Loss		AAL Modeled Loss	
		Building	Contents	Building	Contents	Building	Contents
Elizabeth River	Inside	$6,633,819	$4,130,150	$40,890,665	$26,081,021	$389,974	$265,038
	Outside	$0	$0	$17,098,599	$10,505,178	$102,606	$63,061
	Total	**$6,633,819**	**$4,130,150**	**$57,989,264**	**$36,586,199**	**$492,580**	**$328,099**
Lynnhaven	Inside	$97,861,405	$43,360,629	$246,377,667	$155,455,608	$4,938,326	$2,431,241
	Outside	$2,905,205	$573,348	$101,801,172	$41,933,966	$640,135	$257,668
	Total	**$100,766,610**	**$43,933,977**	**$348,178,839**	**$197,389,574**	**$5,578,461**	**$2,688,909**
Oceanfront	Inside	$2,982,736	$652,269	$7,589,421	$2,788,194	$154,737	$37,873
	Outside	$73,709	$6,018	$6,780,356	$1,726,381	$41,345	$10,413
	Total	**$3,056,445**	**$658,287**	**$14,369,777**	**$4,514,575**	**$196,082**	**$48,286**
Southern Rivers	Inside	$14,238,428	$11,562,185	$29,512,415	$23,993,863	$744,729	$539,422
	Outside	$3,826,560	$3,142,029	$20,631,359	$16,555,988	$206,704	$160,023
	Total	**$18,064,988**	**$14,704,214**	**$50,143,774**	**$40,549,851**	**$951,433**	**$699,445**

Building-Level Residual Risk

Building-level residual risk was computed to reflect the modeled losses that remain after applying flood insurance coverage and deductible amounts, as follows:

Building-Level Residual Risk = modeled loss for building - (total coverage - total deductible)

It should be noted that orphan policies not assigned to buildings through these means are not included in the building-level summary statistics, but they will be rolled up to parcel as described in the next section.

Parcel-Level Residual Risk

Parcel-level residual risk can be calculated in one of two ways: composite residual risk or raw residual risk.

1. **Composite Residual Risk:** Composite residual risk is the result of rolling up all building-level residual risk associated with a parcel, plus an accounting for the orphan records associated with the parcel (either policy records or building footprints), as follows:

   Composite Residual Risk = sum of building level residual risk for all buildings on a parcel + [sum of losses for all orphan buildings on parcel - (sum of coverage for all orphan policies on the parcel - sum of deductibles for all orphan policies on the parcel)]

   The important assumption made in this approach is that orphan coverage acts in aggregate for the entire parcel, separate from the parcel's associated sum of building level residual risk. Without ability to assign the orphan policies to specific buildings, and given the relatively low occurrence of this phenomenon, this approach was the best way to include the impact of orphan records without losing high resolution insights available for a majority of the buildings.

2. **Raw Residual Risk:** Raw residual risks at a parcel-level can be calculated by simply aggregating all coverage and modeled loss associated with the parcel, and then performing the calculations for the parcel as a whole using the same method as for individual buildings, as follows:

   Raw Residual Risk = sum of losses for all buildings on parcel - (sum of coverage for all policies on the parcel - sum of deductibles for all policies on the parcel).

   This method of calculating residual risk is not considered an ideal method, but its inclusion in the data model might help highlight the pitfalls of the practice. By using aggregates of

protection provided by all policies within a multi-structure parcel, it would accidentally "hide" risks by allowing coverage from less risky structures to be shared with other riskier structures within the same parcel. Ultimately, the result would not reflect how insurance actually works.

In either case, similar to building calculations, structure and content residual risk calculations are performed separately and then combined.

It should be noted that in some instances the "in SFHA" and "out of SFHA" residual risk totals added together will not be the same as the "total" residual risk for an entity. This is due to the accounting of the orphan policies. In some cases, an orphan policy may be in the SFHA, whereas structures contributing loss to the parcel for the scenario may be located outside of the SFHA, or vice versa. When looked at as a whole, the mitigating effect of the policy on the parcel's loss will be accounted for; however, when looking solely inside or solely outside the SFHA, there are instances where the loss will be on one side of the line and the policy on the other—in either case leading to the mitigating effect of the policy being lost. It is also important to note that being in or out of the SFHA for orphan policies was determined by the flood zones on the policies themselves.

4.3. Current Condition Analysis Results

This section presents findings on policy penetration rates, historical flood insurance claims, and residual risk estimates to enable an understanding of current conditions across the City of Virginia Beach. It is important to remember that these results are based on the FEMA policy database dated December 31, 2016, and the FEMA claims data dated August 31, 2017. Current conditions may have changed slightly as of the date of this report.

Results in this report are summarized at the City-wide, watershed, and planning subdivision levels. These geographies were chosen given that these scales are large enough to view differences while also protecting PII data. Given the large amounts of data evaluated through this analysis, the full set of data is available in the geospatial database or Excel spreadsheets exhibits that were developed as part of this effort. Please refer to Appendix B for a description of these supplemental materials.

4.3.1. Policy Penetration

As outlined in the methods section, policy penetration can be reported as either a ratio or a percentage. As a reminder, the **ratio** is a measure of the number of policies within a given area to the number of structures or housing units, whereas the **percentage** compares the number of structures

that have at least one policy within a given area to the number of structures. When evaluating policy penetration at larger geographic scales (City-wide and watershed-level), these values are typically very close, given that the signal of local land use and structure occupancy characteristics are diminished when summarized at these scales. At smaller spatial scales, such as at the planning subdivision-level, comparison of these two metrics can provide insight into characteristics driving local penetration.

City-wide Policy Penetration

The total number of existing NFIP policies, number of buildings with policies, and computed penetration rates for the City of Virginia Beach are presented in Table 2. The overall NFIP policy penetration rate across Virginia Beach is approximately **11 percent**, which represents all NFIP policies regardless of location. Within the SFHAs of Virginia Beach, there is an approximately 55 percent penetration rate.

Table 2: Policy penetration rates for the City of Virginia Beach (Based on non 'orphan' policy base)

Total Buildings City-wide	Total NFIP Policies	Total Buildings with Policies	Overall	Inside SFHA	Outside SFHA
147,726	16,284	15,541	10.52%	55.25%	7.56%

Policy Penetration by Watershed

The overall policy penetration within each of the four major watersheds in Virginia Beach, as well as penetration rates inside and outside of the SHFA, are presented in Figure 4. Figure 5 provides a heat map of policy concentration across the City's watersheds by showing number of policies.

The Oceanfront Watershed has the highest overall rate (25 percent), followed by the Lynnhaven Watershed (11 percent), the Southern Rivers Watershed (9 percent), and lastly the Elizabeth River Watershed (7 percent). A comparison to the actual overall modeled annualized flood losses reveals that the highest risk areas do not correspond to the highest flood insurance uptake. For example, as shown earlier, the Oceanfront Watershed only contains approximately 2 percent of the total City-wide flood losses, but it shows the highest overall flood insurance uptake.

Within the SFHA, the Oceanfront Watershed also has the highest penetration rate (85 percent), which is almost 30 percent higher than the City-wide penetration rate within SFHAs. Penetration rates within SFHAs of the Southern Rivers Watershed (59 percent) are also higher than the City-wide rate (by 4 percent). Penetration rates within SFHAs of the Elizabeth River and Lynnhaven Watersheds are slightly lower than the City-wide rate.

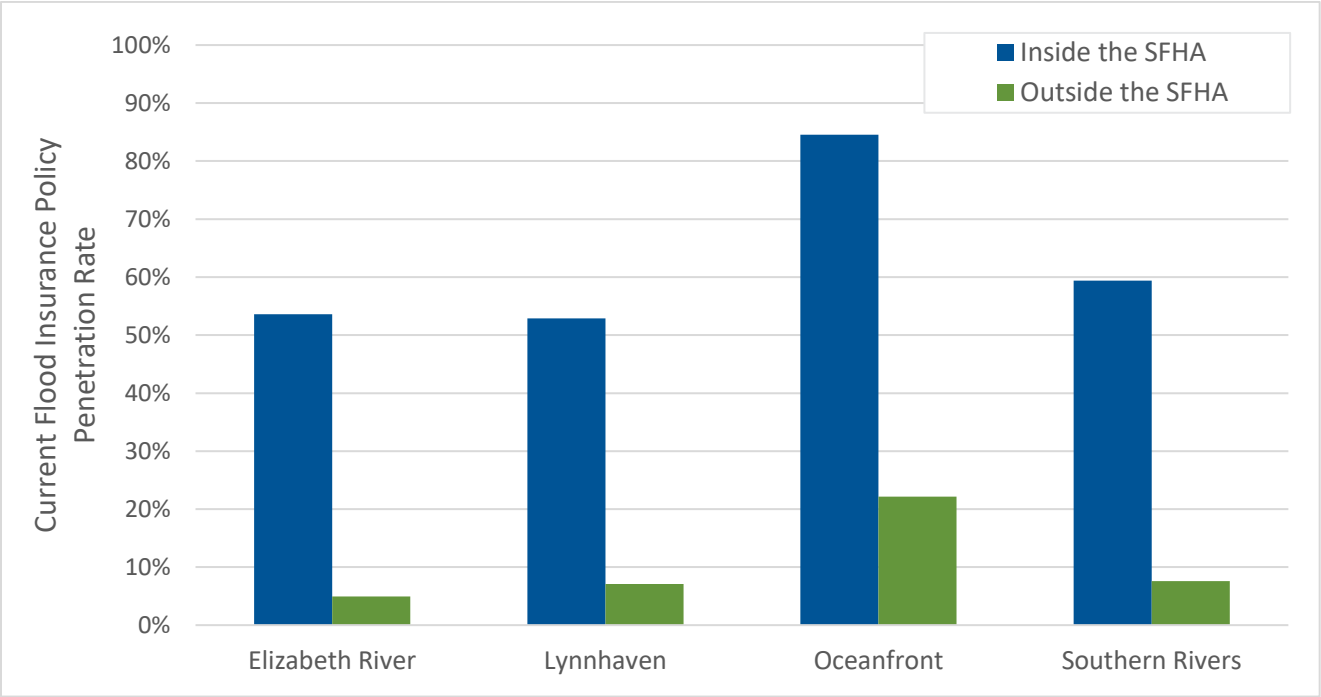

Figure 4: Overall policy penetration rates by watershed, separated by inside and outside SFHAs.

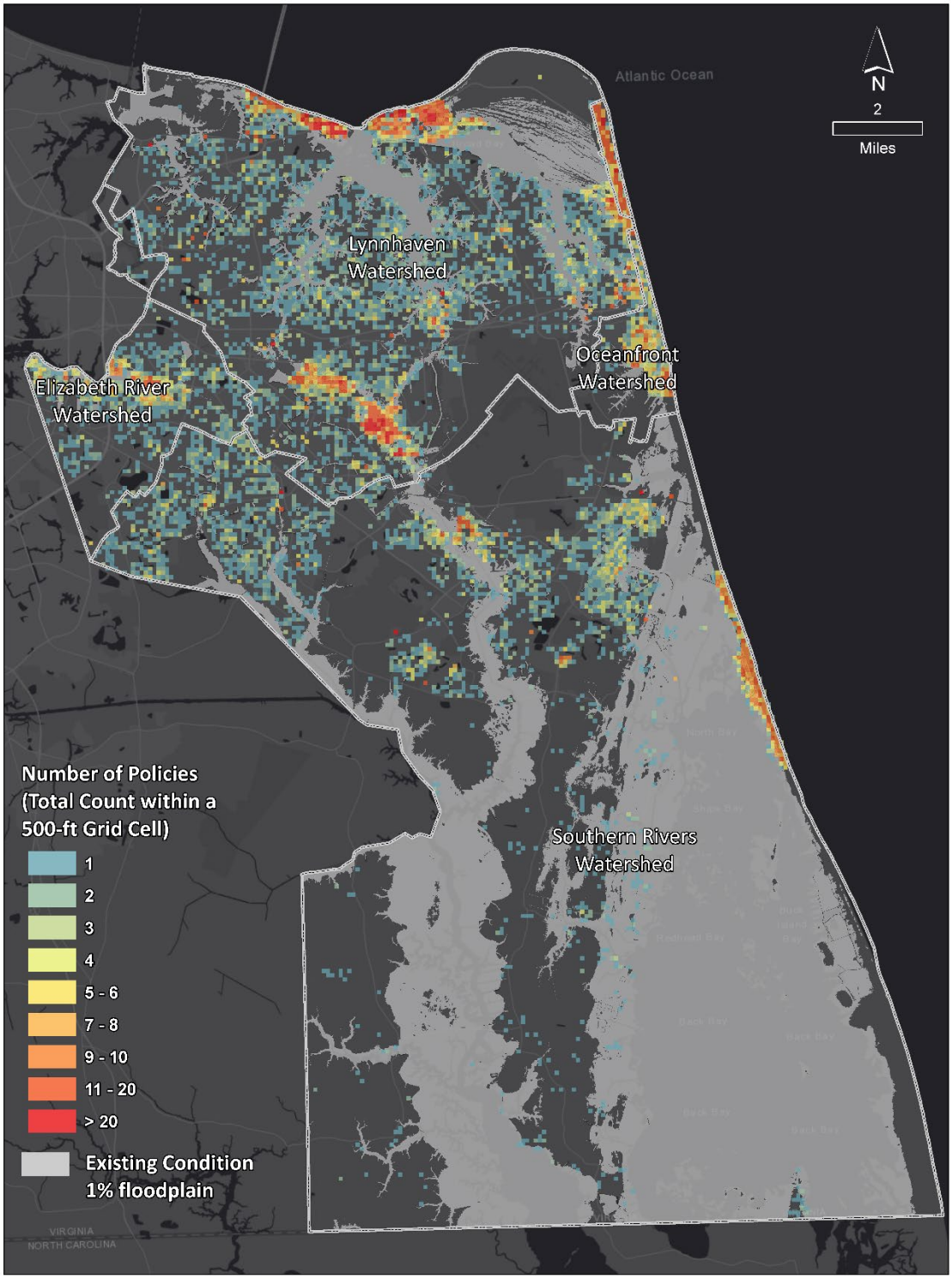

Figure 5: Number of policies shown using the 500-foot grid.

Penetration rates within the four major watersheds, broken down by occupancy type (e.g., single-family, multi-family, non-residential), are summarized in Figure 6 and presented in Table 3 through Table 7. For these tables, the simplified land-use code mapping outlined in Appendix C has been used, although the full source data land use code set can be seen in the raw data outputs.

Across the City, single- and multi-family residential properties show the highest uptake of flood insurance policies. Mixed use properties also have a relatively high coverage, especially in the Lynnhaven and Oceanfront Watersheds.

