Repetitive Flooding in Riverine Towns: Understanding Responses, Barriers, and Challenges for the Future

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Abstract

Climate change is predicted to increase the intensity of precipitation events and increase inland flooding in the United States in the coming decades (Allan et al., 2020; Easterling et al., 2017; Kerlin, 2019; Mallakpour & Villarini, 2015). Unlike coastal communities, which have seen increased attention in the face of climate change, riverine communities have received far less attention (Jongman et al., 2012). This is despite a long history of repetitive riverine flooding and associated responses and barriers to flood mitigation. Important insights can be drawn from towns that have endured repetitive flooding and how they have responded. This thesis explores riverine towns with repetitive flooding, the similarities and differences in their flood responses and barriers to mitigation, similarities that can be deduced for other riverine towns, and how policies may be improved to better support them. To answer these questions, results were compared from semi-structured interviews and historical research from four case study towns in the United States: Harrisburg, Pennsylvania; Freeport, Illinois; Ellicott City, Maryland; and Athens Borough, Pennsylvania. Firstly, results showed several barriers to flood mitigation, including a lack of institutional capacity, challenges with regionalism, and insufficient federal flood mitigation assistance. Secondly, results showed that mitigating flood risk from multiple flood profiles, managed retreat, and structural flood mitigation solutions are proving successful for some riverine towns as flooding events increase in severity. Lastly, results showed that current federal programs must better fully support smaller riverine towns needing funding for flood mitigation, and modifications to existing programs and new programs are necessary to support their unique circumstances. From a resource allocation perspective, this thesis highlights the need to devote more resources to riverine towns with repetitive flooding to help them mitigate the worst effects of flooding in the face of increasingly worse storm events due to climate change.

Thesis Supervisor: Amy Glasmeier, Professor of Economic Geography and Regional Planning

Reader: Brent Ryan, Associate Professor of Urban Design and Public Policy

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1. Introduction

Flooding events are the costliest natural disasters in the United States (Razavi et al., 2020). Climate change's effects are predicted to alter their frequency and increase their severity (Allan et al., 2020; Knutson et al., 2010; Mallakpour & Villarini, 2015). While flooding caused by rising sea levels, storm surges, and tropical storms has garnered increased attention recently due to its widespread devastation for coastal communities, riverine flooding has received far less attention (Jongman et al., 2012). This is despite numerous United States riverine towns with a history of repetitive flooding events stretching back over fifty years or more. In contrast to coastal flooding, exacerbated by rising sea levels, riverine flooding has always happened and has no start date. Learning from towns that have endured repetitive flooding and understanding their response to flooding and the barriers they face in implementing flood mitigation initiatives is critical as inland flooding events are expected to increase (Allan et al., 2020; Easterling et al., 2017; Kerlin, 2019; Mallakpour & Villarini, 2015).

The scale of the potential problem is considerable – the 30 longest rivers in the U.S. are 28,770 miles (Benke & Cushing, 2005), whereas the length of the U.S. coastline, according to the Congressional Research Service (CRS), is 12,479 miles[1]. This comparison highlights the linear scale of potential flooding posed by rivers, although some rivers are more notorious for regular flooding than others. This also does not include the increased flooding potential within the greater watershed surrounding major rivers that pose a significant risk to communities. Our flood risk knowledge has also changed dramatically over the last 100 years since the Flood Control Act of 1917[2] provided the foundation for flood control measures to mitigate flooding from major rivers.

[1] There are two seminal measurements of the U.S. coastline, one by the Congressional Research Office (CRS) and the other by the National Ocean and Atmospheric Administration (NOAA). CRS measured the coastline, whereas NOAA measured the shoreline, which is less defined, and included the Great Lakes. According to NOAA, the U.S. shoreline is 95,509 miles (Beaver, 2016). For comparison, CRS considers the coastline of New Hampshire to be 13 miles, but NOAA considers the shoreline to be 131 miles.

[2] The Flood Control Act of 1917 was passed in response to damaging floods in the early 20th Century. The Act initially applied to the Mississippi, Ohio, and Sacramento Rivers. Subsequent Flood Control Acts in 1928 and 1936 included additional rivers and more authority to implement flood control measures. (U.S. FEMA, n.d.-a)

Even with this disparity in scale and expanded knowledge, there is still a dearth of research examining the flood responses and barriers to flood mitigation for medium- to small-sized riverine towns with repetitive flooding. Many of these towns developed before floodplain regulations or stormwater management requirements. These towns are also faced with complicating factors, such as at-risk historic structures, equally pressing social concerns over available housing or economic decline, and often faced with difficult flood mitigation solutions that either lack public support or are prohibitively expensive. The causes of flooding and barriers to preventing future flooding are complex, but the phenomenon of flooding is simple. Furthermore, riverine flooding and its challenges are a public problem because it affects all people and is not something that affects only one segment of the population. Therefore, it is a public problem and cuts across all geographies and socio-economic groups.

To address this gap in research, this thesis conducted a multi-city analysis of the reaction to river flooding to understand how towns with a history of repetitive flooding have responded and what barriers they have faced. This is in recognition that future flooding events will continue to occur and identifying what flood responses have been successful or what the barriers to success have been will help these and similar towns. This work aims to understand the successes, challenges, and opportunities associated with flood mitigation in response to worsening climate events exacerbating the potential for damaging floods. This research also explores municipalities capacity to act and what improvements can be made to policies to increase the capacity to act to mitigate flooding.

Furthermore, this research focuses on medium- to small-sized towns, which must be more represented in research (Allan et al., 2020). Smaller communities require our assistance and our attention to the problems they face. From an outside perspective, what may seem like an easily solvable problem may be the tip of an intractable problem. Smaller communities face difficulties with big problems, and resources may be hard to access and challenging to apply to the systems necessary for a resolution. Centering this knowledge creation around medium- to small-sized towns is critical to helping communities that have less institutional capacity than larger cities but

still have many of the same problems. This misfit between the scale of municipalities and the scale of their problems is a challenging issue in the United States and one that will become worse with the effects of climate change (Manuele & Haggerty, 2022). Furthermore, flood-prone communities are also often resource-constrained and face steeper challenges in pursuing competitive grants than bigger cities with more resources (Manuele & Haggerty, 2022).

Only recently have expanded federal programs offered to fund communities that have long dealt with flooding through pre-disaster funding (Manuele & Haggerty, 2022). Although, when funding is provided, it often comes on the heels of another damaging flood rising to national headlines and pressuring officials to respond and support is often different from the scale communities require. Even when additional funding opportunities become available, funding for increased institutional capacity to pursue new opportunities is rarely made available, meaning communities must rely upon their existing capacity to pursue expanded opportunities.

In the United States, several examples exist of communities that have experienced repetitive flooding disasters. These communities have recovered, adjusted, and rebuilt and therefore have a lived experience and a history of responses that are critical to understanding as flooding events increase in severity. This thesis studied four towns with a history of flooding: Harrisburg, Pennsylvania, Freeport, Illinois, Ellicott City, Maryland, and Athens Borough, Pennsylvania. These towns vary in population and socio-economic composition but are tied together through their shared experiences with repetitive flooding.

This thesis addresses the following research questions:

(1) What are the similarities and differences in flood responses and barriers to flood mitigation for riverine towns with repetitive flooding?
(2) What can we deduce from these similarities and differences that can inform similarities or expected phenomena for similar riverine towns?
(3) Do improvements need to be made to federal policies and programs, or new programs be created to support these and similar towns better?

In answering these research questions, two comparative lenses will identify similarities and differences between the four towns regarding flood responses and barriers to flood mitigation. Similarities that we might expect to find in other similar riverine towns will be deduced from cross-cutting insights from the case study towns. Deducing similarities or expected phenomena will benefit other communities experiencing the same challenges because it draws attention to a more significant issue that requires solutions that are not currently available. Furthermore, it begins to address a gap in research on smaller riverine communities (Bell & Jayne, 2009). Addressing this gap is essential as more and more smaller communities contend with the adverse impacts of climate change.

2. A Changing Climate and the Impacts on Riverine Communities and the Barriers They Face

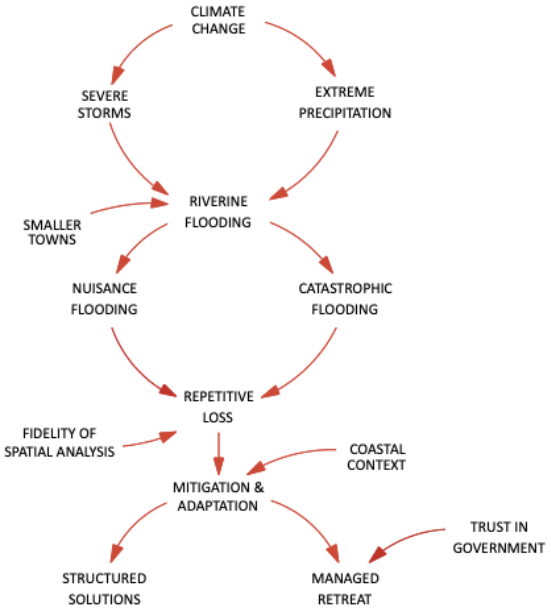

Figure 1 – High-Level Conceptual Literature Review Map
Source: Author

The literature review is divided into multiple categories to position why the work of this thesis needs to be done and where it is building upon existing literature. The literature review is divided into four categories: climate change and increased risks, increased flood risk and riverine flooding, flood mitigation and adaptation, and barriers to flooding mitigation and adaptation. Figure 1 illustrates a high-level conceptual map for the literature review.

Climate Change and Increased Risks

The damaging effects of climate change will touch every community in the United States during this century. The disruptions to daily life and long-term adverse effects will differ across the United States. Regardless, all communities can expect to be affected in one or more ways. Many communities are already feeling adverse effects, with nearly 90 percent of the counties in the United States experiencing a recent disaster declaration (Chester & Lawton, 2022; Flavelle, 2022), and the effects will gradually worsen for more communities.

One of the most evident environmental changes seen as a result of climate change is the increase in the intensity of hurricanes, tropical cyclones, and extreme precipitation events (Knutson et al., 2010). Storms are becoming shorter in duration but more intense in the amount of rainfall a community must contend with (Allan et al., 2020; Easterling et al., 2017; Mallakpour & Villarini, 2015). The increased deluge of rain is partly driven by warmer temperatures and the increased moisture-carrying capacity of the air, which is already leading to more severe storms and increased risks of flooding (Allan et al., 2020; Easterling et al., 2017). Extreme precipitation, worsened by this atmospheric phenomenon, has led to unexpected extreme flooding in Kentucky (Sacchetti, 2022), deluge across the Midwest of the United States (Holpuch, 2022), devastating flash floods in Maryland (Halverson, 2021; Rice, 2016), and countless other extreme flooding events.

Increased Flood Risk and Riverine Flooding

Globally, the frequency of flooding, both fluvial[3] and pluvial[4], has steadily increased over the past 50 years (Razavi et al., 2020). However, this increase may be due to improvements in data collection as more countries have participated (Tanoue et al., 2016). Regardless of past global data, evidence suggests that there will be a 26.4 percent increase in U.S. flood risk by 2050 (Wing et al., 2022). This increase will likely result from fewer, more intense flooding events due to projections of decreased flood frequency by the end of the century in much of North America (Hirabayashi et al., 2013; Prein et al., 2017). Flooding sources are also predicted to change, with a decrease in snow-related flooding events, despite increased flooding from extreme precipitation (S. Zhang et al., 2022).

Furthermore, regionally within the United States, extreme precipitation events have seen a higher rate of occurrence in the Northeast, as shown in Figure 2. This is most likely due to the combination

[3] "[Fluvial] Riverine Flooding is when streams and rivers exceed the capacity of their natural or constructed channels to accommodate water flow and water overflows the banks, spilling out into adjacent low-lying, dry land." (U.S. FEMA, n.d.-b)

[4] "A pluvial flood occurs when an extreme rainfall event creates a flood independent of an overflowing water body. A common misconception about flood is that you must be located near a body of water to be at risk. Yet pluvial flooding can happen in any location, urban or rural, even in areas with no nearby bodies of water." (Zurich Insurance, 2022)

of Nor'Easters, Tropical Hurricanes, and thunderstorm rain events. The Northeast has also experienced more individual precipitation events in the 99th percentile than the rest of the country (Easterling et al., 2017). This is reinforced in Figure 3, which shows projected increases in inland flooding in several states in the Northeast (Climate Central, 2016). Additionally, Figure 4 shows the magnitude of river floods either increasing or showing insignificant changes in the Northeast, indicating that damaging floods are likely to continue and have shown no decreasing trend.

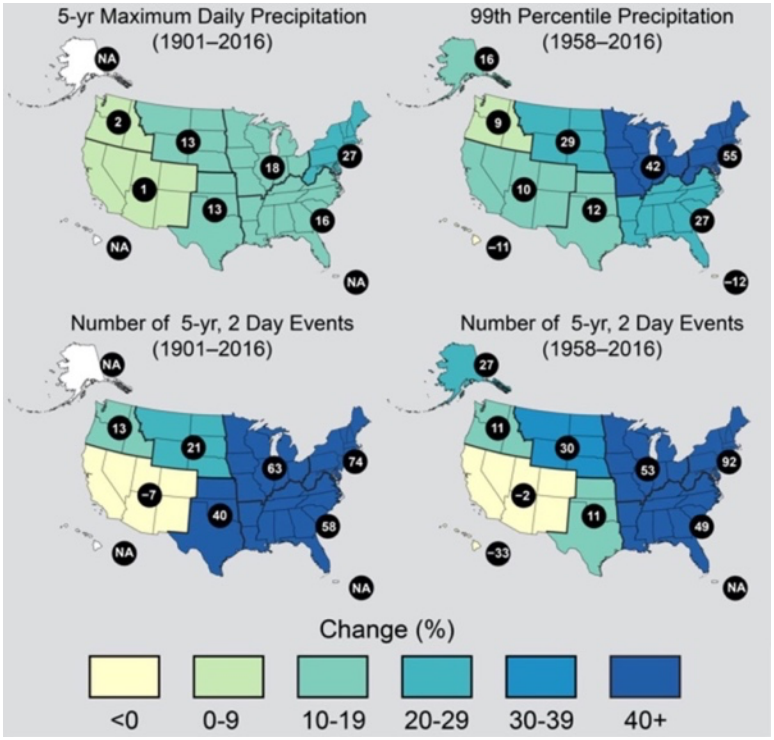

Figure 2 – Observed Change in Heavy Precipitation
Source: (Easterling et al., 2017)

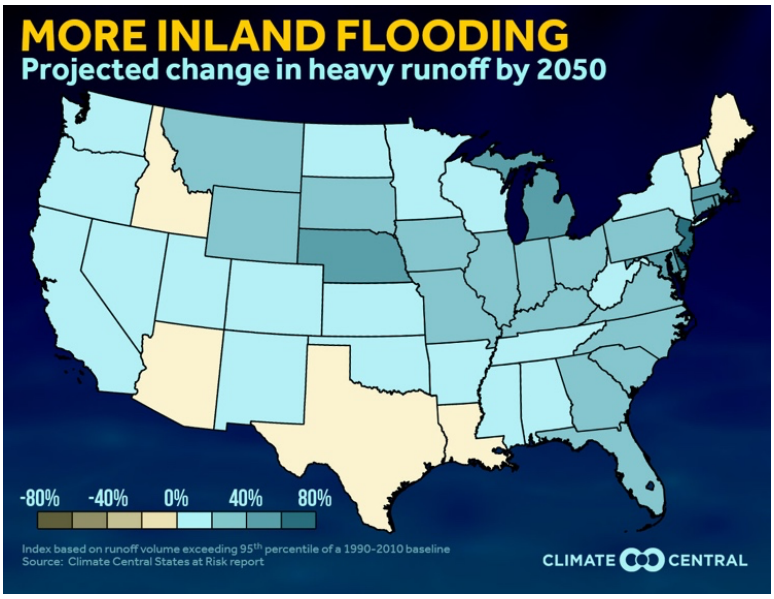

Figure 3 – Increased Inland Flooding Per State By 2050
Source: (Climate Central, 2016)

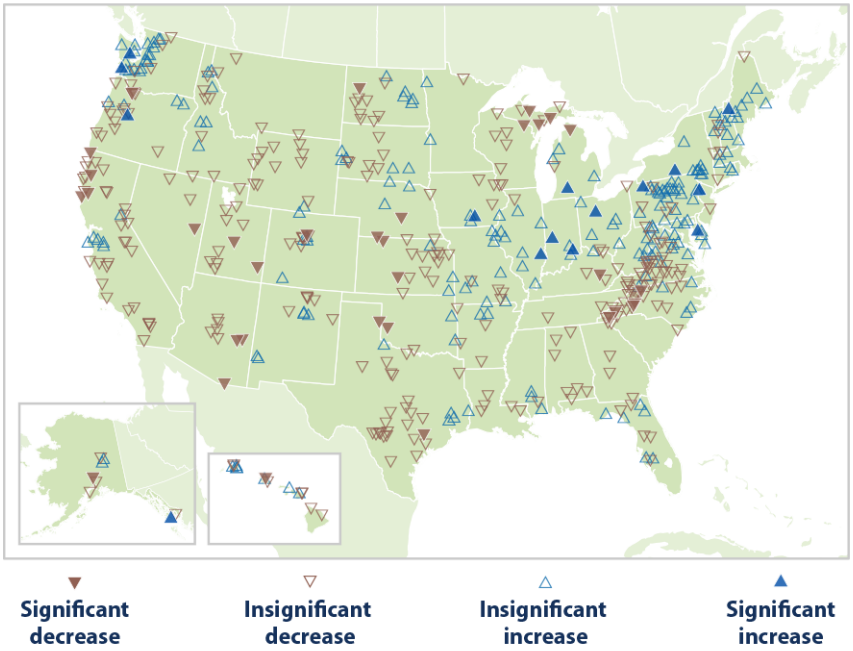

Figure 4 – Change in the Magnitude of River Flooding in the United States, 1965-2015
Source: Slater, L., and G. Villarini. 2016 update and expansion to data originally published in: Mallakpour, I., G. Villarini. 2015. The changing nature of flooding across the central United States. Nature Climate Change 5:250-254.

Flood-Prone Areas & Inland Flooding

Flooding in flood-prone areas and inland flooding[5] is expected to increase due to climate change. At current climate projections, about one-third of U.S. residents will be affected by more frequent inland flooding by 2050 (Kerlin, 2019). Although not exclusively a result of climate change, increased development in flood-prone areas will contribute to the increase in damage: "Global flood damages may increase 20-fold by the end of the twenty-first century due to climate change and continued development in flood-prone areas" (Pinter & Rees, 2021). Development in flood-prone areas is especially problematic in older riverine towns in the U.S. that developed without floodplain regulations, which would have prevented much of the current development. This means that the homes in the flood-prone area are older and pre-1950 homes experience more significant damage from 5ft or less of flooding than homes built after 1980 (Wing et al., 2020). Complicating matters, even more, is the prevalence of riverine towns with historical significance that must wrestle with expensive flood mitigation efforts or the loss of local history. This challenging duality of development in flood-prone areas and increased flooding events is evidenced by 43 percent of global adaptation measures in response to extreme precipitation and inland flooding (Berrang-Ford et al., 2021).

Floodplain Maps

Further exacerbating flooding issues is the need for more accuracy of floodplain maps, critical to understanding vulnerability for riverine communities. In 2019, flooding in the U.S. highlighted severe objections to the accuracy of floodplain maps (Razavi et al., 2020). The challenges associated with the Federal Emergency Management Agency (FEMA) flood maps have been widely studied (Blessing et al., 2017). Many of their issues include river management structures, such as dams or reservoirs, remain unaccounted for in flood maps (Kouhi et al., 2020), along with river debris, which occurs during flooding events and can significantly exacerbate floods (Kouhi et al., 2020). Additionally, FEMA maps do not account for flash flooding in highly impervious areas

[5] "Inland flooding, also known as "urban flooding" or "flash flooding", can be caused by intense, short-term rain or by moderate rainfall over several days that can overwhelm existing drainage infrastructure." (NYC Planning, 2018)

(Oakford et al., 2022) or even for the effects of climate change because they are not required to (Wing et al., 2022).

Furthermore, FEMA floodplains are based upon a stable and predictable climate, which has led to increased vulnerability within and near the floodplains due to more damaging and harder-to-predict flooding events (Sarewitz et al., 2003). Additionally, "land use and land cover (LULC)" changes are one of the most significant drivers of inaccuracies in the FEMA flood maps because these local changes can occur without updates to the maps for many years and result in favorable conditions for flooding (Blessing et al., 2017). Flood maps are also primarily based on historical analysis and fail to capture the increase in frequency and severity of storms (Wing et al., 2022).

The risks associated with flood maps are significant because of the potential for increased damages within documented zones and in adjacent areas where flood maps do not indicate a higher level of risk. Individuals living outside the FEMA flood maps may live in areas with "unmapped pluvial [rain-induced] or fluvial [river-induced] floods" (Wing et al., 2022). These areas may begin to experience flooding due to extreme events but lack preparedness due to infrequently updated flood maps. Furthermore, there is no buffer zone outside of the floodplain-designated area, and history has shown that risk does not suddenly disappear once outside of the FEMA-designated floodplain areas (Blessing et al., 2017; Highfield et al., 2013). 25 percent of flood losses occur outside of floodplain maps each year (Blessing et al., 2017). However, there is no incentive to mitigate against flooding outside of the FEMA floodplains because 100-year maps drive the location of flood mitigation efforts (Blessing et al., 2017). Despite these challenges, work is beginning to map flood losses outside FEMA floodplains to develop improved flood maps (Poon, 2018).

Riverine Towns

Geographically, few towns are more familiar with repetitive flooding than riverine towns that have contended with flooding for much of their existence. The repetitive flooding and risk of inundation that riverine towns face is deeply engrained in their history. Riverine towns and other flood-prone

towns are seeing changes in precipitation due to climate change, affecting FEMA's flood risk estimations and changing the frequency of 100- or 500-year equivalent flood events[6] (Kouhi et al., 2020). The variability and the potential increase in inundation events disproportionately burden those who live within flood risk areas, "repetitive loss properties comprise approximately one percent of [National Flood Insurance Program] NFIP[7] properties, but they make up 25-30 percent of claim losses" (Kick et al., 2011) and "climate-induced risk changes in the [Special Flood Hazard Area] SFHA[8] are expected to be more intense than elsewhere" (Wing et al., 2022). Furthermore, repetitive nuisance flooding events have the potential to be more costly longer-term than singular extreme flooding events (Moftakhari, AghaKouchak, et al., 2017), and many riverine communities experience nuisance flooding annually. Both repetitive losses and nuisance flooding result in significant damage for riverine towns and frequent discussions of how much mitigation they can or should implement.

Unfortunately, little research has been conducted to identify how riverine towns have responded to flooding, nor has research compared their responses to other riverine towns with historical flooding to deduce successes and failures that might prove helpful to similar towns. Much of the literature on riverine flooding has been on a large scale, such as global scale river analysis (Tanoue et al., 2016), multi-county or multi-state analysis (Xiao et al., 2013), large-scale historical analysis (Wetter et al., 2011), or urban flooding from rivers (Chang et al., 2021). Studies have yet to seek to understand how towns with a history of repetitive flooding have responded and what could be learned from the history of their responses as flooding is expected to worsen. These towns have a wealth of knowledge on barriers and obstacles to flood mitigation. Furthermore, studies have yet to research historical responses to flooding events to understand a pattern of responses. When past studies have, it has been limited to singular flooding events or extensive multi-county or

[6] 100-year flood has a 1% chance of occurring in any given year and a 500-year flood has a 0.1% chance of occurring in any given year. These are probabilistic risk measures and, therefore, can lead to confusion and an assumption that a 100-year flood only happens once every 100 years. This confusion is common and leads to a false sense of safety or security after a 100-year flood event. A 100-year flood could occur every single year due to the 1% annual chance of occurring. (USACE, n.d.)

[7] National Flood Insurance Program, administered by FEMA and initiated in 1968 (U.S. FEMA, 2022a)

[8] Special Flood Hazard Area (SFHA) "is the area where the National Flood Insurance Program's (NFIP's) floodplain management regulations must be enforced and the area where the mandatory purchase of flood insurance applies" (U.S. FEMA, 2020b)

multi-state assessments (Xiao et al., 2013), which flattens the historical experience at the local level.

Smaller Communities

The lack of research on flooding responses for smaller riverine towns is not surprising, given the emphasis on larger cities and large-scale coastal flooding analysis (Jongman et al., 2012). Large cities have primarily been the focus of climate change studies (Georgeson et al., 2016), even though methodologies for studies to reflect the future flood risks from climate change are still developing (Wing et al., 2022). Although it is logical to study large cities from the perspective of grasping the most significant aggregation of individuals and developing generalizations about urban forms and interactions (Bell & Jayne, 2009), small communities still need to be researched. Studies of large cities seek to create generalizable understandings, yet more research on small towns is needed to paint a complete picture of lived experiences in the U.S. (Bell & Jayne, 2009). Smaller towns' roles and accompanying regions have been ignored for their theoretical or practical value (Bell & Jayne, 2009). In many cases, towns that may seem small in the context of the whole country may be significant for their region and therefore worthy of research; "cities are only as small as we think they are – or as other cities make them" (Bell & Jayne, 2009).

To address the gap in research regarding smaller riverine communities, it has been suggested that local case studies may overcome the many issues associated with large-scale flood modeling (Wing et al., 2022). Additionally, "focused empirical attention is needed to assess past successful and unsuccessful implementations. For example, as a starting point, we call for a meta-analysis of the conditions and outcomes of case studies conducted by FEMA and those analyzed by a range of scholars in addressing the possible failures and success of a rational, or cost-benefit, community-based approach" (Kick et al., 2011). In essence, literature on flood response in smaller communities is needed. Individual case studies will help identify what has been successful and how we might learn from those lessons for other smaller riverine towns.

Even within smaller riverine towns, vulnerability to flooding is only sometimes universally understood and can sometimes be taken for granted. This is because probabilistic flood risk designations do not account for uncertainties and associated complexities (Razavi et al., 2020) that might make flooding worse, which residents may be unaware of. Additionally, even in towns where the memory of flooding events is still fresh, it may not prepare residents for future events because future flood risk is based upon historical flood risk and is, therefore, slow to respond to the threats posed by climate change (Wing et al., 2022). On the other hand, those who live in flood-prone areas are more resilient than they may appear and have learned to live with flooding, for better or for worse: "learning to live with uncertainty requires building a memory of past events, abandoning the notion of stability, expecting the unexpected, and increasing the capability to learn from crisis" (Berkes, 2007).

Flood Mitigation and Adaptation

Mitigation and adaptation in response to flooding are hardly new and have been researched to determine how much climate adaptation takes place (Berrang-Ford et al., 2011). In the U.S., 50 documented community relocations have responded to flooding over the last 100 years (Pinter, 2021). 41.7 percent of worldwide managed retreat projects deemed successful responded to riverine flooding (Ajibade et al., 2022). This indicates that flood mitigation and adaptation are occurring and are also in response to riverine floods. However, more research is needed on implementing flood mitigation at the local level (Brody et al., 2010). This is especially important because climate adaptation actions often happen at the local municipal level (McNeeley & Lazrus, 2014).

Even with research lacking on local adaptation, we know that flood mitigation will determine the extent of flood damage we expect in the second half of the century (Wing et al., 2022). Furthermore, future climate change risks will compel people to move from the coasts and floodplains (Pinter, 2021). Again, this reinforces the need to have flood mitigation for riverine communities and understand what has or has not been successful. Some smaller riverine communities have already undertaken flood mitigation initiatives, but current flood modeling

"lacks crucial local flood adaptation information" (Wing et al., 2022). Additionally, no federal agency tracks inland flooding on a smaller scale in the United States. Therefore, little is tracked about the cumulative damages to portions of vulnerable towns (Poon, 2018).

Coastal Context

In addition to riverine towns – and potentially gaining more national attention – coastal towns are also on the front line of climate change as they see shorelines receding and worsening storms year after year. Coastal communities are becoming increasingly concerned with the effects of climate change and rising sea-levels (Bukvic & Harrald, 2019), whereas riverine communities have been acutely aware for decades. This asymmetry in research can be seen in case studies on small coastal communities (Fitton et al., 2021) or research on how planning for adaptation occurs only in the context of U.S. coastal cities (Fu et al., 2017). Additional research focusing on policy responses (Moser, 2005) and climate migration (Hauer, 2017) have focused almost exclusively on coastal communities. Some of this can be attributed to the extent of damage from singular coastal storms garnering national attention and dominating discussions and research. This is evidenced by case studies researching flooding from 2000 to 2013, overwhelmingly focusing on Hurricane Katrina and its effects (Rufat et al., 2015). Furthermore, nuisance flooding is also rising in coastal communities (Moftakhari, AghaKouchak, et al., 2017) but is often endemic in riverine communities. Only recently have lessons from flooding begun to translate between riverine and coastal communities through studies on the effect of sea-level rise and fluvial flooding, which were often studied separately (Moftakhari, Salvadori, et al., 2017; Wahl et al., 2015).

Flood Mitigation Solutions

Solutions for mitigating flood damage can be achieved by implementing structural or non-structural solutions (U.S. Army Corps of Engineers – Baltimore District, 2001). Historically, structural solutions have been the most used. These solutions included dams, levees, or flood walls, often designed, and constructed by the U.S. Army Corps of Engineers (USACE)[9]. However, levees

[9] The U.S. Army Corps of Engineers (USACE) is a division of the United States Army that leads significant civil works projects domestically. USACE is the principal federal agency that manages and constructs flood protection solutions.

only partially remove the flood damage threat, even if designed for a 100-year flood (Pinter, 2005). Furthermore, as extreme weather events have increased and structural solutions' costs have soared, structural solutions' long-term viability has been questioned. In the Baltimore USACE district, no structural solutions have yet to be implemented since 1982 (C. Thomas, personal communication, November 23, 2022). Additionally, the 1993 Mississippi flooding positively changed public opinion about non-structural solutions and a desire to preserve the environment (U.S. Army Corps of Engineers – Baltimore District, 2001).

Managed Retreat

In response to a reduction in structural flood mitigation solutions and the acknowledgment that some communities may need to relocate, instances of managed retreat are becoming more prevalent. The scope and scale of relocation can vary from a few homes that are Severe Repetitive Loss (SRL) properties[10] or, in the case of Valmeyer, IL[11], an entire town can relocate if struck by a single significant event. In the case of towns with repetitive flooding, the long history of floods often results in non-structural mitigation strategies (Brody et al., 2010). Although, the percentage of a town within a floodplain, which is often high for riverine towns, does not indicate that there will be a higher incidence of non-structural mitigation present (Brody et al., 2010).

Moreover, managed retreat is complicated by the financial aspects of acquiring private properties, residents' concerns about taking on new debt, and the prospect of limited available housing for relocation (Kick et al., 2011). There is also the financial viability of managed retreat for municipalities relying on property taxes for funding and the erosion of the tax base resulting from the managed retreat. Municipalities that do not rely upon property taxes for most of their funding have seen higher rates of buyouts where properties are flood-prone (Miao & Davlasheridze, 2022). Whereas in municipalities where funding from property taxes is critical, there is less desire to participate in federal buyback programs for fear of a shrinking tax base (Miao & Davlasheridze,

[10] Severe Repetitive Loss (SRL) properties are single-family or multi-family residential buildings that have suffered repetitive NFIP claims either in excess of the market value of the building or four or more claims exceeding $20,000 (U.S. FEMA, 2020a)

[11] Valmeyer, Illinois relocated its town after the 1993 Mississippi flooding (Kerlin, 2019)

2022). Furthermore, implementing managed retreats must also be carefully considered because property-by-property managed retreats can fragment floodplain communities over the long-term (Pinter & Rees, 2021).

Dilling et al., 2015, note several so-called “no/low regret elements: early warning systems; risk communication between decision makers and local citizens; sustainable land management including land use planning; ecosystems management and restoration; improvements to heath surveillance, water supply, sanitation, irrigation, and drainage systems; climate proofing of infrastructure; developing and enforcing of building codes; better education and awareness” (Dilling et al., 2015). These lower-cost solutions with lower barriers to implementation are often the primary toolkit that riverine communities have at their disposal to mitigate floods. However, these strategies often don’t provide enough protection from major floods and primarily serve to mitigate nuisance or moderate flooding.

Barriers to Flood Mitigation and Adaptation

The barriers to flood mitigation and adaptation are broad, complex, and often entangled with each town's underlying structural circumstances. What may seem like an obvious solution runs against many challenges, from lack of financing to poor public support (Bierbaum et al., 2013; Brody et al., 2010). In small riverine towns, barriers may be like those facing larger towns, but the need for more resources places the large solutions, which are often necessary, out of reach. This is exacerbated by federal programs and policies needing to be more adequately funded to fully address the future needs of people living in flood-prone areas (Wing et al., 2022). Furthermore, those who live in smaller communities or have faced flooding before may be considered self-sufficient or more resilient from an outside perspective. Therefore, small towns need to be given the support they require but are often denied (Bukvic & Harrald, 2019).

Quinlin, 2014, notes several technical, regulatory, and political barriers to flood mitigation: “design, engineering and maintenance flaws; failure to heed clear warning signals; flaws in risk assessment; flaws in management systems and changes to work organization; flaws in system auditing;

economic/production and rewards pressures compromising safety; failures to regulatory oversight; expressed concerns prior to the incident; poor communication/trust between those in control and those at risk; flaws in emergency/rescue procedures and resources" (Quinlan, 2014). Additional flood mitigation barriers include: low-income families will lack enough mobility to relocate and are effectively captive to their geographies (Aerts, 2017), and securing funding for the managed retreat can be difficult due to the long timeframe for buyouts, which typically goes beyond local election cycles (Lawrence et al., 2020).

