Stakeholder perceptions of flooding issues in the Wildcat Creek Watershed

by

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Abstract

Wildcat Creek Watershed near Manhattan, Kansas, experiences damaging flash floods that have required evacuations in recent years (Spicer 2011). The purpose of this study was to qualitatively examine the issue of flooding in the Wildcat Creek Watershed through interviewing stakeholders (those that reside, own a business, or study) using a semi – structured approach. Interview discussion examined stakeholders' perceptions of 1) how they understand the processes that create the flooding hazard, 2) whether or not they value the implementation of mitigation efforts to reduce the negative impacts of flooding, 3) whether they feel at risk to flooding, and 4) who they consider a trusted source of information about the hydrologic characteristics of the watershed.

Based on the results of this study, a spatial relationship in perceptions of flooding issues in the Wildcat Creek Watershed was found. Across the study area, stakeholders understood many of the physical causes of flooding, but did not tend to see the connections among the many physical components. Overall, stakeholders believed that mitigation strategies to curb flash flooding were valuable, although many were not supportive of paying for these efforts through potential taxation from a watershed district. Despite the increase of flooding events in the past decade (Anderson 2011), many stakeholders neither saw any changes in their personal risk of exposure to flooding nor a change in their flood vulnerability. In the context of the flooding issue in Wildcat Creek Watershed, most participants trusted their neighbors and community leaders as sources of information instead of professionals who research and/or conduct work on the watershed.

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Acknowledgements

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Dedication

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Chapter 1 - Introduction

Wildcat Creek Watershed, located northwest of the city of Manhattan, Kansas, is susceptible to flash flooding that can cause damage to both public and private property (Anderson 2011). Over the course of the past decade, flash flooding in this area has increased in both frequency and magnitude (Bunger *et al.* 2013; Spicer 2011). Thus, hazard management to mitigate losses becomes an important issue. The cities and towns of Manhattan, Keats, Riley, and Leonardville, as well as Fort Riley and Riley County have significant stake in the watershed, and have different motivations in managing the resources that Wildcat Creek Watershed provides. Due to its location amongst five administrative units, management decisions are often difficult to apply to the entire watershed. To further complicate matters, the United States Army Corps of Engineering manages Tuttle Creek Dam and Reservoir located east of the watershed.

Manhattan serves as a major population center in Northeast Kansas, and flash flooding of Wildcat Creek has endangered residents. Although most of Manhattan is situated east of the watershed, many city residents live inside the watershed in the southwestern part of the city. Over the past twenty-five years, Manhattan has seen an increase of 22,000 residents, a significant rise of 47.4%. Much of this increase is due to Manhattan's proximity to the Fort Riley Army Installation and the influx of military personnel returning from posts overseas. Manhattan is also home to Kansas State University, which serves as one of Kansas' largest public universities that has a student population of nearly 25,000 and employs nearly 3,000 staff and faculty. K-State's student enrollment is expected to increase as part of its "K-State 2025" strategic plan. As Manhattan grows, additional residents will add to those at risk to flash flooding by Wildcat Creek.

1.1 Significance of Study

Although Wildcat Creek Watershed covers a relatively small area, considerable research has been conducted. Most of these studies focus on environmental issues and water resources (e.g., endangered species, water quality, erosion) (Keane *et al.* 2012; Mammoliti 2004) and a few discuss the specific issue of the physical aspects of flooding inside Wildcat Creek Watershed (*i.e.*, mitigation strategies, cost-benefit analyses) (Denlinger 2012; Bunger *et al.* 2013). Despite the multitude of studies of Wildcat Creek Watershed, more work could be done to address the social context of flooding. As White (1945) outlines, it is difficult to create policy without understanding the societal interactions included in flooding hazards. A purpose of this study is to address the lack of social research in context of stream – related flooding hazards. Results from this study will provide the opportunity for residents and community decision makers of Wildcat Creek Watershed to better understand the motivations of people who call it home.

1.2 Justification of Study

Studies in human perception of the environment can provide insight into how people make decisions and interact with their environment (Unwin 1992). Management of the physical environment, particularly natural resources, are a direct result of how humans perceive the natural environment (Lowenthal 1961). Downs (1967) discussed how perceptions are part of an interrelated system between people and their environment. Studying human perceptions of the environment can also give insight into the interconnected relationship between people and the physical environment in context of natural hazards.

In studies of perceptions of natural hazards, conclusions are typically drawn by measuring the multitude of adjustment choices that are available to any individual (White 1945).

By studying flood hazard perception, information can be drawn on: 1) the degree of human occupance in hazard – prone areas, 2) local adjustments to flooding, 3) how people understand the frequency of flooding, 4) the social context of adopting different damage – reducing adjustments, and 5) an optimal formula of adjustments in the context of social consequences (Burton, Kates, and White 1968)

Due to the human-modified landscape, it is important to examine the relationships between people and the flooding that they experience from multiple perspectives. It is also important to understand the complexity of natural and human processes, and how processes are an aggregate of many local systems. Only then, can more complete assumptions about flooding be discussed in a truly meaningful context. Understanding the relationship between micro-processes (flooding in a single watershed) and macro-level systems (Mississippi River Watershed flooding) is needed to better understand how our world works (Turner *et al.* 1990). This bottom-up approach that recognizes the importance of global change in local places was heralded in a seminal paper by Wilbanks and Kates (1999). This study attempts to better understand flood perceptions at the local level.

1.3 Objectives

Findings from this research will inform local decision makers that wish to mitigate flood risk and reduce the negative impacts of flooding in the Wildcat Creek Watershed. This study hopes to achieve that by: 1) providing a better understanding of the motivations of stakeholders in context of flooding issues, 2) highlight stakeholder gaps in knowledge about the causes of flooding, 3) gauge willingness to take part in mitigation efforts to reduce the flood risk, 4) explore stakeholder misconceptions about flood risk and vulnerability, and 5) examine who stakeholders trust in context of information dissemination.

1.4 Research Questions

To understand the perceptions of flooding hazards by stakeholders of the Wildcat Creek Watershed, the following research questions were created. Through consultation with faculty at Kansas State University that are aware of the local issues and/or study Wildcat Creek Watershed, these questions were directed towards particular gaps in knowledge:

1. Do stakeholders of the Wildcat Creek watershed understand watershed/flood processes (*i.e.* how water flows through a watershed, and how a flood develops), and does that understanding change based on their proximity to the floodplain?

2. Do stakeholders of the Wildcat Creek Watershed believe that flood mitigation procedures such as water retention basins, wetland restoration, and building relocation/removal are valuable to reduce flood vulnerability, and who do they believe should pay for these improvements?

3. Do the stakeholders in the Wildcat Creek Watershed believe that their risk of flooding has changed over time? If so, why do they believe that?

4. Who would stakeholders of the Wildcat Creek watershed go to for obtaining information about how the creek functions, and how might this affect their views on flooding in their neighborhoods?

Chapter 2 - Literature Review

2.1 Human Involvement in Flooding

Geologic evidence indicates that flooding existed even before humans arrived on the scene. With human settlement near sources of water, considerations of flooding have occurred. Flooding is a natural phenomenon that becomes a hazard for humans when there is injury, a loss of life, or damage to the resources that humans have acquired. In a number of cases, human actions in modifying the landscape have increased both the frequency and magnitude of flooding. Through their modification of natural features, as well as encroaching on natural floodplains, humans have played a major role in increasing flood hazards (Goudie 2006).

Whether it is for generating power, mitigating flood risk, or to increase agricultural production, humans have deliberately modified the Earth's water resources. These modifications cause changes in the natural cycling of water, and can greatly affect how a system responds to any perturbation. Many of these modifications to natural water resources are created to reduce the risks from flooding that can occur to those that either live in or near the floodplain. A conundrum can occur in these cases of mitigation, however. The flooding hazard still exists and there is potential that mitigation efforts, such as levee building, will be insufficient in extreme cases and create an even larger flood event that negatively affects the people that the mitigation sought to protect (Burton and Kates 1964).

Modifications to the physical environment for the sake of managing natural resources, have implications for both the natural system and those that choose to live or work in hazard prone areas. In many situations, human adjustments to natural hazards combined with modified natural processes have the potential to increase the destruction caused by hazards in flood prone areas. It was not until White's (1945) *Human Adjustment to Floods* that adjustment strategies were examined as a function of the combined experience and knowledge of decision-makers who implement them. Adjustments are an adapted behavior that is directly affected by perceived risk (Burton and Kates 1964). By examining the hazard perceptions of stakeholders living in hazardous environments, geographers can better understand the decision-making processes that occur in the development of human-created flood adjustments (Brilly & Polic 2005).

2.2 Perceiving Flood Hazards

Perception studies saw their beginning in sociology and psychology based on the idea that an individual's knowledge of the world is created by the senses and stimuli that act upon the senses (Wood 1970; Unwin 1992). Psychologists studied how the effects of learning and experience caused changes in how people viewed their own lives. Take the glass half empty/half full analogy for example; people perceive the glass as half empty or half full based on a combination of their own experience, as well as their attitude. Human perception of a reservoir can suggest that the level is below the normal pool volume or that the impoundment is almost full. According to Wood (1970), psychological studies on human perceptions failed to address the relationship between people and the physical environment. To many geographers, these studies were as if people existed by themselves in the universe, left to form their own opinions and develop their own behaviors solely based on personal experience and knowledge.

It was not until the 1960's that studies of human perception were a consideration for application to not only geographic research, but for research on the environment. According to Unwin (1992), many geographers such as David Lowenthal and Reg Golledge began to consider using human perceptions of the environment to study how people interact with the physical world. Management of the physical environment, particularly natural resources, is a direct result of how humans perceive the natural environment (Lowenthal 1961). Despite these assertions, it was not until the late 1960's when Cox and Golledge (1969) connected the study of perceptions with behavioral geography. Downs (1967) discussed how perceptions are part of an interrelated system between people and their environment (Figure 2-1):

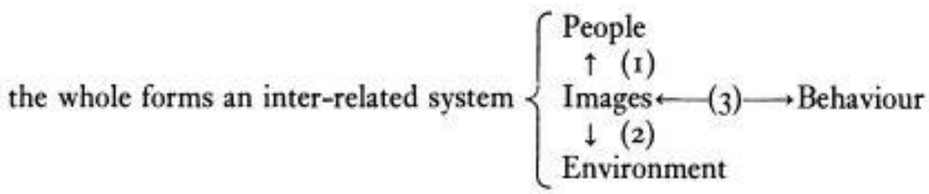

Figure 2-1: Conceptual model of behavioral geography as a result of human perceptions (images) of their environment (Source: Downs 1967)

In the Downs model, there is an outcome of the exchange between people and the environment (images in the human mind). However, this interaction is not the only thing of concern. Human created images of the environment (perceptions) are developed through human's experience with the physical world and human knowledge of environmental processes (Burton and Kates 1964). The intersection of experience and knowledge directly affects the decisions that an individual makes concerning their environment. Saarinen (1969) stated that perception can depend on any phenomenon and one's ability to sense that phenomenon. Perceptions can only then be inferred by examination of the behaviors of those sensing the phenomenon (Saarinen 1969). By examining perceptions, geographers can begin to understand what causes people to make specific decisions about adjustments to flooding.

Another way of conceptualizing this is the nested human-environment model created by Sonnenfeld (1969). By nesting the many different environments, Figure 2-2 shows that the entire world (geographic environment) can be thought of as: 1) an operational environment (areas that an individual is part of), 2) a perceptual environment (experience and knowledge that an individual obtains about their operational environment), and 3) a behavioral environment (where individuals act out the decisions they have made about their environment). This model stresses the importance of the development of behavior by having it as the inner-most level. Individual behavior is a result of the physical environment, where that individual chooses to operate, and finally, their experience and knowledge about the operational environment.

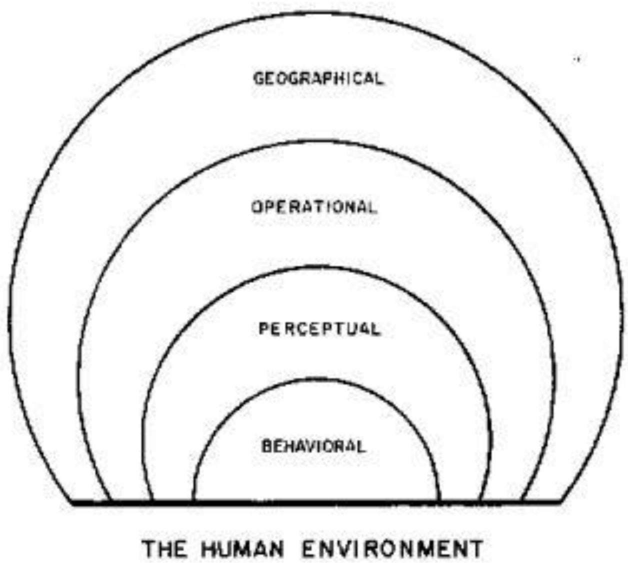

Figure 2-2: The nested human environment. Each nested circle is a result of the combination of circles above it. (Source: Sonnenfeld 1969)

A more modern conception of environmental behavior is the values, beliefs, norms (VBN) model of environmentalism (Figure 2-3). In the VBN model, environmentally significant behavior is a causal chain of the individual's values, their beliefs, and personal norms that lead to a decision about one's environment (Stern 2000). Individualistic values are how any individual views their world; in Stern's model, three values are identified: 1) biospheric (for the benefit of the Earth), 2) altruistic (for the betterment of others), and 3) egoistic (people acting for themselves). An individual's beliefs are then influenced by one or more of these three motivations: the New Environmental Paradigm (NEP), their awareness of adverse consequences

(AC), and their personal feelings of responsibility (AR) (Stern 2000). The NEP is the viewpoint that humans represent only part of an increasingly complicated and interconnected biosphere (Dunlap *et al.* 2000). For example, if an individual held an altruistic value towards flooding, their beliefs would center on adverse consequences to others, and how they believe they can contribute to correcting the issue. Both values and beliefs influence personal norms of obligation towards environmental behavior. Environmental behavior is a result of value and belief interpreted norms. However, if an individual holds egoistic values, they are unlikely to make positive environmental decisions (Stern 2000).

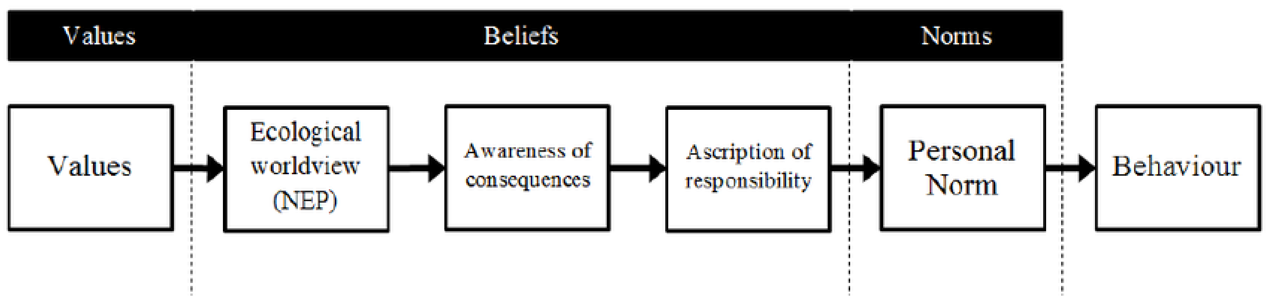

Figure 2-3: The Values, Beliefs, Norms (VBN) model of environmental behavior (Source: Klockner 2013, adapted from Stern 2000)

Behavioral geography examines the relationship between people and their environment and how that interaction effects decision-making across space. It was not until the studies of Gilbert White and his colleagues at the University of Chicago that human perceptions were used as a means of addressing and assessing human interactions with their environment (Unwin 1992). Work by members of the Chicago school of geographers concerned the use of natural resources, human adjustments, and how the intersection of these factors can affect natural hazards. Much of their early work was conducted on floodplain management and development of a better understanding of the flood hazard.

Hazard perception developed at the intersection of many different factors. Experience, knowledge, and multiple socio-economic factors combine to form an individual's perception of flooding (Burton and Kates 1964; Saarinen 1969; Raska 2015). In studies of perceptions of natural hazards, conclusions are typically drawn by measuring the multitude of adjustment choices that are available to any individual. Burton, Kates, and White (1968) asserted that perceptions research in context of natural hazards would help to approach the following:

> 1) Assess the extent of human occupance by hazard zones, 2) identify the full range of possible human adjustments to the hazard, 3) study how man perceives and estimates the occurrence of hazard, 4) describe the process of adoption of damage-reducing adjustments in their social context, and, 5) estimate the optimal set of adjustments in terms of anticipated social consequences. (Burton, Kates, and White 1968)

For this reason, perceptions studies on natural hazards are typically geared toward decision-makers that can affect policy development and rule making. The same adjustments cannot always be applied to every location, and for that reason there are a variety of adjustment choices. Decisions involve adjustments that are both structural and/or preventative in nature. This process does not just consider the physical repercussions of any hazard adjustment, but also the social issues that may arise out of adopting hazard mitigation procedures. By examining the different types of adjustments to flooding, one can appreciate how mitigation efforts can be applied alone or in concert to help reduce the human and physical impacts of a natural hazard.

Studies on the perceptions of flooding range from how people behave around flood waters, manage water resources and reduce risk concerning nuisance flooding, how people view the response by emergency managers to warn citizens about risk, and the differences between perceptions of riverine flooding and flash flooding (Moftakhari *et al.* 2017; Becker *et al.* 2015; Hayden *et al.* 2007; Knocke and Kolivras 2007). Becker *et al.* (2010) examined why people entered floodwaters, and the reasons behind those decisions. It was found that people enter flooded areas for five main reasons: 1) for recreation, 2) to reach a destination, 3) retrieve lost property, 4) undertaking employment tasks, and 5) rescuing/assisting evacuation (Becker *et al.* 2015; FitzGerald *et al.* 2010; French *et al.* 1983; Jonkman and Kelman 2005; Becker *et al.* 2010; Coates 1999). Human behavior around flooding was a result of their perceptions of their flood risk and social influences (Becker *et al.* 2015). For example, people underestimate their risk to flooding because they overestimate their ability to survive a negative impact (Franklin *et al.* 2014; Ruin *et al.* 2007). This underestimation of risk can also be due to familiarity with an area (Maples and Tiefenbacher 2009; Petrucci and Pasqua 2012). Differences in demographics can also play a role in how people behave around flood waters (Becker *et al.* 2015). Those who are young and old tend to see more negative impacts from flooding, with inexperience in the case of the former, and lack of mobility the latter (French *et al.* 1983).

2.3 Adjusting to Flooding Hazards

In response to the flood hazard in river valleys, people have created a multitude of adjustment strategies to alleviate negative impacts (Figure 2-4). A large portion of these options have been focused on engineered solutions that limit or prevent the movement of water into inhabited areas, but some options involve a design with a nature mindset as well (Burton and Kates 1964). Engineered solutions are focused on creating infrastructure to protect populations from storm water; this can be in the form of dams, levees, or embankments. On the other hand, preventative measures are focused on preparing both cities and individuals to cope with the impacts of natural flooding events. Examples of preventative measures in context of flooding include: zoning ordinances, better land-use practices, storm water taxation, and flood insurance.

By prevention/limitation of housing development in the floodplain, there is less opportunity for people to build valuable structures in hazard prone areas. However, in the case that they do, they may be protected from any potential negative impact through insurance.

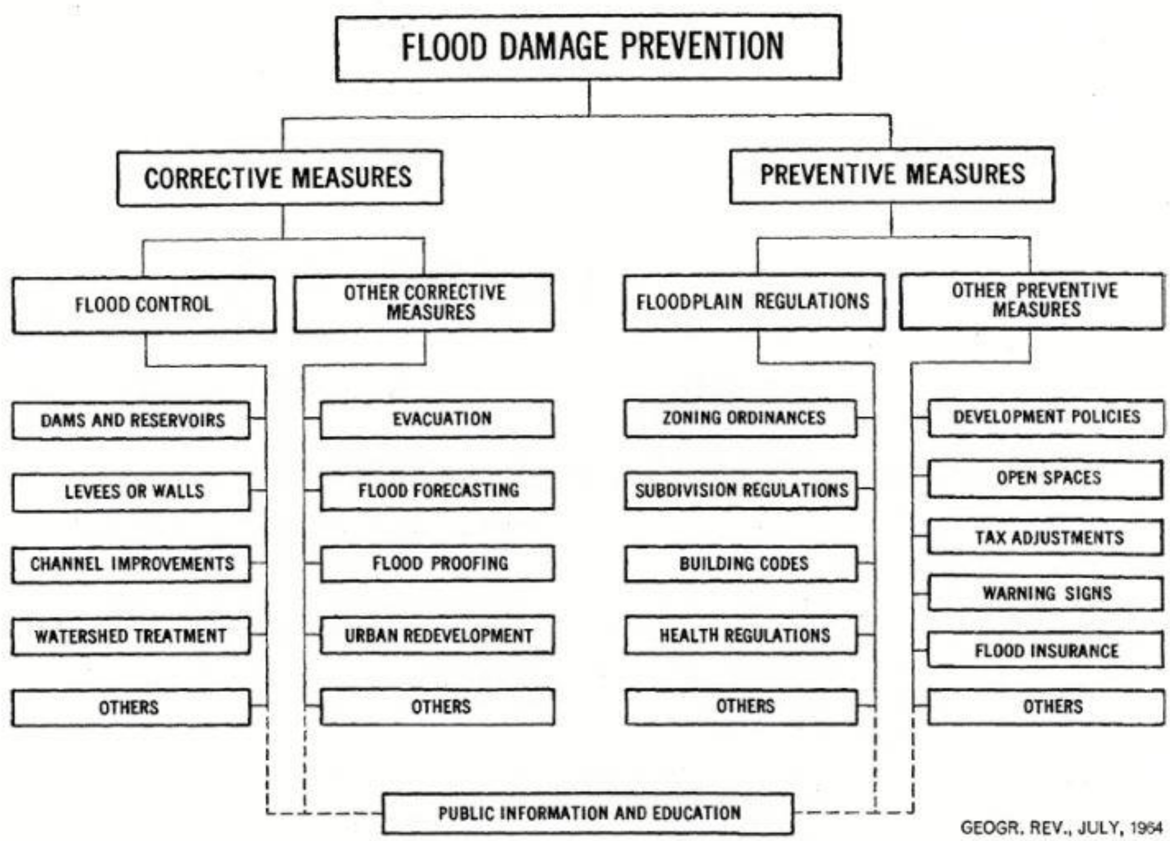

Figure 2-4: Tennessee Valley Authority (TVA) adjustment strategies to flooding (Source: cited in Burton and Kates 1964)

Although structural adjustments are designed to alleviate negative impacts from flooding, there are many cases where they fail to do so (Goudie 2006; Burton and Kates 1964; Hazarinka *et al.* 2016). When this happens, the negative effects of flooding hazards can be exponentially greater than they would have been without the structural measure in place. Hurricane Katrina in 2005 is a recent reminder of a failed structural adjustment to flooding. When major levee breaches occurred along the Industrial Canal, the Lower Ninth Ward was inundated (Kates *et al.*

2006). Structural measures are typically created to withstand only a certain level of exposure (e.g., a 100-year return period event) (Thieken *et al.* 2014). Many times, the structure creates a false sense of security to stakeholders that depend on the limited protection of the control infrastructure, causing them to be less prepared as well as less knowledgeable about the hazard. In the case of structural integrity failure of engineered adjustments, people are caught off guard and are more susceptible to the flooding event (Wisner *et al.* 2003; Bosher 2014; Wheater and Evans 2009; Motoyoshi 2006; Slovic *et al.* 1974). Levee failure during Hurricane Katrina caused parts of New Orleans to be completely devastated (Kates *et al.* 2006). Resident's perceived safety was based on their faith in the levee system. Montz and Tobin (2011) indicated that people's perceptions of hazards are dependent on their recognition of the hazard. For many, hazards are not perceived as dangerous because of the infrastructure set in place to protect them. For this reason, it is important to educate people about the combination of both structural and preventative adjustments so that negative impacts to flooding hazards be reduced as much as possible.