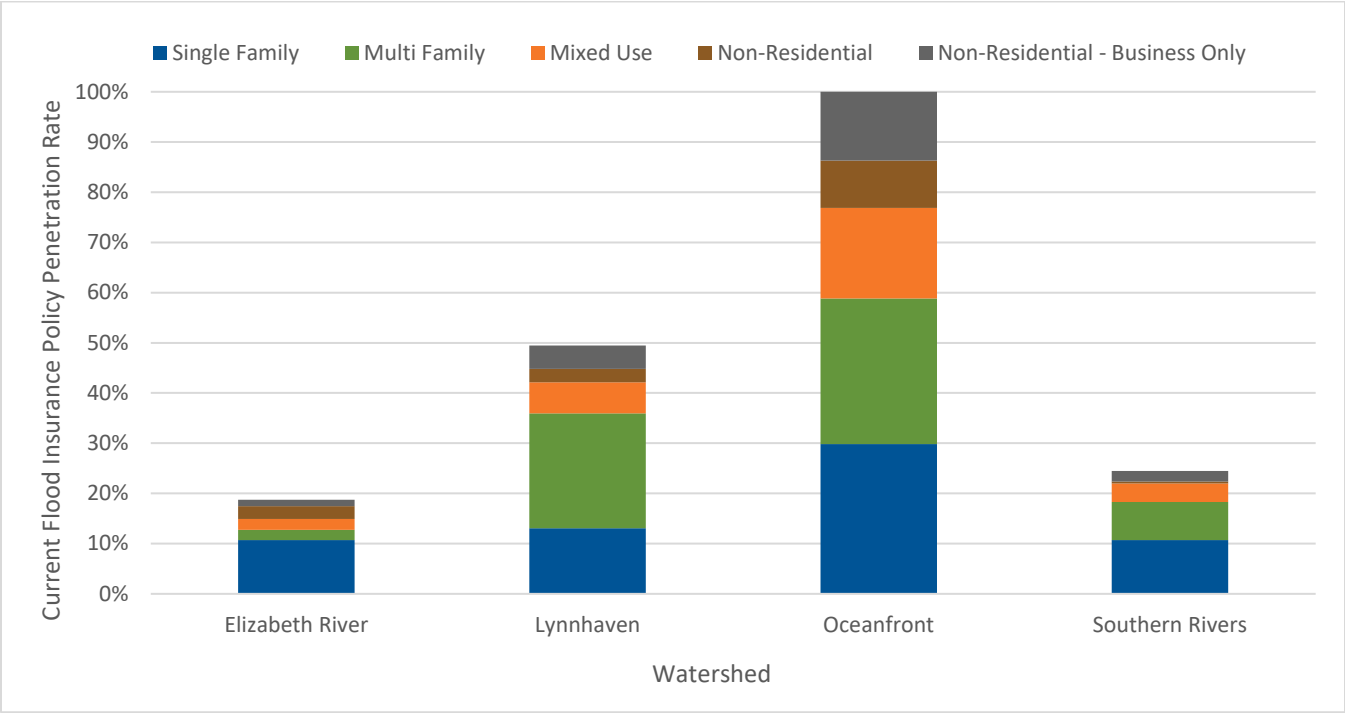

Figure 6: Overall penetration rates by watershed, broken down by occupancy type.

Tables 3 through 7 below demonstrate the policy penetration breakdown for each watershed by occupancy type, both inside and outside of the SFHA. The penetration rates here reflect the ratio of total number of buildings with at least 1 associated policy (non-orphan) in a specific occupancy category to the total number of buildings in that occupancy category. In very limited cases, policy penetration rates exceeded 100% due to geospatial irregularities between the building and policy data. Penetration rates were capped at 100% in such instances.

Table 3: Policy penetration rates by watershed, separated by inside and outside of the SFHA, for single-family structures only.

Watershed	Overall	Inside the SFHA	Outside the SFHA
Elizabeth River	10.7%	54.1%	6.9%
Lynnhaven	13.1%	57.5%	9.1%
Oceanfront	29.9%	86.3%	25.9%
Southern Rivers	10.7%	65.9%	8.6%

Table 4: Policy penetration rates by watershed, separated by inside and outside of the SFHA, for multi-family structures only.

Watershed	Overall	Inside the SFHA	Outside the SFHA
Elizabeth	2.0%	0.0%	2.0%
Lynnhaven	22.9%	64.5%	9.7%
Oceanfront	29.0%	90.0%	27.9%
Southern Rivers	7.6%	100.0%	7.4%

Table 5: Policy penetration rates by watershed, separated by inside and outside of the SFHA, for 'other residential' (e.g. mixed use) structures only.

Watershed	Overall	Inside the SFHA	Outside the SFHA
Elizabeth	2.2%	100.00%	2.1%
Lynnhaven	6.1%	41.8%	3.5%
Oceanfront	18.0%	83.7%	16.0%
Southern Rivers	3.7%	100.00%	3.6%

Table 6: Policy penetration rates by watershed, separated by inside and outside of the SFHA, for non-residential structures only.

Watershed	Overall	Inside the SFHA	Outside the SFHA
Elizabeth River	2.5%	30.0%	1.6%
Lynnhaven	2.7%	16.7%	1.3%
Oceanfront	9.4%	75.0%	7.9%
Southern Rivers	0.4%	2.2%	0.2%

Table 7: Policy penetration rates by watershed, separated by inside and outside of the SFHA, for non-residential - business structures only.

Watershed	Overall	Inside the SFHA	Outside the SFHA
Elizabeth River	1.3%	17.4%	0.9%
Lynnhaven	4.7%	35.7%	2.3%
Oceanfront	15.6%	60.0%	13.8%
Southern Rivers	2.1%	12.7%	1.4%

Policy Penetration Rates by Planning Subdivision

Policy penetration rates within the planning subdivisions within the City of Virginia Beach are shown in Figure 7. Darker areas represent higher policy penetration rates. Several areas across the City of Virginia Beach have high concentrations, including a majority of subdivisions in the Lynnhaven Watershed, and subdivisions in the North End, Sandbridge, and along the Elizabeth River.

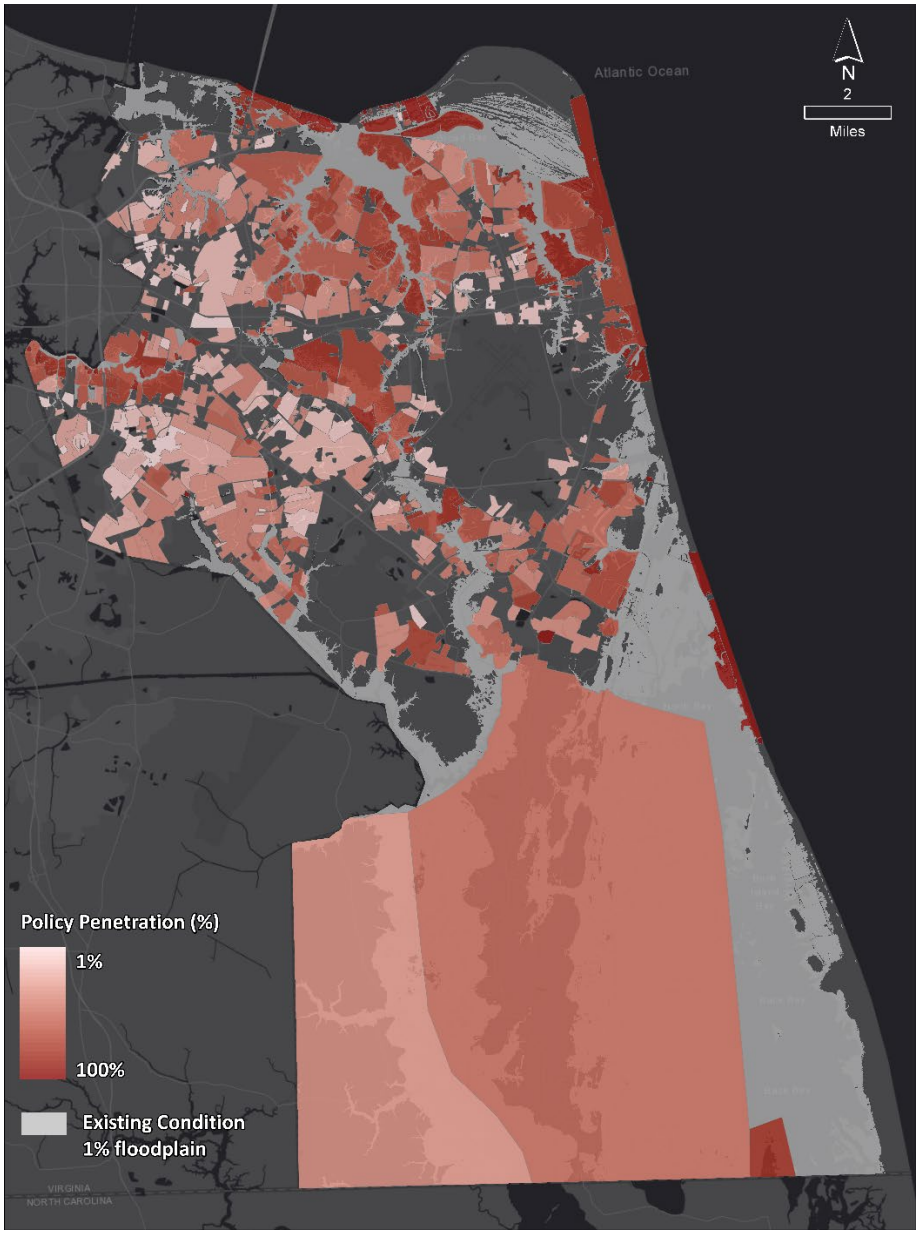

Figure 7: Policy penetration by planning subdivisions, calculated as the ratio of buildings with at least 1 policy to total buildings.

The ten planning subdivisions with the highest number of NFIP policies are presented in Table 8, alongside a count of total buildings in those subdivisions, and a count of the number of buildings with at least one associated policy. Total coverage levels for buildings and contents are also provided for these planning subdivisions.

Table 8: Ten planning subdivisions within the City of Virginia Beach with the most NFIP policies in force.

Planning Subdivisions	Total Buildings	Total NFIP Policies	Total Buildings with Policies	Total Building Coverage	Total Contents Coverage	Policy Penetration Ratio	Policy Penetration Rate
NORTH END	2,077	1061	826	$305,248,900	$94,288,400	51.08%	39.77%
PRINCESS ANNE PLAZA	3,364	729	694	$145,761,000	$29,966,600	21.67%	20.63%
SOUTH SANDBRIDGE	718	585	567	$143,098,000	$37,294,500	81.48%	78.97%
WINDSOR WOODS	1,542	489	483	$100,893,600	$25,272,700	31.71%	31.32%
OCEAN PARK	499	483	352	$124,473,700	$21,403,000	96.79%	70.54%
THE LAKES	699	350	335	$60,951,300	$10,376,800	50.07%	47.93%
CAPE STORY BY THE SEA	435	315	303	$72,535,700	$13,461,100	72.41%	69.66%
RESORT AREA	1,048	254	180	$122,343,200	$31,555,500	24.24%	17.18%
PUNGO	2,327	251	224	$58,318,900	$16,612,600	10.79%	9.63%
OCEAN LAKES	2,575	221	218	$46,194,300	$17,879,200	8.58%	8.47%

Interestingly, there is some discrepancy between the policy penetration ratio and policy penetration rate within some of the planning subdivisions. For example, the North End has a high policy count to structure ratio (51 percent), which appears favorable on the surface. However, many of these policies may be concentrated in multi-family homes and duplexes, which are common in this area, potentially leaving some single-family homes uninsured. In this case, the policy penetration rate (40 percent) is likely a more telling metric. The Ocean Park planning subdivision is another good

example of this phenomenon, with a much higher policy count to structure ratio (97 percent) than percentage of structures with at least one policy (71 percent).

4.3.2. Claims Data

The historical claims database provides records from 1977 through 2017. Claims statistics were evaluated at the City-wide, watershed, and planning subdivision reporting geographies.

Claims Across the City of Virginia Beach

At the City-wide scale, there have been 5,982 loss records, totaling approximately $252 million in building damage and approximately $16 million in content damage since the date of the earliest claim in the set, April 7, 1977. Of these records, 2016 had the most claims of any single year with 1,487 claims. Figure 8 below shows a distribution of claims made per year. The spikes in 1998, 2003, 2009, and 2016 correspond to the timing of Hurricane Bonnie, Hurricane Isabel, the Mid-Atlantic nor'easter (also referred to as "Nor'Ida"), and Hurricane Matthew, respectively. A map showing the concentration of claims across the City is provided in Figure 9.