There can also be delays in developing solutions due to the need for more familiarity with flooding at the government decision-maker level (Bukvic & Harrald, 2019). Additionally, 'Top Down' climate projects can slow the adaptation process due to the uncertainty of climate projects and the desire for more accuracy (Dilling et al., 2015). Many solutions for mitigating the economic risk of climate change are centered around "proofing" physical elements against the damaging phenomenon (Adger, 1996). This hardening-in-place approach increases the prospect of a resident's home surviving the next flood but does nothing to mitigate the physical and emotional toll of flooding on residents. Furthermore, poor code enforcement or requirements can exacerbate issues in areas with repetitive flooding (Poon, 2018).

In smaller towns, the barriers are often a combination of many different barriers and not one single barrier, such as funding, that needs to be overcome. However, a town may consider funding to be its most significant barrier. Still, there may also be public support issues, impacts on tax revenue, historic preservation concerns, and the need for more capacity to study solutions. Furthermore, funding barriers may be challenging for the problems that may seem less obvious, such as drainage and sewer systems that are equally important in flood mitigation strategies but often considered less pressing (Poon, 2018).

3. Finding and Understanding Riverine Towns with Stories to Tell: Research Methods

The research methods employed in this thesis utilized qualitative methods. Qualitative methods were selected because of their ability to identify and analyze nuances of the places of study and a lack of comprehensive quantitative data on flooding due to resource constraints in the towns studied. The methods consist of Part I: Historical & Archival Research, Part II: Semi-Structured Interviews, and Part III: Flood Mitigation Policies Review. These three parts are structured around a comparative case study application to identify similarities and differences in the flood responses and barriers to mitigation for each town to develop similarities or expected phenomena for other similar towns and identify potential policy improvements.

Town Selection

River gauge data from the National Weather Service (NWS) was used to identify a shortlist of towns with a history of repetitive flooding. The NWS provides historical, current, and predicted river gauge data for nearly all major and minor U.S. waterways. River forecasts for minor, moderate, and major[12] floodings were selected to narrow the search within the NWS river gauge data. This narrowed search identified numerous towns with documented historic flood gauge data. However, this search method showed towns with short-term flood predictions. Therefore, it did not capture towns that may not be experiencing flooding in the short-term but may have documented historic flood gauge data.

Therefore, the NWS's long-range flood risk river gauges were also explored to identify towns with documented historical flood gauge data. Utilizing the long-range data and previously narrowed search, a list of potential case study towns was derived from the NWS data. The exclusion of some towns is possible for several reasons: a town has fully mitigated its flood risk or has changed over time due to droughts or upstream mitigation solutions. Other towns may have been excluded if

[12] Minor, moderate, and major are flood level classifications from the National Weather Service.

their river gauges are too recent to display enough historic flood gauge data. Larger cities and sparsely populated agricultural areas were excluded from the shortlist of towns because they do not align with the research focus on medium- to small-sized towns.

In addition to the NWS river gauge data search, to ensure that towns that may have inaccurate or short histories of NWS river gauge data, a manual search for other towns was conducted through national newspaper searches for towns with historic flooding. This search validated many of the towns already identified from the NWS data but also uncovered some towns with a history of flooding but lacked the NWS gauge data. The other towns identified during this process were validated through conversations with USACE staff to ensure they had long flooding histories. In the case of Ellicott City, USACE staff were intrigued as to why NWS river gauge data was absent for Ellicott City, given the storied history of flooding (C. Thomas, personal communication, November 23, 2022). However, they did caveat that Ellicott City has multiple flooding profiles, which may be why no historic river gauge data is available from the NWS.

The combined manually collected and NWS-collected towns yielded 35 towns. These towns were plotted with population, median household income, and the number of moderate or major flooding events (see Figure 5) to aid in the final selection of case study towns. The three metrics for plotting were selected to ensure variety in the population and median household income for the selected case study towns. However, the most important factor in narrowing the selection was ensuring that the towns had long histories of flooding and available information on their flooding responses. For many of the 35 towns, the lack of documented histories on flood responses led to their removal from the final selection.

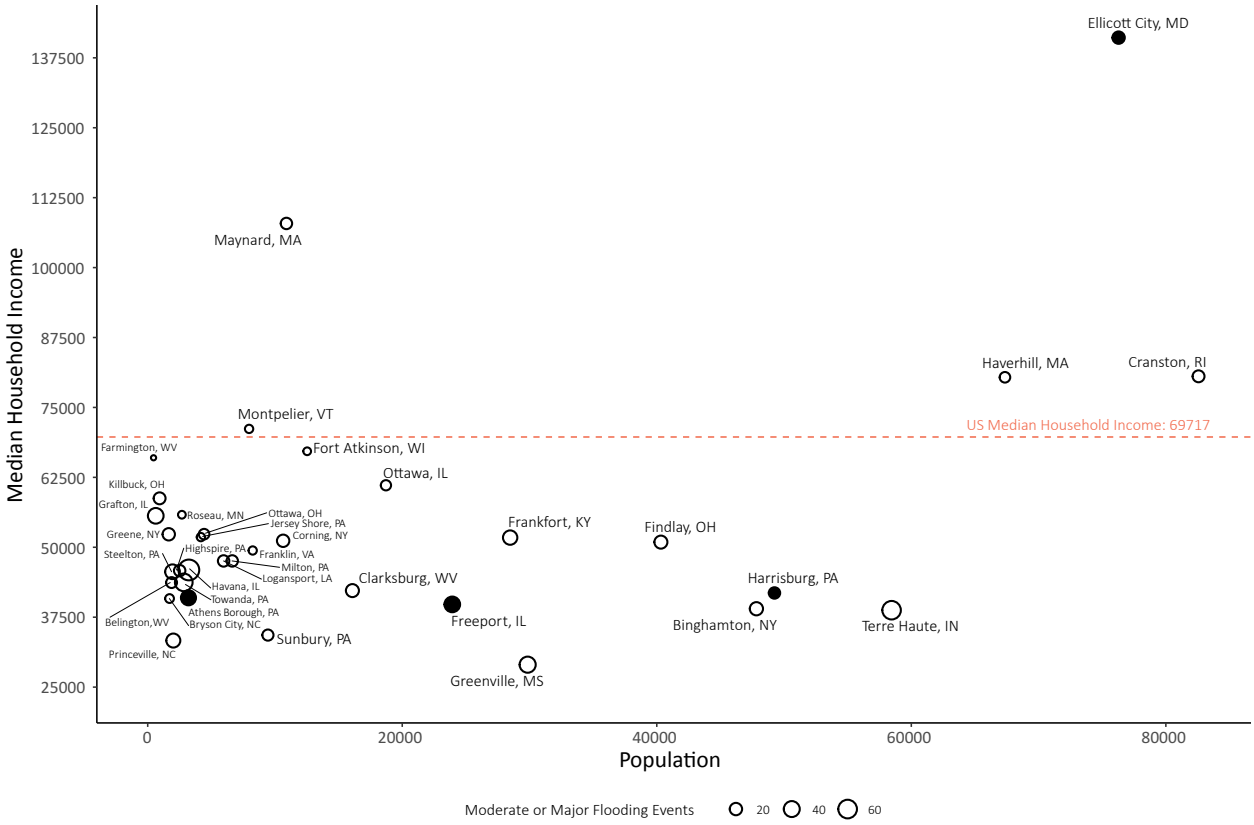

Figure 5 – Potential Towns for Case Studies
Source: Median Household Income, Population: U.S. Census ACS 5-Year Estimate, 2021
Town Flooding Events: National Oceanic and Atmospheric Administration, National Weather Service, River Observations

Within the 35 potential case study towns with a history of flooding, further refinement was required to not only select a small subset of towns for the comparative case studies but ensure that the towns selected had well-documented histories. Figure 6 illustrates the refinement process leading to the final case study town selection. First, searches of historical documentation of flooding responses in the towns narrowed the search. Although many towns had a known history of flooding events and river gauge data to support a long history of flooding events, the availability of documented histories in archives, newspapers, and other media was critical. Lastly, interview requests were sent to selected towns, and responses were received before the town selection was finalized. In a few cases, no response was received after contacting several town officials, as was the case with nearly all the smallest towns. This resulted in their exclusion from the final selection of case studies.

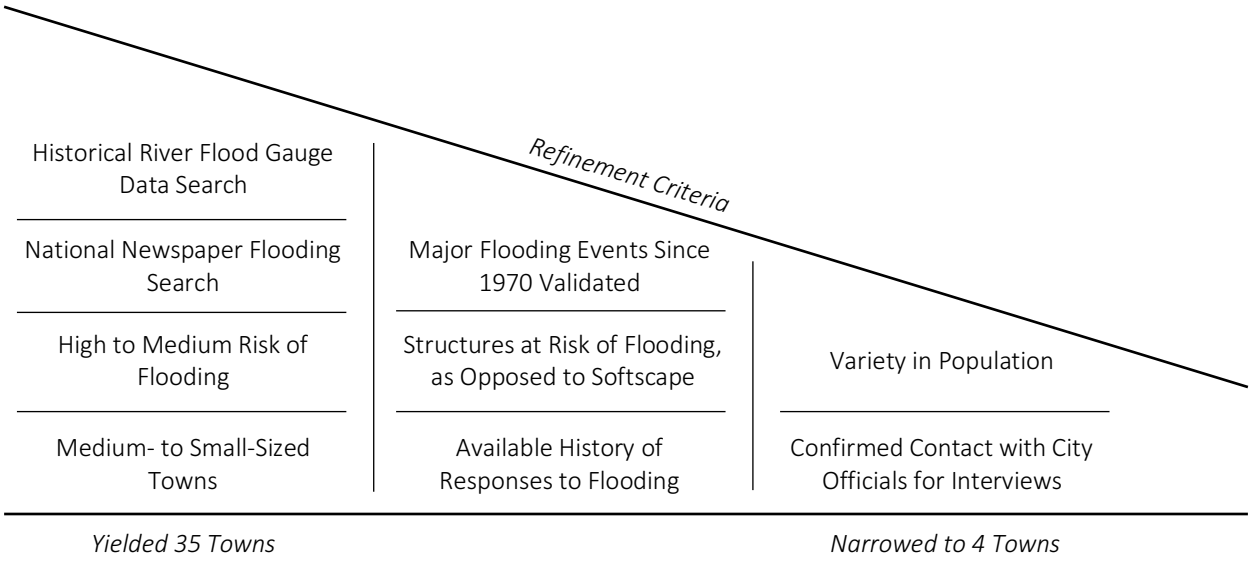

Figure 6 – Case Study Town Selection and Refinement Process
Source: Author

Furthermore, the existence of historic flood gauge data classified as moderate or major flood stage levels sometimes translated into a different perceived level of vulnerability on the ground. In one case, Maynard, MA, was listed as having moderate or major flooding since 1970. However, township officials later confirmed that the construction of a private dam diverting water from the Assabet River into Mill Pond and a recent drought has led to no significant flooding in many years, despite NWS data[13] (Town of Maynard Official, personal communication, December 13, 2022). As a result, the shortlist of 35 towns was vetted to confirm that major or moderate flooding had occurred since 1970.

Ultimately, four towns were selected to conduct the comparative case study analysis of flooding responses and barriers to mitigation: Harrisburg, Pennsylvania, Freeport, Illinois, Ellicott City, Maryland, and Athens Borough, Pennsylvania.

[13] This may also be due to the designation of the flood stage levels and a discrepancy between what the NWS considers to be a moderate flood stage and what the local municipality considers to be a moderate flood.

Comparative Case Study Structure

The structure of a comparative case study analysis is how each town and its flood responses and barriers to mitigation were analyzed. This means that flood responses and barriers to mitigation collected in Part I and Part II of the research methods formed an analysis matrix of similarities and differences. These similarities and differences informed the foundation of policy modifications developed during Part III: Flood Mitigation Policy Review. Figure 7 shows the structure of this thesis's research design and analysis.

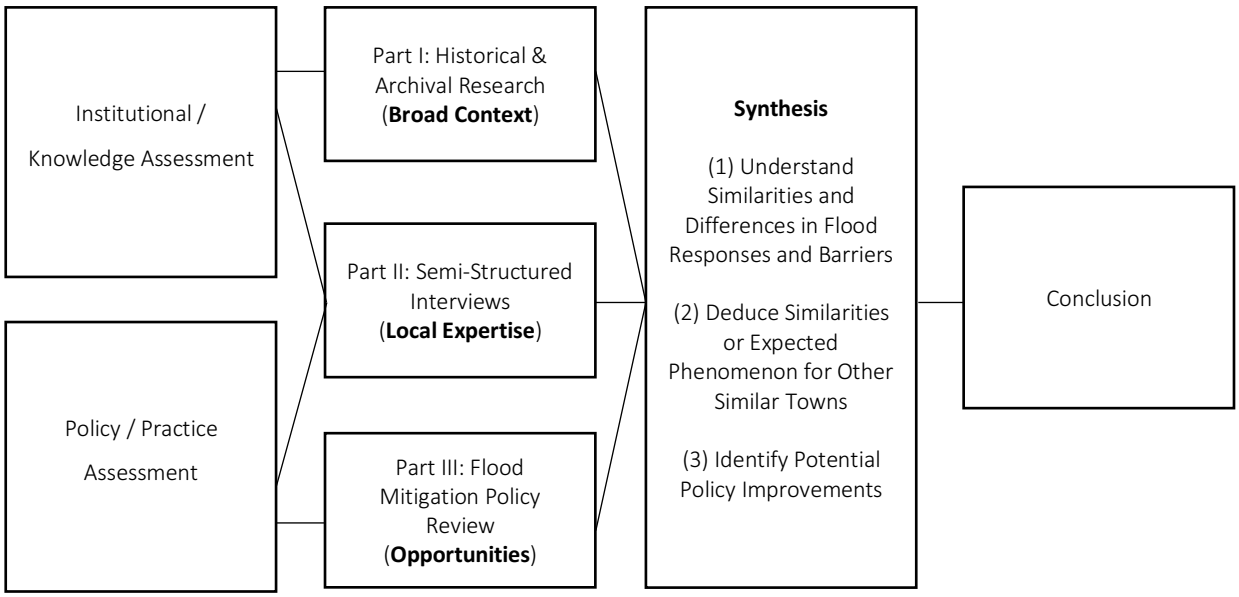

Figure 7 – Research Design and Analysis
Source: Author, Adapted from (Moser, 2005)

Abductive Analysis

Although each town selected has a well-documented history of flood responses, the entirety of their documented responses and actual and perceived successes was not known at the beginning of this research. Therefore, this thesis relies upon Abductive Analysis (Tavory & Timmermans, 2014), allowing new information to guide the research direction. Furthermore, each town has a long and entangled history of flooding, which means responses and barriers have changed over time. An abductive analysis is essential in developing a flood response analysis matrix, as new information is unearthed, and insights are discovered based on historical research and semi-structured interviews.

Part I: Historical & Archival Research

Historical and archival research was conducted to understand how each of the towns dealt with flooding events in the past and their successful and unsuccessful responses. Historical resources included newspapers, reports, studies, and visits to local historical societies to review available documents. Historical research provided an essential insight into how these towns have developed alongside repetitive flooding events and how the structure of the cities influenced their responses to flood mitigation. The historical research identified the extent of past flooding events, the responses to the flooding events, if any preventative measures were employed, what mitigation efforts were most successful, and how structural elements[14] of the town affected the flood response. The historical research also included an analysis of policies and initiatives to mitigate the effects of flooding to identify what state, county, or local policies were successful or unsuccessful and why some policies may have never been implemented.

The historical and archival research provided an understanding of each town's flooding response and risk from past decades until the present. This illustrated what risk or vulnerability riverine flooding poses for the future. This context and understanding provided the critical background for the semi-structured interviews to fill in gaps in historical research, such as historical flood knowledge from a specific climactic event that one town has well-documented and other towns do not. This helps to develop an understanding of the current level of perceived risk and the challenges and barriers each town faces in mitigating the worst effects of flooding.

Part II: Semi-Structured Interviews

Semi-structured interviews were conducted with city, county, and federal officials to understand what efforts have been taken to address past flooding or are planned to be taken to prepare for future flooding and what challenges they are experiencing. Interviewees for each town were selected based on their assumed knowledge of flooding issues in their jurisdiction. Additional

[14] Structural elements can include: socio-economic factors, crime, politics, housing issues, poverty, and other challenges that may be endemic and specific to a place.

interviewees were recommended after conducting the first interviews per town. All interviews were conducted remotely and with the exception of two interviews, all interviews were conducted one-on-one. The interviews aimed to understand current plans to address flooding, fill in gaps in historical responses to flooding events, and understand the structural elements that influenced responses. Additionally, interviewees were asked about policies and programs intended to support flood mitigation and how well they work for their town. Interviewees were also given a chance to respond to how well flood mitigation policies are working and how they could be improved, or new programs could support their flood mitigation needs.

Interview notes were qualitatively coded using inductive and deductive coding to identify response patterns and trends. Deductive coding was derived from the literature review, and inductive coding was derived from answers provided by interviewees. Deductive coding allowed for existing flood response frameworks, whereas inductive coding allowed for incorporating locally specific flood responses into the qualitative coding methodology. The final coded responses were compared across the four towns to identify the most frequently cited similarities and differences in flood response and mitigation.

Part III: Flood Mitigation Policies Review

In addition to determining similarities and differences, the semi-structured interviews and historical research identified policies that could be improved or new policies that could be implemented to support smaller riverine towns with repetitive flooding issues. Interviewees were asked about specific policies and were allowed to provide answers for policies or programs they thought could be improved. Flood mitigation policies and programs selected for discussion during semi-structured interviews were the most used flood mitigation programs at the federal level. In addition to existing federal policies, interviewees were able to highlight local and state policies that they think can be improved or entirely new policies that should be created. Responses from interviewees were compared across the four towns within each policy or program.

To outline improvements to policies identified during semi-structured interviews, additional research determined how these policies can be modified to serve smaller riverine communities better. This gap or opportunity analysis proposed solutions that more closely align with the unique challenges the towns in this study face. In doing so, the policy analysis proposed potential solutions that focus on the dilemmas facing smaller riverine towns with constrained resources.

4. Riverine Flooding and Stories from the Places it Impacts: Case Studies

The case study towns for this thesis are Harrisburg, Pennsylvania, Freeport, Illinois, Ellicott City, Maryland, and Athens Borough, Pennsylvania (see Figure 8). The case studies are structured into four parts: flood risks and hazards, historic flooding events, adaptation and mitigation responses, and barriers and opportunities. This structure allows each town's narrative to unfold objectively and identify locally specific factors that have influenced their responses to flooding and their challenges. In doing so, the structural elements of each town will directly inform why specific flood mitigation initiatives were implemented and others were not. In structuring each case study similarly, comparison for similarities and differences is more easily facilitated. Table 1 gives an overview and comparison of the case study towns' socio-economic, hydrological, and governmental characteristics.

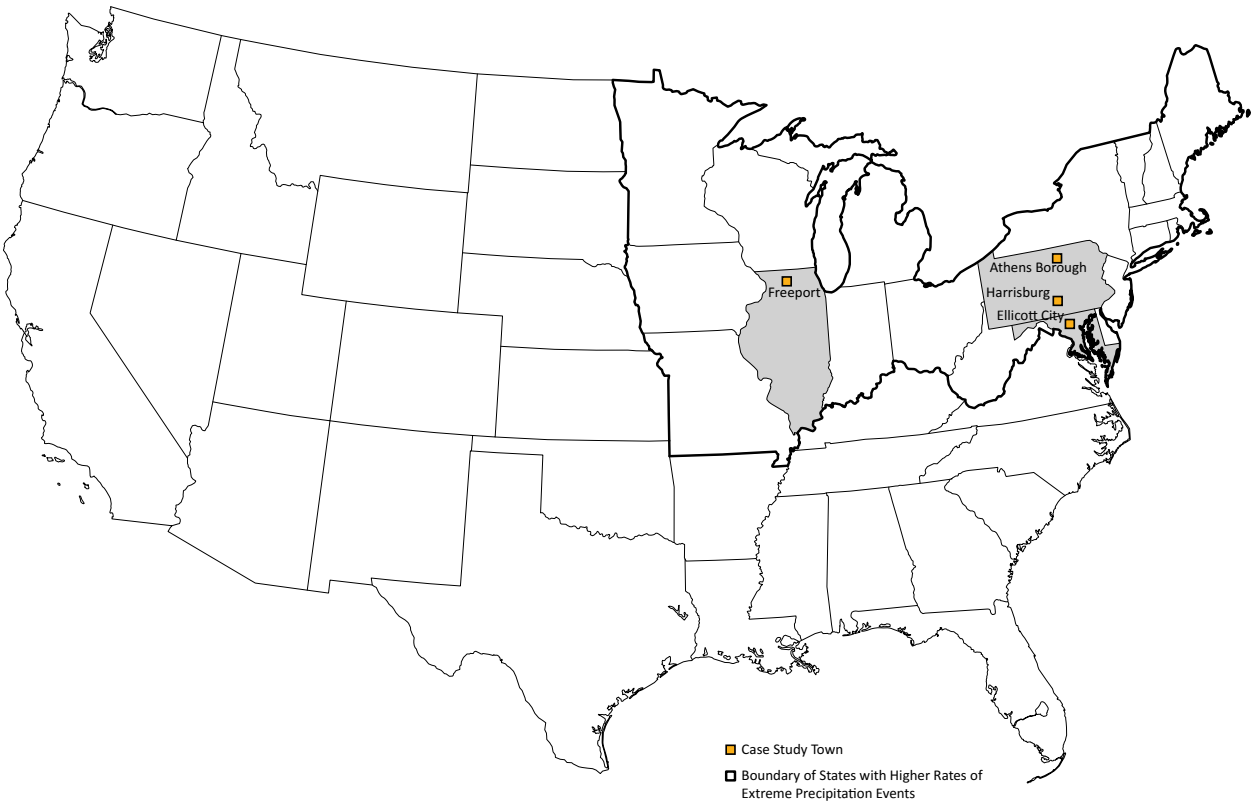

Figure 8 – Locator Map of Case Study Towns
Source: Author, (Easterling et al., 2017)

Table 1 – Socio-Economic, Hydrological, and Governmental Characteristics of the Case Study Towns
Source: [1]U.S. Census ACS 5-Year Estimate, 2021, [2]Steven Manson, Jonathan Schroeder, David Van Riper, Tracy Kugler, and Steven Ruggles. IPUMS National Historical Geographic Information System: Version 17.0 [dataset]. Minneapolis, MN: IPUMS. 2022. http://doi.org/10.18128/D050.V17.0, [3]National Oceanic and Atmospheric Administration, National Weather Service, River Observations, [4]Semi-Structured Interviews,[5]Federal Emergency Management Agency (FEMA), OpenFEMA Dataset: FIMA NFIP Redacted Claims – v1. Retrieved from https://www.fema.gov/openfema-data-page/fima-nfip-redacted-claims-v1 on January 09, 2023, [6]Preservation Maryland

	Harrisburg, PA	**Freeport, IL**	**Ellicott City, MD**	**Athens Borough, PA**
County	Dauphin	Stephenson	Howard	Bradford
Micro or Metro Area[1]	Harrisburg-Carlisle Metro Area	Freeport, IL Micro Area	Baltimore-Columbia-Towson Metro Area	Sayre, PA Micro Area
Population[1]	49,969	24,087	76,286	3,268
Population Density[1]	6,065.8/Sq Mile	2,014.1/Sq Mile	2,542.3/Sq Mile	1,826.1/Sq Mile
% White (2021[1]/1970[2])	24%/68.7%	70%/91.8%	47%/95.9%	95%/99.5%
% Black (2021[1]/1970[2])	44%/30.7%	16%/8%	8%/3.6%	<1%/<1%
% Hispanic (2021[1])	25%	6%	7%	0%
Population Change Since 1970[2]	-26.6%	-13.2%	+834%	-21.7%
Median Household Income[1]	$44,444	$41,831	$141,110	$44,063
Poverty Rate[1]	28.2%	20.3%	4.8%	11.5%
Median Year Structure Built[1]	1944	1957	1990	1953
Established	1791	1837	1772	1831
Structure of Local Government[4]	Elected Mayor, Elected City Council	Elected Mayor, Elected Alderman	Elected County Executive, Elected County Council	Elected Mayor, Elected Borough Council
Floodplain Management Responsibility[4]	Harrisburg Planning Dept.	Stephenson County	Howard County	Bradford County
Moderate or Major Flooding Events[3]	16	36	16[6]	34
Flood of Record[3]	1972	1929	2018	2011
Recent Moderate or Major Flood[3]	2011	2019	2018	2020
Repetitive Flooding Source	Riverine, Severe Rainfall	Riverine, Severe Rainfall	Riverine, Severe Rainfall	Riverine, Severe Rainfall
Pursued/Secured Federal Grants[4]	Yes/No	Yes/Yes	No/No	Yes/No
Managed Retreat[4]	Yes	Yes	No	No
Structured Solutions[4]	Exploring	No	Yes	Yes
NFIP Claims Per County[5]	2,691	117	225	243
FEMA CRS Class[4]	6	None	5	None

Harrisburg, Pennsylvania

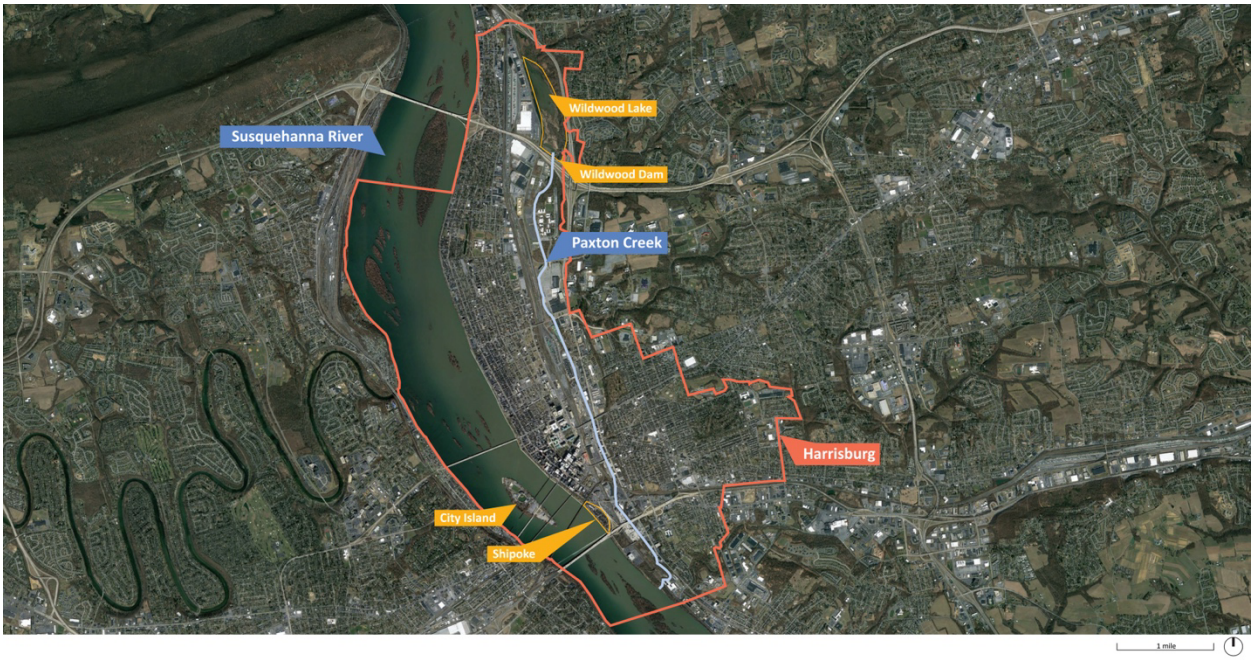

Figure 9 – Map of Harrisburg and the Surrounding Area
Source: Author, Google Earth for Base Image

Harrisburg, Pennsylvania is the capital of the Commonwealth of Pennsylvania[15] and is located along the banks of the Susquehanna River in Dauphin County (see Figure 9). Harrisburg and the surrounding area have a long history of flooding from the Susquehanna River and the Paxton Creek. Harrisburg has faced difficulties in mitigating the worst effects of flooding, and the threat of further flooding is ever-present. According to city officials, Harrisburg also has other structural issues like blight and lack of affordable housing, and flooding often needs to catch up to those priorities.

The local government comprises an elected mayor and an elected city council. Municipal bankruptcy in 2011[16] created a litany of issues that the city is still dealing with today – 900 staff pre-bankruptcy whittled down to 300 today, according to city officials. Before bankruptcy,

[15] "The climate pattern in Pennsylvania is such that major flooding may occur at almost any time of the year" (Shank, 1972).

[16] Harrisburg filed bankruptcy in 2011 with over $400 million in debt (Tavernise, 2011). The source of debt leading to bankruptcy was largely attributed to Harrisburg's incinerator plant, originally constructed in the 1970s to burn waste to generate steam for energy (Girl, 2011). A tumultuous history and poor financial decisions ballooned debt for the incinerator. Municipal finances were worsened by municipal investments in a Civil War Museum, when Gettysburg was a mere 40 minutes away, according to city officials.

Harrisburg could have focused on larger flood mitigation projects, but has been unable to as it works to meet its financial obligations. As a result, Harrisburg suffers from institutional capacity issues and a lack of capacity for grant writing. Furthermore, Harrisburg is an entitlement city, meaning they receive federal funding directly and not through administration by the state or county, according to county officials.

As the capital of Pennsylvania, Harrisburg has a high turnover rate and renters, complicating social memory (Razavi et al., 2020) of floods and often interferes with mitigation. City officials note a strange dichotomy between long- and short-term residents, which can be attributed to the commuter town status for Harrisburg and the influx of 40,000[17] people into the city every day for the capital. Complications arise from the city serving as the state capital, such as state ownership of a large share of roads and bridges and the need for voluntary collaboration with the city when repairing or rebuilding infrastructure. Further complications include a high aggregation of tax-exempt places due to the proximity to state leadership that erode tax revenue for the city: stated-owned buildings, non-profits, and places of worship.

Flood Risks and Hazards

Harrisburg is located near the middle of the Lower Susquehanna Subbasin of the larger Susquehanna River Basin[18], within the Hydrological Unit Code (HUC)[19] cataloging unit of 02050301. Locating near the bottom of the Susquehanna River Basin means that Harrisburg may flood from extreme precipitation or rapid snowmelt that occurs further North in the Basin, potentially as far North as Southern New York State. Fortunately, flooding from the Susquehanna River is low velocity and often predicted well in advance to give residents warning.

[17] 40,000 is a rough estimate provided by city officials. According to the U.S. Census Bureau, Center for Economic Studies, LEHD data, in 2019, 49,063 were employed in Harrisburg, but live outside of the city.

[18] The Susquehanna River Basin is a dendritic stream system with considerable tributaries and river branches.

[19] A hydrological unit (HUC) is a classification system for identifying the region, subregion, accounting unit, and cataloging unit for water resources. The eight-digit cataloging unit is the smallest unit and delineates a drainage basin and is often referred to as a watershed. (U.S. Geological Survey, 2022)

In addition to flooding from the Susquehanna, Harrisburg also floods from the Paxton Creek, which runs North-South through the town following the industrial corridor and railroad. This results in two flooding profiles for Harrisburg. Flooding from the Paxton Creek is high velocity and is triggered by localized rain events and may provide little warning for residents. Paxton Creek is also channelized[20], which restricts the ability of soil to absorb water as it moves downstream. However, significant retention capacity of Paxton Creek is held behind the Wildwood Dam at Wildwood Lake, in the Northern portion of Harrisburg.

Figure 10 shows the extent of Harrisburg at risk of flooding as defined by the FEMA flood insurance risk map. The properties at risk of flooding are a mixture of residential and commercial buildings, including the governor's mansion. Many properties at risk were built over a hundred years ago, and little was known about stormwater management. Additionally, since most properties at risk of flooding are residential, there needs to be more economic value at risk for Benefit-Cost Ration[21] to warrant structural flood mitigation solutions. Harrisburg also has a combined sewer overflow (CSO)[22] system that worsens flooding, and infrastructure related to water management dates back to 1800-1900s (D. Miller, 2021). A semi-consent decree between Harrisburg and the Environmental Protection Agency (EPA) to remove the CSO aims to alleviate some localized flooding issues, according to city officials.

Furthermore, the Shipoke neighborhood at the convergence of the Susquehanna River and Paxton Creek, and the lowest point in the town, floods more regularly, and residents are keenly aware of the risks they face. City Island, home to the local baseball team, also regularly floods when the Susquehanna River increases (Kiner, 2019a). This creates a spectrum of perceptions of flood risk in Harrisburg, "There is no common definition of what constitutes a flood. To a Shipoker[23] or West

[20] Channelized rivers or creeks are restricted by concrete walls, but open to the sky, to allow for development to occur closer to the river or creek.

[21] The Benefit-Cost Ratio (BCR) is the outcome of a Benefit-Cost Analysis (BCA), which "is a method that determines the future risk reduction benefits of a hazard mitigation project and compares those benefits to its costs." (U.S. FEMA, 2022b)

[22] "A combined sewer system collects rainwater runoff, domestic sewage, and industrial wastewater into one pipe. Under normal conditions, it transports all of the wastewater it collects to a sewage treatment plant for treatment, then discharges to a waterbody. The volume of wastewater can sometimes exceed the capacity of the combined sewer system or treatment plant (e.g., during heavy rainfall events or snowmelt). When this occurs, untreated stormwater and wastewater, discharges directly to nearby streams, rivers, and other waterbodies." (U.S. EPA, 2022b)

[23] Shipoker is the demonym for a resident who lives in the small Shipoke neighborhood in Harrisburg, wedged between Highway 83, the Susquehanna River, and the Capital Beltway.

Fairviewer[24], a flood is when you need a rowboat to get bread and milk. To many suburbanites, a flood is when the manicured lawn is drenched." (Beers, 1996).