2.4 Local Scale Perceptions

Due to the human-modified landscape, it is important to examine the relationships between people and their environment at every level. Only then, can large scale assumptions about flooding be discussed. For example, there are thousands of catchments in the Greater Mississippi Watershed. Each one of these sub-units has been modified in different ways. The conditions that exist within the Wildcat Creek Watershed cannot be replicated at another location, because local conditions are a combination of many unique physical factors (e.g. Flint Hills topography, local soil types, and native vegetation) as well as many unique human factors (e.g. urban development along Scenic Drive, unique cultural norms, and demographic makeup). Within an academic focus that tends to concentrate on continental to global scale changes, it is important to understand the complexity of natural and human processes, and how processes are an aggregate of many local systems. Understanding the relationship between micro-processes (flooding in a single watershed) and macro-level systems (Mississippi River Watershed flooding) is needed to better understand how our world works (Turner *et al.* 1990). This bottom-up approach recognizes the importance of local places (Wilbanks and Kates 1999).

It is easy for a geographer to say that "scale matters", but examining complex processes from a bottom up perspective allows for an examination of the differences in human agency (individuals making their own choices in different locations), the application of local scale studies to larger areas for comparison, as well as an examination of the differences among places (Harrington and Harrington 2011; Wilbanks and Kates 1999). Although many studies have been conducted on watershed-level hazard perceptions, it is important to study Wildcat Creek Watershed in particular due to its unique characteristics.

2.4.1 Wildcat Creek Studies

Environmental issues have been the focus of the majority of research on the relatively small Wildcat Creek watershed (Keane *et al.* 2012; Bunger *et al.* 2013, Mammoliti 2004). Only a few discuss the physical aspects of flooding inside Wildcat Creek Watershed including mitigation strategies and related cost-benefit analyses (Engelke 2012; Denlinger 2012).

Under the direction of Dr. Tim Keane at Kansas State University, a series of studies were conducted on environmental issues in the Wildcat Creek Watershed. A major contribution was the watershed assessment study which considered the varying physical characteristics of nineteen reaches of the watershed (Keane *et al.* 2011). The assessment was able to identify that the lower reaches of the watershed were more prone to flooding for reasons such as urban development, channel straightening, and storm water redirection. In the same vein, there have been several studies that provide suggestions for reducing flooding in the Wildcat Creek Watershed. These options include: the creation of riparian corridors in both agricultural and urban areas, construction of golf courses in the floodplain to slow runoff and absorb more moisture, implementation of wetland areas, and the creation of rainwater harvesting networks (Denlinger 2012; Clark 2012; Musoke 2012; Engelke 2012). Other studies have focused on the Topeka Shiner, a small, endangered fish species in stream ecosystems of the Flint Hills that is found in the Wildcat Creek Watershed. Recovery plans including the development of specific aquatic habitats for the Topeka Shiner within the watershed have been proposed (Mammoliti 2004).

One of the most influential studies on the Wildcat Creek Watershed was the Wildcat Creek Resiliency Project (WCRP). Developed and submitted by Kansas State University, the Kansas Department of Agriculture, Riley County, Kansas, the Flint Hills Regional Council, and the City of Manhattan, the WCRP was a 2015 grant proposal to obtain funds (approximately $60 million) from the US Department of Housing and Urban Development (HUD) for the purpose of mitigating flood risk in the Wildcat Creek Watershed. This proposed project sought to create a system – wide solution to flooding by developing flood mitigation efforts through property and easement acquisitions from landowners. Some of the proposed mitigation efforts included detention and retention basins, development of trails and parks, and wetland restoration. Unfortunately, the WCRP was not granted funding and left many associated with the proposed project very disappointed.

Despite the multitude of studies in the Wildcat Creek Watershed, there have yet to be any on the perceptions of stakeholders in the watershed. As White outlines, it is difficult to create policy without understanding the social context of flooding hazards (White 1945). This study seeks to provide that social context to the issues of flooding along Wildcat Creek. It is hoped that this study can be combined with other work to influence decisions and policy makers so that they consider not only the physical aspects, but also the social context of flooding in the Wildcat Creek Watershed.

2.5 Vulnerability, Risk, and Mitigation

A study on natural hazards is not complete without discussing vulnerability, risk, and mitigation. Vulnerability is the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including exposure to the hazard, sensitivity or susceptibility to harm, and an ability to adapt or perhaps the lack of capacity to cope with a negative impact. To go along with vulnerability, risk is the potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability or likelihood of occurrence of hazardous events multiplied by the impacts if these events do occur. In simple terms, risk is how likely an individual or group of individuals is to being negatively impacted by a hazard, while vulnerability is the combination of exposure, sensitivity, and adaptive capacity of those individuals if they were to experience a negative impact. Turner *et al.* (2003) provide an insightful explanation into vulnerability:

> "Research demonstrates that vulnerability is registered not by exposure to hazards (perturbations and stresses) alone but also resides in the sensitivity and resilience of the system experiencing such hazards."

Mitigation efforts are focused on reducing both the risk and vulnerability to natural hazards through structural and non-structural adjustments (Burton and Kates 1964). Structural adjustments to hazards could be the development of a levee to reduce the risk of flooding up to a certain amount of exposure. Non-structural adjustments are things like purchasing flood insurance or removing one's self or property of value from the flood plain.

Vulnerability research in natural hazards is focused on three subject areas: 1) vulnerability as a biophysical condition or source of exposure (Rosenfeld 1994), 2) vulnerability as socially constructed and/or social responses (Blaikie *et al.* 1994), and 3) vulnerability as both a biophysical condition and a social response (Cutter *et al*. 2000). Studies on the biophysical conditions of vulnerability focus on how people and places are vulnerable due to being in areas that are at a high risk to a hazard. Studies concerning the social context of vulnerability focus on how places and people are vulnerable due to settlement patterns ignoring hazards and how access to resources are unevenly distributed throughout a society. The third focus seeks to combine the two (Montz *et al.* 2004). White (1964) discusses how vulnerability can increase as time passes following a major hazard. After a major event, people are concerned about not only their risk, but the risks to others in their communities causing an increased awareness of the hazard. As time passes without an event, people tend to worry less about the hazard causing their awareness to decrease. This decrease in awareness can cause communities that are prone to hazard events to have a heightened vulnerability to the hazard (White 1964).

Chapter 3 - Study Area

3.1 Introduction

Wildcat Creek Watershed, located in Northeast, Kansas, is prone to flash flooding that has caused significant damage to both public and private properties (Anderson 2011). Beginning with the headwaters northwest of the city of Leonardville, Kansas, Wildcat Creek flows nearly 36 km straight line distance over a substrate of limestone bedrock to the confluence of the Kansas River just southwest of the city of Manhattan, Kansas (Figure 3-1). According to Franssen and Gido (2006), the catchment is 190 km^2, with an average discharge of 0.06 m^3s^{-1}, with moderate discharge increases in the spring.

Due to its size, the Wildcat Creek Watershed spans across several administrative units. Starting with the upper reaches; the creek flows from the headwaters southwest of Leonardville in a southeasterly direction through the town of Riley. Continuing its southeasterly course, Wildcat Creek runs through the unincorporated town of Keats until it reaches the southwestern part of the City of Manhattan in the lower reaches. Manhattan, which got its foundation at the junction of the Big Blue and Kansas Rivers, has extended westward so that a growing portion of the city is nestled between the confluence of Wildcat Creek and the Kansas River in the southeastern portion of the watershed. The western third of Wildcat Creek Watershed is owned and managed by the US Army's Fort Riley Military Installation. The entirety of the watershed is within the boundaries of Riley County, Kansas.

Administration of the Wildcat Creek Watershed is difficult due to the plurality of cities and governmental entities that might be involved in resource management (Figure 3-1). The cities and towns of Manhattan, Keats, Riley, and Leonardville, as well as Fort Riley and Riley County all have significant stake in the watershed.

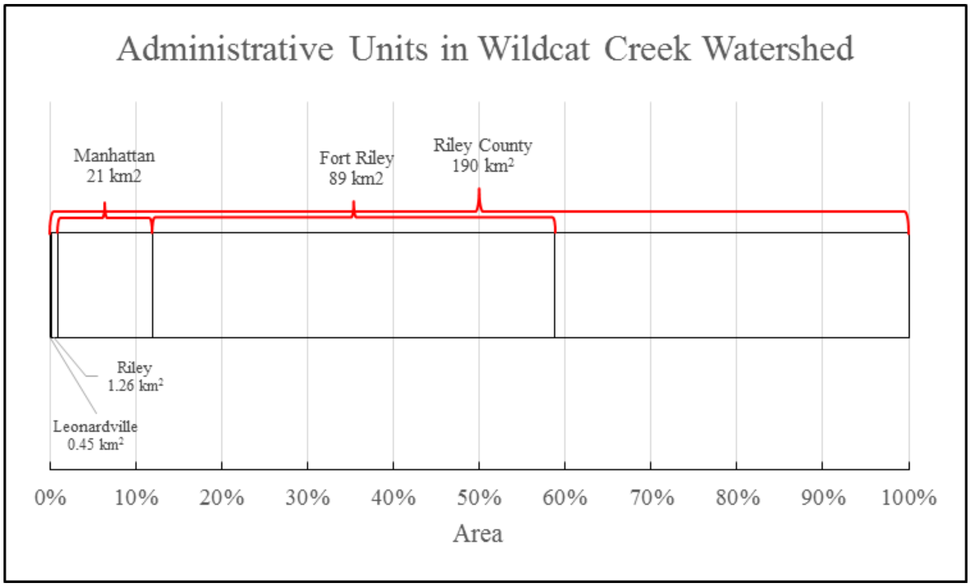

Figure 3-1: Administrative bodies inside Wildcat Creek Watershed (Source: Author)

To further compound matters, the United States Army Corps of Engineering (USACE) also has significant stake. This is due to the central location of Wildcat Creek between USACE managed Tuttle Creek and Milford Lake reservoirs. To illustrate management difficulties, take Fort Riley for example. If Fort Riley were to propose a land use practice for the entirety of the watershed, the governments of Riley, Leonardville, Riley County, and the City of Manhattan must first be consulted. For this reason, a watershed district has been proposed for the Wildcat Creek Watershed so that it can be managed as one unit rather than a part of many separate entities (Bunger *et al.* 2013).

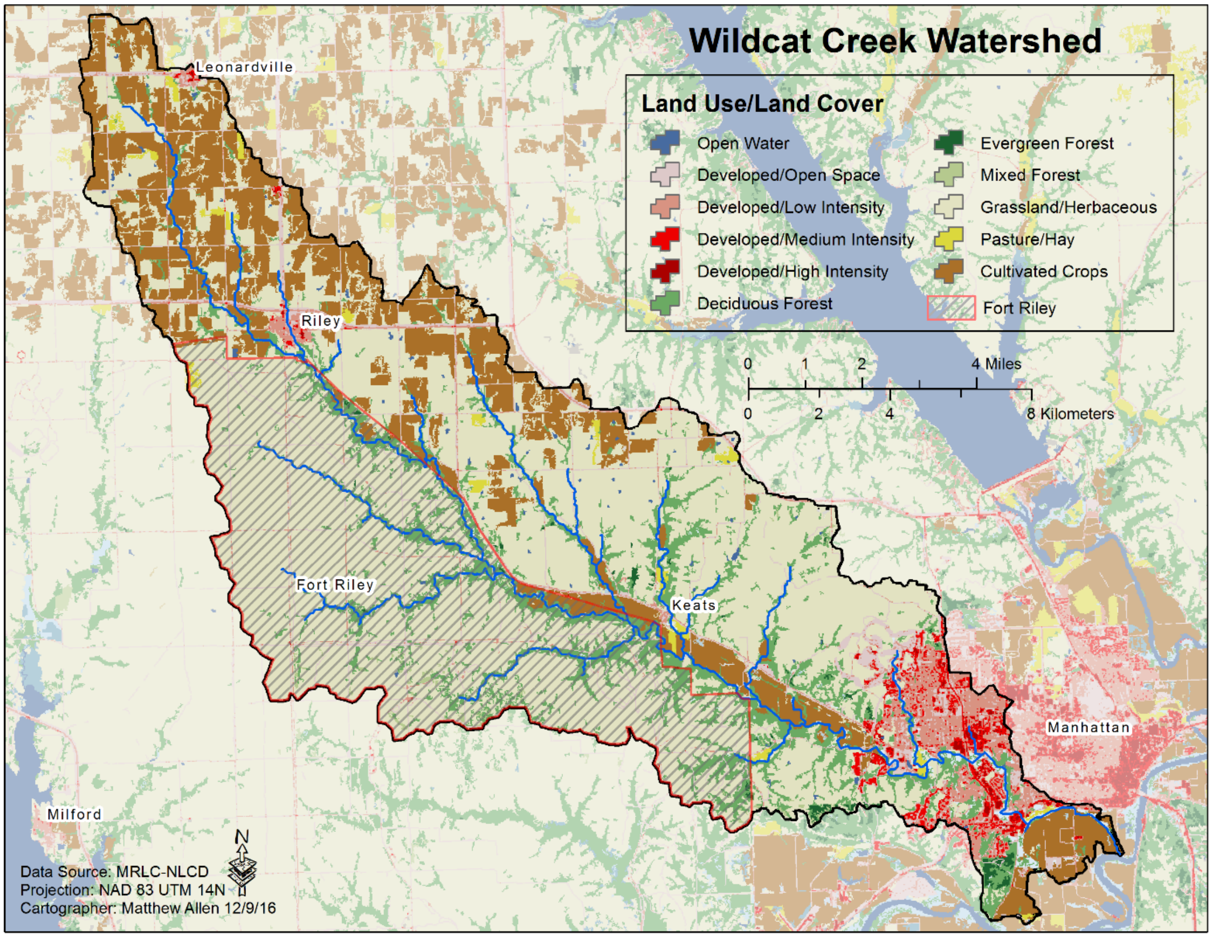

Figure 3-2: Land Use/Land Cover map of the Wildcat Creek Watershed (Source: Author, Data: National Land Cover Dataset 2011; Fort Riley Integrated Training and Management)

3.2 Areas of Interest

3.2.1 Manhattan

The City of Manhattan is a major population center in Northeastern Kansas and an urbanized area based on US Census definitions of city size. Manhattan residents occupy the area of highest population density in the Wildcat Creek Watershed. Although the majority of Manhattan lies east of the watershed, a large number of city residents live in the western portion of the city that coincides with the watershed. For this reason, there are consequences for both the watershed in terms of future development, and the city in terms of flood vulnerability. The western growth of Manhattan can be attributed to significant increases in the population over the last twenty years. In 1990, Manhattan had roughly 38,000 residents. Ten years later that number increased to nearly 45,000 people; an increase of 19%. In the 2010 Census, Manhattan had 52,281 residents (Bunger *et al.* 2013). Five years later, the US Census Bureau estimated that nearly 56,000 people lived inside the Manhattan city limits (US Census Bureau 2015). A large portion of this increase can be attributed to the restructuring of Army forces as part of the Base Realignment and Closure (BRAC) Project, and the return to the United States of the Big Red One First Infantry unit now housed at Fort Riley. Military personnel at Fort Riley nearly doubled from 9,500 to 18,000 (Lynch 2011). Military personnel receive a housing allowance from the federal government that many use to select Manhattan for a place to live due to quality of schools and housing stock. Over the recent twenty-five year period, Manhattan has had an influx of 22,000 residents, a staggering increase of 47.4%. Manhattan has also surpassed the city of Lenexa (suburb of Kansas City), as the eighth largest city in Kansas (Bunger *et al.* 2013).

Manhattan is home to Kansas State University, a Division – I research university that serves nearly 25,000 students, and employs nearly 3,000 people. K-State's student enrollment is expected to increase as part of its "K-State 2025" strategic plan. One of the pillars of the K-State 2025 plan is to improve the institutional infrastructure to become more competitive with comparable institutions, as well as increase the amount of engagement and outreach for current students and prospective students (2025 Visionary Plan 2016). The K-State 2025 strategic plan cannot be achieved without increases in student enrollment, and some of that increase may find housing within the Wildcat Creek Watershed. Another aspect for consideration is the location of proposed infrastructure improvements. Kansas State owns land inside the Wildcat Creek Watershed, which could have consequences for both the watershed and the university if infrastructure were to be developed inside the watershed (Bunger *et al.* 2013). Kansas State and Manhattan will also become home to the estimated $1.25 billion Department of Homeland Security National Bio and Agro-defense Facility (NBAF). This project is expected to bring hundreds of jobs and the prospect for additional housing to the area (National Bio and Agro-Defense Facility 2016).

Finally, Manhattan serves as a regional commercial center just north of Interstate 70 in Northeast Kansas. With a centrally-located downtown and several commercial areas, Manhattan is the primary service and retail hub from many counties in its vicinity. In 2013, Manhattan was estimated to serve more than 100,000 people. Although several of the commercial areas are outside of the watershed, many residential areas are located west of town in or near Wildcat Creek. The coincidence of residential areas and the funneling of water from the entire watershed has caused, and will continue to cause, flooding problems for the west side of Manhattan. Due to the region's expected growth, there are implications for flooding in the Wildcat Creek Watershed.

3.2.2 Keats

An unincorporated community of the Manhattan and Fort Riley area, Keats, Kansas was created during railroad construction in Kansas during the 1880's (History of Riley County). Keats is located along Wildcat Creek five miles west of the City of Manhattan. Keats Park backs up to Wildcat Creek, and serves as a buffer between the floodplain and the town center. Due to its central location in the watershed and proximity to the creek itself, Wildcat Creek in Keats experiences swift responses to upstream precipitation.

3.2.3 Fort Riley

Home to the 1st Infantry Division, also known as “Big Red One”, Fort Riley serves as one of the US Army’s largest installations in the Midwest. Located in both Riley and Geary Counties, Fort Riley extends into the western portion of the Wildcat Creek Watershed. The majority of the watershed in Fort Riley territory is characterized primarily by grasslands with small patches of riparian woodlands. Cropland also exists in the Fort Riley portion, and those lands are leased to contracted producers (Letter from Garrison Command 2016). Although the majority of Fort Riley land in the watershed is left unused, portions of it have been used for armored vehicle training exercises (Banner 2008). Fort Riley has been identified as a positive partner in resource management in the Wildcat Creek Watershed. After the major flood in 2011 that caused the evacuation of several communities in Manhattan and millions of dollars in damages, Fort Riley donated funds so that a stream gauge station could be set up in Keats. Fort Riley is also active in managing the watershed for the future, as it is provides a member to the Wildcat Creek Watershed Working Group; a collection of individuals from communities affected by flooding in the Wildcat Creek Watershed working towards better land use practices in the watershed. According to Wildcat Creek Watershed Working Group’s Floodplain Management Plan the demand for employees in the Manhattan and Fort Riley area will continue to increase, causing greater stress on residential areas inside of the watershed (Bunger *et al.* 2013).

3.2.4 Riley

Riley, Kansas, is a small residential community serving Kansas State University and Fort Riley located twenty miles northwest of Manhattan. Riley has had a steady population of nearly 1,000 residents with most commuting to either Manhattan or Fort Riley for work (US Census Bureau 2015). Although the community of Riley accounts for less than three square kilometers, it adds a significant amount of impervious surface through roadways and buildings. Due to its proximity to the main channel of Wildcat Creek, this additional impervious surface has implications for residents located downstream.

3.2.5 Riley County

The watershed can be characterized by several different land uses that are determined mainly by soil types and/or proximity to population centers. The southeastern portion of the watershed is characterized by residential and commercial developments in the city of Manhattan. The western side of Manhattan in the watershed is a mix of single-home residential areas, duplexes, and several large apartment complexes. There are several commercial centers in this area as well, which include the Target shopping center on Seth Child Road, as well as the Westloop shopping center at the intersection of Anderson and Seth Child. Central areas of the watershed (both the north and south sides of Wildcat Creek) are primarily mixed grass/rangeland. This land use is consistent with areas both inside and outside the management of Fort Riley. With the exception of Riley and Leonardville, the northwestern region and upper reaches of the watershed are dedicated to agricultural use with mixed rangeland and cropland spread throughout. The western third of the watershed managed by Fort Riley is left mostly untouched with the occasional heavy armor vehicle training exercises and follow up land rehabilitation in the flat areas of the watershed.

The concentration of agricultural land uses in the northwestern – most part of the watershed is in stark contrast to the rest of the watershed. This can partially be explained for areas south of Wildcat Creek by land management practices enacted by Fort Riley. There is a variation between soil types between the northern and middle portions of the watershed that corresponds with the change in land use practices north of Wildcat Creek. The area that has agricultural land uses is primarily Wymore soil, while the rest of the watershed is primarily Labette and Clime soils (Figure 3-3). Both Labette and Clime soil types exist in areas that have steep slopes: 0 – 12 percent and 1 – 60 percent, respectively, while Wymore soil types are in areas that typically have less local relief (*e.g.*, from 0 – 9 percent slope) (USDA – NRCS Soil Series). The soil types suggest that the difference in land use is a result of changes in local topography

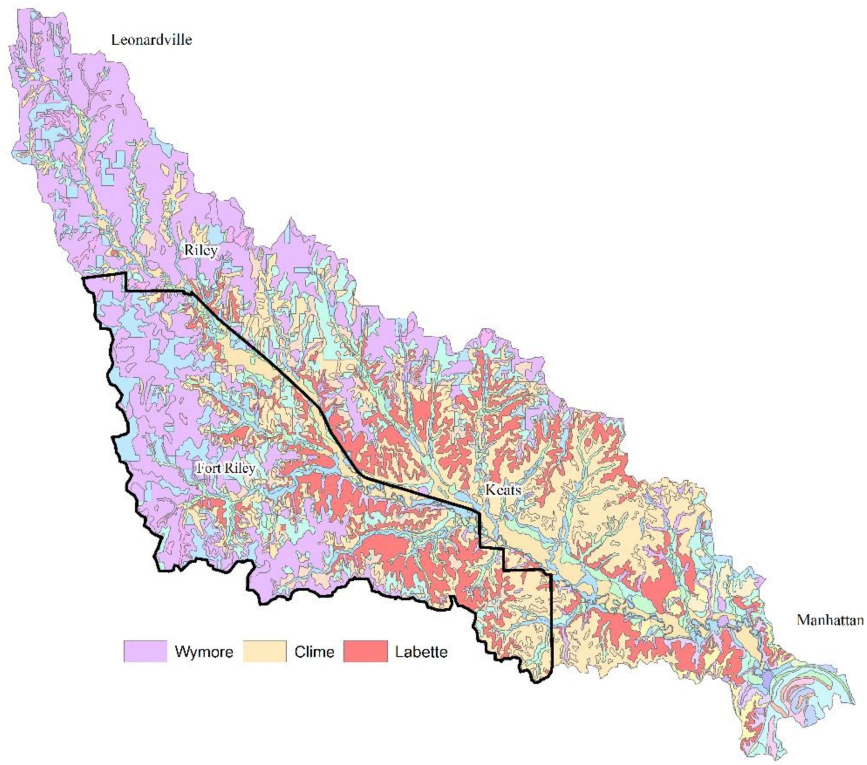

Figure 3-3: Predominant soil types in the Wildcat Creek Watershed. (Source: Author, Data: USDA – Natural Resources Conservation Service)

3.3 Reaches of Wildcat Creek Watershed

As with any watershed, there are multiple sub-units of Wildcat Creek Watershed that are of interest. These sub-watersheds act interdependently with one another, and those connections can hold serious consequences in context of flooding. In the Wildcat Creek Floodplain Management Plan, several sub-watersheds are highlighted with the primary focus on those around the city limits of Manhattan. Although the management plan discusses sub-watersheds in/near Manhattan in depth, those outside of the city limits are briefly discussed. Notable stream reaches near the city of Manhattan include: 1) Kansas River to Seth Child Road, 2) Seth Child Road to Scenic Drive, 3) Virginia – Nevada, 4) CiCo Creek, 5) Little Kitten Creek, 6) Rolling

Hills, 7) Manhattan to Keats, 8) Keats to Riley, and 9) the headwaters of Wildcat Creek. Tributaries that hold a higher risk of flood exposure are discussed in greater detail below.