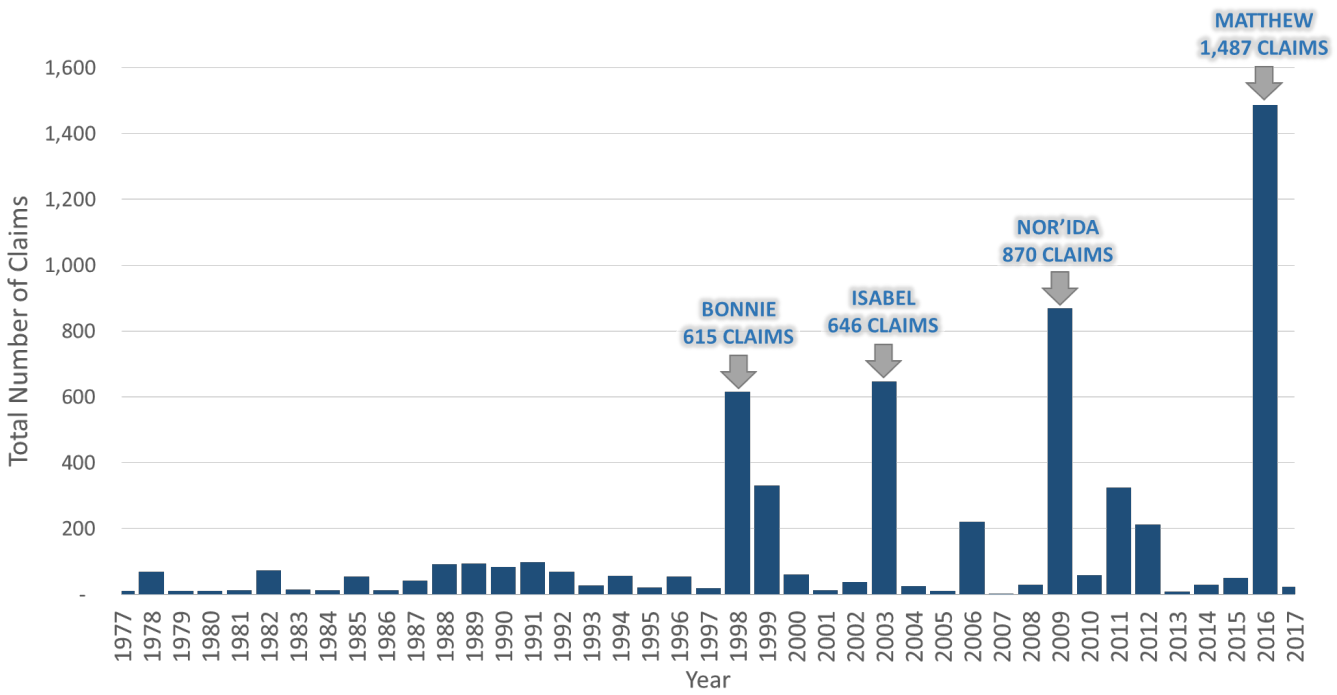

Figure 8: Claim counts per year for the City of Virginia Beach

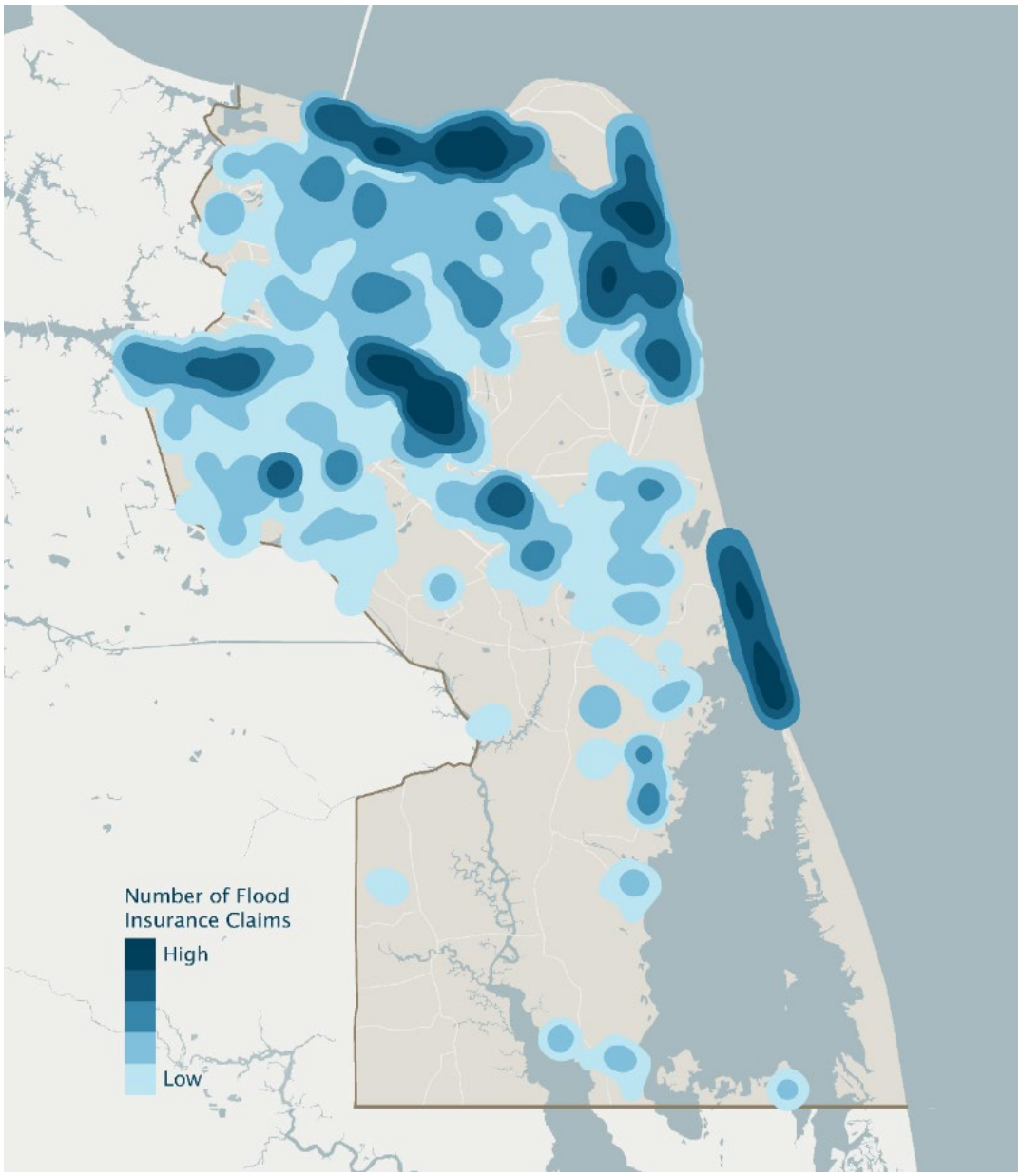

Figure 9: Concentration of historical flood insurance claims in Virginia Beach between 1977 and 2017

Claims by Planning Subdivision

The distribution and magnitude of historic claims within the City of Virginia Beach, broken down by planning subdivision, is shown in Figure 10. The distribution of claims follows a similar pattern to the distribution of policy penetration. This observation is not surprising given the distribution of NFIP

policies. High areas of concentration where more than 400 claims have been made over the period of record include South Sandbridge, Princess Anne Plaza, The Lakes, and Lynnhaven Colony.

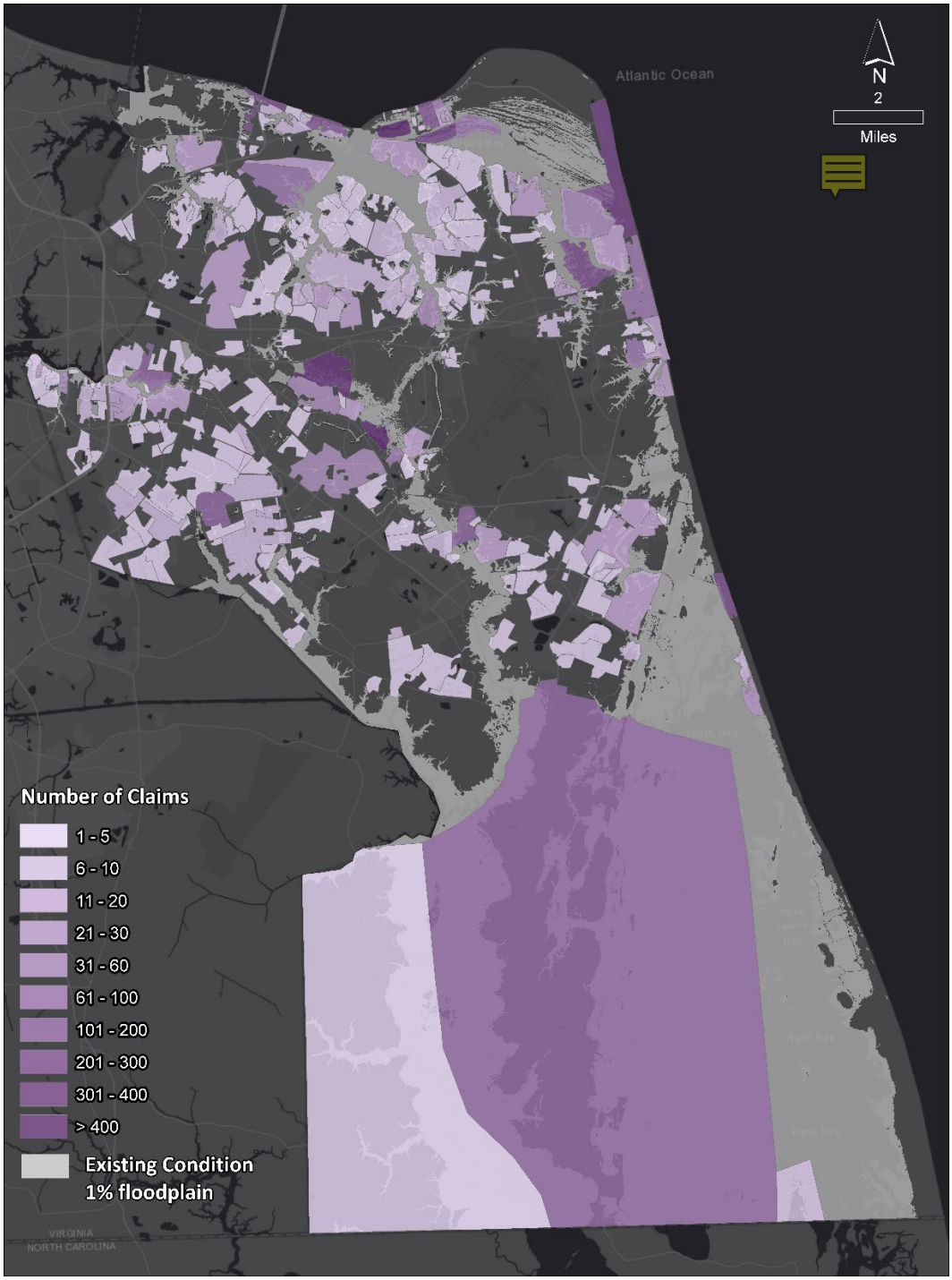

Figure 10: Claim count by planning subdivision.

Claims by Watershed

The claims data were also summarized within the four major watersheds in the City of Virginia Beach. The percentage of total flood insurance claims by watershed is shown in Figure 11, and further broken down by location within and outside of the SFHA in Figure 12. Table 10 provides value of assets, damage totals, and loss ratios within each watershed. The Lynnhaven Watershed has the highest number of total claims and associated total losses reported from the claims.

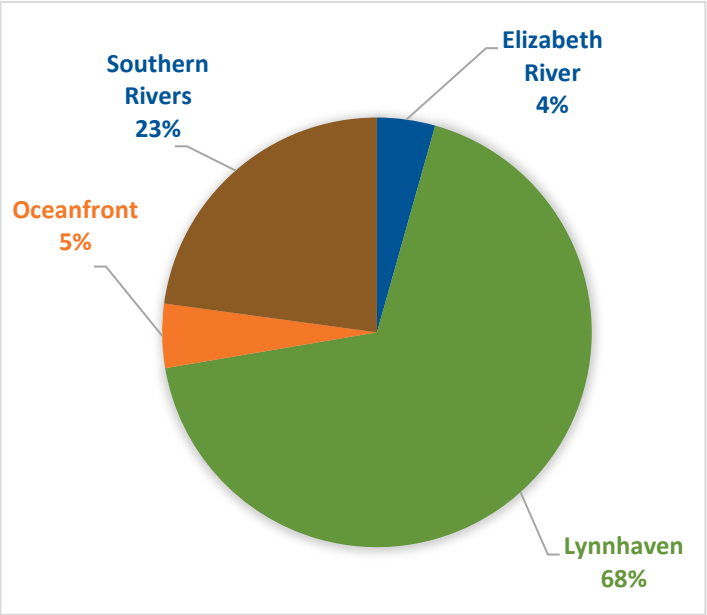

Figure 11: Percentage of total claims within each of the City's four major watersheds.

Historical claims follow a similar distribution to the total modeled losses presented earlier (Section 3). The Lynnhaven Watershed has the highest number of historical claims and associated losses, with almost 4,000 claims over 40 years totaling over $239 million in building and content losses (Table 9). More than 75 percent of the claims were concentrated within the SFHA. The Lynnhaven Watershed also has a high ratio of historic losses to the total value of assets in the watershed, meaning that this area has historically experienced higher losses as compared to the value of the building stock.

The Southern Rivers Watershed shows the second highest concentration of claims in the City, with almost 1,400 claims in 40 years totaling over $21 million in building and content losses. More than 68 percent of those claims were concentrated within the SFHA. Claims reported in the SFHA in the Southern Rivers Watershed also have a notably high ratio of historic losses to the total value of assets, meaning that this area has historically experienced higher losses as compared to the value of the building stock.

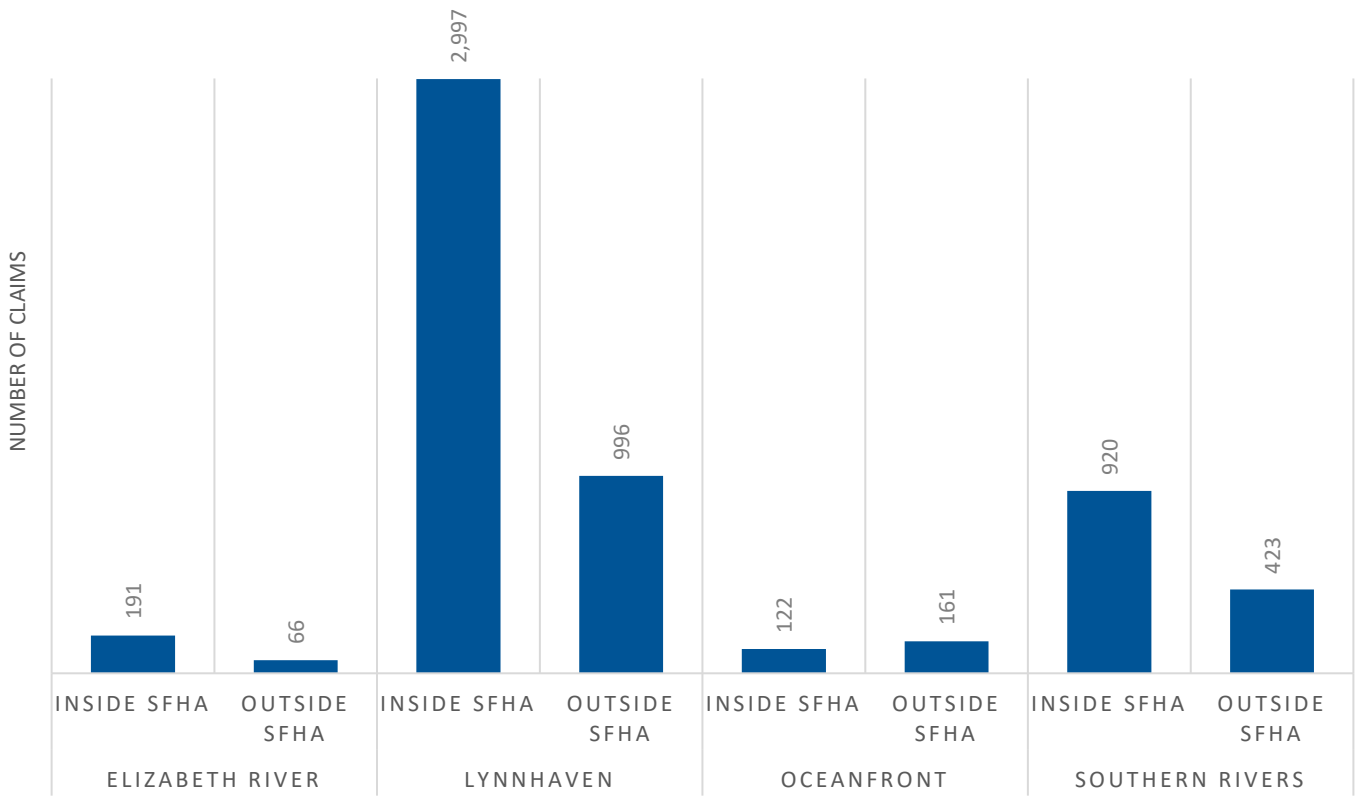

Figure 12: Number of claims inside and outside of the SFHA, broken down by watershed.

Table 9: Historic claim losses summary by watershed, including claim counts, aggregate loss amounts, value of assets within the watershed, and ratio of aggregate loss amounts to aggregate asset values.

Watershed	Location (In/Out SFHA)	Ratio of Total Losses from Claims to Value	Claims	Value of Assets (Building + Content) from Building Footprint Database	Total Losses (Building + Content) from Claims
Elizabeth River	Inside	0.70%	191	$ 408,774,089	$ 2,867,862
	Outside	0.00%	66	$ 9,875,221,417	$ 343,268
	Total	**0.03%**	**257**	**$ 10,283,995,506**	**$ 3,211,130**
Lynnhaven	Inside	5.23%	2,997	$ 4,001,991,888	$ 209,335,554
	Outside	0.08%	996	$ 38,740,543,767	$ 30,017,720
	Total	**0.56%**	**3,993**	**$ 42,742,535,654**	**$ 239,353,274**

Watershed	Location (In/Out SFHA)	Ratio of Total Losses from Claims to Value	Claims	Value of Assets (Building + Content) from Building Footprint Database	Total Losses (Building + Content) from Claims
Oceanfront	Inside	0.30%	122	$ 253,830,994	$ 755,728
	Outside	0.06%	161	$ 3,348,527,856	$ 1,925,094
	Total	**0.07%**	**283**	**$ 3,602,358,850**	**$ 2,680,822**
Southern Rivers	Inside	2.01%	920	$ 796,929,158	$ 15,991,024
	Outside	0.02%	423	$ 23,669,950,996	$ 5,450,862
	Total	**0.09%**	**1,343**	**$ 24,466,880,153**	**$ 21,441,886**

4.3.3. Residual Risk

Residual risk estimates represent potential loss remaining for a given scenario after applying flood insurance coverage and deductible amounts. Residual risks were summarized at the watershed and planning subdivision levels. Residual risk calculations at the other reporting geographies may be found in the geospatial database (see Appendix B for more information).

Care was taken during the analysis to ensure that building coverage values within the policy data were only applied to modeled building losses for the sake of determining residual risk, and likewise for content coverage and modeled content losses. The effect of this is that, in instances where modeled losses result in both building and content loss but the structure has no associated coverage for one or the other, then any losses to the uncovered assets will show as residual. In other words, there may be building-only or content-only residual risk results for these properties. This may result in areas of high policy penetration, which also have remaining residual risk.

