North Carolina Museum of Art

MUSEUM PARK VISION PLAN

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Prepared by Andropogon Associates, Ltd.
with contributions from Biohabitats, Inc., and WK Dickson
December 2021

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1 INTRODUCTION

LETTER FROM THE DIRECTOR OF THE NORTH CAROLINA MUSEUM OF ART

In 2019 the North Carolina Museum of Art staff collaboratively developed a five-year strategic plan for 2020–25 that prioritized becoming a national leader in creating a welcoming experience of belonging and joy. It was clear to all that the Museum Park, the most visited and universally beloved part of our campus, would play a significant role in achieving the plan's goals.

We recognized that the land, in both the literal and figurative senses of that word, reflected the long and varied history of the place where the Museum is situated. We identified opportunities for healing and inspiring by acknowledging the sometimes painful and often harmful practices of the past while developing a vision for the future that invites multiple perspectives and embraces the positive potential of change.

The revitalization of the stream system served as a point of departure as we sought to determine how we might enhance visitor experience while restoring and protecting this most inviting natural resource and corresponding habitats and wildlife. We engaged Andropogon, Biohabitats, and WK Dickson to help us study how we might achieve these goals while building climate resiliency into the project to fulfill our commitment to steward our Park by reinforcing its ability to withstand the impact of significant weather events.

While developing a stream restoration plan, we also contemplated Park-wide landscape interventions that reflect our intention to become an ever more welcoming and accessible museum. We focused our study on increasing trail accessibility and connectivity among the Park, the Museum buildings, the Capital Area Greenway, and the Triangle Bikeway; upgrading stormwater management to be more aesthetically pleasing and efficient; creating new opportunities for engagement in educational programming; and identifying locations where artists could realize innovative projects and works that respond to the landscape, environment, and site history.

This vision plan reflects the NCMA's belief in the importance of forging connections among art, nature, and people as we strive to fulfill our mission to inspire creativity by connecting our diverse communities to cultural and natural resources.

Valerie Hillings, Director and CEO

North Carolina Museum of Art

Photo: NCMA

ACKNOWLEDGMENTS

The North Carolina Museum of Art, Dr. Valerie Hillings, Director, is an agency of the North Carolina Department of Natural and Cultural Resources, Reid Wilson, Secretary, and Staci Meyer, Chief Deputy Secretary.

This plan and publication are made possible by a grant from the North Carolina Land and Water Fund (formerly known as Clean Water Management Trust Fund); an in-kind donation from Stewart Engineering, Willy Stewart, chief executive officer; and by the gracious support of the North Carolina Museum of Art Board of Trustees, Joyce Fitzpatrick, chair; the Buildings and Grounds Committee, Gene Davis, chair; NC State Construction Office, and the Vision Plan Advisory Committee.

The North Carolina Museum of Art expresses its gratitude to its partner, the City of Raleigh Park, Recreation, and Cultural Resources, for its past and current commitments to Greenway realignment and stormwater management.

Contributors: Dan Gottlieb, Rachel Woods, Linda Dougherty, Lydia Cleveland, Valerie Hillings, Katherine White, Felicia Ingram, Luke Mehaffie, and Brye Senor.

NCMA Photography: Karen Malinofski, Christopher Ciccone

NC DEPARTMENT OF NATURAL AND CULTURAL RESOURCES

NORTH CAROLINA LAND & WATER FUND

CITY OF Raleigh

STEWART

LETTER FROM JOSÉ ALMIÑANA PRINCIPAL, ANDROPOGON ASSOCIATES

We are so excited to share with you the culmination of our efforts over the past year to create a plan for healing the riparian and upland landscapes in the North Carolina Museum of Art's Park Preserve. Through this Vision Plan, Andropogon has partnered with Biohabitats and WK Dickson to develop strategies that will improve habitat, resiliency, and aesthetics within the most ecologically rich section of this beloved property.

The natural forested condition that once covered the Park Preserve property was converted to a cultivated landscape comprising agricultural fields and pastures that supported uses such as a military training camp and a prison farm. This "production landscape" lasted for over 160 years. When combined with the more recent urbanization of the larger watershed that drains through the Museum property, it has altered the relationship of water, soil, and plants at the expense of aquatic and terrestrial habitats and the experience of the people who visit the Museum Park.

The Museum Park Vision Plan will reconnect waterways with their natural floodplains, create biodiverse successional zones between riparian woodlands and grasslands, and employ soil-building strategies within the upland meadows by introducing warm-season grasses, targeted cover crops, and a regenerative maintenance regimen. The plan will enhance visitors' experience and create social spaces where people can be deeply immersed in nature.

This restoration process will be a multiyear endeavor to manage ecological succession and achieve long-term success. The design of a process in which phasing maximizes the return on the Museum's investments and highlights the steps toward the regenerative transformation of this landscape will enrich the visitor experience and enhance educational opportunities.

Our team has developed a plan that supports the Museum's role as a leader in regenerative design in the Southeast by improving water quality, embedding resiliency, and augmenting carbon sequestration and storage opportunities within the Park Preserve. We hope that this plan will also have impacts far beyond the Museum's boundaries, inspiring visitors and other institutions to become active stewards of the ecological systems on their own properties.

We envision this plan as a critical chapter in the long history of this land. We have strived to set a trajectory that will contribute to the Park Preserve's legacy as a laboratory for exploring the relationships among humans, art, and the natural world.

José Almiñana, PLA, FASLA, SITES AP, LEED AP

Principal, Andropogon Associates

Photo: Andropogon

Existing greenway bridge at confluence of House Creek and unnamed tributary; Photo: Luke Mehaffie

EXECUTIVE SUMMARY

MUSEUM PARK VISION

The Museum Park Vision Plan will create a set of strategies to heal the site's degraded natural systems, unify the Park's zones, and connect visitors' experiences with the site's unique natural and cultural ecologies.

MUSEUM PARK GOALS

1. Create a plan to restore and protect the NCMA's stream system and natural areas.
2. Improve the Park's circulation and visitors' experience with art, nature, and people, broadening the NCMA's appeal to more diverse audiences.
3. Build climate resiliency, environmental awareness, and opportunities for future artists' projects that work with both upstream and downstream conditions.

CLIMATE IMPACTS

The Vision Plan's proposed improvements to the Park preserve will help the Museum reduce its carbon footprint over time and position the NCMA as a model and resource for other institutions and landowners seeking to improve climate resiliency on their own property. To ensure long-term success, the Steering Committee and Design Team developed the following goals, which will help guide the decision-making process in future design phases:

- Increase carbon storage capacity in soils and vegetation.
- Increase biodiversity to provide habitat for species threatened by climate change.
- Reduce the amount of carbon used in management and maintenance activities.
- Support regional efforts to reduce carbon emissions and fight climate change.
- Reduce negative impacts of large storm events.

VISITOR IMPACTS

Connecting people with art and nature is a foundational principal of the Museum Park. The Vision Plan seeks to build upon the Park's legacy as a welcoming, green respite within Raleigh's urban core by providing visitors with an immersive experience in nature. By revealing the relationships among flora, fauna, water, soil, climate, and people on the site, the NCMA will help visitors experience the beauty and importance of this rich ecosystem.

The proposed changes in circulation will allow visitors of all degrees of mobility to fully enjoy the Park, providing a level of access to nature and art that is rare in both the urban and museum environment. Cyclists and walkers entering the Park from the greenway will be better connected to the core of the NCMA property and its main buildings. Visitors from the buildings will be able to experience nature in the Park more easily, whether by enjoying an immersive experience at a stone step crossing of a small stream or taking in the rich, diverse landscape at the confluence of the unnamed tributary and House Creek from a boardwalk above.

KEY RECOMMENDATIONS

- Heal the riparian corridors by restoring the streams' abilities to access their floodplains and implementing green infrastructure in upland areas.
- Adjust circulation to improve access for all and help visitors experience nature in a meaningful way.
- Transition monoculture plant communities to more biodiverse, beautiful, and resilient landscapes.
- Create a gateway feature in the Lower Meadow to better connect the greenway with the main buildings.
- Allow climate resiliency goals to impact management, programming, and educational activities.
- Coordinate education and research opportunities with academic institutions, nonprofits, and other governmental partners.
- Communicate the restoration story with the public, both within the Museum property and beyond.

Proposed Vision Plan for the Museum Park

THE PLANNING PROCESS

The development of a vision plan is a dynamic, inclusive process in which an organization's stakeholders collaboratively envision a site's future physical development. Decisions during the planning process respond to the organization's mission and vision, stakeholder needs, and the site's opportunities and constraints. The result is a visionary document that uses graphics and narrative to guide a process of transformation for the benefit of current and future generations.