The Kansas River to Seth Child Road reach stretches from the confluence of Wildcat Creek and the Kansas River in the southeast to just west of the intersection of Anderson Avenue and Seth Child Road in Manhattan (Figure 3-4). The southeastern-most portion of this sub-watershed, referred to as Hunter's Island, is in the 100-year floodplain and is characterized primarily by open space and agricultural land uses. However, there are several residential areas scattered throughout this reach. This portion of Wildcat Creek Watershed has not been developed due to its acquisition by the city through funds from the Federal Hazard Mitigation Grant Program following the flooding that occurred in 1993 (Bunger *et al.* 2013). The northwestern portion of this reach is characterized by housing and urban development. Areas around Fort Riley Boulevard are primarily zoned for industrial use. Areas near Anderson Avenue and Seth Child Road are zoned as either commercial or residential. Redbud Estates, a mobile home community, is located just east of Seth Child Road. Flooding that required evacuation impacted Redbud Estates during a 2011 high water event.

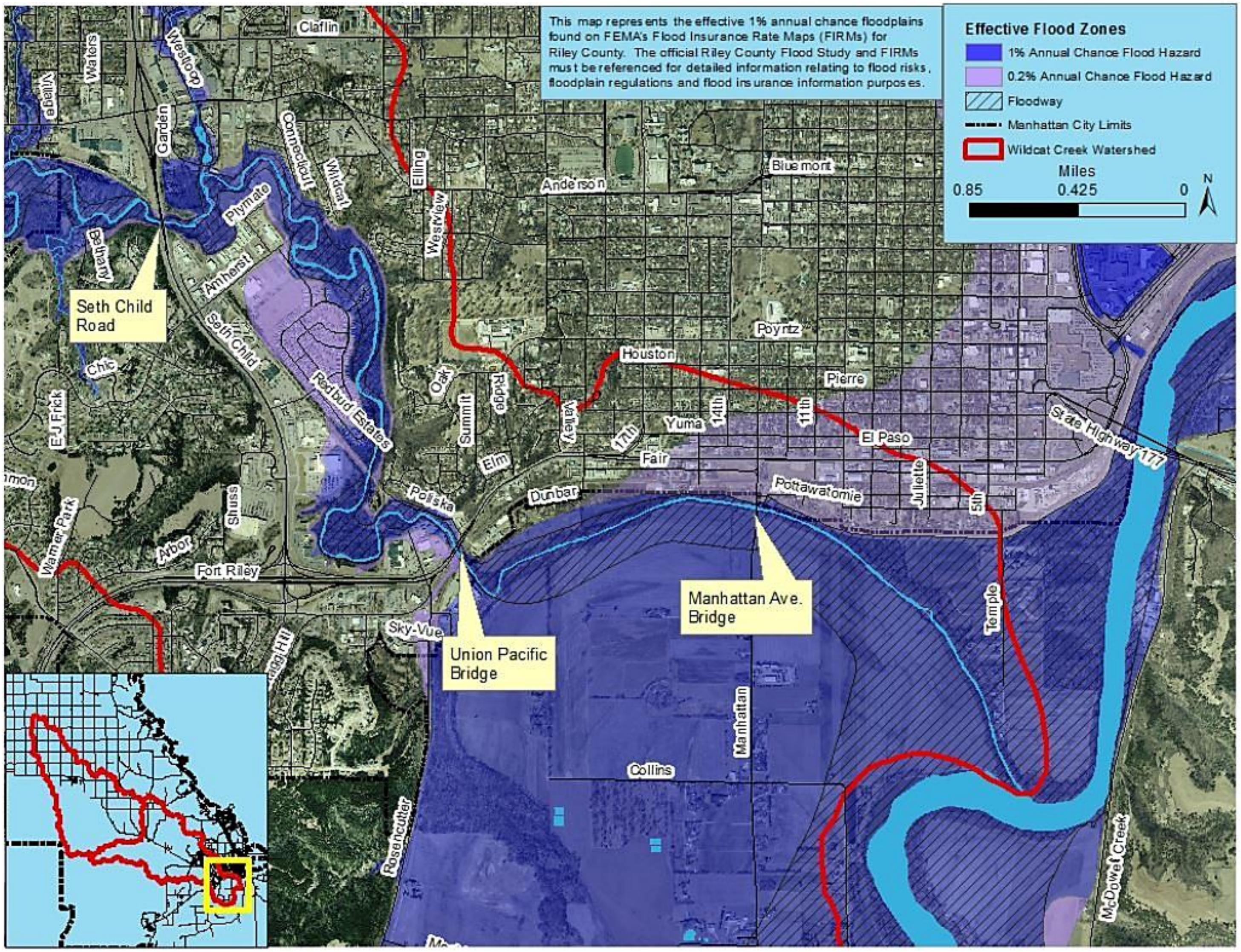

Figure 3-4: Kansas River to Seth Child Road reach of Wildcat Creek Watershed (Source: Bunger *et al.* 2013)

The next upstream reach extends westward towards Scenic Drive on the western edge of Manhattan. This reach is centered on Anderson Avenue between Seth Child Road to the east and Scenic Drive to the west. The primary tributaries, CiCo Creek and Little Kitten Creek, drain into Wildcat Creek from the north and are near large-scale residential neighborhoods. Four of the five residential areas that required evacuation during the 2011 flooding event, are located along Wildcat Creek in this reach. New residential development and road-widening along Scenic Drive and Anderson Avenue are of significant concern in the context of future flash flooding for this reach. The Scenic Drive reach is shown in Figure 3-5.

Although the Floodplain Management Plan touches on reaches outside of the Manhattan city limits, it does not address some of the important issues in those areas. Keane *et al.* (2011) examined physical processes of the watershed including, surface erosion, streamflow change, direct channel impacts, and streambank erosion. Conducted at the sub-watershed level they identified 19 different reaches within the Wildcat Creek Watershed (Figure 3-6). One of the key variables in the analysis, streamflow change, had at least a high risk in seven of the fifteen sub-units outside of Manhattan city limits. Portions of these seven reaches include the communities of Leonardville, Riley, and Keats. Land cover and stream changes in these reaches of the watershed create areas that are susceptible to increased runoff, with major implications for flooding in the upper reaches of the Wildcat Creek watershed (Keane et. al 2011).

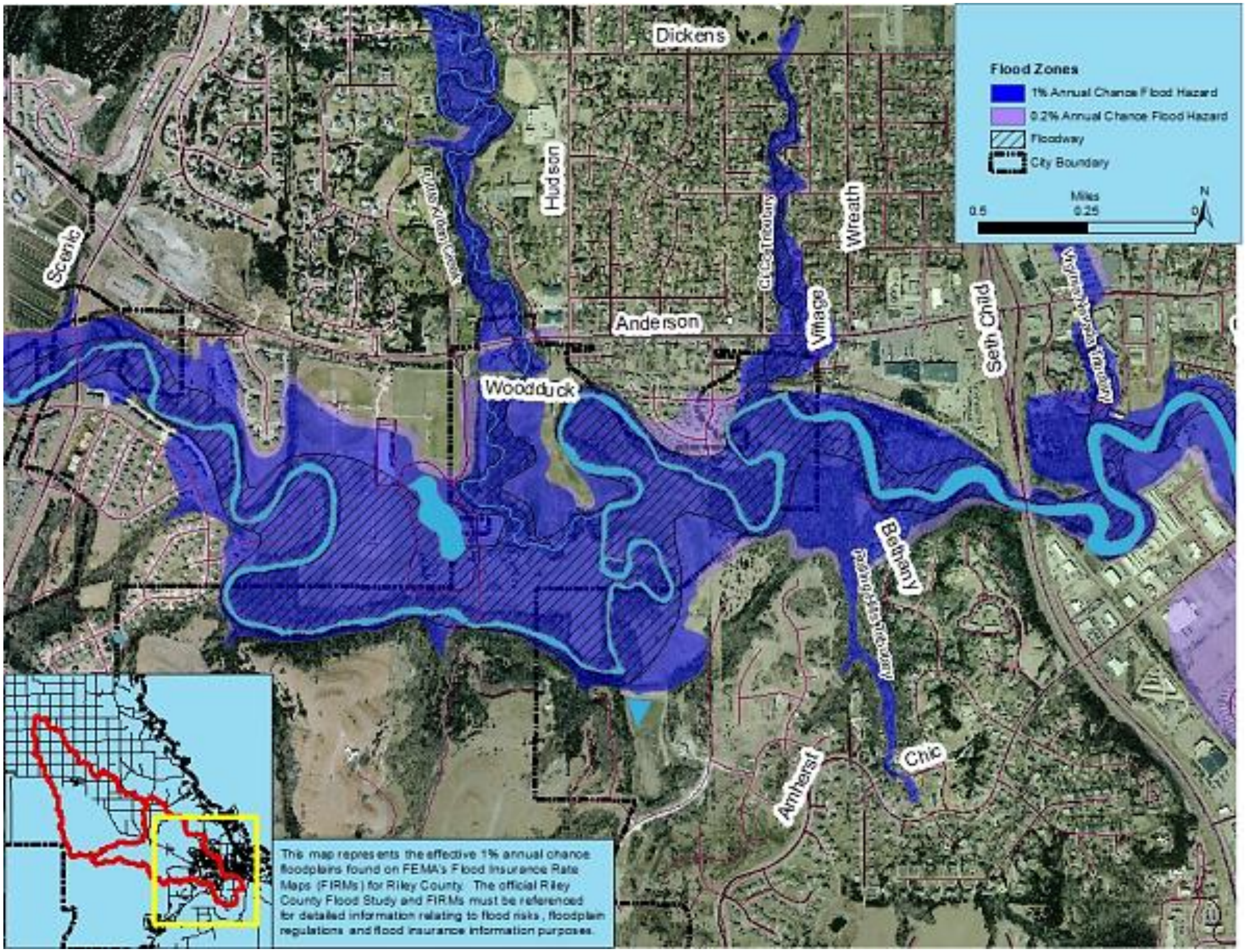

Figure 3-5: Floodplain of the Scenic Drive Reach (Source: Bunger *et al.* 2013)

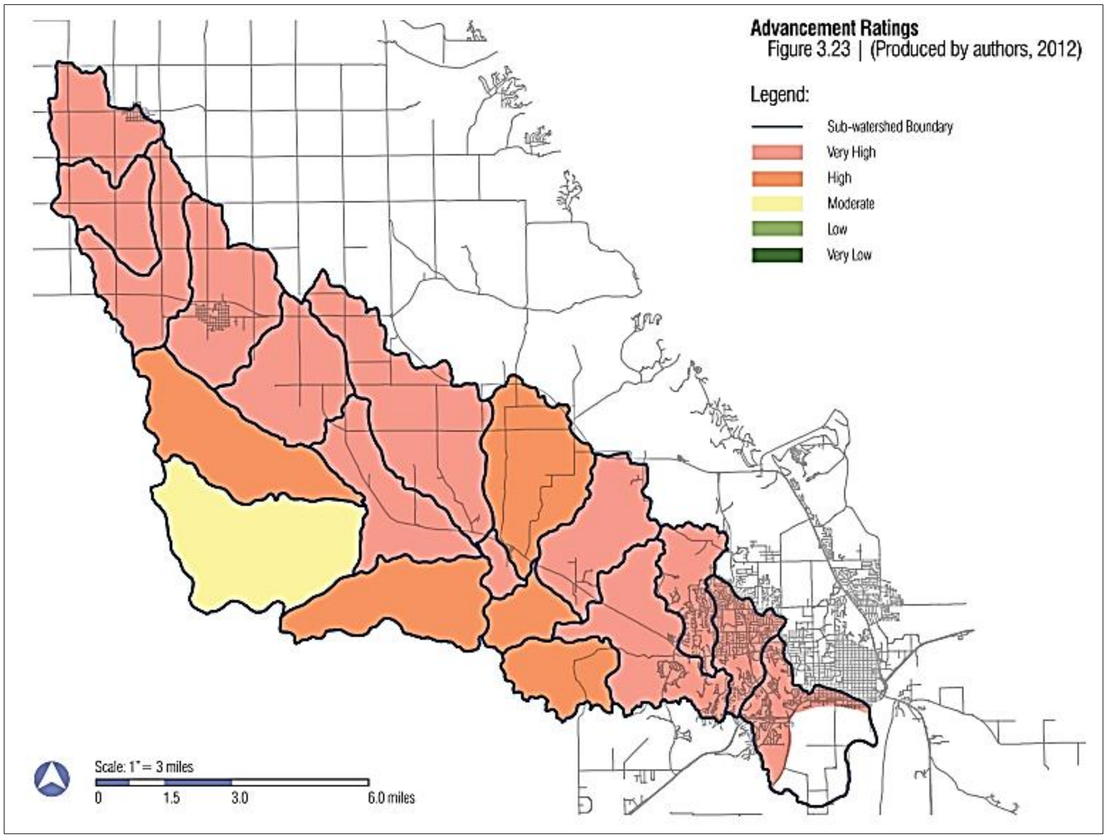

Figure 3-6: Sub-watersheds/stream reaches defined by Keane *et al.* Areas in pink are at high risk for flooding (Source: Keane *et al.* 2012)

3.4 Wildcat Creek Flooding

Wildcat Creek Watershed has experienced several significant flooding events over the last one-hundred years. Although the flood hazard is well known in the area, it appears that the frequency of flood events has increased over that century. From 1903 – 1960, Wildcat Creek Watershed experienced seven (1903, 1914, 1915, 1935, 1941, 1951, and 1954) significant flooding events, while the last fifty years have brought eleven documented flood events (1970, 1977, 1993, 1999, 2001, 2004, 2007, 2010, 2011, 2014, and 2015) with five in the most recent decade. This change in frequency may not be statistically significant, however, it suggests that flooding will remain an issue for those whose lives are linked to Wildcat Creek. In 2011, the K-

State Collegian Newspaper posted an article about the increase of major floods in the Manhattan area citing that four major floods had occurred in the preceding ten year time period (Spicer 2011). Table 3-1, modified from the Wildcat Creek Floodplain Management Plan with data available from the National Centers for Environmental Information Storm Events on-line data base, outlines significant floods that occurred not only in the Wildcat Creek Watershed, and also the general Manhattan area (Bunger *et al.* 2013). Based on the dates in the table of the major floods in Wildcat Creek Watershed, the number of floods has increased over the last century. Nearly double the amount of major floods occurred in the second half of the past century, and six of those occurred in the last sixteen years.

Date	Year	Water Body Affected	Estimated Probability of Occurrence in Each Year (limited by uncertainty in period of record)
May 31	1903	Kansas & Big Blue Rivers	2% (50-yr return frequency)
September	1914	Wildcat Creek	Not Available
May	1915	Wildcat Creek, Kansas, and Big Blue Rivers	Not Available
June 4	1935	Wildcat Creek, Kansas, and Big Blue Rivers	Not Available
October	1941	Kansas River	Not Available
July 12	1951	Wildcat Creek, Kansas, and Big Blue Rivers	1% (100-yr return frequency)
June	1954	Wildcat Creek	0.2% (500-yr return frequency)
September 12	1970	Wildcat Creek	Not Available
June 18	1977	Wildcat Creek	4% (25-yr return frequency)
July 23 (summer season)	1993	Wildcat Creek, Kansas, and Big Blue Rivers	1% (100-yr return frequency)
April 26	1999	Kansas & Big Blue Rivers	Not Available
April 21	2001	Big Blue River & Wildcat Creek	Not Available
June 27	2004	Wildcat Creek	Not Available
May 6	2007	Wildcat Creek & Kansas River	2% (50-yr return frequency)
June 16	2010	Wildcat Creek	Not Available
June 2	2011	Wildcat Creek	1% (100-yr return frequency)
June 9	2014	Wildcat Creek	Not Available
May 4	2015	Kansas & Big Blue Rivers	Not Available

Table 3-1: Historical floods in the Manhattan Area (Source: Modified from Bunger et al. 2013 by author; Combs and Perry 2003; NOAA Storm Events Database)

Along with the increase in the number of floods over the past half-century, changes in the magnitude and intensity of floods have also changed. Floods in Wildcat Creek Watershed are becoming both more frequent, and seemingly larger. This is particularly true of the last twenty year period. Several 100-year flooding events have occurred in this time window, causing severe issues for residents, producers, and business owners in the watershed. In 1993, unprecedented precipitation in the late spring and early summer months caused large scale regional flooding in greater parts of the Missouri and Mississippi Rivers. Wildcat Creek experienced significant flooding as part of this large scale regional event.

In more recent memory, major flooding occurred in 2011. This time affecting just the Wildcat Creek basin, the 2011 flooding event was characterized by a wet May month that experience 131 millimeters (5 inches) of rainfall accounting for nearly 13% of the average yearly rainfall. Most of this rainfall occurred in the week before the June 2 flood (78 millimeters) causing the ground to be saturated (Figure 3-7). After the midnight hour of June 2, 2011, the Manhattan area experienced over 65 millimeters (2.5 inches) of rainfall in a 4-hour time period (Figure 3-8). Due to the timing of the rainfall (overnight), residents of six communities were awoken the morning of June 2 by law enforcement officials warning them that their homes could be inundated from coming flood waters (Deines 2011; Anderson 2011).

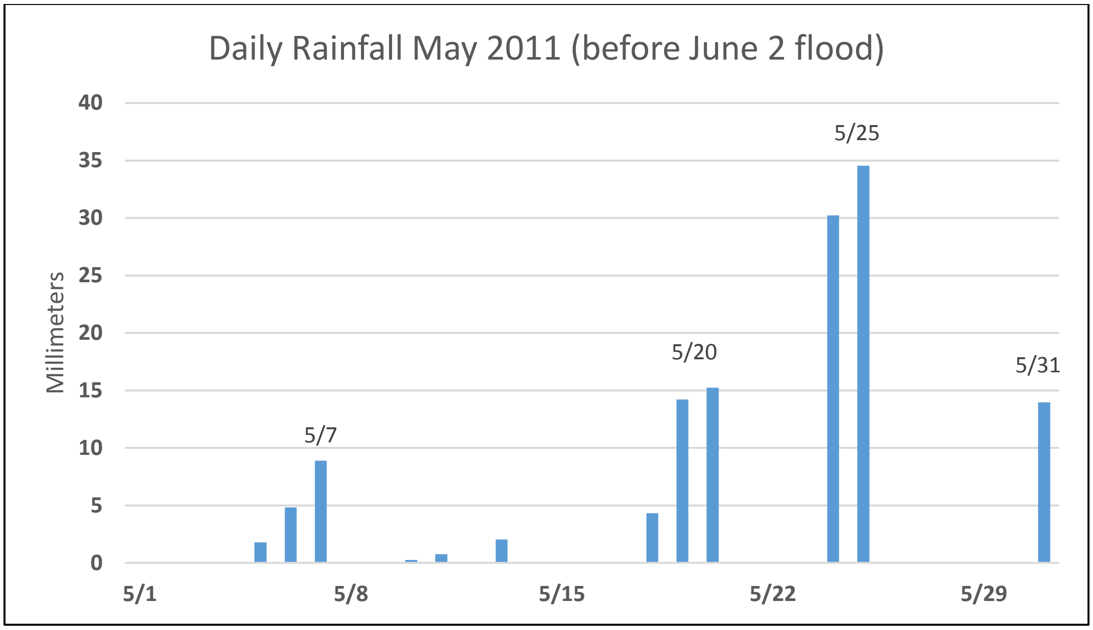

Figure 3-7: Daily rainfall for May 2011 (Source: Author, Data Source: Kansas Mesonet)

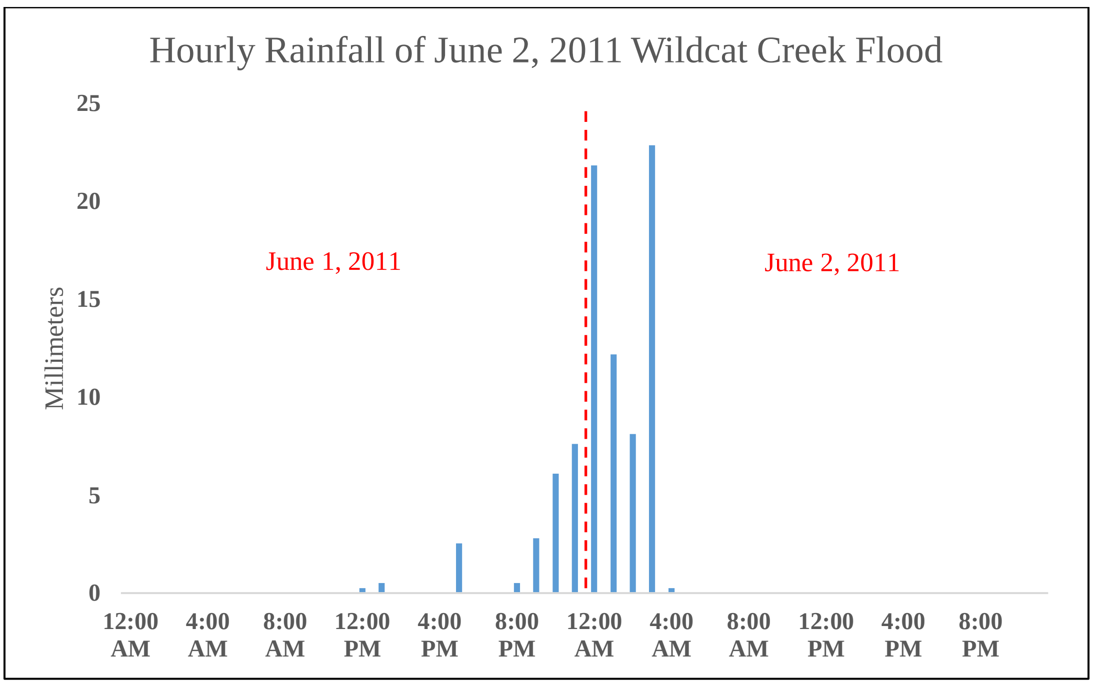

Figure 3-8: Hourly rainfall for the 2011 Wildcat Creek Flood (Source: Author, Data Source: Kansas Mesonet)

This event occurred as a second consecutive major flood event in as many years for the area, and the 2011 event caused estimated damages of over $5 million (Mercury 2012). Although this storm was unique in its movement and precipitation pattern (moved down the watershed with concentrated rainfall in Wildcat Creek drainage basins), it highlights the increase in magnitude of flooding events affecting this region.