Residual Risk by Watershed

Results of the residual risk analysis were summarized by watershed for the 100- and 500- year events, as well as under the AAL scenario, and are provided in Table 10. The analysis found that the Lynnhaven Watershed has the highest residual risk total, followed by the Southern Rivers Watershed. However, the Southern Rivers Watershed has the highest residual risk remaining as compared to the total modeled flood losses (before applying insurance coverage and deductible amounts—presented earlier in this report in Table 1, as shown in Figure 13). A breakdown of residual risk as compared to total flood losses is provided as follows:

- In the Elizabeth River Watershed, residual risk represents **52 percent** of the total flood losses.
- In the Lynnhaven Watershed, residual risk represents **39 percent** of the total flood losses.
- In the Oceanfront Watershed, residual risk represents **33 percent** of total flood losses.
- In the Southern Rivers Watershed , residual risk represents **68 percent** of flood losses.

These high percentages emphasize the need for increased policy penetration to mitigate these residual risks.

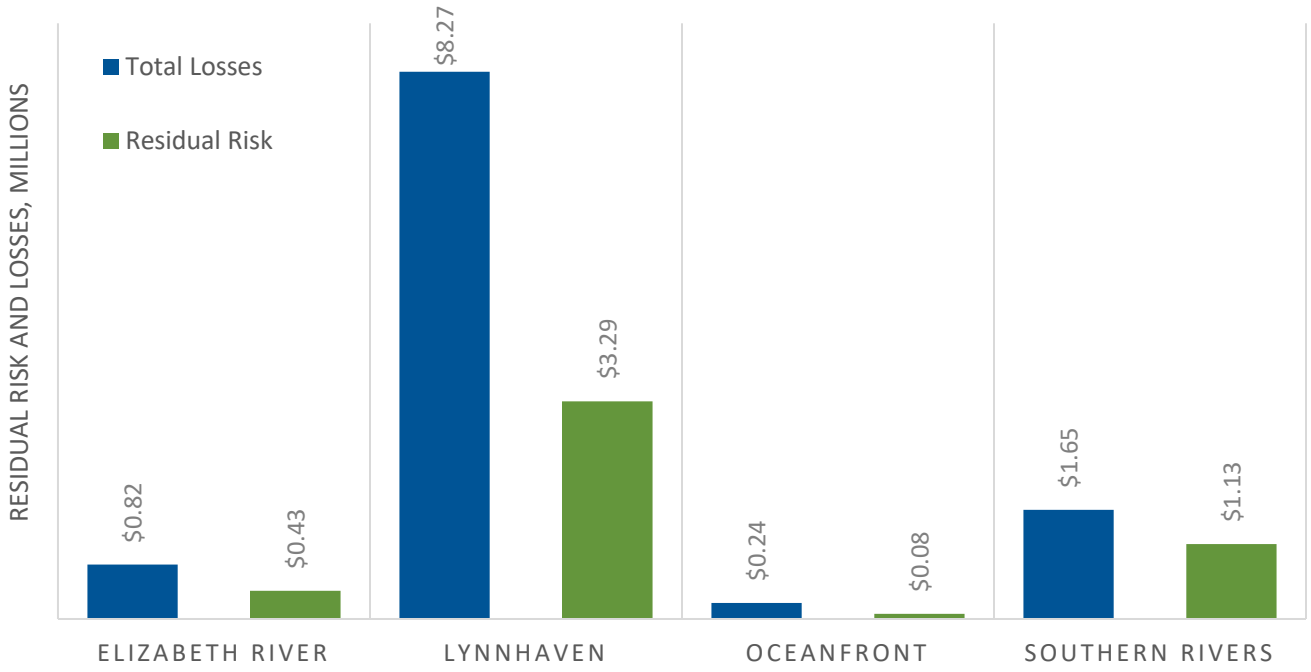

Figure 13: Residual risk compared to total annualized losses under current conditions.

Table 10: Aggregate residual risk by watershed for the 100-year and 500-year events, as well as the average annualized loss scenario (AAL), separated by building and content loss amounts, as well as by inside and outside SFHA.

Watershed	Location	100-Year Event Residual Risk		500-Year Event Residual Risk		Average Annualized Loss (AAL) Residual Risk	
		Building	Contents	Building	Contents	Building	Contents
Elizabeth River	Inside	$1,820,526	$2,565,052	$12,853,962	$16,388,726	$120,172	$163,658
	Outside	$0	$0	$14,643,075	$9,305,348	$87,871	$55,771
	Total	**$1,820,526**	**$2,565,052**	**$27,497,037**	**$25,694,074**	**$208,043**	**$219,429**
Lynnhaven	Inside	$27,040,531	$30,511,233	$78,640,421	$114,992,302	$1,236,584	$1,530,299
	Outside	$1,861,219	$427,925	$83,661,741	$35,915,401	$511,933	$213,077
	Total	**$28,901,750**	**$30,939,158**	**$162,302,162**	**$150,907,703**	**$1,748,517**	**$1,743,376**
Oceanfront	Inside	$534,652	$356,630	$2,329,580	$1,897,407	$28,479	$24,154
	Outside	$47,793	$6,018	$3,127,174	$807,457	$19,198	$4,889
	Total	**$582,445**	**$362,648**	**$5,456,754**	**$2,704,864**	**$47,677**	**$29,043**
Southern Rivers	Inside	$8,646,562	$10,278,410	$15,131,649	$18,879,507	$422,286	$456,030
	Outside	$2,272,282	$2,671,312	$14,460,026	$13,824,251	$133,555	$132,829
	Total	**$10,918,844**	**$12,949,722**	**$29,591,675**	**$32,703,758**	**$555,841**	**$588,859**

Residual Risks by Planning Subdivision

The ten planning subdivisions with the highest AAL residual risk totals are listed in Table 11. The Pungo area stands out as having the highest total residual risk while all other subdivisions in the top 10 are in the Lynnhaven Watershed.

Table 11: Ten planning subdivisions within the City of Virginia Beach with the highest calculated residual risk amounts for the average annualized loss (AAL) scenario

Planning Subdivisions	Total Building NFIP Coverage	Total Contents NFIP Coverage	Annual Residual Risks - Buildings	Annual Residual Risks - Contents	Annual Combined Residual Risks -in SFHA	Annual Combined Residual Risks -out of SFHA	Annual Combined Residual Risks
PUNGO	$58,318,900	$16,612,600	$256,075	$296,528	$429,550	$126,978	$552,603
OCEAN PARK	$124,473,700	$21,403,000	$154,748	$321,038	$534,827	$958	$475,786
PRINCESS ANNE PLAZA	$145,761,000	$29,966,600	$175,685	$189,868	$364,846	$100,042	$365,553
LYNNHAVEN COLONY	$47,185,600	$8,285,500	$126,223	$145,778	$271,905	$96	$272,001
WINDSOR WOODS	$100,893,600	$25,272,700	$81,125	$75,137	$86,629	$69,633	$156,262
CAPE STORY BY THE SEA	$72,535,700	$13,461,100	$67,094	$75,159	$141,742	$511	$142,253
SCARBOROUGH SQUARE	$14,577,100	$2,903,500	$104,841	$34,128	$34,140	$104,829	$138,969
THE LAKES	$60,951,300	$10,376,800	$82,342	$44,781	$48,675	$78,448	$127,123
MAGIC HOLLOW	$18,138,300	$5,492,300	$76,178	$37,396	$16,920	$96,654	$113,574
KINGS ARMS	$9,086,400	$945,800	$48,439	$22,354	$70,793	$0	$552,603

5. INCREASED POLICY AND FUTURE CONDITIONS ANALYSIS

5.1. Introduction

The purpose of evaluating increased policy penetration is to understand how guiding the uptake of flood insurance in various areas might reduce the overall residual risk of the City, today and under future conditions. Two types of increased policy penetration approaches were explored, including:

- **Set Target Policy Penetration Rate** – This approach aims to increase the number of policies within a specific area by establishing a target penetration rate. Target penetration rates of 1.25 times or 1.5 times the current rate were identified as reasonable goals for Virginia Beach, as discussed with, and agreed to, by the City. In this case, the existing ratios of policies to structures serves as the baseline for which to multiply the target penetration rates.

- **Fill in Missing Coverage** – Adding missing coverage for all properties currently carrying content-only or building-only coverage. This approach reduces the protection gaps for those properties.

The following sub-sections outline the specific scenarios evaluated, describe the methodology and assumptions used for calculating increased policy penetration, and present the residual risk results of the scenario analysis.

5.2. Scenario Controls

Two control scenarios were established in order to facilitate comparison of benefits (i.e., reduction in residual risk) across the various scenario approaches. These two scenarios serve different control purposes, explained as follows:

Baseline Control: No Change to Policy Base

An extension of the current conditions analysis, this baseline control scenario represents a policy base that remains unchanged into the future. Homes that currently have a policy maintain that coverage, but no new policies are added even under the future SLR scenarios. This control will be used to compute percent reduction in residual risk across the increased policy penetration scenarios.

Alternative Control: Current Buying Trends Remain Constant

This second control scenario represents a policy base where current buying trends continue into the future at existing rates, in response to changing conditions. Today's policy penetration rates (i.e., percentage within and outside of the SFHA) are extrapolated to create an equivalent future policy base within and outside of the future condition SFHA. In other words, this scenario reflects a future where residents react to increasing flood hazards by buying policies at a similar uptake rate as today. This scenario will be compared against the baseline control to reveal the importance of continuing to encourage uptake across the entire City—not just within targeted areas.

5.3. Increased Policy Penetration Scenarios

The following five scenarios were identified to evaluate the benefits of increasing policy penetration within specific areas in Virginia Beach, or filling in missing coverage. Each scenario evaluates the resulting residual risk today (i.e., current conditions), as well as under the two SLR scenarios (1.5 and 3 feet). The full list of scenario names that correspond to the geospatial deliverable database is provided in Appendix D.

Scenario 1: Increased Policy Penetration Within the SFHA

This scenario examines a situation where policy penetration targets (1.25x and 1.5x the current rate) are achieved within the currently defined SFHA. Targeting increased uptake within the SFHA is a relevant starting point given the mandatory purchase of flood insurance for homes with federally backed mortgages located in these high risk areas.

Scenario 2: Increased Policy Penetration Within the 500-Year Floodplain

This scenario examines a situation where policy penetration targets (1.25x and 1.5x the current rate) are achieved within the currently defined 500-year floodplain (not including increase within the SFHA). Targeting increased uptake in this band is logical since it represents areas beyond the SFHA

most likely to be impacted by flooding. Within the City of Virginia Beach, there are more than 8,300 buildings in the current 500-year floodplain—a number not far below the number of buildings within the SFHA.

Scenario 3: Increased Policy Penetration Within Identified High-Risk Areas

This scenario examines a situation where policy penetration targets (1.25x and 1.5x the current rate) are achieved within the six high-risk flood areas identified by the economic flood loss analysis conducted as part of the CSLRRF study. These focus areas are being used to guide development of adaptation strategies and, therefore, are logical places to encourage increased policy penetration.

Scenario 4: Increased Policy Penetration for Low-Lying Structures

This scenario examines a situation where policy penetration targets (1.25x and 1.5x the current rate) are achieved for structures whose finished first floor elevation is lower than the current Base Flood Elevation (BFE). During a flood event, these structures are more likely to experience damage and therefore would have increased protection through the purchase of flood insurance.

Scenario 5: Added Coverage Among Structures That Currently Carry Either Content-Only or Building-Only Coverage

This scenario examines a situation where owners of properties currently carrying content-only or building-only coverage purchase the lacking coverage, thereby reducing the protection gaps for those properties.

5.4. Methods

The analysis of increased policy penetration for the above listed scenarios required calculation of estimated flood insurance premiums and coverage amounts for hypothetical policies (i.e., those for structures without an existing policy, or those with an existing policy but that have a zone change under the 1.5- and 3-foot SLR scenarios). Estimated NFIP premiums were also calculated even for those structures that already had coverage in the policy base. However, it is important to note that for structures with existing coverage, the total of existing coverage was used in the residual risk calculations.

Estimated NFIP premiums were calculated for every valid structure within Virginia Beach using the rating guidance established and documented within the October 2017 FEMA Flood Insurance Manual

(FIM) (dated October 2017) and the April 2017 FEMA National Flood Insurance Program Specific Rating Guidance (SRG). Premiums for structures were estimated individually using either the FIM or the SRG based upon the current FEMA flood zone and the structure's first floor elevation (relative to the BFE).

Coverage levels and deductibles for all added policies were based on local Insurance to Value (ITV) ratios and local average deductibles for the same occupancy type. In both cases, for adding coverage within the SFHA, local existing policies within the SFHA were used to determine these values, and likewise non-SFHA policies for adding coverage outside the SFHA. "Local" here means Census Block Group when enough policies were present to provide comparison; otherwise, it refers to the 10 nearest policies of the same type (location in/out of SFHA and occupancy). These limitations ensured that added policy coverage levels and deductibles mimicked established local trends rather than being randomly assigned.

Appendix C provides additional details on the data inputs and associated assumptions common to both FIM- and SRG-based premium estimate calculations. It should be noted that coverage amounts provided in the raw policy data from FEMA are reported in 100's, meaning that multiplication by 100 is necessary in order to read the actual coverage limit. In some instances, this led to values higher than the permitted coverage limits. During investigations, it was found that some of these outliers actually appear to be valid instances where the structure was rated using Residential Condominium Building Association Policy rating guidelines, which can allow for some very high coverage limits. As such, the coverage limits from the policies have been used for this study "as is" once the 100 factor has been accounted for.

The following guiding principles/assumptions were used for calculation of the increased policy penetration, future conditions, and regulatory change scenarios.

- **All increases in policy penetration that take place within defined floodplain mapping areas (i.e., SHFA, 500-year, structure elevation relative to the BFE) have been enforced to occur within the current definitions of those areas.**

  For example, increases to the policy base within the SFHA would take place within the same SFHA area that is currently delineated on the effective FEMA floodplain maps. This decision was made to limit the number of potential output permutations and to ensure that the output provided would be actionable and easily considered within a current spatial framework for decision-making.

- **Additional policy uptake within the identified geographic areas takes place locally, and by random selection, when adding to the existing policy base**.

  Added policies within the target areas expand from existing uptake rates and mimic the deductibles and coverage to replacement cost ratios of existing policies within those and nearby areas. This approach intends to respect current buying trends and assumes new policy holders would exhibit similar insurance coverage (as compared to the replacement cost of their home) and deductible choices as their neighborhoods.

- **Counts of additional structures to be included when increasing the policy count were always rounded up to the nearest whole number**.

  For example, if an increase of 1.25x the structures with policies to structures ratio within a block group indicated that there should be a total of 8.35 structures with policies, that number would be rounded up to 9.

- **All target area scenarios are independent of one another**.

  It should be noted that, in this analysis, each series of residual risk calculations was performed stand-alone. That is to say that the analyses consider only a single event of the frequency in question for a policy term, for example, the residual risk from a single 100-year event, the residual risk from a single 500-year event, or the residual risk remaining after applying annualized losses. Should multiple events occur within a given year, the calculations would be presented differently.

- **Within a given scenario, as policy base is increased, it is also maintained into the future SLR scenarios**

  The 1.25x penetration scenarios inherit the penetration from current conditions prior to being increased, and the 1.5x penetration scenarios inherit the increased penetration of the related 1.25x scenario for their target area.

Residual risk was calculated for each scenario at the building- and parcel-level scale and then aggregated to the same reporting geographies as the current condition's analysis (watershed, planning subdivision, census block group, and 500- and 1,500-foot grids). Given the large number of scenario outputs and ways of analyzing the outputs of this analysis (at the various reporting geographies), results are presented in this report as residual risk summaries at the City-wide level.

5.5. Increased Policy Penetration Results

A comparison of the City-wide percent reduction in residual risk for each of the focused increased policy penetration scenarios, as compared to the baseline control scenario, is shown in Figure 14. Not surprisingly, the percent reduction decreases with increasing flood hazards. Increasing the policy penetration target rate (more than 1.5 x) may be an effective way to mitigate the ever increasing risks.