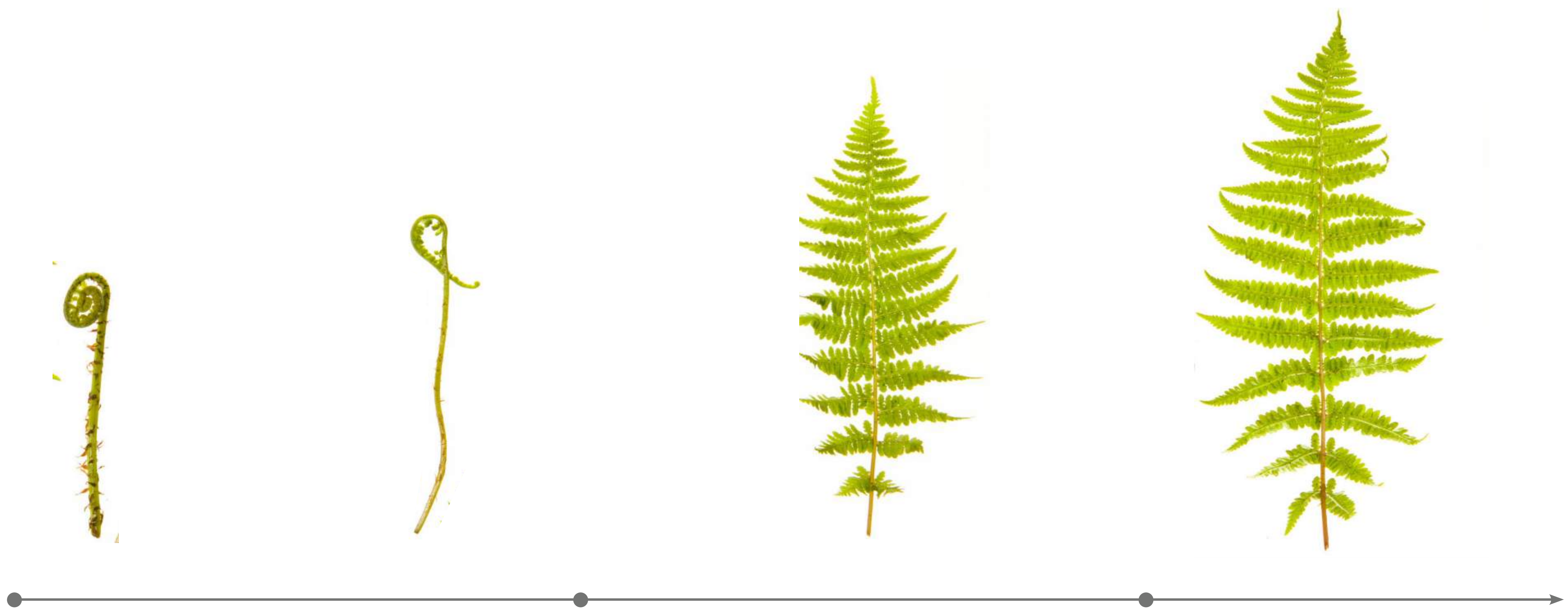
The Museum Park Vision Plan was developed through a three-step process:

1. Cultivating understanding of the site's history, past interventions and campus-wide plans, current site conditions, and stakeholder priorities;

2. Developing a vision for the site's organization, physical improvements, restoration and land management, education and research opportunities; and

3. Outlining a phased implementation strategy with a cost estimate for the stream restoration activities, a summary of establishment trajectories, and a detailed management and maintenance plan.

The resulting document will help the NCMA to implement its vision for the Park.



CULTIVATING UNDERSTANDING

site context and history

previous planning efforts

current site conditions

regulatory considerations

opportunities + constraints

preliminary recommendations

THE VISION

art + education opportunities

site’s organization

upland + stream restoration

plant communities

circulation

carbon sequestration opportunities

PHASED IMPLEMENTATION

proposed sequencing

establishment trajectories

management inputs + biodiversity

cost estimate

management + maintenance plan

PROJECT TEAM

NCMA EXECUTIVE COMMITTEE

Valerie Hillings, PhD, NCMA Director

Katherine White, NCMA Deputy Director

Dan Gottlieb, NCMA retired Director of Planning and Special Projects

Rachel Woods, NCMA Director of Museum Park Operations

Lydia Cleveland, NCMA Museum Project Manager

Tony Romaine, NC Department of Natural and Cultural Resources

Lewis Nigel Clarke, NC Department of Natural and Cultural Resources

MUSEUM PARK VISION PLAN STEERING COMMITTEE

Kimberly Daniels Taws, NCMA Grounds Committee and NCMA Board of Trustees

Willy Stewart, NCMA Board of Directors

Heather Dutra, City of Raleigh Engineering Services

Gene Bressler, Former Department Chair, NC State University Department of Landscape Architecture

CONSULTANT TEAM

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Landscape Architecture and Ecological Planning

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Martha Eberle, PLA, ASLA – Associate, Landscape Architect, and Project Manager

Dorothy Jacobs – Landscape Designer

Rachel Stevens, PLA – Landscape Architect

Le Xu – Landscape Designer

Emily Rothrock, PLA, ASLA – Landscape Architect

Eric Thomas, ASLA – Landscape Planner and GIS Technician

Loretta Desvernine – Graphic Designer

Biohabitats, Inc.
Site Ecological Transformation Strategies

Kevin Nunnery, PhD, LSS, LEED AP – Senior Ecologist

Jim Cooper, PLA, ASLA, PWS – Senior Landscape Architect

WK Dickson Engineering

Tom Murray, PE – Stormwater Program Manager

Steering Committee and Design Team representatives on site; Photo: Andropogon

2 CULTIVATING UNDERSTANDING

UNDERSTANDING THE SITE'S CONTEXT

Aerial view looking north across the Museum Park, July 2021; Photo: Luke Mehaffie

ECOREGION

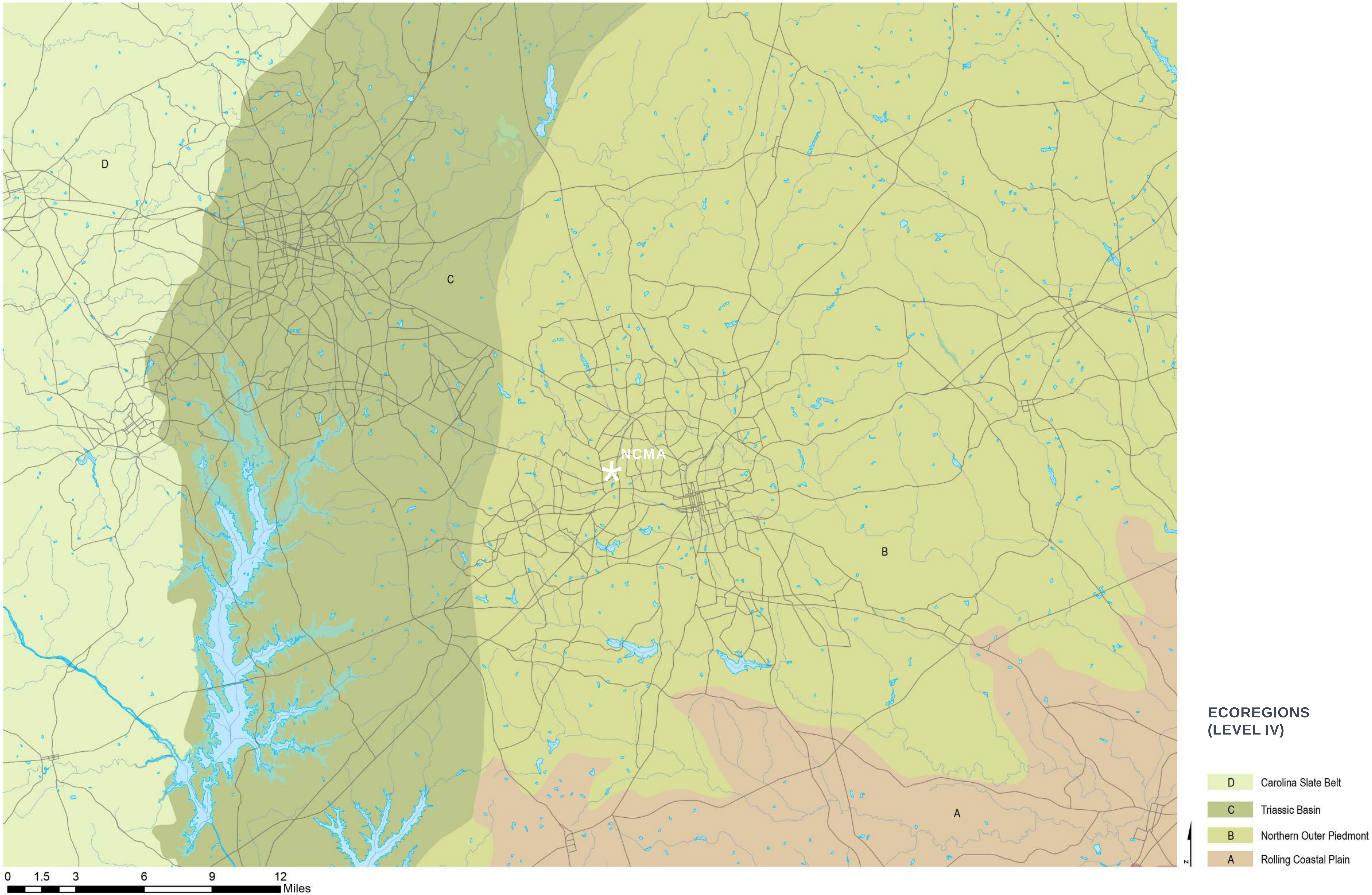
The NCMA is situated within the Northern Outer Piedmont ecoregion, which stretches from Virginia to North Carolina and is characterized by low hills, rounded ridges, and shallow ravines. Soils in this zone are acidic, rich in clay, and low in calcium.