Harrisburg's emergency operations center can be activated if flooding is predicted to cause disruption and damage. An improved flood warning system for the Cameron Street Corridor in the Paxton Creek Watershed has helped to improve flood notifications locally (U.S. Army Corps of Engineers – Baltimore District, 2001). Harrisburg also has a river rescue team that can be deployed if flooding worsens and has helped neighboring communities as needed. Collaboration between Harrisburg and Dauphin County is standard during disruptive flooding.

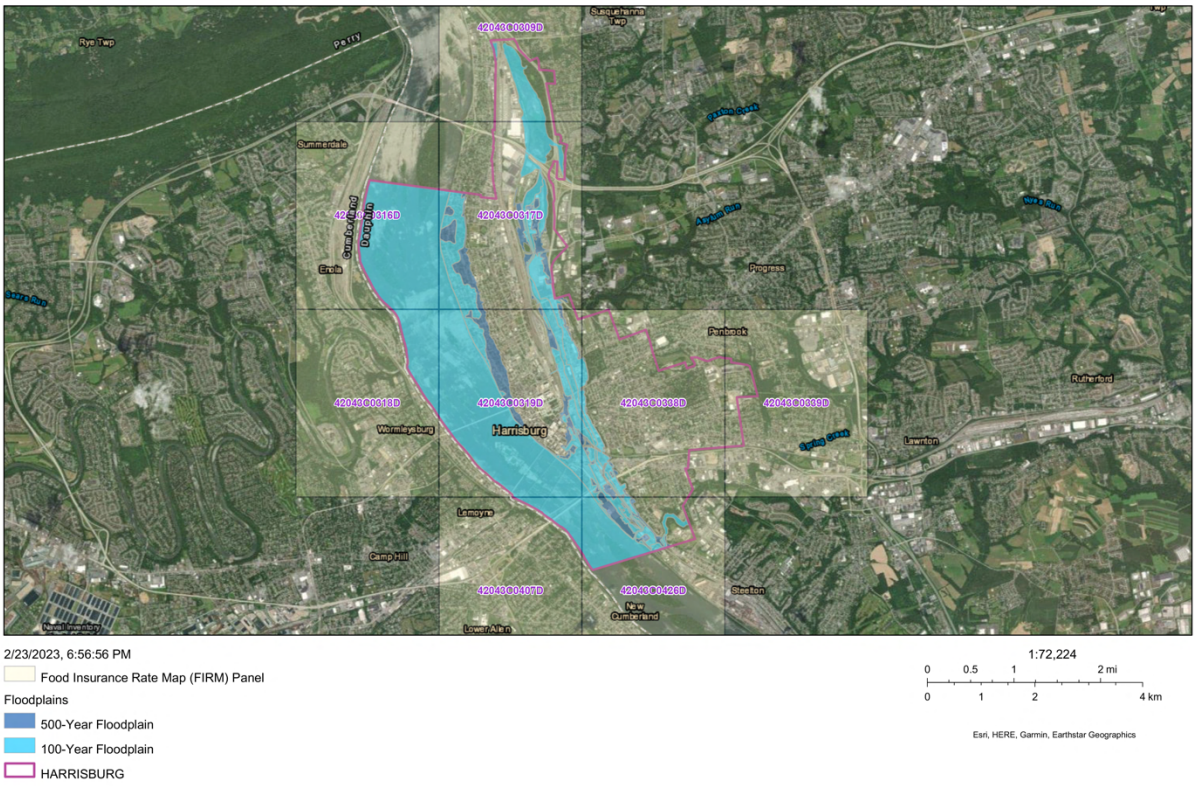

Figure 10 – Harrisburg, PA Flood Inundation Map
Source: Earthstar Geographics | USACE, USACE-Philadelphia District (CENAP), USACE-Baltimore District (CENAB), PAMAP, Esri

[24] West Fairviewer is the demonym for a resident who live in West Fairview, a census designated place, wedged between the Susquehanna River and the Conodoguinet Creek on the opposite side of the Susquehanna River from Harrisburg.

Historical Flooding Events

Harrisburg has regularly flooded since Native Americans inhabited the area (Shank, 1972) and a long documented history supports early flooding claims. Table 2 shows the history of flooding and associated damage and responses Harrisburg has experienced, going back decades. The most damaging flood event in Harrisburg's history was Hurricane Agnes in 1972 – "on a typical day around 23 billion gallons of water flow past Harrisburg. On June 24, 650 billion gallons of water flowed by and around the city, turning Harrisburg into an island" (Tristan, 2022). At the peak of the flooding, nearly 15 percent of the town was underwater. Agnes caused significant damage across Pennsylvania, but the hardest hit towns were Harrisburg and Wilkes-Barre. After the flood waters receded and the rebuilding effort began, some Pennsylvanians called for relocating the capital away from Harrisburg (Binda, 2022, p. 50).

At the time of Hurricane Agnes, Harrisburg and the surrounding area still had considerable manufacturing operations. This helped bring federal support to Harrisburg to save or replace the steel plant on Front Street because of its economic importance to Harrisburg, which President Nixon supported (Demmy, 1972). Further support was provided by the Appalachian Regional Commission for floodplain mapping and analysis (Sharp, 1973). The Susquehanna River Basin Commission also called for non-structural solutions such as zoning to address flood mitigation post-Agnes (Associated Press, 1973).

Due to the significant damage from Hurricane Agnes, the USACE immediately removed an entire neighborhood along the Susquehanna, South of the Shipoke neighborhood. This top-down approach spurred public outcry and ultimately led to the development of a historic district in Harrisburg and the Harrisburg Historical Society itself (Binda, 2022, p. 50). However, the historical movement grew on the backdrop of a significant population decline in Harrisburg due to flooding in the 1970s, dropping from 90,000 in 1970 to 53,000 in 1980 (Solomon, 1991).

Post-Agnes, Harrisburg experienced several significant flooding events in 1975, 1996, 2004, and 2011. Tropical Storm Lee in 2011 caused widespread flooding, the most recent major flood to

strike Harrisburg. The flooding caused sinkholes in South Harrisburg, leading to a buyout of affected homes. Buyouts beyond homes affected by sinkholes were unsuccessful because of too many 'what ifs' that led homeowners to stay instead of relocating. According to county officials, residents of the Shipoke neighborhood, the most flood-prone neighborhood in Harrisburg, saw flood insurance increase from $500 to $5,000.

Table 2 – Harrisburg, PA Historic Flooding Events and Associated Damage and Response
Source: Crest and Date: National Oceanic and Atmospheric Administration, National Weather Service, River Observations

Crest (ft)	Date	Climactic Event	Notable Damage	Response	Notes
25.17	09/09/2011	Tropical Storm Lee	294 Homes and Business Destroyed in Dauphin County[25]; Sinkholes in South Harrisburg	Buyout Program for 48-49 Properties[26]	Flooding from Susquehanna River and Paxton Creek
20.09	03/12/2011	Extreme Precipitation	Moderate Inundation, Primarily for City Island, Shipoke, and Front Street	-	Flooding from Susquehanna River and Paxton Creek
24.40	09/19/2004	Hurricane Ivan	Significant Inundation	-	Flooding from the Susquehanna River and Paxton Creek
25.08	01/20/1996	Rapid Snowmelt	4,000 Homes Inundated[27]; Famed Walnut Street Bridge Loses Three Spans (Never Repaired)[26]	-	Flooding from the Susquehanna River and Paxton Creek
20.50	04/02/1993	Rapid Snowmelt	Moderate Inundation, Primarily for City Island, Shipoke, and Front Street	-	-
20.74	02/16/1984	Extreme Precipitation	Moderate Inundation, Primarily to City Island, Shipoke, and Front Street	-	-
20.43	03/07/1979	Extreme Precipitation	Moderate Inundation	-	-
23.81	09/27/1975	Hurricane Eloise	Significant Inundation, Primarily for City Island, Shipoke, and Front Street	-	Flooding from the Susquehanna River and Paxton Creek
33.27	06/24/1972	Hurricane Agnes	Severe Inundation Throughout Harrisburg; 20,000	Flood Forecasting System for Susquehanna River, 600-Homes Slated for Removal (Not All Removed); Flood	Flooding from the Susquehanna River and Paxton Creek

[25] (Kiner, 2019b)
[26] Semi-structured interviews
[27] (Feeley & Lewis, 1996)

			People Left Homeless[28]	Insurance Adoption; Study for Paxton Creek Flood Wall at Cameron Street[29]	
21.51	03/12/1964	Extreme Precipitation	-	Susquehanna River Basin Commission Created (created in 1970, but discussed and planned since the mid- to late 1960s)	-
21.80	05/29/1946	Extreme Precipitation	-	-	-
29.23	03/19/1936	Rapid Snowmelt	Severe Inundation	-	Flooding from the Susquehanna River and Paxton Creek, "St. Patrick's Day Floods of 1936"
20.52	03/13/1936	Rapid Snowmelt	-	-	-
25.70	05/22/1894	Extreme Precipitation	-	-	-
26.80	06/02/1889	Extreme Precipitation/ Rapid Snowmelt	Significant Inundation	-	-
24.66	03/18/1865	Extreme Precipitation/ Rapid Snowmelt	Significant Inundation	-	-
River Gauge Levels: Action Stage[30]: 11; Flood Stage[31]: 17; Moderate Flood Stage[32]: 20; Major Flood Stage[33]: 23					

2011 Flooding (Shipoke Neighborhood)
Source: Sean Simmers, The Patriot-News

1972 Flooding (Governor's Mansion)
Source: Harrisburg Historic Association

[28] ("'agnes' Strikes with Fury," 1972)

[29] (Binda, 2022; Nichols & Etten, 2022; Sarvey, 1973)

[30] According to the National Weather Service (NWS), action stage is defined as "the stage which, when reached by a rising stream, represents the level where the NWS or a partner/user needs to take some type of mitigation action in preparation for possible significant hydrologic activity." (National Weather Service, n.d.)

[31] According to the NWS, flood stage is defined as "an established gage height for a given location above which a rise in water surface level begins to create a hazard to lives, property, or commerce." (National Weather Service, n.d.)

[32] According to the NWS, moderate flood stage is defined as "some inundation of structures and roads near the stream. Some evacuations of people and/or transfer of property to higher elevations may be necessary." (National Weather Service, n.d.)

[33] According to the NWS, major flood stage is defined as "extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations are necessary." (National Weather Service, n.d.)

Adaptation and Mitigation Responses

Harrisburg's largest flood mitigation solution is one that is still under development, but recently received one of its necessary approvals. It is a de-channelization project for the Paxton Creek (see Figure 11) that is tied to a Transit Oriented Development (TOD) being led by Pennsylvania Department of Transportation (PennDOT). While the flood mitigation impacts are still being studied, with support from the USACE, the project is expected to reduce flood risk along the Paxton Creek from Wildwood Dam to downtown. Updating existing flood maps is an important first step for this project because the existing maps are from the 1970s, according to USACE officials, and do not reflect current conditions. The goal of the project is to allow for stormwater retention to occur along the Paxton Creek by removing the concrete side walls. In doing this, the water will decrease in velocity, and the soil can absorb more water. To complete this project, several properties that abut the channelized creek will need to be acquired. However, the opportunity for economic development and flood mitigation is seen as highly beneficial for Harrisburg. There have also been discussions with county officials to dredge Wildwood Dam to increase its capacity, further mitigating flood risk from Paxton Creek.

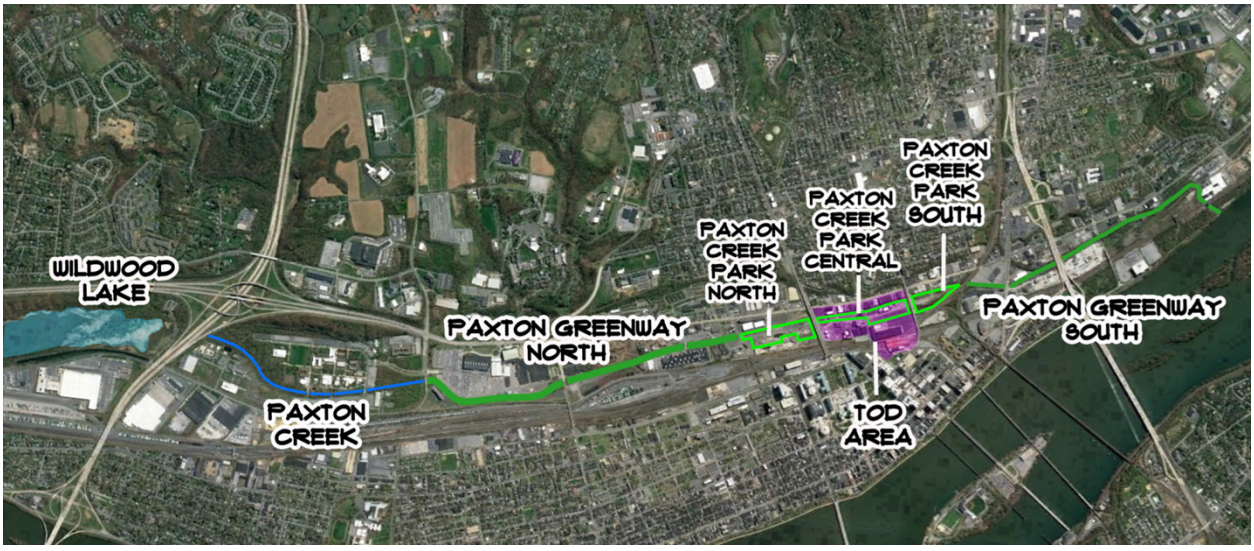

Figure 11 – Harrisburg, PA Paxton Creek Flood Mitigation Plan
Source: Paxton Creek Master Plan, Pennsylvania Department of Transportation

On a smaller scale than the de-channelization project, Harrisburg has been working with residents to install backflow valves to prevent basement flooding. City officials said they have yet to move onto million-dollar projects due to lack of funding and are following best practices and implementing small projects over the long term. This has included maintenance of existing infrastructure, removing debris from river inlets, and stabilizing the river's edge, which was capped during the City Beautiful project in the early 1900s. City officials have not pursued buyouts because of the negative financial impacts of lost tax revenue and lack of support from the public. More recently, Harrisburg received federal funding for the High-Water Mark Initiative, which funded the installation of signs through Harrisburg memorializing the 1972 flooding for community education (B. Miller, 2013).

In the aftermath of Hurricane Agnes, several studies were conducted by the USACE to explore structural solutions to flooding. A flood wall to protect Central and Northern Harrisburg was unable to move forward due to the high-cost relative to the benefits and public resistance (Sarvey, 1973). A $117 million flood wall along Paxton Street was never implemented due to the Benefit-Cost Ratio not reaching one or greater (Nichols & Etten, 2022). Alternate USACE solutions, such as upstream impoundment reservoirs, evacuation of the floodplain, or widening and deepening of the Susquehanna River channel, would have been even more expensive than structural solutions (Sarvey, 1973). Ultimately, none of the flood control measures proposed after Agnes were built, losing nearly all momentum by 1982 (Tristan, 2022).

Despite the failure to implement substantial flood mitigation solutions post-Agnes, policy changes were made to safeguard residents' property and provide municipalities with more tools for adaptation. This included expanded adoption of flood insurance (Nichols & Etten, 2022) and modified laws to make it easier to acquire properties for flood mitigation projects. Agnes also holds a certain prominence in Harrisburg and is the benchmark against other flooding is compared.

Barriers and Opportunities

Harrisburg has faced several barriers to flood mitigation that have prevented large-scale solutions from being implemented. Challenges have included the tension between individual property rights and difficulties with overlapping jurisdictional oversight of properties, according to city officials. Some residents consider their property rights more important than the needs of the community and flood mitigation projects that benefit more than just them. The state is also not always a good neighbor and can be a bureaucratic hinderance and has resisted paying stormwater management fees that are levied against all properties, regardless of tax-exempt status. The stormwater management fees have the potential to fund much needed flood mitigation initiatives and the state would be a large contributor because of its significant footprint in the city. According to city officials, it comes down to mismatched priorities – one example being a parking lot that encroaches on Paxton Creek and the lack of coordination with future dechannelization efforts and no coordination with city officials.

There is also a distinct difference in public opinion about how to address flooding from the Susquehanna River and for Paxton Creek. After Hurricane Agnes, the USACE developed plans for a concrete flood wall along Front Street, parallel to the Susquehanna River, but were met with fierce disapproval from the public, whereas plans to prevent flooding from Paxton Creek are welcomed (Sarvey, 1973). Furthermore, Shipoke residents fought back after 1972 to keep their homes and be allowed to rebuild, despite losing the first floor in most homes (Binda, 2022, p. 50). By allowing the Shipoke neighborhood to rebuild, Harrisburg missed an opportunity to prevent future flood damage in the most precarious part of the town. Harrisburg also allowed homes that the city acquired post-Agnes to be sold for $1,000 on the condition that the new homeowners renovated and lived in the homes (Binda, 2022, p. 50).

The greatest opportunities for Harrisburg to mitigate flooding are their current plans for Paxton Creek and the end of their bankruptcy terms, which will allow the city to begin investing in long-term flood mitigation solutions. With the financial ability to make investments in long range flood mitigation, Harrisburg can prepare for adverse conditions that are likely to worsen due to climate

change. Harrisburg also has the potential to explore joining regional cooperative agreements aimed at addressing regional flooding through shared financing. Currently, Harrisburg is not participating in such agreements and would benefit from working with municipalities in the greater Susquehanna River Basin.

Freeport, Illinois

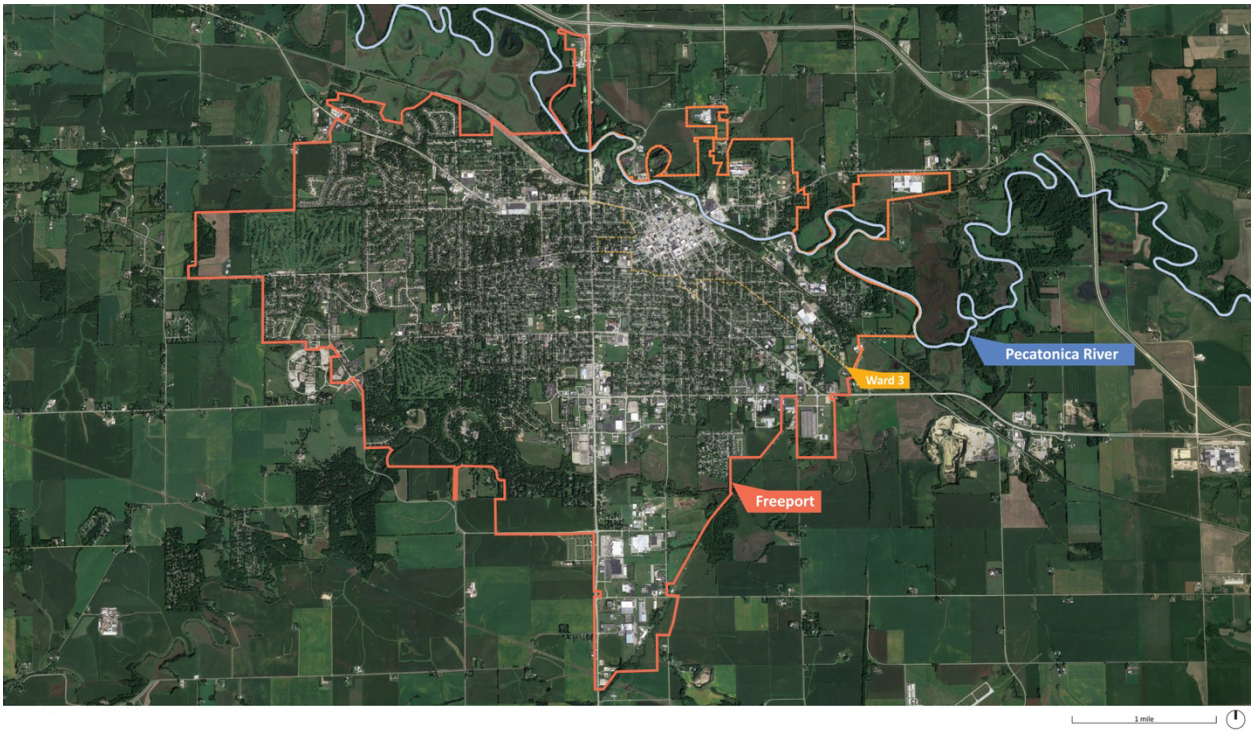

Figure 12 – Map of Freeport and the Surrounding Area
Source: Author, Google Earth for Base Image

Freeport, Illinois, is located 2-hours Northwest of Chicago along the Pecatonica River (see Figure 12). Freeport has a long and repetitive history of flooding caused by extreme rain events, leading to 130 floods in the last 100 years (Hinds, 2019). Positive historical trends in the magnitude and frequency of flooding have been documented in and around the Freeport area (Mallakpour & Villarini, 2015). However, flooding is only widespread across some of Freeport and is most often isolated to the portion of the Third Ward Northeast of the Pecatonica River. This area of Freeport is under-resourced and economically depressed, with some residents having lost their properties due to as little as $37 in unpaid property taxes, according to city officials. These residents are also predominantly African American and the victims of redlining (Hinds & Kopanski, n.d.). This has resulted in a "community within a community" and challenges with trusting local government (Hinds & Kopanski, n.d.).

The local government comprises an elected mayor and elected alderman representing Freeport's seven wards. Due to the small size of Freeport, challenges arise from a need for more institutional capacity to address flooding. Freeport provides many municipal services expected for a town of its size, including emergency personnel with specialized equipment for flooding rescues.

Flood Risks and Hazards

Freeport is located within the Rock Watershed, within the Hydrological Unit Code (HUC) cataloging unit of 07090003. The Pecatonica River, the source of much of the flooding in Freeport, is a tributary of the Rock River that runs through nearby Rockford, IL and causes flooding on the Northeast side of Freeport. The sinewy nature of the Pecatonica River makes it susceptible to flooding under adverse conditions. Less frequent flooding also occurs from Yellow Creek, South of Freeport. Flooding from the Pecatonica River is low velocity but can linger for days or weeks before receding (Mason, 2018). The long periods of inundation are because the storm drains on the Northeast side of Freeport flow into the Pecatonica River, so they flood when the Pecatonica floods and can only drain once the river returns to normal levels (City of Freeport, 2018). Freeport also needed more investment in city infrastructure from 1965-1985 (EPA Office of Water, 2016). Furthermore, Freeport is at a hydrological disadvantage due to its low elevation. According to city officials, river debris can rapidly cause flooding through the low, flat neighborhoods following the Pecatonica River.

Much of the flood-prone properties in Freeport would not have been constructed today due to restrictions on development in floodplains. Additionally, according to city officials, due to FEMA's substantial improvement rule[34], many homes are in ill repair because of repair limitations. For communities like Freeport, residents are often unable to make necessary improvements to their homes due to the low assessed value of their home (Torres et al., 2022). Figure 13 shows the extent of Freeport at risk of flooding as defined by the FEMA flood insurance risk map. Many

[34] "The purpose of the SI/SD [Substantial Improvement/Substantial Damage] requirements is to protect the property owner's investment and safety, and, over time, to reduce the total number of buildings that are exposed to flood damage, thus reducing the burden on taxpayers through the payment of disaster assistance. The SI/SD requirements are triggered when the local official determines that the cost of repairing or improving a building in an SFHA equals or exceeds 50 percent of the building's market value (excluding land value)." (U.S. FEMA, 2010)

properties at risk are residential, except for a few businesses, abandoned structures, and an abandoned elementary school.

An early warning flood system alerts residents when flooding is predicted to occur, and residents also know what to watch for when flooding is imminent (Wilson, 2008). When flooding is predicted, the fire and police departments will go door-to-door to assist residents. Emergency personnel is equipped with a specialized rescue vehicle with an engine snorkel, which many towns of Freeport's size would not possess. Freeport also collaborates with other communities in Stephenson County for flood response. Furthermore, the county develops emergency management plans annually with input from Freeport. The administration of the floodplain management plans is the responsibility of the Freeport Community and Economic Development Department (equivalent to the Planning Department).

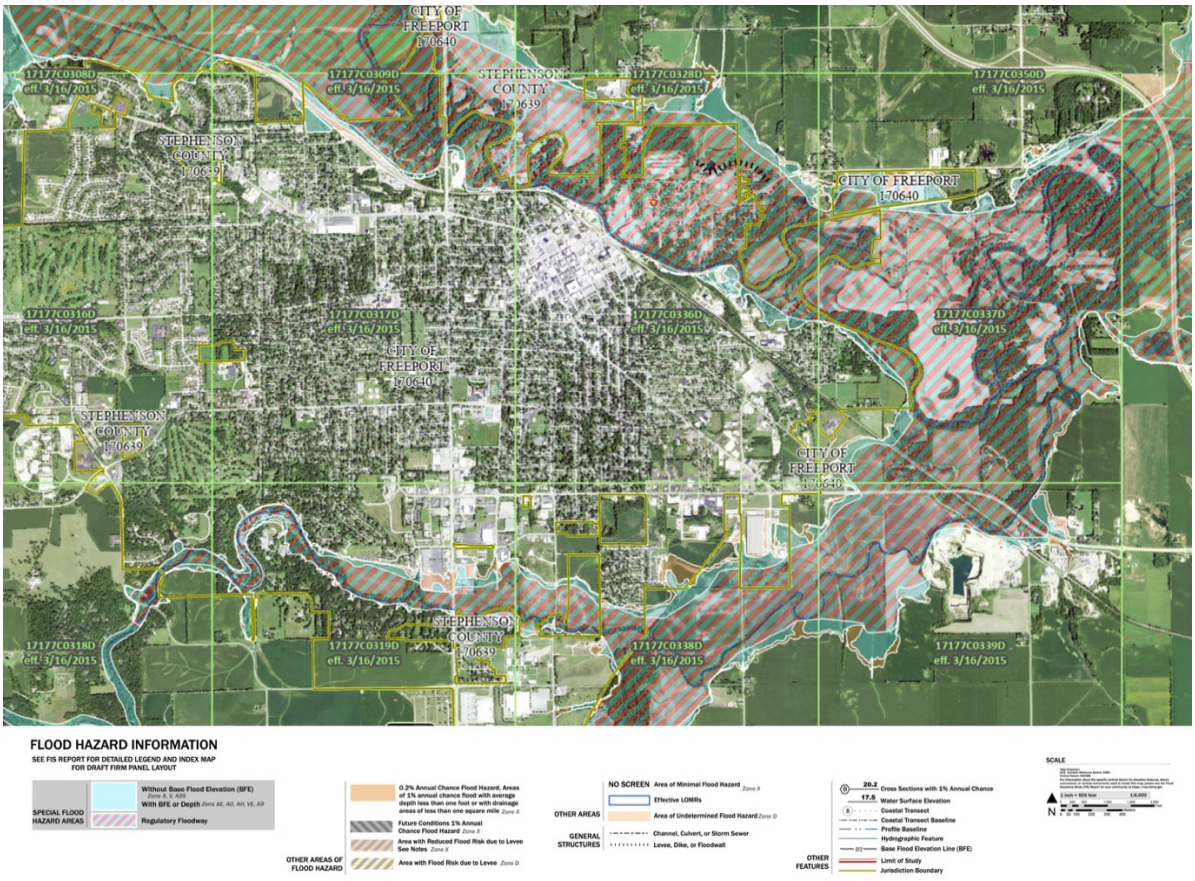

Figure 13 – Freeport, IL Flood Inundation Map
Source: FEMA

Historical Flooding Events

Table 3 shows the history of flooding and associated damage and responses Freeport has experienced over many decades. However, some flooding events are less documented or not documented at all beyond a river flood gauge measurement, but the absence of evidence for some floods does not mean something was absent in the context of disasters (Quinlan, 2020). The most major flood event in Freeport's history was in 1929, but little documentation exists regarding the extent of damage and associated response.

In more recent history, Freeport has contended with significant nuisance flooding every year and multiple major or moderate floods every year from 2017-2019. Flooding in 2019 was significant, "While the Pecatonica has always been an occasional nuisance, it has never before flooded so many homes so routinely. Damage to roads and infrastructure alone in this city of nearly 25,000 totaled more than $600,000 this year, part of the more than $1.5 million spent on flood-related clean up since 2017, City Manager Lowell Crow said" (Chase, 2019). The flooding from 2017-2019 reshaped the landscape of Northeast Freeport, with two churches relocating post-2018 flooding (Hinds & Kopanski, n.d.) and Taylor Park School closing (Heim et al., 2022) after enduring frequent closures due to flooding (Adams, 2018). Some residents on the Northeast side of Freeport have no furnaces or water heaters due to repeated flood damage (Chase, 2019). Levees were discussed as a solution along the Pecatonica River but deemed too expensive, at $160 million (City of Freeport, 2018).

Before the 2017-2019 flooding, major flooding in the 1990s caused significant damage in Northeast Freeport, spurring renewed conversations around a buyout program, and preventing further development. A USACE study in 1994 showed two options: buyouts or a 12ft levee at $5.5 million, with residents showing no support for buyouts (Hinds & Kopanski, n.d.). Structural solutions were further explored, "In 1996, the Army Corps of Engineers studied the area east of the Pecatonica. A proposed retention pond area was studied. There is no way to hold back the water. This area is at the bottom of a watershed. If levees were built, it would cause the river to

rise 2.5 feet" (City of Freeport, 2018). Ultimately, neither buyouts nor structural solutions were successful in Freeport. However, in Missouri and elsewhere in Illinois, after flooding in 1993, 7,700 properties were acquired as part of a buyout program to prevent future flooding (Pinter, 2005).

Table 3 – Freeport, IL Historic Flooding Events and Associated Damage and Response
Source: Crest and Date: National Oceanic and Atmospheric Administration, National Weather Service, River Observations

Crest (ft)	Date	Climactic Event	Notable Damage	Response	Notes
15.61	10/09/2019	Extreme Precipitation	Taylor and Krape Parks and East Side of Freeport Inundated	-	-
17.27	03/17/2019	Extreme Precipitation /Rapid Snowmelt	Severe Inundation; 170 People Evacuated[35]	FEMA Pre-Disaster Mitigation Grant Approved	-
16.14	02/25/2018	Rapid Snowmelt	Taylor Park and East Side of Freeport Inundated; 41 Water Rescues[36]	$85,000 Set Aside in the City Budget for Demolishing Vacant Homes; Began Enforcing Building Codes; Stopped the Sale of Tax Trustee Properties in the Floodplain[37]	100-Year Flood
15.39	07/26/2017	Extreme Precipitation	Flooding Event is Extension of Flood from Two Days Prior	-	-
15.84	07/24/2017	Extreme Precipitation	Taylor Park and East Side of Freeport Inundated	-	100-Year Flood
16.12	07/24/2010	Extreme Precipitation	East Side and South Side of Freeport Inundated	-	100-Year Flood, Flooding from the Pecatonica River and Yellow Creek
15.71	06/15/2008	Extreme Precipitation /Rapid Snowmelt	Taylor Park, Highway 75, and East Side of Freeport Inundated	-	-
15.27	06/05/2000	?	-	-	-
16.40	02/22/1997	Extreme Precipitation	East Side of Freeport Inundated	-	-
16.61	07/11/1993	Extreme Precipitation	East Side of Freeport Inundated	-	-
16.24	07/04/1990	Extreme Precipitation /Rapid Snowmelt	East Side of Freeport Inundated	-	-
15.64	02/27/1985	?	-	-	-
17.13	03/25/1975	?	-	-	-
16.33	02/20/1971	?	-	-	-

[35] (Associated Press, 2019)
[36] (Adams, 2018)
[37] (City of Freeport, 2018; Hinds & Kopanski, n.d.)

17.16	07/03/1969	Extreme Precipitation	East Side of Freeport Inundated	-	-
16.35	04/02/1960	Extreme Precipitation	East Side of Freeport Inundated	-	-
16.90	04/05/1959	Extreme Precipitation	East Side of Freeport Inundated; 31 People Evacuated[38]	-	-
16.41	03/01/1948	?	-	-	-
15.46	01/09/1946	?	-	-	-
16.33	02/09/1938	Extreme Precipitation	East Side of Freeport Inundated	-	-
16.98	03/08/1937	Extreme Precipitation	East Side of Freeport Inundated	-	-
17.41	04/03/1933	?	-	-	-
16.28	03/29/1932	?	-	-	-
16.28	02/24/1930	?	-	-	-
19.76	03/16/1929	?	-	-	-
16.77	03/16/1928	?	-	-	-
16.74	02/09/1927	Extreme Precipitation	East Side of Freeport Inundated	-	-
18.36	04/06/1923	?	-	-	-
18.82	02/25/1922	?	-	-	-
15.48	03/16/1920	?	-	-	-
17.60	03/16/1919	?	-	-	-
16.38	02/15/1918	?	-	-	-
16.09	03/16/1917	?	-	-	-
19.40	03/28/1916	?	-	-	-
17.27	02/27/1915	?	-	-	-
18.45	09/16/1914	?	-	-	-

River Gauge Levels: Action Stage: 11.5; Flood Stage: 13; Moderate Flood Stage: 14; Major Flood Stage: 16

2019 Flooding
Source: Stephenson County EMA

1960s Flooding
Source: City of Freeport

[38] ("Floods in Illinois Cause 1,800 to Flee," 1959)

Adaptation and Mitigation Responses

Freeport's most notable flood mitigation effort is their active buyout program for 127[39] properties in Ward 3, Northeast of the Pecatonica River (see Figure 14). The buyout is funded through a FEMA Pre-Disaster Mitigation (PDM) grant totaling $4 million, with roughly $1 million coming from Freeport. The Illinois Department of Natural Resources (IDNR) is administering the grant on Freeport's behalf and approves all property acquisition prices. It took Freeport several years to successfully secure the funding (Moderow, 2021), and two planning directors were involved in the grant application before the current planning director who is administering the grant. The grant allows Freeport to acquire and demolish flood-prone homes and return the area to open green space. City officials also stated that the grant includes funding for legal costs for residents who have tangled deeds and require assistance getting their ownership documentation in order.