3.5 Physical Components of Flooding

Wildcat Creek experiences moderate increases in discharge during the spring months (Franssen and Gido 2006). This is due to the seasonality of precipitation in Northeast Kansas. Kansas, and Riley County by extension, experiences dryer winter months with an increase in precipitation during the late spring and early summer months (Clement et al. 1989). Nearly 75% of the annual precipitation occurs between April and September. This is due to cold, dry air masses moving south from Canada in the winter, and a shift to warm, moist air from the Gulf of Mexico in the summer. These warm air masses contribute to convective thunderstorm that yield short, yet intense precipitation that can produce up to 5 inches of rain in a matter of hours (Clement et al. 1989). Frontal systems that can stall and produce rainfall over a long period of time are a consequence of being located where air masses come together along a frontal boundary (cold, dry from the north and warm, moist from the south). The 30-year precipitation averages (normals) shown in Figure 3-9 provide a generalization of the annual distribution of precipitation in Riley County.

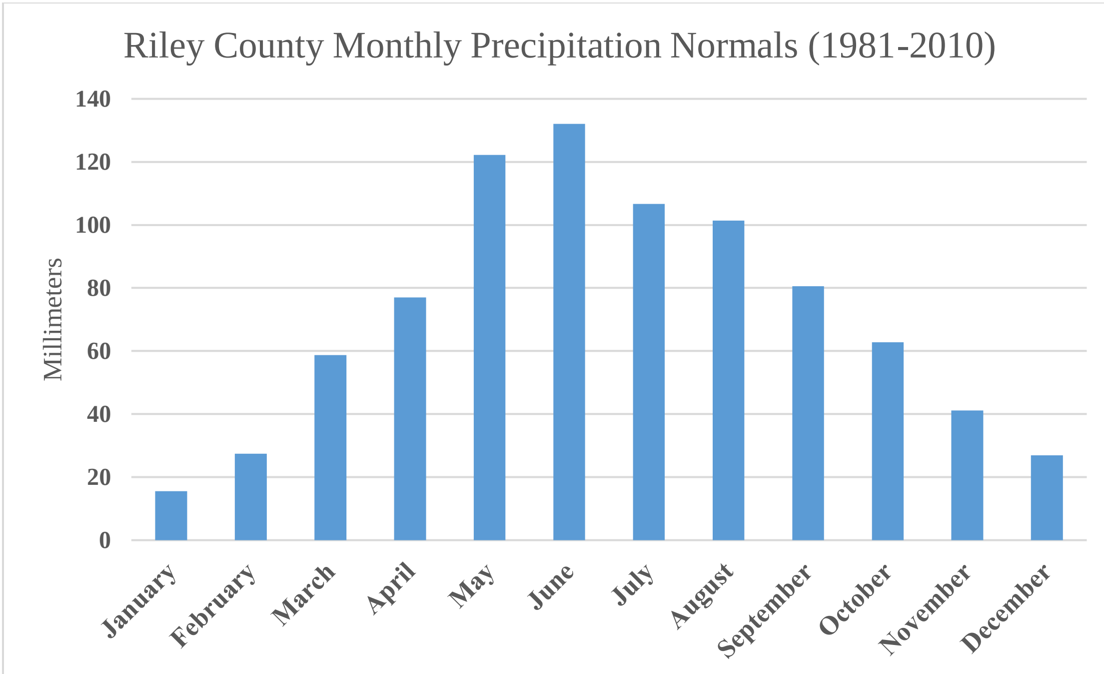

Figure 3-9: Monthly Precipitation Normals for Riley County, Kansas (Source: Author, Data Source: Kansas Mesonet)

When rainfall occurs in Wildcat Creek Watershed, many small tributaries react quickly causing localized flash flooding. As the water is carried southeast (dictated by decreases in elevation) towards Manhattan and the Kansas River, it continues to buildup in the mainstem as the discharge from small tributaries contribute to the flooding (Figure 3-10). For example, Wildcat Creek at Scenic Drive receives flow from all upstream tributaries (i.e. Little Arkansas Creek, Silver Creek, Natalie's Creek, etc.). This is a primary reason why Manhattan is more negatively impacted by floodwaters. Due to its location at the lower end of the watershed, it is downstream of all contributing tributaries (Bunger et al. 2013).

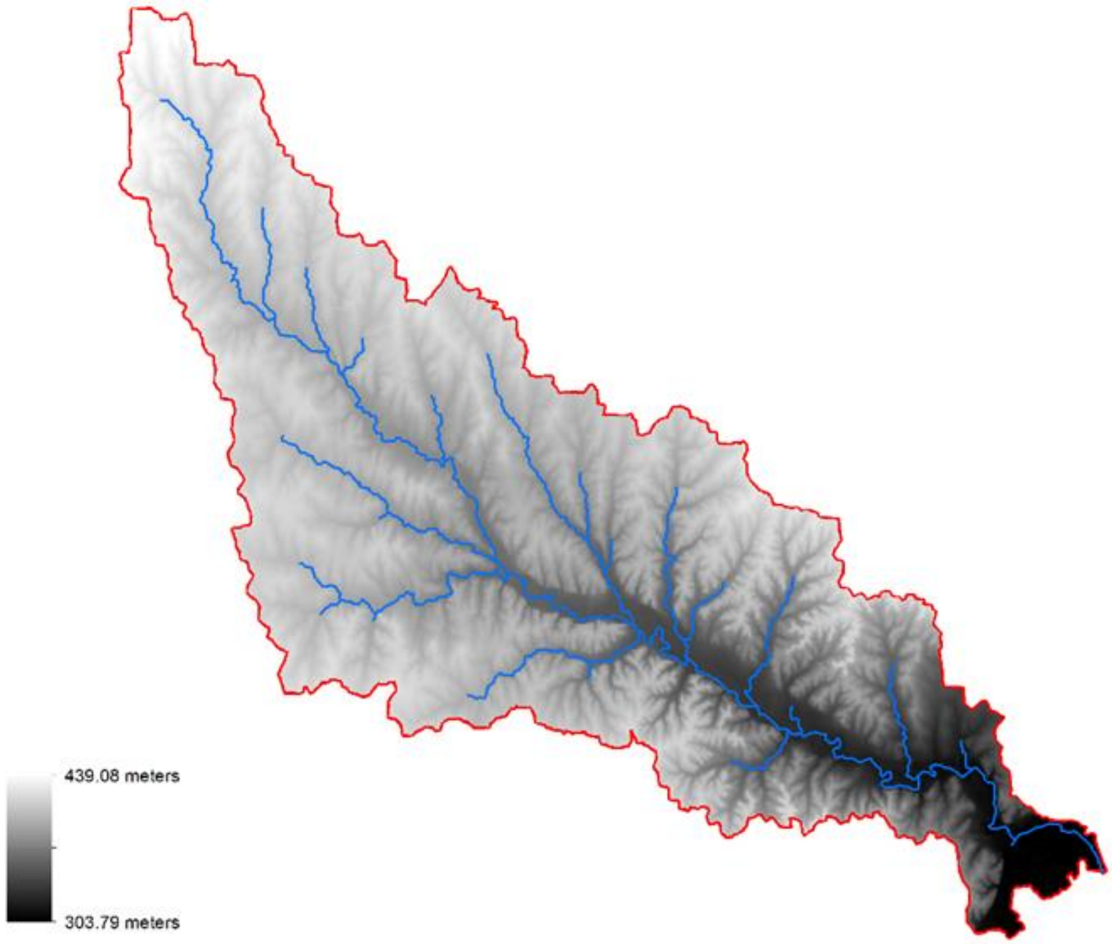

Figure 3-10: Digital elevation model of Wildcat Creek Watershed (Source: Author, Data Source: National Elevation Dataset)

As humans create more impervious surfaces, water fails to be absorbed into the ground causing more surface runoff to quickly drain into the creek. Analysis of the National Land Cover Dataset from 2001 to 2011 indicates that the amount of impervious surface has increased from 13.8 square kilometers to 16.0 square kilometers from 2001 to 2011.

Chapter 4 - Data and Methods

4.1 Data Collection

Due to the exploratory nature of this research, qualitative data were collected through a series of semi-structured interviews with individuals who live, study, or own businesses in the Wildcat Creek Watershed. Interviewees were individuals who hold a significant stake in the well-being of the Wildcat Creek Watershed. Before interviews were conducted, there was need to obtain Institutional Review Board (IRB) for Human Subjects approval through Kansas State University. IRB review helped ensure that this study would protect the participant's privacy and not produce any negative impacts on participants. In addition to semi-structured interviews, watershed delineation was conducted using ESRI's ArcGIS software and data obtained from the National Elevation Dataset to define the boundaries of the Wildcat Creek Watershed and reaches within the area.

4.1.1 Institutional Review Board Approval

Kansas State University requires studies that use human subjects as the primary means for data collection to submit themselves for review. Through this process, a debriefing statement and an informed consent form were created for the purpose of sharing study design information, as well as ensuring that participants in the study are aware of their contribution. Informed consent serves as a contract between the participant and the researcher to maintain confidentiality and honor their need to withdraw their interview from the study if so desired. Generic information about potential participants in this study was provided during the IRB review process to ensure that there were no perceived biases or conflicts of interest in the study. The IRB review process also includes a review of the proposed interview questions to make sure the researcher is not asking questions that could alienate or marginalize any potential participant. This study received IRB approval on October 30, 2016.

4.2 Semi-Structured Interviews

Semi-structured interviews were conducted with stakeholders of the watershed to address the research questions identified in Chapter 1 of this study. Semi-structured interviews are used in a broad range of social science research from perceptions of participants in gay pride rallies to understanding the perspectives of women considered as the primary caregiver (Johnston 2001; Yantzi and Rosenburg 2008). Wallace (2009) used semi-structured interviews to better understand the decision-making process of dam removal in the Pacific Northwest. These studies are similar to this one in their goals: to better understand the relationship between people and their environment. Although the environments are different, the similarity still remains.

Semi-structured interviews, unlike other interview methods are more informal and conversational. The conversation is guided in part by the respondent, rather than the interviewer (Longhurst 2010), and this allows answers to be more open and representative of the interviewees' personal feelings. Although the purpose of a semi-structured interview is to conversationally address ideas, a number of questions were created as a conversation guide (Table 4-1).

Research Question 1: How well do residents of the Wildcat Creek watershed understand watershed/flood processes (*i.e.* how water flows through a watershed, and how a flood develops), and does living closer to the floodplain influence how well informed an individual is about watershed/flood processes?

Discussion Topics:

a. What are the pre-conditions for a major flooding event?

b. What kinds of storms/storm movement cause flooding in this area?

c. What role does soil moisture play in flooding?

d. What role do different kinds of development, such as impervious surfaces, play in flooding?

e. What roles do sediment in the channel and erosion play in flooding?

Research Question 2: Do residents of the Wildcat Creek Watershed believe that flood mitigation procedures such as water retention basins, wetland restoration, and building relocation/removal are valuable to reduce flood vulnerability, and who do residents think should pay for flood mitigation procedures?

Discussion Topics:

a. Should property assessment depend on location in the watershed? Or proximity to floodplain?

b. Should the residents of the watershed be taxed, so that the revenue obtained this way can be used to pay for flood mitigation efforts?

  i. How should amounts be determined? Should this depend on land use/cover?

c. Does your property help retain storm water? If so, how does that work?

  i. Do you think landowners with flood storage ponds should pay less?

d. Are you familiar with watershed districts, and are you aware that there is a proposed watershed district for the Wildcat Creek Watershed?

Research Question 3: Do the residents/business owners in the Wildcat Creek Watershed believe that the risk of flooding has changed over time? If so, what evidence/experiences do they have?

Discussion Topics:

a. Do you believe that you/your property are vulnerable to a flood in the Wildcat Creek Watershed?

b. Have feelings of vulnerability changed over time? Why?

c. What do you believe has caused changes in flood risk?

d. Who or what is responsible for any change in flood risk?

e. How long have you lived in the watershed?

f. Do you live in the floodplain?

Research Question 4: Who would residents/business owners of the Wildcat Creek watershed go to for information about how the creek functions and who/what do residents/business owners think are trusted sources of information?

Discussion Topics:

a. Who/what would you consider as a trusted source for information about the watershed and stream function?

b. Where do you obtain the majority of your weather information?

c. Where do you obtain your information about the risk of flooding?

  i. Are you aware of the new flood warning sirens? The old tornado sirens?

d. Are you familiar with the 2013 Wildcat Creek Watershed Resiliency Project grant proposed by KDA, the City of Manhattan, and Kansas State University to the US Department of Housing and Urban Development?

Table 4-1: Conversation guide for use in interviews (Source: Author)

Conversation guides are a means to focus the discussion towards answers/ideas that address each research question (Longhurst 2010). Each of the four major research questions had four or five ideas to discuss during an interview. Discussion questions for the conversation guide were originally created by the researcher, and taken to Kansas State faculty who were knowledgeable about the watershed for consultation. This iterative process of question refinement caused the conversation guide to not only address the major research questions better, but also target specific issues that are relevant in the Wildcat Creek Watershed.

Many times, similar ideas associated with different major research questions were discussed together. The semi-structured format made the interviews less linear, and more conversational. Notes were taken on specific attitudes, or if a participant was particularly disgruntled about a specific topic. In an effort to target the entirety of the conversation guide, interviews were typically thirty minutes in length. Length of the conversation was dependent on whether or not the participant was considered an expert, alone, or in some cases, a member of a couple. Expert interviews were typically shorter, while those with couples took longer.

A facet of using semi-structured interviews is for the participant to be comfortable with both the interviewer and the interview setting (Denzin 1970). For this reason, the participant was asked to decide on interview location. In many cases, participants were met in their homes, and this format allowed them to show the researcher their properties if they had had past experiences with flooding. At the start of each interview, the question about acceptability of recording the conversation was addressed. Some participants even had their significant others take part in the interview. The dialogue between interviewees that were members of a couple were typically richer.

Interviewees were divided into two different categories: experts and resident/business owners. Experts were defined as those who study or implement infrastructure in the watershed. Members of this class varied from professors at Kansas State University to planners at the City of Manhattan. Residents interviewed ranged from people who have lived in the watershed for a short period of time (less than ten years) to those that have spent their entire lives there. In the case of couples interviewed together, their interview was treated as a single participant.

4.2.1 Sampling method

Sampling for the interview process was a combination of convenience and snowball sampling techniques. Convenience sampling, or accessibility sampling, uses the most accessible members of a population for study (Rice 2010). For example, the initial method for gathering individuals for interview was through their prior participation in the Wildcat Creek Resiliency Project (WCRP). Although participants from the WCRP provided a starting point, they were not necessarily representative of the entire watershed, with the majority of WCRP participants hailing from the Manhattan area. For this reason, the Wildcat Creek Watershed Working Group (WCWSWG), Riley County Planning and Development, and K-State Research & Extension were consulted to assist in obtaining names of stakeholders who had participated in respective programs that each offered. Convenience sampling in this case is an example of purposive sampling. Rice (2010) defined purposive sampling as a method where the researcher subjectively selects a population based on knowledge that they may have about a specific place or time. Many times, purposive sampling is not seen as objective enough, and, Creswell (2014) defends purposive sampling due to its ability to best help the researcher understand the problem as well as the breadth of the research questions. A primary issue with convenience sampling is isolating interviews to only those who are motivated and knowledgeable about their flood risk and vulnerability, since these individuals made contact with the organizations who provided their information. This accessible population provided a beneficial starting point, but snowball sampling was used to provide a more representative sample.

Snowball sampling, or snowballing, is the process of using those already interviewed to help suggest and/or recruit others (Valentine 2005). Longhurst (2010) used snowball sampling to target first-time pregnant women. As each participant was interviewed, they would then "open doors" to other potential participants that were experiencing first-time pregnancies. For this study, the participant was asked at the conclusion of the interview if they would like to provide several names of those who they thought might also be interested in being interviewed. Participants would provide names and phone numbers of those that they thought might be willing to speak with the researcher. The goal of this sampling method was to increase the number of potential interviewees with each interview conducted, while also reducing the amount of purposive bias.

4.2.2 Transcriptions and Coding

At the conclusion of an interview, each recorded interview was transcribed so that it could be coded into themes based on interviewee responses. Transcription was assisted by the *Express Scribe* transcription software. This software has the capability to decrease the speed of recorded audio, allowing for entire interviews to be entered into a digital format without the need to pause the audio. After transcription, interviews were coded to identify relevant ideas and words that were common throughout conversations.

Coding was used to identify similar comments and ideas addressed throughout the interviews. Coding is the process of identifying common thoughts in large data sets to diminish the amount of data for analysis (Hay 2000). By using QSR International's *NVIVO 11*, each transcribed interview was manually coded. Manual transcription requires an in-depth knowledge about the data set. Transcriptions were re-read to identify common ideas. When a phrase or line of text addressed a theme, it was coded to reflect that idea. The following table shows the underlying themes that were identified in this study. Those in bold directly identified a research question, and italicized entries are 'children' of the emboldened themes.

Causes Flooding	**Flood Risk**	**Major Flood Events**
Ag Development	*Changed (in general)*	*1993*
Awareness	*Changed (Personal)*	*2010 – 2011*
Climate	*Unchanged*	*Other*
Soil Moisture	**Government**	**Mitigation Suggestions**
Supernatural	**Information Sources**	**Past flood experience**
Tampering with the Channel	*Expert*	**Payments for Mitigations Strategies**
Urban Development	*Governmental*	*Opposed*
Weather	*Internet –Mobile Applications*	*Proponent*
Climate Change	*Local*	*Skeptical*
Feelings of Vulnerability	**Value in Mitigation Efforts**	**Responsibility (for flooding)**
Has Changed	*No*	**Topeka Shiner**
In-between	*Yes*	**Water function**
No change	**Land Stewardship**	*Incorrect understanding*

Table 4-2: Themes identified through manual coding (Source: Author)

4.3 Watershed Delineation

Although the Wildcat Creek Watershed is already defined by higher elevations that funnel water into Wildcat Creek, there is a need to improve on maps defining the watershed. Many governmental entities make use of old maps of the study area, and although not much has changed, there is still room for improvement. For this reason, a new Wildcat Creek Watershed map was created using up-to-date, higher spatial resolution datasets. Using both Modelbuilder and the Spatial Analyst extension in ArcGIS, a spatial model was created to process digital elevation data into watershed boundary and stream network data sets. The maps produced in this process were also used for reference in discussions with participants in the study.

4.3.1 National Elevation Dataset

The National Elevation Dataset (NED), produced by the USGS, is a suite of elevation data that is free to users. NED provides many variations of elevation data including, light detection and ranging (LiDAR), digital elevation models (DEM), Hillshades, as well as 3-dimensional products. All of these can be obtained at spatial resolutions ranging from thirty meters to sub-meter. For this project, a three meter NED digital elevation model was obtained from the NRCS/USDA Geospatial Data Gateway. The WCWSWG currently uses a thirty meter resolution data set for their watershed map. By increasing the spatial resolution to three meters, the accuracy of watershed boundary maps will increase.

4.3.2 Watershed Delineation Model

To make watershed delineation faster, and usable for others in the future, a spatial model was created in ArcGIS Modelbuilder using geoprocessing tools from the Spatial Analyst

Extension. Taking the NED 3-meter data as input, sinks caused by errors introduced in generalization and rounding of elevation values are “filled” in order to remove imperfections in the elevation raster. This modified elevation raster is used as input to create a flow direction raster that determines plausible directions of overland flow by determining the steepest downslope neighbor to each cell. The flow direction raster is then used as input to determine the amount of flow that accumulates in each cell. Both the flow direction and flow accumulation output are used in creating streams and the sub-watershed boundaries.

The boundary is created by coupling point locations representing the sources of overland flow for both the watershed (the confluence of the Kansas River and Wildcat Creek) and tributaries. The watershed tool creates a boundary by recognizing “contributing” areas as a specific cell value. Contributing cells are defined by the direction of the flow from the source point. All direction values that are equivalent to the source point cell value point are included. The watershed boundary is then converted to vector format so that it can be easily communicated as a polygon boundary on a map.

Stream features for the input DEM can be generated by determining the direction of flow and how much each area accumulates water. Flow accumulation, however, must be processed before being used in creating stream features. Unless a threshold is provided, streams will be created for any cell that has any amount of accumulated flow. For this reason, a threshold of 3,500 upslope cells was imposed. To better understand this, a cell with a flow accumulation of one is an area where only one cell “upstream” pools water into this cell. By setting the threshold at 3,500, it creates a stream raster of only cells who have accumulated flow from 3,500 cells. Since each cell is nine square meters, this threshold sets the contributing flow area to 31,500 square meters. By setting 31,500 square meters as the contributing area, an output of larger creeks and streams in the region is created. So that linear features can be determined, cells with higher flow are coupled with flow direction to create junctions (where tributaries meet the main concentration of cells), and joining linear features at those junctions. These linear features are then assigned a numeric order to represent branches of a larger stream network. This output is most representative of stream features, and is then converted to a vector file. Detailed analysis by ArcGIS allowed for individual reaches within the watershed to be identified (Figure 4-1). These steps were executed over the entire input DEM, and must be analyzed to select only streams in the watershed. Clipping the stream features to the watershed boundary created in the first half of the model accomplished this task. The model created and used in ArcGIS is divided into four figures found in Appendix A.

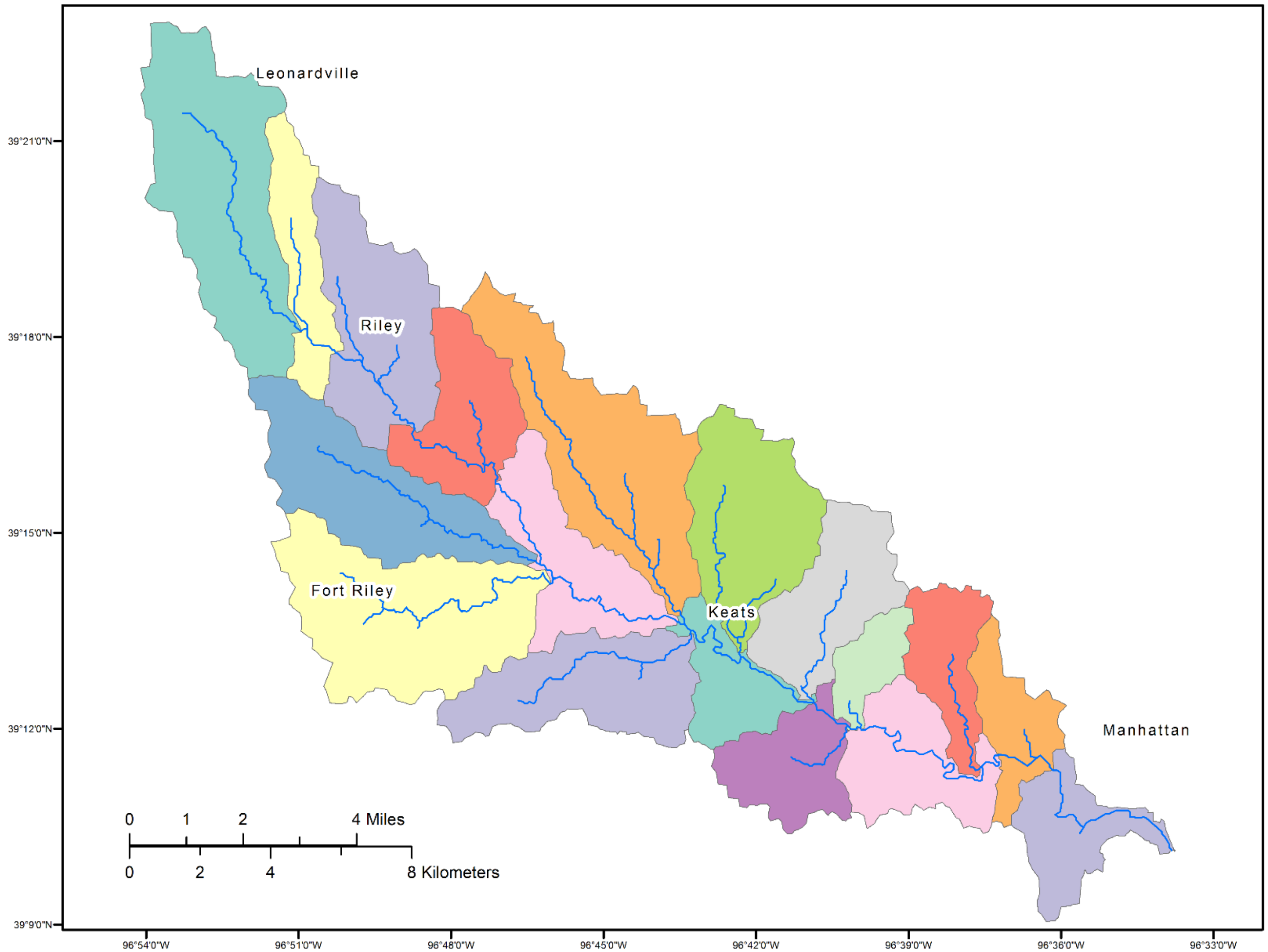

Figure 4-1: Reaches of the Wildcat Creek Watershed defined by model (Source: Author, Data: National Elevation Dataset)

Chapter 5 - Results and Discussion

Thirteen semi-structured interviews of people interested in the Wildcat Creek Watershed were completed over the course of three months. The interviews covered a variety of stakeholders who have different viewpoints about flood issues. Residents, business owners, experts, and members of the Wildcat Creek Watershed Working Group (WCWSWG) were all interviewed. Members of the communities of Manhattan (lower end of watershed), Keats (center of watershed), Riley & Leonardville (upper end of the watershed), and Kansas State & Fort Riley (experts) were interviewed (Figure 5-1). The interviews ranged from twenty to forty minutes and provided a wealth of qualitative data for transcription and coding. A decision to stop after twelve interviews was made because additional interviews were not adding new insights. A thirteenth interview at the north end of the watershed was conducted since the interviewee responded to the request at about the same time the decision was being made to cut off additional interviews.