Although the presettlement forest cover species are not well documented, dominant trees were likely to have been oak, hickory, and pine. Specific species include white oak, southern red oak, black oak, mockernut and pignut hickories, shortleaf pine, loblolly pine, and longleaf pine. Loblolly pine is now the most common pine species in the region. Although tree cover is somewhat extensive throughout the ecoregion, much of the canopy is pine plantation, and healthy, diverse forests are quite rare. This condition is expected to worsen over time, as suburban-style development continues to expand throughout urban areas within the ecoregion, including Raleigh, Richmond, Fredericksburg, and Petersburg.

The Outer Piedmont meets the Rolling Coastal Plain ecoregion just east of Raleigh. This transition is quite dramatic, and it is marked by a fall line where hard, erosion-resistant rocks transition to softer rocks. Rapids typically occur in waterways here.[1]

This Vision Plan will draw primarily from natural communities within the Northern Outer Piedmont ecoregion, but it will also draw from species native to other ecoregions where appropriate in order to respond to the needs of the site and shifting conditions associated with climate change.

1. Woods, et al. (1999)


D
C
B
A
NCMA
0 1.5 3 6 9 12
Miles
ECOREGIONS
(LEVEL IV)
D Carolina Slate Belt
C Triassic Basin
B Northern Outer Piedmont
A Rolling Coastal Plain

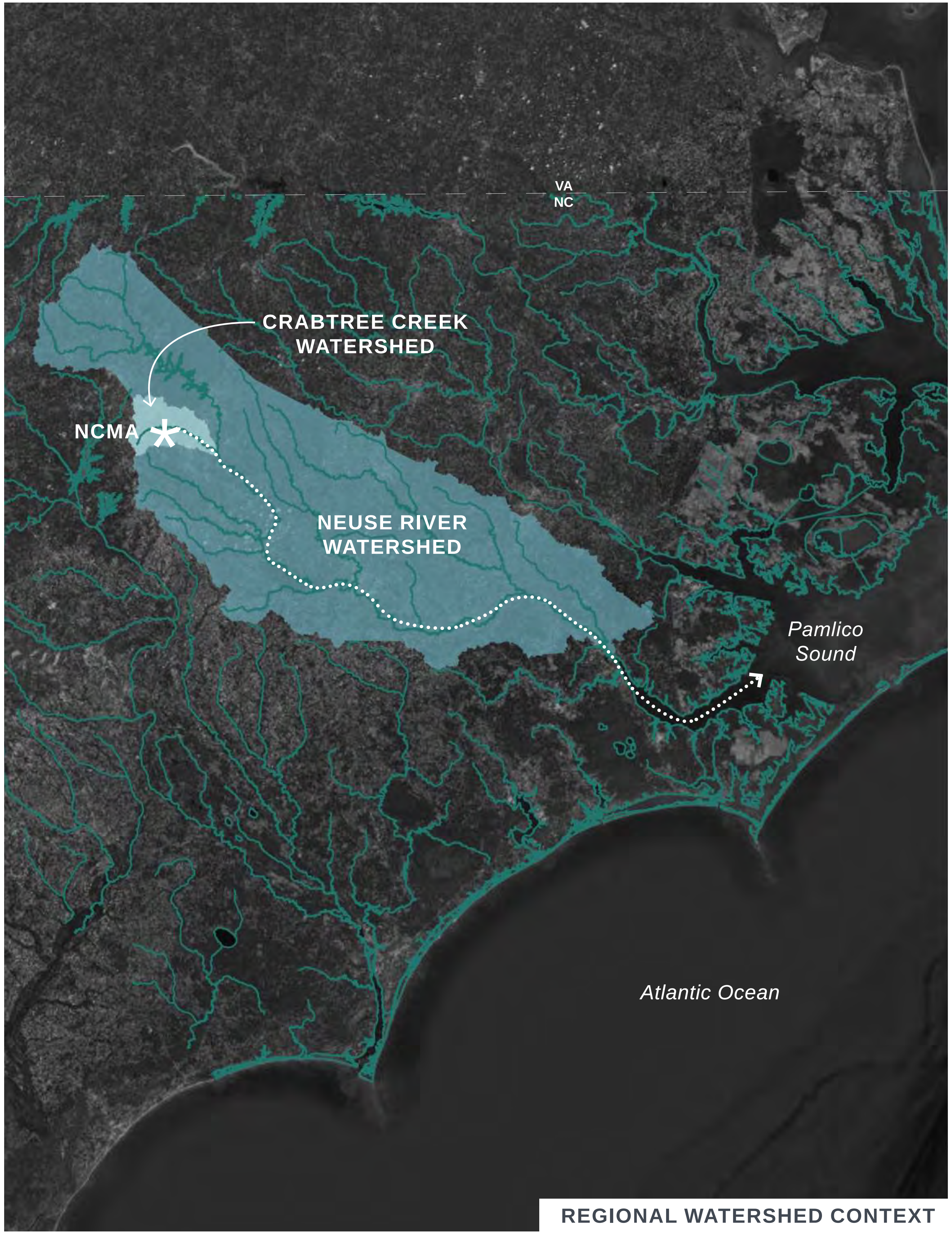
WATERSHED CONTEXT

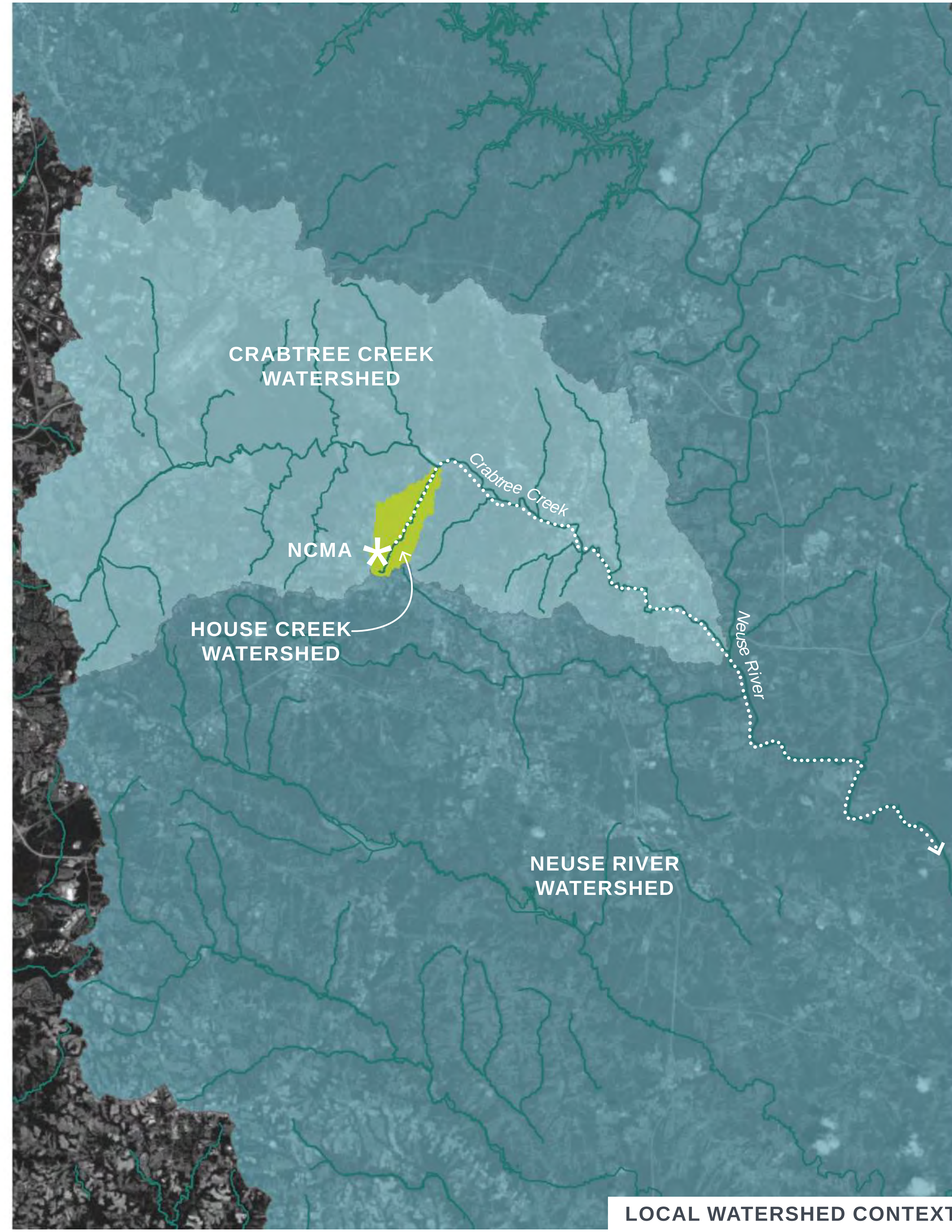
In order to create a vision plan that responds to the pressures of climate change and positions the NCMA as a good upstream and downstream neighbor, it is essential to understand the site's role within its regional and local watersheds. The Museum Park can serve as a model for other landowners and educate visitors about the need for a collective effort to improve water quality throughout the region.

