ABSTRACT

Title of Thesis:	AFTER THE FLOOD: DESIGNING LAND REUSE IN NEW YORK'S HUDSON VALLEY
	Hannah Lee Savio, Master of Landscape Architecture, 2022
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Flooding is a recurring event in the water cycle that has the potential to devastate what is in its path. Climate change is projected to make flooding worse in the Northeastern United States because of increased intensity of rainfall. An increase in the number of flooded homes where homeowners choose not to rebuild in place can be viewed as a symptom of climate change. These issues take place at the confluence of land and water, the balance of humans and our environment, and what can be learned from the past and from projections and models of the future. How can flooded sites that are not suitable for rebuilding be adaptively reused to leverage their ecological, social, and economic value? This question is assessed through a multi-scalar examination of a series of FEMA buyouts along the Kaaterskill Creek, a rural tributary to the Hudson River in New York.

AFTER THE FLOOD: DESIGNING LAND REUSE IN NEW YORK'S HUDSON VALLEY

by

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List of Abbreviations

BCA – Benefit Cost Analysis

BRIC – Building Resilient Infrastructure and Communities

DHS – Department of Homeland Security

FEMA – Federal Emergency Management Agency

FIRM – Flood Insurance Rate Map

FIS – Flood Insurance Study

FMA – Flood Mitigation Assistance

FMV – Fair Market Value

HMGP – Hazard Mitigation Grant Program

NFIP – National Flood Insurance Program

NYS DEC – New York State Department of Environmental Conservation

PFR – Public Fishing Rights

SPDES – State Pollutant Discharge Elimination System

SSURGO – Soil Survey Geographic Database

Chapter 1: Introduction

People have chosen to live near water for transportation, food, aesthetics, and practicality, but permanent settlements next to water are at risk of flooding. The susceptibility of riverine flooding in any given place varies due to local geomorphology, upstream and downstream uses, and climate. In the northeastern United States, an increase in flooding has been seen in the past 30 years, showing early signs of the projections of climate change which will bring more intense rainstorms to this area. Flooding of homes and businesses creates devastating loss and trauma. A symptom of this increase in flooding is an increase in homes that have been flooded where it is not ideal to rebuild in place.

How can flooded sites that are not suitable for rebuilding homes be adaptively reused to leverage their social, ecological, and economic value? What physical and ideological premises can connect non-contiguous parcels? How can this reuse be replicated on similar sites after future flooding?

This thesis takes a multi-scalar approach in exploring a creek in upstate New York and its floodplain through a series of buyouts along the creek. It looks to the past and the future of land use and geomorphology, to the spectrum of land versus water, of wet versus dry, and to balancing the sometimes-conflicting requirements of people and nature.

Specific regional and site scale impacts are considered for a design framework, taking into account a basis of understanding in floodplain management, the projected impacts of climate change in the northeastern United States, and resilient flooding design. This framework can establish strong multifunctional spaces for people and nature. This thesis proposes a framework to consider complementary land uses on parcels adjacent to the creek. This is further examined on a set of four FEMA-funded buyouts and can be applied to more parcels in the future if homeowners choose buyouts after future flooding.

With stark warnings of the consequences of climate change and the best chances for adaptation and mitigation being compiled from leading researchers, this thesis targets one piece of the puzzle in building resilience to the impacts of climate change.

Chapter 2: Literature Review

Flooding can occur for a wide variety of reasons. It is defined by FEMA as “a general and temporary condition of partial or complete inundation of normally dry land areas from: (1) The overflow of inland or tidal waters; (2) The unusual and rapid accumulation or runoff of surface waters from any source. (3) Mudslides.” Flooding is generally categorized as either Riverine, Coastal, or Shallow flooding (FEMA, 2015). This thesis will explore Riverine flooding, which can be further categorized by overbank flooding, flash flooding, and erosion or movable bed streams (FEMA, 2015).

Floodplain and Stormwater Management

Though stream paths are often treated as static and immovable, especially in relation to property rights and the built environment, they have been formed over millennia of weathering and erosion and are still in flux. Water moves downhill along the path of least resistance. A stream path, therefore, is determined over time by climate, especially rainfall and temperature, topography, soils and bedrock geology, and vegetation or land cover (Vian, 2019). The force of water erodes soils and rocks, carrying material with it called bedload. This process of degradation and aggregation contributes to visible physical changes over time (Ibid.). The goal of stream management is to minimize disturbance to existing infrastructure by encouraging stream channel stability. “The shape and size of a stream channel adapts itself to the amount of water and bedload it needs to carry. Within certain limits, the form, or morphology, of a stream is self-adjusting, self-stabilizing, self-sustaining.” (Ibid.)

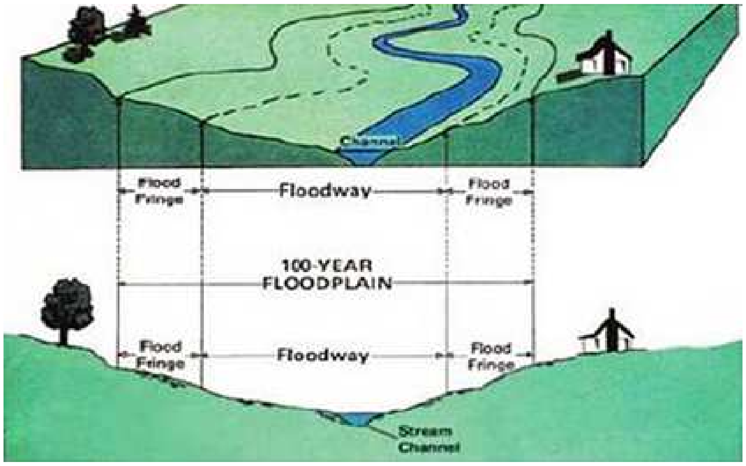

Figure 1: Visualization of channel, floodway, and flood fringe locations (credit Sacramento County Water Resources)

Since riverbeds are shaped over time with varying amounts of water, they not only shape their common flow path, but also the floodplain around them, where water goes during increased flow events. Floodplains are fertile with flat or gently sloping terrain that may *seem* ideally suited for agriculture or building homes and villages, but they are inherently prone to flooding. Floodplain development affects downstream water flows by removing space for water to be stored (FEMA, 2015). This highlights two key issues with floodplain development: "Development alters the floodplain, and the dynamics of flooding and buildings and infrastructure are damaged by periodic flooding." (Ibid.). A common response to flooding is to channelize or otherwise constrain a river's path, but this increases the speed of water flow and therefore the erodible power. Constraining a water body can also serve to disconnect it from its floodplain, limiting its ecological functionality (Opperman, 2014). A best management practice for floodplains is to spread and slow water (Greene County Soil & Water Conservation District, n.d.). While this takes space from other uses, it can improve water quality by giving opportunity for sediment and nutrients to settle out, reduce the velocity of water with its potential to quickly erode land downstream, provide habitat for a wide variety of flora and fauna, and facilitate carbon storage in wetlands and floodplain forests (Loos and Shader, 2016). Flood damage is generally caused by one or more of the following: “hydrodynamic forces or moving water; debris impact; hydrostatic forces or the weight of water, including its potential to make things float; soaking; and sediment and contaminants” (FEMA, 2015).

While traditional stormwater management utilizes flood control dams and reservoirs, levees, floodwalls, and channel modifications, floodplain ecosystem services can be better leveraged through incorporating green infrastructure into flood management. The following principles guide green infrastructure in floodplains: “(1) hydrologic connectivity between the river and the floodplain, (2) a variable hydrograph that reflects seasonal precipitation patterns and retains a range of both high and low flow events, and (3) sufficient spatial scale to encompass dynamic processes and for floodplain benefits to accrue to a meaningful level.” (Opperman 2010). Floodplains provide valuable functions for water quality and quantity and retaining or improving these functions is essential for resilience to flooding.

Federal Disaster Response Policy and History

Across the United States, 14.6 million homes and businesses are currently at a substantial risk of flooding (firststreet.org, n.d.). Private insurance does not cover flooding out of concern for risk and profitability (Montano and Savitt, 2018). A consolidated federal response first came about in 1968 with the National Flood Insurance Act, created to provide a framework to ensure federally backed flood insurance was available to at-risk homeowners for flood risk reduction and response (FEMA, 2019). Several years later the Flood Disaster Protection Act of 1973 required “the purchase of flood insurance on and after March 2,1974, as a condition of receiving any form of Federal or federally-related financial assistance for acquisition or construction purposes with respect to insurable buildings and mobile homes within an identified special flood, mudslide (i.e., mudflow), or flood-related erosion hazard area that is located within any community participating in the program." (FEMA, 2015).

FEMA was founded in 1978 to coordinate federal emergency response and civil defense (FEMA, 2019). The 1988 Robert T. Stafford Disaster Relief and Emergency Assistance Act, or the Stafford Act, built on the Disaster Relief Act of 1974 to refine and further define FEMA's roles and responsibilities and still guides FEMA's actions today. At the creation of the Department of Homeland Security (DHS) in response the September 11 terrorist attacks, FEMA was consolidated into the DHS retaining only its focus on natural disaster response. (Ibid.). Emergency management encompasses more than just disaster response, but also preparedness, recovery, and mitigation (Figure 2).

Figure 2: The Emergency Management Cycle (credit: National Earthquake Hazards Reduction Program)

Flooding has caused 335 billion dollars of damage across the country between 1960-2019, with a further 307 billion dollars in damage due to Hurricanes and Tropical Storms (Friedland, 2019). Recovery for homeowners affected by these disasters can be aided by flood insurance. The National Flood Insurance Program (NFIP) applies to participating communities and obligates homeowners within an identified special hazard area to purchase flood insurance at a federally subsidized rate (FEMA, 2015). These participating communities must have regulations that limit future at-risk construction within these special hazard areas and floodplain management. Special flood hazard areas are mapped by FEMA in most areas of the country through Flood Insurance Studies (FIS) and effective Flood Insurance Rate Maps (FIRMs) that determine special flood hazard areas and other special hazard areas. Since the flood insurance rate is subsidized by the federal government, it does not strongly discourage developers from building in special flood hazard areas because they will not be solely financially responsible for their recovery in the case of flooding (Montano, 2020). Further, as a federal entity, FEMA's priorities have shifted based on priorities of presidential administrations and have had variable focus on risk mitigation (Ibid.).

Federal funding is currently available through grants for disaster mitigation through a variety of programs. The Flood Mitigation Assistance (FMA) program funds communities who are active participants in the NFIP for specific projects that can include planning or implementation of flood mitigation projects, but not those specifically associated with recent disasters (FEMA, 1998). The Building Resilient Infrastructure and Communities (BRIC) program was established in 2018 to provide continuing mitigation funding to communities who were affected by a major disaster declaration within the past seven years (Criswell, 2022).

When large-scale disasters occur that trigger a Presidential Disaster Declaration, additional funding becomes available to communities that participate in the NFIP in the form of the Hazard Mitigation Grant Program (HMGP) (FEMA, 1998). States administer funding from the HMGP by prioritizing and selecting eligible communities and seeking final funding approval from FEMA. This hazard mitigation can include elevation of structures, dryproofing, or property acquisition (FEMA 1998). FEMA provides 75% of the funding needed for mitigation while the remaining 25% is provided from other sources including private grants, local governments, or homeowners themselves. Even with the vast majority of funding being provided from the federal level, this can still be cost prohibitive to small rural communities (Frank, 2021).

This thesis explores property acquisition through FEMA HMGP funding. A property acquisition is a voluntary strategy initiated by a homeowner that must have a positive benefit-cost analysis (BCA) and provide a "substantial reduction of future risk," along with being in compliance with the State Hazard Mitigation Plan and in compliance with environmental legislation (FEMA, 1998). Further criteria may be applied to prioritize buyout sites such as substantial damage, repetitive loss, primary residences, and contiguous lots (Ibid.). A homeowner receives the fair market value (FMV) cost of their home pre-flooding. After acquisition, the properties are owned by the local municipality, and existing structures must be demolished or moved within 90 days. A municipality is allowed to convey property rights to another public or nonprofit entity, but "must dedicate and forever maintain acquired property as open space." (Ibid.)

Critique of Current Disaster Responses

The existing disaster response, particularly the FEMA HMGP, has been criticized for being complicated and cost-prohibitive for small and poorer communities, having a lack of transparency that affects public trust, and the variably long timeline from disaster to final payout. The benefit-cost analysis has drawn particular ire as a complicated process that can perpetuate inequalities (Siders, 2019). Houses that are worth less have an inherently higher likelihood of being declared "substantially damaged" after a flood, with rebuilding costs equal to 50% or more of pre-disaster property value. This is one consideration in the benefit cost analysis that can lead to buyout approval or rejection and may result in more buyouts from low-income homeowners (Ibid.). Further, studies have shown that responses to disasters perpetuate wealth inequality (Howell and Elliot, 2019). The benefit-cost analysis can further "strain areas with little funding or experience" both because they find the process of quantifying the benefits of mitigation particularly cumbersome, and the 25% cost share of buyouts can be cost-prohibitive (Frank, 2021). The lack of transparency in the decision-making process of who will eventually receive buyout funds can lead to public mistrust (Siders, 2019). The factors that influence government decisions about which homes to fund buyouts seem heavily based on economic considerations, but an increased emphasis on conservation potential, ecological benefits, or strength of uses post-buyout could be beneficial in the long run (Greer et al., 2022). Additionally, the timeline for the processing of HMGP buyouts is years, which can lead to homeowner uncertainty, attrition of buyout volunteers, and selling to investors for redevelopment prior to the buyouts being finalized, which does not fulfill the intended purpose of permanently mitigating risk (Binder et al., 2020). This long timeline for project completion can also lead to negative public perception of buyouts and lesser support for future buyouts (Zavar and Hagelman, 2016).

The Government Accountability Office (2021) has recognized these issues and advocated for streamlining the application process for FEMA HMGP and having a system to better provide and share resources related to mitigation and grant applications. Participatory, pre-disaster planning can also help to ameliorate issues in reconstruction after a disaster (Siders, 2019, Zavar and Hagelman, 2016). "Recovery planning presents an opportunity to identify high-risk areas, begin a conversation with the community about buyouts as a possible mitigation measure, and evaluate the potential social, economic, and environmental impacts of a buyout program, before a crisis occurs" (Binder and Greer, 2016).

Buyout land use classification	Frequency of land use at HMGP-funded site (%)
Vacant lot	34.2
Park	14.4
Athletics	9.0
Hike/Bike trail	7.5
Playground	7.5
Wetland restoration	6.9
Parking lot	5.7
Garden/Farm	5.1
Water recreation	2.7
Memorial	0.9
Levee	0.9
Detention basin	0.6
Stage/Amphitheater	0.6
Camp grounds	0.6
Waste dump	0.6
Native vegetation restoration (non-wetland)	0.6
Labyrinth	0.3
Horse arena	0.3
Dog park	0.3
Shed	0.3
Flagpole	0.3
Squatter settlement[b]	0.3
First responder training facility	0.3

Figure 3: Of 333 studied buyouts nationwide between 1990-2000, over 40% have been severely underutilized (credit: Zavar and Hagelman, 2016)

Buyouts

Communities are given broad autonomy in choosing how to use or program the open space created through property acquisition and there is therefore a wide variety of demonstrated uses and intensity of use (Zavar 2015). A property that is acquired by a community is removed from the tax rolls and has the potential to decrease local tax revenue but can also provide valuable community functions including those that offset the lost tax revenue. Unfortunately, a study of HMGP property acquisitions between 1990-2000 showed that 34.2% of buyouts remained vacant lots as of 2016 instead of being developed with a recreation or environmental conservation focus (see Figure 3) (Zavar and Hagelman, 2016). In a survey of floodplain and emergency managers in local governments, the primary stated challenges and barriers for fully utilizing buyout lands were maintenance (40% of respondents) and expenses for maintenance, development, and future flooding (32% of respondents). These barriers were further exacerbated by a lack of knowledge and information sharing about what potential there is for buyout properties. Further, "land use decisions directly affect residents of peripheral communities for many years, and the intentional inclusion of postbuyout land use plans in the initial selection and prioritization of buyout properties may impact quality-of-life outcomes for peripheral communities" (Greer et al., 2022). Concerns like funding and maintenance can limit land reuse and should be carefully considered in the redesign process. Further, community-based programming and decision making can help create desirable and used spaces.

Climate Change

Climate change is projected to cause an "increase in mean and extreme precipitation" and "expected increase in river and pluvial flooding" in Eastern North America (Gutiérrez et al., 2021). Specifically, in the northeastern United States, there is projected to be an increase in heat waves, droughts, and flooding, both due to extreme rain events and sea level rise. (Rosenzweig and New York State Energy Research and Development Authority, 2011). The Intergovernmental Panel on Climate Change Sixth Assessment Report from Working Group II was released in March of 2022 to address the "impacts of climate change, looking at ecosystems, biodiversity, and human communities at global and regional levels [as well as] vulnerabilities and the capacities and limits of the natural world and human societies to adapt to climate change" (Pörtner et al., 2022). The impacts of flooding are addressed within the context of changes to the water cycle due to climate change. Authored by global thought leaders, this document addresses water issues and flooding, highlighting the benefit of nature- based solutions to provide mitigation impacts from fluvial floods through "floodplain restoration, natural flood management, and making room for the river measures" (Ibid.) This positive impact is qualified because "the effectiveness of most water-related adaptation options to reduce projected risks declines with increasing warming." (Ibid.). The IPCC report does highlight the local specificity needed to effectively adapt to increased flooding. While hazard risk is influenced by numerous factors that are exacerbated by climate change, this thesis addresses opportunities within adaptation and mitigation to ameliorate risk (Figure 4).

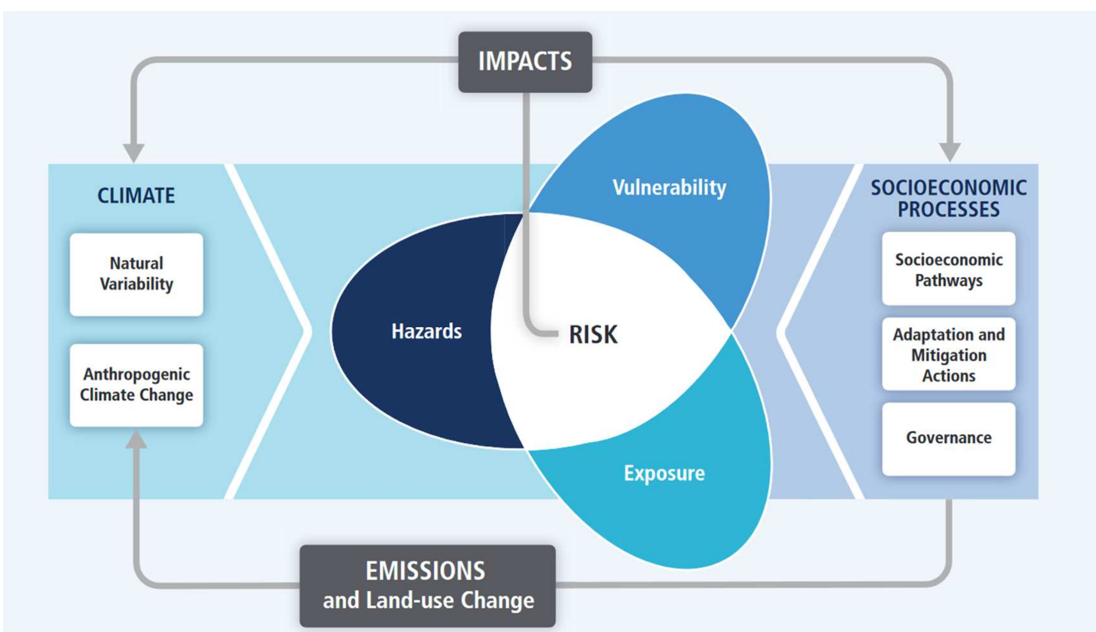

Figure 4: Interrelated drivers of risk related to climate change (credit: IPCC, 2014)

Resilient Flooding Design

The American Society of Landscape Architects promotes resilient design in adapting to the increasingly intense and frequent hazards exacerbated by climate change. Landscape Architects have the experience and training to examine the topography, hydrology, and ecology together to incorporate multi-layered co-benefits into design. Flood damage can be ameliorated through landscape and watershed scale changes like preserving and strengthening ecosystems which has a co-benefit of preserving biodiversity and ecosystem services (ASLA, n.d.).