According to city officials, most of the properties included in the grant are residential, with very low assessed values, averaging $9,000. To encourage participation and allow residents to remain in the Freeport area, homeowners who lived in their homes during the devastating 2019 floods will receive an additional $31,000, funded through the FEMA PDM grant. City officials say residents participating in the buyout program are keen to relocate within Freeport, and no eminent domain has been used. Throughout the application process for the grant and with the buyout program well underway, local government officials have communicated frequently with residents through the Journal-Standard newspaper (Hinds, 2019; J. Miller, 2019, 2020a, 2020b, 2021a, 2021b).

The PDM grant has restrictions that Freeport must enforce, including FEMA's 50 percent improvement rule for homes in the 100-year floodplain (J. Miller, 2019). The grant requires that Freeport enforce the rule requiring homeowners to elevate their homes if they spend more than 50 percent of the home's value on renovations. For the homes located in the 100-year floodplain

[39] "The city of Freeport plans to conduct the acquisition and demolition of 127 properties in three phases: first focusing on occupied homes, then unoccupied structures and finally vacant lots. Each phase is projected to include approximately 45 properties and will each take a year to complete" (News Reports, 2021).

in Freeport, the assessed values are so low that enforcing this rule will prevent homeowners from making simple roof repairs and ultimately pressure residents to participate in the buyout.

Figure 14 – Freeport, IL Flood Mitigation Plans
Source: Author, Semi-Structured Interviews

Before the current grant, flood mitigation efforts were more minor and needed to be more comprehensive, like the current PDM grant. Before the PDM Grant, Freeport received $1 million for buyouts (Chase, 2019) and $300,000 from the Illinois Department of Commerce and Economic Opportunity (DCEO) to purchase and demolish 24 abandoned properties (Hinds & Kopanski, n.d.). Additional studies proposed stormwater detention basins and efforts to manage flooding in the Northeast side of Freeport (Fehr Graham & Skeo, 2016), but have yet to be implemented and will likely not be implemented as a result of the buyout reducing risk to residents.

Barriers and Opportunities

Despite the incredible progress, Freeport has made toward protecting residents, there were difficulties along the way. Some residents initially interested in the PDM grant buyout became

skeptical of the program. Misinformation spread about a golf course planned for their neighborhood once all residents accepted their buyout (Torres et al., 2022). Although the misinformation was refuted, questions arose regarding who will get access to the new greenspace and what it will look like once the buyout is complete (Moderow, 2021). A previous buyout program in 2012 was unsuccessful due to low political will and residents' lack of interest (Hinds & Kopanski, n.d.), so skepticism has impeded buyouts previously.

City officials have also faced difficulties due to a lack of trust from residents in the Northeast of Ward 3. Regional planning officials also noted the difficulty with threading the needle on the buyout program due to challenges of low trust in government coupled with incredibly adverse living conditions in the flood-prone areas. The public sentiment in 2018 was that the city government wasn't doing enough and certainly not helping the elderly residents in inundated areas (Adams, 2018; Mason, 2018). Additionally, residents are often unsure whether flooding problems arise from sewer pipes or drainage (Mason, 2018), indicating that flood issues may be more complex than city officials acknowledge. Residents who accept the buyout also fear they will be unable to relocate within Freeport due to the low offering price of their homes (Chase, 2019) and limited housing availability. City officials acknowledged that residents who accept buyouts love their older homes and will want to move into similar homes, which may not be widely available or within their price range in Freeport.

City officials are very hopeful of the positive impact that the PDM grant will have on the community and the health and wellbeing of the residents affected. They see the buyout program as the most successful solution possible for the flooding issues in Freeport. As the buyout progresses, there is an opportunity for Freeport to honor the history, good and bad, of the residents of the flood prone Third Ward. Freeport can also ensure that the green space that replaces the affected area will be open and accessible to all. Furthermore, with the substantial increase in green space, city officials hope to enroll in FEMA's Community Rating System to reduce the flood insurance premiums for their residents.

Ellicott City, Maryland

Figure 15 – Map of Ellicott City and the Surrounding Area
Source: Author, Google Earth for Base Image

Ellicott City, Maryland, is a historic town outside Baltimore, within the Tiber River Watershed, along the Patapsco River (see Figure 15). The Patabsco River and adjacent tributaries made the area attractive for manufacturing development with readily available mill power. As the city developed, the unique geography proved highly susceptible to flooding. Flooding is primarily concentrated in Old Ellicott City (OEC), the original town footprint near the Patabsco River that runs nearly parallel to the Tiber Branch. OEC is a historic district, and the Ellicott City Station is the oldest passenger railway station remaining in the United States. The presence of historic structures in OEC with the most significant flooding has complicated efforts to mitigate flooding and drawn questions of how historic communities can evolve alongside a changing climate; "Any visitor to any historic city or town in the world is aware that cities and towns change over time. Cities and towns are living things. They evolve – shaped by events such as floods and fires and wares. Ellicott City is no different" (Logan, 2018).

Ellicott City is unincorporated and governed by Howard County. Maryland predominantly has county-centric governance structures, which give smaller communities such as OEC more resources than if they were incorporated towns. The county executive and county council are elected officials and Ellicott City is the seat of Howard County. Howard County is one of the most affluent counties in the country and Ellicott City is the second largest employment hub in Howard County (Clinch, n.d.).

Flood Risks and Hazards

OEC is located within the Tiber Branch Watershed, within the Hydrological Unit Code (HUC) cataloging unit of 02130906. OEC floods from the Patabsco River and the Tiber Branch, a tributary of the Patabsco River. The topography and rocky terrain of OEC make it highly susceptible to flooding; "narrow, steep valleys such as the Patapsco River Valley "make for incredible devastation" (Holzberg, 2012). Damage is exacerbated by development in OEC that nearly parallels the Tiber branch, and structures span across the channelized Tiber Branch in several cases. When flash flooding occurs further up the hill from OEC, flood waters race down main street at extreme velocities. According to county officials, the entire Tiber Branch Watershed passes through one culvert adjacent to OEC.

Figure 16 shows the extent of Ellicott City at risk of flooding as defined by the FEMA flood insurance risk map. The properties at risk are a mix of residential and businesses, often with the residential on upper floors above the businesses. Flooding occurs directly along main street and at the base of OEC, adjacent to the Patabsco River. Flooding from the Patabsco River is often much less damaging than flooding from the Tiber Watershed. The Patabsco River floods from hurricanes and other extreme precipitation events in and around the river.

One of the complicating factors for Ellicott City is concern that development up the hill from OEC is the source of high-velocity flash floods because stormwater cannot be retained before rushing down the hill. According to county officials, engineers modeled the watershed after devastating flooding in 2016. They determined there would have been considerable flooding even if the woods

above OEC were in good condition. The suburban developments in Ellicott City began after 1960 (Plitt, 2019), and 31 percent of Ellicott City was developed with no stormwater drainage requirements (Logan, 2019). However, county officials stated that stormwater management requirements have mandated 100-year flood level requirements for nearly 30 years throughout the county. Furthermore, officials noted a prohibition on new construction within the 100-year floodplain. Regardless, many homes in the floodplain with basements get wet three times per year (Parker, 1997).

In the event of low-velocity flooding from the Patabsco, Howard County emergency management will warn residents. Risks of flash flooding from the Tiber Watershed trigger an automated emergency notice sent to residents. According to county officials, gauges along the Patabsco River monitor flood levels, and 1.5 inches of rain triggers river debris clean-up efforts. Howard County develops and administers emergency management and floodplain management plans.

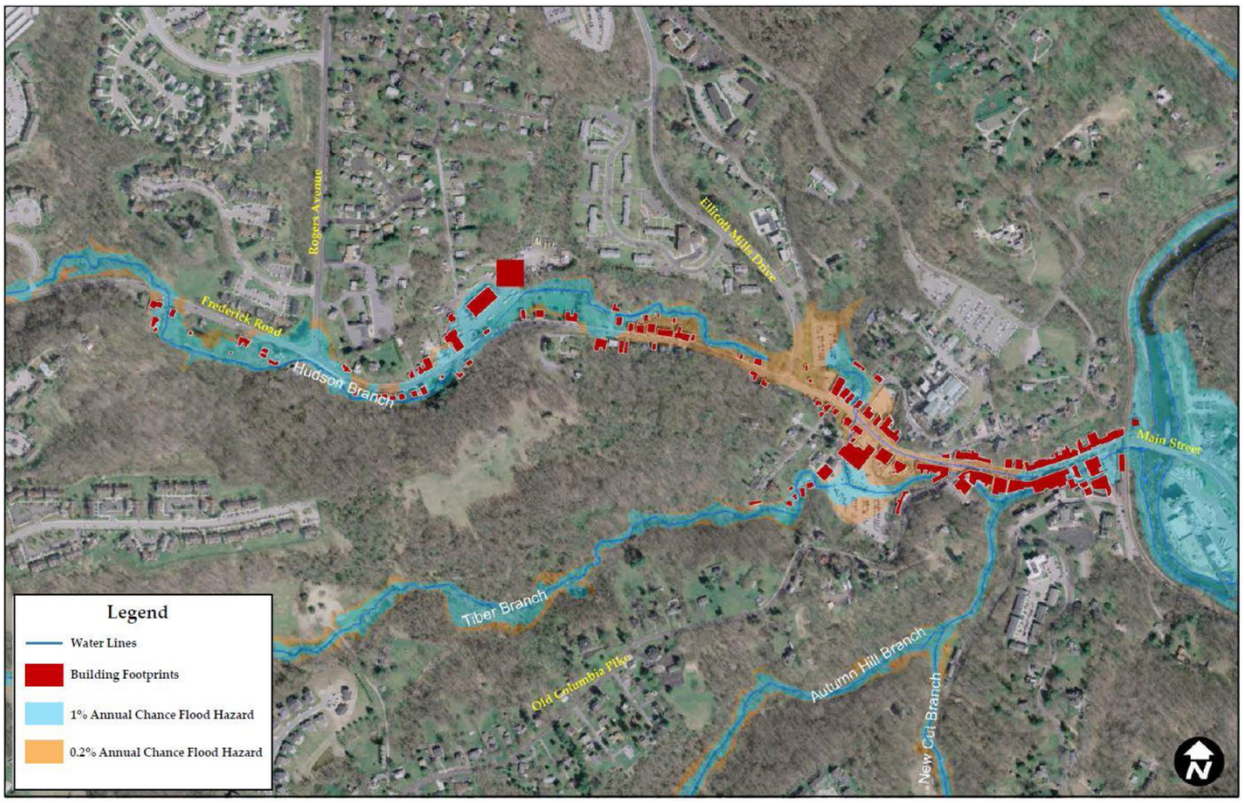

Figure 16 – Ellicott City, MD Flood Inundation Map
Source: U.S. Army Corps of Engineers, Baltimore District, 2018 Nonstructural Floodproofing Study

Historical Flooding Events

Table 4 shows the history of flooding and associated damage and responses Ellicott City has experienced for most of its existence. Ellicott City's most damaging flood event was the near back-to-back flooding in 2016 and 2018. Both floods were 1000-year events resulting from extreme precipitation in the Tiber Branch Watershed, causing significant flooding to rush down the hill toward OEC. The flooding in 2016 shocked the community with its destruction, and if not for Preservation Maryland's quick responses, several damaged historic buildings would have been demolished for fear of collapse. Fortunately, Preservation Maryland quickly contracted their engineers to counter claims by the county that several buildings were in danger of imminent collapse, and the historic buildings were saved (Preservation Maryland, n.d.). Within one year of the flood, 90 percent of businesses had returned to OEC, according to county officials. Unfortunately, many business owners did not have flood insurance in 2016 due to high insurance premiums (Cohn & McDaniels, 2018). To aid the community in rebuilding, the county provided community grants for businesses to rebuild and return to OEC.

Not more than two years later, a similarly damaging flood struck OEC in 2018 and damaged much of what had just recently been rebuilt and repaired. Several families left after the 2018 flood, having endured the 2016 flooding as well. The near back-to-back floods quickly galvanized the community and county leadership to provide solutions that would prevent this magnitude of floods from wreaking havoc again. Before the 2016 floods, there were 181 business in OEC, and there are 111 businesses in OEC today, according to county officials.

Before the devastating 2016 and 2018 flooding, Hurricane Agnes was the most recent record holder of the worst flood for OEC. In the case of Agnes, the source of flooding was from the Patabsco River and less from the Tiber Branch Watershed. Agnes was also one of the most damaging natural disasters in Maryland's history and, for some, was seen as a rogue singular event. County officials reinforced this by saying there was a sense of resignation after Agnes. After Agnes, many officials said there is only so much they could do, and another Agnes would be hard to

prepare for (Burke, 1980b). However, residents were split in their opinions about the future of OEC, with many thinking the town was finished (Arnett, 1974). Other residents were seen as stubborn as the relentless flooding of OEC's history (Burke, 1980a).

Despite the diverging opinions on the future of OEC after Agnes, the county initially made notable strides toward preparing for another big flood by investing in early warning systems and reevaluating construction within the floodplain. Unfortunately, river cleaning projects became less frequent as time went by after Agnes and residents felt the county wasn't doing as much as it should (Burke, 1980a). Another major flood struck in 1975 and shocked the community with another flood so soon after Agnes, reinvigorating discussions about flood prevention. New code regulations and initiatives for increased open space for stormwater management made headway. Fortunately, OEC was spared any major or moderate floods for two decades after the 1975 flooding.

Table 4 – Ellicott City, MD Historic Flooding Events and Associated Damage and Response
Source: Dates: Preservation Maryland

Crest (ft)	Date	Climactic Event	Notable Damage	Response	Notes
-	2018	Extreme Precipitation	OEC Severely Damaged	EC Safe & Sound Flood Mitigation Plan, and Temporary Construction Freeze	1000-Year Flash Flood Event, Tiber Watershed Flash Flood
-	2016	Extreme Precipitation	OEC Severely Damaged, 50 Properties Inundated[40]	Flood Proofing Exterior Building Facades, Stream Cleaning, Reinforced Exterior Doors and Windows, and Studies for Structural Flood Mitigation[40]	1000-Year Flash Flood Event, Tiber Watershed Flash Flood
-	2011	Tropical Storm Lee	Retaining Wall in OEC Collapsed[41]; Buildings at End of OEC Inundated; Flash Floods	Efforts to Prevent River Debris from Obstructing Patapsco River Flow	Patabsco River Flooding and Tiber Watershed Flash Floods
-	2006	Extreme Precipitation	OEC Inundated	-	"The Great Mid-Atlantic Flood"
-	1998	Extreme Precipitation	-	-	-
-	1975	Hurricane Eloise	OEC Inundated	Strict Subdivision Regulations and Building Codes; Open Space and Land	Patabsco River Flooding

[40] Semi-structured interviews
[41] (Greisman & Rector, 2011)

				Acquisition Programs; Improved Warning Systems[42]	
-	1972	Hurricane Agnes	All Bridges in Howard County, except one, were washed away; 80 Properties Destroyed[43]	Flood Warning System; Floodplain Construction Limited; New River Gauges; Utility Relocations[44]	Patabsco River Flooding; Worst Natural Disaster to Strike Maryland; 200-year Flood for OEC[45]
-	1952	Extreme Precipitation	OEC Inundated	-	Tiber Watershed Flooding, "The Great Flood of the Tiber"
-	1942	Extreme Precipitation	-	-	-
-	1923	Extreme Precipitation	-	-	-
-	1917	Extreme Precipitation	-	-	-
-	1901	Extreme Precipitation	-	-	-
-	1868	Extreme Precipitation	Road and Mill Infrastructure Destroyed	-	"The Great Flood of Maryland"
-	1866	Extreme Precipitation	-	-	-
-	1837	Extreme Precipitation	-	-	-
-	1817	Extreme Precipitation	Upper Mills Bridge Destroyed and Union Manufacturing Company Damaged[46]	-	-
-	1768	Extreme Precipitation	Original Mill Destroyed[47]	-	-
River Gauge Levels: Not available or historically reliable due to floodplain basin topography and multiple flood pathways					

2018 Flooding (OEC Main Street)
Source: Preservation Maryland/ Shannon Baranoski

1971 Flooding (OEC Main Street)
Source: Howard County Historical Society

[42] (Leonardi, 1977)
[43] (Stein, 1997)
[44] Semi-structured interviews
[45] (Horton, 1992)
[46] (Isaacs, 2018)
[47] (Preservation Maryland, 2016)

Adaptation and Mitigation Responses

After the 2018 flood, Howard County increased its commitment to a solution for OEC to prevent 2016 and 2018-equivalent floods. Building upon momentum after the 2016 flood, the county executive pressed for a solution to be implemented in five years and a cost of around $50 million. Plans that were developed called for the removal of 10 buildings in OEC. Public outcry was swift, and residents were divided over how to prevent future floods, how much could be done, and at what cost. Residents and historic preservationists worried that the plans would jeopardize OEC's tax credits and incentives that they received for their historical landmark status (Baltimore Sun Editorial Board, 2018). However, 30 business and building owners supported the demolition (Poon, 2019). The election of county executive Calvin Ball quickly scuttled the plans to demolish historic buildings. Executive Ball instead asked for solutions not bound by time or money constraints.

With critical restraints removed, Howard County developed several structural flood mitigation solutions to meet 2018 flood levels. Because the source of flooding was from the Tiber Branch Watershed, the efforts were focused on retaining stormwater uphill from OEC and diverting water through alternate streams. County officials stated that efforts were focused on solving flash floods, not flooding from the Patabsco River since the back-to-back floods were from the Tiber Branch Watershed. However, if the source of flooding had been the Patabsco River, officials would have focused their flood mitigation efforts there. Officials also note that little can be done to mitigate flooding from the Patabsco, and therefore, efforts were focused on tributaries to the river, where mitigation efforts could be successful.

After deliberation and consultation with the USACE, Howard County selected its final solution for Ellicott City (EC) Safe & Sound (see Figure 17). The new plan called for five retention ponds, extending the North Tunnel to divert water to the Patabsco, removing four buildings in OEC, and modifying several buildings to remove obstructions over the Tiber Branch culvert in OEC. Work is ongoing, and construction for many components is expected to begin in 2023. Due to the large infrastructural nature of the solution, the cost was considerable, totaling roughly $150 million. Funding for the project comes from county general funds, an Environmental Protection Agency

(EPA) Water Infrastructure Finance and Innovation Act (WIFIA) loan, and Maryland State grants. All the funding was competitive and not allocated just for Ellicott City, nor did the county have a fund waiting and available.

According to county officials, most residents support the plan, but some question whether the cost is worth it (Baltimore Sun Editorial Board, 2019). Some also question the allocation of funding for OEC when it represents a small portion of tax revenue for the county. As a counterpoint, officials highlighted the historical provenance of OEC and the visitors it draws each year. Furthermore, existing resources were reorganized for EC Safe & Sound, and there was no need to hire new staff for the project. Officials also believe residents will be grateful for EC Safe & Sound when the next major flash flooding event occurs.

Before the devastating 2016 and 2018 floods, Ellicott City implemented floodproofing measures to mitigate the damage from floods. These measures included grants to property owners for floodproofing to protect their homes. Other mitigation efforts included increasing open space for stormwater retention and code regulations for development in the floodplain.

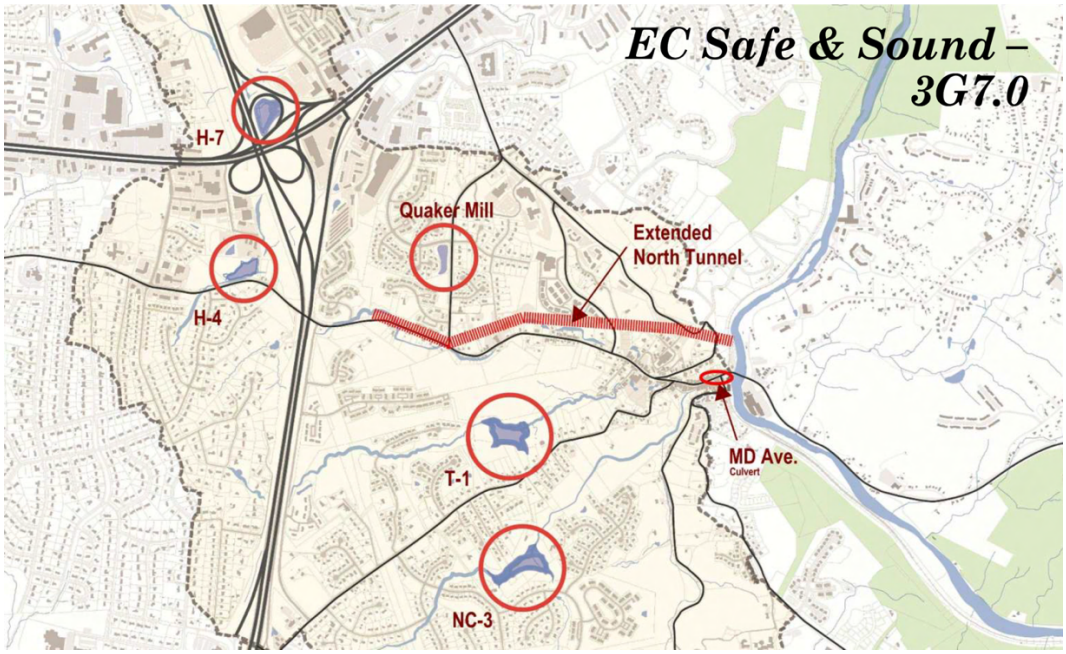

Figure 17 – Ellicott City Safe & Sound Flood Mitigation Plan
Source: Howard County

Barriers and Opportunities

With the significant investment in EC Safe & Sound, OEC will be protected against significant flooding events. However, the solutions from EC Safe & Sound address flooding from the Tiber Branch Watershed rather than the Patabsco River. This means there is still the possibility of major flooding from the Patabsco River, which OEC is relatively unprotected from. Furthermore, the lingering question is whether worsening storms due to climate change will render the structural solutions less effective over time. County officials acknowledged this as a possibility but an incredibly challenging factor to incorporate into flood mitigation solutions.

Even with the positive benefits from EC Safe & Sound, Ellicott City must still ensure that residents are aware of the flooding potential, even though it may now be less severe. Maintaining a certain level of social memory (Razavi et al., 2020) of flooding is essential for residents to make necessary preparations and maintain their homes against flood damage. Risk only partially disappears with the implementation of structural flood mitigation solutions. Residents should be routinely reminded of this to prevent a sense of safety that might prove false due to future storms.

Athens Borough, Pennsylvania

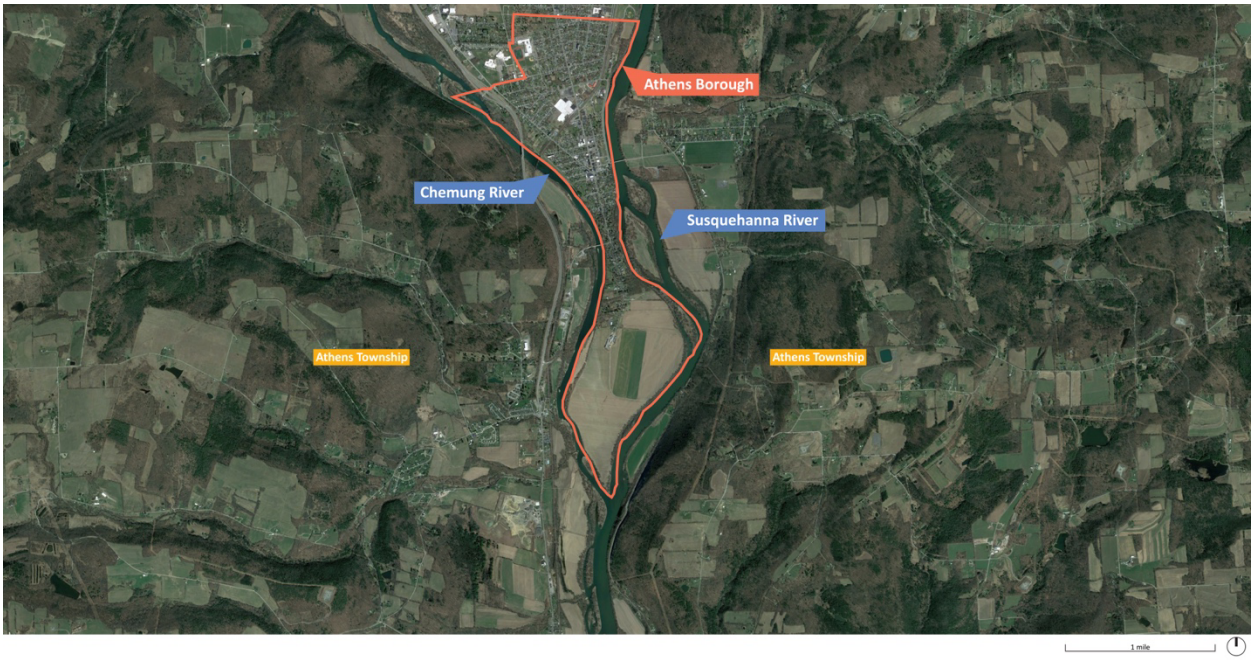

Figure 18 – Map of Athens Borough, PA and the Surrounding Area
Source: Author, Google Earth for Base Image

Athens Borough, Pennsylvania, is a small town wedged between the convergence of the Chemung and Susquehanna Rivers, barely South of the New York State border (see Figure 18). Sited on flood-prone land, Athens Borough has a history of flooding on both sides of the two rivers. Athens Borough is not to be confused with Athens Township[48], which is the municipality that surrounds Athens Borough to the East, West, and South.

The local government comprises an elected mayor and an elected borough council. Services provided include public works, a fire department, and a police department. Athens Borough contracts its permitting and inspection work to a third-party vendor. Due to the town's small size, institutional capacity is a critical challenge for mitigating floods. Many officials hold two or three positions, which leaves little room for pursuing new grants or partnerships.

[48] In the Commonwealth of Pennsylvania, boroughs are considered urban and townships are considered rural. (E. Reid, personal communication, February 16, 2023)

Athens Borough has implemented some flood mitigation solutions but faces considerable flood risk from the Susquehanna River. Volunteer efforts have successfully prevented some flooding from the Susquehanna River, but little could be done if another big flood were to strike the borough. Despite the risks of flooding, Athens Borough has received awards for managing flood protection from the Chemung River by maintaining its levee system (Howeler, 2017).

Flood Risks and Hazards

Athens Borough is located near the Southern convergence of the Chemung Subbasin and the Upper Susquehanna Subbasin of the larger Susquehanna River Basin, within the Hydrological Unit (HUC) cataloging unit of 02050105. Flooding in Athens Borough results from extreme precipitation events further North in the Chemung and Upper Susquehanna subbasins. Localized precipitation events can also cause street flooding due to over-saturated soils (Williams, 2018). Athens Borough hits major flood levels when the Susquehanna River surpasses 20ft. In contrast, anything under that level causes flooding in regularly flooded areas and the borough feels good about its planning for such events (McDonald, 2021b). Flooding from the Susquehanna River is low-velocity and is often easily predicted in time for preparation. Flooding from the Chemung River is high-velocity flooding but is mitigated by an earthen levee system.

Figure 19 shows the extent of Athens Borough at risk of flooding as defined by the FEMA flood insurance risk maps. The flood risk map was updated in 2014 and includes areas inundated in the 2011 flood. Most at-risk properties are residential, except the wastewater treatment facility. When flooding is predicted to occur, Athens Borough activates its Emergency Operations Center (EOC) to coordinate efforts with municipal services, adjacent municipalities, and volunteer efforts by residents. Large flooding events receive assistance and support from the county and the National Guard. However, Borough officials noted that they only sometimes ask for assistance from the county, and the county is just as overburdened as their local officials.

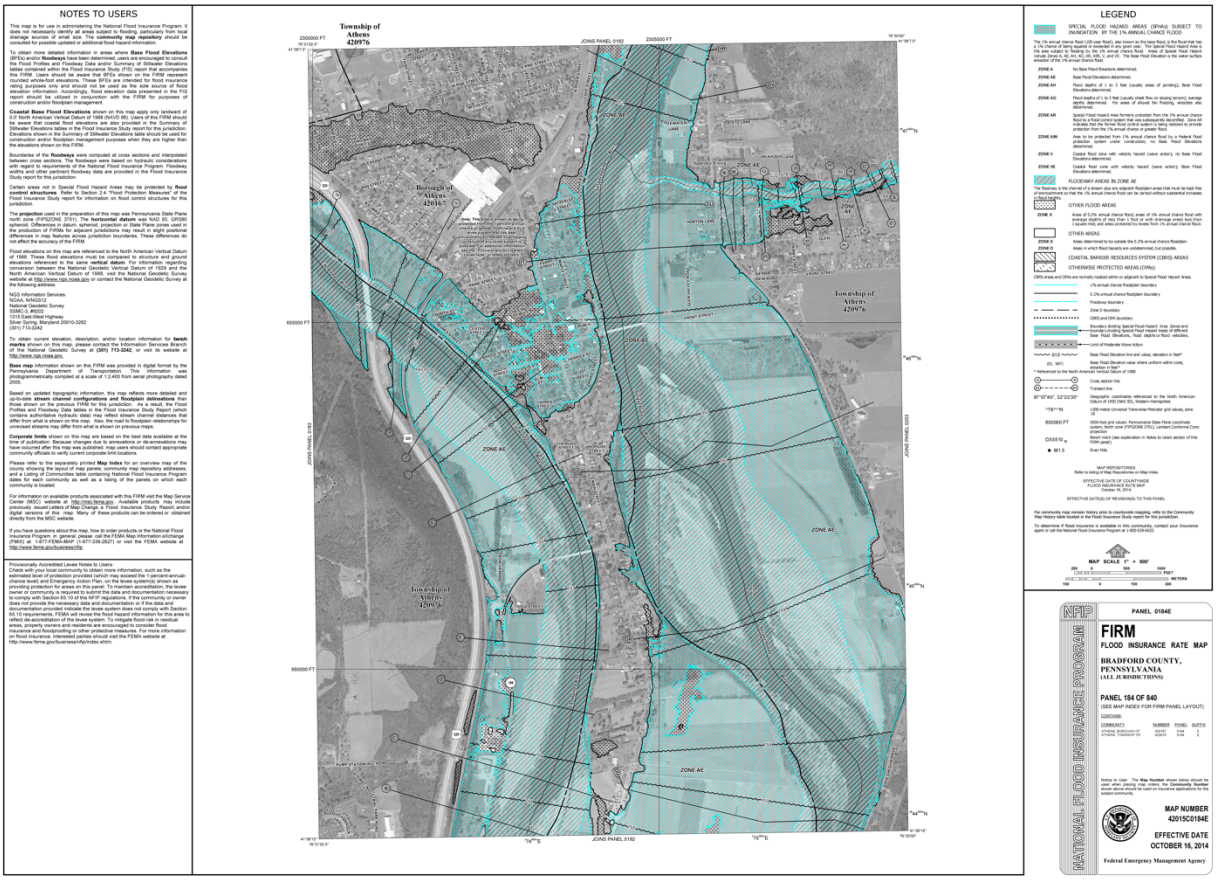

Figure 19 – Athens Borough, PA Flood Inundation Map
Source: FEMA

Historical Flooding Events

Table 5 shows the history of flooding and associated damage and responses Athens Borough has experienced. The most damaging flood event in Athens Borough's history was Tropical Storm Lee in 2011. The storm caused significant inundation from the Susquehanna River, unprotected from the rapidly rising waters. Low-lying portions of Athens Borough saw flooding to the second story of residential homes (O'Dell, 2022). The levee along the Chemung River kept back flooding water on the Western side of the town until floodwaters from the Susquehanna River crossed over the peninsula and caused a partial collapse of the levee (Frantz, 2012; U.S. Army Corps of Engineers – Baltimore District, 2018). This led to significant inundation within the 500-year floodplain area of Athens Borough and damaged many uninsured homes (Frantz, 2012).

City officials described public perceptions of flooding as reaching a critical inflection point in the aftermath of 2011, with residents having different opinions of flooding pre- and post-2011. Most notably, officials derided the metric of 100-year floods as no longer realistic given the extensive damage from Tropical Storm Lee. Fortunately, residents were resilient after the 2011 flooding (Howeler, 2016). Furthermore, due to the fracking boom in Bradford County around 2011, Chesapeake Energy volunteered their employees to help the town rebuild and recover from the flood because their employees could not work (Frantz, 2012). The damage caused by Tropical Storm Lee had lasting effects on Athens Borough and resulted in a tax revenue increase due to the ongoing recovery from the flood (M. Bennett, 2015b). Fortunately, many residents chose to remain and rebuild their homes.

Before the damage from Tropical Storm Lee, Hurricane Agnes was the most recent major inundation event. Flooding occurred primarily from the Chemung River due to the Chemung Basin experiencing significant rain and several dams failing (O'Dell, 2022). Borough officials said that far less flooding was experienced from the Susquehanna River. Therefore, in the aftermath of Hurricane Agnes, flood mitigation was focused on mitigating risk from the Chemung River. Like Tropical Storm Lee, many residents chose to remain and rebuild.