The Neuse River watershed drains 6,200 square miles of the Piedmont and Coastal Plain into the Pamlico Sound and Atlantic Ocean. This watershed is home to over 2.5 million people, and it provides drinking water for many communities in Eastern North Carolina. The Neuse River was listed as one of America's most endangered rivers in 2007, and its water quality is highly impaired due to excessive nitrogen and phosphorous pollution from agricultural wastewater and polluted stormwater runoff from urban and rural areas. Major flooding has become a regular occurrence within the watershed as the frequency of climate change–related extreme storm events increases. [2]

The NCMA property is situated roughly in the center of the Crabtree Creek watershed, which begins in Cary and meets the Neuse River on the east side of Raleigh. The rapid urbanization of Wake County has caused major issues with erosion and flooding within this watershed, threatening infrastructure and buildings near Crabtree Creek, and degrading the natural environment within the riparian corridor.

2. American Rivers (2021)


VA
NC
CRABTREE CREEK WATERSHED
NCMA
NEUSE RIVER WATERSHED
Pamlico Sound
Atlantic Ocean
REGIONAL WATERSHED CONTEXT


CRABTREE CREEK WATERSHED
Crabtree Creek
NCMA
HOUSE CREEK WATERSHED
Neuse River
NEUSE RIVER WATERSHED
LOCAL WATERSHED CONTEXT

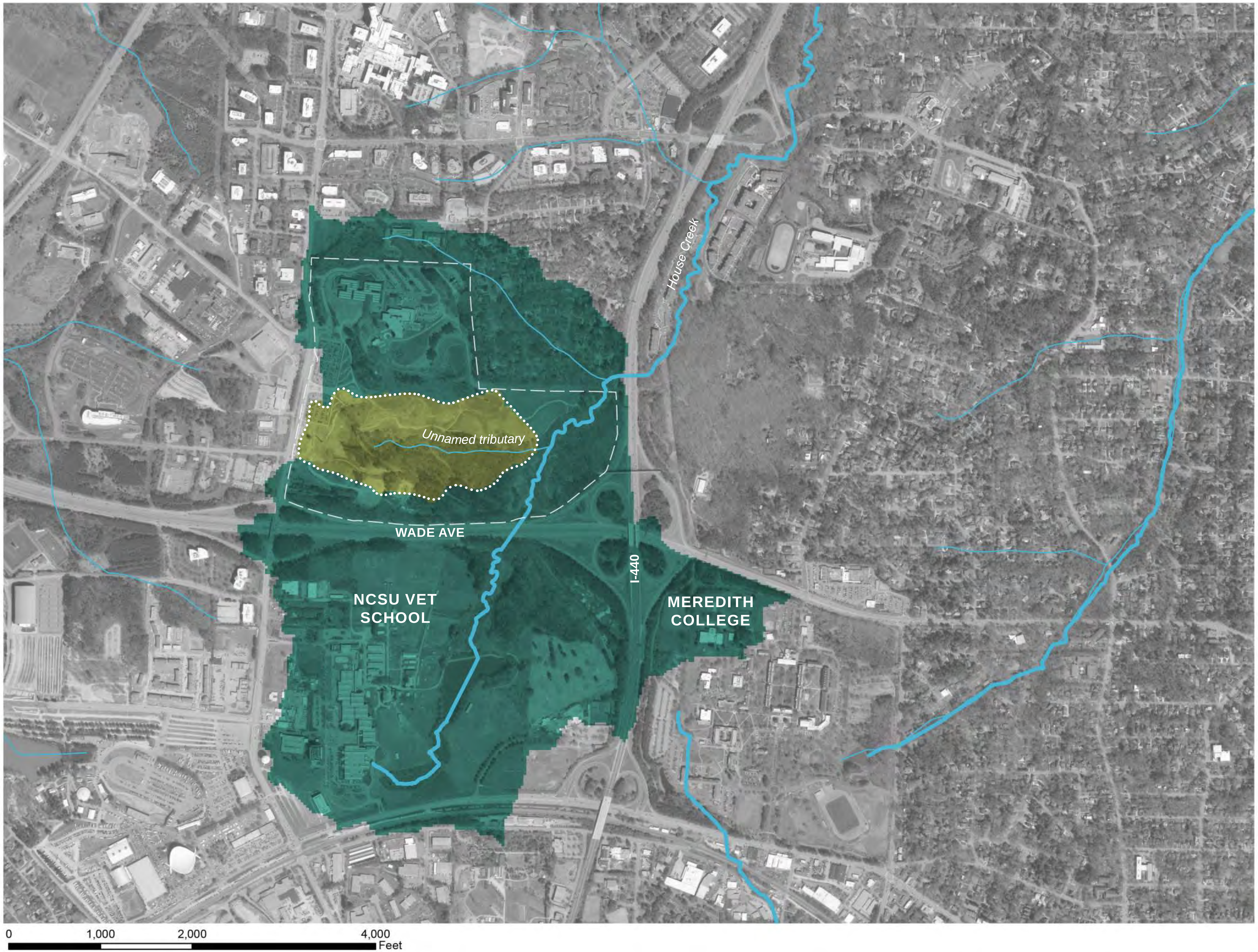
HYDROLOGICAL CONTEXT

House Creek, the primary waterway in the Park preserve, flows north through the NCMA property and meets Crabtree Creek about two miles northeast of the site at Crabtree Valley Mall. The area surrounding the mall floods extensively during major storm events, causing loss of life, property damage, and environmental degradation. House Creek forms just south of the Park preserve on the campus of the NC State University Veterinary School and enters the site via a culvert running underneath Wade Avenue.

Although the NCMA controls a significant portion of the upper House Creek watershed, it is also dependent on its neighbors (NC State University and the NC DOT) to undertake additional efforts to capture and filter runoff before it enters House Creek if the quality of water entering the Park preserve is to be improved.

The NCMA does have full control over the entire watershed of the unnamed tributary, which collects drainage from the southwestern end of the NCMA property and flows east, where it meets House Creek within the central core of the Park preserve.

Efforts to improve water quality in the streams within the Park preserve will be most dramatic and impactful within the unnamed tributary watershed, as the NCMA has control over stormwater treatment, land cover type, and the construction of the stream channel itself. The NCMA will be able to measure the success of its efforts and report on its progress.



UPSTREAM HYDROLOGICAL CONNECTIVITY

- Upper Tributary Drainage Area
- House Creek - Drainage to NCMA Property

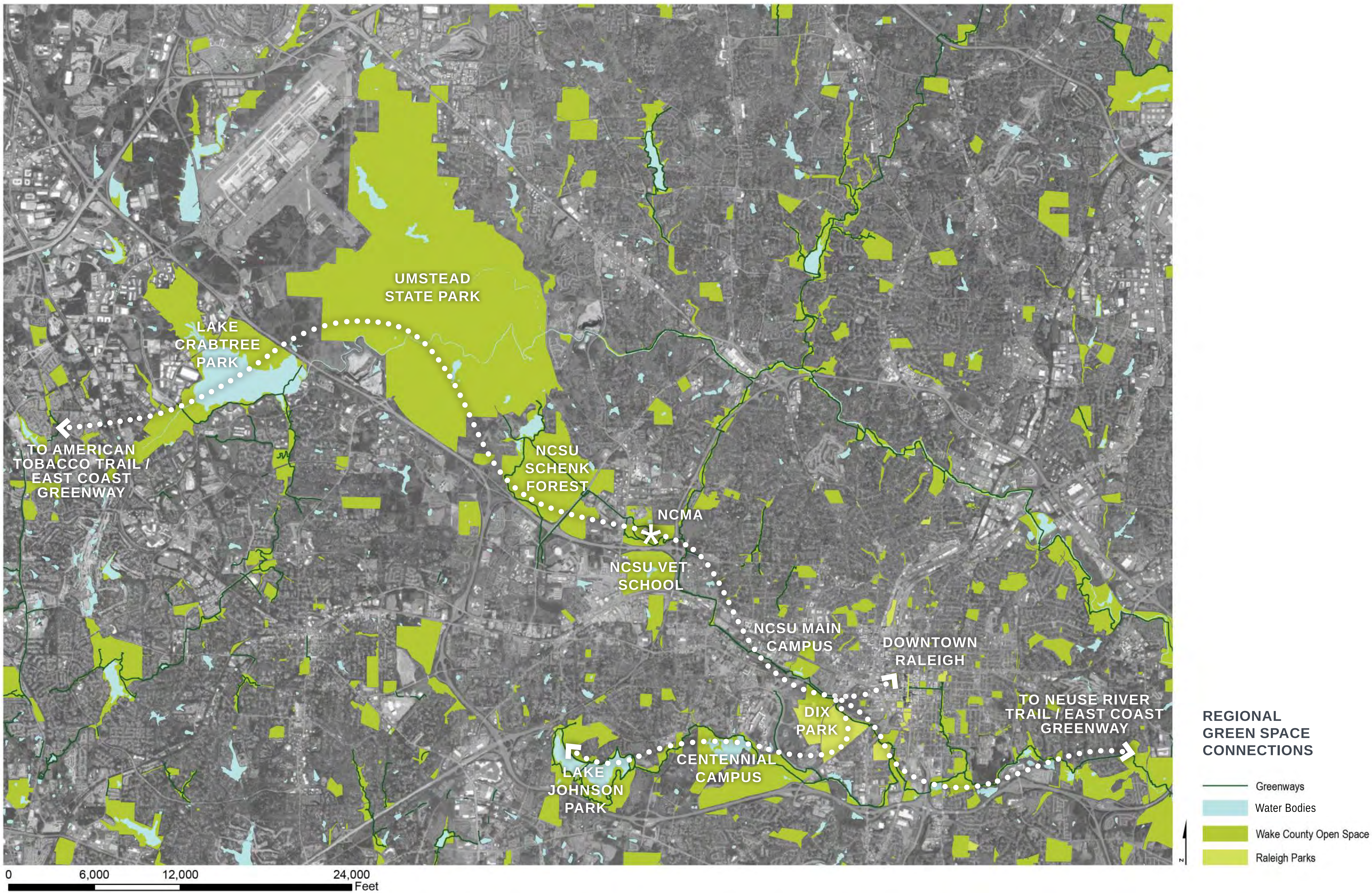
REGIONAL GREEN SPACE CONNECTIONS

The NCMA's location on the west side of Raleigh's urban core positions it within a major network of connected public green spaces, including City of Raleigh parks, Wake County parks, natural areas within the NC State University campus, and a 5,600-acre North Carolina state park.