The concept of prioritizing the preservation or creation of natural systems for multiple co-benefits is alternately referred to as Nature based Solution, Green Infrastructure, natural infrastructure, or Engineering with Nature ® (FEMA, 2020). It is proposed as an alternative or supplement to gray stormwater infrastructure which generally has a high implementation cost, single purpose, and high cost of failure. Nature based solutions can provide hazard mitigation benefits along with environmental, economic, and social benefits as previously discussed in this chapter. Some of these co-benefits include reduction in damage due to flooding and shoreline stabilization, as well as increased fish and other fauna habitat, tourism and recreation opportunities, carbon storage and sequestration, and further benefits to human health (Bridges et al., 2021). A variety of multifunctional benefits should be considered in design and planning for land reuse.

Artful Rainwater Design is a recently popularized strategy for incorporating further amenities in a design along with stormwater management. These amenity goals include utilizing stormwater for education, recreation, safety, public relations, and aesthetic richness (Echols and Pennypacker, 2015). Incorporating educational and interpretive feature that highlight flooding and stormwater management can help engage and inform visitors.

Conclusion and Criteria

Flood buyouts are meant to permanently remove the risk of flooding for a homeowner by physically removing their home from a floodplain, reduce costs of future disaster response, and reduce development in the floodplain. The design for reuse of these buyouts must be rooted in place specificity in order to appropriately meet the environmental, social, and economic context of where they occur. (FEMA, 1998, Pörtner et al., 2022). Nature based solutions can provide valuable co-benefits beyond flood mitigation. The voluntary nature of buyouts causes issues with perpetuating inequity in disaster response and can lead to a piecemeal approach to buyouts. Our existing national disaster responses can be improved to be more equitable through changes to the application process and transparency of that process, but also community planning prior to a disaster.

From this literature review, the following design criteria can be established:

- Promote resilience by retaining floodplain function and improving it wherever possible
- Design for multifunctionality benefiting humans and ecosystems through nature-based solutions or green infrastructure for flooding
- Program spaces to meet the needs of the community
- Engage and inform visitors by providing educational and interpretive features that highlight flood and stormwater management

- Consider maintainability by limiting high-maintenance functions and creating partnerships wherever possible

Chapter 3: Inventory and Analysis

Figure 5: A home in the Catskills flooded during Hurricane Irene (credit: Wilma Beers)

In the late summer of 2011, Hurricane Irene and Tropical Storm Lee drenched upstate New York with heavy rainfall, causing over $1 billion in flooding damage (Frei and Kelly-Voicu, 2017). Flooding from Irene was caused by extreme 3- and 5- day precipitation totals occurring on already saturated soils (Ibid.). In fact, the greatest 60-day stream flows on record for the Catskill Mountains occurred in August to September of 2011 (Ibid.). The period of 1996-2011 was demonstrably wetter than the mid-20th century, increasing the risk of flooding particularly in the warm season (DeGaetano and Castellano, 2013). This deviates from previous trends of primary flooding occurring in the spring due to snow melt. The 100-year rain events now occur every 60 years in the Catskills (Ibid.). The geography of the Catskills tends to cause flooding due to its orography and geology (Ibid.). The rapid elevation gain precipitates rain, and shallow soils over bedrock and steep mountainsides lead to rapid water flows from the headwaters within the mountain range (Ibid.).

The 2011 flooding resulted in over 700 FEMA HMGP buyouts, worth a total of $35 million, not including state sponsored buyouts and managed retreat initiatives (Frei and Kelly Voicu, 2017, Benincasa, 2019).

This thesis focuses on three of these buyouts, which occurred along the Kaaterskill Creek in the Town of Catskill in Greene County, and an additional potential buyout along this same creek which dropped out before the buyout was finalized. In the 10 years post-flooding and buyout these four parcels remain underused or vacant lots, representative of a missed opportunity for the community and surroundings. Further, though these sites were bought out after 2011 flooding, further extreme floods and buyouts can be expected going forward, it would be valuable to develop a framework to analyze potential flood risks and plan for optimizing the use of future buyouts in series along the Kaaterskill Creek. How can flooded sites that are not suitable for rebuilding homes be adaptively reused to leverage their social, ecological, and economic value? What physical and ideological premises can connect non-contiguous parcels? How can this reuse be replicated on similar sites after future flooding along this creek or similar circumstances elsewhere in the region?

Regional History and Context

This thesis explores a region in upstate New York approximately 100 miles north of New York City between the Catskill Mountains and the Hudson River (Figure 6). The Catskills region is heavily influenced by tourism and second homeownership from New York City and Long Island residents as well as other tourists from within 200-400 miles (Greene County Comprehensive Economic Development Plan, 2007). Primary tourist draws are outdoor recreation, including downhill skiing, the arts, crafts, food and music festivals, as well as historic and cultural sites (Ibid.). An abundance of state recreation land, wild forests and

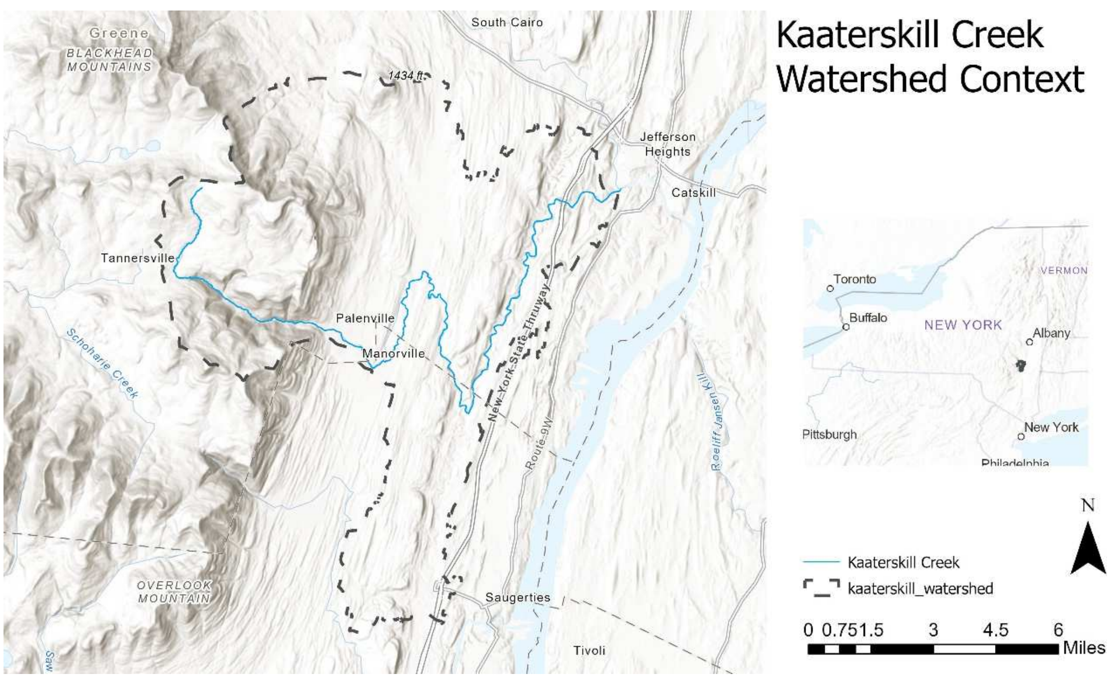

Figure 6: The Kaaterskill Creek is located in the Hudson River Valley between Albany and New York City


Figure 7: "Kindred Spirits" by Asher B. Durand depicts Thomas Cole and poet William Cullen Bryant in a stylized Kaaterskill Clove (credit: Smithsonian American Art Museum)

wilderness areas in the Catskill Mountains bolsters outdoor recreational activities, including hiking, hunting, camping, angling, skiing, snow tubing, snowmobiling, swimming, mountain biking, birding, and more. This area is also home to the Hudson River School of Painters, the "birthplace of American Landscape Painting" (Figure 7)**Error! Reference source not found.** (Ibid.).

The Kaaterskill Creek is 26 miles long, with its headwaters in the Catskill Mountains and flowing into the Catskill Creek approximately 3 miles upstream from where the Catskill Creek meets the Hudson, a tidal estuary that defines this area north of New York City. Tourist guides divide the Catskill Park and Mountaintop Towns from the Historic River Towns in the Catskill Foothills and Hudson River Valley. Areas of note within the Kaaterskill watershed are North-South Lake, a popular hiking and overlook destination; Kaaterskill Falls; Kaaterskill Clove; and Palenville, all concentrated in the western part of the watershed as the creek flows out of the Catskill Mountains.

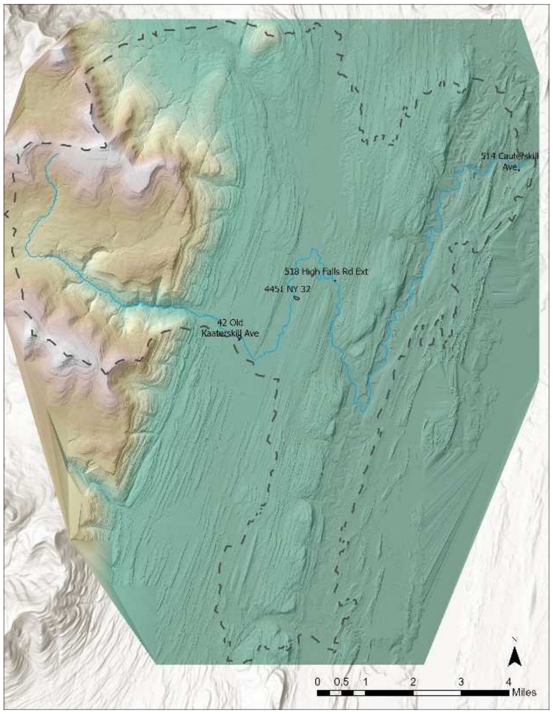

Figure 8: The four examined buyout sites are located adjacent to the Kaaterskill Creek

The flow of the Kaaterskill Creek and its 70 square mile watershed is primarily within the Town of Catskill, in Greene County, but has its upland headwaters in the Town of Hunter and also meanders through the Town of Saugerties in Ulster County. The upland headwaters are also encompassed in Catskill State Park, which is composed of parcels owned privately and those owned by the New York State Department of Environmental Conservation. All of the buyout parcels examined in this thesis are within the Town of Catskill in Greene County, so most plans and municipal documents examined are from these two government entities (Figure 8). Primary documents explored include Greene County Open Space Plan (2002), Tourism Trails Plan (2019), Greene County Natural Resource Inventory (2019), Greene County Hazard Mitigation and Resilience Plan (2016) and the Codes for the Town of Catskill, including Flood Regulations and Zoning.

This thesis is focused on a rural waterbody with limited development in its watershed. The response therefore focuses more on retaining floodplain function than replicating and concentrating natural processes as would be done in an urban or more heavily developed or impervious area. The creek in this study has limited to no disconnection between it and its floodplain.

Local Plans

Figure 9: Hiking is among the most popular outdoor recreation activities in the Catskills Region (credit: Visit the Catskills)

The economy of the Greater Catskill Region is heavily dependent on tourism, with a wide variety of outdoor recreational activities in all seasons (New York State Department of Environmental Conservation, 2020). The Kaaterskill Creek traverses a unique and often unseen course that can be regarded as a hidden gem. The majority of its flow is outside of the primary tourist draws of the State-owned, highly topologically diverse and photogenic Catskills State Park, and upstream from the historic and quaint Village of Catskill – it seems a forgotten through-way to somewhere else. In passing through on the road network, it's easy to underappreciate the Kaaterskill Creek, but it is clearly appreciated by those who built their homes next to it. Those properties that no longer hold homes can provide an opportunity for more people to enjoy the Kaaterskill Creek for its unique charm and beauty.

The Greene County Hazard Mitigation and Resilience Plan highlights flooding as the highest risk within the county, with additional high risks of impacts of severe storms and severe winter storms (AECOM, 2016). Minor risks include landslides, earthquakes, forest fires, drought, and extreme heat. County mitigation goals relate to fostering resilience and, "prevent[ing] loss of life from natural hazards, especially addressing vulnerable populations" (Ibid.) Suggested flood mitigation strategies include property acquisition and structure demolition, property acquisition and structure relocation, structure elevation, mitigation reconstruction, dry floodproofing, localized flood risk reduction projects, and non-localized flood risk reduction projects. Among these options, priorities were established through public and committee meetings, and acquiring and demolishing properties at risk of flooding was deemed a high priority. This is further reinforced as a resilience building measure, "the first resilience-building action is the flood mitigation activity of acquisition, which removes flood prone properties out of harm's way and restores flood prone land to their natural state so that they can perform the natural, beneficial functions of a floodplain by storing flood water and slowly releasing it to surface and ground water." (Ibid.)

There is demand for access to the creek, particularly for swimming and fishing. There have been regular community conversations about access to the Tannery Bridge swimming hole on a town-owned parcel within the hamlet of Palenville, which came to a head in 2020 when it was temporarily fenced to dissuade access. A change.org petition gathered 195 signatures in support of public access to the creek ("Sign the Petition", 2021). A 2021 Catskill Town Board Committee Meeting provided further community conversation about waterfront access where the board voted to remove the temporary fencing and consider signage and the "establish[ment of] a working group of residents of the hamlet to discuss access, liability, education (stewardship) for people" (board meeting, July 2021). A recording of a meeting regarding Kaaterskill Creek Access and Etiquette and issues about trespassing, included guidance on signage to indicate private property, and community questions with a general support for respectful access to the water (Crane

Davis, 2016). Prominent issues raised included litter, noise, parking issues, campfires, and vandalism and a suggestion to clarify acceptable uses on Town-owned lands (Ibid.). Respondents to an Open Space Survey in 2001 expressed a desire for "areas along watercourses [to be] maintained as open space" as well as land dedicated for recreational use to the community (Greene County Planning Department, 2002).

The Kaaterskill Creek can support a variety of recreational activities with fishing, swimming, and boating being primary regional draws (New York State Department of Environmental Conservation, 2020). The majority of the Kaaterskill Creek with the exception of some of its headwaters is a classified stream with a class B or its best use classified as "Primary and secondary contact recreation, and fishing" but not drinking water quality (Consolidated Listing and Assessment Methodology, 2021). This means that maximum allowable daily discharge through the State Pollutant Discharge Elimination System (SPDES) is consistent with maintaining bathing quality in the Kaaterskill Creek (New York State Department of Environmental Conservation, 2020). Citizen monitoring of Enterococcus count (a fecal indicator) of the Kaaterskill near the confluence of the Catskill Creek shows that the water is generally acceptable for safe swimming, with water quality being consistent with a beach advisory 14 out of 47 testing times over the course of seven years of monitoring (Cauterskill-Kaaterskill Creek Tributary, 2021). Site specific monitoring would be required to ensure safe bathing conditions along the creek.

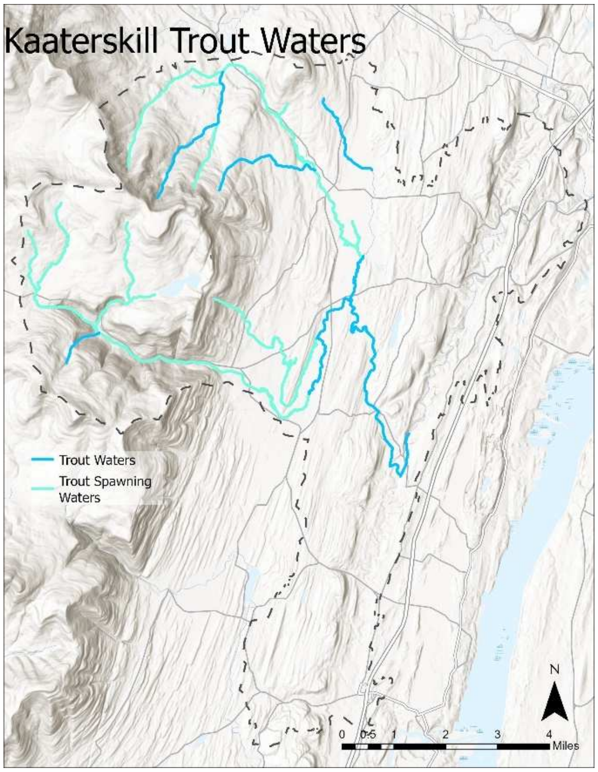

Figure 10: The upper reaches of the Kaaterskill Creek and its tributaries support trout and trout spawning

Unlike some other nearby creeks, the Kaaterskill Creek is not stocked annually with trout, nor does it have Public Fishing Rights (PFRs), permanent easements for fishing access purchased by the NYS Department of Environmental Conservation (DECinfo Locator, 2022). However, an upper portion of the Kaaterskill Creek is classified as Trout Spawning waters and the mid-section of the creek is classified as Trout Waters (Figure 10). This is backed up by the fishing logs on the crowdsourced website fishbrain.com where 25 catches are logged including smallmouth bass, bluegill, largemouth bass, brown trout, rudd, yellow perch, common carp, and channel catfish ("Fishing in Kaaterskill Creek," 2022). In New York State, fishing must be done in season and with a fishing permit.

The Kaaterskill Creek does not have any boat launch sites and is not a navigable water across its flow. There is some anecdotal evidence of whitewater kayaking on various points of the creek, a 3-mile section of the upper headwaters being considered a class IV-V (V+) and 12 miles of the lower section before it meets the Catskill Creek considered a class II-III difficulty according to American Whitewater classifications (New York Whitewater Kaaterskill Creek, 2022). Of 85 historical accidents reported to American Whitewater within the state of New York, two took place on the Kaaterskill Creek, one in an open canoe and one in a whitewater kayak (American Whitewater, n.d.). There is no indication of tubing currently happening on the creek, but there was a tube rental business along another creek nearby that closed permanently during the pandemic. Kayaking, tubing, and stand-up-paddleboarding are desirable water-based recreational activities in the area according to the survey conducted by the Greater Catskills Region Comprehensive Recreation Plan, with a noted barrier of renting equipment (2020).

Figure 11: Kayaking the Kaaterskill Creek (credit: Ken ParkQ)

Upstream risks along the Kaaterskill Creek are limited to a small number of petroleum bulk storage facilities and one "Low Hazard Masonry Dam" of 8 feet just upstream from the High Falls Road Extension Bridge (DECinfo Locator, 2022). Downstream, the Kaaterskill Creek meets the Catskill Creek, which is moderately built up with homes and businesses in the floodplain in the Village of Catskill for its remaining three-mile flow before meeting the Hudson River. Because the Hudson is a tidal estuary, this portion of the Catskill Creek is vulnerable to impacts of sea level rise on top of its existing issues with flooding, but that risk does not extend to the Kaaterskill Creek. A community group that examined flooding in the Village of Catskill provided many recommendations to ameliorate flooding in their Resilient Catskill: Report of the Catskill Waterfront Resilience Task Force (2014) including, "work with other communities in the Catskill Creek Watershed to better manage stormwater and runoff". Efforts to increase floodplain function on the Kaaterskill Creek will have small but additive benefits downstream to the Village of Catskill.

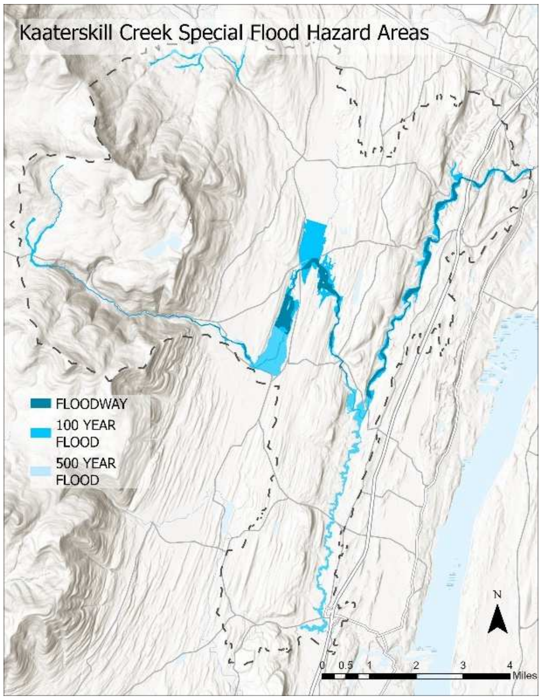

Figure 12: FEMA flood maps along the Kaaterskill Creek and tributaries

The Town of Catskill defines its flood damage prevention within its municipal codes as follows, tying regulations to the FEMA Special Flood Hazard Layers (Figure 12) and regulating that "no new construction, substantial improvements or other development [is permitted] in the floodway (including fill)" and any construction within the 100 year floodplain must "have the lowest floor, including basement or cellar, elevated to or above the base flood elevation; or be floodproofed so that the structure is watertight below two feet above the base flood elevation (Town of Catskill, NY: Flood Damage Prevention, 2019). These regulations were adopted in 2008, replacing 1988 flood damage prevention laws and because of these laws, newer construction should be less vulnerable to flood damage, but many structures are still vulnerable.