Table 5 – Athens Borough, PA Historic Flooding Events and Associated Damage and Response
Source: Crest and Date: National Oceanic and Atmospheric Administration, National Weather Service, River Observations

Crest (ft)	Date	Climactic Event	Notable Damage	Response	Notes
18.44	12/26/2020	?	-	-	-
26.67	09/08/2011	Tropical Storm Lee	Significant Inundation from the Susquehanna River; 300 Homes Damaged[49]; Partial Collapse of Chemung River Levee[50]	Study Conducted for Levee Along Susquehanna River; Flood Response Partnership with Sayre, PA; Slope Stabilization Along Susquehanna River[51]; Floodplain Management Ordinances in the County[52]	Significant Assistance from Fracking Industry[52]
16.70	04/28/2011	?	-	-	-

[49] (Frantz, 2012)
[50] (Frantz, 2012; U.S. Army Corps of Engineers – Baltimore District, 2018)
[51] (Howeler, 2014; McDonald, 2019)
[52] Semi-structured interviews

16.17	03/11/2011	Extreme Precipitation	Moderate Inundation	-	-
22.52	06/29/2006	Extreme Precipitation	Flooding Along River Street and Partial Flooding of Wastewater Treatment Plant	-	Severe Inundation was Prevented by Sandbagging Efforts
20.88	04/03/2005	?	-	-	-
18.63	09/18/2004	Hurricane Ivan			
16.65	02/28/2000	?	-	-	-
16.54	12/02/1996	Extreme Precipitation	-	-	-
20.35	01/20/1996	Rapid Snowmelt	Significant Inundation	-	-
19.28	04/11/1993	?	-	-	-
18.74	04/02/1993	Rapid Snowmelt	-	-	-
16.20	10/24/1990	Extreme Precipitation	-	-	-
18.12	03/15/1986	Extreme Precipitation	-	-	-
18.14	04/06/1984	Extreme Precipitation	-	-	-
18.03	02/16/1984	Extreme Precipitation	-	-	-
19.94	12/14/1983	Extreme Precipitation	-	-	-
19.66	03/06/1979	Extreme Precipitation	-	-	-
20.16	09/27/1975	Hurricane Eloise	Significant Inundation	-	-
16.25	02/25/1975	Hurricane Eloise	-	-	-
21.24	06/23/1972	Hurricane Agnes	Significant Inundation from the Chemung River; 11,000 People Displaced in the County[53]	Levee Constructed Along Chemung River; Floodplain Management Ordinances	-
17.92	03/11/1964	Extreme Precipitation	-	-	-
18.18	03/06/1964	?	-	-	-
17.43	02/26/1961	?	-	-	-
16.26	04/05/1960	?	-	-	-
17.56	04/01/1960	?	-	-	-
16.81	04/08/1958	?	-	-	-
16.84	03/08/1956	?	-	-	-
19.84	03/22/1948	?	-	-	-
16.63	05/28/1946	Extreme Precipitation	170 Homes Inundated[54]		
19.70	12/31/1942	?	-	-	-
16.40	04/09/1940	?	-	-	-
19.00	04/01/1940	?	-	-	-
21.40	03/18/1936	Rapid Snowmelt	-	-	-

River Gauge Levels: Action Stage: 12; Flood Stage: 13; Moderate Flood Stage: 16; Major Flood Stage: 20

[53] (O'Dell, 2022)

[54] (Farley, 2022)

2011 Flooding
Source: 2011 Flood – The Susquehanna River Basin – Neighbors Helping Neighbors Facebook Page

1972 Flooding
Source: Bradford County Historical Society

Adaptation and Mitigation Responses

The most significant mitigation response implemented in Athens Borough was after Hurricane Agnes in 1972. The USACE built an earthen levee on the town's western side to prevent flooding from the Chemung River. The levee was constructed along the Chemung River because it was the source of flooding during Hurricane Agnes, and the levee was designed to withstand a 500-year flood event. New dams were also built along the Chemung River to withstand Agnes-level flooding (O'Dell, 2022). Together, they have prevented numerous floods from the Chemung River, which has a higher velocity flooding profile than the Susquehanna River. Unfortunately, 125ft of the levee collapsed during flooding from Tropical Storm Lee in 2011 (Frantz, 2012; U.S. Army Corps of Engineers – Baltimore District, 2018), but was subsequently repaired by the USACE for $2.2 million (Frantz, 2012).

It wasn't until Tropical Storm Lee in 2011, which wreaked havoc from the Susquehanna River, that structural levee solutions were discussed for the Eastern side of the town. In 2013, the USACE commissioned a study for two rock and earthen levees. The levees were proposed to run from the Front Street bridge to the existing levee protecting the wastewater treatment facility and a smaller levee near the intersection of South Main Street and State Route 199 (see Figure 20). Ultimately, the proposed levee surpassed $10 million in cost, and the local government would have been unable to afford its cost-sharing portion. Economic analysis to determine the Benefit-Cost Ratio

was not undertaken and therefore was not determined to be the limiting factor. However, borough officials speculated that they would not have met the threshold because the properties at risk of flooding are almost all residents and represent less economic value. Borough officials also stated that the levee exploration was discontinued due to concerns from the USACE about disrupting river flow downstream.

Figure 2: Area 1 Levee Alignment

Figure 3: Area 2 Levee Alignment

Figure 20 – Athens Borough, PA Flood Mitigation Plan
Source: U.S. Army Corps of Engineers, Baltimore District

The levee solution was explored because of the need for more support for managed retreats given the already small-town population and concerns of eroding the tax base. Local officials stated they were not interested in pursuing managed retreats because residents were not interested, and people wanted to continue living in their homes. According to their zoning officer, managed retreat was successful for several properties in neighboring Athens Township.

In addition to structural levee solutions, Athens Borough implemented a slope stabilization project along the Susquehanna River to prevent further erosion that occurred during Tropical Storm Lee (Howeler, 2014; McDonald, 2019). The slope stabilization project was funded using community block development disaster recovery grant funds from the county (M. Bennett, 2015a). Athens Borough also maintained a defensive line of Jersey barriers along the Susquehanna where flooding occurred in 2011 to maintain a foundation for sandbagging efforts if needed due to future flooding (Frantz, 2012).

There are no flood mitigation policies or plans for mitigating future floods besides emergency management plans for evacuations and community sandbagging efforts. Borough officials feel confident in their ability to prepare for moderate flooding events, but if significant flooding becomes more frequent, they expect residents to move away. Due to the small size of Athens Borough, support for larger-scale solutions would require county and state support and federal financial assistance.

Barriers and Opportunities

Officials in Athens Borough described the challenges they face in implementing flood mitigation as twofold: the requisite knowledge to apply for federal programs is challenging for small towns, and the thresholds to secure funding from federal programs are difficult to meet. Officials said it gets to the point where they stop applying for grants because they are rejected year after year. Their limited institutional capacity prevents them from endlessly pursuing grants, which most municipalities would also struggle with.

Borough officials have discussed potential flood mitigation opportunities and have included measures such as dredging the tributaries leading into the Susquehanna River and increasing stormwater drainage capacity. However, the Pennsylvania Department of Environmental Protection has thus far blocked dredging efforts. Beyond these efforts, Athens Borough has maintained its cooperative agreement with neighboring Sayre, PA, for combined rescue efforts in the event of flooding. They have also hired a local meteorologist to provide more locally specific

flood data and predictions, a significant milestone since no local early warning system exists. After challenges with residents relying upon social media for weather and flood prediction, officials hope the local meteorologist will help regain support in official weather forecasts. Borough officials also see public education programs as an opportunity to communicate with the community about flood risks and how they should be prepared.

5. Drawing Insights from the Comparison of Riverine Towns

Flooding responses for Harrisburg, Freeport, Ellicott City, and Athens Borough showed a range of effectiveness and scale of implementation. We might expect riverine communities that have dealt with repetitive flooding for decades to have implemented some of the best solutions, but this is not always true. While it is true that momentum for robust flood responses is greatest immediately after a devasting flood, as more time passes, the momentum diminishes. Even as some of the case towns refer to themselves as flood towns, they also understand that the necessary flood mitigation solutions may be out of reach due to lack of funding or public support, according to interviewed officials. Despite challenges, each of the case towns has shown successful progress in mitigating flooding, with some successes more recent than others due to increasingly worse storms because of climate change.

Barriers to flood mitigation for the four case towns varied in scale and magnitude. They ranged from difficulty securing federal funding to a lack of institutional capacity. In many ways the barriers are what we might expect to see in smaller, resource-constrained communities and might parallel what can be seen in smaller coastal communities faced with similar flooding issues. However, the barriers are more nuanced and complicated by several factors, including jurisdictional challenges associated with flood mitigation and development that occurred well before floodplain regulations.

Focusing on flood responses and barriers allows for an understanding of how towns that have repeatedly dealt with flooding have responded and the barriers they may face or have overcome. Identifying the similarities and differences between the four case towns allows for important insights to be drawn that can help us understand what has been successful or a barrier across riverine towns to deduce that it is likely a similar experience for similar towns.

Drawing Insights

In comparing Harrisburg, Freeport, Ellicott City, and Athens Borough, insights were drawn from the similarities and differences between the towns. Two comparative frames were used for the similarities and differences: flood responses and barriers to flood mitigation. These two comparative frames were used to uncover what flood responses have been successful and what barriers they have faced to flood mitigation. In some cases, insights were simultaneously successful flood responses for one town, such as managed retreat or structural flood mitigation, and the barrier to flood mitigation for another town. Because of this, insight themes may be successful flood responses for one town and a barrier for others (e.g., structural flood mitigation has been a successful response for Ellicott City, but a flood mitigation barrier for Harrisburg) Furthermore, comparative frames are always partial, but they allow for vital insights to be drawn from the case study towns.

Insights were identified by the frequency of observation from semi-structured interviews and historical research. Initial flood responses and barriers were drawn from literature reviews and asked of interviewees, and open responses were also collected and cross-referenced with other interviewees. Figure 21 illustrates how some insights combine multiple factors or barriers from literature, historical research, and semi-structured interviews. I used a general frequency interpretation of whether an insight was present or absent. The interval of statements I heard after two times indicated that it was a stable condition for the case town. Insights were considered similarities if three or more case towns shared the same insight experience. For some similarities, only two case towns shared a similar experience. However, they were included as insights if they were the most successful flood mitigation solution for the towns or a significant barrier to flood mitigation. Conversely, insights were considered different if one town had an insight experience and the other three did not. Differing insights were included if the positive effect on flood mitigation was considered integral to the case town's success in mitigating flooding.

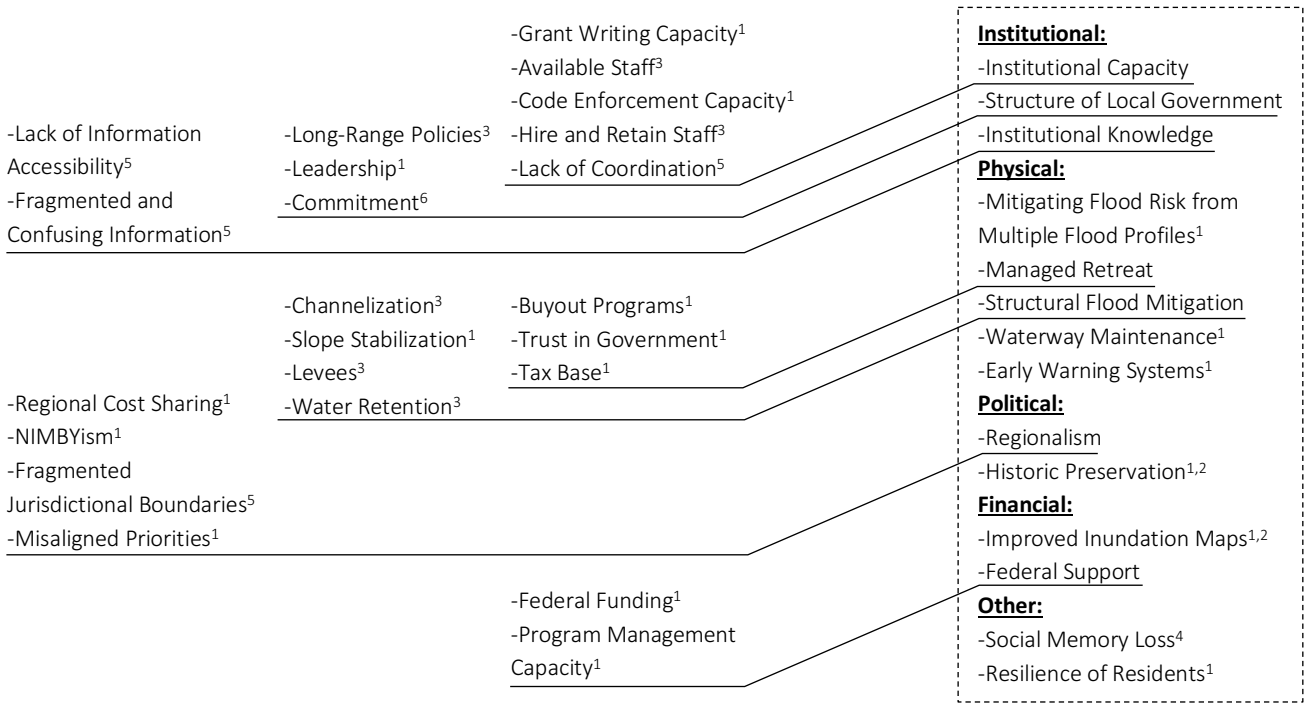

Figure 21 – Flood Response and Barrier Insights
Source: Author, [1]Semi-Structured Interviews, [2]Historical Research, [3](Brody et al., 2010), [4](Razavi et al., 2020), [5](Bierbaum et al., 2013)

Flood responses and barrier insights were grouped into five categories (Bierbaum et al., 2013): Institutional, Physical, Political, Financial, and Other. The five categories structure the insights and allow for a broader discussion around whether one category may have a more significant impact. They also provide the foundation for a more nuanced comparative analysis that accounts for the differences that might occur in a financial comparison versus a physical comparison.

Institutional insights include barriers due to a lack of institutional capacity to seek the resources needed for flood mitigation, successful flood responses associated with local government structure, and barriers associated with a lack institutional knowledge. Physical insights include successful flood responses associated with mitigating flood risk from multiple flood profiles, success and barriers in implemented managed retreat, success and barriers from structural flood mitigation, and success from waterway maintenance and early warning systems. Political insights include successful flood responses and barriers due to regional support and barriers associated

with historic preservation. Financial insights include barriers to flood mitigation due to funding for inundation mapping but not associated mitigation projects and barriers due to challenges regarding funding from federal programs. Other insights include flood response success due to the resilience of residents and flood response success and barriers associated with social memory loss (Razavi et al., 2020).

The flood response and barrier insights were compared against one another by the resources they require and their positive effect on flood mitigation (see Figure 22). This allowed for the impact of each of the insights to be compared against one another regarding the two most important factors – whether they will help communities mitigate flooding and how much resources they will require. For each insight, the four cases will have stronger or weaker experiences of each insight, and no two have identical experiences.

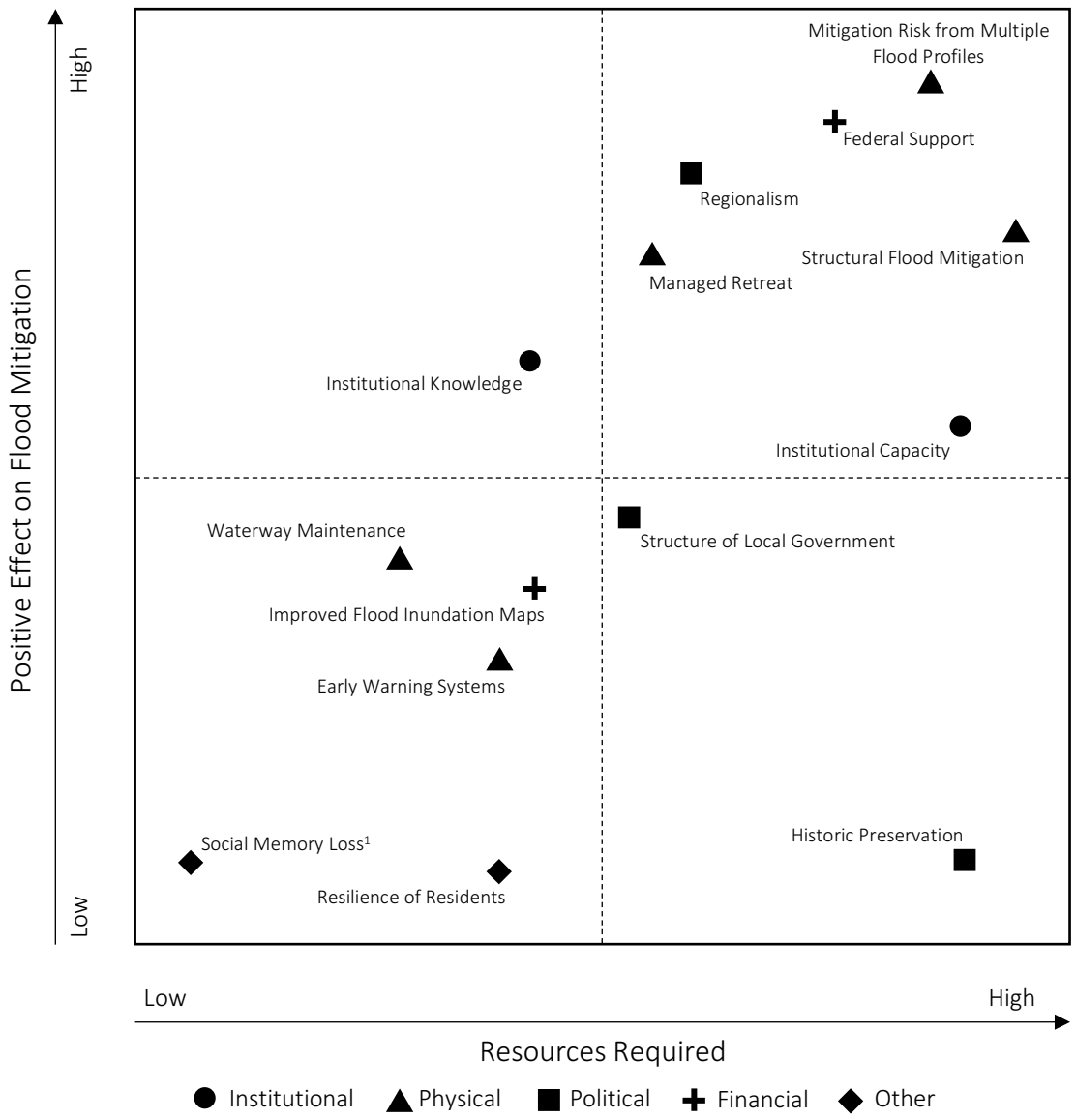

Figure 22 – Similarities and Differences in Flood Responses and Barriers Analysis Matrix
Source: 2x2 Analysis Matrix by Author, Inputs Derived from Historical Research and Semi-Structured Interviews, and [1](Razavi et al., 2020)

Institutional Flood Responses and Barriers

Institutional Capacity

The capacity to pursue grants, hire and retain staff, or even the mere availability (Bierbaum et al., 2013) of staff is vital for riverine communities facing a more significant number of municipal duties

than a comparable, non-flood-prone community. Although, institutional capacity is more than just having staff devoted to flood mitigation efforts and encompasses specific expertise and financial resources (Brody et al., 2010). Many smaller communities lack "the people, the financial resources, the expertise, or the time to [pursue flood mitigation]" (Manuele & Haggerty, 2022). Studies have shown that increasing the number of staff and financial resources leads to better flood mitigation solutions and better preparedness against future damage (Brody et al., 2010; Burby & May, 1998).

Institutional capacity was the most consistent theme among the four case towns. Towns with repetitive flooding still have all the same municipal duties as regular towns but with the added challenge of flooding. This puts these types of towns in a difficult position where they need to prioritize many issues, and if flooding hasn't happened recently, then it might be lower on the priority list but still a risk for the town. Having enough institutional capacity to develop and implement long-term solutions often requires many resources due to constrained municipal budgets but has the potential to affect flood mitigation positively. This is due to the ability to study long-term solutions and seek funding opportunities to implement the plans. When there isn't enough institutional capacity, city officials often run from issue to issue and can't think about issues that require years to solve. Some literature ties commitment to flood protection as part of institutional capacity (Brody et al., 2010). However, this is not true for the case of towns, where each official expressed dedication to flood mitigation but was limited in their ability to act due to other factors.

For Harrisburg, the planning department staff levels have fluctuated significantly and there is currently only the planning director and an assistant planner. The planning director is also the floodplain administrator, historic preservationist, and zoning manager, highlighting the consolidation of duties common in smaller communities but problematic for communities that contend with flooding. Harrisburg's institutional capacity issues provide no ability to move onto long-term planning projects for flood mitigation. However, city officials are hopeful that the forthcoming end of bankruptcy repayments will allow them to engage in long-term flood mitigation planning and expand their institutional capacity. As it stands now, Harrisburg can only

work on smaller flood mitigation initiatives and faces difficulties working with some residents since there hasn't been a major flood since 2011, and residents have little social memory (Razavi et al., 2020) of flooding. Institutional capacity has not always been an issue for Harrisburg and past flooding mitigation initiatives have had enough support for studies but ran into funding challenges due to the scale of the solutions proposed. Previous proposals have called for establishing a grant office in Harrisburg specifically for seeking funding for stormwater management and flood mitigation efforts (Mallinson et al., 2022). However, this proposal has yet to be implemented and grant writing capacity is still limited.

Officials in Dauphin County, PA, stressed that increases in federal support or new programs aiming to help communities in need rarely, if ever, come with additional capacity to pursue the new funding. This highlights a critical challenge that many smaller communities face, where new funding becomes available, but they don't have increased institutional capacity to pursue the new funding. County officials try and support communities as best they can with grant writing, but due to the structure of municipal governments in Pennsylvania, the municipality has the final say and the county cannot act on their behalf.

For Freeport, city officials consider institutional capacity to be a real problem – when the planning director sees a grant opportunity, they know they will likely be unable to pursue the grant. Institutional capacity was evident from the beginning of this research when the planning director told me that I would only be able to interview him because of how busy and occupied other members of the city government were. City officials stated that the way grants are structured is too hard for one planner to submit by themselves and typically requires additional support. Fortunately, Freeport often receives support from Region 1 Planning, their regional planning authority, and from civil engineering firms supporting their grant efforts. However, external support has a financial impact on municipal budgets and isn't always an option.

With the largest flood mitigation effort currently underway with the PDM grant, Freeport's Director of Economic Development is almost entirely consumed with securing buyout agreements

from property owners. Although this work is vital for affected residents, it takes time away from city-wide efforts. Even with a team of five people in the planning department, Freeport is stretched thin with municipal and flood-related responsibilities. Furthermore, according to city officials, municipal governments in Illinois are funded almost entirely by property taxes, and high property value communities often over-hire municipal staff and may not have repetitive issues that require their large teams and ultimately take support away from places like Freeport. This is evidenced by the high turnover rate of planning directors in Freeport. Lastly, beyond institutional capacity, Freeport has struggled with services available in the area. When conducting property appraisals for the buyout program, they had to hire appraisers from Rockford, IL due to Freeport's lack of enough appraisal capacity.

For Ellicott City, institutional capacity has not been challenging for their current flood mitigation efforts or past initiatives. For their current efforts with EC Safe & Sound, the county did not need to hire any new staff and was able to rearrange its priorities within the existing county staff. Their existing capacity was high enough to pivot to the new priorities, and their planning and stormwater management teams have not grown because of EC Safe & Sound. This is due to the county-level administration and the ability to shift resources to where they are needed most. The county has always been able to shift priorities due to county governance over the unincorporated towns in their jurisdiction. This flexibility is not common in all towns and is not something we expect to see in many jurisdictions across the county. Furthermore, Howard County also has more financial resources at its disposal than other counties because of the affluence of the county.

For Athens Borough, institutional capacity has long been a problem given the small size of the town. Many officials in Athens Borough wear multiple hats; for example, the borough council president is also the emergency management authority. This means that officials are often very busy with multiple duties and no single individual is dedicated to grant writing or flood mitigation efforts. Bradford County can provide support for grant writing, but county officials are often just as busy as borough officials due to their own limited institutional capacity. Staff in the borough have taken grant writing classes, but federal programs make the thresholds challenging to meet,

and the lack of ability to meet the threshold leads people to stop filling out the forms because they have yet to be successful in past initiatives. Athens Borough has applied to federal grants several times with limited success and, after several failed attempts, determined that their efforts could be best spent on other municipal priorities. Currently, Athens Borough is not pursuing any grants and has no grants in the future that they are planning to apply for.

Structure of Local Government

The structure of local government plays a crucial role in how well communities respond to flooding or how they overcome barriers. Smaller towns may need help accessing the resources they require, whereas communities administered at the county level may be able to access the required resources. Only sometimes is this the case, but counties with unincorporated towns often try to assist the areas of the county with the least internal resources, as is the case in McHenry County, IL, the county neighboring the county where Freeport is located. It is unsurprising that cities have slightly different government structures, each with positives and negatives. Government is a mechanism and inputs such as jurisdiction, local capacity, and inter-government relationships impacts its function. There are also layers of government, and its ability to respond to certain events can be instrumental in mitigating flooding. The structure of local government can require a decent number of resources for a community. Still, one that works well and brings all the necessary resources for a community to mitigate flooding can be hugely positive.

For Ellicott City, being an unincorporated town with county governance allowed more resources to be expended to mitigate flooding than if it were its own town. County officials acknowledged the advantageous position that Ellicott City was in because it could receive support well beyond its means. Furthermore, according to county officials, the portion of Ellicott City with the most significant flooding damage, OEC, represents a small fraction of the economy of Howard County. Due to the county's AAA-rated bond borrowing ability and enough institutional capacity to pursue competitive funds, the county executive was able to request that a small historical portion of the county be saved because it was a strong draw for tourists, and preserving the history was important. Other towns facing similar challenges may need help undertaking such costly flood

mitigation efforts and may face an uphill battle to secure funding at the scale Howard County was able to. The success of OEC is something other than what we can expect to see across the country. The ability for a county to secure funding for such a large flood mitigation plan is likely the exception and not the rule. However, as we see more damaging floods due to climate change, this may change, and more counties might seek to secure funding to support their smaller communities that are at risk.

Institutional Knowledge

In addition to having the staffing capacity to respond to flooding events and apply for funding, the existing staff must have the necessary knowledge to navigate the often-cumbersome funding applications. Applying for federal funding can require an inordinate amount of time and effort for smaller communities that may only have one planner. In many cases, towns must rely upon support from engineering firms, which typically have technical grant writing services, or regional planning authorities. This requires that municipalities have the funding necessary to pursue grants, which is only sometimes the case. Building institutional knowledge may not require many resources to improve, but it does have the potential to significantly improve the chances of mitigating flooding.

For Harrisburg, even as a medium-sized town, acknowledged the difficulties with federal programs changing requirements and the challenge of keeping up to date with their programs. Since they are not consistently applying for grants, like more prominent cities, there is no definitive expert on federal grants that they can rely upon to streamline the process. Dauphin County officials reinforced this by saying that municipal officials must be jacks of all trades and only sometimes have the technical knowledge for federal forms. County officials have also heard from municipalities that it is too much work to pursue federal grants and requires too much work to apply. These issues may be exacerbated by the fact that municipal officials are stretched thin and have limited time to devote to grants. If they are too complicated or cumbersome, they are not pursued further in favor of more pressing municipal duties.

For Freeport, officials have relied upon support from engineering firms and their regional planning authority to address institutional knowledge gaps. However, this comes at a cost to Freeport, and they only sometimes have the municipal budgets for their services. City officials said that it can be difficult for communities like Freeport to build institutional knowledge when there is often a high turnover rate of planning officials and the well of knowledge diminishes. City officials also noted that working in smaller towns that have pressing issues like flooding, often need help in enticing officials to join their team. This leads to challenges accumulating institutional knowledge necessary for small communities to successfully secure grants.

For Ellicott City, institutional knowledge has not been a challenge, and they have not faced barriers in applying to federal programs. Although, county officials acknowledged that they had hired consultants to assist with their FEMA applications due to difficulties they have faced. Even with a potential lack of institutional knowledge, Ellicott City overcame it with its municipal budgets. For Athens Borough, officials stressed that the knowledge necessary for FEMA programs is constantly changing, and you must be knowledgeable even to know what grants to apply for. These officials have also attended training and informational sessions and still find the programs challenging to navigate.

Physical Flood Responses and Barriers

Mitigating Risk from Multiple Flood Profiles

It is common for riverine towns to have more than one flooding profile, meaning there could be flood risk from a river and one of its tributaries. These flood profiles may also have different velocities and flood triggers. When riverine towns experience flooding from more than one source, it presents a mitigation choice for which flooding source is more damaging and which source can be more easily mitigated. In Harrisburg and Ellicott City, solving the challenge of multiple flood profiles is anticipated to be the most successful flood mitigation plan they have undertaken. City officials in Harrisburg and county officials in Ellicott City anticipate that the solutions will mitigate some of the worst effects experienced from past flooding. Their choice to mitigate one and not both of their flood profiles is centered on the reality that little can be done for the more extensive

flood profile, in both cases, the adjacent river. For them, mitigating one of their flood profiles will have a significantly positive effect on flood mitigation, but also requires significant resources to implement.

For Harrisburg, mitigating flooding from the Susquehanna is infeasible for several reasons and would require support and financing from the federal government, which has yet to gain enough support since 1972. However, mitigating flooding from Paxton Creek is within the realm of possibility because the worst flooding from Paxton Creek occurs entirely within the jurisdiction of Harrisburg. City officials said they have the authority to realistically mitigate the flooding and attempt to reduce risk from one of their flood profiles. Because the flooding occurs almost entirely within Harrisburg, there is no need for coordination with other jurisdictions that may not be interested in working with Harrisburg. For this reason, Harrisburg is pursuing efforts to reduce flood risk along Paxton Creek but has no plans to mitigate flooding from the Susquehanna River. Their flood mitigation planning addresses a quintessential challenge of how much mitigation is possible and what can realistically be implemented given the current state of development. There are also numerous positive outcomes for economic development for Harrisburg because the mitigation plans will reinvigorate the downtown and create more outdoor public space.

For Ellicott City, flooding mitigation from the Patabsco River is virtually impossible, “Experts say the mission to fully omit flooding in the town is impossible” (Logan, 2019). Still, mitigation for the branches of the Tiber Watershed that run through Old Ellicott City (OEC), and are tributaries of the Patabsco River, is possible. After experiencing back-to-back devastating floods, it became clear to county officials that they could significantly reduce the risk from one of their flood profiles but not both. This led to the EC Safe & Sound project to divert and retain stormwater away from OEC. County officials said their plans would be different if the flooding in 2016 and 2018 had been from the Patabsco River – they would not have explored mitigation for the Tiber Watershed. As a result, no efforts are proposed for flood mitigation for the Patabsco River, but significant efforts are underway for the Tiber Watershed. Hopefully, the EC Safe & Sound project will prevent high

velocity flooding from running down main street by retaining water uphill and diverting flood water through a tunnel North of OEC.

In the context of its opportunity costs, securing funding for Ellicott City to implement its flood mitigation initiatives should also be considered. If Howard County had not chosen to implement this project, then the potential financing could have been used for other efforts in the county. While many residents have been supportive of the plans, there are other residents who think it is a colossal waste of money, according to county officials. Howard County also must make loan repayments over the next thirty years and in that time, other more pressing issues may arise that could be challenging to finance due to existing debt levels. These concerns may be unwarranted, but it is important to evaluate the cost of a project against its benefits, especially with increasingly worse storms due to climate change.

Managed Retreat

Managed retreat, in the form of buyouts, have been discussed as a flood mitigation solution for each of the four case towns. This is not surprising, since towns with a long history of flooding often explore non-structural flood mitigation solutions (Brody et al., 2010). Each town has seen varying levels of success and similar themes of a lack of public support emerged, except for Freeport. Some flooding can only be mitigated by buyout programs or incredibly expensive structural flood mitigation solutions, which most municipalities cannot afford. However, many municipalities also do not want to reduce their tax revenue by removing homes. Eroding tax revenue is one of the most common reasons for avoiding buyouts, but the second barrier is a lack of public support from resident who do not want to move away.

For Freeport, managed retreat was initially explored after flooding in the 1990s, but lack of public support prevented any progress on the plans. City officials also failed to enforce floodplain regulations for buildings on the East side of Freeport (Hinds & Kopanski, n.d.) and therefore, there was no incentive to move since regulations that would have encourage residents to relocate were not enforced. Ultimately, due to the geography of Freeport, it became clearer that managed

retreat was the only path forward for affected areas. After securing federal funding, Freeport is currently administering their buyout program and city officials believe it will be their most successful flood mitigation project. City officials balanced the needs of affected residents needing a better quality of life – one without persistent flooding – and the financial responsibility of what is most cost effective for their community and the best use of federal grant funds (U.S. FEMA, 2018). They believe that buyouts are the only solution for the flooding in Freeport and residents will now be able to either relocate within Freeport or choose to live elsewhere, but either way, living without the threat of flooding.

For Harrisburg, managed retreat was discussed in 1972, but ultimately abandoned in favor of enticing residents to stay by selling homes to residents for low costs (Binda, 2022). Harrisburg was also struggling with population decline (Solomon, 1991) and wanted to keep residents in the city. There have been buyout programs for Southern Harrisburg after 2011 flooding due to sinkholes threatening properties. However, additional managed retreat initiatives along Paxton Creek have been unsuccessful due to challenges with property owners not wanting to leave, even after repeated flooding. City officials said they have no plans to pursue any buyout programs because they cannot sustain further erosion of the tax base and residents have no interest in relocating. This is especially true for historic homes along Front Street, parallel to the Susquehanna River, and residents in the Shipoke neighborhood. Furthermore, if the Paxton Creek de-channelization project is as successful in mitigating flooding as officials hope, then more homes along Paxton Creek will no longer need to be considered for potential buyouts in the future.

For Athens Borough, managed retreat was discussed after the 2011 floods, but did not make progress due to lack of public support and concerns over eroding the borough's tax base. Borough officials acknowledge that there may be more interest in managed retreat if storms worsen and flooding becomes more regularly damaging. Neighboring Athens Township implemented managed retreat after the 2011 floods, but space restrictions make the managed retreat more difficult for Athens Borough. If residents accepted a buyout in Athens Borough, they would likely need to move to Sayre or Waverly, and Athens Borough would lose the residents. In a small

community like Athens Borough, residents are not interested in moving away and would like to stay in their homes for as long as possible.

Structural Flood Mitigation

Structural flood mitigation solutions used to be the solution of choice in the United States but have declined in recent decades. However, given their unique flooding profiles and topography, some riverine communities see them as their best solution. Riverine communities are also exploring removing structural solutions, such as daylighting channelized streams, to allow for natural flood management (Morrison, 2023). Three of the case towns either have implemented or plan to implement structural flood mitigation solutions.