If linked by adequately sized wildlife corridors, this critical mass of green space provides much-needed habitat for native flora and fauna at a scale rarely seen in the urbanized areas of the North Carolina Triangle.

The connectivity between these green spaces that the Capital Area Greenway network provides for cyclists and pedestrians is an incredible asset for the Museum. Traveling along the East Coast Greenway, trail users can arrive to the Park from as far away as the Neuse River in East Raleigh or the American Tobacco Trail in Durham without ever having to leave a greenway trail. Easy connections to downtown Raleigh and NC State University's campus allow students, workers, and residents to make the NCMA a part of their regular commute or recreational ride. The Museum's proximity to Schenk Forest and Umstead State Park attracts users seeking to be immersed in nature and experience the natural communities of the North Carolina Piedmont.

Raleigh's greenway trails have seen a huge increase in use over the past decade, as the city's population has grown and the need for publicly accessible green space has become more pressing. The Vision Plan will define strategies to draw people from this heavily used trail into the core of the Museum property.



UMSTEAD STATE PARK
LAKE CRABTREE PARK
TO AMERICAN TOBACCO TRAIL / EAST COAST GREENWAY
NCSU SCHENK FOREST
NCMA
NCSU VET SCHOOL
NCSU MAIN CAMPUS
DOWNTOWN RALEIGH
DIX PARK
TO NEUSE RIVER TRAIL / EAST COAST GREENWAY
LAKE JOHNSON PARK
CENTENNIAL CAMPUS
0
6,000
12,000
24,000
Feet
N
REGIONAL GREEN SPACE CONNECTIONS
Greenways
Water Bodies
Wake County Open Space
Raleigh Parks

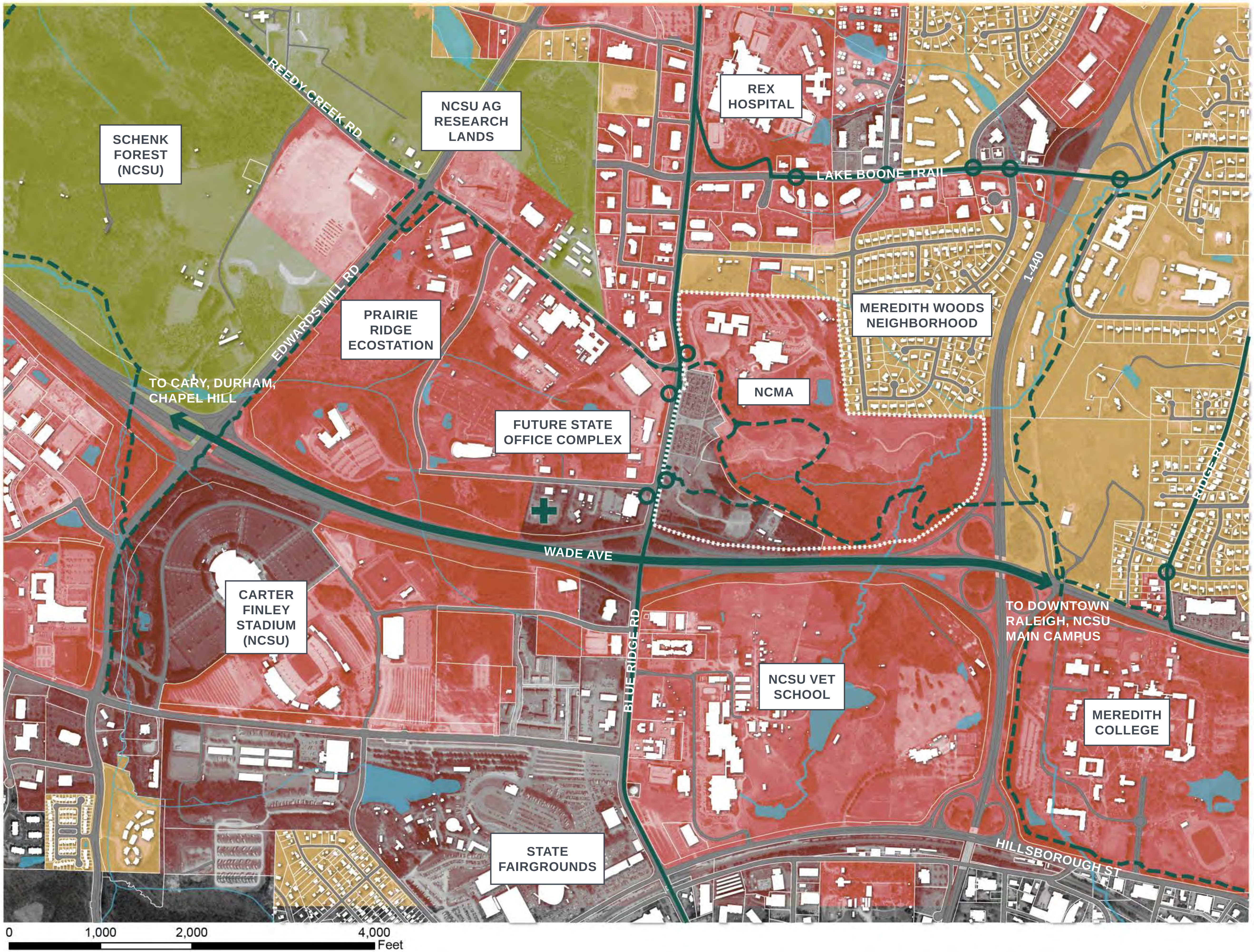
ACCESS + ZONING

The Blue Ridge Road corridor, located along the west side of the NCMA property, is currently experiencing a major increase in development, and it has been the subject of numerous planning efforts by the City of Raleigh and local nonprofit groups over recent years. Land use types in this area are shifting from primarily office and institutional uses to host a more diverse mix, including retail and residential. The City is actively encouraging higher-density development and a transition away from one-story buildings sited within suburban-style landscapes in this area.

With the upcoming move of the North Carolina Department of Health and Human Services from its current location at Dorothea Dix Park to a newly constructed campus just west of the site, the NCMA will likely see a major increase in visitors to the Park, particularly during the work week.

The ongoing expansion of the Rex Hospital campus and its associated medical facilities north of the site will also continue to bring an increasing number of visitors to the site over the coming years.

As the City of Raleigh continues to invest more in its public transportation system, the Museum Park will likely benefit from its proximity to GoRaleigh bus stops, a GoTriangle commuter stop, and a GoTriangle Park N Ride. The Museum is uniquely positioned to draw visitors from these transit riders, including cyclists who use the greenway system as a link between transit stops and their final destination.



ACCESS + ZONING

- NCMA Property
- GoRaleigh Bus Stop
- GoTriangle Park N Ride
- GoTriangle Commuter Bus
- GoRaleigh Bus Route
- Greenway
- Agricultural Productive Zoning
- Commercial/Industrial Mixed-Use Zoning
- Office Mixed-Use Zoning
- Residential Zoning

SITE HISTORY

The Ann and Jim Goodnight Museum Park originated with the Museum's move from downtown Raleigh to the edge of the city, a location chosen specifically for its accessibility to all North Carolinians and its potential to one day become a cultural park. The North Carolina Museum of Art has been fortunate to uncover that potential.

East Building, designed by the office of Edward Durrell Stone, opened in 1983. Visitors to the new State art museum passed the adjacent Polk Youth Center, which operated as a prison farm and correctional center for both men and youth from 1920 until 1997. Before Polk's establishment, the land housed military encampments during the Civil and First World War; between the wars and in the antebellum era, the land served agricultural purposes and was owned by several individuals.

While no American Indian sites were then or have since been identified within the now 164-acre boundaries of the Museum Park, archaeological work in nearby sections of western Wake County has recovered artifacts from the Archaic period (8,000–1,000 BCE) and the Woodland period (1,000 BCE–1600 CE). Since the site now encompasses a creek, it is probable that American Indian activity occurred on the property. In the fall of 2020, the Museum partnered with the NC Division of Archives and History and Danny Bell, president of the Triangle Native American Society and retired professor of American Indian and Indigenous Studies, to acknowledge this history formally in its first ancestral land acknowledgment.

American Indians have lived in Wake County and the House Creek area in which the Museum Park is located for thousands of years. To date no archaeological work has been done to identify specific sites associated with American Indian use of this land, but it is likely such places exist.