To better understand the differences in sentiment across space, the watershed was divided into three different sections (Figure 5-1). This was based on several factors: 1) differences in predominant land cover in each region, 2) the amount of stream distance in each section, 3) the amount of contributing drainage area, and 4) the distance from the mouth of the watershed. There is a stark contrast in the land cover for each area. The upper portion of the watershed is characterized by large tracts of cultivated crops, while the center is predominately rangeland, and finally the lower portion is mostly covered by highly developed suburban areas associated with Manhattan. The stream distance of each section was roughly the same to maintain some uniformity. The upper region is approximately 13 kilometers of stream distance, while the other two are about 11 kilometers. The amount of area (after removing Fort Riley from the center portion) is within 10 km^2 of each section: 1) lower is approximately 46 km^2, 2) central is approximately 64 km^2, and 3) upper is approximately 55 km^2.

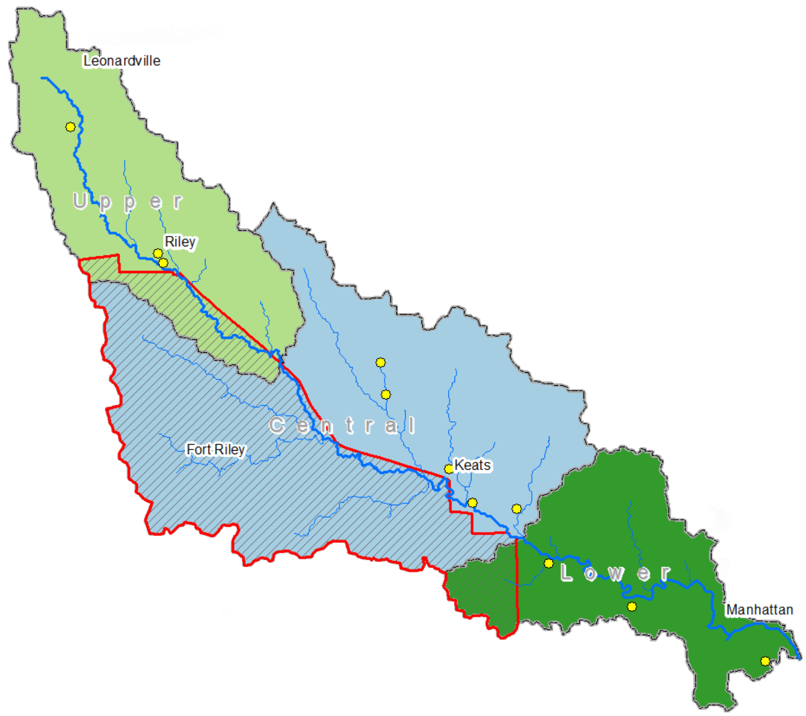

Figure 5-1: Wildcat Creek Watershed: Interview Locations (Source: Author, Data: DASC and RiCo Planning and Development)

An analysis of 111 pages of transcribed text from the interviews using *NVIVO 11* was conducted in an attempt to understand the differences in opinions about flooding issues based on location in the watershed, distance to the floodplain, and whether or not the interviewee was considered an expert. Analysis of the transcribed interviews identified thirty four codes that covered fifteen underlying themes that were prevalent in many interviews. Of those fifteen themes, there were six major themes among stakeholders of Wildcat Creek Watershed: 1) *causes of flooding*, 2) *value in mitigation efforts*, 3) *payments for flood mitigation strategies*, 4) *sources* *of information*, 5) *feelings of vulnerability and risk*, and 6) *responsibility for flooding issues*. The major themes followed along with the overarching research questions, and conclusions regarding each question were able to be drawn. The theme concerning causes of flooding held the most importance to interviewees exemplified by the frequency of the codes related to it (Table 5-1).

Causes Flooding (13/170)	**Payments for Mitigation Strategies (13/90)**	**Information Sources (13/75)**	**Past flood experience (9/20)**
Ag Development (5/8)	*Opposed (7/25)*	*Expert (4/8)*	**Major Flood Events (10/36)**
Awareness (2/2)	*Proponent (10/37)*	*Governmental (10/26)*	*1993 (6/11)*
Climate (6/11)	*Skeptical (9/28)*	*Internet –Mobile Apps (2/2)*	*2010 – 2011 (7/14)*
Soil Moisture (10/16)	**Flood Risk (7/12)**	*Local (11/39)*	*Other (6/11)*
Supernatural (1/1)	*Changed (in general) (5/7)*	**Climate Change (3/4)**	**Water function (9/16)**
Tampering with the Channel (6/18)	*Changed (Personal) (2/3)*	**Responsibility (for flooding) (11/54)**	*Incorrect understanding (2/2)*
Urban Development (13/84)	*Unchanged (1/2)*	**Topeka Shiner (5/12)**	**Government (10/46)**
Weather (13/30)	**Feelings about Vulnerability (12/29)**	**Land Stewardship (8/29)**	
Value in Mitigation Efforts (11/45)	*Has Changed (10/17)*		
No (3/5)	*In-between (1/2)*		
Yes (11/40)	*No change (5/10)*		
Mitigation Suggestions (7/18)			

Table 5-1: Important codes identified from the interviews. First value is the number of interviewees that mentioned the topic, second is the total number of times that the item was referenced. (Source: Author)

5.1 Causes of Flooding and Understanding Water Dynamics

Codes were divided by location in the watershed to identify any spatial distributions of responses. Upper refers to participants that lived in the Riley and Leonardville area (3 interviewees); Central refers to the 5 interviewees who live near Keats; those that live in the lower section of the watershed (3 interviewees) resided in or near the city limits of Manhattan. Members of the expert class (2 interviewees) did not reside in the watershed and were not included in the three previous groups. Members of the WCWSWG (5 interviewees) came from all four groups, making it the only class that includes interviewees from the other groups.

To gauge participant understanding of flood processes and stream function, when an interviewee mentioned a cause of flooding, it was recorded and classified into one of eight codes: 1) agricultural development, 2) awareness (referring to lack of awareness causing greater impact), 3) changes in climate causing more extreme rainfall patterns, 4) soil saturation, 5) references to God or Mother Nature, 6) disconnecting the channel from the floodplain, 7) urban development, and 8) weather. Disconnection of the floodplain is a result of urban and agricultural development, so this code was created when an interviewee understood the implication of increased runoff from either urban or agricultural development. Any time text was coded as agricultural or urban development it meant that the interviewee was not identifying *why* both can be causes of flooding. Most of these codes are known causes of flooding, so a mention of each reason for flooding is desired from each class of interviewees.

Due to an uneven distribution of interviewees from each location (Lower: 3, Central: 5, and Upper: 3), references were scaled to reflect the number of times each code was referenced per interview. Figure 5-2 shows that many causes of flooding were identified, however, the number of references to urban development (84) far outnumbered other causes of flooding. People in Wildcat Creek Watershed understand that urban development causes flooding, but did not readily identify why that is. Other causes of flooding that were frequently cited by interviewees were weather (30), disconnecting the channel from the floodplain (18), and ground saturation (16). These values are reasonable, due to the amount of urban development that is occurring in western Manhattan (e.g., Anderson – Scenic roundabout, Pebblebrook apartments, etc.) (Figure 5-2).

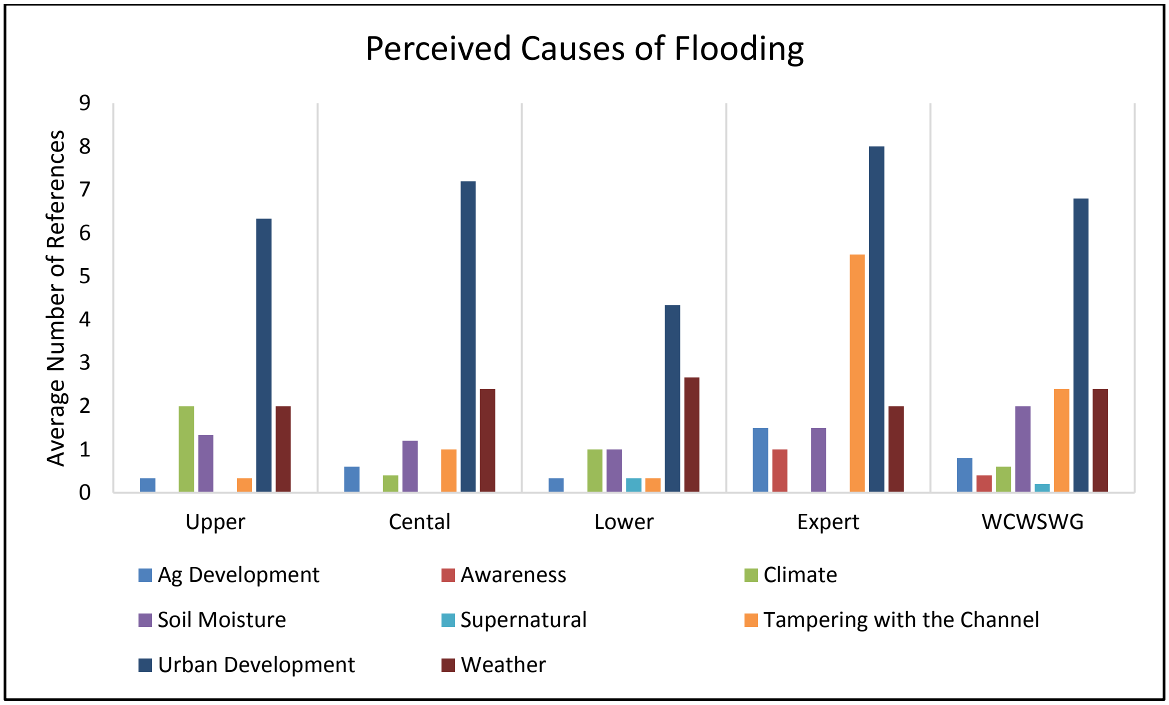

Figure 5-2: Average frequency of codes related to causes of flooding in Wildcat Creek Watershed (Source: Author)

Urban development as the main cause of flooding was further accentuated when examining the total number of references. Urban development was mentioned eighty four times, while the next most referenced cause was weather with thirty references (Figure 5-3). Although climate change was mentioned four times, many stakeholders recognized changes in weather patterns over the course of living in the watershed. They cited less frequent precipitation, but an increase in the intensity of rainfall.

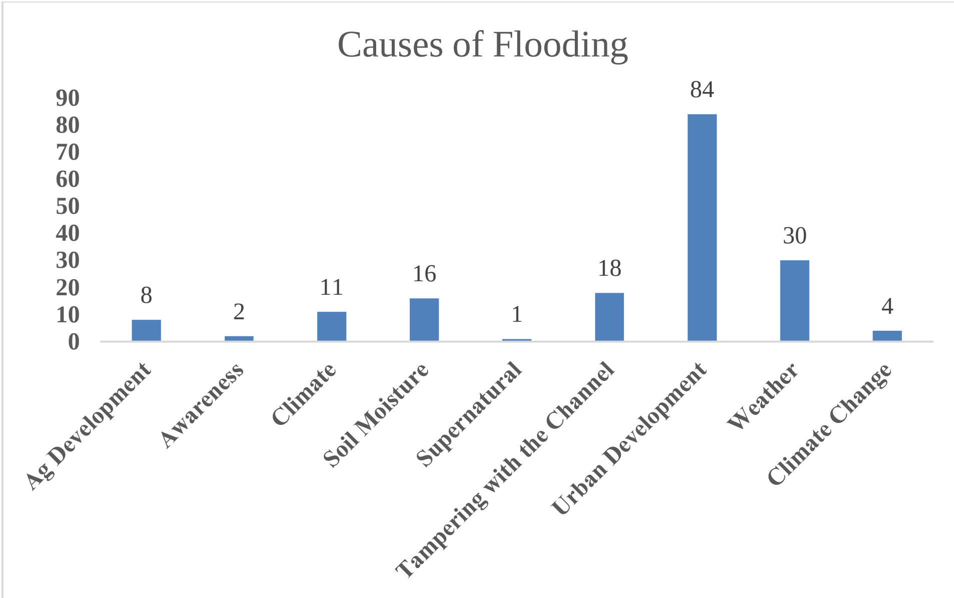

Figure 5-3: Total references of flooding causes (Source: Author)

Stakeholders in the lower section of the watershed mentioned seven of the eight identified codes related to flooding, while members of the other three groups mentioned six (Figure 5-4). Due to their location, these lower reach stakeholders are more prone to experience flooding and may have an increased awareness of the underlying causes of flooding. This group mentioned urban development and weather as the primary causes of flooding. The only group that provided frequent references to most of these causes was the experts. Due to working on research and stream preservation projects in the watershed, they are more likely to be aware of the many factors that contribute to flooding.

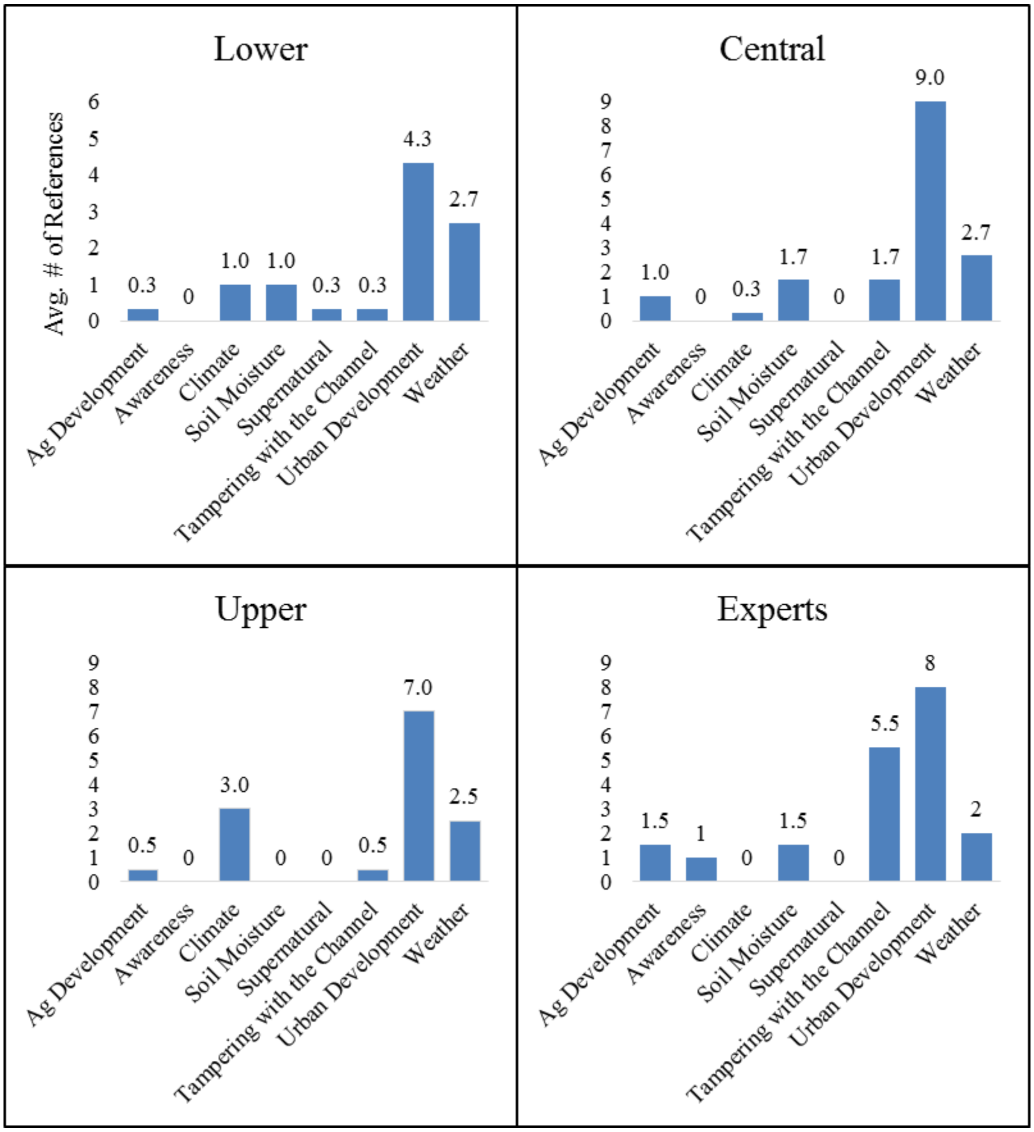

Figure 5-4: Causes of flooding by location in watershed (Source: Author)

Most of the interviewees identified weather (specifically, rain) as the only cause of flooding when first asked about the causes of flooding. It was not until asked more specific questions, that other possibilities were identified. The following is a snippet of text from an interview:

> Interviewer: “So flooding that you’ve seen in and around your property, what has been, in your eyes, the cause of that?” Participant: “Rain.” Interviewer: “Just the rain?” Participant: “Just the rain, and the intensity of the rain. Sometimes we get, and it comes down about an inch an hour. And sometimes it lasts 3, 4, 5 hours. When that happens, a lot of water comes down the creek.” – *Respondent from Keats*

It was rare for a stakeholder to identify multiple causes of flooding without being prompted by other questions, but the following shows that some stakeholders readily identified multiple causes of flooding:

> “But these big huge rains coming very fast is just the exact reason why you need to respect floodplains and leave them there, because sometime you’re going to wish you had them to allow that creek somewhere to go and not damage someone’s property.” – *Respondent from Keats*

5.2 Value of Flood Mitigation and Payments for Implementation

Responses about the value of mitigation strategies were relatively uniform. Respondents were asked about retention ponds, detention dams, and building removal/relocation. It was expected that participants in the upper portion of the watershed would be less likely to see value in implementing mitigation strategies, while participants in the lower end of the watershed were expected to have more positive feelings due to receiving the greater part of the benefit from flood mitigation. However, it was found that nearly all stakeholders of the watershed saw value in implementing flood mitigation strategies (Figure 5-5).

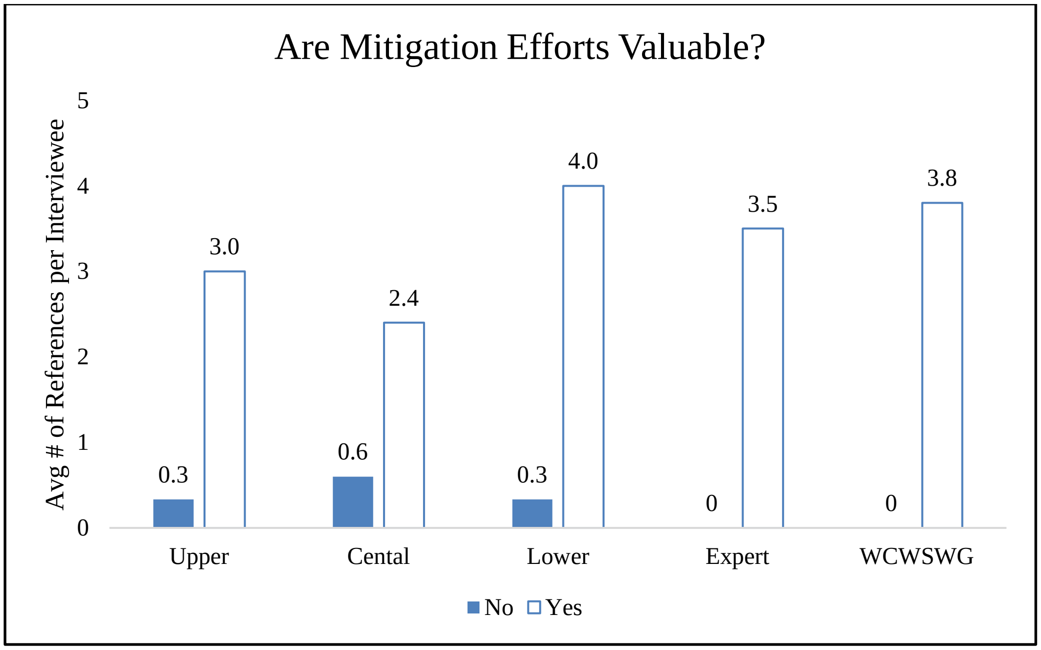

Figure 5-5: Value of Flood Mitigation Strategies. (Source: Author)

One watershed resident in the upper and two in the center owned businesses in the Manhattan area. These participants are more likely to be exposed to some of the sentiment in Manhattan, so Figure 5-6 removes business owners from each location:

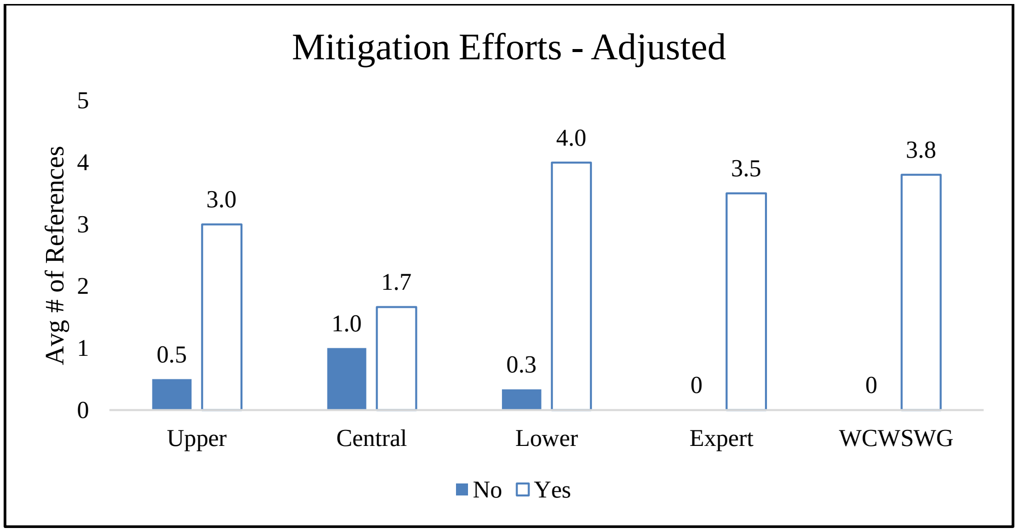

Figure 5-6: Value of Mitigation Strategies adjusted to remove stakeholders who own businesses in Manhattan. (Source: Author)

By removing the business owners associated with Manhattan, the average number of references to interest in mitigation goes down dramatically in the central portion of the watershed, and the opposition in the upper portion goes up. People of the center and upper portions of the watershed are less likely to see value in mitigation efforts, while participants in the lower portion are more likely to support such efforts. Most stream – related flood problems occur within the lower portion of the watershed, so this area would receive more benefit from mitigation efforts. Due to the lower risk of the flooding hazard in other parts of Wildcat Creek Watershed, stakeholders do not see flood mitigation as valuable to their way of life compared with those who are more likely to receive negative impacts from stream – related flooding. The overwhelming sentiment in value in mitigation efforts is further communicated by examining the total number of references. Positive references to mitigation efforts was referenced forty times, while there were only five negative references to mitigation efforts (Figure 5-7).