For Harrisburg, federal support has been secured for numerous USACE studies for flood mitigation solutions, most notably after Hurricane Agnes, when the USACE developed several structural solutions. However, they were never implemented due to the high cost of these proposed solutions and mixed public support. Harrisburg has struggled with meeting federal Benefit-Cost Ration for funding due to the need for high-value economic properties at risk of flooding.

Despite past challenges with structural flood mitigation solutions, Harrisburg recently received one of the necessary approvals for removing a structural flood mitigation solution. The plan calls for removing the channelization of Paxton Creek and allowing for natural boundaries that will retain water more effectively along its length. The proposal for daylighting their channelized creek is becoming a standard flood mitigation solution across the United States (Morrison, 2023). Flood studies are still underway, but city officials expect that the flood risk for residents along the Paxton Creek corridor will reduce significantly and remove over 200 homes from the 100-year floodplain.

For Ellicott City, their most successful flood mitigation solution is a structural flood mitigation solution currently being constructed. The devasting flooding in 2016 and 2018 created the momentum necessary for county officials to pursue considerable funding for flood mitigation. Wealthier communities, such as Howard County, can often implement large-scale, long-term

solutions to flooding, whereas lower-income communities must rely upon piecemeal projects (McFarland, 2019). Additionally, the type of flooding experienced in 2016 and 2018 could only be solved by a structural solution unless the town removed much of its historic district. The opposing options made it challenging for the community to decide how much of a structural solution they should develop. Still, ultimately, through securing considerable funding, Howard County was able to provide the best possible structural flood mitigation solution with the least impact on the historic district.

For Athens Borough, the levee constructed along the Chemung River after Hurricane Agnes has been the most successful flood mitigation solution they have implemented. Although, there have been some more recent challenges with flooding from the Susquehanna River causing damage to the levee. At the time of construction, flooding from the Chemung River was considered more dangerous and damaging than the Susquehanna River. Still, a changing climate may challenge these past assumptions. Athens Borough has also received awards for its maintenance of the levee and the protection it provides for the community.

Waterway Maintenance

Maintenance of waterways to remove debris is a typical pre-flood response and something that each of the towns has implemented. For each town, the policies have come after major floods exacerbated by river debris. For Harrisburg, river debris was responsible for destroying two sections of the Walnut Street Bridge, and debris accumulation in the river inlets along the Susquehanna River have caused issues. Harrisburg has been working to clear inlets and prevent river debris from accumulating. However, these efforts are part of Harrisburg's best practices approach to flooding due to the lack of funding for more significant, potentially more impactful initiatives. For Ellicott City, past flooding events have been made far worse by debris accumulating along the Patabsco River and as water races down the main street in OEC. As a result, Ellicott City has an automatic river debris clean-up protocol after experiencing 1.5 inches of rain. County officials consider this policy highly effective at mitigating conditions that can quickly become amenable to flooding.

For Freeport, some waterway maintenance has been successful in clearing debris. Still, the snaking nature of the Pecatonica River means that debris can accumulate quickly before removal, leading to flooding. For Athens Borough, waterway maintenance has focused primarily on the creek tributaries to the Chemung and Susquehanna Rivers. Creek maintenance has been challenging because the Pennsylvania Department of Environmental Protection (DEP) has resisted clearing debris from the creek due to ecological concerns. Borough officials stated that they go through cycles of progress with DEP, and the lack of consistency had been challenging for officials and residents whose properties are near creeks.

The biggest challenge for waterway maintenance is that debris and blockage can occur upstream of where a town is located but lead to flooding in the town. Lack of coordination and jurisdictional boundaries can prevent towns at the bottom of watersheds from mitigating flooding exacerbated by river debris. This is often the case in Freeport, where river debris causes blockage downstream, leading to rising river levels in Freeport. Although waterway maintenance is an important proactive strategy for flood mitigation, it is a "low regret" (Dilling et al., 2015) mitigation solution that is easy to implement but does not necessarily provide a high level of flood protection. For smaller communities with flooding issues, this is a typical response because it is easily implemented and receives public approval.

Early Warning Systems

Many towns at risk of flooding have early warning systems to alert residents of dangerous conditions. The same is true for each of the four towns, except for Athens Borough, which works with a local meteorologist to assist with short-term adverse weather predictions. For Harrisburg and Ellicott City, early warning systems were implemented after Hurricane Agnes in 1972 and have been subsequently improved with advances in smartphone technology and neighborhood-level warnings. For Freeport, early warning systems have been in place for several years and are supplemented by door-to-door warnings.

While early warning systems have a tremendous impact on preventing the loss of life during a flooding event, they provide little to no protection against the town and the community's built environment. Major flooding in Harrisburg and Ellicott City post-Agnes still saw significant damage despite early warning systems. Fatalities were lower because of early warning systems and the advance notice they provide to residents. Still, the lack of structural or non-structural flood mitigation solutions left the city with considerable damage. This shows that early warning systems are invaluable in saving lives but fail to prompt the necessary long-term solutions to mitigate flooding. They are often inexpensive systems to implement and therefore have little stakeholder resistance. Early warning systems, like waterway maintenance, are “low regret” (Dilling et al., 2015) mitigation solutions.

Political Flood Responses and Barriers

Regionalism

Support at the regional scale can be incredibly important for flood responses and bring additional resources to municipalities than they would have otherwise. This can come in the form of regional planning authorities or county-level support. This is especially important when municipalities need help with institutional capacity, or their needs are more significant than what is available internally. Additionally, climate adaptation occurs at the local level (McNeeley & Lazrus, 2014), and regional support can aid in achieving results and helping smaller communities. However, regionalism can also be a barrier to meaningful flood mitigation efforts when municipalities are unwilling to work with one another, or jurisdictional boundaries make collaboration difficult.

For Harrisburg, regional support has not been as helpful as it could be, and competing priorities can often get in the way, according to city officials. Harrisburg is in a unique position where it is also the state capital and therefore has jurisdictional overlap with the state but also with the county. This is further complicated by the entitlement designation of Harrisburg, which means it can receive federal support directly and does not need to come through state and or county channels. However, relationships with the county are better than with the state, “too often, the state’s approach has been a one-way street – it took what it wanted from its host city and,

otherwise, just sort of neglected it" (Conley, 2022). The lack of meaningful cooperation with the state prevents valuable progress that could be made in coordinating infrastructure projects from taking place. Harrisburg has also had limited support from the Susquehanna River Basin and the Appalachia Regional Commission.

Harrisburg receives regional support from Dauphin County through Community Development Block Grants (CDBG) and from the operation of a gaming casino in the county. Gaming grants from the Hollywood Casino are distributed to municipalities throughout Dauphin County, and as of 2023, totaled $8.3 million (Schweigert, 2023). However, these grants are often not for flood mitigation and typically go to purchasing new equipment or studies. The county is also helping Harrisburg with the dechannelization project for Paxton Creek, but city officials describe the interaction as less than optimal. The project was initially funded and managed by PennDOT, but they have increasingly taken on a minor role, and Dauphin County has yet to allow Harrisburg to get more of a seat at the table. City officials also pointed to interference on the part of the county in acquiring properties that will ultimately be demolished for the project. Still, the county is buying them while the city is also trying to acquire the same properties. The confusion around the project can be attributed to the need for more apparent jurisdictional roles and some of the pitfalls of government structures in Pennsylvania.

The structure of Pennsylvania as a commonwealth also comes with its challenges since municipalities have the final say and have no incentive to work with their neighbors. According to Dauphin County officials, this relegates the county to a coordinating role, where they must rely upon the municipality asking for help before they can provide support. County officials note that it can be difficult for large-scale flood mitigation because of how small the municipalities are. Furthermore, because the municipalities are smaller and are not required to think of other communities around them, local municipalities can hamper flood mitigation. County officials describe some municipalities as unwilling to work regionally, even though they acknowledge that flooding has a regional impact. However, the most challenging is the tendency towards NIMBYism and parochialism that prevents conversations from progressing.

Despite challenges with regionalism, some progress is being made. Pennsylvania collects stormwater management fees, called rain taxes, to fund stormwater and flood mitigation initiatives. Currently, these fees are managed at the municipal level, but a cooperative agreement has garnered buy-in from 16 communities. According to the Tri-County Regional Planning Commission, Pennsylvania law allows for creating mini authorities that can levy additional fees. The cooperative agreement will enable the participating communities to invest in flood mitigation plans that can only be solved at a regional level. For now, Harrisburg has chosen not to participate in the cooperative agreement, but the 16 communities that are participating show significant progress toward regional flood mitigation.

For Freeport, regional support is provided by Region 1 Planning, which sees itself as additional capacity for municipalities. They can provide Freeport with grant writing capacity at an hourly rate and will keep Freeport abreast of upcoming grant opportunities that are suitable for them. They are not able to act on Freeport's behalf for grants, and with Freeport's limited institutional capacity, this means that there are many grants that they are not able to apply for. However, Region 1 Planning is always looking out for opportunities for Freeport because they are a repetitive flood community and know it could use the support. Officials appreciate the regional support they receive but would benefit from the increased institutional capacity to enable them to respond directly.

For Athens Borough, as a small municipality in Pennsylvania, officials echoed many of the concerns that officials in Dauphin County shared about the challenges of regionalism hindering flood mitigation. Borough officials explained that there is much competitiveness among the municipalities. They attempt to do shared services, but meetings drag on for years, leaving them waiting for an outcome. The municipalities can also be greedy for what they want and fear sharing what works well in their municipality. This conservative approach to sharing ideas prevents any progress on flood mitigation efforts. However, after damaging floods in 2006 and 2011, Sayre and Athens Borough have built a history of supporting one another in times of need (M. Zhang, 2016).

Furthermore, the Valley Relief Council provided disaster relief in 2011 to Athens Borough to help organize volunteers and rebuild homes (McDonald, 2021a). Given the mixed success with regional support, one resident authored an opinion piece about merging Athens Borough and Sayre and moving Athens Borough's downtown to higher ground. The resident highlighted that the municipalities already work together and future floods will happen, and the economic boom of the gas industry will soon depart (Crawford, 2012).

Historic Preservation

Due to the age of the four case towns, historic preservation played an integral role in flood mitigation decision-making. Although, it was only relevant for Harrisburg and Ellicott City because of the age and geographic prominence of the two towns as the state capital and former industrial center, respectively. Conversely, although older towns, Freeport and Athens Borough have no historically significant properties at risk of flooding. For Freeport, this is likely because the flood-prone parts of town are under-invested and redlined. For Athens Borough, there are several older structures, but borough officials said they are not considered historic buildings because they do not drive flood mitigation decision-making. Despite the differences, the four towns were all developed well before floodplain and stormwater management regulations. Still, only Harrisburg and Ellicott City had developed important and, subsequently, historic properties in vulnerable parts of town. As a result, essential destinations and vital pieces of their town's history have faced the brunt of repetitive flooding. Deciding to modify flood mitigation plans to preserve historical buildings can require substantially more resources and may not always positively impact flood mitigation.

For Harrisburg, the floods of 1972 were the touchpoint that initiated the historical association movement. Before 1972, there were no historic districts in Harrisburg, but quickly after the USACE began tearing down buildings, residents were galvanized to establish historic districts and protect their history. As a result, more structures have been preserved as historic buildings, and Harrisburg has a strong historic preservation sentiment. The governor's mansion, a historic landmark, has flooded numerous times since 1972. Because of the age of buildings along the Susquehanna, city

officials doubt they would ever engage in buyouts of those homes because of the character they bring to the community and their value for property taxes.

For Ellicott City, the worst damage from flooding occurs in Old Ellicott City (OEC), a historic district. What was once advantageous topography for mill power ultimately created adverse conditions for flooding. After the flooding in 2018, the county executive determined that the best course of action was to tear down ten buildings for a flood mitigation plan to complete in five years and under $50 million. Considerable public outcry and resistance from preservation groups ultimately led to the county executive losing his reelection bid. Calvin Ball, the new and current county executive, quickly scrapped the previous administrations' plan. He told county officials that time and money constraints were not best suited to the unique conditions for flood mitigation in OEC. Without these constraints, the county unveiled plans that would only remove 4 buildings in OEC and protect the remaining properties. Even though OEC comprises a small percentage of the economic activity of Howard County, the county dedicated substantial resources to protecting it from future floods. Much of the effort is attributed to the historical value of OEC and the county's dedication towards its most historic area. Preservation Maryland also played an integral role in saving several buildings after the floods and their critique of the initial plans to remove 10 historic buildings. Since OEC is designated as a historic district, tax exemptions and credits come with that designation, and the initial plans were also criticized as potentially jeopardizing their historic designation.

Financial Flood Responses and Barriers

Improved Flood Inundation Maps

Many communities that have suffered from flooding have received funding or support for improved flood inundation maps. These improved maps are often commissioned by FEMA or the USACE and serve as necessary educational tools for residents to understand their potential risks and guide future developments. However, improved flood inundation maps often need more funding to implement flood mitigation solutions. Although the improved maps are essential as

land cover and land use change (Blessing et al., 2017) impact flooding, they highlight potential risks and present no solutions to mitigate them.

Harrisburg, a town that has dealt with repetitive flooding, has been studied extensively, and funding for planning and technical assistance has been provided. However, funding to implement solutions that are the outcome of the assistance have not been provided. City officials appreciate the improved inundation maps developed for them by the USACE but wish more could be done. Technical assistance can also not overcome a lack of institutional capacity and can help communities only so much (Manuele & Haggerty, 2022). They see the inundation maps as an educational tool, but what good is it if residents see that they are at risk of flooding but need more financial assistance to make improvements to their homes to prepare? This gap between vulnerability assessments and funding to address the vulnerabilities has proven challenging for Harrisburg. The same is true for Freeport and Athens Borough, where improved maps have been created to reflect risk more accurately after disastrous flooding events, but no funding comes with the maps. This reflects a decision to invest in mapping to visualize risk but also an even more important decision not to bring funding for the community to implement solutions.

Federal Support

Securing funding from the federal government is often the largest barrier to flood mitigation implementation. The issues that smaller communities face are too large to be addressed locally and will require substantial cooperation between all levels of government (Bierbaum et al., 2013). Due to the high cost of many flood mitigation solutions, federal funding is necessary for smaller municipalities to meet their needs. Federal funding is commonly provided through competitive grants or as aid post-disaster. Each of the four towns is familiar with post-disaster aid through FEMA, but pre-disaster federal aid can be more challenging to secure. Due to the constant threat of damage from repetitive flooding, each town has sought federal aid to implement flood mitigation solutions. The case study towns have seen mixed results in securing federal grants, and long-standing Benefit-Cost Ratios have been seen as a significant impediment.

For Harrisburg, federal support has been secured for numerous flood mitigation and mapping studies but not for projects at the scale that are needed. Federal support has always stalled after structural flood mitigation projects are deemed too expensive. Aside from disaster funding, the federal government has provided grants to Harrisburg for its High-Water Mark Initiative, which is an educational program, not a flood mitigation initiative. The Harrisburg Redevelopment Authority is currently working to secure federal grants for flood mitigation but still needs to submit their application. Furthermore, the Paxton Creek de-channelization will likely require some federal funding, but the project's overall cost has yet to be finalized.

For Freeport, securing federal funding has been the most helpful flood mitigation solution for them, enabling flood-prone residents to relocate. However, it took three rounds of applications to secure the funding, and the long process further strained and affected residents' trust in the government. City and neighboring county officials described an uphill battle for funding and the demoralizing effects of not securing funding. City officials also described the compounding challenges of residents feeling like the city isn't doing enough, but the scale of support they need must come from the federal government.

Freeport is also familiar with the challenges of federal bureaucracy when federal funding failed to gain support in the 1990s when a series of damaging floods struck them. Some of the challenges with securing federal funding were eased by support from residents for a buyout, which can sometimes be a barrier. Even though Freeport has finally secured the federal support they need, a flood-prone community in nearby McHenry City wants a buyout program, but has yet to secure federal support. Freeport's path to securing federal funding also highlights that even communities that have flooded over 100 times can face difficulty securing necessary federal funds. The quantity of flooding does not always indicate success in securing federal grants.

Securing federal funding has been difficult for Ellicott City due to challenges meeting the Benefit-Cost Ratio required for federal grants. County officials would like to receive federal funding, but they understand their privileged position due to the affluence of their residents and, therefore,

the county tax revenue. However, they have received federal funding in the form of Environmental Protection Agency (EPA) loans, which required 51 percent matching, and the loans are not forgivable.

For Athens Borough, federal funding was vital for constructing the levee along the Chemung River after Hurricane Agnes. However, there needs to be more funding approved for subsequent flood mitigation projects, most notably for levees along the Susquehanna River after flooding in 2011. Borough officials would greatly appreciate federal funding, but they know that their community, mostly comprised of residential properties, needs more economic value for traditional Benefit-Cost Ration to meet federal thresholds for funding. Borough officials have yet to seek other federal funding, primarily because they do not want funding for buyouts and managed retreat is their likely next course of action since structural flood mitigation cannot pencil out.

Other Flood Responses and Barriers

Social Memory Loss

Social memory loss (Razavi et al., 2020) and the challenge of residents remembering past flooding events less and less is a serious problem, even in communities with repetitive flooding. Loss of social memory when a flood has not happened recently can lead to unnecessary risk being undertaken or a lack of motivation to pursue long-term solutions (Razavi et al., 2020). Several factors lead to social memory loss, including misunderstandings of probabilistic flood risk (i.e., 100-year flood vs. 1% annual risk), high turnover of residents, and a spectrum of recent memory related to flooding. In communities that suffer from repetitive flooding, social memory loss can be a spectrum, with officials in Harrisburg describing certain neighborhoods as being more attuned to flooding than others. There can also be a sense of resignation after a major flood strikes or residents and officials feeling motivated to make necessary changes to prevent such events from occurring again, but momentum inevitably diminishes. The lack of social memory loss, or merely social memory, has the opposite effect and can be a pressure point that residents use against officials to enact change.

For Harrisburg, social memory loss has been experienced after nearly every major flood. While momentum for flood mitigation solutions has initially been high, it quickly diminished over the following years (Tristan, 2022). Even after flooding in 1972, the most damaging flood in Harrisburg's history, efforts were discussed for significant flood mitigation plans, including flood walls and buyouts. However, each of these plans ultimately lost momentum and were never implemented. The city even sold the homes they have purchased for buyouts back to residents to encourage people to stay in Harrisburg (Binda, 2022, p. 50).

Despite the lack of city-wide social memory loss, some neighborhoods in Harrisburg have long social memories of flooding. The Shipoke neighborhood and residents who live near Paxton Creek are aware that they could flood anytime it rains and little can be done to protect them (Beers, 1996). However, for residents in Shipoke, county officials stated that residents are at peace with the potential for flooding and don't let it get to them. City officials described the fractured social memory loss in Harrisburg as a barrier, with many residents unaware of the risks of flooding or more concerned with other issues. When city officials do not have buy-in from residents, it can be challenging to garner the support needed for required flood mitigation solutions. We would not have expected social memory loss to be an issue in a city like Harrisburg, but the commuter status of the city due to the capital complicates matters.

For Freeport, the chronic flooding that residents Northeast of the Pecatonica experience is a near-constant social memory for them. The loss of social memory doesn't exist because of the frequency of flooding they experience. Unfortunately, unlike other communities where social memory has led to flood mitigation initiatives, Freeport has only recently secured funding for buyouts. The extended social memory of flooding that residents have, coupled with a lack of flood mitigation solutions, has strained the relationship between residents and the government. Residents are all too familiar with flooding, and their repeated troubles have not resulted in the necessary solutions. This has slowed the progress of the buyout program because of the lack of trust. Fortunately, as more residents have signed on to the buyout, additional residents are following suit and trust appears to be rebuilding, according to city officials.

For Ellicott City, social memory galvanized county officials to search for long-term structural solutions to flood mitigation after back-to-back 1000-year flood events in 2016 and 2018. Previously, little effort had been made to mitigate flooding from the Tiber Branch, but the social memory of the 2016 flood was still fresh when the 2018 flood struck. This focused all flood mitigation efforts on the Tiber Branch, where there was realistic potential to mitigate flooding. County officials stated that had the flooding been from the Patabsco River in 2016 and 2018, their efforts would have been focused on the Patabsco River. Even though Ellicott City was struck by damaging floods in 1972, 1975, 1998, 2006, and 2011, the momentum to implement flood mitigation solutions needed to be stronger for a period long enough to implement. Back-to-back flooding pushed flood mitigation issues to the forefront of county discussions.

Resilience of Residents

A common theme among the four case towns was the resilience of residents in the face of adversity and their perseverance in rebuilding their community time and time again. Like social memory loss, the resilience of residents has an impact on the momentum of flood responses. Residents in flood-prone areas also learn to live with uncertainty and become more resilient as a result (Berkes, 2007). Due to the infrequency of major floods, residents often want to rebuild and remain in their towns. This has been the case for each of the four case study towns, except for a few instances. However, there are limits to what residents are willing to endure and each community has a different coping range (Smit & Wandel, 2006).

For Harrisburg, residents had recovered and rebuilt after each significant flood, except for 1972, when there was a shift in population to the suburbs due to flooding damage. Residents even refer to their town as a “flood” town, highlighting the awareness of flooding and a sense of ease with future risk. For Freeport, residents in flood-prone areas have been forced to be resilient because of the lack of funding for flood mitigation and geographic mobility. Unlike other towns, Freeport has residents who feel abandoned and would like to relocate if they could. Whereas other towns

have residents who want to stay where they are and are unperturbed by flooding, given the fact that it is not very frequent.

For Ellicott City, it was the resilience of residents after 2016 flooding that enabled OEC to be nearly fully repaired one year after the floods. Due to the resilience of the residents and their efforts to rebuild, when 2018 floods struck, residents demanded solutions to mitigate future flood risk because of the efforts they made to rebuild from the 2016 flood. For Athens Borough, resilience of the residents after flooding in 2011 led to efforts to rebuild their community, but some residents chose to move away. Officials note a definite distinction between the attitude about flooding pre- and post-2011 floods. Post-2011, residents are more aware of flooding because of the extent of damage from the 2011 Tropical Storm Lee flooding. Many residents felt that they were protected by the Chemung River levee and had little cause for concern. However, flooding from the Susquehanna River crossed the peninsula and caused the partial collapse of the levee. As a result, residents are far more aware of flooding and the potential for damage. Borough officials predicted that if similar flooding events become more frequent, then more residents will likely move away for safer areas.

6. Lessons for Other Riverine Towns and How Policies Can Better Serve Them

In addition to and building upon the insights from the previous chapter, this chapter aims to deduce similarities or expected phenomena from the four case study towns that are likely applicable to similar towns. This chapter also aims to understand how policies meant to assist communities with flood mitigation may or may not work for the four towns studied. Given the long history of flooding for each town, many federal programs have been pursued, but with varying levels of success. Harrisburg, Freeport, Ellicott City, and Athens Borough are subject matter expert towns regarding flood mitigation programs. Therefore, they have vital suggestions for new policies or programs that would benefit their towns and towns like them.

Deducing Similarities or Expected Phenomena for Similar Riverine Towns

Given the lack of research on riverine towns in the face of repetitive flooding, deducing similarities or expected phenomena allows for knowledge from the case study towns to be extended to similar towns. Insights from the similarities and differences of the four case study towns illustrate conditions and phenomena that may also be present in similar towns. These similarities help to develop a theory around a type of place and the conditions that may be present.

Six similarities or expected phenomena were deduced from the four case towns. Firstly, institutional capacity is expected to be challenging for many riverine communities due to chronic flooding issues and regular municipal duties. Secondly, historic preservation may complicate flood mitigation and decision-making for some riverine towns that developed well before regulations. Thirdly, regional support is vital to flood mitigation, and many smaller towns likely rely upon regional support. Fourthly, climate change will likely change the effects of social memory loss in many communities as more severe floods strike and residents demand action due to past major floods still fresh in their minds. Fifthly, institutional knowledge – distinctly different from institutional capacity – is a barrier many riverine towns likely face due to burdensome and ever-changing federal grant programs. Lastly, many riverine communities have likely implemented “low

regret" (Dilling et al., 2015) flood mitigation solutions and have been unable to move onto long-term solutions.

Institutional Capacity

As a result of the findings for each of the four case study towns, we can expect to see challenges associated with institutional capacity in many, if not most, medium- to small-sized riverine towns. Except for some more affluent towns with a robust regional support system, we expect many towns to face the same challenges that Harrisburg, Freeport, and Athens Borough face. However, the lack of institutional capacity is a spectrum, and some towns will be better off than others. However, towns with more chronic flooding issues are likely over-strained and need help to pursue more significant, competitive grants necessary for long-term flood mitigation. Furthermore, municipalities often take on more and more responsibilities, or their populations increase, and they usually respond slowly from a hiring perspective. It is not uncommon for smaller communities to have officials holding numerous responsibilities and officials to have limited capacity to act beyond their existing responsibilities (Manuele & Haggerty, 2022). Towns also face severe financial hardship when faced with multiple disasters. The wear and tear on institutional capacity affect their ability to hire and retain staff that is greatly needed (Brody et al., 2010). Considering each of these factors and what was learned from the four case study towns is why we would expect to see challenges associated with institutional capacity in similar towns.

Historic Preservation May Complicate Flood Mitigation

Historic preservation plays a vital role in many older towns in the United States, or at least for the old town portion of what may be a larger town today. Because older towns were developed before floodplain regulations or stormwater management requirements, there is the potential for historical places to be in flood-prone areas that may be difficult to protect from worsening storms. This is especially problematic for older mill towns that developed near rivers for industrial purposes. While industrial operations are likely no longer in use, the buildings that developed around the industrial uses have value to the community and are likely revered by community members and historical associations. Historic properties are also vital to communities that rely

upon them for economic value (Appler & Rumbach, 2016). This will likely complicate flood mitigation efforts as elected officials and the public decide what is best for the community while balancing historic preservation. Additionally, there is limited ability to protect historic properties against flooding (Jones, 1986).

As a result of the findings in Ellicott City and Harrisburg – two towns containing extensive historic buildings – we would expect to see similar cases across the country. Cases where we would see flood-prone towns with a notable presence of historic buildings. These towns may not be on the National Register of Historic Places, like Old Ellicott City, but their historic properties are still significant to the towns. Furthermore, the scale of historic properties affected will differ from town to town, but divisions will arise among community members over how to proceed.

Regionalism

Regional support for flood mitigation, either through county support or regional planning authorities, is highly beneficial to smaller communities struggling with flooding. Additional resources for planning or grant writing can be vital for communities lacking institutional capacity. However, regionalism can also be a jurisdictional hindrance preventing meaningful regional flood mitigation solutions or funding mechanisms from being implemented. It was surprising to understand that some communities would resist working together on vital flood mitigation projects. We would expect that communities would be more amendable to cooperative agreements after enduring repeated flooding, but that was not always the case.

Based upon the successes and potential for future successes due to regional support, it is likely that other riverine towns have seen success with regional support as well, or as storms become worse, may pursue more regional support to meet their needs. However, not all communities have regional planning authorities and may be without a regional support partner. In this case, they may look to cooperative agreements with neighboring municipalities, but as we saw in Harrisburg and Athens Borough, this is only sometimes a positive experience. Because Harrisburg and Athens Borough are both in Pennsylvania, this is likely more of a state-specific experience and is not

necessarily something we would expect to see in other states. Although, smaller communities will likely face some challenges in forming cooperative agreements if there is skepticism.

Climate Change and Social Memory Loss

One of the biggest challenges with disaster mitigation is that residents think about it less and less as time goes by after a disaster. This is an issue even in communities with repetitive flooding and has proven to hinder the implementation of flood mitigation solutions at the needed scale. Although climate change is expected to increase the severity of precipitation events leading to floods, the frequency of flooding events may need to be more frequent to initiate the types of conversations that occurred in Ellicott City when back-to-back record-breaking floods struck them. It also remains to be seen if the worsening effects due to climate change will spark the widespread change in flood response that is needed due to the relatively short duration of hurricanes or extreme precipitation events and subsequent repairs (Belasen & Polachek, 2008).

In response to challenges and changes in public opinion associated with social memory loss in the four case study towns, we can expect that social memory loss is a complicating factor for many riverine communities but may be changing as flooding events become more frequent. For the flooding in Harrisburg and Ellicott City in 1972, city officials said there was a general resignation that little could have been done to prepare but hoped to do better next time. As time went by, momentum for long-term solutions diminished and 1975 brought another major flood that both Harrisburg and Ellicott City were relatively unprepared for. Some of these challenges are due to confusion around how probabilistic flood risk works and residents thinking that the risk for a major flood is lower after experiencing one. Despite this, we expect that as communities experience less time between damaging floods, residents will demand action and hopefully enough visibility will provide federal support for mitigation solutions. This means the concerns that city officials in Harrisburg, Ellicott City, and Athens Borough shared about residents coming and going and the memory of past floods diminishing may no longer be the case, for better or for worse.

Institutional Knowledge

Institutional knowledge is the knowledge within a municipality of how external programs work and how to pursue federal grants. Although institutional capacity is a significant barrier to flood mitigation for riverine towns, even with some capacity, more institutional knowledge is often needed. Many smaller communities often need the internal municipal knowledge of navigating federal programs and the lengthy application and supplemental material. Furthermore, as noted by several officials in the four case study towns, programs are constantly changing, and it can be difficult for a small planning office to keep up to date. Unlike seasoned larger cities, smaller communities are also not consistently applying for federal programs, and it can take multiple rounds of applications to secure funding.

As a result of the findings in Harrisburg, Freeport, Ellicott City, and Athens Borough, we would expect many similar riverine towns to need help with the institutional knowledge necessary for successfully securing grants and navigating cumbersome federal programs. In some cases, like Ellicott City, communities may supplement a lack of institutional knowledge by hiring a consultant to assist with a federal grant application. However, this is likely only the case for a few towns. Additionally, many towns may rely upon support from regional planning authorities to compensate for a lack of institutional knowledge. Both support options assume that a community has the financial means to seek assistance, which may differ. It is likely that communities need to apply for federal programs more than once and learn why they were unsuccessful from debriefs. Over time, as more federal aid is sought due to increasingly damaging floods, more knowledge may be cultivated.

Low Regret Flood Mitigation Efforts

Each case town has implemented some form of "low regret" (Dilling et al., 2015) flood mitigation efforts, such as waterway maintenance or early warning systems. These implementations followed damaging floods and were easily implemented with public support. They have also helped reduce the loss of lives but very little in preventing property damage. Due to the low threshold to implementation and widely considered best practices, we can expect that many similar towns have

implemented these or similar "low regret" (Dilling et al., 2015) flood mitigation efforts. Although these efforts are important and have a positive impact on flooding, they have a relatively low long-term positive impact on flood mitigation. Many communities likely implement these solutions because they are inexpensive and can be implemented quickly and easily. By implementing these solutions, towns address the low-hanging fruit and not move on to larger flooding issues. Much of this can be attributed to the lack of funding for larger solutions, which means communities are doing their best with more easily implemented flood mitigation solutions.

Potential Federal Policy Improvements

As evidenced by riverine towns' flood responses and barriers to implementing flood mitigation, existing policies must be modified to serve these communities better. Moreover, new policies need to be created to address the unique challenges and set of circumstances that these and similar towns face. These changes could address concerns about where funding is being distributed and how we can better support medium- to small-sized towns (Lal et al., 2011). Federal, state, and local policies currently endeavor to help communities mitigate flooding. However, state, and local policies are inconsistent in effectiveness across the United States, with some states investing more in flood mitigation than others. In contrast, federal policies are more structured and have larger budgets. Due to the reach of federal budgets across the entire country and the ability of the federal government to fund larger projects than state or local policies may be able to, improvements should be made at the federal level.

Existing federal programs have the right intent and necessary structure. However, communities would benefit from federal policy reforms to expand the reach and lower thresholds for participation. Federal policies also provide a litany of funding structures and project types for funding, enabling options for communities to make their own choices. In not advocating for one specific type of flood mitigation initiative, the federal government allows local leaders to determine what is best for their community. This is especially important because adaptation happens locally (McNeeley & Lazrus, 2014). Improving existing policies that are effective in some parts of the country, but not all, and establishing new policies to address issues that are

widespread but more challenging to address will help to support an even more significant number of towns that have endured repetitive riverine flooding.

Each of the public officials I spoke with expressed their interest in seeing programs to address flooding be improved, especially at the federal level. Interviews in the four case study towns elicited feedback on three of the most common federal policies and funding mechanisms to address flood risk and mitigation (see Table 6). Feedback and recommendations were also elicited for new policies that could be adopted. Each new policy recommendation originated from one or more of the interviews. I incorporated the responses into the follow-up interviews with the other towns to elicit their feedback for comparison.

Feedback from the four towns highlighted challenges related to a lack of institutional capacity to participate in federal programs and the challenges associated with applying year after year for programs. Interviewees also highlighted challenges with the Benefit-Cost Ratio used for determining if a project meets minimum funding criteria and the high-cost sharing threshold for some programs. Surprisingly, interviewees also noted that the individuals administering federal programs or planners assisting city officials are often academics, and residents and city officials need help to interface with them. Responses varied across the four towns, but the funding mechanisms are cumbersome and utilize a largely one-size fits all approach to applications, with a few exceptions.

Existing Federal Flood Mitigation Programs

Several federal programs are available to assist flood-prone communities with funding for flood mitigation projects or to reduce the cost of flood insurance. One of the most common programs is the FEMA Community Rating System (CRS)[55], a voluntary program that municipalities can participate in and receive reductions in required flood insurance costs. CRS is a score-based system

[55] FEMA Community Rating System was initiated in 1990. As of 2021, there are 1,518 participating communities in the country. Of the participating communities, 27 are in Pennsylvania, 15 are in Maryland, and 71 are in Illinois. (U.S. FEMA, 2021)

allowing municipalities to receive credit for their flood mitigation strategies. According to FEMA, the program has three primary goals (U.S. FEMA, 2023a):

- "Reduce and avoid flood damage to insurable property,
- Strengthen and support the insurance aspects of the flood insurance programs, and
- Encourage a comprehensive approach to floodplain management."