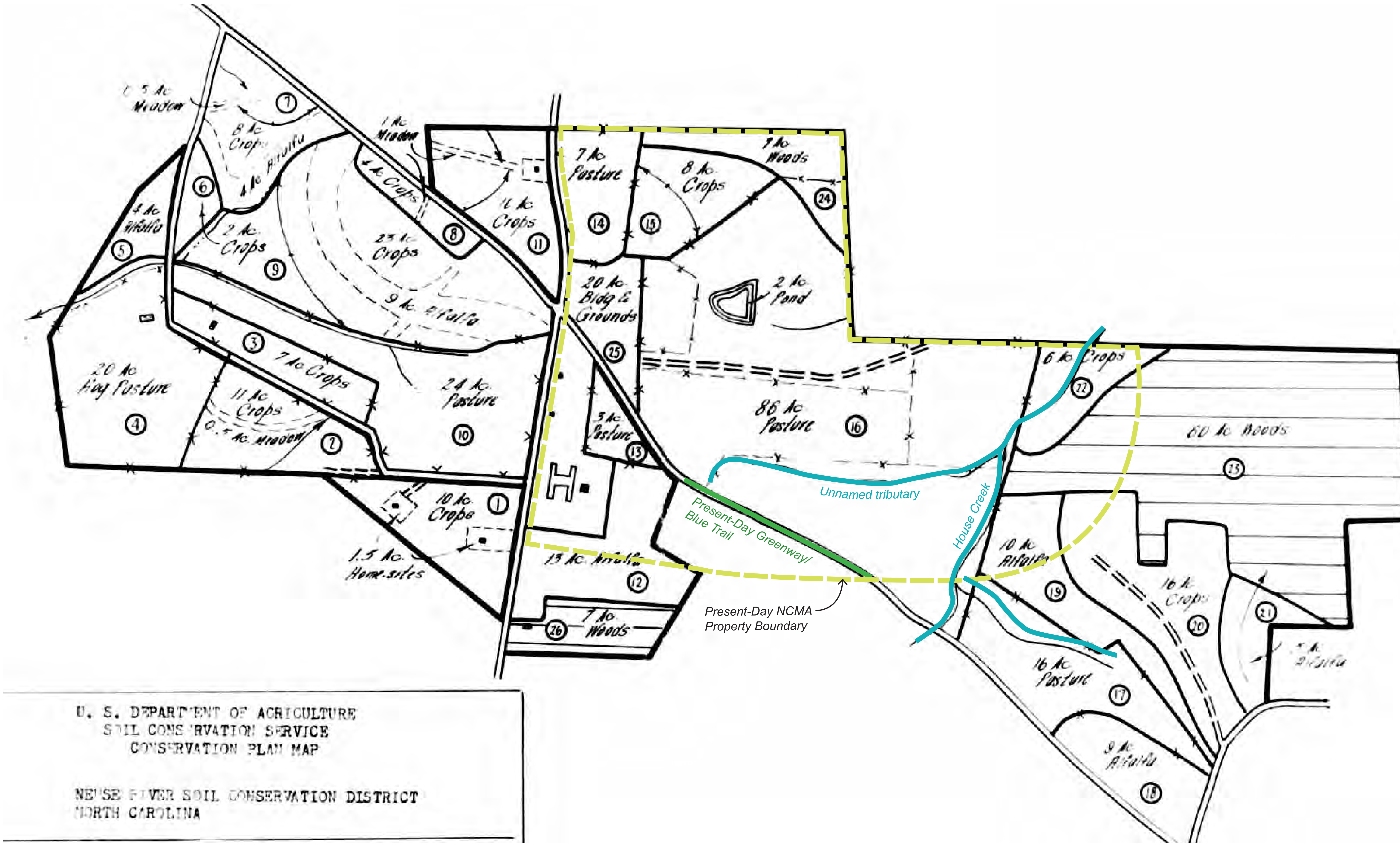
As a result of population displacement caused by colonialism, several groups of Siouan and Iroquoian ancestry have ties to the Museum Park property. Contemporary North Carolina American Indian tribes that live in and have traveled throughout North Carolina include the Cherokee, Coharie, Haliwa-Saponi, Lumbee, Meherrin, Occaneechi, Sappony, and Waccamaw Siouan.

In 1986, shortly after the opening of East Building, the Museum turned its attention to the future of its site and its imagined potential. A grant was awarded by the National Endowment for the Arts to conduct a national search for a Design Team to include an artist and design professionals; thus began *Art + Landscape*, an umbrella program conceived to coordinate the design competition, selection, and future implementation of a site plan, establishing the primacy of art and design collaboration in nature.

The result was a radical plan titled *Imperfect Utopia: A Park for the New World*, created by a collaborative team that included artist Barbara Kruger, architects Henry Smith-Miller and Laurie Hawkinson, and landscape architect Nicholas Quennell. *Imperfect Utopia* laid out a framework for the site to "throw the museum outside," to invite a more diverse public to enjoy everyday pastimes in an outdoor cultural setting. At the heart of *Imperfect Utopia*'s framework was the Park, which denoted the site as a landscape to be preserved, repaired, and restored. The Plan was published internationally in 1989 and put the Museum at the forefront of public art and museum planning.

In 1997 the Joseph M. Bryan Jr. Theater, a site-specific, text-based work by Kruger et al., was completed, realizing the plan's first phase. The project catalyzed the progress on the future Park, and in 2000 the first recreational trails through former Department of Corrections land were established. Environmental improvements began in earnest in 2001 with the Department of Transportation extension of the Capital Area Greenway through the Museum Park. These environmental improvements have continued over the years through partnerships and support. Highlights include the establishment of the Partnership for Art and Ecology with NCSU in 2003, Clean Water Management Trust funded enhancements to stormwater management at the Pond in 2010, the 2016 Park expansion's transformation of the brownfield of the former prison site into a public garden with sustainable design features, and, in 2018, the initiation of a Park-wide program to control invasive species.

The success of these projects solidified the Museum's commitment to stewarding its natural assets and advancing its goal of creating a cohesive, accessible, and interconnected experience for visitors. The 2020–25 Strategic Plan defined next steps in the future development of the Museum Park, including the creation of a plan for a 100-acre portion of the Park, known as the preserve, which encompasses the stream system and its watershed, celebrates natural habitats, unifies the Park's zones, and preserves the campus.



Polk Prison Farm land use plan, 1956 (Daniels, 2001; Courtesy of the North Carolina Department of Natural and Cultural Resources) with present-day NCMA property and streams overlaid in color

TIMELINE

American Indians living in the areas today known as Wake County and House Creek

1861 – **1864**
Camp Mangum, Civil War encampment for Confederate Soldiers

1918 – **1919**
Camp Polk, World War I Tank Training Facility

1920s – **1960s**
State Prison Farm

1963 – **1997**
Polk Youth Center, Juvenile Detention Center Facility

1975 – **1995**
NCSU Veterinary School used fields for animal grazing

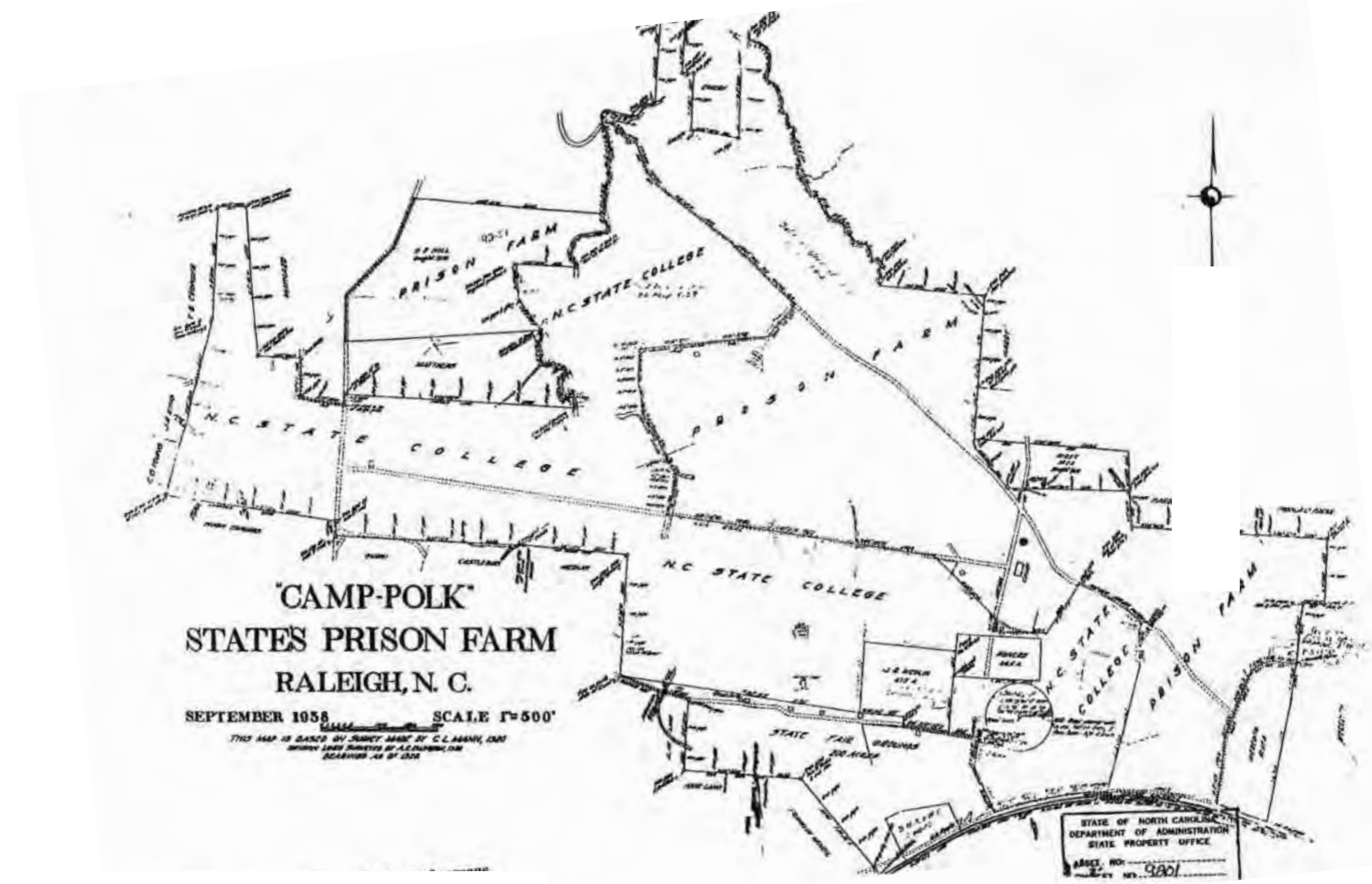
1983
NCMA opens next to Polk Youth Center