Regional Inventory

This project was examined at the scale of the entire creek as well as the site scale. The entire creek was analyzed through GIS inventory and overlay mapping to find commonalities in categorization and opportunities and limitations to site design. As stated in Chapter 2, stream paths are primarily determined over time by climate, especially rainfall and temperature, topography, soils and bedrock geology, and vegetation or land cover (Vian, 2019). The primary drivers in this analysis were bedrock, soils, and slope.

The Upper Hudson Valley has a temperate climate with significant seasonal variations. The mean annual temperature is 50.5 □ with a winter average minimum of 20.5 □ and a summer average maximum of 82.5 □ (National Oceanic and Atmospheric Administration, 2022). It receives 41.90 inches of average annual precipitation spread fairly evenly throughout the year, with the lowest precipitation occurring in the winter at 8.42 inches on average, and the highest average precipitation occurring in the summer at 11.97 inches (Ibid.).

This area is characterized by a rural setting and limited areas of low to medium density development (Figure 13). The creek itself maintains a naturalistic connection to its floodplain without major channelization or constraints. The vegetation is predominantly deciduous

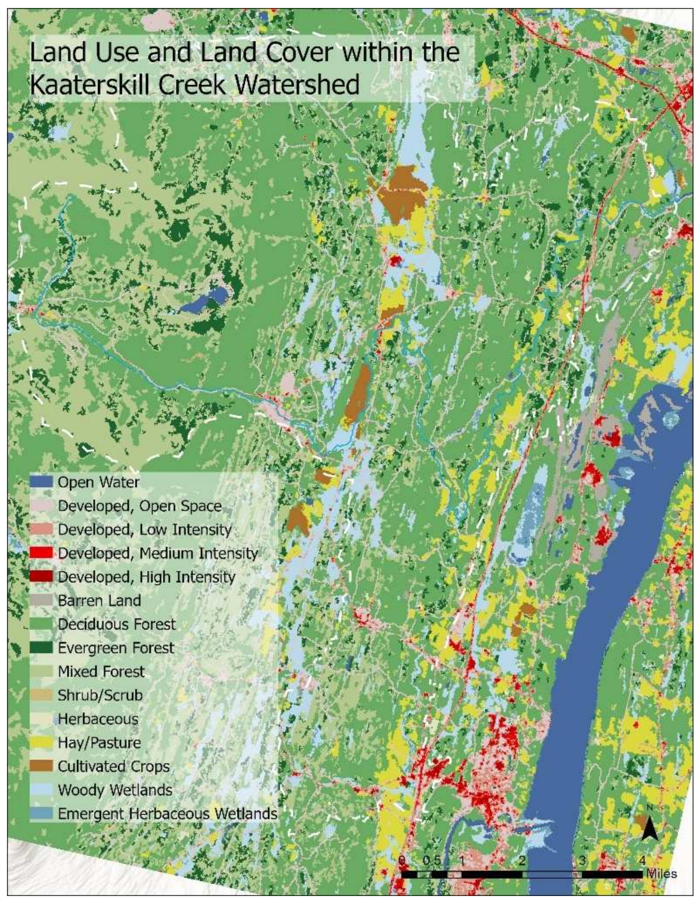

Figure 13: The Kaaterskill Creek watershed is largely undeveloped with a mix of deciduous forest, emergent herbaceous wetlands, and cropland

forests with some areas of woody wetlands as well as cultivated crops and hay or pastureland.

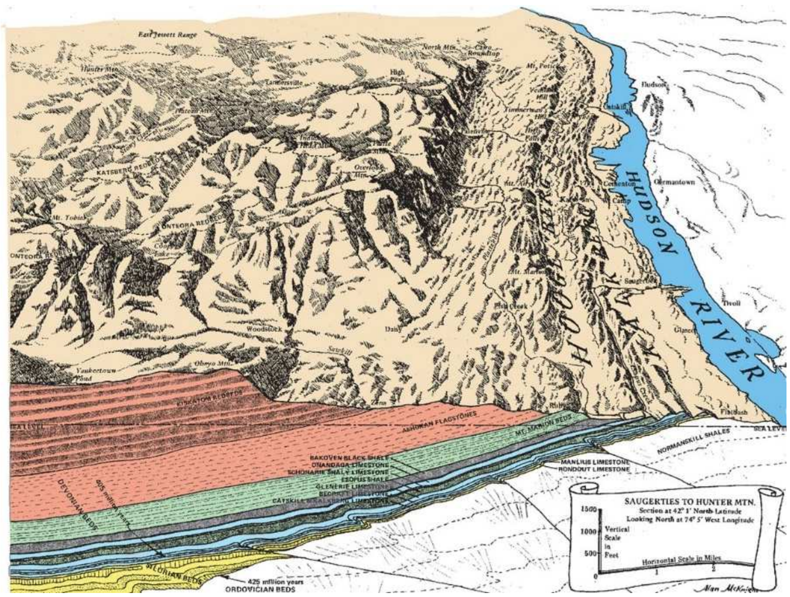

Figure 14: Bedrock strata of the eastern Catskills to the Hudson River (credit Alan McKnight)

The bedrock of the Catskill Mountains and its foothills is primarily composed of Devonian age sedimentary rocks, consisting mostly of sandstones and mudrocks, with some pockets of limestone (Figure 14Figure 14). Their formation was heavily influenced by "repeated glaciations through the Pleistocene (2.6 million to 11,700 years ago) [and] surface weathering over geological time scales (tens to hundreds of millions of years) since the renewed uplift of eastern North America sometime in the last 200 Myr." that created the Appalachians and the Allegheny

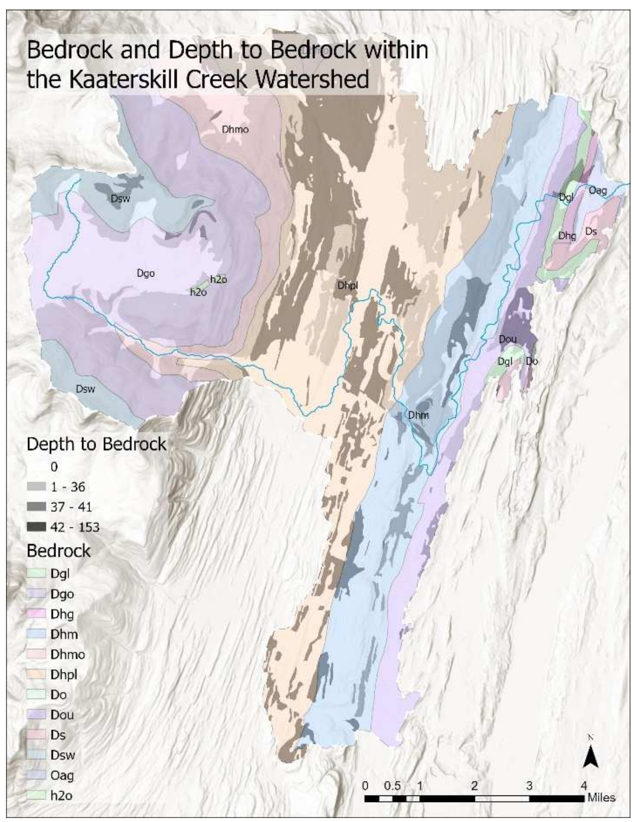

Figure 15: The bedrock of the eastern Catskills and Hudson Valley follows east-west banding and varies in depth.

Plateau, of which the Catskills are a part. (Ver Straeten, 2013). These sedimentary rocks are defined by horizontal layering with vertical and lateral variations in bedrocks of varied weathering resistance that heavily influence the locations and paths of creeks and streams (Ibid.). The geographic distribution of bedrock data shown in Figure 15 came from the New York State Education Department while depth to bedrock was derived from the national SSURGO database.

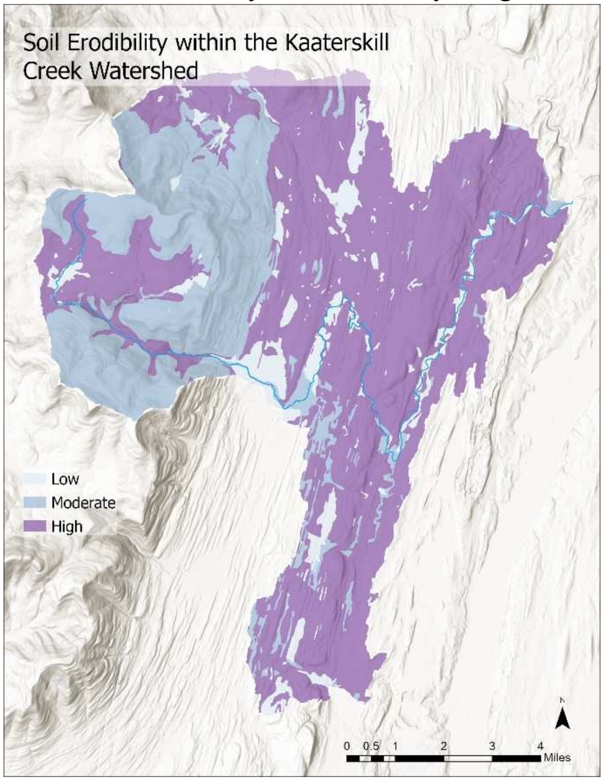

Figure 16: The Kaaterskill Creek follows a path on soils from high to moderate to low erodibility

The soils in the Kaaterskill Watershed are primarily composed of bedrock weathered to varying degrees and transported through erosion and deposition. Soil thickness varies greatly through the flow path of the Kaaterskill Creek, with some areas being directly on bedrock, while others, particularly in wide and shallow floodplains, have a much greater depth of soil. The dataset for exploring this region is on a national scale (Soil Survey Geographic Database, 2015) and could benefit from further site and periodic creek scale exploration. As shown in Figure 16, the soil types have a wide degree of geographic variability and are primarily differentiated by their erodibility. The headwaters of the creek are defined by low to no depth to bedrock and highly erodible soils. At the base of the mountains there is a wide alluvial fan caused by deposition of eroded material from upstream and characterized by poorly stratified silt, sand, and boulders. The creek follows a path of moderately erodible soils here. A majority of the lower portion of the watershed is highly erodible, but the creek follows a path through less erodible soils.

Creek slope is a major factor that determines flow rate of water and consequentially, the rate and degree of erosion and deposition. It also has a significant impact on the types of recreational activities that can be accommodated. The Kaaterskill Creek begins at an elevation of approximately 2850 feet and meets the Catskill Creek at an elevation of approximately 10 feet. Over the course of its 26-mile flow, that is an average of 2% slope, but it is highly variable. Slope data for the Kaaterskill Creek was derived from topographic data as described in the methods section below. As shown in Figure 17 the slope is steep coming out of the mountains and becomes more gradual and almost flat in the central valley before passing through a variable steep area before it meets the Catskill Creek.

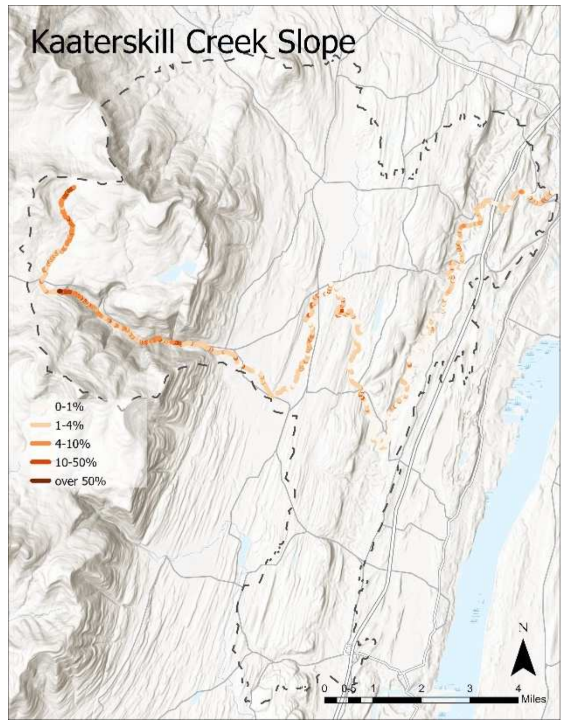

Figure 17: The slope of the Kaaterskill Creek is greatest coming out of the mountains through Kaaterskill Clove, and shows variability for the remainder of its flow

A site visit was conducted on November 23, 2021, in the afternoon. The conditions were sunny and cold, between 37 and 31 degrees. The site visit was conducted by driving to each of the potential buyout sites as well as encountering the Kaaterskill Creek at each point where there was a road crossing. The overall takeaways of this site visit reinforced the variability of the creek, where the roads crisscrossed the watershed at points perpendicular to the creek and many encounters with the creek felt like they could be a different waterbody as shown in (Figure 18). Each potential buyout site was evaluated based on characteristics in (Table 1) below. A further visual analysis was conducted via google satellite imagery to gauge creek character and google satellite imagery and street view, particularly historical images, were reviewed for each buyout site.

Figure 18: Variations in creek character as encountered during site visits

Table 1: Site visit criteria and exploration

Address	Site Boundaries Clear?	Current Evidence of Building/Structures?	Former Foundation Visible?	Topography	Vegetation	Shoreline	Other notes	Brief
42 Old Kaaterskill Ave	No	No	No	Practically No Slope	Palustrine wetland further back? Mugwort on what was likely home site, rhodedendrons at back, oak, moss buckthorn?	Steep eroded edge, ~4 foot drop to water level	Strong existent driveway leading to water and likely former home site, undulating terrain in woods, seemingly calm waterfront, some neighboring houses visible. Dead end road, dirt for last 250 feet, 2 other houses on road	potential site
4451 NY-32 - not town owned	Yes	yes, trailer on site in condition that looks like it was never fixed up after the flood	n/a	Practically No Slope	mowed lawn, brushy overgrowth around house, trees dotted through yard	unsure, possibly eroded soil up to creek edge	someone is clearly taking care of the yard but the house looks like a liability at this point	still has flooded trailer, potential site
518 High Falls Road Ext	No	No	No	Gradual Slope	low grass, sumac and other woody plants at riparian edge	rocky, vegetated	at sharp bend in road, next to a scenic bridge. House next door looks like it is out of the flood plain with a porch high on stilts	potential site
514 Cauterskill Ave	No	neighbors have a high fence that obscures site lines - perhaps this land is lower down on the stream bank	No	unsure where the property actually is	wooded riparian edge	rocky bend in stream	seems largely taken over by stream - access is completely unclear	access unclear, potential site with further exploration

Methods

The primary form of site analysis for the creek was conducted through GIS mapping and overlay. With multiple sources of raw data, the analysis highlighted some inconsistencies due to variations in data collection, scale, and age. The topography and slope data were created through the following processing. LIDAR data was downloaded from the New York State portal. This dataset has a horizontal accuracy "in compliance with the National Standard for Spatial Data Accuracy (NSSDA) RMSE estimation of elevation data in support of 2ft. contour mapping products as it is referenced in the FEMA guidelines for flood hazard mapping, appendix A." (Greene County 2010 LiDAR Data Collection, NY (NYSDEC)). A LAS Dataset was created for all LAS tiles with a coordinate system set to NAD_1983_UTM_Zone_18N. The LAS Dataset was then filtered for ground returns only, then converted to a Raster through the LAS Dataset to Raster function with output coordinates set to NAD_1983_StatePlane_New_York_East_FIPS_3101_Feet. A hill shade raster was created for visualization, and contours were created at 2', 10', and 50' intervals.

The slope was calculated for each section of the creek at five-foot vertical intervals to provide a rough estimate of slope variations across the length of the creek. Overall slope for longer sections of the creek was split where soil types changed to meet a broader categorization of the Kaaterskill Creek. This was done by creating a dividing line where the centerline of the creek meets contour lines: Feature to line; inputs KaaterskillCreek_Dissolve; project_contours_raster5. Creek segments were extracted and checked to ensure that the line breaks match where they meet contour lines. Surface information was added to the attribute table of the creek line file based on elevations from the raster file. Field geometry was used to generate segment length, and field calculator to generate difference in elevation and slope. Each creek segment can now be visualized by slope.

Regional Analysis

By viewing the important creek-defining characteristics in overlay, the creek showed clear differentiation between areas of differing categories. At its headwaters, the creek is deeply incised, rocky and steep. The area downstream from that, where eroded material from the mountains has collected, is characterized by erodible soils, moderate, gradual slopes, and a more sinuous form. The creek is then categorized by a flat, straight, and wide section, largely used for agriculture that is pocketed with wetlands. A highly variable section characterizes the creek's flow through the foothill ridge with areas of exposed bedrock, variability in slope and variable but sometimes

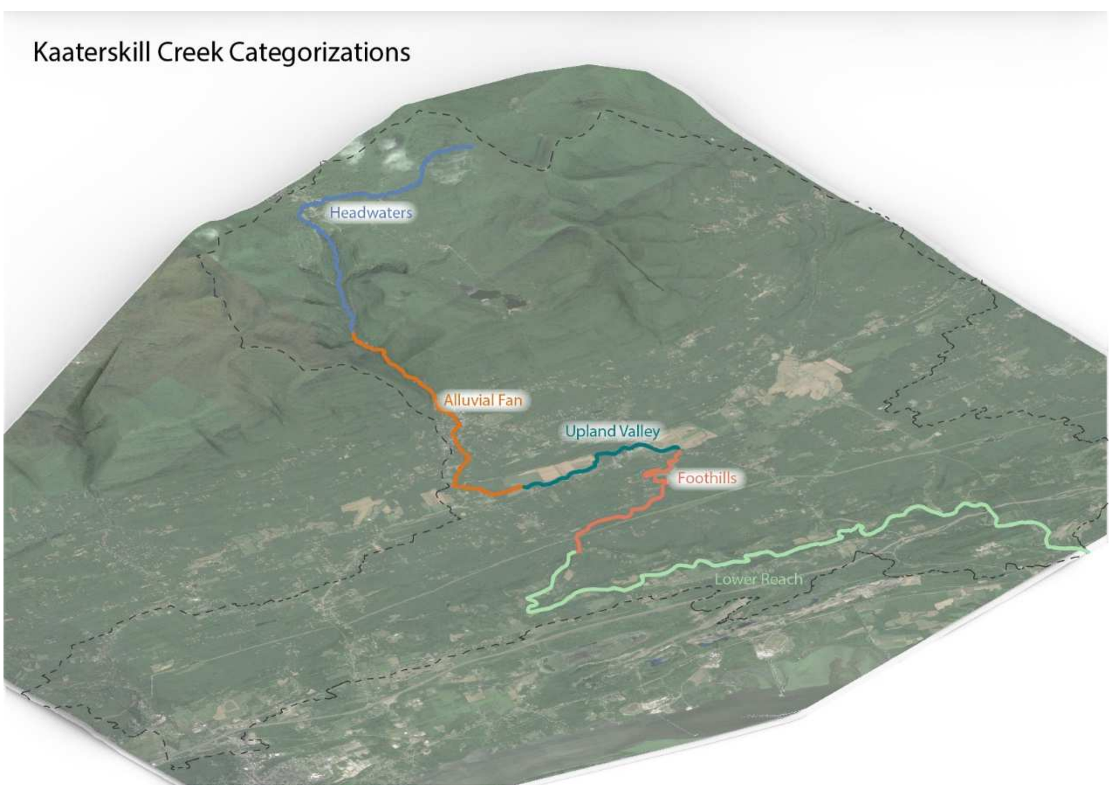

Figure 19: Isometric map of the Kaaterskill Creek showing five creek categories.

extreme sinuousness. The last section of the creek before it meets the Catskill Creek is wider with boulders and riffles, has moderate sinuousness and few but significant waterfalls that pocket a slope. These creek categories support and constrain varied adjacent site uses as shown in (Table 2).