Enrolling in CRS requires comprehensive documentation of flooding and which flood mitigation activities the community will or has already implemented. Communities must also coordinate a visit with FEMA to show their compliance. For many smaller communities, the initial documentation is a high participation threshold, and only a few resources are provided to overcome the resource constraints. Once communities can enroll in CRS, they must certify their continuing performance yearly through documentation and a FEMA site visit every five years to maintain good standing. Despite the large amount of work required to participate, the benefits for the community can be substantial. In the case of Ellicott City, which is a CRS class 5 community, they benefit from a 25 percent reduction in their flood insurance premiums. Participation in CRS is proven to reduce flood damages, although there is geographic disparities, with some communities seeing greater reductions than others (Gourevitch & Pinter, 2023)

In addition to the points-based CRS system for reduced insurance premiums, FEMA also administers grant programs for mitigation projects. FEMA's Building Resilient Infrastructure and Communities (BRIC, formerly Pre-Disaster Mitigation (PDM) grants) program supports communities across the country to reduce their disaster risk (U.S. FEMA, 2023b). BRIC grants rely on a cost-sharing model of 75 percent federal and 25 percent local government funding. Applications must also provide a benefit-cost analysis to show that the project will provide more financial benefit for the community than the cost to implement the project. In October 2022, FEMA lowered the required Benefit-Cost Ration (BCR) from 1.0 to 0.75 (G. W. Bennett, 2022), with

some exceptions[56], to aid disadvantaged communities and communities with hard-to-quantify benefits.

Beyond grant programs, EPA administers the Water Infrastructure Finance and Innovation Act of 2014 (WIFIA). WIFIA is a loan fund for water and wastewater infrastructure projects available to all communities nationwide (U.S. EPA, 2022a). Communities must pay 51 percent of the total project costs, and flood management projects must be designed for 500-year flood events or greater (R. Z. Hollenback, personal communication, December 15, 2022). Before securing funding, applicants undergo credit, technical, and legal due diligence. This rigorous process includes a review of construction costs, terms and conditions for financing, the borrower's credit history, and the strength of the project economics, among many other factors. Typically, WIFIA loans are used for large-scale infrastructure projects, and a common project type is the replacement of combined sewer outflows (CSOs).

Table 6 – Characterization of Comments Made by Interviewees Regarding the Applicability and Efficacy of Existing Policy Mechanisms Available to Communities
Source: Author, Semi-Structured Interviews

	Harrisburg, PA	Freeport, IL	Ellicott City, MD	Athens Borough, PA
FEMA Community Rating System (CRS)	Too Rigid and Time Consuming; Helpful for Reduced Flood Insurance Rates	Interested in Participating; Limited Capacity Preventing Participation	Working Well	Too Time Consuming; Limited Capacity Preventing Participation
FEMA PDM/BRIC Grants	Currently Pursuing; Lengthy to Secure Funding	Funding Helpful; Lengthy to Secure Funding	Benefit-Cost Ratio Falls Below Threshold Required for Funding	Lengthy to Secure Funding; Limited Capacity to Pursue
EPA WIFIA Loans	Threshold to Secure Funding is Too High	Threshold to Secure Funding is Too High	Very Helpful Funding; Very High Threshold to Secure Funding	Not Sure

[56] Projects will need to meet a BCR of 1.0 with a 7% discount rate, a BCR of 0.75 with a discount rate of 3%, and meet one of three criteria: "Primarily benefits an area at the census tract level with a score of greater than or equal to 0.6 on the Centers for Disease Control and Prevention's (CDC) Social Vulnerability Index (SVI); Primarily benefits a geographic area within a tribal jurisdiction, or an Insular Area as defined by 48 U.S.C. § 1469a1; or primarily benefits an Economically Disadvantaged Rural Community (also known as a small impoverished community as defined in 42 U.S.C. § 5133(a)). Economically Disadvantaged Rural Community (EDRC) means a community of 3,000 or fewer individuals identified by the applicant that is economically disadvantaged, with residents having an average per capita annual income not exceeding 80 percent of the national per capita income, based on best available data." (G. W. Bennett, 2022)

FEMA's Community Rating System (CRS)

Harrisburg and Ellicott City are the only two towns participating in FEMA's CRS program from the four case towns. Freeport has the intention to participate in CRS, but they are waiting until their buyout initiative is complete because they will then have substantial open space[57] to achieve a higher score. Athens Borough would also like to participate in CRS, but for a community of their size and limited institutional capacity, it would almost require another person to administer and maintain the program. Borough officials have been through training on the program, but they are still not ready to implement it in their borough.

Some of the biggest challenges city and county officials noted for the FEMA CRS program is the rigidity of the program and the significant threshold to enrolling. County officials noted that smaller communities, even those not included in this research, need help collecting the maps and documents necessary for application and resent the rigid requirements. Even when communities could compile and submit the required documents, they are unable to schedule a site visit with FEMA, which is required for final certification. The need for more resources for helping communities enroll is a significant burden to participation, and there is also a need for prescriptive guidance that could streamline documentation. To address the lack of resources, Dauphin County officials have provided support to smaller communities to pursue CRS but have experienced mixed results.

Officials in Harrisburg described a mismatch between the program and the historical nature of Harrisburg. For example, Harrisburg would struggle with lifting homes above the flood datum and sloping water away from between homes that are close together. This highlights the difficulties that older communities face when participating in the CRS program. The program intended to provide relief from high insurance rates is primarily designed for new communities and only for some of the older communities across the county. On the other hand, there is the need to be strict and require that communities implement flood protection measures before securing insurance

[57] Open space is the largest point category for CRS and its effectiveness at flood mitigation has been studied from 1999-2009 and shown to be a very effective flood mitigation solution (Brody & Highfield, 2013).

discounts, but accommodations need to be made. Additionally, some officials stressed that working with FEMA can be difficult. Sometimes, hiring a consultant to coordinate with FEMA has eased the burden, whereas working with the EPA has been more straightforward.

To improve the FEMA CRS program, there needs to be flexibility in maintaining good standing, new funding for enrollment, and alternate means of compliance for older towns. To increase flexibility, FEMA could provide prescriptive guidance and examples to streamline documentation. FEMA could also work with local officials to designate authorized personnel to conduct site visits to ensure communities have enough time to secure enrollment. To further increase enrollment, FEMA should provide grants to smaller communities that would like to enroll in CRS to cover the administrative costs of preparing the required documentation. What may be perceived as a small financial cost to enroll may be cost-prohibitive for communities facing budgetary shortfalls or other more pressing municipal priorities. Local capacity is essential in determining if a community participates in the CRS program, and additional funding can ease capacity issues (Sadiq & Noonan, 2015). Past studies have shown that communities may pursue low threshold mitigation solutions to achieve the highest score possible for the lowest cost (Brody et al., 2009; Sadiq & Noonan, 2015). This can be problematic for communities that have larger flood problems, and low threshold solutions are not enough to meaningfully mitigate flooding.

Lastly, FEMA needs to develop a secondary class of CRS for historic towns or alternate means of compliance for communities older than a specific age. There are exemptions for historic structures for FEMA's substantial completion requirements. Furthering the intent of those exemptions will help older communities benefit from the insurance reduction, but also acknowledges that many older communities were built before floodplain regulations and, therefore, would be nearly impossible to modify to achieve higher CRS scores.

FEMA PDM/BRIC Grants

Freeport secured a PDM grant from FEMA in 2020 after applications from the two previous years were unsuccessful. Freeport officials speculated that they finally secured the funding due to

damaging floods in 2019 that drew national attention to the area. The PDM grant is enabling the most extensive flood mitigation plan in Freeport's history and will significantly benefit residents who have long lived with chronic flooding. The grant is for three years, and Freeport allocates 25 percent of the total cost. Because the grant funds a buyout program, funds are allocated to assist residents with legal issues regarding tangled deeds. In addition to Freeport, Harrisburg is pursuing a BRIC grant through the Harrisburg Redevelopment Authority but has not yet submitted it.

Some of the challenges with the FEMA PDM/BRIC grant program is the need for adequate funding for projects that apply. There is concern that communities with the greatest need cannot secure funding, with FEMA favoring larger infrastructural projects (Manuele & Haggerty, 2022). In 2020, 94 percent of BRIC grants were allocated to coastal states and wealthier communities (Smith, 2022). In 2021, 80 percent of grants were allocated to the East and West coasts, with little allocated to inland states (Smith, 2022). Wealthier communities with greater institutional capacity can often more successfully secure BRIC grants. Furthermore, the federal government needs to allocate more funding to FEMA's BRIC program to meet the needs of communities across the country (Smith, 2022). Officials shared similar sentiments – they believed most of the funding was going to coastal communities and inland flooding is not being adequately addressed. Freeport had flooded over a hundred times before their first application, but it took them three rounds before securing funding. Even when approved, the total was roughly $4 million, a small fraction of federal flood mitigation programs[58]. From an economic perspective, spending money for pre-disaster mitigation today saves taxpayers a significant amount of money compared to post-disaster[59]. Furthermore, in neighboring McHenry County, some communities need more funds to participate in a buyout program, but there is a lack of additional funds available, according to county officials.

[58] In 2020 and 2021, $1.5 billion was dispersed as BRIC grants nationwide (Manuele & Haggerty, 2022).

[59] "The bottom-line is that above-code design and public- sector mitigation grant projects for riverine floods save more than they cost. The losses avoided by federally- funded riverine flood mitigation projects far exceeds the money spent (with a 7x return on investment). Both above-code design and public-sector mitigation for riverine floods result in increased occupant safety, reduced business interruption, and beneficial economic impacts for the community." (U.S. FEMA, 2018)

One improvement FEMA could make would be to provide prescriptive guidance and templates to help communities more easily apply. The time required and complexity of BRIC grants can lead communities to pursue other funding sources, which may delay securing funding (Manuele & Haggerty, 2022). Additionally, for larger grants, projects must be ready for implementation, meaning communities have already invested in planning or feasibility studies (Manuele & Haggerty, 2022). This means communities must already invest in plans before securing necessary funding. Other proposals have suggested that FEMA should provide more noncompetitive grants aimed at smaller communities that are less competitive nationally, but vital for community resilience (Manuele & Haggerty, 2022). The Bipartisan Infrastructure Law increased BRIC grant funding, which we expect will begin to reach more medium- to small-sized towns that have dealt with repetitive flooding (Manuele & Haggerty, 2022).

EPA WIFIA Loans

Ellicott City is the only town among the four studied that successfully secured a WIFIA loan. This was primarily due to the severity of flooding in 2016 and 2018 and the county executive's decision to design flood mitigation to meet the severity of these storms, effectively designed to accommodate a 1,000-year flood event. This meant the project met the 500-year or more significant flood design threshold. Furthermore, Ellicott City was able to provide 51 percent financing for the project, a threshold in the magnitude of $75 million. In the case of Harrisburg and Freeport, securing WIFIA loans have failed due to the high design threshold and significant cost sharing. Athens Borough was unfamiliar with the WIFIA funding and has yet to pursue it as a funding source.

Despite Ellicott City's success in securing WIFIA funding, their county officials highlighted that the thresholds are very high and often out of reach for many municipalities. The dual thresholds of a 500-year flood and 51 percent funding match make the loans easier for smaller towns that may face big-town problems but need more financial resources for the funding match. This presents an opportunity for an alternate class of WIFIA funding that could be made available to communities below a certain population or with a higher frequency of flooding events that would

benefit from more extensive infrastructural flood mitigation solutions. Secondary thresholds for rural communities exist for many federal funding programs to ensure resource-constrained communities are included. The intent of those secondary thresholds needs to be expanded to accommodate smaller riverine communities with documented histories of flooding that lack the support they require.

As the intensity of storms increases due to climate change, we can expect to see more communities requiring more extensive infrastructural solutions that WIFIA is intended to help finance. Developing a secondary threshold will enable these communities to begin planning and making the necessary investments to adapt to a changing climate. Additionally, since WIFIA is a non-forgivable loan, there is less concern about ballooning federal expenditures because the municipality will eventually repay the loan. Furthermore, due to the potential success of structural flood solutions in Ellicott City with EC Safe & Sound and Harrisburg's dechannelization project, there may be an increase in the desire for structural solutions that benefit from WIFIA funding.

Grant Administration and Overhead Cost Coverage

For smaller communities with limited resources, one of the most significant thresholds is the time required to pursue grants and the uncertainty of whether they will successfully secure the grant. To address this, some grants cover the administrative costs of applying for a grant, but often only if the applicant is selected for funding. This cost coverage is manageable for municipalities that successfully secure funding, but for smaller municipalities that are unsuccessful, the cost of applying is burdensome. Officials on Freeport stated that they struggle to pursue any grants that do not cover administrative costs due to constrained municipal budgets and limited institutional capacity. Other proposals have suggested, in addition to administrative overhead, the federal government needs to cover the cost of personnel working on the grant (Manuele & Haggerty, 2022).

To better support smaller towns, federal grants should provide administrative financial support for communities under a specific size or with limited institutional capacity. Many federal grants

already do this for Economically Disadvantaged Rural Communities (EDRCs) with populations under 3,000. However, this does not capture other larger communities still in need of support. Institutional capacity only sometimes increases as towns increase, and federal grant programs must acknowledge and account for this. Furthermore, federal grant programs should also dedicate staff to assist smaller communities with questions they may have when pursuing grants and provide guidance on which grants to pursue. This takes the burden off strained city officials and ensures that municipalities are pursuing the proper grants and have the assistance they need to be successful. Larger municipalities have large grant administration teams, and they know the ins and outs of programs, but this knowledge can be lacking in small communities.

Support for Institutional Capacity for Flood-Prone Towns

Challenges associated with institutional capacity were consistent throughout conversations with officials in the four case towns. Even in the case of Ellicott City, where institutional capacity is not an issue, officials acknowledged they are fortunate and could understand the challenges other towns may face. Therefore, it was no surprise that institutional capacity specifically for flood-prone towns was discussed as an urgently needed policy. Flood-prone towns, of which all four case study towns would qualify, are faced with all the everyday challenges of running a city but compounded by the omnipresent threat of damaging floods.

Officials in Dauphin County, PA stressed the point that increases in federal support or new programs aiming to help communities in need rarely, if ever, come with additional capacity to pursue the new funding. Furthermore, officials in Harrisburg lament that they are often pursuing grants to secure funding to pursue more grants, and that process can be slow and drawn out. This highlights a critical challenge that many smaller communities face, where new funding becomes available, but they don't have increased institutional capacity to pursue the new funding. Furthermore, Dauphin County officials highlighted that proactive planning for small communities requires technical assistance and model ordinances, both of which may be something that small town planners are unfamiliar with.

New policies to increase institutional capacity for flood-prone towns would allow municipalities to have dedicated support to apply for grants for larger flood mitigation solutions. Capacity building for communities at risk of flood disaster is a topic previously explored (Kick et al., 2011), but more progress needs to be made. The additional capacity could also help communities enroll in FEMA's CRS program and reduce insurance premiums for residents. Just as FEMA designates floodplains and Special Flood Hazard Areas (SFHAs), they could allocate funding for institutional capacity for towns in those designated areas. Utilizing the existing classifications for flood-prone areas would acknowledge that those designations may be more recent than the existing developments and therefore require special support. Funding for additional capacity could come in the form of 3-year funding for one person with the option to renew. This would allow communities to pursue targeted funding with their additional capacity and mitigate flooding issues in a fixed time.

Other Potential Policy Improvements

Another challenge riverine towns face is the low assessed values of homes that have suffered repetitive flooding. The assessed value of these homes has precipitously fallen due to repeated damage and local knowledge of flooding frequency that further depresses their value. This phenomenon becomes a barrier when funding is secured for buyout programs, and hesitation builds up among residents that they will be able to relocate within the community. Their hesitation is legitimate, and in the case of Freeport, IL, officials shared that many of the homes targeted for buyouts are assessed at $9,000 or less, and the highest assessed value was $30,000. Even with the additional $31,000 for residents who lived in the area during the devastating 2019 floods, residents worry they may need help to afford to live elsewhere in Freeport. Fortunately, as of February 2023, 15 properties have closed, and momentum is building for more residents to participate. However, Freeport's planner shared that there was some skepticism initially, but the increase in properties closing is directly linked to the additional compensation offered to residents.

Residents' hesitation and difficult choices ultimately pressure the local government to canvas the community and convince residents to accept the buyout offers. This puts further strain on local officials who are often already at capacity. In conversations with officials in Freeport, IL, they

wondered why the additional $31,000 could not simply be higher to incentivize families to relocate. The additional compensation does not need to be significantly higher – for Freeport, it could be a matter of $50,000 instead of $31,000. This increase is slight in the grand scheme for 127 properties but would alleviate institutional capacity issues for the planning department and allow the buyout to close out faster. Regional planning officials reiterated this concern, noting that assessed value for homes isn't always the fairest way to determine buyout costs, especially in communities that have suffered from repetitive flooding. This additional compensation begins to address some of the barriers to flood mitigation. It could lead to comprehensive relocation plans that would increase the participation needed for more beneficial outcomes (Kick et al., 2011). Some similar success can be seen with the New Jersey Blue Acres Buyout Program, which helps homeowners who owe more on their home than its market value, thereby lessening the barriers to a buyout (Ajibade et al., 2022).

Improvements and more expedient updates to FEMA's floodplain maps is another policy improvement that riverine communities would benefit from. Issues with the FEMA's floodplain maps and the process for updating and expanding maps have been widely studied (Blessing et al., 2017). Floodplain maps take several years to update, and some communities have maps dating back to the 1970s. In the case of some smaller boroughs in Pennsylvania, they have no floodplain maps at all, according to county officials. Although floodplain maps are not intended to communicate risk (Wing et al., 2022), they are often the most effective way to do so and FEMA would benefit from changing their approach to floodplain maps.

FEMA could make several updates to improve the process for updating and expanding the effectiveness of floodplain maps. First, FEMA must require that all floodplain maps are under five years old. Progress is being made in updating maps, but adequate federal funding to expedite the process needs to be improved. FEMA also needs to require that local municipalities advise FEMA when land use and land cover (Blessing et al., 2017) updates will alter the floodplain maps – helping FEMA identify where updates are needed. FEMA must be careful not to burden local municipalities that are likely already facing institutional capacity issues with these new

requirements. Secondly, FEMA must ensure that all communities in the United States with any level of flood risk are included in floodplain maps. Lastly, FEMA must endeavor to incorporate the increased risk of flooding due to climate change in their maps by incorporating flash flood risk, improving 100- and 500-year flood risk areas to account for expanded risk areas, and a buffer zone beyond traditional flood risk areas to acknowledge that risk is relative and not discretely confined to certain areas. These improvements will benefit riverine communities by codifying what they have already experienced and know to be true – that flooding occurs outside of 100- and 500-year flood areas and will worsen due to climate change. FEMA's floodplain maps are vital communication tools for local municipalities to plan for flooding, and improvements are greatly needed.

Limitations

As with most research, some limitations may affect the research and outcomes. In the case of this thesis, there are limitations associated with the number of case study towns included. If more towns had been studied, more insights could have been drawn, and a more significant body of evidence would exist for similarities and differences between the towns. Four case towns begin to identify insights, but this is just the beginning, and four is the minimum number of cases needed to draw meaningful insights. As we saw in the insights and expected similarities for other riverine towns, there are still a fair amount of variability and underlying causes for flood response and barriers to implementation. However, no matter how many cases are included, underlying challenges will always be unique to a place. Using four case towns allows for the story of each town to be fully uncovered and put forth as it relates to flooding. Whereas, if 20 case towns were used, some individual experiences might be flattened for the study or excluded due to data or time constraints.

There are also limitations due to the geographic locations of the towns selected. Localized insights could have been drawn if the towns had all been within one state. Results may also be skewed because two of the towns are in Pennsylvania, which may emphasize specific experiences due to

state-specific laws or circumstances. Including more case towns would have been able to control for locally specific flood responses and barriers to implementation.

Regarding research methods, the semi-structured interviews and historical research were effective methods for answering the research questions. However, more time could have been devoted to seeking additional interviewees, especially individuals who might have had an even more profound historical knowledge of flooding than those I spoke with. Additionally, since this research only interviewed public officials, there is the potential that views or insights from private individuals or businesses have yet to be captured and may conflict with public officials. The decision to interview public officials was intentional since they are actively involved in flooding matters and are the primary individuals leading the efforts to implement solutions. Involving residents would have provided more insights, and this thesis would have benefited from their inclusion. However, they were excluded due to time constraints and needing help to identify which residents to interview.

In addition to the methods used for this thesis, spatial mapping of land use and land cover changes and migration would have helped understand how zoning changes or individual resident decisions to move were affected by flooding over time. Spatial mapping would have shown where changes effectively reduced flood risk or where development continued in previously flooded areas and contributed to increased risk. Spatial mapping would have also reinforced social memory loss for some towns by identifying where residents moved away following a major flood but were soon replaced with new residents after social memory faded. Spatial mapping was not possible for this research due to time constraints and limited data availability on migration at the town level, and a lack of complete spatial changes over time.

7. Conclusion

The research for this thesis sought to understand how riverine towns with repetitive flooding have responded and the barriers they have faced to mitigation and what similarities or expected phenomena could be deduced for similar towns and potential policy improvements. Fourteen insights were identified in exploring the case towns, ranging from flood mitigation success through structural solutions to difficulties from a lack of institutional capacity. These insights were further deduced into six similarities that we would expect to see for similar riverine towns. Lastly, modifications to three existing federal policies and the creation of two new policies were discussed that can greatly benefit the case towns and towns like them.

Key Findings

The key findings from this thesis are that riverine towns dealing with repetitive flooding face many difficulties in implementing mitigation efforts. Still, communities are beginning to see more support and funding is becoming more available to some. Despite progress, institutional capacity is an ongoing challenge with limited solutions. Federal policies must acknowledge riverine communities' endemic challenges from flooding and provide much-needed support. Even communities with repetitive flooding need help with securing funding to mitigate flooding. As storms become more damaging or frequent, riverine communities will face difficult decisions about how to adapt. However, the barriers to flood mitigation are not insurmountable. Investments in institutional capacity, managed retreat, and expanding regional partnerships have the potential to better support communities faced with repetitive flooding.

This thesis also found that federal policies must meet the needs of medium- to small-sized riverine towns, and the participation threshold is too high for some. Modifying existing federal policies can increase their reach and remove unnecessary burdens for smaller communities. Additionally, new federal policies should be created to increase institutional capacity and requirements to cover the cost of grant administration for flood-prone towns. Together, modifications of existing federal

policies and the creation of new policies will help to address the needs of communities that have endured repetitive riverine flooding.

We also saw, in the case of Ellicott City and Harrisburg, that old conventional planning for structural flood mitigation solutions may still be appropriate for some communities. Not all solutions require communities to relocate or fundamentally alter large portions of their town. However, for some it may be the most appropriate and financially responsible decision. For other riverine towns, rational planning that furthers structural solutions may help to keep historic towns intact and safe from damaging floods. There is no need for planners to limit the solutions at their disposal and conventional best practices of past decades, such as retention ponds or diversion tunnels, may still be solutions that should be explored and implemented. Green infrastructure plays an important role and expensive structural solutions should not be advocated for when low impact green solutions are more suitable, but structural solutions should also not be shunned as a flood mitigation solution.

Opportunities for Future Research

Given the scale and prevalence of riverine flooding in the United States and the other towns identified during the case study selection that were not studied further (see Figure 5), there is the potential for future research to broaden and build upon the work of this thesis. In selecting four towns to study, this thesis began to develop an understanding of how riverine towns with repetitive flooding have sought to mitigate the threat of floods, what efforts have been most successful, and where changes may benefit these towns. However, more research could uncover additional challenges that need to be addressed or flood mitigation efforts that have been successful yet lesser known. This thesis hopes that conducting further research will draw more attention to and better understand riverine towns' unique circumstances and challenges and the increased threats due to climate change.

Additional research could also explore, in more depth, the potential policy improvements that could better support communities that have endured flooding for decades. So often, we seek to

develop policies that benefit the greatest cross-section of society and geographies. However, as this thesis has shown, that approach can harm smaller communities with limited resources. Furthermore, this thesis did not explore state policies and the different approaches across the country to support smaller communities with a history of flooding, which could also be studied further. Understanding where the most outstanding deficiencies are and at what level of government – local, state, or federal – would allow for more precision in policy improvements.

Another aspect of future research is understanding how zoning has changed for riverine communities and if repetitive flooding events have led to restrictive zoning. We expect communities that have endured repeated damage from flooding would improve zoning ordinances to prevent future damage. However, this may not be true and was not a focus of this thesis. Furthermore, older communities developed well before floodplain or stormwater management regulations may be limited in what they can do with zoning. Developing a better understanding through future research could lead to improvements for older communities. Since zoning is a principal tool for planners, it is important to understand how it can be best utilized to benefit riverine communities.

Epilogue

I gravitated toward the research for this thesis out of my interest in helping smaller communities prepare for the effects of climate change. I wanted to learn how the changing nature of our climate would alter the fabric and economies of smaller communities. However, instead of inferring what might happen to these communities in the future, I realized that it would be more valuable to understand how they have dealt with repetitive disasters up until now. It can be dangerous to infer how medium- to small-sized towns might change due to climate change, but understanding their past responses provides essential insights into events that have already occurred. Due to the wide-ranging impacts of climate change, we are responsible for ensuring that communities of all sizes and compositions are included in the research. I focused on smaller communities often excluded from essential research that would benefit them.

Before this research, I believed we should focus flood mitigation efforts on moving communities away from any level of flood risk that could be repetitive. I still believe this is the best path forward for coastal communities, due to rising sea levels. However, there is the potential to support riverine communities better and implement solutions that protect residents without fundamentally realtering their town nor only supporting buyout programs. With climate change causing more and more damage, smaller communities may be faced with fundamentally realtering their town. We cannot expect every older town with flooding to move or buy out a large share of its properties. There needs to be a middle ground between hardening in place and moving away, especially for under-supported smaller communities.

Bibliography

Adams, K. (2018, February 27). Freeport residents react to the major flooding, city working to clean up. *23 WIFR*. https://www.wifr.com/content/news/Freeport-residents-react-to-the-major-flooding-city-working-to-clean-up-475349493.html

Adger, W. N. (1996). Approaches to Vulnerability to Climate Change. *CSERGE Working Paper GEC 96-05*, *Centre for Social and Economic Research on the Global Environment University of East Anglia and University College London*, 66.

Aerts, J. C. J. H. (2017). Impacts Beyond the Coast. *Nature Climate Change*, *7*(5), Article 5. https://doi.org/10.1038/nclimate3279

"agnes" strikes with fury. (1972, June 28). *West Shore Guide*.

Ajibade, I., Sullivan, M., Lower, C., Yarina, L., & Reilly, A. (2022). Are managed retreat programs successful and just? A global mapping of success typologies, justice dimensions, and trade-offs. *Global Environmental Change*, *76*, 102576. https://doi.org/10.1016/j.gloenvcha.2022.102576

Allan, R. P., Barlow, M., Byrne, M. P., Cherchi, A., Douville, H., Fowler, H. J., Gan, T. Y., Pendergrass, A. G., Rosenfeld, D., Swann, A. L. S., Wilcox, L. J., & Zolina, O. (2020). Advances in understanding large-scale responses of the water cycle to climate change. *Annals of the New York Academy of Sciences*, *1472*(1), 49–75. https://doi.org/10.1111/nyas.14337

Appler, D., & Rumbach, A. (2016). Building Community Resilience Through Historic Preservation. *Journal of the American Planning Association*, *82*(2), 92–103. https://doi.org/10.1080/01944363.2015.1123640

Arnett, E. (1974, June 21). Ellicott City is in Splurge of Restoration, Confidence. *Baltimore Sun*, B1.

Associated Press. (1973, July 11). *Flood Control Plan Centers on Zoning*. 27.

Associated Press. (2019, March 19). More than 170 evacuate due to flooding in northern Illinois. *Daily Herald*. https://www.dailyherald.com/apps/pbcs.dll/article?avis=da&date=20190319&category=news&lopenr=303199944&ref=ar

Baltimore Sun Editorial Board. (2018, August 24). Ellicott City: Must we destroy this village in order to save it? – Baltimore Sun. *Baltimore Sun*. https://www.baltimoresun.com/opinion/editorial/bs-ed-0827-ellicott-city-20180824-story.html

Baltimore Sun Editorial Board. (2019, May 17). Is Calvin Ball's Ellicott City flood mitigation plan worth the cost? – Baltimore Sun. *Baltimore Sun*. https://www.baltimoresun.com/opinion/editorial/bs-ed-0520-ellicott-city-flood-20190517-story.html

Beaver, J. C. (2016). U.S. International Borders: Brief Facts. *Congressional Research Office, Library of Congress*, 5. https://sgp.fas.org/crs/misc/RS21729.pdf

Beers, P. B. (1996, January 22). A Historic Nonchalance for Flooding. *The Patriot News*, A8.

Belasen, A. R., & Polachek, S. W. (2008). How Hurricanes Affect Wages and Employment in Local Labor Markets. *American Economic Review*, *98*(2), 49–53. https://doi.org/10.1257/aer.98.2.49

Bell, D., & Jayne, M. (2009). Small Cities? Towards a Research Agenda. *International Journal of Urban and Regional Research*, *33*(3), 683–699. https://doi.org/10.1111/j.1468-2427.2009.00886.x

Benke, A. C., & Cushing, C. E. (Eds.). (2005). *Rivers of North America*. Elsevier/Academic Press.

Bennett, G. W. (2022). *MEMORANDUM FOR: Building Resilient Infrastructure and Communities (BRIC) and Flood Mitigation Assistance (FMA) Grant Program Applicants and Subapplicants*. FEMA.

Bennett, M. (2015a, December 11). Riverbank stabilization underway. *The Daily Review*. https://www.thedailyreview.com/todays_top_stories/riverbank-stabilization-underway/article_a9ee3c3b-1c0e-5cd8-9af3-1c5c21441b8d.html

Bennett, M. (2015b, December 16). Athens Boro Council approves first tax increase since 2010. *The Daily Review*. https://www.thedailyreview.com/todays_top_stories/athens-boro-council-approves-first-tax-increase-since-2010/article_72607acb-dbc3-570e-a6ff-de2e5fdaa194.html

Berkes, F. (2007). Understanding Uncertainty and Reducing Vulnerability: Lessons from Resilience Thinking. *Natural Hazards*, *41*(2), 283–295. https://doi.org/10.1007/s11069-006-9036-7

Berrang-Ford, L., Ford, J. D., & Paterson, J. (2011). Are we adapting to climate change? *Global Environmental Change*, *21*(1), 25–33. https://doi.org/10.1016/j.gloenvcha.2010.09.012

Berrang-Ford, L., Siders, A. R., Lesnikowski, A., Fischer, A. P., Callaghan, M. W., Haddaway, N. R., Mach, K. J., Araos, M., Shah, M. A. R., Wannewitz, M., Doshi, D., Leiter, T., Matavel, C., Musah-Surugu, J. I., Wong-Parodi, G., Antwi-Agyei, P., Ajibade, I., Chauhan, N., Kakenmaster, W., … Abu, T. Z. (2021). A systematic global stocktake of evidence on human adaptation to climate change. *Nature Climate Change*, *11*(11), 989–1000. https://doi.org/10.1038/s41558-021-01170-y

Bierbaum, R., Smith, J. B., Lee, A., Blair, M., Carter, L., Chapin, F. S., Fleming, P., Ruffo, S., Stults, M., McNeeley, S., Wasley, E., & Verduzco, L. (2013). A comprehensive review of climate adaptation in the United States: More than before, but less than needed. *Mitigation and Adaptation Strategies for Global Change*, *18*(3), 361–406. https://doi.org/10.1007/s11027-012-9423-1

Binda, L. (2022, May 31). Agnes at 50: This month marks five decades since the most devastating flood in Harrisburg history. *TheBurg*. https://theburgnews.com/in-the-burg/agnes-at-50-this-month-marks-five-decades-since-the-most-devastating-flood-in-harrisburg-history

Blessing, R., Sebastian, A., & Brody, S. D. (2017). Flood Risk Delineation in the United States: How Much Loss Are We Capturing? *Natural Hazards Review*, *18*(3), 04017002. https://doi.org/10.1061/(ASCE)NH.1527-6996.0000242

Brody, S. D., & Highfield, W. E. (2013). Open space protection and flood mitigation: A national study. *Land Use Policy*, *32*, 89–95. https://doi.org/10.1016/j.landusepol.2012.10.017

Brody, S. D., Kang, J. E., & Bernhardt, S. (2010). Identifying factors influencing flood mitigation at the local level in Texas and Florida: The role of organizational capacity. *Natural Hazards*, *52*(1), 167–184. https://doi.org/10.1007/s11069-009-9364-5

Brody, S. D., Zahran, S., Highfield, W. E., Bernhardt, S. P., & Vedlitz, A. (2009). Policy Learning for Flood Mitigation: A Longitudinal Assessment of the Community Rating System in Florida. *Risk Analysis*, *29*(6), 912–929. https://doi.org/10.1111/j.1539-6924.2009.01210.x

Bukvic, A., & Harrald, J. (2019). Rural versus urban perspective on coastal flooding: The insights from the U.S. Mid-Atlantic communities. *Climate Risk Management*, *23*, 7–18. https://doi.org/10.1016/j.crm.2018.10.004

Burby, R. J., & May, P. J. (1998). IntergovernmentalEnvironmental Planning: Addressing the Commitment Conundrum. *Journal of Environmental Planning and Management*, *41*(1), 95–110. https://doi.org/10.1080/09640569811812

Burke, R. (1980a, October 23). ...And the next. *The Howard County Times*.

Burke, R. (1980b, October 23). The last time... *The Howard County Times*.