2003
Museum Park opens to the public

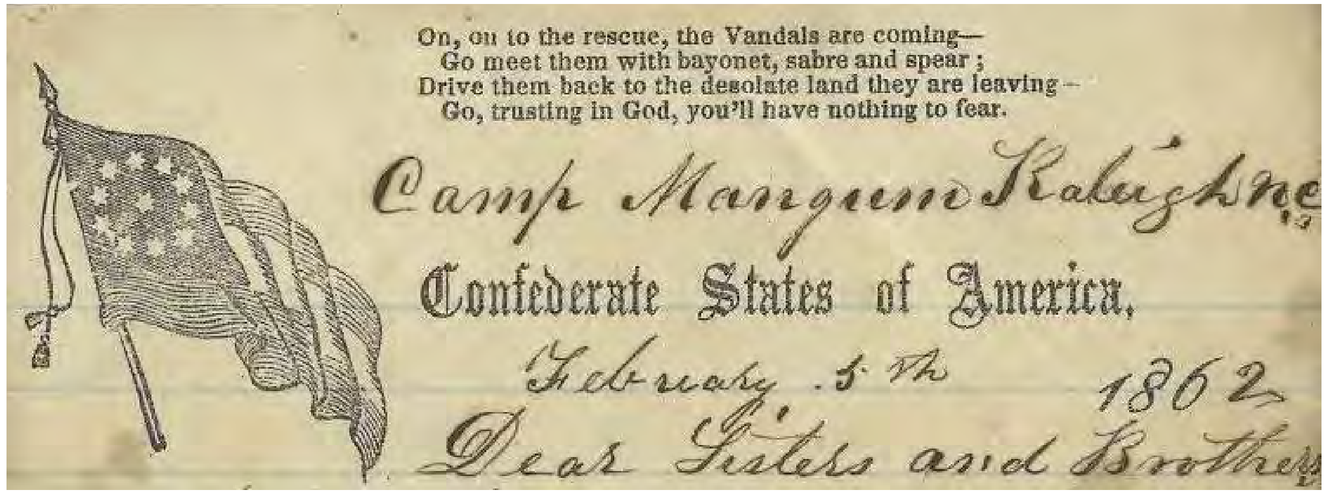
2004
Prison is demolished

2016
Museum Park Expansion opens on former prison site

Camp Polk Military Installation, 1918 (Left: Peek, 2021. Right: Daniels, 2001; Courtesy of the North Carolina Department of Natural and Cultural Resources)



Polk Prison Farm, 1938 (Daniels, 2001; Courtesy of the North Carolina Department of Natural and Cultural Resources)


On, on to the rescue, the Vandals are coming—
Go meet them with bayonet, sabre and spear;
Drive them back to the desolate land they are leaving—
Go, trusting in God, you'll have nothing to fear.

Camp Mangum Raleigh N.C.

Confederate States of America,

February 5th 1862

Dear Sisters and Brothers

Letter from Camp Mangum, 1862 (Courtesy of Ashe County Historical Society, 2021)

Fendol Bever's Map of Wake County, 1871 (Daniels, 2001; Courtesy of the North Carolina Department of Natural and Cultural Resources)

Polk Youth Center (closed in 1997) and NCMA, 2003; Photo: Google Earth

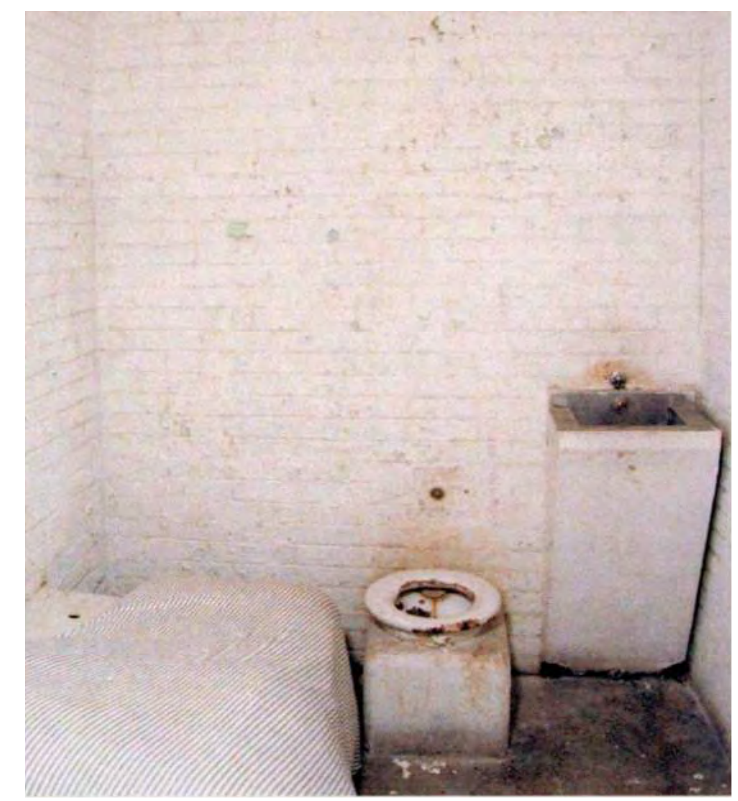
Above and upper right: Polk Prison Farm, 1939 (Daniels, 2001; Courtesy of the North Carolina Department of Natural and Cultural Resources)

Polk Youth Center, 1964 (Daniels, 2001; Courtesy of the North Carolina Department of Natural and Cultural Resources)

Polk Youth Center (foreground) with NCMA East Building in background, 1983 (NC State Archives)

Guard tower along Blue Ridge Road, 2003; Photo: Mike Legeros

Fire at prison’s mattress factory,1963 (Daniels, 2001; Courtesy of the North Carolina Department of Natural and Cultural Resources)



Polk Youth Center’s interior segregation unit, 2001 (Daniels, 2001; Courtesy of the North Carolina Department of Natural and Cultural Resources)

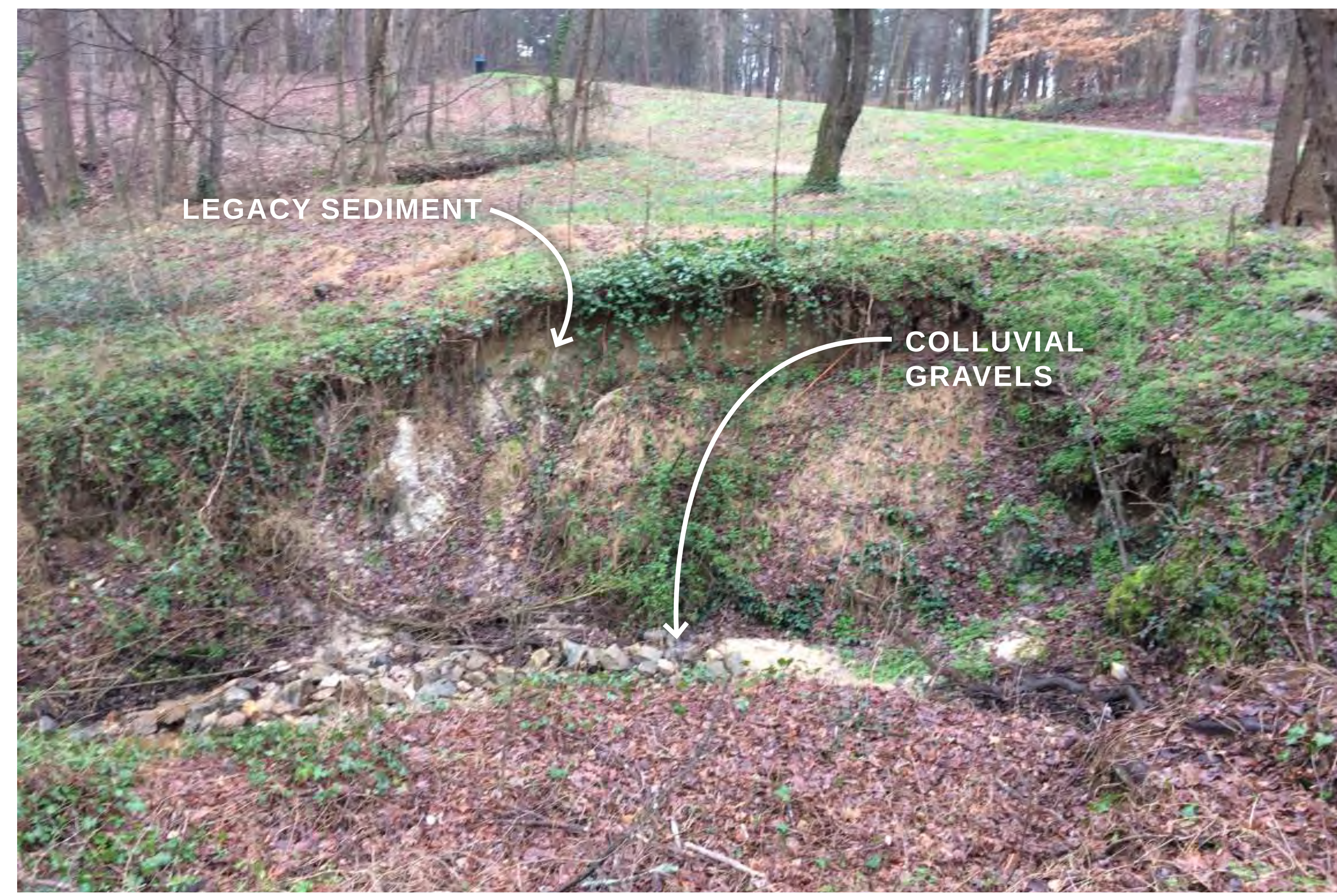
Polk Youth Center, 1968 (Daniels, 2001; Courtesy of the North Carolina Department of Natural and Cultural Resources)