Several strategies consistently provide high returns on all flood hazard conditions. Over the next 20 to 40 years, increasing policy penetration within the SFHA provides substantial reduction in residual risk. Encouraging uptake for the lowest-lying structures also provides large reductions in residual risk. Interestingly, when looking at longer-term strategies to mitigate residual risks in the next 50 to 70 years, focusing additional uptake of flood insurance within the six high-risk flood areas becomes increasingly important.

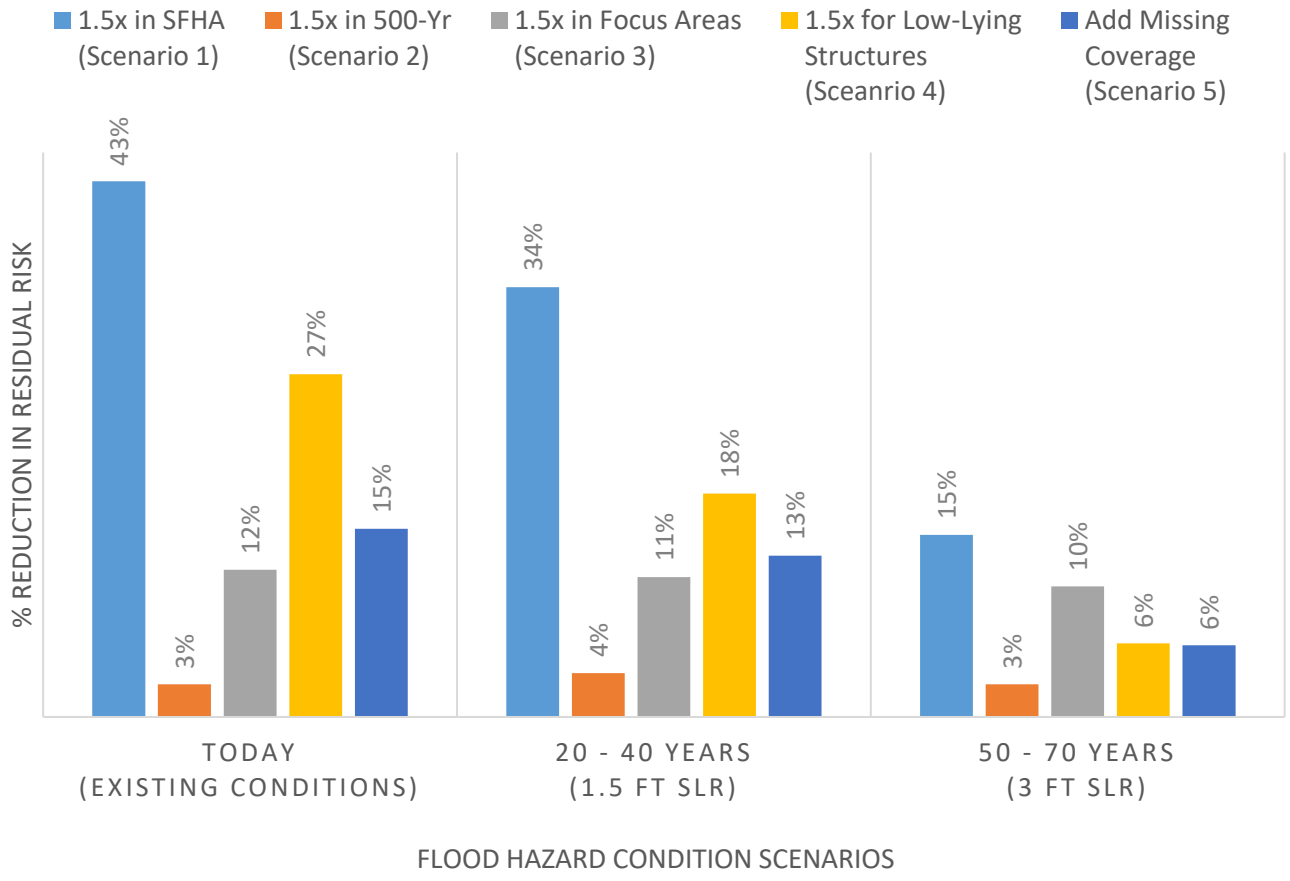

Figure 14: Comparison of reduction in residual risk across increased policy penetration and flood hazard scenarios.

In addition to targeted increased policy penetration strategies, the analysis of scenario outputs also revealed the importance of maintaining the current buying trends across the entire City, in response to future conditions. As shown in Figure 15, maintaining current buying trends in response to future flood hazards provides a 15 percent reduction in residual risk under the 1.5-foot SLR scenario and a 22 percent reduction in residual risk under the 3-foot SLR scenario, when compared to simply maintaining the current policy base with no further policies added.

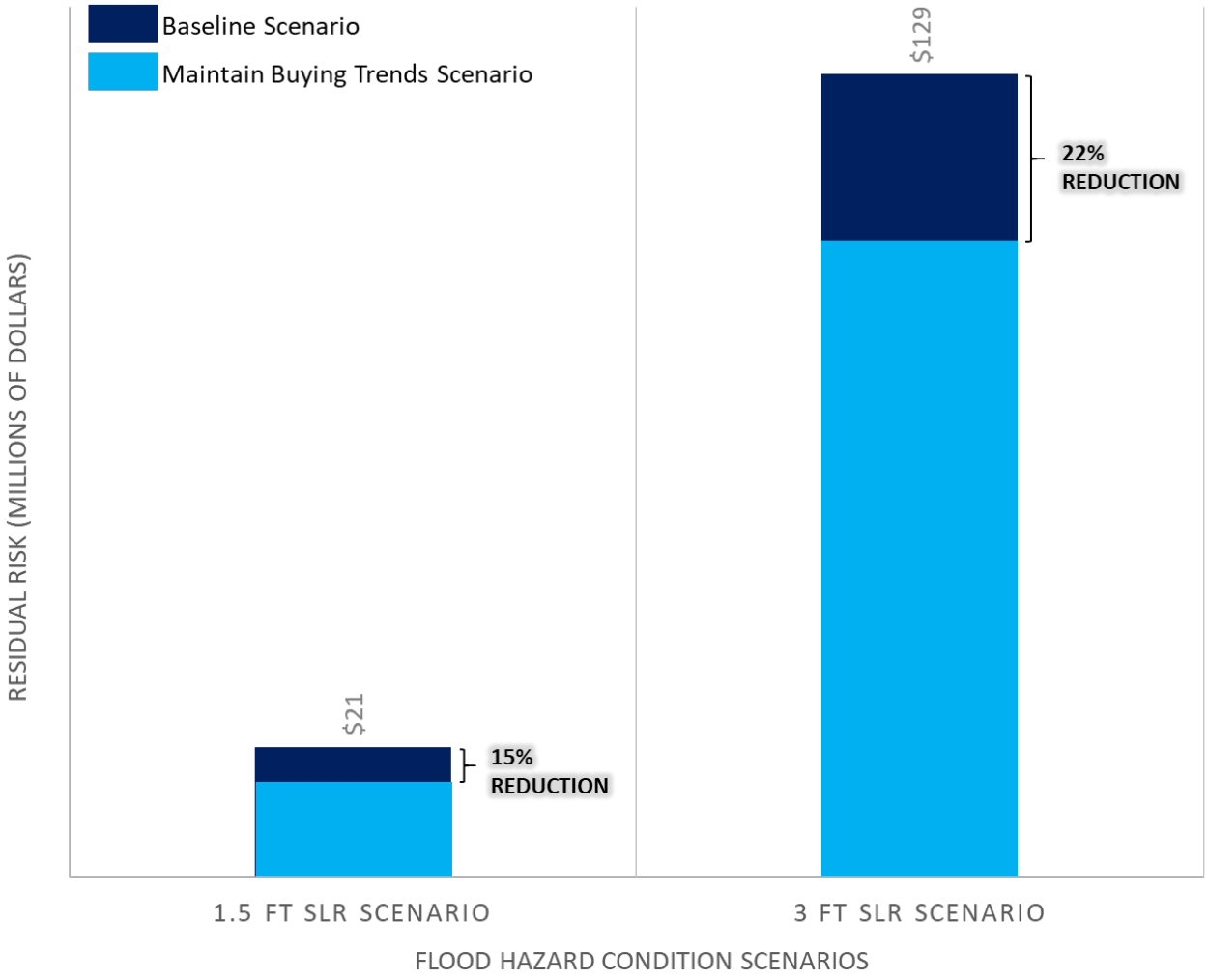

Figure 15: Comparison of residual risk reduction between baseline and maintaining current buying trends control scenarios.

6. INSURANCE AFFORDABILITY ANALYSIS

6.1. Introduction

The purpose of evaluating insurance affordability is to identify areas that are likely to be impacted by increasing cost burdens of flood insurance.

6.2. Methods

To evaluate flood insurance affordability, policy premiums were compared against the median household income data as provided by the latest available U.S. Census American Community Survey 5-Year Summary Data. Ratios of estimated premiums to median block group household income were computed for each building in Virginia Beach. The averages of those ratios were used to aggregate the data to the following reporting geographies: census block groups, planning subdivisions, and the 500- and 1,500-foot grids. The result of this analysis is a sortable affordability index for the entire City, provided at these geographic resolutions.

Given the challenges associated with estimated median household income into the future, this analysis assumed that the average median income at the census block group remains constant throughout time. For the 1.5- and 3-foot SLR scenarios, the estimated NFIP policy premiums, that were developed for the increased policy and future conditions analysis (taking into consideration the floodplain and BFEs during the SLR scenario), were compared against today's median household income to provide insight into possible affordability concerns in the future. This also assumes that building stock remains constant and unchanged and that their premiums can reliably be based on the floodplain characteristics provided in the SLR scenario data.

6.3. Insurance Affordability Results

A higher percentage of premium to median household income represents lower affordability, whereas a lower percentage of premium to median household income represents higher affordability. For example, consider the scenario shown in Table 12 where there are two houses that hold the same type of policy but with substantial differences in household income. The $800 policy premium is more affordable for the household with the $150,000 median income as compared to the household with the $50,000 median income.

Table 12: Example affordability ratio comparison for two hypothetical houses.

House	Median Household Income	Policy Premium	Affordability Percentage
1	**$150,000**	$ 800	0.5%
2	**$50,000**	$ 800	1.6%

Not surprisingly, the average affordability percentage across the City increases (i.e., less affordable) under the future SLR scenarios, as shown in Figure 16. As the median incomes are held constant but the flood risk increases, thereby increasing modeled FEMA premiums, the percentage increase.

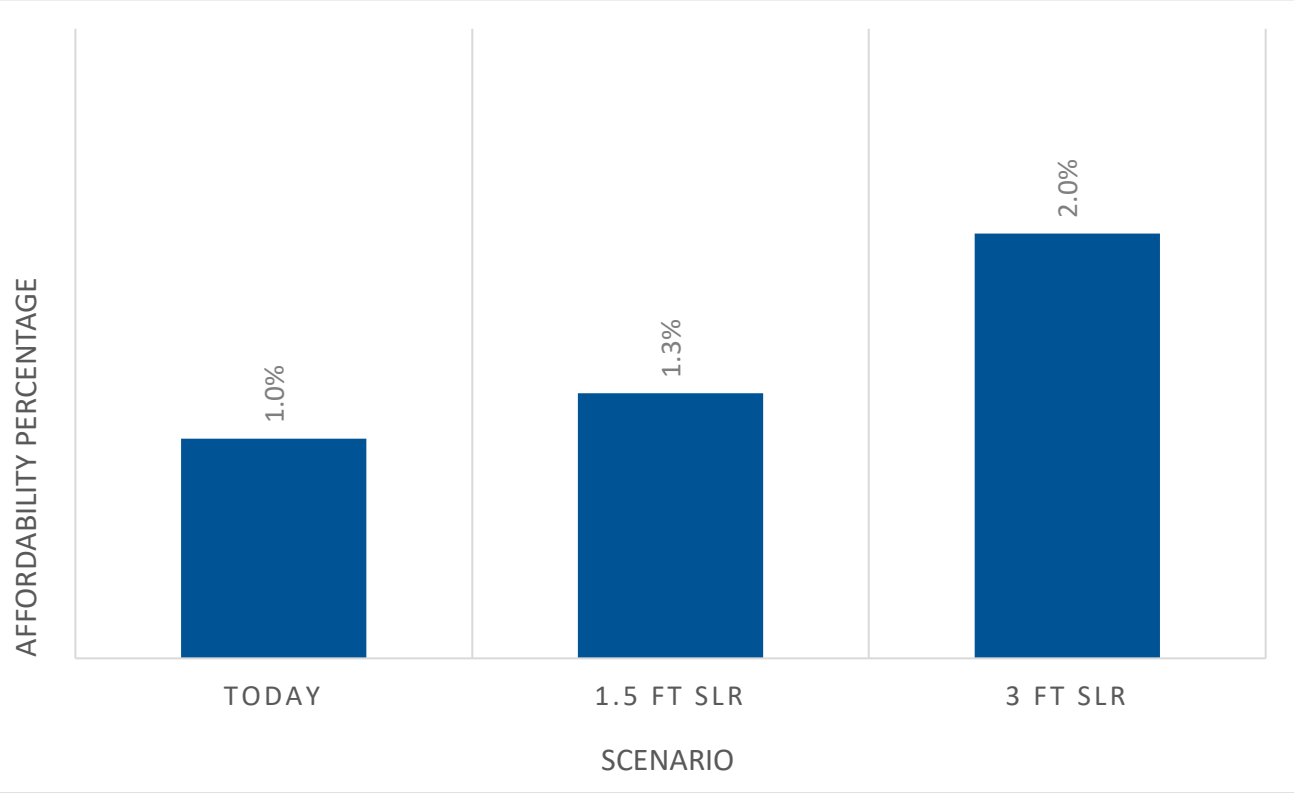

Figure 16: Average flood insurance affordability percentages for Virginia Beach, today, and under future SLR scenarios.

The ten planning subdivisions with the highest ratio of premium to median household income, under existing conditions, is presented in Table 13. These subdivisions represent the areas of lowest flood insurance affordability.

Table 13: Ten planning subdivisions within the City of Virginia Beach with the highest calculated affordability ratio.

RANK	PLANNING SUBDIVISION	AFFORDABILITY PERCENTAGE
1	REEF COURT APARTMENTS	20%
2	JUDEO-CHRISTIAN APARTMENTS	15%
3	VILLAS @ LINKHORN BAY	14%
4	INLET COLONY	12%
5	CAPTAINS WALK CONDOMINIUMS	12%
6	NORTHAMPTON APTS	11%
7	THE SANCTUARY AT FALSE CAPE	11%
8	OCEAN TRACE CONDS & APARTMENTS	9%
9	BAYLAKE ASSISTED LIVING FACILITY	9%
10	FREMAC SHORES	9%

Looking forward, the cost burden of flood insurance is expected to increase with respect to affordability, especially given no changes to the median household income. A map showing the flood insurance affordability ratio in response to future flooding conditions is provided in Figure 17.