Chang, H., Pallathadka, A., Sauer, J., Grimm, N. B., Zimmerman, R., Cheng, C., Iwaniec, D. M., Kim, Y., Lloyd, R., McPhearson, T., Rosenzweig, B., Troxler, T., Welty, C., Brenner, R., & Herreros-Cantis, P. (2021). Assessment of urban flood vulnerability using the social-ecological-technological systems framework in six US cities. *Sustainable Cities and Society*, *68*, 102786. https://doi.org/10.1016/j.scs.2021.102786

Chase, B. (2019, November 11). Neighborhoods Face Extinction As Floods Increase. *Illinois Answers Project*. http://illinoisanswers.org/2019/11/11/neighborhoods-face-extinction-as-floods-increase/

Chester, A., & Lawton, J. (2022). *Atlas of Disaster* (p. 343). Rebuild by Design. https://rebuildbydesign.org/atlas-of-disaster/

City of Freeport. (2018). *Town Hall Meeting 3rd Ward Flood Mitigation Minutes*. https://cityoffreeport.org/citygovernment/Minutes/Town%20Hall%20Meeting%203rd%20Ward%20Flood%20Mitigation%20Minutes%2020180508.pdf

Climate Central. (2016, May 4). *Inland Flooding Threat*. Climate Central. https://www.climatecentral.org/climate-matters/inland-flooding-threat

Clinch, R. (n.d.). The Economic Impact of the 2016 Ellicott City Flood. *The Jacob Frances Institute*. https://www.howardcountymd.gov/sites/default/files/2021-08/Ellicott%20City%20Flood%20Report%20Final.pdf?fileticket=eMST_nkc4RU=&portalid=0

Cohn, M., & McDaniels, A. K. (2018, May 30). Insured or not, flood-ravaged Old Ellicott City small businesses daunted by rebuilding. *Baltimore Sun*. https://www.baltimoresun.com/maryland/bs-md-flood-rebuilding-20180530-story.html

Conley, M. (2022, November 30). Greetings, Governor: We roll out the welcome mat for our newest Harrisburg resident. *TheBurg*. https://theburgnews.com/burg-blog/greetings-governor-we-roll-out-the-welcome-mat-for-our-newest-harrisburg-resident

Crawford, S. L. (2012, January 4). Why rebuild downtown Athens? *Morning Times*. https://www.morning-times.com/opinion/article_ebaba2ef-d037-5a1c-babe-badd64bc8ff0.html

Demmy, C. (1972, June 28). The Flood—. *The Paxton Herald*.

Dilling, L., Daly, M. E., Travis, W. R., Wilhelmi, O. V., & Klein, R. A. (2015). The dynamics of vulnerability: Why adapting to climate variability will not always prepare us for climate change: Dynamics of vulnerability. *Wiley Interdisciplinary Reviews: Climate Change*, *6*(4), 413–425. https://doi.org/10.1002/wcc.341

Easterling, D. R., Arnold, J. R., Knutson, T., Kunkel, K. E., LeGrande, A. N., Leung, L. R., Vose, R. S., Waliser, D. E., & Wehner, M. F. (2017). *Ch. 7: Precipitation Change in the United States. Climate Science Special Report: Fourth National Climate Assessment, Volume I*. U.S. Global Change Research Program. https://doi.org/10.7930/J0H993CC

EPA Office of Water. (2016). *Interviews with Local Government Officials Gaining Public Support for Water Infrastructure Costs: Freeport, Illinois*. United States Environmental Protection Agency.

Farley, H. (2022, June 24). Floods. *Morning Times*. https://www.morning-times.com/article_78147e8f-ff1c-5dec-890b-fd1beaf78e94.html

Feeley, M., & Lewis, C. (1996, January 21). City Island heavily damaged, 8,000 evacuees in Harrisburg. *Sunday Patriot News*.

Fehr Graham & Skeo. (2016). *Freeport Forward! Riverfront Enterprise Area Plan*. https://projects.skeo.com/wp-content/uploads/2017/05/Freeport-Riverfront-Enterprise-Area-Plan.pdf

Fitton, J. M., Addo, K. A., Jayson-Quashigah, P.-N., Nagy, G. J., Gutiérrez, O., Panario, D., Carro, I., Seijo, L., Segura, C., Verocai, J. E., Luoma, S., Klein, J., Zhang, T.-T., Birchall, J., & Stempel, P. (2021). Challenges to climate change adaptation in coastal small towns: Examples from Ghana, Uruguay, Finland, Denmark, and Alaska. *Ocean & Coastal Management*, *212*, 105787. https://doi.org/10.1016/j.ocecoaman.2021.105787

Flavelle, C. (2022, November 16). New Measure of Climate's Toll: Disasters Are Now Common Across U.S. *The New York Times*. https://www.nytimes.com/2022/11/16/climate/climate-change-county-natural-disaster.html

Floods in Illinois cause 1,800 to flee. (1959, April 5). *The New York Times*. https://www.nytimes.com/1959/04/05/archives/floods-in-illinois-cause-1800-to-flee.html

Frantz, J. (2012, September 14). Tropical Storm Lee's lasting impact: Tiny Pennsylvania town recovers faster than its residents. *Pennlive*. https://www.pennlive.com/midstate/2012/09/tropical_storm_lees_lasting_im_5.html

Fu, X., Gomaa, M., Deng, Y., & Peng, Z.-R. (2017). Adaptation planning for sea level rise: A study of US coastal cities. *Journal of Environmental Planning and Management*, *60*(2), 249–265. https://doi.org/10.1080/09640568.2016.1151771

Georgeson, L., Maslin, M., Poessinouw, M., & Howard, S. (2016). Adaptation responses to climate change differ between global megacities. *Nature Climate Change*, *6*(6), 584–588. https://doi.org/10.1038/nclimate2944

Girl, B. (2011, October 16). THE MONEY PIT: The Real Reason Harrisburg Pennsylvania Went Bankrupt. *Business Insider*. https://www.businessinsider.com/the-money-pit-the-real-reason-harrisburg-pennsylvania-went-bankrupt-2011-10

Gourevitch, J. D., & Pinter, N. (2023). Federal incentives for community-level climate adaptation: An evaluation of FEMA's Community Rating System. *Environmental Research Letters*, *18*(3), 034037. https://doi.org/10.1088/1748-9326/acbaae

Greisman, D., & Rector, K. (2011, September 8). Retaining wall collapses, damages vehicles in Ellicott City. *Baltimore Sun*. https://www.baltimoresun.com/ph-ho-cf-flooding-thursday-0915-20110908-story.html

Halverson, J. (2021, December 3). Analysis | The second 1,000-year rainstorm in two years engulfed Ellicott City. Here's how it happened. *Washington Post*. https://www.washingtonpost.com/news/capital-weather-gang/wp/2018/05/28/the-second-1000-year-rainstorm-in-two-years-engulfed-ellicott-city-heres-how-it-happened/

Hauer, M. E. (2017). Migration induced by sea-level rise could reshape the US population landscape. *Nature Climate Change*, *7*(5), Article 5. https://doi.org/10.1038/nclimate3271

Heim, M., Ramirez-Franco, J., & Brewer, K. (2022, October 12). To stay or to go: Increased flooding forces towns to make hard choices. *KCUR 89.3 - NPR in Kansas City*. https://www.kcur.org/2022-10-06/to-stay-or-to-go-increased-flooding-forces-towns-to-make-hard-choices

Highfield, W. E., Norman, S. A., & Brody, S. D. (2013). Examining the 100-Year Floodplain as a Metric of Risk, Loss, and Household Adjustment: Perspective. *Risk Analysis*, *33*(2), 186–191. https://doi.org/10.1111/j.1539-6924.2012.01840.x

Hinds, K. (2019, September 14). Assistant City Manager's View: Freeport seeks grant to move floodway residents and businesses. *The Journal Standard*. https://www.journalstandard.com/story/opinion/columns/guest/2019/09/14/assistant-city-manager-s-view/2791781007/

Hinds, K., & Kopanski, T. (n.d.). *Freeport Pecatonica Flooding Brief*. https://www.illinoisfloods.org/content/documents/5b_-_freeport_pecatonica_flooding_brief.pdf

Hirabayashi, Y., Mahendran, R., Koirala, S., Konoshima, L., Yamazaki, D., Watanabe, S., Kim, H., & Kanae, S. (2013). Global flood risk under climate change. *Nature Climate Change*, *3*(9), 816–821. https://doi.org/10.1038/nclimate1911

Hollenback, R. Z. (2022, December 15). *Shaler Campbell's Graduate Thesis* [Zoom].

Holpuch, A. (2022, August 5). 3 Downpours in 8 Days: How Extreme Rain Soaked the Midwest. *The New York Times*. https://www.nytimes.com/2022/08/05/us/kentucky-missouri-illinois-rain-flooding.html

Holzberg, J. (2012, April 15). The storm called Agnes. *The Baltimore Sun*. https://www.baltimoresun.com/maryland/howard/bs-ho-hurricane-agnes-40th-0415-20120415-story.html

Horton, T. (1992, June 27). Tropical Storm Agnes only accelerated inevitable damage to the Chesapeake. *Baltimore Sun*, 2B.

Howeler, W. (2014, January 14). Athens Borough riverbank project could go out for bid in the spring. *Morning Times*. https://www.morning-times.com/news/article_4c46cf9a-ada6-51eb-a152-201356265541.html

Howeler, W. (2016, September 8). Five years later—'How do we ever come back from that?'—Athens borough officials reflect on the flood of 2011. *Morning-Times.Com*. https://www.morning-times.com/news/article_4593f4a2-425a-5ca0-b345-ba8bc06b24c9.html

Howeler, W. (2017, May 9). Athens: Borough receives DEP award for Chemung River flood protection system. *Morning Times*. https://www.morning-times.com/news/article_1afdd729-88c4-59b6-8fa9-2590780b96bb.html

Isaacs, A. (2018, May 30). Ellicott City's long history of flooding. *WMAR2 Baltimore*. https://www.wmar2news.com/news/crime-checker/harford-county-crime/ellicott-citys-long-history-of-devastating-floods

Jones, B. G. (1986). *Protecting Historic Architecture and Museum Collections from Natural Disasters*. Butterworth-Heinemann.

Jongman, B., Ward, P. J., & Aerts, J. C. J. H. (2012). Global exposure to river and coastal flooding: Long term trends and changes. *Global Environmental Change*, *22*(4), 823–835. https://doi.org/10.1016/j.gloenvcha.2012.07.004

Kerlin, K. (2019, May 15). *Small Towns, Big Flood Waters*. UC Davis. https://www.ucdavis.edu/climate/news/small-towns-big-flood-waters

Kick, E. L., Fraser, J. C., Fulkerson, G. M., McKinney, L. A., & De Vries, D. H. (2011). Repetitive flood victims and acceptance of FEMA mitigation offers: An analysis with community-system policy implications. *Disasters*, *35*(3), 510–539. https://doi.org/10.1111/j.1467-7717.2011.01226.x

Kiner, D. (2019a, May 30). Harrisburg's City Island under water through the years: Vintage photos. *Pennlive*. https://www.pennlive.com/life/2019/05/city-island-under-water-through-the-years.html

Kiner, D. (2019b, September 7). Central Pa.'s 100-year flood—Tropical Storm Lee in 2011. *Pennlive*. https://www.pennlive.com/life/2019/09/central-pas-100-year-flood-tropical-storm-lee-in-2011.html

Knutson, T. R., McBride, J. L., Chan, J., Emanuel, K., Holland, G., Landsea, C., Held, I., Kossin, J. P., Srivastava, A. K., & Sugi, M. (2010). Tropical cyclones and climate change. *Nature Geoscience*, *3*(3), 157–163. https://doi.org/10.1038/ngeo779

Kouhi, S., Hashemi, M. R., Kian, R., Spaulding, M., Lewis, M., & Ginis, I. (2020). Flood risk in past and future: A case study for the Pawtuxet River's record-breaking March 2010 flood event. *Journal of Flood Risk Management*, *13*(4). https://doi.org/10.1111/jfr3.12655

Lal, P., Alavalapati, J. R. R., & Mercer, E. D. (2011). Socio-economic impacts of climate change on rural United States. *Mitigation and Adaptation Strategies for Global Change*, *16*(7), 819–844. https://doi.org/10.1007/s11027-011-9295-9

Lawrence, J., Boston, J., Bell, R., Olufson, S., Kool, R., Hardcastle, M., & Stroombergen, A. (2020). Implementing Pre-Emptive Managed Retreat: Constraints and Novel Insights. *Current Climate Change Reports*, *6*(3), 66–80. https://doi.org/10.1007/s40641-020-00161-z

Leonardi, M. (1977, December 8). Community readiness key to flood control. *Howard County News*.

Logan, E. B. (2018, September 20). Residents back plan to tear down buildings. *The Howard County Times*. https://www.baltimoresun.com/maryland/howard/ph-ho-cf-flood-mitigation-0918-story.html

Logan, E. B. (2019, May 22). Experts weight in on development's impact. *The Howard County Times*. https://www.baltimoresun.com/maryland/howard/ph-ho-cf-flood-development-0523-story.html

Mallakpour, I., & Villarini, G. (2015). The changing nature of flooding across the central United States. *Nature Climate Change*, *5*(3), 250–254. https://doi.org/10.1038/nclimate2516

Mallinson, D. J., Alcantara, E., Behringer, J., Beittel, N., Daniel, A., Paul, J., Redelberger, B., Reeves, M., Schlegel, E., & Xiao, B. (2022). Coping with Severe Weather in Harrisburg. *Penn State Harrisburg*, *PUBPL 304 White Paper No. 3*, 66.

Manuele, K., & Haggerty, M. (2022, October 6). How FEMA Can Build Rural Resilience Through Disaster Preparedness. *Center for American Progress*. https://www.americanprogress.org/article/how-fema-can-build-rural-resilience-through-disaster-preparedness/

Mason, D. (2018, October 10). Floods take toll on Freeport's 3rd Ward, residents plea for help. *The Journal Standard*. https://www.journalstandard.com/story/news/disaster/2018/10/10/floods-take-toll-on-freeport/9587163007/

McDonald, P. (2019, May 29). Despite heavy rain, Susquehanna River in no danger of flooding. *Morning Times*. https://www.morning-times.com/news/article_327841d8-e8b7-5f71-8bc8-566fdae4ea3e.html

McDonald, P. (2021a, September 11). 10 years later, Valley Relief Council still giving back. *The Daily Review*. https://www.thedailyreview.com/news/local/10-years-later-valley-relief-council-still-giving-back/article_7fefd694-d04d-5ee6-9fe1-135d0c3472e9.html

McDonald, P. (2021b, October 28). Susquehanna River nears moderate flood stage, should recede today. *Morning Times*. https://www.morning-times.com/news/article_6f185537-4f86-55ad-bbfe-e05588f2b948.html

McFarland, P. H. (2019, July 3). *Ellicott City, Md., Advances Projects And Refines Plans to Fight Future Floods*. Engineering News-Record. https://www.enr.com/articles/47168-ellicott-city-md-advances-projects-and-refines-plans-to-fight-future-floods

McNeeley, S. M., & Lazrus, H. (2014). The Cultural Theory of Risk for Climate Change Adaptation. *Weather, Climate, and Society*, *6*(4), 506–519. https://doi.org/10.1175/WCAS-D-13-00027.1

Miao, Q., & Davlasheridze, M. (2022). Managed Retreat in the Face of Climate Change: Examining Factors Influencing Buyouts of Floodplain Properties. *Natural Hazards Review*, *23*(1), 04021063. https://doi.org/10.1061/(ASCE)NH.1527-6996.0000534

Miller, B. (2013, April 29). Mayor Linda Thompson unveils "high-water mark" initiative to mark flood levels in Harrisburg—Pennlive.com. *Pennlive*. https://www.pennlive.com/midstate/2013/04/mayor_linda_thompson_unveils_h.html

Miller, D. (2021, July 2). Green infrastructure in Harrisburg combats flooding, pollution. *FOX43*. https://www.fox43.com/article/weather/green-infrastructure-in-harrisburg-combats-flooding-pollution/521-9b60cc52-8091-4c6a-a7a6-52272483192e

Miller, J. (2019, April 20). The story behind the FEMA flood mitigation grant. *The Journal Standard*. https://www.journalstandard.com/story/opinion/columns/guest/2019/04/20/the-story-behind-fema-flood/5384745007/

Miller, J. (2020a, August 21). Mayor's View: Grant helps move downtown streetscape plan forward. *The Journal Standard*. https://www.journalstandard.com/story/opinion/columns/guest/2020/08/21/mayorrsquos-view-grant-helps-move-downtown-streetscape-plan-forward/42798591/

Miller, J. (2020b, December 26). Want to move to drier ground? The city wants to help. *The Journal Standard*. https://www.journalstandard.com/story/opinion/2020/12/26/freeport-wants-help-property-owners-flood-prone-areas/4014147001/

Miller, J. (2021a, August 27). Mayor's View: I can answer some questions on FEMA assistance and flooding. *The Journal Standard*. https://www.journalstandard.com/story/news/2021/08/27/mayors-view-i-can-answer-some-fema-questions/5599476001/

Miller, J. (2021b, August 31). Mayor's View: Freeport has been awarded a grant to buy, demolish flood-prone homes. *The Journal Standard*. https://www.journalstandard.com/story/opinion/2021/08/13/mayors-view-freeport-has-been-awarded-flood-grant/8107182002/

Moderow, A. (2021, August 17). A Moderow Moment: Questions about the Freeport floodway buyout plan. *The Journal Standard*. https://www.journalstandard.com/story/opinion/2021/08/17/moderow-moment-questions-floodway-plan/8148502002/

Moftakhari, H. R., AghaKouchak, A., Sanders, B. F., & Matthew, R. A. (2017). Cumulative hazard: The case of nuisance flooding. *Earth's Future*, *5*(2), 214–223. https://doi.org/10.1002/2016EF000494

Moftakhari, H. R., Salvadori, G., AghaKouchak, A., Sanders, B. F., & Matthew, R. A. (2017). Compounding effects of sea level rise and fluvial flooding. *Proceedings of the National Academy of Sciences*, *114*(37), 9785–9790. https://doi.org/10.1073/pnas.1620325114

Morrison, J. (2023, March 15). How "Daylighting" Buried Waterways Is Revitalizing Cities Across America. *Smithsonian Magazine*. https://www.smithsonianmag.com/innovation/how-daylighting-buried-waterways-is-revitalizing-cities-across-america-180981793/

Moser, S. C. (2005). Impact assessments and policy responses to sea-level rise in three US states: An exploration of human-dimension uncertainties. *Global Environmental Change*, *15*(4), 353–369. https://doi.org/10.1016/j.gloenvcha.2005.08.002

National Weather Service. (n.d.). *High Water Level Terminology*. NOAA's National Weather Service. Retrieved March 16, 2023, from https://www.weather.gov/aprfc/terminology

News Reports. (2021, August 17). Freeport plans to purchase nearly 130 properties prone to Pecatonica River flooding. *The Journal Standard*. https://www.journalstandard.com/story/news/local/2021/08/17/freeport-awarded-fema-grant-to-assist-property-owners-in-floodway/8148589002/

Nichols, K., & Etten, A. V. (2022, June 27). Post-Agnes flood prevention: What's changed in the last 50 years. *ABC27*. https://www.abc27.com/local-news/harrisburg/post-agnes-flood-prevention-whats-changed-in-the-last-50-years/

NYC Planning. (2018). What is inland flooding? *Resiliency FAQ Newsletter*, 2. https://www.nyc.gov/assets/planning/download/pdf/plans-studies/climate-resiliency/resiliency-newsletter-10-inland-flooding.pdf

Oakford, S., Muyskens, J., Cahlan, S., & Lee, J. S. (2022, December 6). *Extreme floods expose the flaws in FEMA's risk maps*. Washington Post. https://www.washingtonpost.com/climate-environment/interactive/2022/fema-flood-risk-maps-failures/

O'Dell, P. (2022, June 23). 2022 marks 50th anniversary of Hurricane Agnes. *The Daily Review*. https://www.thedailyreview.com/news/local/2022-marks-50th-anniversary-of-hurricane-agnes/article_fd1ec82d-ae5b-5695-aadc-d14ff2acd04c.html

Parker, L. (1997, November 6). *Project aims to stem flooding in Ellicott City*.

Pinter, N. (2005). One Step Forward, Two Steps Back on U.S. Floodplains. *Science*, *308*(5719), 207–208. https://doi.org/10.1126/science.1108411

Pinter, N. (2021). The lost history of managed retreat and community relocation in the United States. *Elementa: Science of the Anthropocene*, *9*(1), 00036. https://doi.org/10.1525/elementa.2021.00036

Pinter, N., & Rees, J. C. (2021). Assessing managed flood retreat and community relocation in the Midwest USA. *Natural Hazards*, *107*(1), 497–518. https://doi.org/10.1007/s11069-021-04592-1

Plitt, A. (2019, November 7). Ellicott City, Maryland, flooding—Curbed. *Curbed*. https://archive.curbed.com/2019/11/7/20952101/ellicott-city-maryland-flooding-stormwater-management

Poon, L. (2018, December 12). Why Frequent Urban Flooding Is the Nation's "Hidden Challenge." *Bloomberg*. https://www.bloomberg.com/news/articles/2018-12-12/u-s-urban-flooding-study-it-s-bad-and-getting-worse

Poon, L. (2019, May 24). In a Town Shaped by Water, the River Is Winning. *Bloomberg*. https://www.bloomberg.com/news/articles/2019-05-24/a-historic-river-town-confronts-a-flooded-future

Prein, A. F., Rasmussen, R. M., Ikeda, K., Liu, C., Clark, M. P., & Holland, G. J. (2017). The future intensification of hourly precipitation extremes. *Nature Climate Change*, *7*(1), 48–52. https://doi.org/10.1038/nclimate3168

Preservation Maryland. (n.d.). *After Action Report: Ellicott City, Maryland Flood of 2016*. Preservation Maryland. https://www.preservationmaryland.org/wp-content/uploads/2017/07/preservation-maryland-ellicott-city-flood-after-action-report-2017-web.pdf

Preservation Maryland. (2016, August 4). *Historic Context of the Ellicott City Flood*. Preservation Maryland. https://www.preservationmaryland.org/historic-context-ellicott-city-flood/

Quinlan, M. (2014). *Ten pathways to death and disaster: Learning from fatal incidents in mines and other high hazard workplaces*. The Federation Press.

Quinlan, M. (2020). Five challenges to humanity: Learning from pattern/repeat failures in past disasters? *The Economic and Labour Relations Review*, *31*(3), 444–466. https://doi.org/10.1177/1035304620944301

Razavi, S., Gober, P., Maier, H. R., Brouwer, R., & Wheater, H. (2020). Anthropocene flooding: Challenges for science and society. *Hydrological Processes*, *34*(8), 1996–2000. https://doi.org/10.1002/hyp.13723

Reid, E. (2023, February 16). *Shaler Campbell's Graduate Thesis* [Zoom].

Rice, D. (2016, August 1). Rain that caused deadly Md. Flood a "1-in-1,000" year event. *USA TODAY*. https://www.usatoday.com/story/weather/2016/08/01/ellicott-city-maryland-flood/87914944/

Rufat, S., Tate, E., Burton, C. G., & Maroof, A. S. (2015). Social vulnerability to floods: Review of case studies and implications for measurement. *International Journal of Disaster Risk Reduction*, *14*, 470–486. https://doi.org/10.1016/j.ijdrr.2015.09.013

Sacchetti, M. (2022, August 2). Death toll for Kentucky floods climbs to 28, with more storms coming. *Washington Post*. https://www.washingtonpost.com/nation/2022/07/31/kentucky-flood-climate/

Sadiq, A.-A., & Noonan, D. (2015). Local capacity and resilience to flooding: Community responsiveness to the community ratings system program incentives. *Natural Hazards*, *78*(2), 1413–1428. https://doi.org/10.1007/s11069-015-1776-9

Sarewitz, D., Pielke, R., & Keykhah, M. (2003). Vulnerability and Risk: Some Thoughts from a Political and Policy Perspective. *Risk Analysis*, *23*(4), 805–810. https://doi.org/10.1111/1539-6924.00357

Sarvey, D. (1973, June 23). "An Ounce of Prevention's Worth..." Flood Control Plans Raise Controversy in Area. *The Patriot News*.

Schweigert, K. (2023, February 23). Dauphin County Commissioners award more than $8.3 million from Hollywood Casino gaming grants to local nonprofits and other community programs. *FOX43*. https://www.fox43.com/article/news/local/dauphin-county/dauphin-county-gaming-grant-recipients-2023/521-282cddf4-da51-4ffe-98e6-f9948dec0faf

Shank, W. H. (1972). *Great floods of Pennsylvania: A two-century history* (2nd ed). American Canal and Transportation Center.

Sharp, M. (1973). *Commonwealth of Pennsylvania: Office of the Governor, Harrisburg*.

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, *16*(3), 282–292. https://doi.org/10.1016/j.gloenvcha.2006.03.008

Smith, K. (2022, August 4). *Capacity-limited states still struggle to access FEMA BRIC grants*. Headwaters Economics. https://headwaterseconomics.org/equity/capacity-limited-fema-bric-grants/

Solomon, W. E. (1991, August 25). Northeast Notebook: Harrisburg, Pa.; Cafe-Hotel To Apartments. *The New York Times*. https://www.nytimes.com/1991/08/25/realestate/northeast-notebook-harrisburg-pa-cafehotel-to-apartments.html

Stein, B. (1997, June 19). Floods won't surprise county again. *The Howard County Times*, 10.

Tanoue, M., Hirabayashi, Y., & Ikeuchi, H. (2016). Global-scale river flood vulnerability in the last 50 years. *Scientific Reports*, *6*(1), 36021. https://doi.org/10.1038/srep36021

Tavernise, S. (2011, October 12). City Council in Harrisburg Files Petition of Bankruptcy. *The New York Times*. https://www.nytimes.com/2011/10/13/us/harrisburg-pennsylvania-files-for-bankruptcy.html

Tavory, I., & Timmermans, S. (2014). *Abductive analysis: Theorizing qualitative research*. The University of Chicago Press.

Thomas, C. (2022, November 23). *Shaler Campbell's Graduate Thesis* [Zoom].

Torres, M. N., Lubben, A., & Cassel, Z. (2022, August 10). The government's failure to move vulnerable people out of harm's way in the era of massive flooding. *Mother Jones*. https://www.motherjones.com/environment/2022/08/the-governments-failure-to-move-vulnerable-people-out-of-harms-way-in-the-era-of-climate-change/

Town of Maynard Official. (2022, December 13). *Request for Interview—MIT Urban Studies Research* [Personal communication].

Tristan, D. (2022, June 23). Hurricane Agnes: A disaster timeline. *ABC27*. https://www.abc27.com/digital-originals/hurricane-agnes-a-disaster-timeline/

U.S. Army Corps of Engineers – Baltimore District. (2001). *Non-Structural Flood Damage Reduction Within the Corps of Engineers: What Districts Are Doing:* Defense Technical Information Center. https://doi.org/10.21236/ADA629409

U.S. Army Corps of Engineers – Baltimore District. (2018). *Athens Borough, Bradford County, PA Fact Sheet*. https://usace.contentdm.oclc.org/digital/collection/p16021coll11/id/577/

U.S. EPA. (2022a, June 13). *What is WIFIA?* [Overviews and Factsheets]. https://www.epa.gov/wifia/what-wifia

U.S. EPA. (2022b, June 22). *Combined Sewer Overflows (CSOs)* [Overviews and Factsheets]. https://www.epa.gov/npdes/combined-sewer-overflows-csos

U.S. FEMA. (n.d.-a). *History of Levees*. https://www.fema.gov/sites/default/files/2020-08/fema_history-of-levees_fact-sheet_0512.pdf

U.S. FEMA. (n.d.-b). *Riverine Flooding | National Risk Index*. Retrieved April 3, 2023, from https://hazards.fema.gov/nri/riverine-flooding

U.S. FEMA. (2010). *Substantial Improvement/Substantial Damage Desk Reference*. https://www.fema.gov/sites/default/files/documents/fema_nfip_substantial-improvement-substantial-damage-desk-reference.pdf

U.S. FEMA. (2018). *FEMA Federal Insurance and Mitigation Administration Fact Sheet*. https://www.fema.gov/sites/default/files/2020-07/fema_mitsaves-factsheet_2018.pdf

U.S. FEMA. (2020a, March 5). *Severe Repetitive Loss Building*. https://www.fema.gov/node/405312

U.S. FEMA. (2020b, July 7). *Special Flood Hazard Area (SFHA)*. https://www.fema.gov/glossary/special-flood-hazard-area-sfha

U.S. FEMA. (2021, November 12). *Community Rating System Overview and Participation*. https://www.fema.gov/fact-sheet/community-rating-system-overview-and-participation

U.S. FEMA. (2022a, March 9). *Flood Insurance*. https://www.fema.gov/flood-insurance

U.S. FEMA. (2022b, October 12). *Benefit-Cost Analysis*. https://www.fema.gov/grants/tools/benefit-cost-analysis

U.S. FEMA. (2023a, February 22). *Community Rating System*. https://www.fema.gov/floodplain-management/community-rating-system

U.S. FEMA. (2023b, March 14). *Building Resilient Infrastructure and Communities*. https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities

U.S. Geological Survey. (2022, February 9). *Hydrologic Unit Maps*. https://water.usgs.gov/GIS/huc.html

USACE. (n.d.). *Understanding Flood Risk*. Retrieved March 18, 2023, from https://www.mvr.usace.army.mil/Missions/Flood-Risk-Management/Understanding-Flood-Risk/

Wahl, T., Jain, S., Bender, J., Meyers, S. D., & Luther, M. E. (2015). Increasing risk of compound flooding from storm surge and rainfall for major US cities. *Nature Climate Change*, *5*(12), 1093–1097. https://doi.org/10.1038/nclimate2736

Wetter, O., Pfister, C., Weingartner, R., Luterbacher, J., Reist, T., & Trösch, J. (2011). The largest floods in the High Rhine basin since 1268 assessed from documentary and instrumental evidence. *Hydrological Sciences Journal*, *56*(5), 733–758. https://doi.org/10.1080/02626667.2011.583613

Williams, J. (2018, July 26). Flash flooding hits region. *Morning Times*. https://www.morning-times.com/news/article_1dda1c93-6cef-57c4-8a18-27d5dacb32ad.html

Wilson, D. R. and J. C. (2008, June 15). East side of Freeport flooded. *The Journal Standard*. https://www.journalstandard.com/story/news/2008/06/15/east-side-freeport-flooded/45156423007/

Wing, O. E. J., Lehman, W., Bates, P. D., Sampson, C. C., Quinn, N., Smith, A. M., Neal, J. C., Porter, J. R., & Kousky, C. (2022). Inequitable patterns of US flood risk in the Anthropocene. *Nature Climate Change*, *12*(2), 156–162. https://doi.org/10.1038/s41558-021-01265-6

Wing, O. E. J., Pinter, N., Bates, P. D., & Kousky, C. (2020). New insights into US flood vulnerability revealed from flood insurance big data. *Nature Communications*, *11*(1), 1444. https://doi.org/10.1038/s41467-020-15264-2

Zhang, M. (2016, July 1). Sayre and Athens Communities Brought Together by 2006, 2011 Floods. *Spectrum News*. https://www.ny1.com/nyc/queens/news/2016/06/21/sayre-and-athens-communities-brought-together-by-2006-and-2011-floods

Zhang, S., Zhou, L., Zhang, L., Yang, Y., Wei, Z., Zhou, S., Yang, D., Yang, X., Wu, X., Zhang, Y., Li, X., & Dai, Y. (2022). Reconciling disagreement on global river flood changes in a warming climate. *Nature Climate Change*, *12*(12), 1160–1167. https://doi.org/10.1038/s41558-022-01539-7

Zurich Insurance. (2022, June 8). *Three common types of flood explained*. https://www.zurich.com/en/knowledge/topics/flood-and-water-damage/three-common-types-of-flood

Appendix

Table 7 – List of Interviewees
Source: Author

List of Interviewees						
#	Name	City or Agency	Position	Comments	Interview 1	Interview 2
1	Craig Thomas	US Army Corps of Engineers (USACE)	Regional Technical Specialist (RTS) for the North Atlantic Division	Baltimore District	11/23/2022	02/14/2023
2	Geoffrey Knight	City of Harrisburg, PA	Planning Director, Floodplain Manager, Zoning Director, and Historic Preservation Leader		11/23/2022	02/24/2023
3	R. Zachary Hollenbeck	Howard County, MD	Department of Public Works, Deputy Chief, Bureau of Facilities		12/15/2022	02/23/2023
4	Wayne Duckmann	City of Freeport, IL	Director of Community & Economic Development	Equivalent of Planning Director	12/16/2022	02/14/2023
5	Mark Richmond	Howard County, MD	Chief of Stormwater Management Division		12/29/2022	-
6	Christopher Fisher	Dauphin County, PA	Department of Public Safety, Office of Emergency Management, Deputy Director		01/05/2023	-
7	Lexi Passaro	Dauphin County, PA	Department of Public Safety, Office of Emergency Management, Planning Specialist		01/05/2023	-
8	Johanna Coletti	McHenry County, IL	Water Resources Manager & Chief Stormwater Engineer	Local Expert on FEMA CRS	01/10/2023	-
9	Gerard Duke	Dauphin County Planning Commission/Tri-	Planning Coordinator		01/12/2023	-

		County Regional Planning Commission				
10	George Connor	Dauphin County, PA	Executive Director, Community and Economic Development		01/13/2023	-
11	Doug Brown	Dauphin County, PA	Deputy Director, Community and Economic Development		01/24/2023	-
12	Eric Setter	Region 1 Planning	Land Bank Coordinator	Region 1 Assists Freeport, IL	02/16/2023	-
13	Edmund Reid	Athens Township, PA	Zoning Officer		02/16/2023	-
14	Scott Riley	Athens Borough, PA	Borough Council President and Emergency Management Director		02/16/2023	-