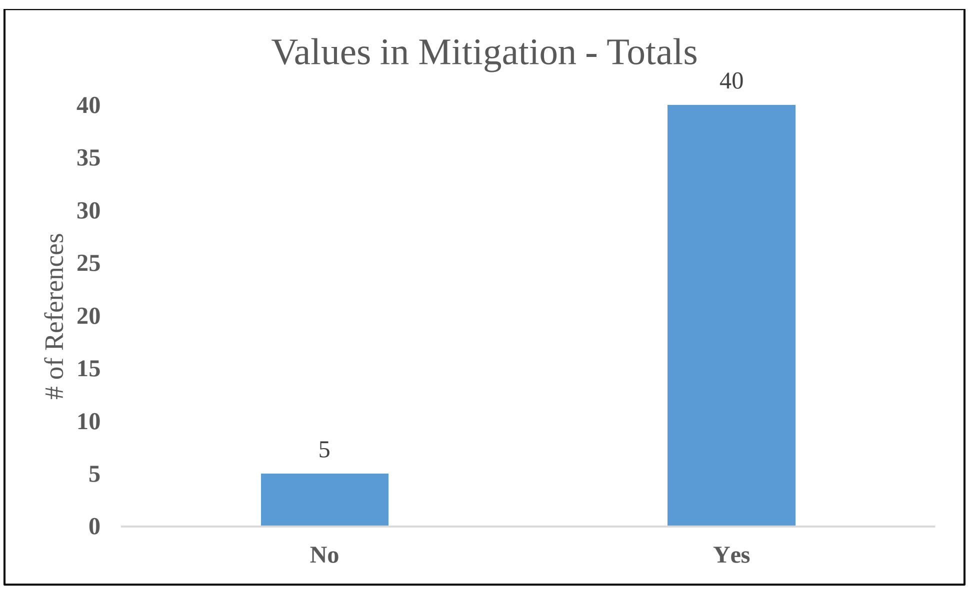

Figure 5-7: Total references to value in mitigation efforts (Source: Author)

The spatial dependence of mitigation responses idea is reinforced by examining the data on willingness to help pay for flood mitigation implementation. The idea of creating a watershed district was discussed with each interviewee along with the implications of having that district (e.g. issues such as taxation to help pay for flood mitigation efforts). Responses about paying for mitigation efforts were divided into three codes: 1) those opposed to helping pay for mitigation, 2) those willing to help pay for mitigation, and 3) those who maintained a level of pragmatism about paying for mitigation (Figure 5-8). Ideas related to opposition followed along a common line: the idea that it was Manhattan's problem and not the fault of stakeholders that live in rural, up – stream portions of the watershed. Why should they have to pay for problems in Manhattan that Manhattan caused?

> "As long as it's [potential taxation from watershed district] just Manhattan. They'll have to deal with that themselves, but you can't put it out in Riley County, because it's not our fault." – *Respondent from Riley*

Pragmatism to the idea of paying for mitigation came in the form of uncertainty about how watershed districts function and doubt that mitigation efforts would be helpful. This was typically driven from a sense of distrust in government. One respondent from Keats saw the reinforcement of Tuttle Creek Reservoir as a reason for the Corps of Engineers to justify their own existence. This participant was more pragmatic about paying and seeing value in flood mitigation:

> "For example, since we're talking about watersheds, they just recently spent 200 million dollars reinforcing Tuttle Creek Dam. Are you aware of that? In the last 20 years, that happened. That was, in my opinion, that was the Corps of Engineers justifying their own existence." – *Respondent from Keats*

In this respondent's case, government distrust caused skepticism about whether the construction of flood water retention structures would actually function for their intended use:

> “It would be interesting to know what kind of impact that [mitigation efforts] might have, but I think it would have some impact if they were all full, and a big flood comes they might not have a lot of help. If they are empty, they can probably catch a lot of water, so it could vary. The impact could vary depending on how many dams there are...” – *Respondent from Keats*

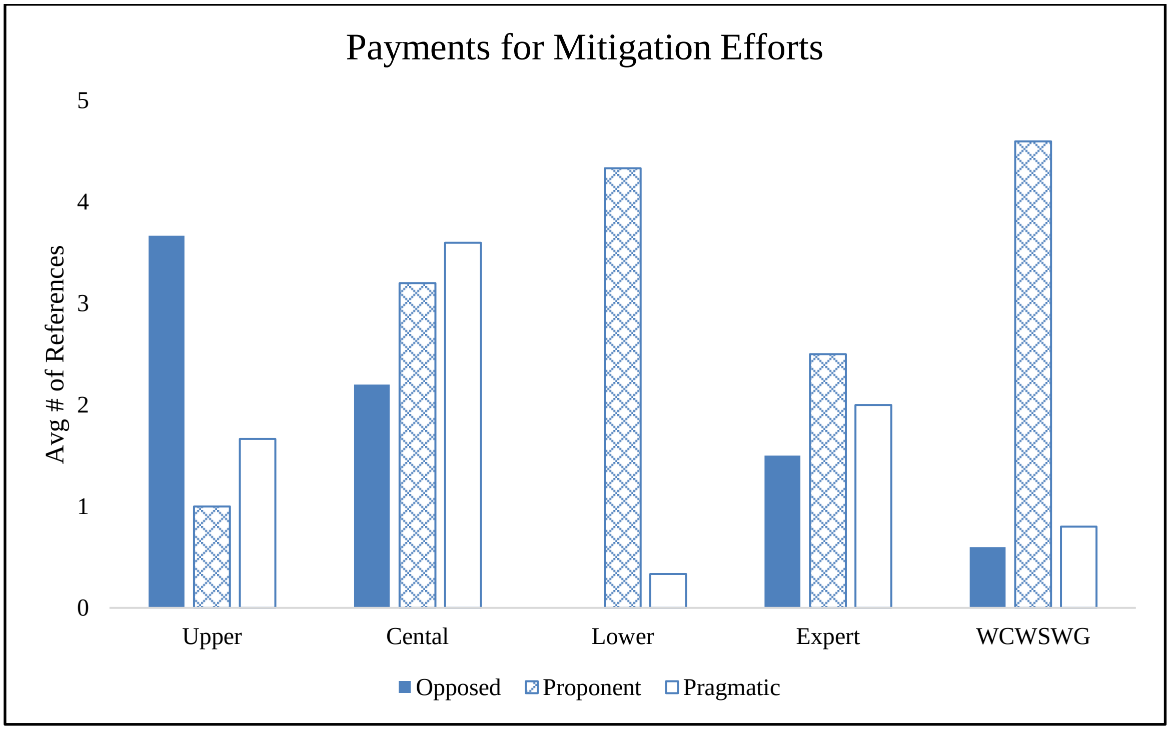

Figure 5-8: Spatial distribution of willingness to help in paying for mitigation efforts (Source: Author)

The amount of opposition for monetarily supporting the implementation of mitigation efforts was overwhelming in both the upper and central portions of the watershed. Although many in this area opposed paying for mitigation efforts, there were others who were hesitant and pragmatic about mitigation efforts, while opposing and/or pragmatic sentiments were non-existent in the Manhattan area. Figure 5-9 provides an indication of the responses after removing those who own businesses in the Manhattan area.

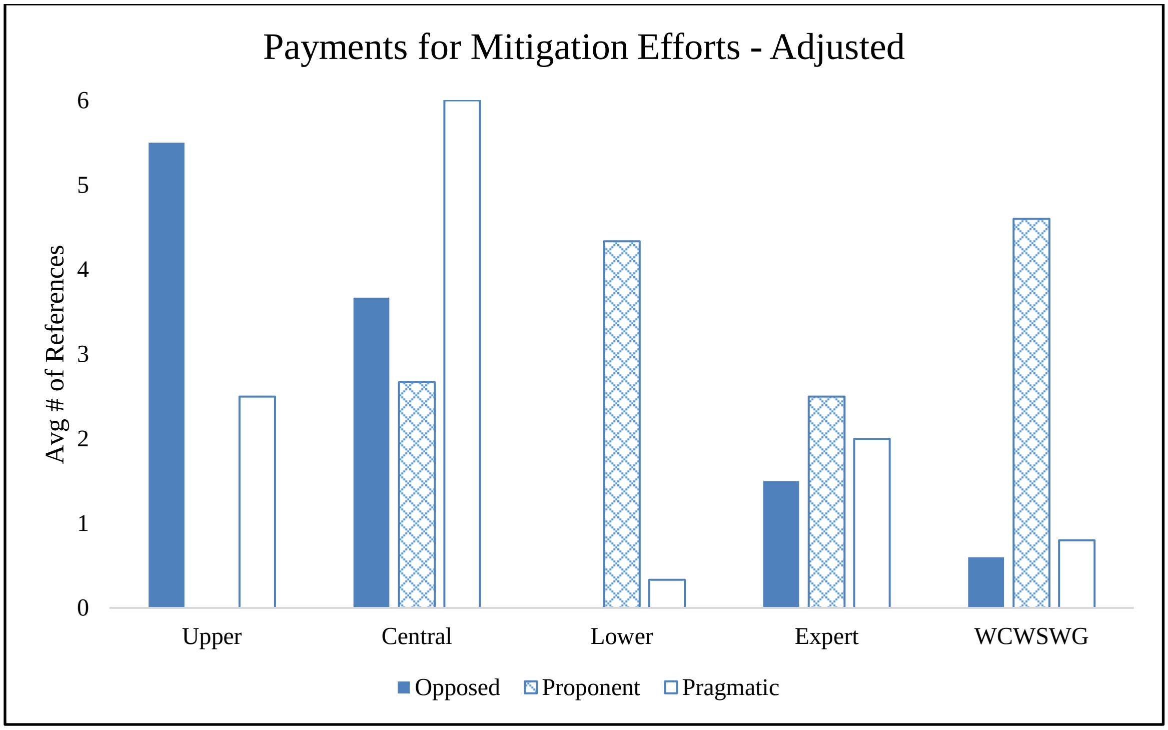

Figure 5-9: Willingness to help pay in mitigation efforts adjusted to reflect stakeholders who own businesses in Manhattan. (Source: Author)

Nearly all positive sentiment was from respondents associated within the Manhattan area, while the concentration of either pragmatic or opposed to assisting in payments for mitigation strategies was from interviewees in the center and upper sections of the watershed. This stark spatial relationship is reasonable based on the location of flood impacts from stream – related flooding in the Wildcat Creek Watershed. The farther one gets from the hazard, the less willing residents are to help in lessening it. The number of references by expert interviewees to payments for mitigation was limited because neither were residents of Wildcat Creek Watershed. Both expert interviewees were proponents of creating an urban watershed district for Wildcat Creek. Interviewees of the WCWSWG were advocates of paying to decrease the flood risk across the watershed. The total amount of references (Figure 5-10) shows a more even distribution in payments for mitigation efforts. Overall, more are willing to help assist in mitigation efforts.

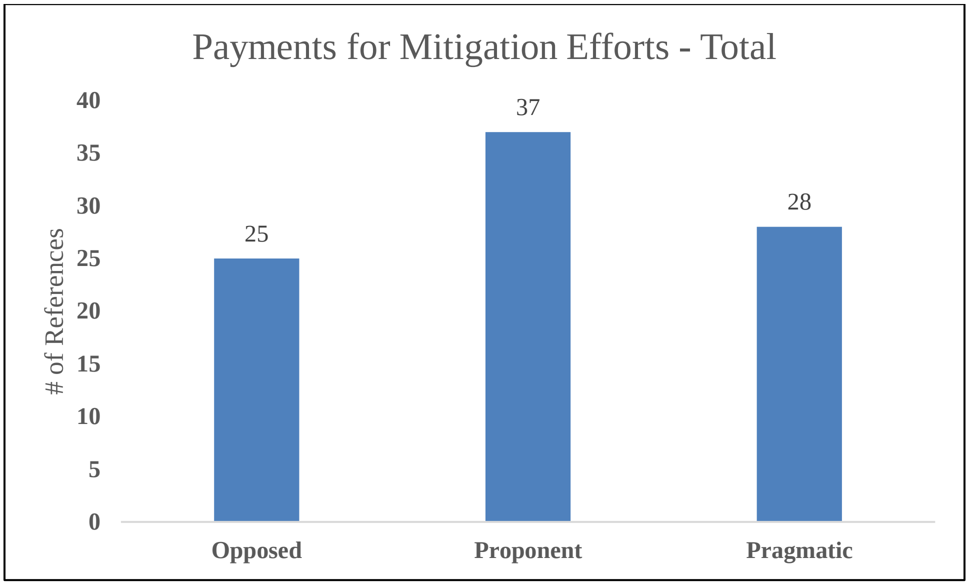

Figure 5-10: Total references about willingness to pay for mitigation efforts (Source: Author)

Another measure of mitigation advocacy was interviewees suggesting their own ideas to mitigate the flood risk (Figure 5-11). These ideas ranged from wetland restoration to the development of retention basins in every reach of the watershed.

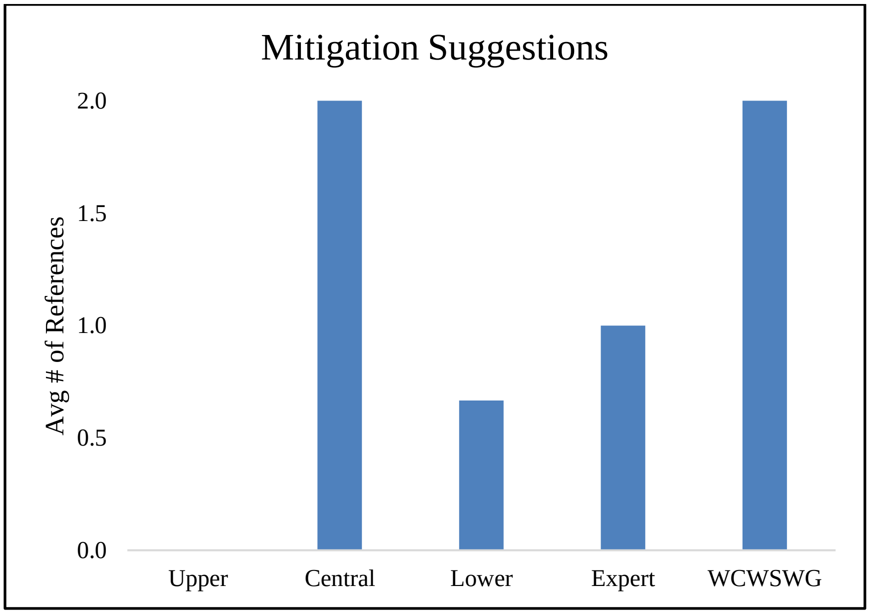

Figure 5-11: Stakeholder conceived ideas to mitigate flood risk. (Source: Author)

Mitigation suggestions included references to ideas that an individual had conceived about reducing the flood risk in the study area. Participants who made these suggestions were typically proponents of watershed districts and of paying for mitigation strategies to reduce the overall flood risk. Stakeholders in the central portion of the watershed were more likely to conceive their own mitigation strategies. As expected, members of the WCWSWG discussed mitigation strategies because that is one purpose of their group. Overall, mitigation efforts were suggested a total of eighteen times throughout the interviews.

5.3 Flood Risk and Vulnerability

5.3.1 Flood Risk

Discussion of flood risk with interviewees was interesting due to many believing that the overall risk of flooding across the watershed had increased. Of that group, many also believed that their own personal risk had remained the same throughout the course of living in the watershed. This was especially true of interviewees whose families had lived along Wildcat Creek long before they were born. They believed that the watershed has always flooded, and always will. Participants were not asked whether they thought the flood risk had increased or decreased, but rather if they had seen a change. Flood risk was divided into three sub-themes: 1) changed (across the watershed), 2) changed (personal feelings associated with interviewees' properties), and 3) unchanged (Figure 5-12). References to flood risk from interviewees classified as experts were removed because they do not reside in the study area.

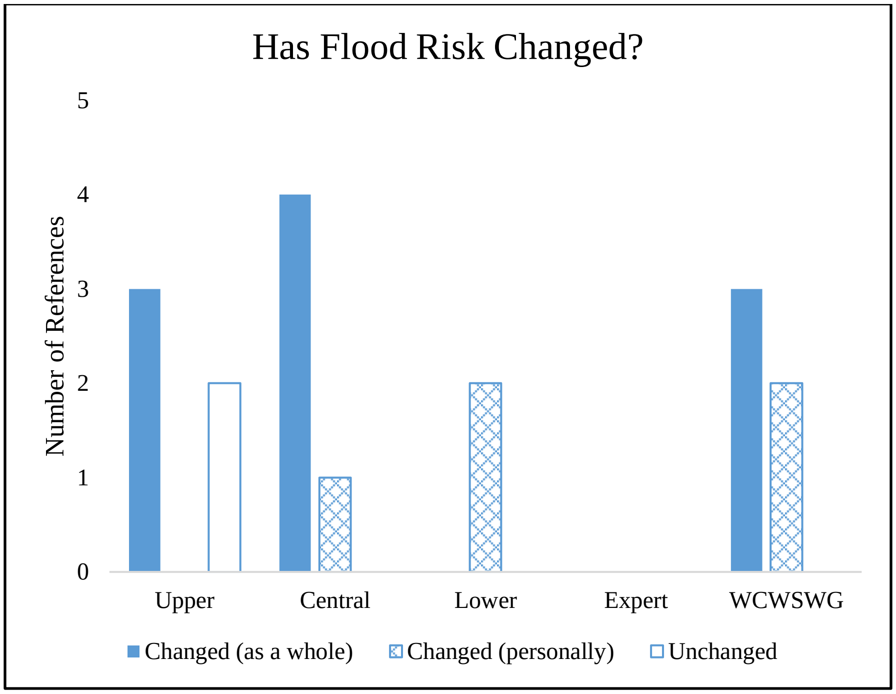

Figure 5-12: Perceptions of changes in flood risk in Wildcat Creek Watershed. (Source: Author)

Before adjusting each cluster by removing members of the WCWSWG, it appears that stakeholders believe that the flood risk has changed over time. There are more references to a change in risk across the watershed rather than personal changes in risk. This suggests that stakeholders believe that flooding has become a greater problem as a whole, but they did not think that this change in risk is impacting them. The two stakeholders who mentioned an increase in personal risk own property that is adjacent to the main stem of Wildcat Creek. Those who mentioned an overall change in risk were typically further from the floodplain, and were basing their responses on the flooding that occurs in Manhattan. These values were also adjusted to reflect only the members of each community that were not involved in working group activities (Figure 5-13).

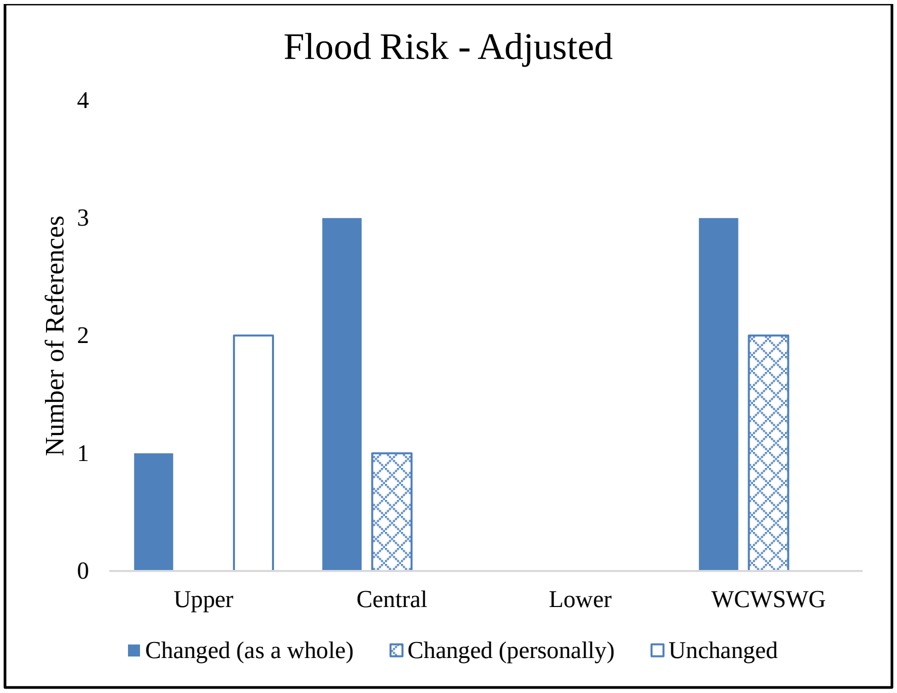

Figure 5-13: Perceptions of flood risk adjusted to remove WCWSWG members from each location (Source: Author)

Removing members of the WCWSWG from each location shows an interesting trend for the lower end of the watershed. The area that experiences the most flooding does not appear concerned of their own flood risk, while other areas are cognizant of increased flood risk in Manhattan. One respondent from the upper portion of the watershed did not believe that flood risk has changed throughout the course of living in the area.

> Interviewer: "Over this course of time, have you seen a change in the flooding? Has it gotten worse?" Participant: "No…and the oral histories of the things that, of what Wildcat did and what it can do, and should be expected to do again. My parents used to tell about one of the wet summers in the 30s. That Wildcat Creek came up so high, and so fast that it had Natalie's, what's now called Natalie's Creek, going at the house there running backwards. Running uphill three quarters a mile from the creek bed. So it's done it forever." – *Respondent from Riley*

Although spatial aspects in flood risk perception are present, they should not be focused on due to low counts of references to flood risk. After the adjustment to remove WCWSWG members, changes in flood risk across the watershed was only mentioned seven times, while changes in personal flood risk was mentioned three times. The low count in references to flood risk is also seen by looking at the total amount of references (Figure 5-14). The most mentioned code to the flood risk theme (overall changes) was only referenced seven times. This indicates that stakeholders are relatively unaware of flood risk in Wildcat Creek Watershed. Despite the low count of flood risk references, stakeholders were more interested in their vulnerability to floods.