Table 2: Creek categories and characteristics

Adjacent Creek Typology	Intensity of Use Supported	Water-based Programming Supported	Limitations	Design Ideas	Length (miles)	Overall Slope
Headwaters	○○○○○	whitewater kayaking, hiking, sightseeing and overlooks	topography, depth to bedrock and water table, flashy flood conditions	Minimal suitable areas adjacent to creek	5.24	6.84%
Alluvial Fan	●○○○○	whitewater kayaking, tubing, fishing, swimming	erodibility	Emphasis on restoration	4.51	2.46%
Upland Valley	●●●●○	tubing, swimming, fishing	low slope, potential for stagnation, proximity to agricultural runoff	Wide variety of possibilities	2.46	0.25%
Foothills	●●○○○	whitewater kayaking, tubing, fishing, swimming	topography, rocky portions of creek	Intimate, contained spaces	3.30	0.81%
Lower Reach	●●●○○	tubing, fishing, swimming, ice skating, hiking	waterfalls	Wide variety of possibilities	10.73	0.33%

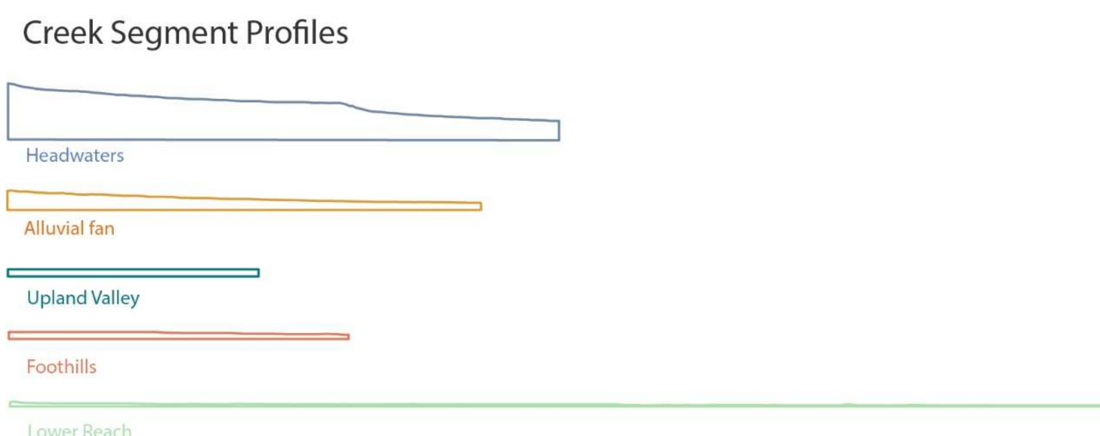

Figure 20: Comparison of creek profiles categorized by common characteristics

The creek Headwaters are where the flow begins in the Catskill Mountains and begins to traverse downhill through Kaaterskill Clove. It is characterized by erodible soils, very steep slopes, and shallow depth to bedrock. Because of these characteristics it is not very suitable for home building or other human land uses directly adjacent to the creek so therefore buyouts have been and will likely be rare. The creek itself can be utilized for some water-based programming but development should have a very low impact on surrounding land.

The Alluvial Fan of the creek represents the area where large, eroded soil materials have settled. The soils along the creek path are moderately erodible and the creek shows some sinuosity in this section and changes in its flow path. While there are many homes along this portion of the creek as well as the hamlet of Palenville, future land uses on flooded buyouts should emphasize ecosystem restoration to stabilize the soils along the creek and limit damage and costly rebuilding.

The Upland Valley represents the fairly flat creek section that passes through wetland and agricultural land uses. The creek itself has very minimal slope here and the potential for stagnation with low precipitation, but a broad floodplain that can accommodate a wide variety of land uses as long as they do not constrain its floodplain function.

The Foothills represent the sinuous and variable portion of the creek as it passes through the rocky foothills of the Catskill Mountains. The sedimentary and limestone bedrock is close to or at the surface in some areas and creates varied topography along the creek's path and in the surrounding areas. This topography leads to intimate, contained spaces, and constrains the types of activities that can occur next to this portion of the creek.

The Lower Reach is the furthest downstream section of the creek before it meets the Catskill Creek. It is characterized by a wider creek path, some sinuosity, and a fairly low slope with some waterfalls and riffles. The wider flow of water leads to increased water-based functions and the soils and topography do not hugely limit the land uses adjacent to the creek.

Site Inventory and Analysis

The four buyout sites along the Kaaterskill Creek were examined within the broader context of the creek as well as at a more granular site scale. Each one is situated adjacent to a different category of the Kaaterskill Creek, with four of the five categories represented. From upstream to downstream, the properties are: the former Schaefer residence at 42 Old Kaaterskill Ave, the former Walsh residence at 4451 NY-32, the former Magnotta residence at 518 High Falls Road Extension, and the

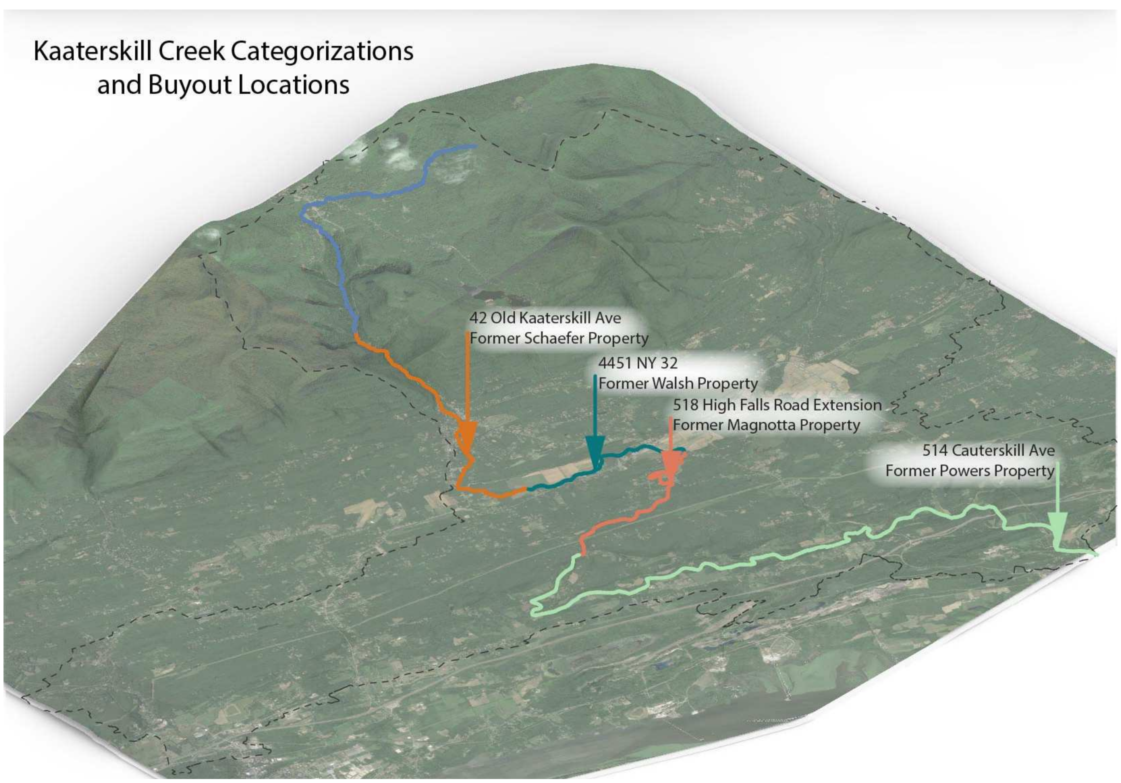

Figure 21: Isometric map of the Kaaterskill Creek watershed with creek pathway and buyout properties.

former Powers residence at 514 Cauterskill Ave (Figure 21)Figure 21: Isometric map of the Kaaterskill Creek watershed with creek pathway and buyout properties.. The Greene County Legislature approved a resolution on February 15, 2012, that "authorized application for hazardous mitigation funding to the State Office of Emergency Management for Participating Local Municipalities for Property Acquisition Activities for the FEMA Flood Buyout Program." (Special Committee Meeting Minutes May 19, 2014). Each of these properties initially applied for buyout funding but only three followed through and are currently owned by the Town of Catskill (Kemble, 2013, Benincasa, 2019). These four properties represent devastating losses due to flooding, but as voluntary buyouts can also represent acceptance of the uncertain world in which we live.

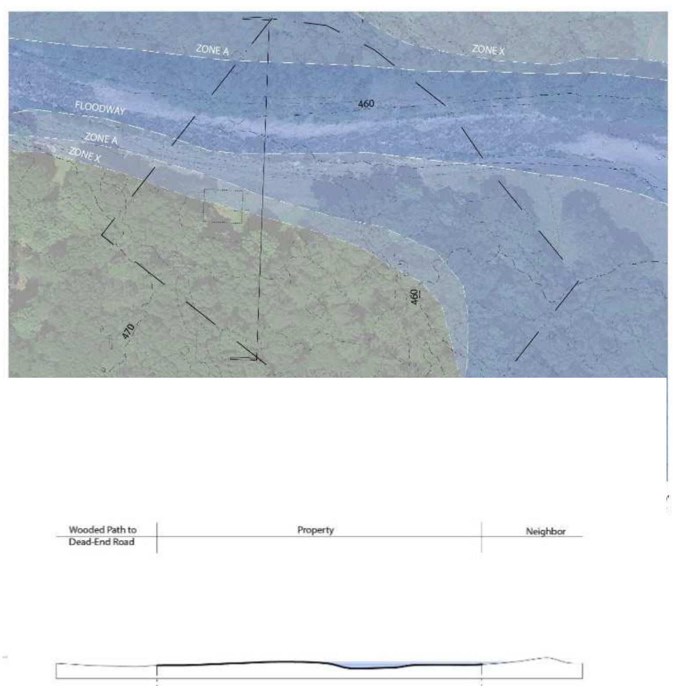

Figure 23: Section view of 42 Old Kaaterskill Ave showing topography and flood zones as well as neighboring properties.

The former Schaefer residence at 42 Old Kaaterskill Ave is situated next to the erodible portion of the Kaaterskill Creek in the Alluvial Fan. The home itself was not located within zone A, or the 100-year FEMA floodplain, but suffered severe foundation damage and flooding when the creek path changed during Hurricane Irene (Elsom and Bliss, 2013). It was an owner-occupied principal residence, and the owners received a $82,264 buyout to complete their relocation (Benincasa, 2019). The home was evaluated for potential hazards in September of 2013 and demolished following a bid approval in May of 2014. This approximately 2.5-acre parcel has very little slope and encompasses a clearing, a portion of the creek, and forested area[11]. The property is accessed via a quiet road through a residential community that dead ends at the long driveway to this parcel. The current state of the property is overgrown mugwort with some evidence of former residential decorative plantings. The driveway is still existent and passes through the deciduous wooded portion of the lot before arriving at the clearing where the home was. The creek edge is steep, potentially a 3–4-foot drop to the water level and shows severe erosion. There is a long view to the west at the creek edge looking toward Kaaterskill Clove. The location feels secluded with only one neighboring home visible through the trees. There is no evidence of the former foundation or an outbuilding that was on the site.

1 Due to inconsistencies in data sources and utilizing large scale topography data at site scale, and anecdotal evidence of modifications to the creek flow path, the current FEMA flood maps do not align with the existing topography of the creek as modeled. A site survey shall be completed before further site interventions can be designed.

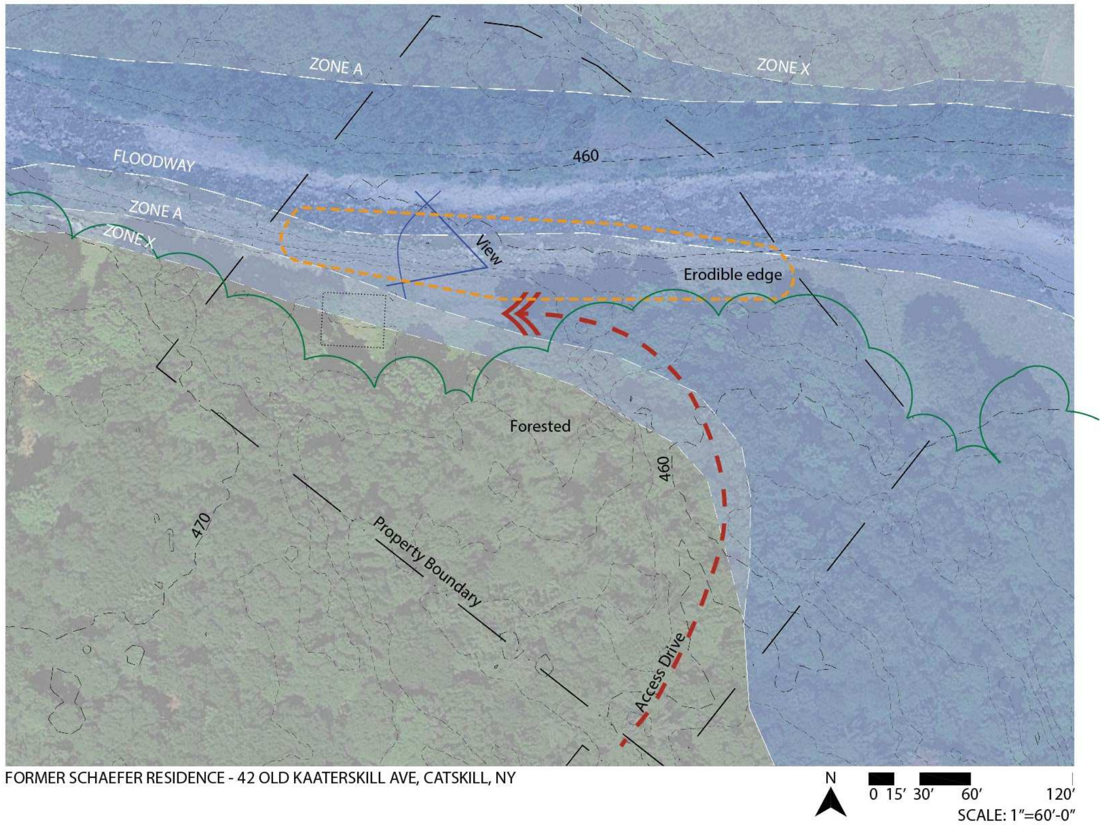

Figure 24: Site analysis map of 42 Old Kaaterskill Ave with site access, opportunities, and constraints.

At the water's edge, there is a picturesque view up the creek toward the Kaaterskill Clove that can be enhanced and highlighted. The site also has existing forest coverage that should be maintained for its ecosystem services, including carbon sequestration, ability to hold soil in place, and habitat for wildlife. The topography of the site and regional-scale land use land cover mapping suggest the forested area may be palustrine wetlands. The soil's erodibility at the creek's edge limits the intensity of use and supports an emphasis on nature-based stabilization. Low-impact recreation can be encouraged to complement a newly stabilized edge and naturalized forest. While this site has a secluded feel that can be leveraged as a calming and reflective space, it also runs the risk of encouraging unwanted anti-social behavior because of its lack of visibility. The property lines here extend all the way across the creek and can support in-water wading and fly fishing.

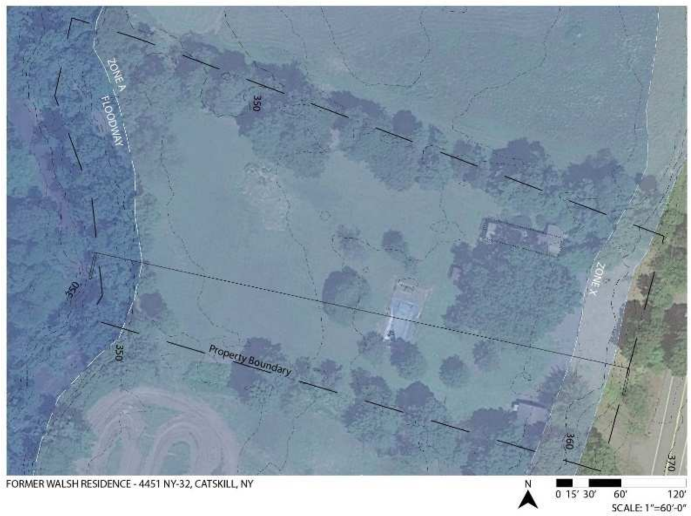

Figure 25: Site inventory map of 4451 NY 32 with property boundaries, topography, flood zones, and home site.

The former Walsh property at 4451 NY-32 is situated next to the Upland Valley portion of the Kaaterskill Creek. This home was considered for a buyout but was ultimately bought by a neighboring homeowner in 2016 for $45,000 (Imagemate Online 2022). There are multiple structures on the site that are in poor condition and look abandoned including a mobile home, inground pool, and several outbuildings. While this property was not bought out through FEMA HMGP funding, it will be treated as if were bought out and currently owned by the Town of Catskill, though in reality, alternative funding would need to be procured to acquire the site and demolish the structures on site. This approximately 3-acre parcel has a steep downhill slope

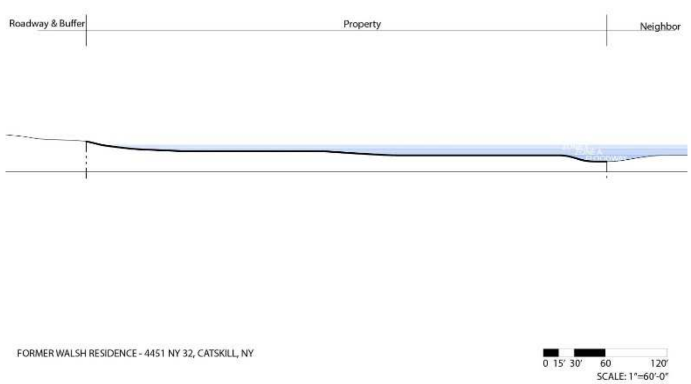

Figure 26: Section view of 4451 NY 32 showing topography and flood zones as well as neighboring properties.

Figure 27: Site analysis map of 4451 NY 32 with site access, opportunities, and constraints.

next to the busy state road, then gently slopes back toward the creek. It has an existing riparian buffer of deciduous trees and shrubs and various ornamental vegetation throughout the yard.

This property benefits from its generous size and existing riparian buffer. It is further benefitted by its visible location on a busy road yet has enough depth from the road that it will not feel dominated by cars. Since nearly all of the site is within the 100-year floodplain, development of site facilities will be limited and only significant topography on the property is limited to the road's edge. Its broad, gently sloping terrain can support a variety of land uses. Since the property boundary includes the near creek edge and potentially the entirety of the creek, waterfront access is not limited.

The former Magnotta residence at 518 High Falls Road Extension is adjacent to the Foothills of the Kaaterskill Creek. It is a very small parcel, only .12 acres bounded by the turn of a road. Half of the parcel is within the floodway while almost the remainder is located within FEMA zone A or the 100-year floodplain. The creek edge includes nearly 30 ft of frontage but is limited by a permanent easement in the southeast corner that accommodates a bridge owned by the county and rebuilt in 2009. This was the site of an owner-occupied secondary residence that was purchased for $195,000 (Benincasa, 2019). The home was evaluated for potential hazards in September of 2013 with notes to further evaluate potential asbestos, and decommissioning needed for a private well, private septic,

Figure 28: Site inventory map of 518 High Falls Road Extension with property boundaries, topography, flood zones, and former home site.