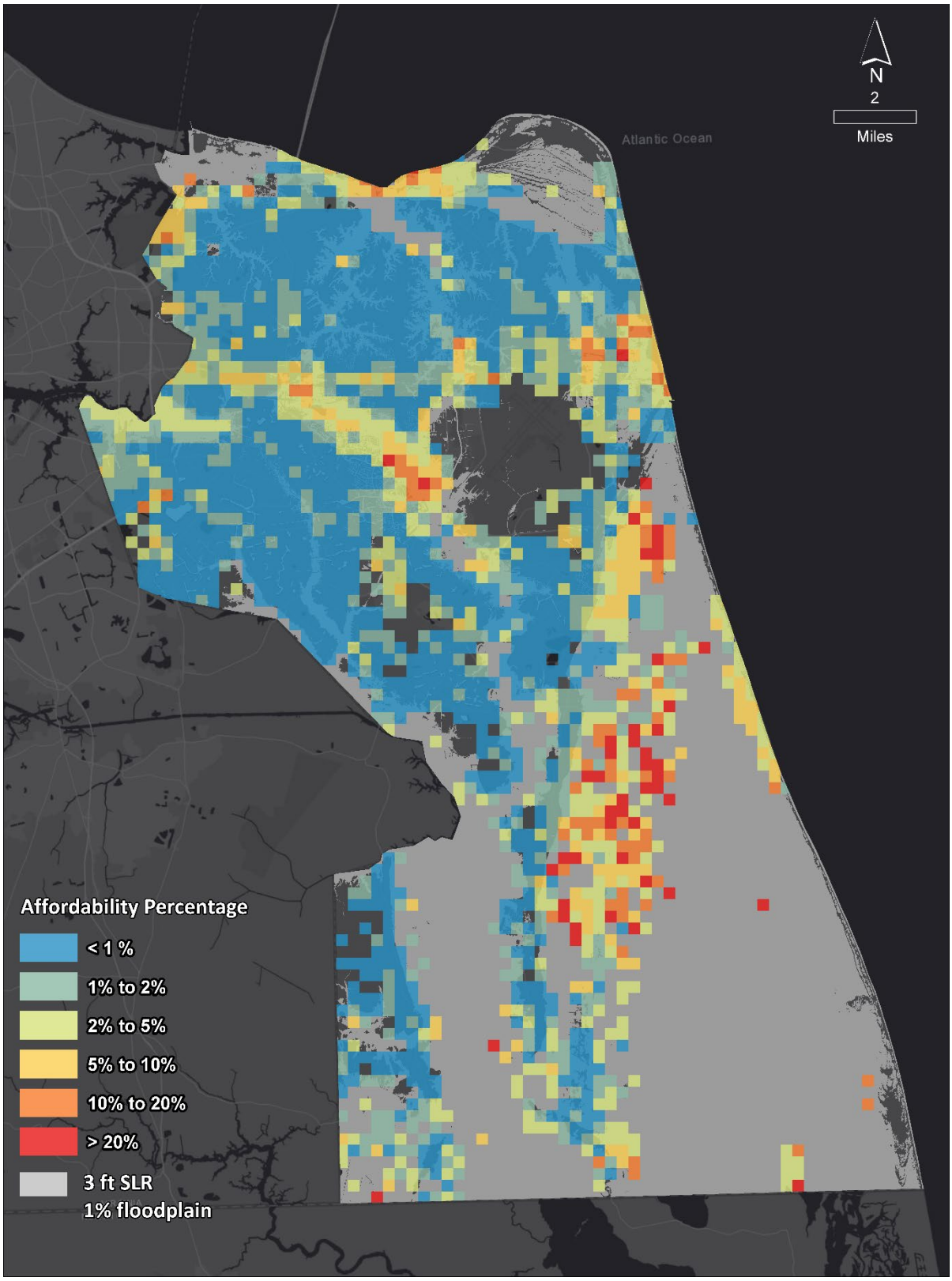

Figure 17: Flood insurance affordability ratios under the 3-foot SLR scenario.

7. CONCLUSIONS

Successful adaptation planning necessitates understanding existing flood insurance policy coverage, identifying opportunities for encouraging the uptake of flood insurance in high-risk areas, and identifying where affordability will need to be addressed in order to meet those uptake goals today and in the future. The outputs of this analysis can be used by the City to develop targeted outreach campaigns to both encourage residents who already hold flood insurance to maintain coverage, as well as encourage increased uptake in high-risk areas, in advance of future threats—a high-priority action item identified in the Virginia Beach Sea Level Rise Policy Response Report. The City's recent adoption into the National Flood Insurance CRS program means the City can obtain additional CRS credits by providing flood risk information to the public, leading to flood insurance premium discounts for residents and businesses across the City of Virginia Beach. Affordability will be especially important as changing flood hazards increase the cost burden of flood insurance.

A logical first step for targeted outreach would be to focus on increasing policy penetration within planning subdivisions identified as having high residual risk today, such as Pungo, Ocean Park, Princess Anne Plaza, Lynnhaven Colony, and Windsor Woods. Within these high-risk neighborhoods, public outreach should focus on increasing penetration in the SFHA and for low-lying structures. Another highly effective strategy would be to focus on increasing policy penetration within the high-risk focus areas identified for adaptation strategy development under the CSLRRF study. It is important to note that areas subject to stormwater flooding are often not included in the SFHA. While not part of this analysis, which focuses on coastal flooding, such areas offer additional opportunities to focus increased policy penetration.

In addition to targeted outreach in specific locations, the City should encourage all residents to purchase flood insurance. This analysis revealed the importance of maintaining a City-wide flood insurance policy base that reflects, at a minimum, the policy base that exists today. This outcome could only be achieved through effective messaging on changing flood hazards and regulatory changes to floodplain maps that drive insurance requirements. Unfortunately, FEMA flood hazard studies are typically updated on average, only every 10 years, and the base data under the maps that drive the floodplain boundaries are only updated on average, on a 30-year cycle (Batten et al. 2008). This can lead to underestimation of flood risk. In fact, the newly mapped floodplains that were developed using robust numerical modeling framework demonstrate that the existing Flood Insurance Study for Virginia

Beach (effective in 2015) underestimates flood risk, especially in the southern portion of the City. Although FEMA recognizes changing flood hazards, sea level rise is not yet incorporated into the floodplain mapping or risk rating process. The significant uncertainty related to the future of floodplain mapping poses a significant risk to the City. Therefore, it will be especially important that the City actively educate residents on how the existing risk rating process may underestimate risk, and the importance of flood insurance in existing and future high-risk areas. One tactic for accomplishing this goal includes expanding and redefining the "regulatory floodplain" (i.e., the area where there are flood insurance requirements and floodplain regulations), which is an action item identified in the Virginia Beach Sea Level Rise Policy Response Report.

Encouraging maintenance and uptake of flood insurance can be accomplished through targeted outreach via numerous mediums (radio, newspaper, digital ads, etc.) while providing educational background on the importance of flood insurance and who exactly should buy it. Partnership with FEMA can also provide pre-made marketing materials and data to reach high potential insurance buyers. Insurance outreach and engagement can be supported by FEMA regional staff members, and marketing materials may be available through FEMA. Existing platforms for public outreach could also be leveraged, such as the Get Flood Fluent campaign that was recently launched to educate the Hampton Roads region on the benefits of carrying flood insurance.

Strategies such as these will help protect the welfare of residents and businesses in the City of Virginia Beach so they are able to afford the coverage, are insured when a flood occurs, and are informed about what they can do to reduce likelihood of flooding impacts.

8. REFERENCES

Batten, B.K., Weberg, P., Mampara, M., and L. Xu. (2008). Evaluation of Sea Level Rise for FEMA Flood Insurance Studies: Magnitude and Time-Frames of Relevance. ASCE Proceedings of Solutions to Coastal Disasters: https://doi.org/10.1061/40968(312)6.

FEMA (2017a). Flood Insurance Manual, Effective October 1, 2017 (Website).

FEMA (2017b). National Flood Insurance Program Specific Rating Guidance (PDF).

FEMA (2018) Residential Condominium Building Association Policy Rating Guidelines (PDF)

RAND Corporation (2006). The National Flood Insurance Program's Market Penetration Rate: Estimates and Policy Implications (PDF).

APPENDIX A: DATA MANGEMENT

The data provided by FEMA to the City of Virginia Beach, Virginia, is expected to include address, policy number, and some financial details such as premiums and claim amounts. These data contain Personally Identifiable Information (PII), as the values within could be "used to distinguish or trace an individual's identity or could be combined with other personal or identifying information which is linked or linkable to a specific individual, such as medical, educational, financial, and employment information." (GAO Report 08-536).

Proposed project activities involve accessing flood insurance policy and claim data that contain PII. Prior to receiving the PII data, involved parties have conducted an evaluation of their infrastructure and strategies for handling PII data. This evaluation follows the recommendations as set forth in the *Guide to Protecting the Confidentiality of Personally Identifiable Information (PII), Special Publication 800-122*, National Institute of Standards and Technology. This document subsequently summarizes the evaluation outcomes and provides proposed methods for handling PII during the project lifecycle.

Nondisclosure Agreement

All project team members who will have access to PII throughout the project, aside from City of Virginia Beach personnel (assumed to already be under either an explicit or implied Nondisclosure Agreement (NDA) by virtue of being shared data by FEMA as a trusted party), will be required to sign an approved NDA that binds them to following through with the agreed upon PII handling strategies, creates a legal obligation, and compels said parties to maintain security.

Privacy Impact and Data Breach Responsibilities

Per documented best practices relating to PII, it is imperative that the project team evaluate the harm that might be experienced by individuals if this information were to be used inappropriately by the team during or after proposed project activities, or were it to be unprotected from breach and subsequent access by others. Individual harm includes the potential for identity theft, embarrassment, or blackmail. Potential harm to FEMA, the City of Virginia Beach, and/or the project team includes loss of public trust, legal liability, and the potential high cost of handling the breaches. Entities that could potentially attempt to benefit from a breach of this information include insurance organizations, banks, government agencies, the general public, and special interest groups. In the event of a data breach, the potential harm to individuals or organizations is anticipated to have a limited adverse

effect. However, the obligation to protect confidentiality, and the likely negative impact that would occur should a breach break public trust, could have a serious adverse effect on the organizations involved.

The potential impact of a breach will be evaluated by the definitions provided in Special Publication 800-122 as follows:

- **LOW** - the loss of confidentiality is expected to have a limited adverse effect on individuals or organizations.
- **MODERATE** - the loss is expected to have a serious adverse effect.
- **HIGH** - the loss is expected to have a severe or catastrophic adverse effect.

In the event of a breach of PII, federal law requires that affected agencies report all incidents to the United States Computer Emergency Readiness Team (US-CERT) within one hour (OMB M-06-19). For the sake of the proposed project work, were a breach or suspected breach to occur, project teams must immediately notify the City of Virginia Beach (as stewards of FEMA data) and take reasonable actions to prevent further breach. The City of Virginia Beach would in turn notify FEMA as the affected agency. With respect to potential identity theft-related breach incidents, the Identity Theft Task Force (Identity Theft Related Data Security Breach Notification Guidance) recommends that (1) Agencies should preemptively identify a core response group that can be convened in the event of a breach, (2) If an incident occurs, the core response group should engage in a risk analysis to determine whether the incident poses problems related to theft identity, and (3) If it is determined that an identity theft risk is present, the agency should tailor its response to the nature and scope of the risk presented. While the potential for breaches of PII data resulting in identity theft is believed to be low for the proposed project activities (no Social Security Number data are present), project management staff will confer with the City of Virginia Beach prior to any data transfer to determine preferred practices based upon the suggestions of the Identity Theft Task Force.

Table 14 summarizes the baseline confidentiality impact evaluation of an access breach to the project data. The confidentiality impact level is scored, and then the appropriate policy, procedure, or control is listed.

Table 14: Baseline Confidentiality Impact Evaluation

Evaluation Factor	Confidentiality Impact Level	Appropriate Safeguards Based on Impact Level					
		Policy & Procedure	Training	De-Identifying PII	Access Enforcement	Transmission Confidentiality	Auditing
Distinguishability	LOW	101	102	204			
Aggregation and Data Field Sensitivity	LOW			204, 301			
Obligations to Protect Confidentiality	MODERATE	101	102	204, 501	103, See table for all	201, 401, 501	303, 501
Access to and Location of PII	LOW	102, 103	103	204, 501	See table for all	202, 203, 206, 501	303, 501

Project PII Control Group and Management Strategy

For the purposes of protecting PII on this project, the following control groups are identified:

- Project Management (PM): These members are responsible for the overall project management of this project (maximum number of people = 2)
- Control Officers (CO): These members are responsible for the overall confidentiality control within this project (maximum number of people = 1)
- Control Team 1 (CT1): These members are the only staff that will have working access to PII data within this project (maximum number of people = 1)

All data storage practices and work efforts will be in keeping with the basic privacy principle of minimizing the use, collection, and retention of PII data to the greatest extent practicable. In all cases, only the minimum necessary personnel will have access to PII data, up to the point where it is returned to the City of Virginia Beach and/or destroyed via proper sterilization of storage media. At times during the lifespan of the project (as determined by requirements and conditions agreed upon between the City of Virginia Beach and the project teams) both raw data and that used for analysis will be stored on access-controlled storage media. Replication of any PII within the designated media will be minimized throughout the course of analysis. No copies of PII data outside of the designated access controlled media will be allowed.

Relating specifically to the use of external geocoding resources, only de-identified data consisting of unique completely non-inferable key values and related address strings would be allowed to pass between the project team (CT1) and the external resource(s).

The following procedures are outlined to appropriately protect the project PII data (Table 15). Special considerations have been given during key transitions throughout the project where data are transmitted, accessed, shared, or analyzed by team members or the City of Virginia Beach.

Table 15: Project Procedures for Protection PII

No	Procedure	Control	Responsibility
101	Identify project roles and sign project NDAs.	Policy Procedure, Access Enforcement	PM
102	Update CT on PII confidentiality and the procedures for this project.	Training	PM, CO
103	Establish secure digital storage areas and CT access credentials.	Access Enforcement	CO
201	CO receives PII data from the City of Virginia Beach or their agent via registered mail (signature of CO required).	Transmission Confidentiality	City of Virginia Beach, CO
202	CO copies data into secure vault folder. This folder will contain all original data (secured original source folder).	Access Enforcement	CO
203	CO copies data to secure CT1 folder (secured working folder).	Access Enforcement	CO
204	CT1 creates unique identifier for each data record and then de-identifies all data EXCEPT address. This dataset is called the ADDRESS INDEX and only includes the address fields and the unique identifier. This de-identified data will serve as input for any geocoding processes. Re-identification information will reside solely within secure CT1 folder.	De-identifying PII	CT1
205	CT1 performs geocoding using pre-determined (by PM group) engine, resulting in GIS point locations.	Access Enforcement	CT1
206	CT1 joins geocoded GIS point locations with original data within the secure CT1 folder, creating a master spatially enabled dataset.	De-identifying PII	CT1
207	CO sends original media back to City of Virginia Beach, or their agent, via registered mail.	Access Enforcement	CO

301	The City of Virginia Beach (or their agent), PM, and CO determine an appropriate spatial resolution for reporting aggregate results (e.g., census resolution, heat map cell size, etc.), such that the resulting summarizations can be shared with other relevant project groups as needed, without concern for PII exposure.	De-identifying PII	City of Virginia Beach, PM, CO
302	CT1 performs scoped work as outlined in approved work order.	De-identifying PII, Access enforcement	CT1
303	CT1 prepares address specific and aggregate tabular data for delivery, and transmits data to CO.	Access enforcement	CO, CT1
401	CO transfers address specific and aggregate tabular data to PM and to the City of Virginia Beach or their agent pursuant to agree upon deliverable schedule.	Transmission Confidentiality, Access Enforcement	PM, CO, CT1
501	At the end of the project all PII data will be destroyed including all raw data within the vault and CT1 folders, and a letter of destruction will be submitted to the City of Virginia Beach.	Access Enforcement, Audit	PM, CO, CT1

The following risk analysis is presented for the project procedures (Table 16). The PM and CO will maintain heightened awareness and care during these periods.