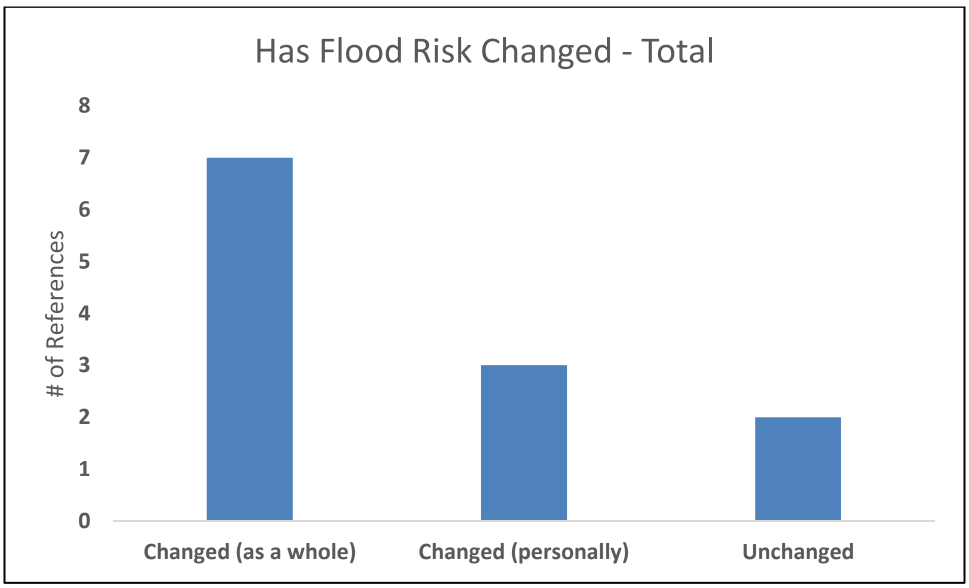

Figure 5-14: Total references to flood risk change (Source: Author)

5.3.2 Flood Vulnerability

Like risk, interviewees were asked whether they had seen a change in their flood vulnerability (Figure 5-15). Responses about interviewees' feelings about vulnerability were divided into three categories: 1) a change has occurred (when this was mentioned it was associated with an increase in vulnerability, 2) mixed feelings about vulnerability (the idea that exposure is not impossible, but would take a very large flood), and 3) no change in the overall vulnerability to stream – related flooding over the course of time. When asked about their vulnerability, stakeholders were more vocal than when asked about their risk. This could be due to the implications of vulnerability rather than risk. By definition, risk is the probability of exposure to a hazard, while vulnerability is the ability of an individual or community to cope with exposure to a hazard. While stakeholders don't feel at risk, they might feel vulnerable to the negative effects from flooding.

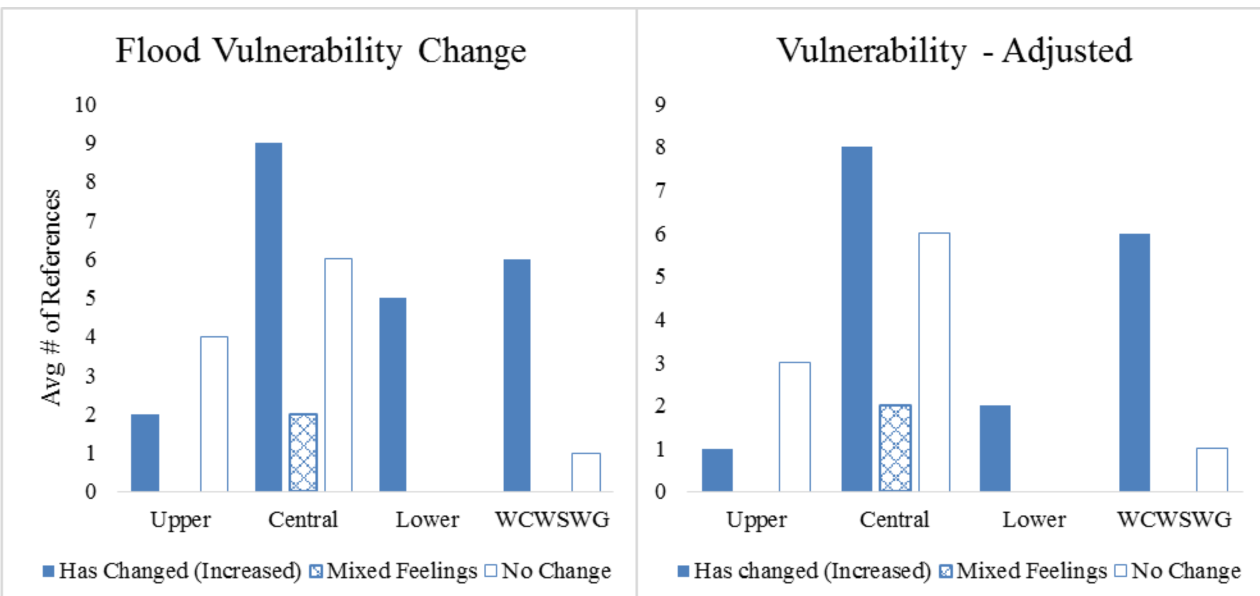

Figure 5-15: Perceptions of flood vulnerability (Source: Author)

Although stakeholders were more responsive to questions about vulnerability, this was not necessarily an affirmation of their belief that vulnerability has changed. Stakeholders from two areas (upper and central) believe that there is no change in vulnerability, with some having additional mixed feelings observed in the center portion of the watershed. Interviewees who had mixed feelings combined with an idea that there was no change in vulnerability typically thought that exposure to flooding at their property was not impossible, but would take a large flood to do so. The following line of text from a respondent from Keats highlights this idea:

> Interviewer: "How vulnerable do you feel your property is to a flood?" Participant: "Based on past experiences, it's going to take a lot of water. I don't think it's going to, I don't think it's, probably shouldn't say it. I don't think it's totally impossible...I mean we live not too far from the creek, but it's going to take a lot of water, because there was a lot of water coming down then [2011]." – *Respondent from Keats*

The number of references to "No Change" could be due to the framing of how stakeholders were asked about their vulnerability. Rather than ask about vulnerability overall, they were asked if they felt vulnerable to flooding at their homes. A large number of interviewees did not live in close proximity to the floodplain, and are less likely to feel vulnerable to flooding.

Examining the total amount of references to changes in flood vulnerability shows most believe that there is a change in vulnerability, but there is also a high amount of references to no changes (Figure 5-16). Mixed feelings about changes in vulnerability were only seen twice throughout the interviews.

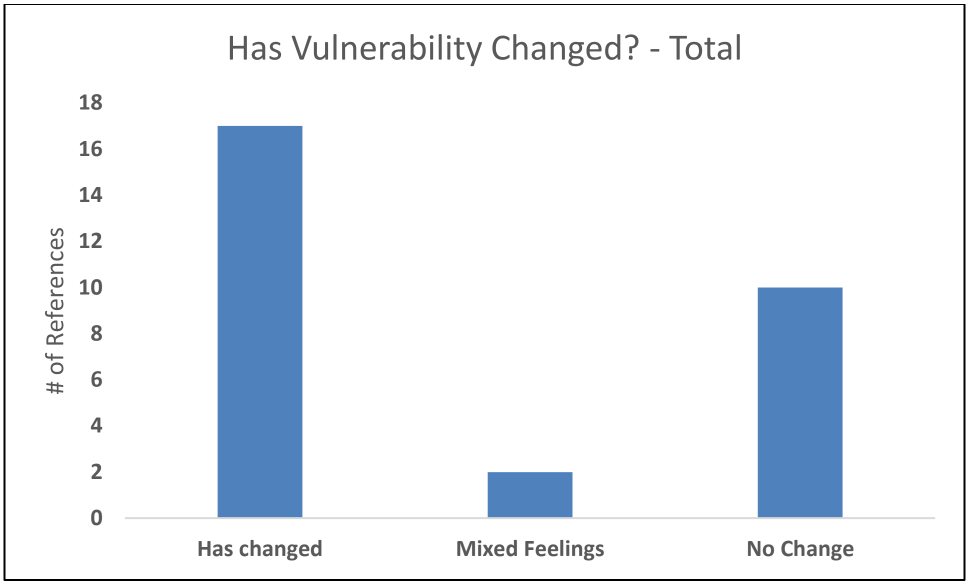

Figure 5-16: Total number of references to changes in vulnerability (Source: Author)

5.4 Sources of Information

To examine how sources of information can affect understanding of the flood hazard, interviewees were also asked about who and what they consider a trusted source of information. By determining where stakeholders of Wildcat Creek Watershed obtain information, conclusions can be drawn about their beliefs on flooding issues. Based on responses during the discussion, major sources of information were divided into four classes: 1) expert (scientists or people who conduct work on the watershed), 2) government entities, 3) local agents (friends or neighbors that a participant would reference), and 4) internet or mobile applications (Figure 5-17).

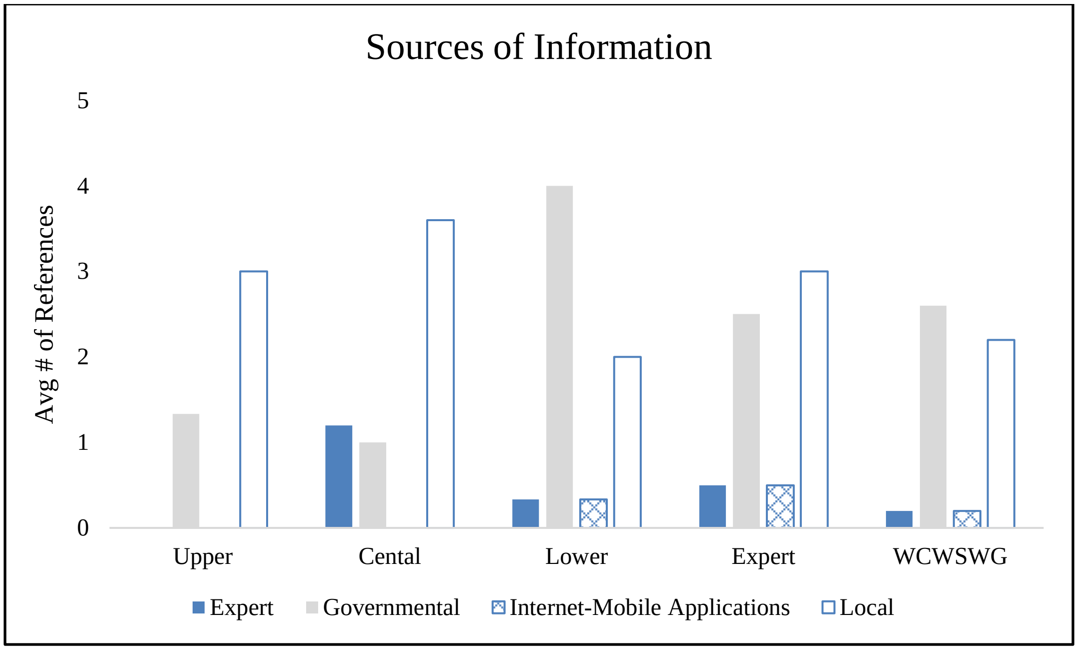

Figure 5-17: Trusted sources of information by interviewed stakeholders. (Source: Author)

The distribution of references to sources of information was fairly uniform across the three locations and expert interviews. Based on the number of references, most stakeholders of Wildcat Creek Watershed prefer obtaining information from people with whom they are familiar. Responses were classified as both local and government when a stakeholder referenced local government officials/agencies. A greater trust in expert sources of information, like that of researchers at Kansas State University, was seen in interviews with stakeholders in the area around Keats. This could be related the outreach of experts who conduct studies of the watershed in Keats. Stakeholders in the central portion mentioned interest from researchers in examining their property more so than those from the other two areas. Outreach by experts conducting work on the watershed is believed to be the reason behind a greater trust in expert sources of information in the central of the watershed.

A greater trust in governmental sources of information was seen in the lower part of the watershed around the City of Manhattan. This could be due to outreach by city officials through internet sources like the City of Manhattan's "Know Your Flood Risk". It could also be a result of greater governmental presence in this area because of past damage from floods in Manhattan. Governmental sources of information were mentioned twelve times from interviewees located near Manhattan, accounting for nearly half of the twenty-six references across all five classes.

Trust in local sources of information was far greater than the other three classes (Figure 5-18). Many participants have lived in Wildcat Creek Watershed for a long period of time, giving them a greater knowledge of not only their neighbors, but people from other communities across Wildcat Creek. Many times, trust in local agents was observed because "they have first-hand experience".

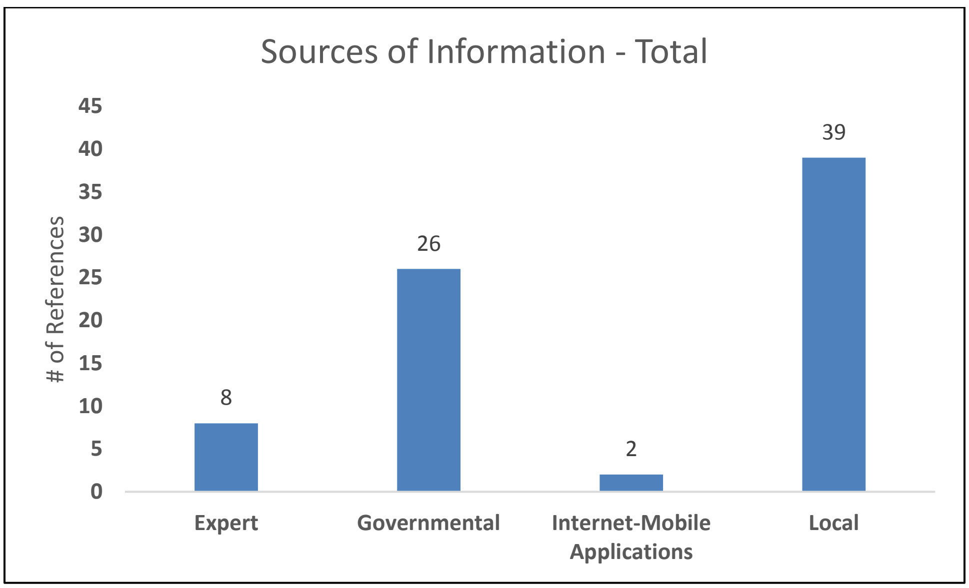

Figure 5-18: Total number of references to trusted sources of information (Source: Author)

This is reinforced through the following quotes:

> Participant 1: "So I haven't gotten it [information] from, and we went, we did go to several of the meetings where they talked about the flood. Where the water was, where it was coming from, tributaries. But, I guess, most of it I get from people that have lived here. Actually you can come out and survey, you can do anything you want. You talk to people that went through it, just like we've been through. We know what happened, we know where it went." Participant 2: "First-hand knowledge is better than any computer-generated projection." – *Couple from Keats*

Even residents of Manhattan where the population is typically more transient leaned towards local agents as trusted sources of information:

> "They've [neighbors] lived there 35 years. When we bought the land [and] built our house, Jim said when we have a flood, 12 hours after the rain event it peaks, and 12 hours later we cross over the water again...Now that it might be 2 hours later that the water makes it impassable." – *Resident of Manhattan*

5.5 Major Themes that Emerged During Interviews

Although most of the major themes addressed the overlying research questions, several themes emerged during the interview process that were unrelated to any research questions. The following ideas were important to stakeholders of the watershed based on the number of times they were referenced in an interview: 1) the idea that one person or a collection of people are responsible for flooding issues, 2) good stewardship by landowners is now undervalued, and 3) the Topeka Shiner. The Topeka Shiner, an endangered species of fish that calls Wildcat Creek home, was seen as a reason that mitigation efforts have not been adopted.

5.5.1 Responsibility for Flooding

In addition to causes of flooding, many interviewees believed that one group or a collection of groups was responsible for the flooding issues that exist with Wildcat Creek. Many times, stakeholders would indicate that *they* did something that caused flooding or *they* have been developing where *they* probably shouldn't. This idea that a group of people could be responsible for flooding issues was prevalent across the entirety of the watershed. References to responsibility had several common lines:

1) Fort Riley is not doing as much as they could to prevent flooding that occurs on Wildcat Creek:

> [When asked if respondent had any flood mitigation on property] "No. That's what Fort Riley supposed to do. They was going to put in, you know, retention ponds." – *Respondent from Riley*

2) Builders and developers are constructing residential spaces in flood-prone areas:

> "It's just hard to understand why some of this building was done where it was done. Now they're crying in their beer." – *Respondent from Riley*

3) Local government allows developments to construct where they shouldn't:

> "It makes you really wonder when the city, when they planned the layouts of Scenic. Do they even think about the water?" – *Respondent from Manhattan*

This pass off on responsibility to local decision-makers suggests that stakeholders of Wildcat Creek Watershed do not believe that they are part of the problem. The belief that someone else is causing the flooding problems seems to prevail across all locations of the watershed (Figure 5-19). This sentiment is concentrated in the upper portion of the watershed with nearly double the amount of references to responsibility than the other categories. This is likely related to negative sentiment towards the government in Manhattan in this part of the watershed. The same area that does not want to pay for mitigation efforts because they are not affected, also have the highest amount of belief that they themselves are not causing flooding issues. Responses from the lower portion of the watershed had a higher concentration of those with the belief that a group of people is responsible for the flooding issue. Being affected by flooding more often than other locations, stakeholders in this section of the watershed could potentially be more aware of the activities of different agents that could cause more people to be at risk of flooding.

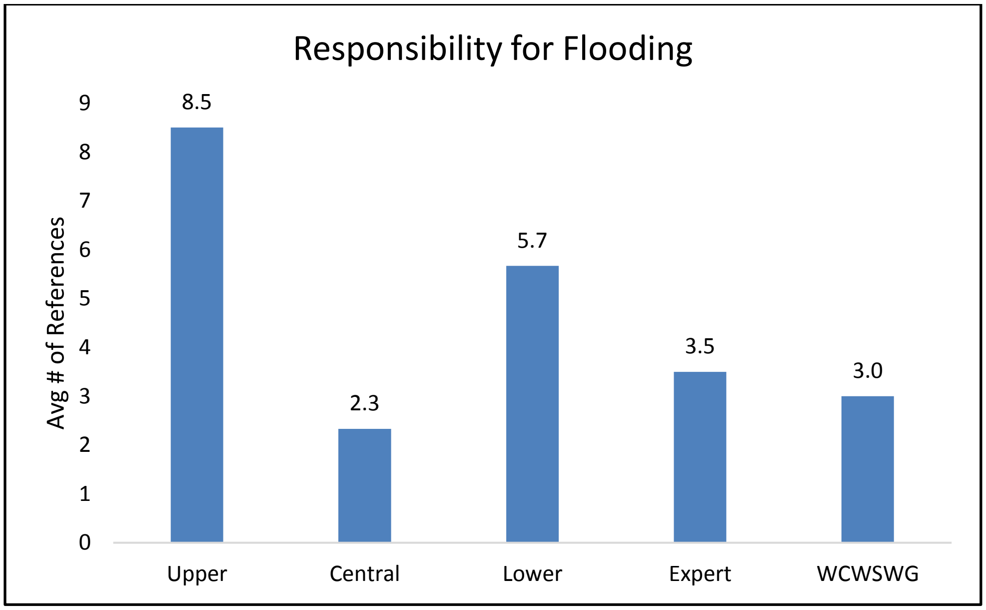

Figure 5-19: Perceptions of people being responsible for flooding issues. (Source: Author)

5.5.2 Land Stewardship

Many stakeholders believed that landowners in Wildcat Creek Watershed are no longer good stewards of their properties. Interviewees claimed that landowners in the past had maintained riparian buffers and kept the creek devoid of debris by removing it from the floodplain. It is interesting to note that natural processes do not remove branches and tree trunks from the stream, but local residents see this as a stream improvement.

The people near Keats believed that landowners in the watershed now own more property and are no longer able to take care of their properties like in the past:

> "They were more apt to keep it clean. That's when we had smaller farmers, and they had their own area around the creek. They would take care of their own area. Now you've got a big time operator that's farming several acres, and they may be renting it from these owners. The owners don't have the equipment, and they may live down in town somewhere. They don't have any way of coming and cleaning it out. The renter isn't going to do it for them from the goodness of his heart. So it doesn't get cleaned out like it used to."
> – *Respondent from Keats*

There was a stark spatial relationship in the perception that landowners are no longer good stewards of their properties, with a concentration of people contributing to this idea existing in the central portion of the watershed (Figure 5-20). This idea received a smaller response level in the Manhattan area. This could be caused by people from this portion of the watershed owning smaller tracts of land. In addition, a large percentage of land near Wildcat Creek within in the city limits of Manhattan is owned by the city, and is used for parks. By not having any residents' properties backing up to the stream, they could be less likely to see the effects of other landowners not removing debris from the stream channel. Bad land stewardship was not addressed in the upper portion of the watershed and this could be related to people in this area owning large tracts of land. The stream may be less impacted by human actions in this upper portion, so they might not address the idea that they may be bad stewards of their own properties.

Land stewardship was rarely addressed by members of the expert group or the Wildcat Creek Watershed Working Group indicating that most people who mentioned this were stakeholders that do not have any professional connections to information regarding the watershed.

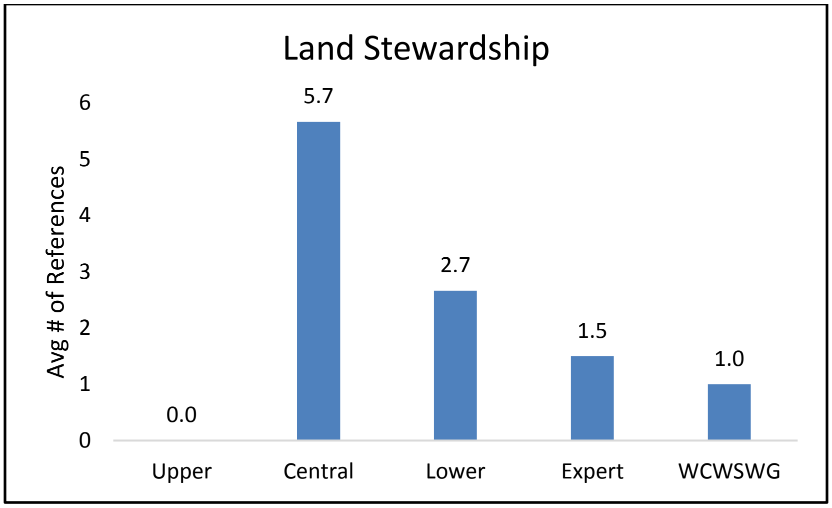

Figure 5-20: Perception of landowners being bad stewards of their property. (Source: Author)

5.5.3 Environmental Issues and the Topeka Shiner

Environmental issues, such as the Topeka Shiner, also saw discussion from stakeholders. The perception of environmental concerns were that they were impeding progress on mitigation efforts that could reduce the impacts of stream – related flooding. Many stakeholders felt that environmental issues like the Topeka Shiner held precedence over protecting people from flooding.

> "I'm not concerned about the Topeka Shiner. Species have been dying out since the beginning, and were, somebody has got the idea that some little fish is more important than people. I don't buy that." – *Respondent from Keats*

Many stakeholders may not be aware of the underlying stream quality issues that cause the Topeka Shiner's habitat to be threatened. Spatial aspects of perceptions of the Topeka Shiner were strikingly similar to that of bad land stewardship (Figure 5-21). For example, the focus on the Topeka Shiner was concentrated in the center of the watershed with an average of two references per interviewee. Also like perceptions of stewardship, there was no mention of the

Topeka Shiner in the upper portion. This is likely due to the smaller size of the headwater streams in this section, which potentially limit the Topeka Shiner from inhabiting areas near Riley or Leonardville.