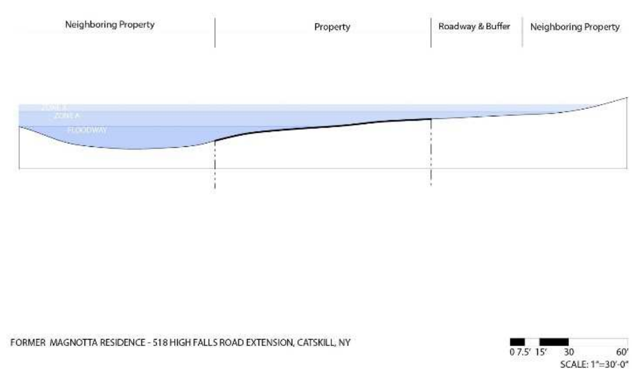

Figure 29: Section view of 518 High Falls Road Extension showing topography and flood zones as well as neighboring properties.

electric, propane, and a heating oil tank (Massman and Barengolts, 2014). The responsibility for decommissioning and responsibly dealing with these hazards, with the exception of asbestos, was passed to the bid awardee for demolishing as per the bid approval documentation in May 2014 (Sciavillo, 2014). The current state of the property is neat with mowed grass and a rocky riparian buffer with riprap and some woody plants including sumac. There are five homes within a 300-foot radius, including an existing home on the property to the northwest that is very nearby which gives this site a residential, hamlet-like feel.

This property is extremely limited by its small size. While it does have prominent visibility due to its proximity to the road and bridge, it risks being dominated by vehicles. It is further limited with half of the property within the

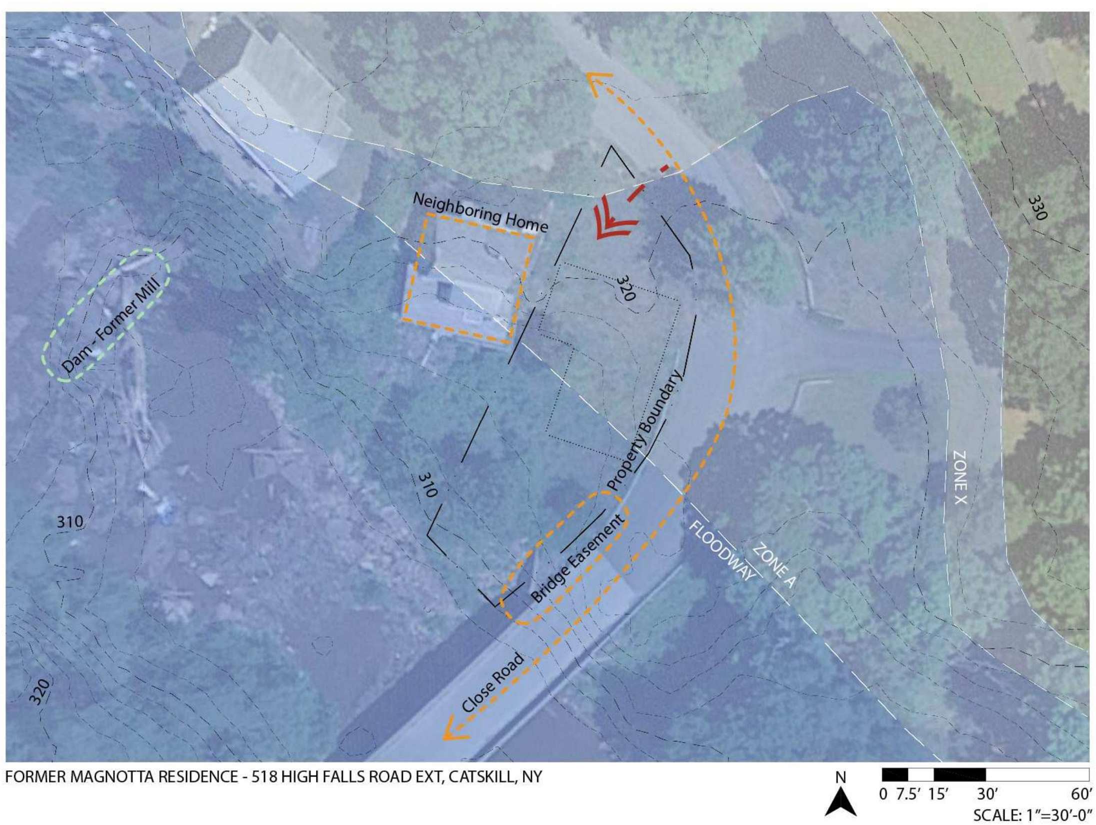

Figure 30: Site analysis map of 518 High Falls Road Extension with site access, opportunities, and constraints.

floodway, and the rest within the 100-year floodplain. Close neighbors will need to be on board with changes to land use due to their extreme proximity. The rocky creek at this location is uniquely beautiful, but actual water access is limited because this property boundary ends at the near creek edge and the creek itself is part of the parcel owned by the property owner across the creek.

The former Powers residence at 514 Cauterskill Ave is adjacent to the Lower Reach of the Kaaterskill Creek and is located at a bend of the creek approximately a quarter mile downstream from one of the larger waterfalls and about a half a mile upstream from the confluence of the Kaaterskill and the Catskill Creeks. The home itself was likely located within zone A or the 100-year floodplain. It was an owner-occupied primary residence that was purchased for $32,752 (Benincasa, 2019). The home location is not included in the statewide database and there is no publicly available report of potential hazards on this property, but the address is included on the Demolition Bid in May of 2014 and the property is currently owned by the Town of Catskill (Sciavillo, 2014). Evaluation of this property was limited by its location on a fast road with no shoulder, and a neighbor's fence that currently extends past the former driveway. Through research of

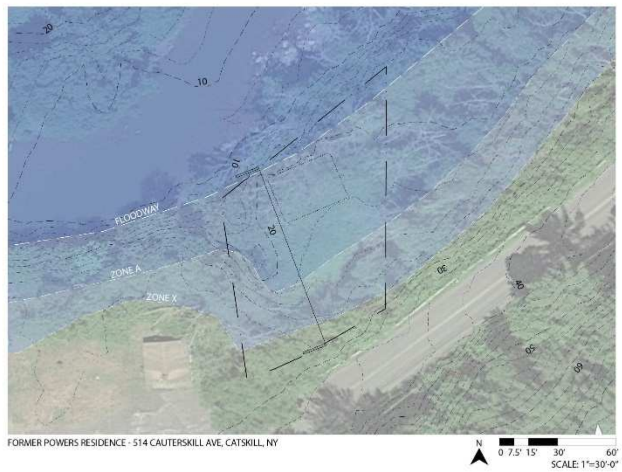

Figure 31: Site inventory map of 514 Cauterskill Ave with property boundaries, topography, flood zones, and former home site.

current and historical google satellite and street view imagery as well as site mapping created from a variety of data sources, the site appears to be lower than the adjacent road at a moderate slope, with a clearing for the home site and forested area around the property including some riparian buffer. The property is approximately .2 acres. There is one adjacent neighbor and a higher elevation from this property and given the wooded condition it is likely a secluded space.

This property is closest to the Village of Catskill which provides greater opportunities for local access or even non-vehicular transportation, but its location on the bend of a fairly busy road will be a limiting factor. It is further limited by the property boundary which does not extend beyond the near water's edge. The existing tree cover on the site is a benefit that can be leveraged to enhance the secluded feel of the site as well as ecosystem services. The property does have a sizable portion outside

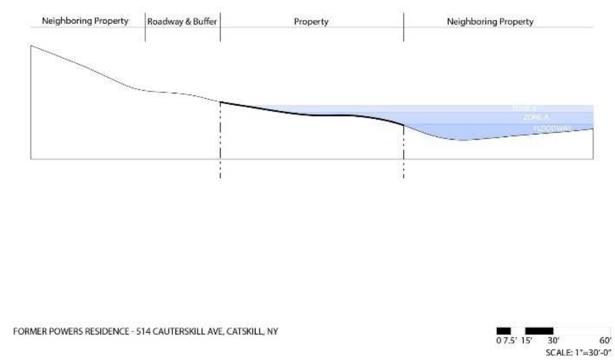

Figure 32: Section view of 514 Cauterskill Ave showing topography and flood zones as well as neighboring properties.

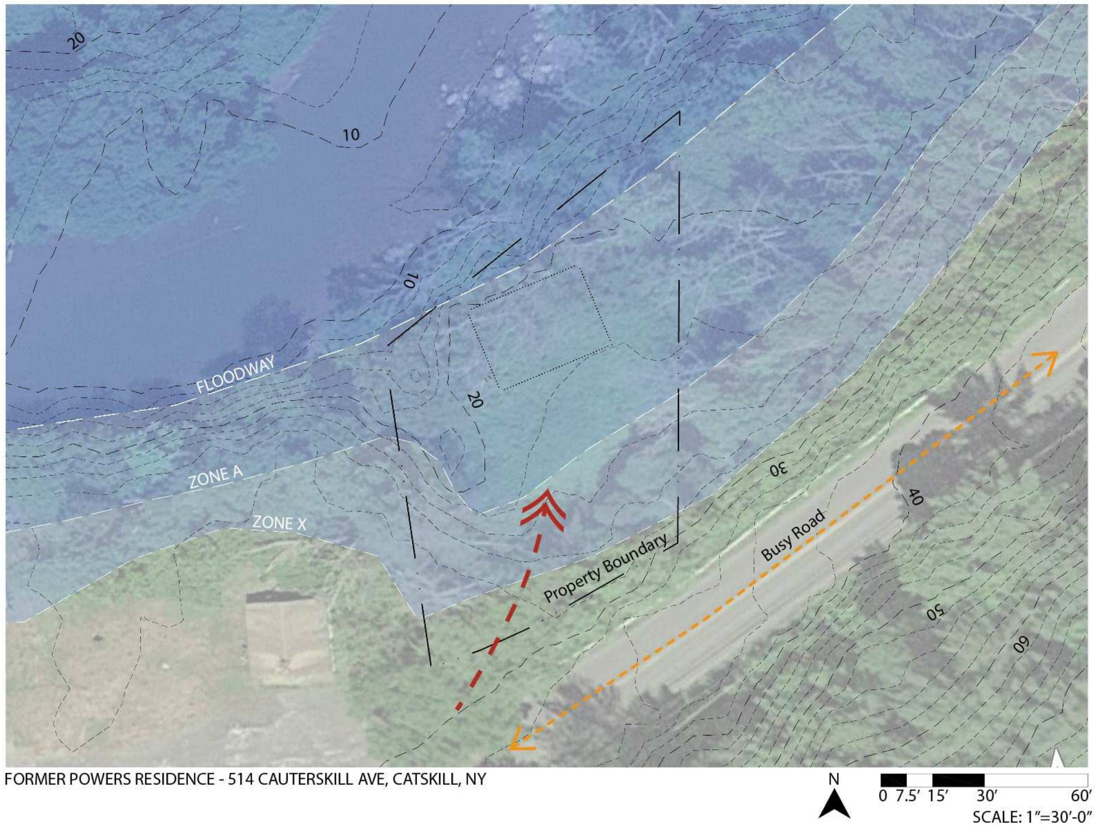

Figure 33: Site analysis map of 514 Cauterskill Ave with site access, opportunities, and constraints.

of the 100-year floodplain which should allow for a variety of site uses at its entry and a layered approach to the waterfront guided by its potential to flood.

These four properties share a proximity to the Kaaterskill Creek, the fact that they used to hold homes and foundations and have common vegetation and climatic conditions. Like many other parcels along the Kaaterskill Creek, they will flood again, whether it is in 500 years, 100 years, or sooner, but can provide valuable community benefits despite their propensity to flooding.

Chapter 4: Design

Design Criteria and Framework

The established criteria for designing land reuse after flooding are as follows:

- Promote resilience by retaining floodplain function and improving it wherever possible
- Design for multifunctionality benefiting humans and ecosystems through nature-based solutions or green infrastructure for flooding
- Program spaces to meet the needs of the community
- Engage and inform visitors by providing educational and interpretive features that highlight flood and stormwater management
- Consider maintainability by limiting high-maintenance functions and creating partnerships wherever possible

Taking these criteria into account, a framework can be established to specifically target the environmental, social, and economic benefits of land reuse after flooding as well as site-specific considerations and connectivity between non-contiguous parcels as shown in Figure 34. Land reuse after flooding must be designed in a way that is sensitive to site specific conditions and needs. While many sites can accommodate people and recreation as well as floodplain restoration, a balance must be found on each parcel that will weigh more heavily in one direction or the other.

This design framework does not currently include essential community input. When these decision-making processes occur after a flooding event, this framework can be a resource for a community-centered design process. This process can also be replicated in similar situations through a mapping process of the creek typology and regional research into existing community needs and plans.

Figure 34: Design framework for land reuse after flooding

Site Designs

42 Old Kaaterskill Ave

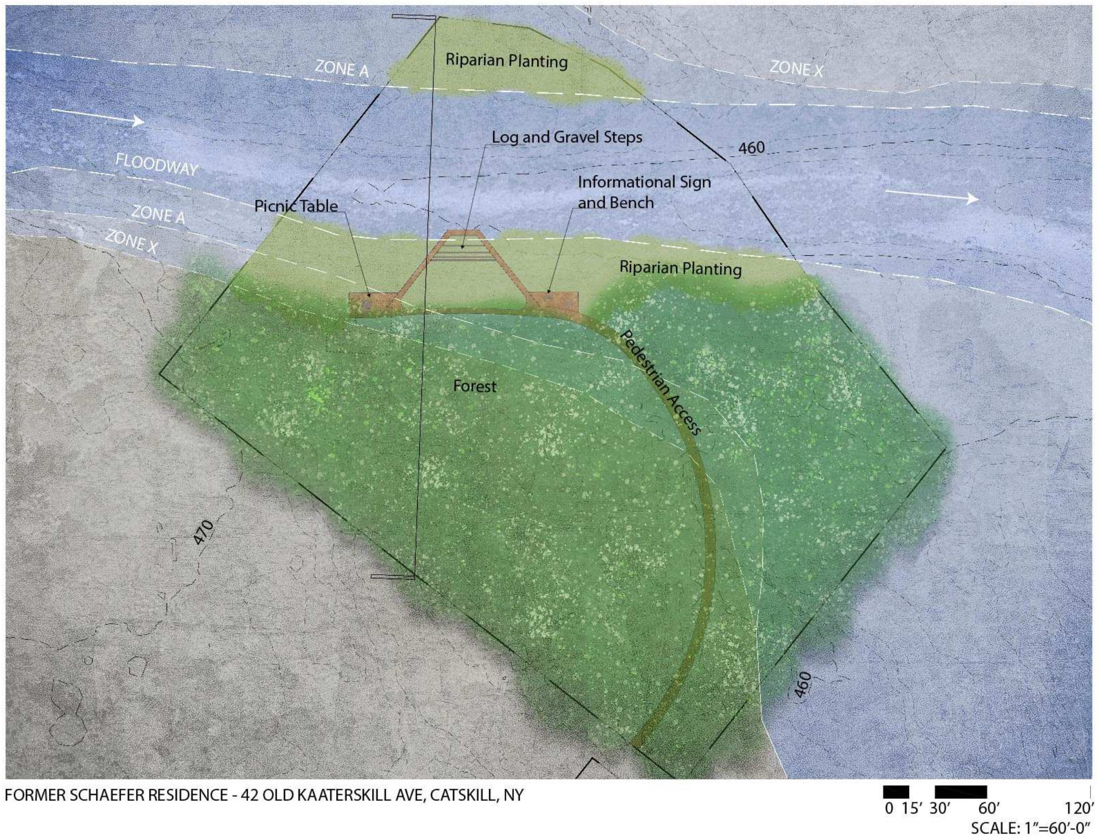

Figure 35: Site Plan of 42 Old Kaaterskill Ave showing layout and locations of plantings and site amenities.

The former Schaefer property requires a light touch due to its erodible soils and existing forest canopy. The design leans heavily toward environmental restoration with limited opportunities for recreation. This is accomplished by limiting site disturbance to the former home site and already eroded edge. The edge will be graded back to create a gentler slope and larger gradient of wet to dry area and therefore riparian habitat. The edge will be planted with riparian plants to help prevent erosion and increase habitat opportunities. Direct access to the water is provided via a gravelly beach for wading or fly fishing. The forest edge will be planted further into the clearing, providing just a small clearing for a staging area near the water. A picnic table is provided at the highest point of the site to encourage picnicking and relaxation. Parking will be limited to the far edge of the site, at the beginning of the existing driveway and end of the dead-end road. Site access will be entirely by foot, in keeping with having a light touch on the land. Signage is posted to indicate the property is only open dawn to dusk and carry in-carry out as well as educational facts about fishing and riparian life. With no formal benchmarking to highlight high water marks or a changing creek path, signage will help guide visitors to see the cues that indicate changes in flood conditions and ecological implications.

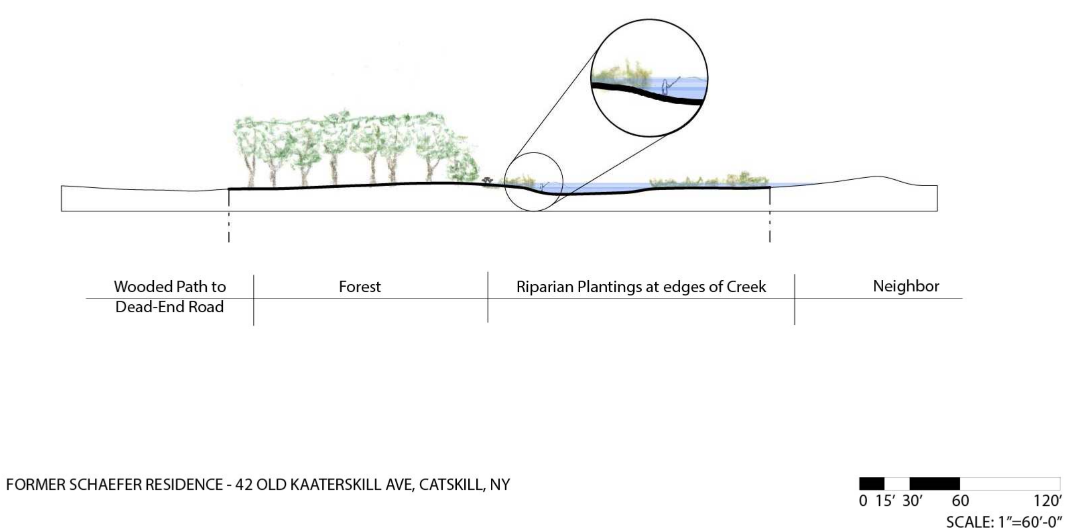

Figure 36: Section of 42 Old Kaaterskill Ave showing scaling and relationships between site amenities and floodwaters.

Maintenance will be minimal in this naturalistic site. The waterfront within the 100-year floodplain is planted with hearty riparian plants which will recover from flooding without further input and keep the shoreline intact. If flooding occurs shortly after planting date, the site may need to be planted more than once. Within the 500-year floodplain there are no large structures that will either entrap debris and cause damming or come loose and cause severe damage downstream.

To meet the need of promoting resilience and retaining floodplain function, this design enhances shoreline stability through riparian plantings and retains floodplain capacity. The existing forested area is retained and expanded for carbon sequestration. For multifunctionality, this design provides some, but limited programming opportunities near the water's edge that will minimize disturbance to the delicate ecosystem. To meet to needs of the community, this design provides some recreational activities (primarily fishing and picnicking) and strives to overcome the lack of site visibility by having parking at the street. To engage and inform visitors, this design provides interpretive signage about the creek and allowed and prohibited uses. In consideration of maintainability, this design is meant to have a naturalistic feel that does not require much more than annual maintenance. This site promotes environmental and ecological needs by emphasizing plantings, while supporting some recreational activities for social, and economic. While it has limited connectivity to other parcels, it can provide a public fishing area in series with others along the creek.

4451 NY-32

The former Walsh property is utilized primarily as a recreational site due to its easy access to a busy road, large space for programming, and access to the water. An entry area with parking is sited along the high edge of the 500-year floodplain with a composting toilet tucked into the edge, outside of any floodplain. A multipurpose green space surrounded by low areas provides recreational space for a wide variety of sports and entertainment with room for water at the edges. Raised landforms closer to the creek give space for a pergola raised above the 100-year floodplain to provide some storage for site amenities as well as an entertainment stage. These raised landforms provide further passive educational value to help highlight high water marks and reinforce the variability of the water's edge. All of the regrading within the floodplain has a net neutral cut and fill so the floodplain volume is not impeded. Meandering pathways through the landforms continue into and through the expanded riparian buffer and directly to the water. Wading and fishing are encouraged here and access for kayaks, stand up paddleboards, or tubes can be facilitated in the future as additional access points are added upstream or downstream. Because this space is programmed to be high utility it will also require a fair amount of maintenance, likely a crew of groundskeepers arriving weekly with all of the tools needed.