Table 16: Risk Analysis

No	No of Copies	Location of Data Copies	No Staff w/ Access to PII	Access Controls
201	1	Mail transmission.	0	Registered mail
202	2	Original media, secure project vault.	2	64-bit OS with domain credentials
203	3	Original media, secure project vault, secure CT1 folder.	2	64-bit OS with domain credentials
204	4	Original media, secure project vault, original in secure CT1 folder, de-identified ADDRESS INDEX in secure CT1 folder.	2	64-bit OS with domain credentials
205	4	Original media, secure project vault, original in secure CT1 folder, de-identified ADDRESS INDEX in secure CT1 folder.	2	64-bit OS with domain credentials

206	3	Original media, secure project vault, spatially located de-identified ADDRESS INDEX joined to original data in secure CT1 folder.	2	64-bit OS with domain credentials, registered mail
207	2	Secure project vault, spatially located de-identified ADDRESS INDEX joined to original data in secure CT1 folder.	2	64-bit OS with domain credentials, registered mail
301	2	Secure project vault, spatially located de-identified ADDRESS INDEX joined to original data in secure CT1 folder.	2	64-bit OS with domain credentials
302	2	Secure project vault, spatially located de-identified ADDRESS INDEX joined to original data in secure CT1 folder.	2	64-bit OS with domain credentials
303	2	Secure project vault, spatially located de-identified ADDRESS INDEX joined to original data in secure CT1 folder.	2	64-bit OS with domain credentials, registered mail
401	2	Secure project vault, spatially located de-identified ADDRESS INDEX joined to original data in secure CT1 folder.	2	64-bit OS with domain credentials
501	1	Deliverables to City of Virginia Beach via digital media, registered mail.	0	64-bit OS with domain credentials, registered mail

This management plan pertains to work completed under task orders issued to Syndeste, LLC for work associated with subcontract S/C-VABCH-PWCN-15-0014-SL for contract PWCN-15-0014A work order 3A.

APPENDIX B: SUPPLEMENTAL MATERIALS

The full set of data analysis results, including both current condition and future condition/increased policy penetration scenarios, are provided in a geospatial database. The data dictionary that includes field names, field name alias, and descriptions is provided in Table 17. The future conditions database is also accompanied by a table of naming convention and descriptions of the future condition/increased policy penetration scenarios, which are also provided below in Table 18.

Table 17: Geospatial data dictionary for the flood insurance analysis results.

Field Name	Alias	Description
cbg	Census Block Group	Census Block Group ID
block	Block	Census Block ID
bm_objid_text	bm_objid_text	Building Footprint ID
g1500_id	1,500-foot Grid	1,500-ft grid ID
g500_id	500-foot Grid	500-ft grid ID
parcel_uid	Parcel	Parcel ID
subd_id	Subdivision	Planning Subdivision ID
subd_desc	Subdivision	Name of Planning Subdivision
sga_name	Strategic Growth Area	Strategic Growth Areas ID
swd_basin	Storm Water Drainage Basin	Storm Water Drainage Basin ID
watershed	Watershed	Hydrologic Unit Code (HUC) 8, name of watershed
bldg_count	Buildings	Count of Buildings within a given Reporting Layer
pol_count	Policies	Count of Policies within a given Reporting Layer
bldgs_w_pol	Buildings w Policy	Count of Buildings that have at least one Policy within a given Reporting Layer
tot_bldg_cov_sum_sfha	Total BLDG Cover SFHA	Total dollar amount of buildings coverage within the Special Flood Hazard Area (SFHA)
tot_cont_cov_sum_sfha	Total CONT Cover SFHA	Total dollar amount of contents coverage within the SFHA
tot_bldg_cov_sum_nsfha	Total BLDG Cover NSFHA	Total dollar amount of buildings coverage Outside the SFHA
tot_cont_cov_sum_nsfha	Total CONT Cover NSFHA	Total dollar amount of contents coverage Outside the SFHA
tot_bldg_cov_sum	Total BLDG Cover	Total dollar amount of buildings coverage within a given Reporting Layer
tot_cont_cov_sum	Total CONT Cover	Total dollar amount of contents coverage within a given Reporting Layer

Field Name	Alias	Description
b_comb_rr_10yr_sfha	Building RR 10-yr SFHA	Residual Risk total dollar amount of buildings within the 10 year frequency and SFHA
b_comb_rr_25yr_sfha	Building RR 25-yr SFHA	Residual Risk total dollar amount of buildings within the 25 year frequency and SFHA
b_comb_rr_50yr_sfha	Building RR 50-yr SFHA	Residual Risk total dollar amount of buildings within the 50 year frequency and SFHA
b_comb_rr_100yr_sfha	Building RR 100-yr SFHA	Residual Risk total dollar amount of buildings within the 100 year frequency and SFHA
b_comb_rr_500yr_sfha	Building RR 500-yr SFHA	Residual Risk total dollar amount of buildings within the 500 year frequency and SFHA
b_comb_rr_aal_sfha	Building RR aal SFHA	Residual Risk total dollar amount of Average Annualized Loss (AAL) buildings within the SFHA
b_comb_rr_10yr_nsfha	Building RR 10-yr NSFHA	Residual Risk total dollar amount of buildings within the 10 year frequency but outside the SFHA
b_comb_rr_25yr_nsfha	Building RR 25-yr NSFHA	Residual Risk total dollar amount of buildings within the 25 year frequency but outside the SFHA
b_comb_rr_50yr_nsfha	Building RR 50-yr NSFHA	Residual Risk total dollar amount of buildings within the 50 year frequency but outside the SFHA
b_comb_rr_100yr_nsfha	Building RR 100-yr NSFHA	Residual Risk total dollar amount of buildings within the 100 year frequency but outside the SFHA
b_comb_rr_500yr_nsfha	Building RR 500-yr NSFHA	Residual Risk total dollar amount of buildings within the 500 year frequency but outside the SFHA
b_comb_rr_aal_nsfha	Building RR aal NSFHA	Residual Risk total dollar amount of Average Annualized Loss (AAL) buildings Outside the SFHA
b_comb_rr_10yr	Building RR 10-yr	Residual Risk total dollar amount of buildings within the 10 year frequency
b_comb_rr_25yr	Building RR 25-yr	Residual Risk total dollar amount of buildings within the 25 year frequency
b_comb_rr_50yr	Building RR 50-yr	Residual Risk total dollar amount of buildings within the 50 year frequency
b_comb_rr_100yr	Building RR 100-yr	Residual Risk total dollar amount of buildings within the 100 year frequency
b_comb_rr_500yr	Building RR 500-yr	Residual Risk total dollar amount of buildings within the 500 year frequency
b_comb_rr_aal	Building RR aal	Residual Risk total dollar amount of Average Annualized Loss (AAL) buildings
c_comb_rr_10yr_sfha	Contents RR 10-yr SFHA	Residual Risk total dollar amount of contents within the 10 year frequency and SFHA
c_comb_rr_25yr_sfha	Contents RR 25-yr SFHA	Residual Risk total dollar amount of contents within the 25 year frequency and SFHA
c_comb_rr_50yr_sfha	Contents RR 50-yr SFHA	Residual Risk total dollar amount of contents within the 50 year frequency and SFHA
c_comb_rr_100yr_sfha	Contents RR 100-yr SFHA	Residual Risk total dollar amount of contents within the 100 year frequency and SFHA
c_comb_rr_500yr_sfha	Contents RR 500-yr SFHA	Residual Risk total dollar amount of contents within the 500 year frequency and SFHA

Field Name	Alias	Description
c_comb_rr_aal_sfha	Contents RR aal SFHA	Residual Risk total dollar amount of Average Annualized Loss (AAL) contents within the SFHA
c_comb_rr_10yr_nsfha	Contents RR 10-yr NSFHA	Residual Risk total dollar amount of contents within the 10 year frequency but outside the SFHA
c_comb_rr_25yr_nsfha	Contents RR 25-yr NSFHA	Residual Risk total dollar amount of contents within the 25 year frequency but outside the SFHA
c_comb_rr_50yr_nsfha	Contents RR 50-yr NSFHA	Residual Risk total dollar amount of contents within the 50 year frequency but outside the SFHA
c_comb_rr_100yr_nsfha	Contents RR 100-yr NSFHA	Residual Risk total dollar amount of contents within the 100 year frequency but outside the SFHA
c_comb_rr_500yr_nsfha	Contents RR 500-yr NSFHA	Residual Risk total dollar amount of contents within the 500 year frequency but outside the SFHA
c_comb_rr_aal_nsfha	Contents RR aal NSFHA	Residual Risk total dollar amount of Average Annualized Loss (AAL) contents Outside the SFHA
c_comb_rr_10yr	Contents RR 10-yr	Residual Risk total dollar amount of contents within the 10 year frequency
c_comb_rr_25yr	Contents RR 25-yr	Residual Risk total dollar amount of contents within the 25 year frequency
c_comb_rr_50yr	Contents RR 50-yr	Residual Risk total dollar amount of contents within the 50 year frequency
c_comb_rr_100yr	Contents RR 100-yr	Residual Risk total dollar amount of contents within the 100 year frequency
c_comb_rr_500yr	Contents RR 500-yr	Residual Risk total dollar amount of contents within the 500 year frequency
c_comb_rr_aal	Contents RR aal	Residual Risk total dollar amount of Average Annualized Loss (AAL) contents
t_comb_rr_10yr_sfha	Total RR 10-yr SFHA	Residual Risk total dollar amount of buildings and contents within the 10 year frequency and SFHA
t_comb_rr_25yr_sfha	Total RR 25-yr SFHA	Residual Risk total dollar amount of buildings and contents within the 25 year frequency and SFHA
t_comb_rr_50yr_sfha	Total RR 50-yr SFHA	Residual Risk total dollar amount of buildings and contents within the 50 year frequency and SFHA
t_comb_rr_100yr_sfha	Total RR 100-yr SFHA	Residual Risk total dollar amount of buildings and contents within the 100 year frequency and SFHA
t_comb_rr_500yr_sfha	Total RR 500-yr SFHA	Residual Risk total dollar amount of buildings and contents within the 500 year frequency and SFHA
t_comb_rr_aal_sfha	Total RR aal SFHA	Residual Risk total dollar amount of Average Annualized Loss (AAL) buildings and contents within the SFHA
t_comb_rr_10yr_nsfha	Total RR 10-yr NSFHA	Residual Risk total dollar amount of buildings and contents within the 10 year frequency but outside the SFHA
t_comb_rr_25yr_nsfha	Total RR 25-yr NSFHA	Residual Risk total dollar amount of buildings and contents within the 25 year frequency but outside the SFHA
t_comb_rr_50yr_nsfha	Total RR 50-yr NSFHA	Residual Risk total dollar amount of buildings and contents within the 50 year frequency but outside the SFHA
t_comb_rr_100yr_nsfha	Total RR 100-yr NSFHA	Residual Risk total dollar amount of buildings and contents within the 100 year frequency but outside the SFHA

Field Name	Alias	Description
t_comb_rr_500yr_nsfha	Total RR 500-yr NSFHA	Residual Risk total dollar amount of buildings and contents within the 500 year frequency but outside the SFHA
t_comb_rr_aal_nsfha	Total RR aal NSFHA	Residual Risk total dollar amount of Average Annualized Loss (AAL) buildings and contents Outside the SFHA
t_comb_rr_10yr	Total RR 10-yr	Residual Risk total dollar amount of buildings and contents within the 10 year frequency
t_comb_rr_25yr	Total RR 25-yr	Residual Risk total dollar amount of buildings and contents within the 25 year frequency
t_comb_rr_50yr	Total RR 50-yr	Residual Risk total dollar amount of buildings and contents within the 50 year frequency
t_comb_rr_100yr	Total RR 100-yr	Residual Risk total dollar amount of buildings and contents within the 100 year frequency
t_comb_rr_500yr	Total RR 500-yr	Residual Risk total dollar amount of buildings and contents within the 500 year frequency
t_comb_rr_aal	Total RR aal	Residual Risk total dollar amount of Average Annualized Loss (AAL) buildings and contents
land_use	Land Use	Land use associated with the building footprint
lag	Lowest Adjacent Grade	Lowest Adjacent Grade of the building
hag	Highest Adjacent Grade	Highest Adjacent Grade of the building
fld_zone	Flood Zone	flood zone associated with the building
bfe	Base Flood Elevation	base flood elevation associated with the building
bfe_delta	LAG BFE difference	LAG minus BFE
in_sfha	In or Out of SFHA	1/0 in sfha or not. 1 = yes, 0 = no
b_rr_10yr	Building RR 10-yr	Residual Risk dollar amount of the building from the 10 year frequency
b_rr_25yr	Building RR 25-yr	Residual Risk dollar amount of the building from the 25 year frequency
b_rr_50yr	Building RR 50-yr	Residual Risk dollar amount of the building from the 50 year frequency
b_rr_100yr	Building RR 100-yr	Residual Risk dollar amount of the building from the 100 year frequency
b_rr_500yr	Building RR 500-yr	Residual Risk dollar amount of the building from the 500 year frequency
b_rr_aal	Building RR aal	Residual Risk dollar amount of the building from Average Annualized Loss (AAL)
c_rr_10yr	Contents RR 10-yr	Residual Risk dollar amount of the contents from the 10 year frequency
c_rr_25yr	Contents RR 25-yr	Residual Risk dollar amount of the contents from the 25 year frequency

Field Name	Alias	Description
c_rr_50yr	Contents RR 50-yr	Residual Risk dollar amount of the contents from the 50 year frequency
c_rr_100yr	Contents RR 100-yr	Residual Risk dollar amount of the contents from the 100 year frequency
c_rr_500yr	Contents RR 500-yr	Residual Risk dollar amount of the contents from the 500 year frequency
c_rr_aal	Contents RR aal	Residual Risk dollar amount of the contents from Average Annualized Loss (AAL)
t_rr_10yr	Total RR 10-yr	Residual Risk dollar amount of the building and contents from the 10 year frequency
t_rr_25yr	Total RR 25-yr	Residual Risk dollar amount of the building and contents from the 25 year frequency
t_rr_50yr	Total RR 50-yr	Residual Risk dollar amount of the building and contents from the 50 year frequency
t_rr_100yr	Total RR 100-yr	Residual Risk dollar amount of the building and contents from the 100 year frequency
t_rr_500yr	Total RR 500-yr	Residual Risk dollar amount of the building and contents from the 500 year frequency
t_rr_aal	Total RR aal	Residual Risk dollar amount of the building and contents from Average Annualized Loss (AAL)

Table 18: Scenario field names and descriptions for the future condition/increased policy penetration analysis.

Scenario Name	Field Name	Flood Condition	Scenario Description
Control - No Regulatory Change	C1_s1	1.5 ft SLR	If policy base remains unchanged, what would be the residual risk under the 1.5 ft SLR scenario?
	C1_s2	3 ft SLR	If policy base remains unchanged, what would be the residual risk under the 3 ft SLR scenario?
Control – Maintain Equivalent Buying Trends	C2_s1	1.5 ft SLR	If the current condition policy base penetration rates were extrapolated to create an equivalent future policy base in and out of the 1.5 ft SLR SFHA, what would be the residual risk under the 1.5 ft SLR scenario?
	C3_s2	3 ft SLR	If the current condition policy base penetration rates were extrapolated to create an equivalent future policy base in and out of the 3 ft SLR SFHA, what would be the residual risk under the 3 ft SLR scenario?
Increased Penetration in SFHA	1_125x_s0	Existing	If policy base increased by 1.25x within the Current Conditions SFHA, what would be the residual risk today?
	1_125x_s1	1.5 ft SLR	If policy base increased by 1.25x within the Current Conditions SFHA, what would be the residual risk under the 1.5 ft SLR scenario?
	1_125x_s2	3 ft SLR	If policy base increased by 1.25x within the Current Conditions SFHA, what would be the residual risk under the 3 ft SLR scenario?