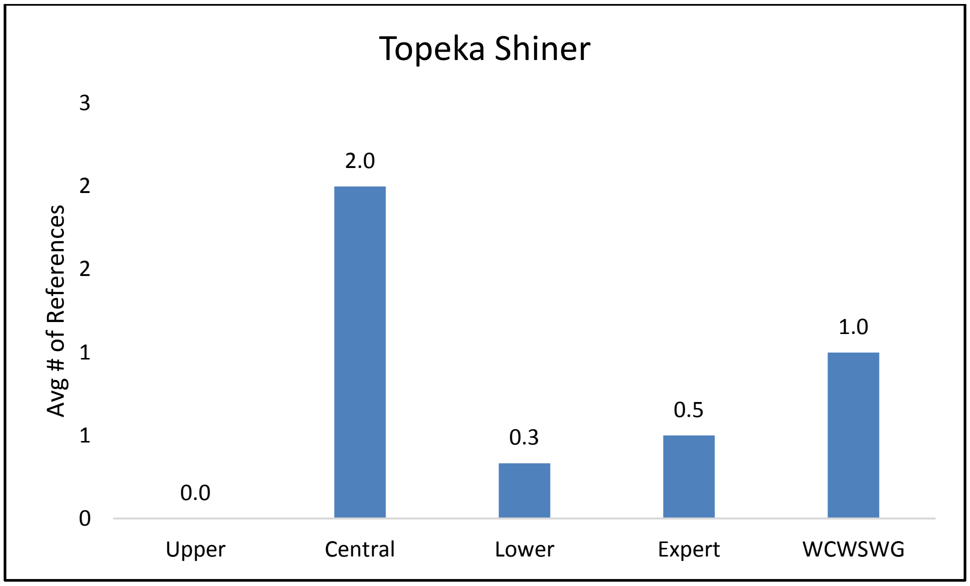

Figure 5-21: Perceptions of the Topeka Shiner. (Source: Author)

5.6 Conclusion

Based on these results, conclusions were drawn for each research question. There were definite spatial relationships in perception of flooding issues in the Wildcat Creek Watershed. Across every area, stakeholders understand many of the physical causes of flooding, but do not tend to see the connections among the many physical components. Overall, stakeholders believed that mitigation strategies to curb flash flooding were valuable, although many were not supportive of paying for these through potential taxation from a watershed district. Despite the increase of flooding events in the past decade as discussed in Chapter 3, many stakeholders neither saw any changes in their personal risk of exposure to flooding nor a change in their flood vulnerability. In context of the flooding issue in Wildcat Creek Watershed, most participants trusted their neighbors and community leaders as sources of information.

Chapter 6 - Summary

6.1 Research Questions Revisited

RQ – 1: Do residents of the Wildcat Creek watershed understand watershed/flood processes (i.e. how water flows through a watershed, and how a flood develops), and does that understanding change based on their proximity to the floodplain?

The results of the first theme identified in Chapter 5 (causes of flooding) addresses the first research question regarding how stakeholders understand surface hydrologic processes and the flooding issue in the Wildcat Creek Watershed. These results tend to suggest that stakeholders have a good understanding of how water flows throughout a watershed, as well as potential causes of flooding. However, that understanding is often incomplete. For example, stakeholders often focused on urban development as the biggest cause of flooding in the Wildcat Creek Watershed, but many times did not address *how* factors such as an increase in impervious surface area caused flooding. Also, stakeholders when asked about the causes of flooding typically identified only weather (specifically rain). It was not until participants were asked for more specific information did they begin to address many of the other causes of flooding. The fact that interviewees addressed urban development more than double the number of times as the next cause is likely due to discontent with governmental approvals of housing developments around the intersection of Scenic Drive and Anderson Avenue. Understanding of the causes of flooding was similar throughout the entire watershed. The largest difference among the locations of the watershed was that changes in climate were mentioned more frequently as a cause of flooding in the upper portion. This could be due to the amount of agricultural production that occurs in the northwestern portion near Riley and Leonardville. Since their income depends on weather and climate, producers are more likely to be cognizant of changes in seasonal weather patterns that would affect their crops.

RQ – 2: Do residents of the Wildcat Creek Watershed believe that flood mitigation procedures such as water retention basins, wetland restoration, and building relocation/removal are valuable to reduce flood vulnerability, and who do they believe should pay for these improvements?

Many interviewees saw value in implementing flood mitigation strategies to reduce the negative impacts from stream – related flooding issues. The perception of mitigation efforts changed across space with interviewees near Manhattan referencing mitigation more often than interviewees in the Riley or Leonardville areas. This idea was complicated, however, by the (un)willingness of stakeholders to assist in paying for mitigation efforts. Although most saw value in mitigation, willingness to assist in payments for mitigation diminished the further one traveled northwest towards the headwaters of the watershed. This is likely a result of the benefit of mitigation being focused on Manhattan, rather than in other upstream areas. The idea of bad stewardship of landowners by interviewees in the central portion of the watershed suggests that residents believe that being a good caretaker of your land can reduce the negative impacts of flooding for others. When asked about who they thought should pay for mitigation efforts, most interviewees outside of Manhattan believed that residents of the City of Manhattan should pay. Others thought that Fort Riley should take some responsibility by placing retention ponds in their portion of the watershed.

RQ – 3: Do the residents/business owners in the Wildcat Creek Watershed believe that their risk of flooding has changed over time? If so, why do they believe that?

Although residents have reported seeing changes across the watershed in both flood risk and vulnerability, they were less likely to believe that these changes directly affected them. This is likely due to many of the interviewees living outside of the floodplain. Those who lived near the floodplain were more likely to reference their risk, which was reflected by the number of references to personal vulnerability in the central portion of the watershed (region that had the greatest number of interviewees living near the floodplain). The upper portion was the only area that had references to no changes in flood risk. However, the no change in vulnerability code was observed in both the central and upper portions, suggesting that stakeholders near the headwaters of Wildcat Creek are not concerned with issues of flooding. Interviewees near Manhattan saw an increase in both personal flood risk and vulnerability. This is likely because of the increased frequency of damaging flash floods specific to Wildcat Creek mentioned in Chapter 3 and the ongoing development of new residential areas.

The idea that *somebody* was responsible for many of the flooding issues that occur in Wildcat Creek Watershed was prevalent throughout the entire watershed. Much of this was focused towards dissent about the approval of and recent increase in urban development near the intersection of Scenic Drive and Anderson Avenue. Other ideas towards responsibility were focused on Fort Riley needing to make a better effort in implementing mitigation efforts on their third of the watershed. Every participant in this study emphasized that there were people or groups of people responsible for many of the flooding issues in the Wildcat Creek Watershed.

RQ – 4: Who would residents/business owners of the Wildcat Creek watershed go to for obtaining information about how the creek functions, and how might this affect their views on flooding in their neighborhoods?

For the most part, interviewees held the belief that local sources of information were trustworthy. Whether this was local government or members of their communities, references to local sources of information far out – weighed that of trust in professionals, government, or internet sources. Within this local trust, there were more references to neighbors or prominent members of a community than local government. The idea that those local agents had experienced the same level of exposure to flooding as they had was prevalent.

6.2 Recommendations for Further Research

This study provides a foundation on the social context of flooding in the Wildcat Creek Watershed so that others may build upon it. In many cases, qualitative data obtained through interviews is coded by several individuals at a time (Hay 2000). This allows for many perspectives to examine the data and code it to create themes that others may not see. This creates a more holistic view on the data from a qualitative study allowing for a much richer analysis to be had. The data from this study could be used for that purpose, so that more relationships can be discovered.

Based on the discussions with stakeholders of Wildcat Creek Watershed, it is important to examine *who* is a cause of flooding rather than focusing on just the physical aspects. Many stakeholders believe that somebody and/or group of people were responsible for creating flooding issues near Manhattan, and it may be beneficial to delve deeper into why they believe that. Seeing who they specifically believe is at fault can inform decision – makers to bring about change in the management of water resources in the Wildcat Creek Watershed (Burton and Kates 1964). Many stakeholders cited the urban development around the intersection of Scenic Drive and Anderson Avenue as a major reason that flooding is an issue. Coupled with the distrust of government sentiment, this relationship needs to be examined at greater length.

Comparing results of this study to similar studies at the same local level can provide beneficial insight into how people make management decisions in other semi-urban watersheds that are prone to flash flooding. By integrating research on Wildcat Creek Watershed with studies on other small streams systems in the Flint Hills, a better understanding of the Flint Hills can be created. Differences drawn between studies at the same level can also allow for decision – makers who manage water resources in the Wildcat Creek Watershed to better understand what makes it unique in terms of the social context of flooding. It is also beneficial to combine the social view of the flooding hazard provided by this study with physical studies of the same area. Burton, Kates, and White (1968) outlined that combining research on hazard perceptions with studies of the physical development of a hazard can provide insight into the optimal set human adjustments to the hazard as well provide a description of the process of adopting damage – reducing adjustment in their social context.

Although saturation occurred after 12/13 interviews, it is important to address that more interviews could provide greater insight into the perceptions of stakeholders in Wildcat Creek Watershed. The saturation of ideas may have occurred due to many of the interviewees having similar demographic characteristics. White (1988) stressed the importance of obtaining demographic data about populations being studied in a natural hazards framework. Since perception is partly caused by experience, obtaining data from various demographics can provide insightful differences in how stakeholders perceive a hazard.

Not only can this document provide insights for local decision – makers about how stakeholders understand flooding, it can also shed light on subject matter that needs to be better communicated/educated to communities. In some cases, stakeholder perceptions were incorrect. For example, the idea that the Topeka Shiner inhibits progress on developing mitigation efforts throughout Wildcat Creek Watershed is a misconception. Additionally, stakeholders misunderstood flood vulnerability. Given that some stakeholder perceptions were incorrect and that residents trust their neighbors for good information, this situation provides decision – makers with a challenge related to improved watershed process education for the communities in the watershed. This research also provides a locational reference to where certain ideas were misconceived. By highlighting these geographic locations, education efforts can target communities where these gaps in knowledge occur. By increasing the knowledge base of stakeholders of Wildcat Creek Watershed, an increased awareness about flood risk can result (Burton and Kates 1964). By increasing awareness about the hazard, overall social vulnerability can be reduced in these communities (Cutter and Finch 2008).

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Appendix A - Watershed Delineation Model

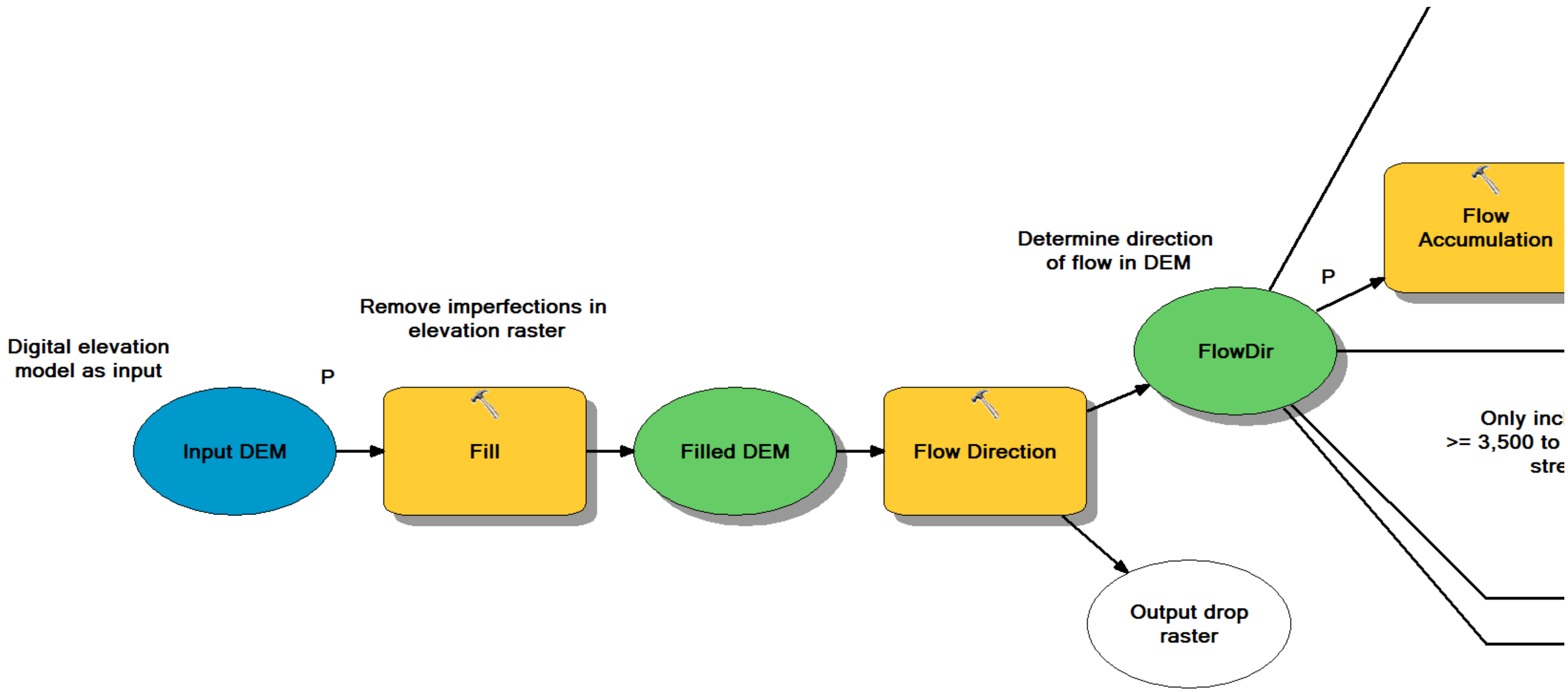

Figure A-6: Step 1 of Watershed Delineation Model. (Data Source: National Elevation Dataset; created by Author)

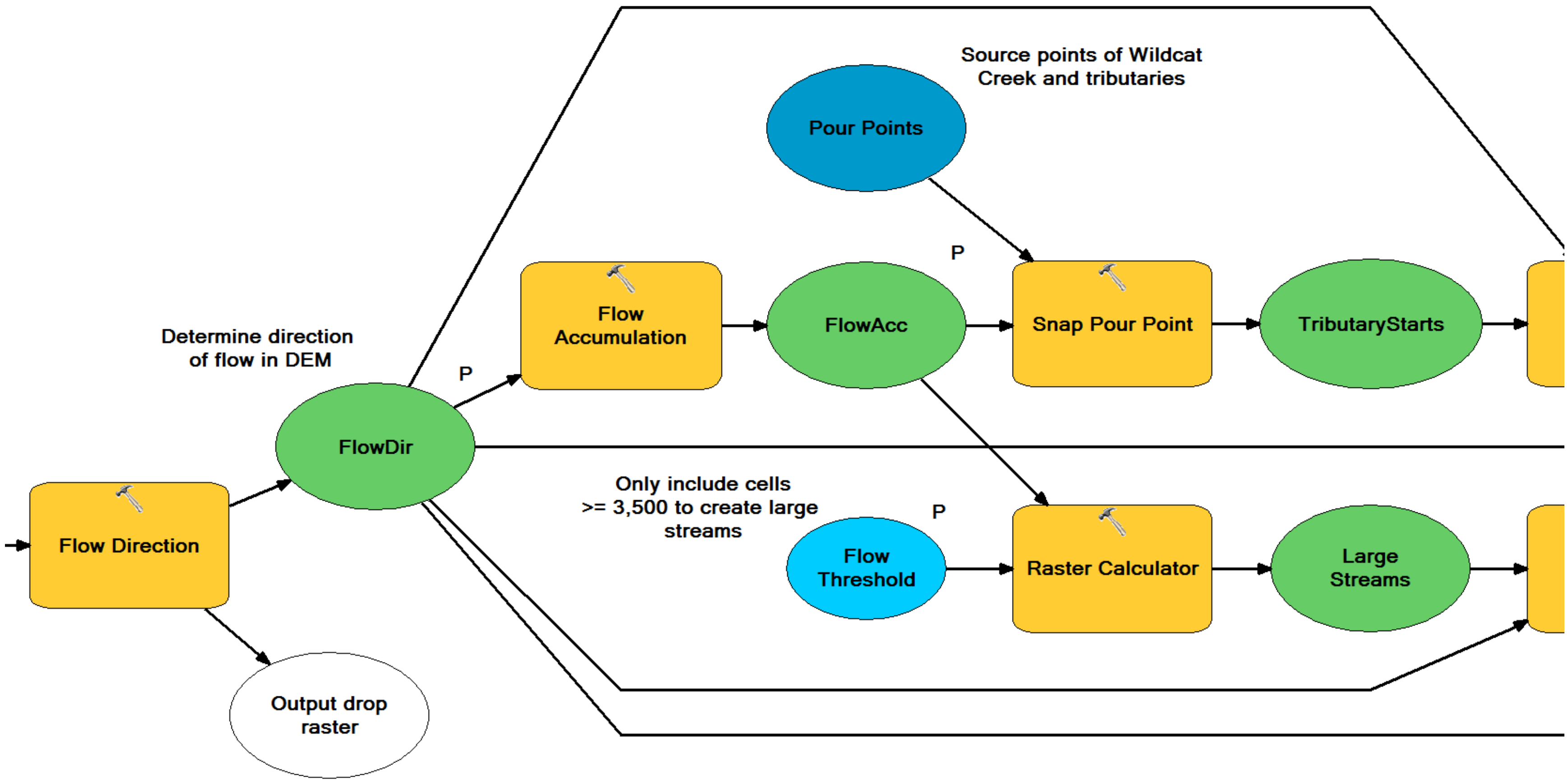

Figure A-2: Step 2 of Watershed Delineation Model. (Data Source: National Elevation Dataset; created by Author)

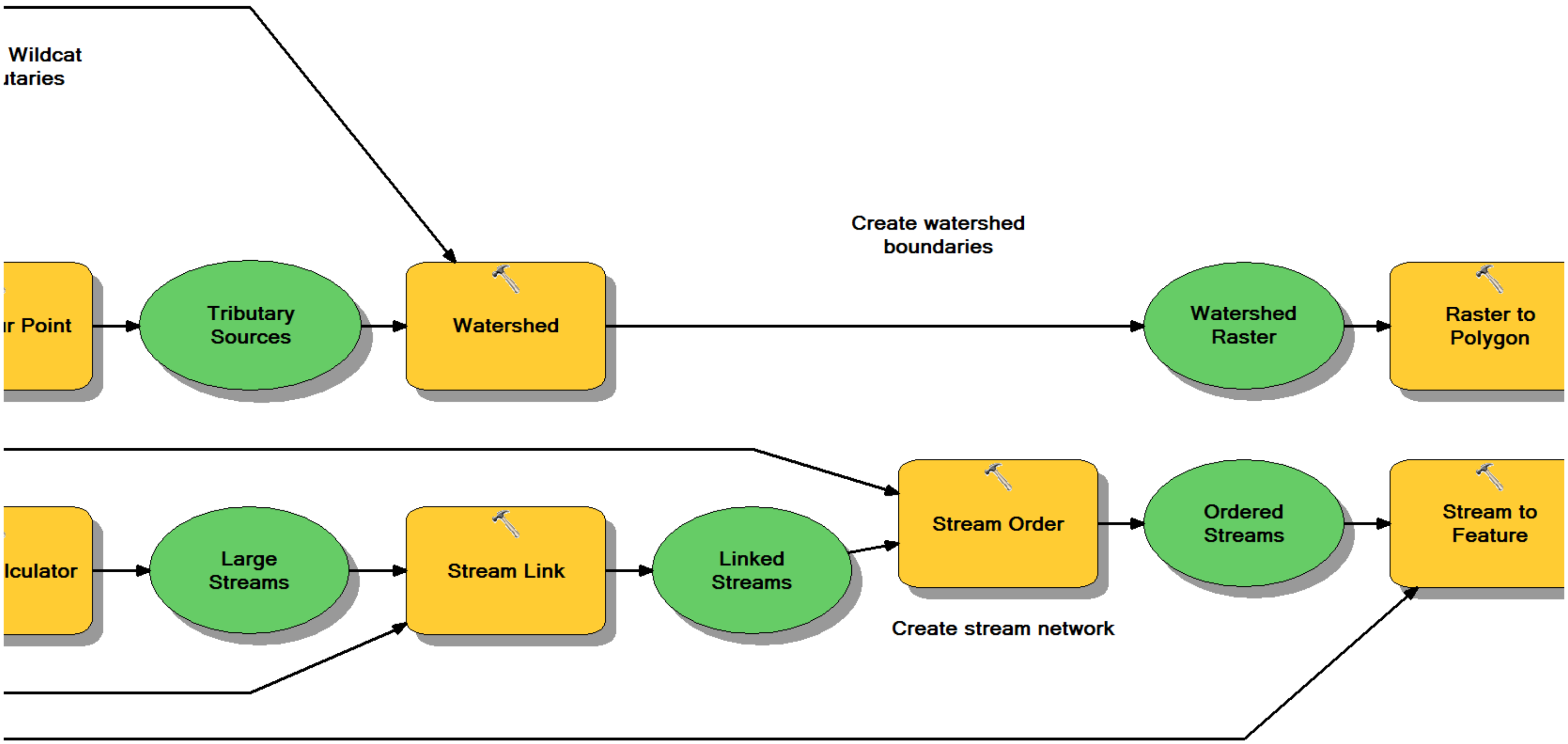

Figure A-3: Step 3 of Watershed Delineation Model (Data Source: National Elevation Dataset; created by Author)

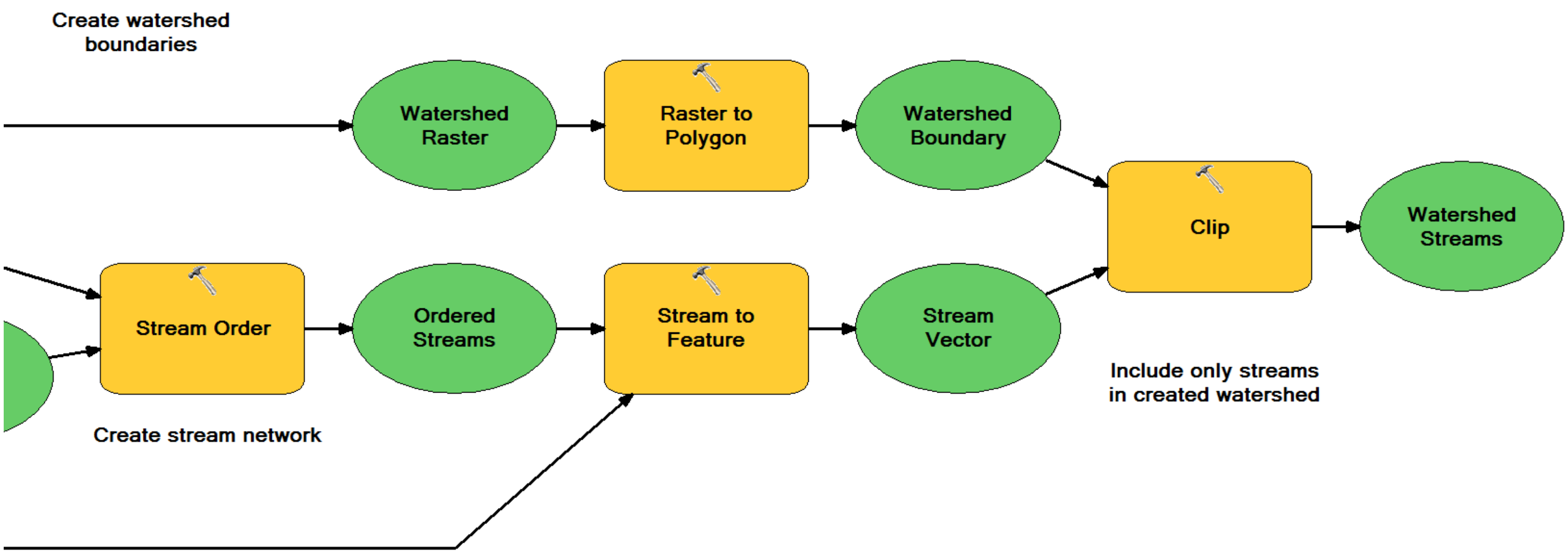

Figure A-4: Step 4 of Watershed Delineation Model. (Data Source: National Elevation Dataset; created by Author