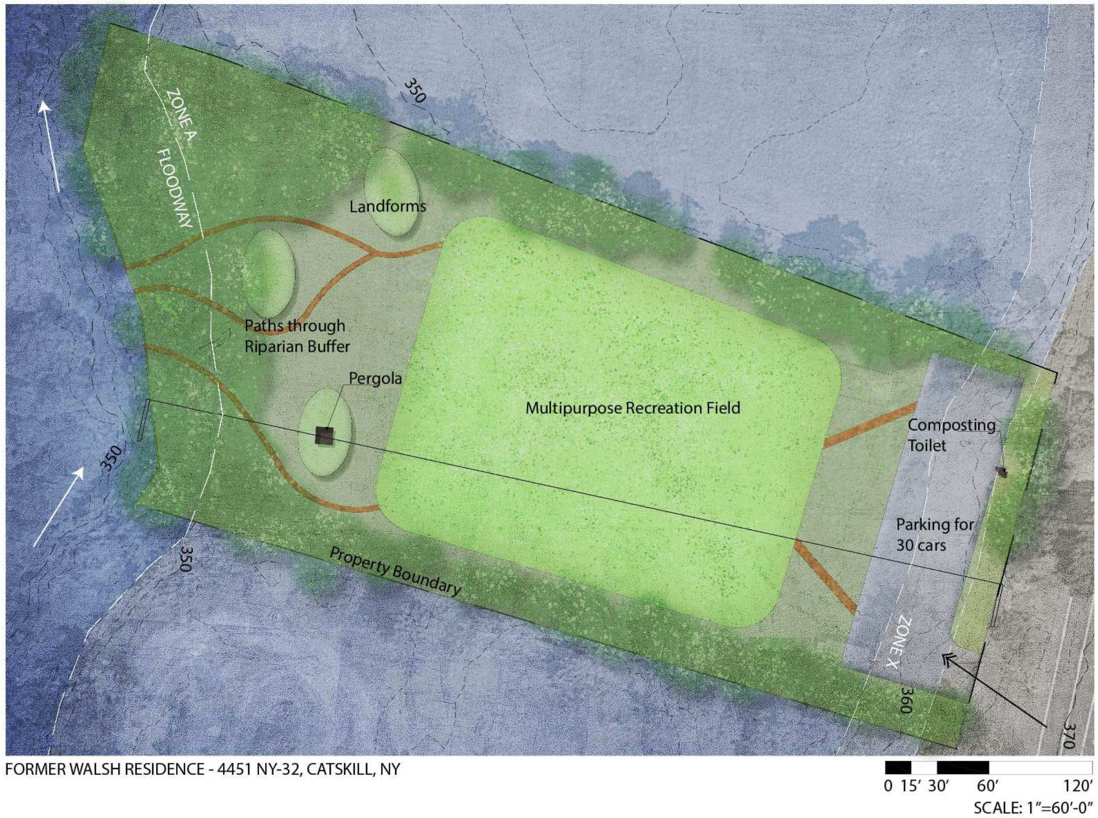

Figure 38: Site Plan of 4451 NY 32 showing layout and locations of plantings and site amenities.

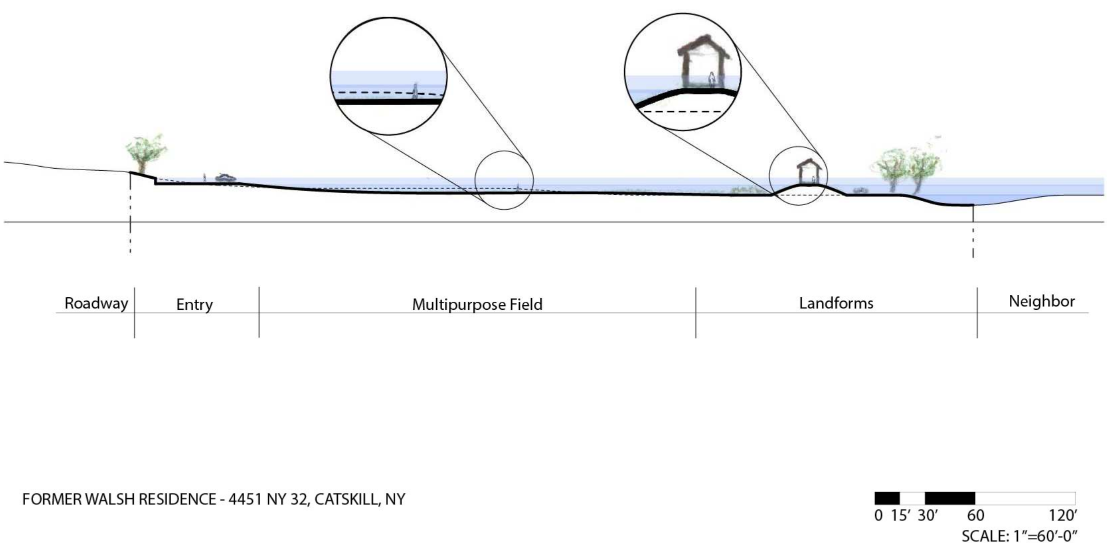

Figure 37: Section of 4451 NY 32 showing scaling and relationships between site amenities and floodwaters.

To meet the need of promoting resilience and retaining floodplain function, this design maintains the existing riparian buffer, and provides an even amount of cut and fill within the floodplain to retain its existing capacity. For multifunctionality, this design provides various programmable spaces for community needs that are also able to flood during large storm events. To meet the needs of the community, this design promotes recreation, entertainment, and educational opportunities through the multipurpose recreation field, raised pergola, and paths to the creek. To engage and inform visitors, this design provides raised landforms that highlight high water marks and increase the visibility of varied water levels in the perception of visitors. In consideration of maintainability, this design will require regular maintenance, but that will be matched by the high utility spaces. This design emphasizes social needs of the community by acting as a gathering space for recreation and entertainment, which provides further economic opportunities through tourism and local events, while also supporting environmental needs with a strong riparian buffer and diversity of ecological niches. The public access to the creek provides opportunities for future connectivity such as boat or tube launching as well as swimming.

518 High Falls Road Extension

The limited space and enclosed feel of the former Magnotta property support the primary use of this space for reflection and relaxation. A small parking and entry area encourages use by few people at a time. A meandering pathway with a wide diversity of flowering and medicinal plants leads the way to the water's edge, which will sometimes come halfway up the site. Large boulders are placed strategically for sitting and taking in the views of the water, mountains afar, and wildlife drawn in by the plants as well as the sounds of the nearby water passing over the old dam upstream. The boulders are placed at varied elevations along the site as literal benchmarks for repeat visitors to acknowledge varied water levels while providing sturdy and naturalistic seating areas. The extent of site plantings is determined by interest in local gardening groups or neighbors willing to aid in maintenance.

To meet the need of promoting resilience and retaining floodplain function, this design does not regrade or increase impermeable areas within the floodway or flood zone and increases plantings for soil stability and carbon sequestration. For multifunctionality, this design integrates spaces for people to relax within the planting and floodable areas. To meet to needs of the community, this design provides low impact spaces for visitors to relax and enjoy nature around them. To engage and inform visitors, this design provides informative signage and benchmarks to highlight changes in water level. In consideration of maintainability, this design encourages plant diversity, but the breadth of that diversity will be dependent on community partnerships and willingness to aid in maintenance. While this site promotes social needs of reflection and relaxation, it also provides benefits for tourism and therefore the economy, as well as environmental needs with increased planting for seasonal interest and pollinator benefit. The fact that the property boundary ends at the water's edge limits the site connectivity with other non-contiguous parcels, but it can connect thematically with other parcels as part of a tour that is connected via the road by driving, biking, or walking.

Figure 39: Site Plan of 518 High Falls Road Ext. showing layout and locations of plantings and site amenities.

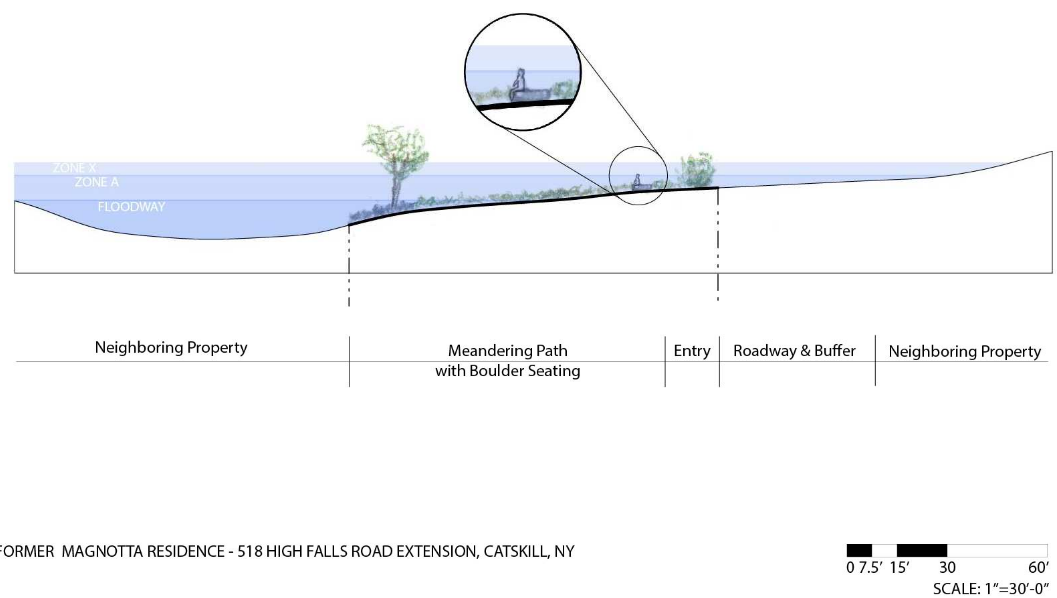

Figure 40: Section of 518 High Falls Road Extension showing scaling and relationships between site amenities and floodwaters.

514 Cauterskill Ave

The former Powers residence has an education focus due to its proximity to town, limited water access, and fairly small size. Extensive regrading of all cleared areas increases the depth of land in the 100-year floodplain, increasing the likelihood of regular flooding and creating more riparian land, while providing fill to raise the entry area for parking, a pergola for picnics and classrooms, and a composting toilet. Raised pathways through the riparian area provide opportunities for students, guided day-trippers, and all interested visitors to see riparian flora and fauna up close. Signage helps identify common species. The pathway continues to the creek edge to provide a site for water sampling and a comparison of flowing water to the riparian and flooded edges. Partnerships with environmentally minded community groups can provide maintenance as well as removal of invasive species in this demonstration area.

To meet the need of promoting resilience and retaining floodplain function, this design increases floodable capacity in the 100-year flood zone by cutting land away and placing it within the 500-year flood zone. For multifunctionality, this design highlights the functions of the riparian zone through increased plantings as well as through educational opportunities. To meet to needs of the community, this design provides formal and informal educational activities. To engage and inform visitors, this design has informative signage, pathways to encourage visibility of the riparian plantings, and an outdoor classroom for interpretation. In consideration of maintainability, this design can partner with existing environmental organizations in the area for periodic cleanups, programming, and invasive species removal. This design is focused on the social factors of education but ties in with environmental needs through environmental education and leverages economic opportunities through tourism as well as enhanced visibility for fundraising. While this site is located between two waterfalls that limit its water-based connectivity to other parcels, an emphasis on water testing can highlight the physical connectivity of the water between this and other parcels, and it can connect thematically with other non-contiguous sites along the road network.

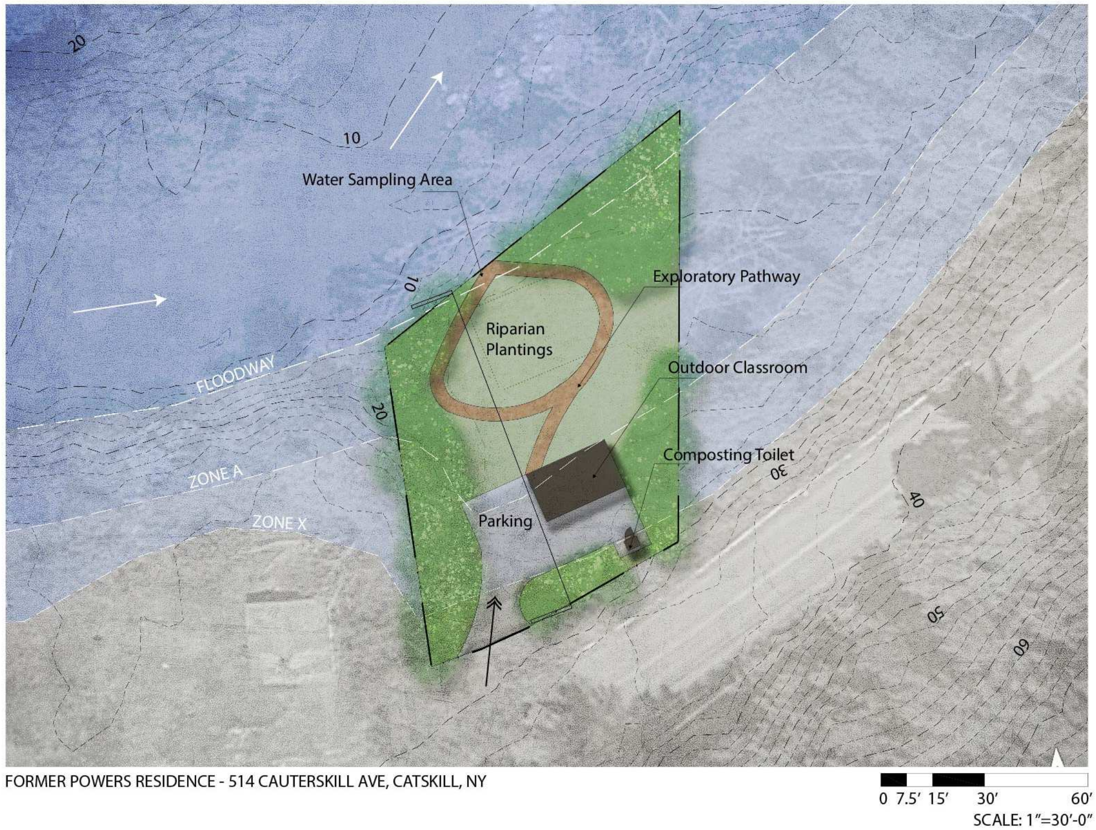

Figure 43: Site Plan of 514 Cauterskill Ave showing layout and locations of plantings and site amenities.

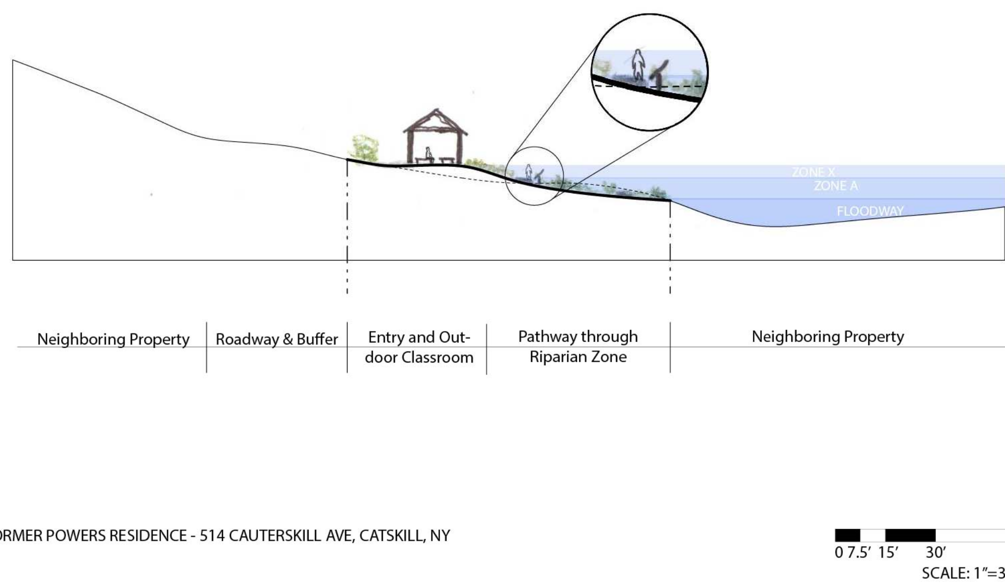

Figure 42: Section of 514 Cauterskill Ave showing scaling and relationships between site amenities and floodwaters.

Chapter 5: Reflection and Critique

Critique

The criteria established for this design were as follows:

- Promote resilience by retaining floodplain function and improving it wherever possible
- Design for multifunctionality benefiting humans and ecosystems through nature-based solutions or green infrastructure for flooding
- Program spaces to meet the needs of the community and visitors
- Engage and inform visitors by providing educational and interpretive features that highlight flooding and stormwater management
- Consider maintainability by limiting high-maintenance functions and creating partnerships wherever possible

The site designs are successful in meeting these criteria in a variety of ways, with a site-specific emphasis on different elements. The overall framework fits within and expands on these criteria as guidance for design. The four site examples all retain floodplain function by either maintaining or increasing the volume of area within the 100-year floodplain, with either no disturbance, equal volume of cut and fill of soil, or more cut than fill. Each site provides an example of both human and ecosystem benefits with a greater emphasis on one or the other on each site. Green infrastructure and nature-based solutions deployed include planting and increasing riparian buffers, planting trees, and plantings for pollinators. Various projected needs of the community and visitors as gleaned through research are addressed on these sites including multipurpose recreation and entertainment space, public fishing access, and environmental education. Most sites include benchmarks to highlight flooding and make it more visible for passive education, and some sites include more formal educational opportunities as well. Maintenance is considered on all four sites, with the highest need being on the highest utility site, and the intensity of use on the other sites being guided by community engagement and partnerships.

Reflection and Further Study

This thesis addresses a complex topic that has an impact on the lives of vulnerable people whose lives have been upended by flooding. My intention is that this research can provide any sense of solace and hope to those who are considering or who have accepted a buyout, not to contribute to further trauma to their lives.

The research would be strengthened by community input to ensure the designs adequately meet community needs and do not exacerbate unknown community issues or tensions. This input was unfortunately not possible due to the limited timeline of research and lingering effects of the Covid-19 pandemic. As such, it is not meant to be completed designs, but a framework and suggestions for the community to consider in a design process.

The methods of this thesis can be applied to other rural creeks in the northeastern US with similar flooding issues. The multi-scalar approach can be replicated with regionally specific data to enhance site specific considerations and limitations. This can enhance the resilience of site designs and the community as designs fit the creek in a multi-scalar analysis.

Further research influenced by this thesis may include examination of place attachment and spatial nostalgia in the buyout process and how design for land reuse can help heal these issues. Various design features could be evaluated for their ecosystem service benefits and an ensuing cost-benefit analysis could be conducted on buyout properties.

Chapter 6: Conclusion

Designing land reuse on flooded buyout sites along a rural creek in the northeastern United States has the potential to provide social, ecological, and economic value to surrounding and downstream communities. Focus should be placed on multifunctionality and site specificity while retaining floodplain function and engaging visitors.

To meet the need of promoting resilience and retaining floodplain function, these site designs enhance shoreline stability through riparian plantings, retain and expand existing forested area for carbon sequestration, provide even cut and fill within the floodplain to retain its existing capacity, limit the addition of impermeable surfaces, and/or increase the floodplain capacity by cutting more land from the floodplain than is being filled.

For multifunctionality, these designs provide limited programming opportunities near the water's edge to minimize disturbance to the delicate ecosystem, provide various programmable spaces for community needs that are also able to flood during large storm events, integrate spaces for people to relax within the planted and floodable areas, and highlight the benefits of the riparian zone through educational and observational opportunities.

To meet to needs of the community, these designs provide fishing and picnicking recreational activities, promote recreation, entertainment, and educational opportunities through a multipurpose recreation field, raised pergola, and paths to the creek, provide low impact spaces for visitors to relax and enjoy nature around them, and provide educational opportunities to connect to the environment.

To engage and inform visitors, these designs provide interpretive signage about the creek and allowed uses, create raised landforms that highlight high water marks and increase the visibility of varied water levels in the perception of visitors, provide informative signage and benchmarks to highlight the changes in water level, and provide pathways to encourage visibility of the riparian plantings, and an outdoor classroom for interpretation.