	1_15x_s0	Existing	If policy base increased by 1.5x within the Current Conditions SFHA, what would be the residual risk today?
	1_15x_s1	1.5 ft SLR	If policy base increased by 1.5x within the Current Conditions SFHA, what would be the residual risk under the 1.5 ft SLR scenario?
	1_15x_s2	3 ft SLR	If policy base increased by 1.5x within the Current Conditions SFHA, what would be the residual risk under the 3 ft SLR scenario?
Increased Penetration in 500-Yr Floodplain	2_125x_s0	Existing	If policy base increased by 1.25x within the Current Conditions 500YR band (excluding SFHA), what would be the residual risk today?
	2_125x_s1	1.5 ft SLR	If policy base increased by 1.25x within the Current Conditions 500YR band (excluding SFHA), what would be the residual risk under the 1.5 ft SLR scenario?
	2_125x_s2	3 ft SLR	If policy base increased by 1.25x within the Current Conditions 500YR band (excluding SFHA), what would be the residual risk under the 3 ft SLR scenario?
	2_15x_s0	Existing	If policy base increased by 1.5x within the Current Conditions 500YR band (excluding SFHA), what would be the residual risk today?
	2_15x_s1	1.5 ft SLR	If policy base increased by 1.5x within the Current Conditions 500YR band (excluding SFHA), what would be the residual risk under the 1.5 ft SLR scenario?
	2_15x_s2	3 ft SLR	If policy base increased by 1.5x within the Current Conditions 500YR band (excluding SFHA), what would be the residual risk under the 3 ft SLR scenario?
Increase Penetration in Focus Areas	3_125x_s0	Existing	If policy base increased by 1.25x within the Focus Areas, what would be the residual risk today?
	3_125x_s1	1.5 ft SLR	If policy base increased by 1.25x within the Focus Areas, what would be the residual risk under the 1.5 ft SLR scenario?
	3_125x_s2	3 ft SLR	If policy base increased by 1.25x within the Focus Areas, what would be the residual risk under the 3 ft SLR scenario?
	3_15x_s0	Existing	If policy base increased by 1.5x within the Focus Areas, what would be the residual risk today
	3_15x_s1	1.5 ft SLR	If policy base increased by 1.5x within the Focus Areas, what would be the residual risk under the 1.5 ft SLR scenario?
	3_15x_s2	3 ft SLR	If policy base increased by 1.5x within the Focus Areas, what would be the residual risk under the 3 ft SLR scenario?
Increase Penetration for Low-Lying Structures	4_125x_s0	Existing	If policy base increased by 1.25x among structures whose FFE was lower than Current Conditions BFE (note these represent a subset within the SFHA), what would be the residual risk today?
	4_125x_s1	1.5 ft SLR	If policy base increased by 1.25x among structures whose FFE was lower than Current Conditions BFE (note these represent a subset within the SFHA), what would be the residual risk under the 1.5 ft SLR scenario?
	4_125x_s2	3 ft SLR	If policy base increased by 1.25x among structures whose FFE was lower than Current Conditions BFE (note these represent a subset within the SFHA), what would be the residual risk under the 3 ft SLR scenario?
	4_15x_s0	Existing	If policy base increased by 1.5x among structures whose FFE was lower than Current Conditions BFE (note these represent a subset within the SFHA), what would be the residual risk today?

	4_15x_s1	1.5 ft SLR	If policy base increased by 1.5x among structures whose FFE was lower than Current Conditions BFE (note these represent a subset within the SFHA), what would be the residual risk under the 1.5 ft SLR scenario?
	4_15x_s2	3 ft SLR	If policy base increased by 1.5x among structures whose FFE was lower than Current Conditions BFE (note these represent a subset within the SFHA), what would be the residual risk under the 3 ft SLR scenario?
Increase Coverage	5_s0	Existing	If all building coverage was added to all content only policies, and content coverage was added to all building only policies, what would be the residual risk today?
	5_s1	1.5 ft SLR	If all building coverage was added to all content only policies, and content coverage was added to all building only policies, what would be the residual risk under the 1.5 ft SLR scenario?
	5_s2	3 ft SLR	If all building coverage was added to all content only policies, and content coverage was added to all building only policies, what would be the residual risk under the 3 ft SLR scenario?

Several excel spreadsheets were also developed to aid the City in summarization of results at the planning subdivision geography. These exhibits are described as follows:

- **Exhibit A** further breaks down penetration rates, such as providing rates both inside and outside of the SFHA for every planning subdivision within the City. This includes building counts, counts of buildings with at least one policy, policy counts, and both penetration rate calculation methods.
- **Exhibit B** provides a ranking scheme for the data provided in Exhibit A so that intersections of low penetration rates and substantial building counts or low policy counts can be gleaned. In this exhibit, a RANK of 1 is assigned to the highest count values (buildings, buildings with at least 1 policy, and policies), and RANK 1 is also assigned to the lowest penetration rates (both calculation methods) typically, 0.00%.
- **Exhibit C** summarizes the results of the planning subdivision analysis by placing the subdivisions into bins based on their penetration rates calculated as number of policies to buildings.
- **Exhibit D** provides a similar summary, though by calculating penetration as percentage of buildings with at least one policy.
- **Exhibit E** breaks down penetration by occupancy type (e.g., single-family, multi-family, non-residential). For these tables, the simplified land use code mapping outlined in Appendix A was used, although the full source data land use code set from the building footprint database is included in the analysis and can be seen in the raw data outputs. The tabs in

Exhibit E correspond to the simplified land use codes: Single Family, 2-4 Family, Other Residential, Non-Residential, and Non-Residential - Business.

- **Exhibit F** provides claims statistics broken down by planning subdivision. The exhibit includes claim counts, and damage totals by planning subdivision, both inside and outside the SFHA. The first three columns also provide a ratio of historic losses (building + content) to the total value (building + content) for each planning subdivision in total, as well as inside and outside the SFHA. A higher ratio in these columns indicates more significant losses as compared to the value of assets within those planning subdivisions and highlights areas which experienced the most significant historic losses by that particular metric.
- **Exhibits H and I** provide ways to explore the results of the residual risk analysis at a planning subdivision resolution, both by magnitude of residual risk and by residual risk related to local total asset value respectively. The values with Exhibit H are residual risk dollar amount values. Exhibit I builds off of these numbers as well as Exhibit G, which provides aggregated asset values for each planning subdivision. Exhibit I shows a ratio of residual risk to total asset value. Of note, there is some cross-over between the list of the ten planning subdivisions with the greatest residual risk and the list of the ten with the highest residual risk to value ratio. Also of note is that these lists further differ from the list of the ten planning subdivisions with highest modeled losses.

APPENDIX C: PREMIUM ESTIMATION SOURCES AND ASSUMPTIONS

Data inputs and the associated assumptions common to both FIM and SRG-based premium calculations are as follows below, noting that this list represents a master set, and that not all factors will be relevant or required in the case of each individual structure. Additionally, in the instances where actual policy data detail characteristics of a structure (number of floors, foundation type, whether it is elevated, occupancy, construction date and pre/post firm indicator) have been associated with a given structure, those data will supersede any assumptions and will be utilized even when in conflict with the assumptions detailed below.

Data Source and Field Mapping Assumptions

- Policy Type
    - Assumptions: Assumed to be a standard policy when the structure intersects the SFHA, otherwise considered a Preferred Risk Policy (PRP) candidate unless claim information exists such as to disqualify the property from PRP eligibility. For the SLR scenario calculations, structures intersecting the SFHA that did not intersect the SFHA within the current effective data will have premiums calculated using the Newly Mapped procedure as well as full risk rating.
- Pre vs Post Firm Construction
    - Assumptions: Based upon UDF_YearBuilt value from the master building footprint dataset, and known initial FIRM date for the community (10/3/1970). In the absence of Year Built information, structures are to be considered Post FIRM.
- Flood Zone
    - Assumptions: For Current Condition Analysis and Increased Policy Penetration Analysis, assigned per structure using the most recent DFIRM flood zone boundaries (FIRM effective date 1/16/2015). For Future Conditions and Regulatory Changes Analysis, assigned using floodplain boundary extents (100-year flooding extents) for the 1.5-foot and 3-foot SLR scenarios. In cases where structures intersect more than one zone, they will always be assigned the assumed riskiest of the flood zones that they intersect. Extents of future VE zones will be approximated (for the sake of assigning zone VE to structures when calculating premiums) using 'vepoly' extents provided by the ENGINEER, which represent the extents of areas affected by 3 foot or greater wave heights. Extents of future AO and AH zones will be approximated by comparing the extents of future floodplains to the current DFIRM flood zones with those designations.

- Base Flood Elevation
    - Assumptions: For Current Condition Analysis and Increased Policy Penetration Analysis, assigned per structure using the most recent DFIRM flood zone boundaries (FIRM effective date 1/16/2015). For Future Conditions and Regulatory Changes Analysis, assigned using a combination of the high resolution digital elevation model and the flooding extend depth grids (100-year flooding extents) for the 1.5-foot and 3-foot SLR scenarios. In cases where structures intersect multiple base flood elevation zones or areas, they will always be assigned the higher base flood elevation. Base flood elevation of future VE and tidally influenced AE will be estimated using values from the flood height raster (considers both wave height and stillwater elevations) provided by the ENGINEER.
- First Floor Elevation
    - Assumptions: Based upon FINAL_FFE value from the master building footprint dataset when available. When the FINAL_FFE value is not populated, First Floor Elevation will be assigned by adding the UDF_FirstFloorHt and LAG_ELEV from the master building footprint dataset.
- Presence of Elevation Certificate
    - Assumptions: In the absence of specific data, structures will be assumed not to have associated elevation certificates.
- Occupancy
    - Assumptions: Based upon UDF_Occupancy value from the master building footprint dataset. Occupancy will be assigned as either 'Single Family', '2 - 4 Family', 'Other Residential', or 'Non-Residential' based upon the following mapping.
        - AGR1 - Agriculture to Non-Residential
        - COM – Only General Occupancy Known to Non-Residential
        - COM1 - Retail Trade to Non-Residential
        - COM10 - Parking Garages (Not Parking Lots) to Non-Residential
        - COM2 - Wholesale Trade to Non-Residential
        - COM3 - Personal and Repairs Services to Non-Residential
        - COM4 - Business/Professional/Technical Services to Non-Residential
        - COM5 - Depository Institutions to Non-Residential
        - COM6 - Hospital to Non-Residential
        - COM7 - Medical Office/Clinic to Non-Residential

- COM8 - Entertainment & Recreation to Non-Residential
- COM9 - Theaters to Non-Residential
- DG - Detached Garage to Non-Residential
- EDU? - Only General Occupancy Known to Non-Residential
- EDU1 - Schools/Libraries to Non-Residential
- EDU2 - Colleges/Universities to Non-Residential
- GOV? - Only General Occupancy Known to Non-Residential
- GOV1 - General Services to Non-Residential
- GOV2 - Emergency Response to Non-Residential
- IND? - Only General Occupancy Known to Non-Residential
- IND1 - Heavy Industrial to Non-Residential
- IND2 - Light Industrial to Non-Residential
- IND3 - Food/Drugs/Chemicals to Non-Residential
- IND4 - Metal / Minerals Processing to Non-Residential
- IND5 - High Technology to Non-Residential
- IND6 - Construction (Facilities and Offices) to Non-Residential
- NB - No Building per Information At-Hand to Non-Residential
- NBV - No Building Verified to Non-Residential
- OTHER - Other Structure (e.g., carport, shed, etc) to Non-Residential
- REL1 - Church/Membership Organizations to Non-Residential
- RES? - Only General Occupancy Known to Other Residential
- RES1 - Single-Family Dwelling to Single Family
- RES2 - Mobile Home to Single Family
- RES3? - Only General Occupancy Known to Other Residential
- RES3A - Multi-Family Dwelling - Duplex to 2 - 4 Family
- RES3B - Multi-Family Dwelling - 3 to 4 Units to Other Residential
- RES3C - Multi-Family Dwelling - 5 to 9 Units to Other Residential
- RES3D - Multi-Family Dwelling - 10 to 19 Units to Other Residential
- RES3E - Multi-Family Dwelling - 20 to 49 Units to Other Residential

        - RES3F - Multi-Family Dwelling > 50+ Units to Other Residential
        - RES4 - Temporary Lodging to Non-Residential
        - RES5 - Institutional Dormitory to Non-Residential
        - RES6 - Nursing Home to Non-Residential
- Foundation Type
    - Assumptions: Based upon UDF_FoundationType value from the master building footprint dataset with the addition of the identification of mobile homes based upon the UDF_Occupancy value. In the absence of actual foundation type data, structures are assumed to be slab on grade, with no basement, enclosure, or crawlspace.
        - 1 - Pile to Elevated, No Basement / Enclosure / Crawlspace
        - 2 - Pier to Elevated, No Basement / Enclosure / Crawlspace
        - 3 - Solid Wall to Elevated on an Enclosure
        - 5 - Crawl Space to Elevated on Crawlspace
        - 6 - Fill to No Basement / Enclosure / Crawlspace
        - 7 - Slab On Grade to No Basement / Enclosure / Crawlspace
- Property Type
    - Assumptions: In the absence of conflicting information, all residential structures will be considered to be primary residences.
- Year Built
    - Assumptions: Based upon UDF_YearBuilt value from the master building footprint dataset, otherwise left blank. Related to the assumption of pre vs post FIRM construction.
- Replacement Cost
    - Assumptions: Based upon UDF_Cost value from the master building footprint dataset which was derived by the ENGINEER using the established HAZUS methodologies which take into account square footage and further modify the value using additional structure specific information.

- Content Value
    - Assumptions: Based upon UDF_ContentsCost value from the master building footprint dataset which was derived by the ENGINEER using established HAZUS methodologies.
- Number of Floors
    - Assumptions: Based upon NumStories value from the master building footprint dataset.
- Whether or Not the Structure is Elevated
    - Assumptions: Based upon UDF_FoundationType value from the master building footprint dataset, and assigned as described above in the Foundation Type description.
- If Elevated, Whether or Not the Area Under the Elevated Structure is Obstructed
    - Assumptions: Based upon UDF_FoundationType value from the master building footprint dataset, and assigned as described above in the Foundation Type description.
- Location of Contents within the Structure
    - Assumptions: It is assumed that contents will be distributed throughout all available floors within a structure.
- Building Coverage Desired
    - Assumptions: Assumed to be the lesser of the replacement cost and the cap for the associated amount of building insurance available based on occupancy.
- Content Coverage Desired
    - Assumptions: Assumed to be a proportion of the available content insurance cap amount equal to the assumed building coverage desired divided by the building insurance amount cap, up to a maximum of the available content insurance cap based on occupancy.
- Building Coverage Deductible Desired
    - Assumptions: Deductible will be set as the minimum deductible allowed based on coverage amount, pre-firm status, and flood zone, per FEMA's Flood Insurance Manual Rating Section Table 8A.
- Content Coverage Deductible Desired
    - Assumptions: Deductible will be set as the minimum deductible allowed based on coverage amount, pre-firm status, and flood zone, per FEMA's Flood Insurance Manual Rating Section Table 8A.

- Community Rating System Participation and Scoring
    - Assumptions: Community Rating System discounts are applied to all calculated policy premiums, based upon the latest (October 2017) listing of CRS Eligible Communities published by FEMA. As of the date of this listing, the City of Virginia Beach does not appear within the list of eligible communities.
- Community Probation Status
    - Assumptions: A surcharge is added to any structures within communities that are on probation from the NFIP. The City of Virginia Beach is known to be in good standing within the NFIP, and so no probation surcharge would apply.

Further inputs and assumptions required for SRG-based calculations only are as follows.

- If Elevated, Whether or Not the Area There is Machinery Below the Elevated Structure
    - Assumptions: Since unknown, it is assumed that elevated structures do not have machinery below them.
- If Elevated, Whether or Not the Area There are Appliances Below the Elevated Structure
    - Assumptions: Since unknown, it is assumed that elevated structures do not have appliances below them.
- Crawl Space Area
    - Assumptions: Crawlspace area in square feet is assumed to equal the area in square feet of the structure as defined by its outline. This is only relevant when structures are known to have a crawlspace foundation type.
- Enclosed Area
    - Assumptions: Enclosed area in square feet is assumed to equal the area in square feet of the structure as defined by its outline. This is only relevant when structures are known to have an elevated foundation type with an enclosure.