In consideration of maintainability, these designs utilize a variety of strategies including, having a naturalistic feel that does not require much more than annual maintenance, requiring regular maintenance that is matched by high utility spaces, encouraging a diversity of plantings that is dependent on community partnerships and willingness to aid in maintenance, and partnering with existing environmental organizations in the area for periodic cleanups, programming, and invasive species removal.

Each site design finds a balance between environmental, social, and economic priorities while finding ways to support each factor. The first site promotes environmental and ecological needs by emphasizing plantings, while supporting some recreational activities for social, and economic. The second emphasizes social needs of the community by acting as a gathering space for recreation and entertainment, which provides further economic opportunities through tourism and local events, while also supporting environmental needs with a strong riparian buffer and diversity of ecological niches. The third promotes social needs of reflection and relaxation, while also providing benefits for tourism and therefore the economy, as well as environmental needs with increased planting for seasonal interest and pollinator benefit. The fourth site design is focused on the social factors of education but ties in with environmental needs through environmental education and leverages economic opportunities through tourism as well as enhanced visibility for fundraising.

While sites may not be contiguous, their designed uses can complement and balance each other, have similar treatments, or be part of continuous themed trail with current access via roads. They can serve as opportunities to be seen in series for specific recreational activities such as public fishing, thematic tours, or water testing to highlight the existing connectivity through the water. In the future, connectivity may be possible along the creek, encouraging boating or tubing between future buyout sites as a water trail.

This design process is replicable through mapping of the creek typology and regional research into existing community needs and plans, applying the outlined framework and criteria to a community-led design making process.

While flooding may have caused trauma and sorrow on a property, it can be redesigned to creates spaces informed by the past and future projections, for people and nature, and water and land.

Bibliography

1981-2010 Normals | Data Tools | Climate Data Online (CDO) | National Climatic Data Center (NCDC). (n.d.). Retrieved April 19, 2021, from https://www.ncdc.noaa.gov/cdo-web/datatools/normals

AECOM. (2016). *Greene County Hazard Mitigation and Resilience Plan*. Greene County Emergency Services. https://www.greenegovernment.com/wp-content/uploads/2018/01/FULL-PLAN-PUBLIC.pdf

Andre, R. (2016, September 3). *Irene five years later: Eight untold stories from the Catskills flood*. Watershed Post. http://www.watershedpost.com/2016/irene-five-years-later-eight-untold-stories-catskills-flood

ASLA. (n.d.). *Resilient Design | asla.org*. Retrieved March 24, 2022, from https://www.asla.org/resilientdesign.aspx

Bahadur, A. V., Ibrahim, M., & Tanner, T. (2010). *The resilience renaissance? Unpacking of resilience for tackling climate change and disasters*. https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/2368

Balling, R., & Goodrich, G. (2011). Spatial analysis of variations in precipitation intensity in the USA. *Theoretical and Applied Climatology*, *104*, 415–421. https://doi.org/10.1007/s00704-010-0353-0

Benincasa, R. (2019, March 5). Search The Thousands Of Disaster Buyouts FEMA Didn't Want You To See. *NPR*. https://www.npr.org/2019/03/05/696995788/search-the-thousands-of-disaster-buyouts-fema-didnt-want-you-to-see

Best Hiking in the Catskills | Official Catskills Region Website. (n.d.). Retrieved April 13, 2022, from https://www.visitthecatskills.com/hiking

Binder, S. B., & Greer, A. (2016). The Devil Is in the Details: Linking Home Buyout Policy, Practice, and Experience After Hurricane Sandy. *Politics and Governance*, *4*(4), 97–106. https://doi.org/10.17645/pag.v4i4.738

Binder, S. B., Link to external site, this link will open in a new window, Greer, A., & Zavar, E. (2020). Home buyouts: A tool for mitigation or recovery? *Disaster Prevention and Management*, *29*(4), 497–510. http://dx.doi.org/10.1108/DPM-09-2019-0298

Bonaiuto, M., Alves, S., De Dominicis, S., & Petruccelli, I. (2016). Place attachment and natural hazard risk: Research review and agenda. *Journal of Environmental Psychology*, *48*, 33–53. https://doi.org/10.1016/j.jenvp.2016.07.007

Bradt, J. T., Kousky, C., & Wing, O. E. J. (2021). Voluntary purchases and adverse selection in the market for flood insurance. *Journal of Environmental Economics and Management*, *110*, 102515. https://doi.org/10.1016/j.jeem.2021.102515

Bridgehunter.com | Greene County, New York. (n.d.). Retrieved February 7, 2022, from https://bridgehunter.com/ny/greene/guide/

Bridges, T. S., King, J. K., Simm, J. D., Beck, M. W., Collins, G., Lodder, Q., & Mohan, R. K. (2021). *International Guidelines on Natural and Nature-Based Features for Flood Risk Management* [Report]. Engineer Research and Development Center (U.S.). https://erdc-library.erdc.dren.mil/jspui/handle/11681/41946

Bruns, D., Haustein, N., & Willecke, J. (2008). Landscape planning for flood risk management planning with SEA. *Journal of Landscape Architecture*, *3*(1), 24–35. https://doi.org/10.1080/18626033.2008.9723393

Cauterskill Bridge—Greene County Libraries Association—New York Heritage Digital Collections. (n.d.). Retrieved April 6, 2022, from https://nyheritage.contentdm.oclc.org/digital/collection/gcla/id/640/rec/183

Cauterskill- Kaaterskill Creek tributary. (2021, October 14). Riverkeeper. https://www.riverkeeper.org/water-quality/citizen-data/catskill-creek-watershed/cauterskill-kaaterskill-creek-tributary/

Cerra, J. F. (2016). Inland Adaptation: Developing a Studio Model for Climate-adaptive Design as a Framework for Design Practice. *Landscape Journal*, *35*(1), 37–56. https://doi.org/10.3368/lj.35.1.37

Chapter 14: Enhancing Structural Measures for Environmental, Social, and Engineering Benefits. (n.d.).

Climate Adaptation and Resilience Across Scales: From Buildings to Cities. (n.d.). Retrieved April 7, 2022, from https://web.p.ebscohost.com/ehost/ebookviewer/ebook/bmxlYmtfXzI5MzM5MzdfX0FO0?sid=e85458c9-acef-4202-85fd-75c2f04f0fbf@redis&vid=0&format=EB&lpid=lp_172&rid=0

Consolidated Assessment and Listing Methodology. (2021). NYSDEC.

Crane Davis. (2016, March 30). *Kaaterskill Creek Access and Etiquette*. https://www.youtube.com/watch?v=sI6kFXaz-zI

Mitigation Assistance: Building Resilient Infrastructure and Communities, Pub. L. No. FEMA POLICY FP-104-008-05 (2022). https://www.fema.gov/sites/default/files/documents/fema_bric-policy-fp-008-05_program_policy.pdf

CS_very_heavy_precip_V8.png (2017×1817). (n.d.). Retrieved April 19, 2022, from https://data.globalchange.gov/assets/1d/f7/020c8c233335fd1aeb4599ae29d3/CS_very_heavy_precip_V8.png?download=1

Cuomo, A. M., & Visnauskas, R. (2019). *NY Rising Buyout and Acquisition Program*. 71.

Davidson, J., Jacobson, C., Lyth, A., Dedekorkut-Howes, A., Baldwin, C., Ellison, J., Holbrook, N., Howes, M., Serrao-Neumann, S., Singh-Peterson, L., & Smith, T. (2016). Interrogating resilience: Toward a typology to improve its operationalization. *Ecology and Society*, *21*(2). https://doi.org/10.5751/ES-08450-210227

DECinfo Locator. (n.d.). [Webmap]. NYSDEC. Retrieved April 3, 2022, from https://gisservices.dec.ny.gov/gis/dil/index.html?cat=wrl

DeGaetano, A. T., & Castellano, C. M. (2013). Recent and future changes in extreme rainfall in the Catskills region of New York. *Annals of the New York Academy of Sciences*, *1298*(1), 43–51. https://doi.org/10.1111/nyas.12245

Dokken, D. (n.d.). *Summary for Policymakers*.

Echols, S., & Pennypacker, E. (2015). *Artful Rainwater Design: Creative Ways to Manage Stormwater*. Island Press/Center for Resource Economics.

Eisenman, T., Anzevino, J., Rosenberg, S., & Spector, S. (2010). *Revitalizing Hudson Waterfronts: Illustrated Conservation & Development Strategies for Creating*

Healthy, Prosperous Communities. Scenic Hudson, Poughkeepsie, NY. https://www.dos.ny.gov/opd/programs/pdfs/Guidebooks/Revit_Hudsonguide.pdf

Elkin, R. S., & Keenan, J. M. (2018). Retreat or Rebuild: Exploring Geographic Retreat in Humanitarian Practices in Coastal Communities. In W. Leal Filho (Ed.), *Climate Change Impacts and Adaptation Strategies for Coastal Communities* (pp. 149–165). Springer International Publishing. https://doi.org/10.1007/978-3-319-70703-7_8

Elsom, D., & Bliss, M. P. (2013a). *Schaffer Phase 1 Environmental Site Assessment*. Kaaterskill Associates. https://www.greenegovernment.com/wp-content/uploads/2014/04/Schaffer-Phase-I-Report.pdf

Elsom, D., & Bliss, M. P. (2013b). *Magnotta Phase 1 Environmental Site Assessment*. Kaaterskill Associates. https://www.greenegovernment.com/wp-content/uploads/2014/04/Magnotta-Phase-1-report.pdf

Falls at Fernwood, Kaaterskill Creek, Palenville, Catskill Mts., N.Y. - Greene County Libraries Association—New York Heritage Digital Collections. (n.d.-a). Retrieved April 6, 2022, from https://nyheritage.contentdm.oclc.org/digital/collection/gcla/id/848/rec/1

Falls at Fernwood, Kaaterskill Creek, Palenville, Catskill Mts., N.Y. - Greene County Libraries Association—New York Heritage Digital Collections. (n.d.-b). Retrieved April 6, 2022, from https://nyheritage.contentdm.oclc.org/digital/collection/gcla/id/848/rec/1

FEMA. (1998). *Property Acquisition Handbook for Local Communities*. FEMA. https://www.fema.gov/pdf/government/grant/resources/hbfullpak.pdf

FEMA. (2005). NFIP Floodplain Management Requirements: A Study Guide and Desk Reference for Local Officials. *FEMA 480*, 583.

FEMA. (2015). *Hazard Mitigation Assistance Guidance Addendum*. Federal Emergency Management Agency Department of Homeland Security. https://www.fema.gov/sites/default/files/2020-07/fy15_hma_addendum.pdf

FEMA. (2019). *Publication One*. https://www.fema.gov/sites/default/files/2020-03/publication-one_english_2019.pdf

FEMA. (2020). *Building Community Resilience with Nature-Based Solutions*. https://www.fema.gov/sites/default/files/2020-08/fema_riskmap_nature-based-solutions-guide_2020.pdf

firststreet.org. (n.d.). *Highlights From The First National Flood Risk Assessment*. FirstStreet. Retrieved March 8, 2022, from https://firststreet.org/research-lab/published-research/2020-national-flood-risk-assessment-highlights/

Fishing in Kaaterskill Creek. (n.d.). Fishbrain. Retrieved April 3, 2022, from https://fishbrain.com/fishing-waters/RuFLoA3W/kaaterskill-creek

Flood Insurance Study, Greene County, New York (Flood Insurance Study No. 36039CV001B). (2015). FEMA.

Floodplain Functions. (n.d.). Retrieved April 13, 2022, from https://waterresources.saccounty.net:443/stormready/Pages/Floodplain-Functions.aspx

Frank, T. (2021, February 26). States shun billions in federal aid as climate costs soar. *E&E News*. https://subscriber-politicopro-com.proxy-um.researchport.umd.edu/article/eenews/1063726077

Frei, A., & Kelly-Voicu, P. (2017). Hurricane Irene and Tropical Storm Lee: How Unusual Were They in the Catskill Mountains? *Journal of Extreme Events*, *04*(02), 1750009. https://doi.org/10.1142/S2345737617500099

Freudenberg, R., Calvin, E., Tolkoff, L., & Brawley, D. (2016). *Buy-in for buyouts: The case for managed retreat from flood zones*.

Friedland, C. J. (2019). *1960-2019 U.S. Hazard Losses*. SPATIAL HAZARDS EVENTS AND LOSSES DATABASE (SHELDUS), VERSION 19.0.

GAO. (2021). *FEMA Should Take Additional Steps to Streamline Hazard Mitigation Grants and Assess Program Effects* (Report to Congressional Committees GAO-21-140; Disaster Resilience, p. 58). United States Government Accountability Office. https://www.gao.gov/assets/gao-21-140.pdf

Geographic Information System (GIS) | The New York State Museum. (n.d.). [Map]. Retrieved January 27, 2022, from http://www.nysm.nysed.gov/research-collections/geology/gis

Geolex—Kalkberg. (n.d.). Retrieved March 18, 2022, from https://ngmdb.usgs.gov/Geolex/Units/Kalkberg_2272.html

Glover, T. D., Stewart, W. P., & Gladdys, K. (2008). Social Ethics of Landscape Change: Toward Community-Based Land-Use Planning. *Qualitative Inquiry*, *14*(3), 384–401. https://doi.org/10.1177/1077800407309409

Governor Hochul Announces $600 Million In Grants Available for Water Infrastructure and Resiliency Projects Statewide, Outlines New Resilient New York Agenda. (n.d.). Retrieved March 4, 2022, from https://www.governor.ny.gov/news/governor-hochul-announces-600-million-grants-available-water-infrastructure-and-resiliency

Green, J. (2022, March 2). *Latest IPCC Report: "Safeguarding and Strengthening Nature Is Key to Securing a Livable Future."* THE DIRT. https://dirt.asla.org/2022/03/02/latest-ipcc-report-safeguarding-and-strengthening-nature-is-key-to-securing-a-livable-future/

Greene County Comprehensive Economic Development Plan: A Roadmap for Our Future Chapter 10: Tourism Industry Analysis. (2007). Greene County Planning and Economic Development. https://www.greenegovernment.com/wp-content/uploads/2013/10/ChapterTen_TourismIndustryAnalysis.pdf

Greene County Planning Department. (2002). *Greene County Open Space and Recreation Plan*. https://greenegovernment.com/wp-content/uploads/2013/10/Open-Space-Plan-2.pdf

Greene County Soil & Water Conservation District. (n.d.-a). *Floodplain Management—Greene County Soil & Water Conservation District*. Retrieved March 6, 2022, from https://www.gcswcd.com/flooding/floodplain-mngmt

Greene County Soil & Water Conservation District. (n.d.-b). *Living and Building by Streams*. Retrieved March 15, 2022, from https://www.gcswcd.com/images/stories/flood/floodplainmanagementguide.pdf

Greer, A., Brokopp Binder, S., & Zavar, E. (2022). From Hazard Mitigation to Climate Adaptation: A Review of Home Buyout Program Literature. *Housing Policy Debate*, *32*(1), 152–170. https://doi.org/10.1080/10511482.2021.1931930

Gutiérrez, J. M., Jones, R. G., Narisma, G. T., Alves, L. M., Amjad, M., Gorodetskaya, I. V., Grose, M., Klutse, N. A. B., Krakovska, S., Li, J., Martínez-Castro, D., Mearns, L. O., Mernild, S. H., Ngo-Duc, T., van den Hurk, B., & Yoon, J.-H. (n.d.). *Regional Fact Sheet—North and Central America* (Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change 2021: Atlas Supplementary Material; Climate Change 2021: The Physical Science Basis.). https://www.ipcc.ch/

Howell, J., & Elliott, J. R. (2019). Damages Done: The Longitudinal Impacts of Natural Hazards on Wealth Inequality in the United States. *Social Problems*, *66*(3), 448–467. https://doi.org/10.1093/socpro/spy016

Huang, Y., Tian, Z., Ke, Q., Liu, J., Irannezhad, M., Fan, D., Hou, M., & Sun, L. (2020). Nature-based solutions for urban pluvial flood risk management. *WIREs Water*, *7*(3), e1421. https://doi.org/10.1002/wat2.1421

Hudson River Watershed – Hudson River Watershed Alliance. (n.d.). Hudson River Watershed Alliance. Retrieved May 18, 2021, from https://hudsonwatershed.org/hudson-watershed/

Hudsonia. (2019). *Natural Resources Inventory for Greene County, New York*. Greene Land Trust and the Cornell Cooperative Extension of Columbia and Greene Counties. https://www.greenelandtrust.org/images/Greene_Co_NRI_19Oct2019_for_online.pdf

Ii, S., & Lee, M. (2016). *The Influence of Place Attachment, Aspirations, and Rapidly Changing Environments on Resettlement Decisions*. https://doi.org/10.13016/M21R5F

In the Catskills, 1937—Greene County Libraries Association—New York Heritage Digital Collections. (n.d.). Retrieved April 6, 2022, from https://nyheritage.contentdm.oclc.org/digital/collection/gcla/id/9980/rec/99

Jha, A. K., Bloch, R., & Lamond, J. (2012). *Cities and flooding: A guide to integrated urban flood risk management for the 21st century*. World Bank.

Jimenez-Magdaleno, K. (2017). *FEMA-Funded Property Buyouts: The Impacts on Land and People*. https://ncgrowth.unc.edu/wp-content/uploads/2018/01/Buyouts_Impact_LIteratureReview_Final.pdf

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

Kaaterskill Creek. (n.d.). Outdoor Project. Retrieved April 19, 2022, from https://www.outdoorproject.com/united-states/new-york/kaaterskill-creek

Kaaterskill Creek and Niobe Falls, Palenville, Catskill Mountains, N.Y. - Greene County Libraries Association—New York Heritage Digital Collections. (n.d.). Retrieved April 6, 2022, from https://nyheritage.contentdm.oclc.org/digital/collection/gcla/id/738/rec/50

Kaaterskill Creek in the Catskill Mountains—Canal Society of New York State—New York Heritage Digital Collections. (n.d.). Retrieved April 6, 2022, from https://nyheritage.contentdm.oclc.org/digital/collection/p16694coll51/id/1089/rec/82

Kaaterskill Falls—One of New York's Most Popular Falls. (n.d.). Retrieved April 20, 2022, from https://www.world-of-waterfalls.com/waterfalls/eastern-us-kaaterskill-falls/

Kemble, W. J. (2013, March 7). Catskill seeks FEMA buyouts of flood-prone properties. *Daily Freeman*. https://www.dailyfreeman.com/news/catskill-seeks-fema-buyouts-of-flood-prone-properties/article_38189140-0d95-5347-992c-7243152eec6a.html

Ken ParkQ. (2018, February 2). *Kayaking the Kaaterskill Creek*. https://www.youtube.com/watch?v=io1NPfttcaU

Kindred Spirits: Asher B. Durand and the American Landscape. (1849). Smithsonian American Art Museum. https://americanart.si.edu/exhibitions/durand

Kousky, C., Olmstead, S. M., Walls, M. A., & Macauley, M. (2013). Strategically Placing Green Infrastructure: Cost-Effective Land Conservation in the Floodplain. *Environmental Science & Technology*, *47*(8), 3563–3570. https://doi.org/10.1021/es303938c

Krancer, B. (n.d.). *Untitled Landscape (Sunrise in the Clove) | Thomas Cole National Historic Site*. Retrieved April 13, 2022, from https://thomascole.org/untitled-landscape-sunrise-in-the-clove/

Kreibich, H., Bubeck, P., Van Vliet, M., & De Moel, H. (2015). A review of damage-reducing measures to manage fluvial flood risks in a changing climate. *Mitigation and Adaptation Strategies for Global Change*, *20*(6), 967–989. https://doi.org/10.1007/s11027-014-9629-5

Landscape Dynamics—CONUS - NLCD Land Cover Level 2, 2016 (version 2016)—Data.doi.gov. (n.d.). Retrieved March 27, 2022, from https://data.doi.gov/dataset/landscape-dynamics-conus-nlcd-land-cover-level-2-2016-version-2016

Layman, A. (n.d.). *Evaluation of Ellicot City Flood Risk Management Strategies*. Retrieved March 5, 2021, from https://f7ffdcab-43e5-473c-85ed-f1db9af7ab7a.filesusr.com/ugd/34b2b4_5a07637d56f44afabf3cdce386452063.pdf

Looking down the famous Kaaterskill Clove from La Belle Falls, Palenville, Catskill Mts., N.Y. - Greene County Libraries Association—New York Heritage Digital Collections. (n.d.). Retrieved April 6, 2022, from https://nyheritage.contentdm.oclc.org/digital/collection/gcla/id/794/rec/10

Loos, J., & Shader, E. (2016). *Reconnecting Rivers to Floodplains*. 34.

Massman, B., & Barengolts, A. (n.d.). *Magnotta Asbestos Report*. 16.

Mathur, A., & da Cunha, D. (2020). Wetness Is Everywhere. *Journal of Architectural Education*, *74*(1), 139–140. https://doi.org/10.1080/10464883.2020.1693843

McDonnell, S., Desai, S., Berkovits, D., Ghorbani, P., Cruz, M. J., & Breinin, A. (n.d.). A Managed- Participatory Approach to Community Resiliency. *Disaster Recovery*, 48.

Meerow, S., Newell, J. P., & Stults, M. (2016). Defining urban resilience: A review. *Landscape and Urban Planning*, *147*, 38–49. https://doi.org/10.1016/j.landurbplan.2015.11.011

Meeting Minutes of the County Resources Committee, Greene County Legislator (2014). https://greenecountyny.iqm2.com/Citizens/FileOpen.aspx?Type=12&ID=1054&Inline=True

Meeting Minutes of the Finance Committee, Greene County Legislature (2014). https://greenecountyny.iqm2.com/Citizens/FileOpen.aspx?Type=15&ID=1058&Inline=True

Melnick, R. Z., Kerr, N. P., Malinay, V., & Burry-Trice, O. (n.d.). *CLIMATE CHANGE AND CULTURAL LANDSCAPES:* 66.

MISSISSIPPI FLOODS. (n.d.). Mathur / Da Cunha. Retrieved March 8, 2022, from https://www.mathurdacunha.com/mississippi-floods

Mitchell, D. (2022, March 14). Rebuild or leave? In a flood-prone Tennessee town, one family must decide. *NPR*. https://www.npr.org/2022/03/14/1083643509/waverly-tennessee-flooding-climate-change-extreme-weather

Moftakhari, H. R., AghaKouchak, A., Sanders, B. F., Allaire, M., & Matthew, R. A. (2018). What Is Nuisance Flooding? Defining and Monitoring an Emerging Challenge. *Water Resources Research*, *54*(7), 4218–4227. https://doi.org/10.1029/2018WR022828

Mohd Ismail, I. (2017). *Place attachment to waterfront revitalisation development: Case study of Lumut and Kuching, Malaysia / Mohd Ismail Isa* [Phd, University of Malaya]. http://studentsrepo.um.edu.my/7507/

Montano, S. (2021). *Disasterology: Dispatches from the Frontlines of the Climate Crisis*. Park Row Books.

Montano, S., & Savitt, A. (2018, August 1). The Cost of Flood Insurance Is a Price Worth Paying. *Bloomberg.Com*. https://www.bloomberg.com/news/articles/2018-08-01/the-cost-of-flood-insurance-is-one-america-must-shoulder

National Earthquake Hazards Reduction Program. (n.d.). Retrieved April 20, 2022, from https://training.fema.gov/emiweb/earthquake/neh0101220.htm

National Mitigation Investment Strategy. (n.d.). 33.

National Oceanic and Atmospheric Administration. (n.d.). *Climatalogical Normals 1991-2020 Poughkeepsie, NY*. Retrieved April 13, 2022, from https://www.weather.gov/media/aly/Climate/POU/POU_Compare%201991-2020.pdf

Natural Resources Conservation Service, U. S. D. O. A. (2015). *Soil Survey Geographic Database (SSURGO)* [Data set]. Natural Resources Conservation Service, United States Department of Agriculture. https://doi.org/10.15482/USDA.ADC/1242479

Nelson, D. R. (2011). Adaptation and resilience: Responding to a changing climate. *WIREs Climate Change*, *2*(1), 113–120. https://doi.org/10.1002/wcc.91

Nevarez, L., & Simons, J. (2020). Small–City Dualism in the Metro Hinterland: The Racialized "Brooklynization" of New York's Hudson Valley. *City & Community*, *19*(1), 16–43. https://doi.org/10.1111/cico.12429

New York City Panel on Climate Change., Rosenzweig, Cynthia., Solecki, William., & New York Academy of Sciences. (2010). *Climate change adaptation in New York City: Building a risk management response: New York City Panel on Climate Change 2010 report* (Vol. 1–1 online resource (viii, 354 pages) : color illustrations, color maps). Published by Blackwell Pub. on behalf of the New York Academy of Sciences; WorldCat.org. http://books.google.com/books?id=5wNSAQAAIAAJ

New York geologic map data. (n.d.). Retrieved January 24, 2022, from https://mrdata.usgs.gov/geology/state/state.php?state=NY

New York State Department of Environmental Conservation. (2020). *Greater Catskill Region Comprehensive Recreation Plan*. Catskill Watershed Corporation. https://cwconline.org/wp-content/uploads/2020/12/Final-PDF.pdf

New York State Department of Environmental Conservation, Division of Water, Watershed GIT Support Group (Ed.). (2010). *Greene County 2010 LiDAR Data Collection, NY (NYSDEC)* [Tabular digital data]. NYSDEC. http://gis.ny.gov/elevation/metadata/2010-Greene-LiDAR.xml

New York whitewater Kaaterskill Creek. (n.d.). Retrieved April 3, 2022, from http://www.riverfacts.com/rivers/12131.html

NY Projected IDF Curves. (n.d.). Retrieved April 19, 2022, from http://ny-idf-projections.nrcc.cornell.edu/map_viewer.html

NY State Highway Bridge Data. (2022). 13.

O'Keefe, T., & Secter, J. (n.d.). *River Access Planning Guide: A Decision Making Framework for Enhancing River Access*. 66.

Old Woolen Mill Falls, Kaaterskill Clove—Greene County Libraries Association—New York Heritage Digital Collections. (n.d.). Retrieved April 6, 2022, from https://nyheritage.contentdm.oclc.org/digital/collection/gcla/id/720/rec/47

Opperman, J. J. (2014). *A Flood of Benefits – Using Green Infrastructure to Reduce Flood Risk*. The Nature Conservancy. https://www.conservationgateway.org/ConservationPractices/Freshwater/HabitatProtectionandRestoration/Pages/floodofbenefits.aspx

Opperman, J. J., Luster, R., McKenney, B. A., Roberts, M., & Meadows, A. W. (2010). Ecologically Functional Floodplains: Connectivity, Flow Regime, and Scale1. *JAWRA Journal of the American Water Resources Association*, *46*(2), 211–226. https://doi.org/10.1111/j.1752-1688.2010.00426.x

Palmadesso, A. R. (n.d.). *Mediating Boundaries of Abandonment Along the Hudson River*. 144.

Pörtner, H.-O., Roberts, D. C., Poloczanka, E. S., Mintenbeck, K., Tignor, M., Alegría, A., Craig, M., Langsdorf, S., Löschke, S., Moller, V., & Okem, A. (2022). *IPCC, 2022: Summary for Policymakers* (Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change; Climate Change 2022: Impacts, Adaptation, and Vulnerability). Cambridge University Press.

https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_SummaryForPolicymakers.pdf

Portner, H.-O., Roberts, D. C., Poloczanka, E. S., Mintenbeck, K., Tignor, M., Alegría, A., Craig, M., Langsdorf, S., Löschke, S., Moller, V., & Okem, A. (2022). *IPCC, 2022: Technical Summary* (Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change; Climate Change 2022: Impacts, Adaptation, and Vulnerability). Cambridge University Press. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_SummaryForPolicymakers.pdf

Portuondo, N. (2021, November 5). House approves bills to reform disaster relief, mitigation. *E&E News*. https://subscriber-politicopro-com.proxy-um.researchport.umd.edu/article/eenews/2021/11/05/house-approves-bills-to-reform-disaster-relief-mitigation-282805

Public Fishing Rights—NYS Dept. Of Environmental Conservation. (n.d.). Retrieved April 3, 2022, from https://www.dec.ny.gov/outdoor/9924.html

Public Notice of the Intent of FEMA to Fund a Project. (2013, February 1). Greene Government. https://www.greenegovernment.com/notices/public-notice-of-the-intent-of-fema-to-fund-a-project

Public Notice—Acquisition & Demolition of Substantially Damaged Properties—Town of Catskill. (2013, April 30). Greene Government. https://www.greenegovernment.com/notices/acquisition-demolition-of-substantially-damaged-properties-town-of-catskill

River Systems and Fluvial Landforms—Geology (U.S. National Park Service). (n.d.). Retrieved March 9, 2022, from https://www.nps.gov/subjects/geology/fluvial-landforms.htm

Rosenzweig, B. R., McPhillips, L., Chang, H., Cheng, C., Welty, C., Matsler, M., Iwaniec, D., & Davidson, C. I. (2018). Pluvial flood risk and opportunities for resilience. *WIREs Water*, *5*(6), e1302. https://doi.org/10.1002/wat2.1302

Rosenzweig, Cynthia., & New York State Energy Research and Development Authority. (2011). Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation in New York State. *Annals of the New York Academy of Sciences*, *1244*(1), 2–649. https://doi.org/10.1111/j.1749-6632.2011.06331.x

Rush, E. A. (2018). *Rising: Dispatches from the new American shore* (First edition). Milkweed Editions.

Scenic Hudson Preservation Conference, Town of Cortlandt, Town of Putnam Valley and Town of Yorktown, Petitioners, v. Federal Power Commission, Respondent, Andconsolidated Edison Company of New York, Inc., Intervener, 354 F.2d 608 (2d Cir. 1965). Retrieved May 18, 2021, from https://law.justia.com/cases/federal/appellate-courts/F2/354/608/151121/

Sciavillo, T. L. (2014). *Notice to Bidders*. https://www.greenegovernment.com/wp-content/uploads/2014/11/Demolition_Bid_-_Legal_Notice.pdf

Siders, A., Ajibade, I., & Casagrande, D. (2021). Transformative potential of managed retreat as climate adaptation. *Current Opinion in Environmental Sustainability*, *50*, 272–280. https://doi.org/10.1016/j.cosust.2021.06.007

Siders, A. R. (2019). Social justice implications of US managed retreat buyout programs. *Climatic Change*, *152*(2), 239–257. https://doi.org/10.1007/s10584-018-2272-5

Siders, A. R., Hino, M., & Mach, K. J. (2019). The case for strategic and managed climate retreat. *Science*, *365*(6455), 761–763. https://doi.org/10.1126/science.aax8346

Sign the Petition. (n.d.). Change.Org. Retrieved November 15, 2021, from https://www.change.org/p/palenville-residents-preserve-public-access-to-kaaterskill-creek

Smart Policies for a Changing Climate | asla.org. (n.d.). Retrieved March 22, 2022, from https://www.asla.org/climatepolicies.aspx

Smith, G. H., Cerra, J. F., & Zemaitis, L. (2019, May). People and place: Understanding social dimensions of resilience in the Climate-adaptive Design Studio. *Proceedings of the Environmental Design Research Association 50th Conference*. https://cuny.manifoldapp.org/read/people-and-place/section/826aabb6-95c0-4ac3-933e-aa5445667518

Smith, G., & Seeley, V. J. (n.d.). *Village of Catskill Comprehensive Plan Steering Committee (CPSC)*. 78.

Solecki, William., Frei, A., Sofranko, S., Gruber, S., Matonse, A., Patrick, L., Leichenko, R., & Brady, M. (2014). *Hydrology, Vulnerability, and Adaptation Implications of Hurricane Irene and Tropical Storm Lee: Case Study of the Mid-Hudson Valley and Greater Catskills Regions*.

Song, J., Fu, X., Wang, R., Peng, Z.-R., & Gu, Z. (2018). Does planned retreat matter? Investigating land use change under the impacts of flooding induced by sea level rise. *Mitigation and Adaptation Strategies for Global Change*, *23*(5), 703–733. https://doi.org/10.1007/s11027-017-9756-x

Spidalieri, K., & Bennett, A. (n.d.). *Managed Retreat Toolkit » Introduction—Georgetown Climate Center*. Georgetownclimatecenter.Org. Retrieved April 20, 2021, from https://www.georgetownclimate.org/adaptation/toolkits/managed-retreat-toolkit/introduction.html?full

Stafford Act, as Amended—FEMA P-592 vol. 1 May 2021. (n.d.). 103.

Staples, C., Zemaitis, L., Rahm, B. G., & LoGiudice, E. (n.d.). Climate justice and flood governance: Are New York's flood-governance networks equipped to succeed? *Cornell University College of Agriculture and Life Sciences: Research & Policy Brief Series*, 2.

Summary for Policymakers—IPCC. (n.d.). Retrieved April 20, 2022, from https://www.ipcc.ch/report/ar5/wg2/summary-for-policymakers/

The Dell at the University of Virginia | Artful Rainwater Design. (n.d.). Retrieved April 20, 2022, from http://artfulrainwaterdesign.psu.edu/project/dell-university-virginia

The (Other) Catskills. (n.d.). Paflyfish. Retrieved April 3, 2022, from https://www.paflyfish.com/threads/the-other-catskills.45842/

The Waterfront Alliance. (2018). *Waterfront Edge Design Guidelines*. http://wedg.waterfrontalliance.org/wp-content/uploads/delightful-

downloads/2021/02/WEDG-Manual-Categories_extended_Hi_Res_w-Appendices_190916.pdf
Tidball, K. (2012). Urgent Biophilia: Human-Nature Interactions and Biological Attractions in Disaster Resilience. *Ecology and Society*, *17*(2). https://doi.org/10.5751/ES-04596-170205
Titus, R. (2019, February 14). The Hoogeberg Range Feb. 14, 2019. *The Catskill Geologist*. https://thecatskillgeologist.com/2019/02/14/the-hoogeberg-range-feb-14-2019/
Tourism Trails Plan. (n.d.). Retrieved January 30, 2022, from https://www.greenegovernment.com/wp-content/uploads/2019/06/FINAL_GreeneCountyTourismTrailsPlan_063014.pdf
Town of Catskill, NY: Flood Damage Prevention. (2021, December 29). Town of Catskill, NY Code. https://ecode360.com/6949054
Trout Stream Fishing Map User Guide—NYS Dept. Of Environmental Conservation. (n.d.). Retrieved April 3, 2022, from https://www.dec.ny.gov/outdoor/122444.html
U.S. Census Bureau QuickFacts: Catskill town, Greene County, New York. (n.d.). Retrieved April 19, 2022, from https://www.census.gov/quickfacts/fact/table/catskilltowngreenecountynewyork/PST045221
USGCRP. (2018). *Fourth National Climate Assessment* (pp. 1–470). U.S. Global Change Research Program, Washington, DC. https://nca2018.globalchange.govhttps://nca2018.globalchange.gov/chapter/5
Venkataramanan, V., Lopez, D., McCuskey, D. J., Kiefus, D., McDonald, R. I., Miller, W. M., Packman, A. I., & Young, S. L. (2020). Knowledge, attitudes, intentions, and behavior related to green infrastructure for flood management: A systematic literature review. *Science of The Total Environment*, *720*, 137606. https://doi.org/10.1016/j.scitotenv.2020.137606
Ver Straeten, C. A. (2013). Beneath it all: Bedrock geology of the Catskill Mountains and implications of its weathering. *Annals of the New York Academy of Sciences*, *1298*(1), 1–29. https://doi.org/10.1111/nyas.12221
Vian, M. (2019). *Introduction to Stream Processes*. 12.
Village of Catskill. (2014). *Resilient Catskill: Report of the Catskill Waterfront Resilience Task Force*.
Walker, B., & Salt, D. (2006). *Resilience Thinking: Sustaining Ecosystems and People in a Changing World*. Island Press. http://search.ebscohost.com/login.aspx?direct=true&db=nlebk&AN=203979&site=ehost-live
Walker, E. J. (2014). *Exploring Socio-Cultural Dimensions of Sustainability. How Cultural and Social Factors Inform a Sustainable Redesign of Whitmore Park (Annapolis, MD).* [Thesis]. https://drum.lib.umd.edu/handle/1903/15504
Waterman, T. (2016). THERE'S ROOM Dutch officials have been undertaking a national project to reshape their rivers for a forecast of higher water in a low country. *Landscape Architecture*, *106*(6), 118–135. WorldCat.org.

Watershed Post. (2011). *Irene Flood waters Wilma Beers* [Photo]. https://www.flickr.com/photos/watershedpost/28810261153/
Watson, D., & Adams, M. (2011). *Design for flooding: Architecture, landscape, and urban design for resilience to flooding and climate change*. John Wiley & Sons.
Weiss, G. (2017). Climate Change in the Hudson River Estuary: Promoting Adaptation and Resilience through Stakeholder Engagement in Design and Visualization. *Bard Center for Environmental Policy*. https://digitalcommons.bard.edu/bcep/4
What Should I Consider if I Choose to Develop in a Floodplain | FEMA.gov. (n.d.). Retrieved April 9, 2022, from https://www.fema.gov/floodplain-management/wildlife-conservation/consider-develop
Wilson, B. B. (Barbara B. (2018). *Resilience for all: Striving for equity through community-driven design*. Island Press; WorldCat.org.
Wobus, C., Porter, J., Lorie, M., Martinich, J., & Bash, R. (2021). Climate change, riverine flood risk and adaptation for the conterminous United States. *Environmental Research Letters*, *16*(9), 094034. https://doi.org/10.1088/1748-9326/ac1bd7
Woodruff, S., BenDor, T. K., & Strong, A. L. (2018). Fighting the inevitable: Infrastructure investment and coastal community adaptation to sea level rise. *System Dynamics Review*, *34*(1–2), 48–77. https://doi.org/10.1002/sdr.1597
WSP USA. (2021). *Flood Resilience Handbook for Public Access Sites Along the Hudson River from Troy to Yonkers*. New York State Department of Environmental Conservation and NEIWPCC.
Yarina, L., Mazereeuw, M., & Ovalles, L. (2019). A retreat critique: Deliberations on design and ethics in the flood zone. *Journal of Landscape Architecture*, *14*(3), 8–23. https://doi.org/10.1080/18626033.2019.1705570
Zangla, A. (2012, August 13). 40 owners of Irene-damaged properties in Greene County apply for FEMA buyouts. *Daily Freeman*. https://www.dailyfreeman.com/news/40-owners-of-irene-damaged-properties-in-greene-county-apply-for-fema-buyouts-video/article_2badb4c7-0f10-5440-9688-27edd2407c31.html
Zavar, E. (2015). Residential Perspectives: The Value of Floodplain- Buyout Open Space *. *Geographical Review*, *105*(1), 78–95.
Zavar, E., & Hagelman, R. R. (2016). Land use change on U.S. floodplain buyout sites, 1990-2000. *Disaster Prevention and Management*, *25*(3), 360–374. http://dx.doi.org/10.1108/DPM-01-2016-0021
Zavar, E., Lavy, B. L., & Hagelman, R. R. (2020). Chain tourism in post-disaster recovery. *Tourist Studies*, *20*(4), 429–449. https://doi.org/10.1177/1468797620939413
Zavar, E. M., & Schumann, R. L. (2019). Patterns of Disaster Commemoration in Long-Term Recovery *. *Geographical Review*, *109*(2), 157–179. http://dx.doi.org/10.1111/gere.12316
Zavar, E. M., & Schumann, R. L. (2020). Post-disaster communalism: Land use, ownership, and the shifting 'publicness' of urban space in recovery.

Environmental Hazards, *19*(4), 398–416. https://doi.org/10.1080/17477891.2019.1690969
Zemaitis, L. (n.d.). *Climate Change in the Hudson Valley: A summary for the public*. Retrieved March 23, 2021, from https://www.dec.ny.gov/docs/remediation_hudson_pdf/ccinthehvms.pdf
Zemaitis, L., Tabak, N., Marcell, K., Brooks, B., & Noble, J. (2020). Working Together to Build Climate Resilience in Hudson Riverfront Communities. In W. Leal Filho (Ed.), *Handbook of Climate Change Resilience* (pp. 1443–1461). Springer International Publishing. https://doi.org/10.1007/978-3-319-93336-8_41