IMPACTS OF PAST LAND USE

The history of the Museum property and the NC State Veterinary School to the south, which forms the watershed of House Creek, is relatively well documented starting in 1861, when the entire area became the site of a Civil War training camp. Before that time the property was in private ownership, likely supporting agricultural fields and pastures. Thus, for over 160 years, most of the landscape was converted from its natural forested condition and altered to that of a "production" landscape. The adverse effects on streams of clearing forest and conversion of land to agriculture uses have been well-documented by science.

When a forest is removed for agriculture, the year-round soil stabilization that trees furnish is exchanged for the much less effective temporary, seasonal patchwork of protection that agricultural crops can provide. The effects on the receiving stream waters can be powerful. Increased stormwater runoff sends more water to the channels during storms. The additional flow causes erosion of the channel downward vertically. As the channel deepens, taller banks are created, which begin to erode during larger storm events. Taller eroding banks become undercut, and trees whose roots were providing bank stability fall and die, and bank erosion continues. Sediment from plowed and eroding fields comes with the stormwater runoff, which clouds the flow and blankets the channel, degrading water quality and aquatic habitat. If fertilizers or pesticides are applied, these also can be carried to the stream, polluting the flow and degrading the aquatic ecosystem.

In the photos to the right, "legacy sediment," which refers to soil that has eroded from upland areas following the arrival of early settlers, is still evident in the soil profile along the eroded banks. The presence of both Holocene paleosol and colluvial gravels are indicators of erosive forces from upland areas that have negatively impacted water quality and riparian habitat in the postsettlement period.



Eroded banks of unnamed tributary; Photo: Biohabitats

Impacts of clearing for agricultural use, 1959 (NC State Archives)

UNDERSTANDING EXISTING CONDITIONS

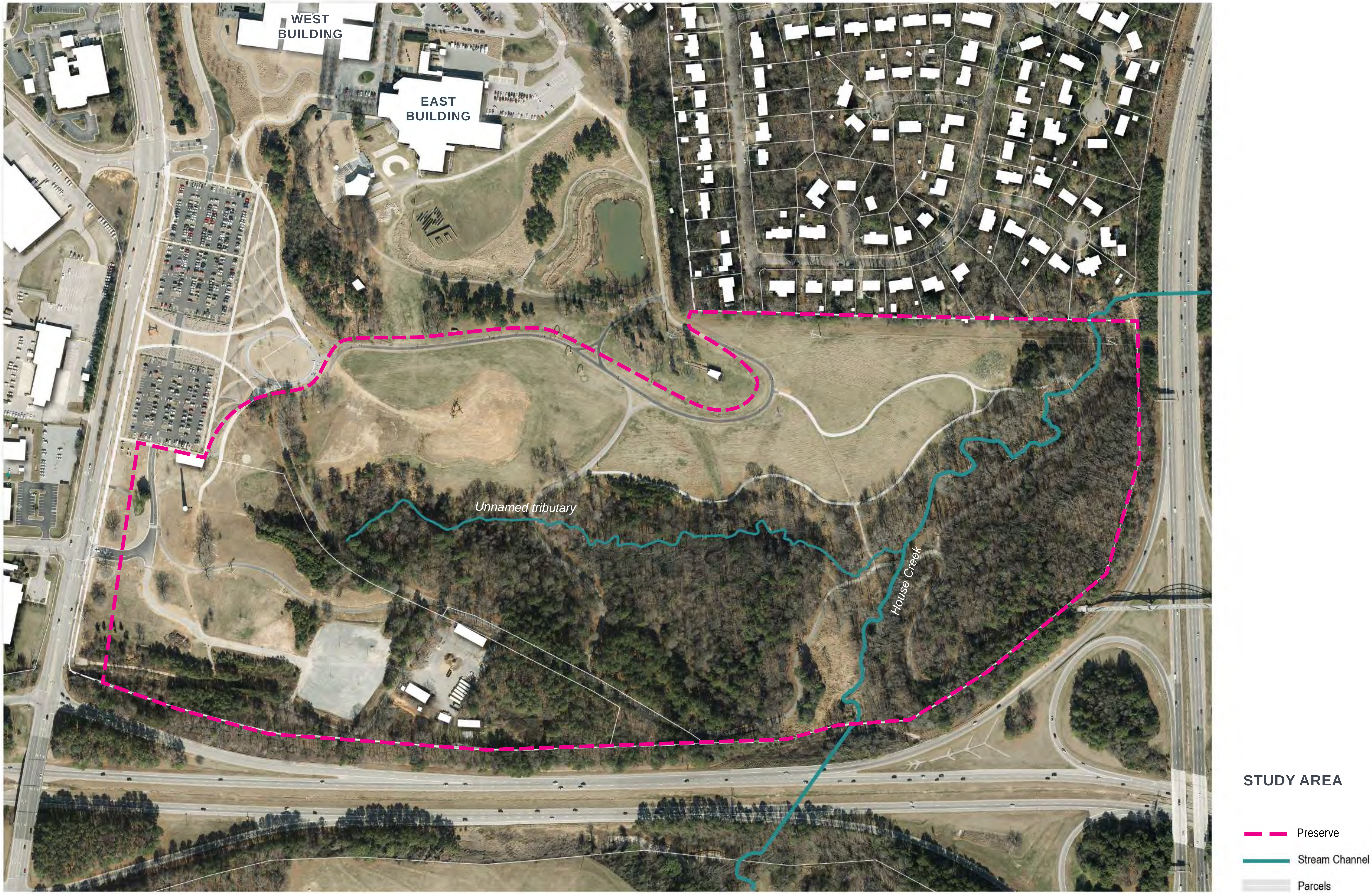
Sediment deposited from eroded banks along House Creek; Photo: Andropogon

SITE EXTENTS

The extent of the study area originally proposed in the Park Preserve Masterplan Brief (2020) included most of the riparian and forested areas in the southern half of the NCMA property. In the early stages of site analysis, the Design Team and Steering Committee expanded this boundary to include the entire watershed of the unnamed tributary, which contains additional areas surrounding the smokestack, overflow parking lot, and maintenance and operations center.

The expanded boundary was intended to provide opportunities to understand how runoff from impervious and meadow areas can impact the water quality of both the unnamed tributary and House Creek. The expanded boundary also captures circulation needs related to the new Welcome Center and the main Blue Loop trail as it enters the Park from the main parking area on Blue Ridge Road as well as the area within the Duke Power easement along the property line shared with the Meredith Woods neighborhood.

View across Lower Meadow; Photo: NCMA


WEST BUILDING
EAST BUILDING
Unnamed tributary
House Creek
STUDY AREA
Preserve
Stream Channel
Parcels

SITE HYDROLOGY

Due to the existing ridge west of the site along Blue Ridge Road, almost all of the water that falls on the NCMA property finds its way to House Creek. A ridge running east/ west within the NCMA campus divides the property's drainage into two basins: one on the northern half of the campus and one on the southern half. The northern portion of the property drains into the stormwater pond below the East Building and smaller drainage ways that meet House Creek downstream from the NCMA property.

On the southern half of the Museum property, three distinct basins drain into House Creek on the Museum property. The first basin includes the watershed for the unnamed tributary, which is completely contained within NCMA property. This area encompasses the smokestack and Welcome Center areas, the Upper Meadow, a portion of the Lower Meadow, the South Woods, the Middle Woods, portions of the overflow parking area, and portions of the maintenance and operations center. Water quality–related improvements within this drainage basin will have the most dramatic impact on the health of the stream corridors in the Park preserve.

Water in the second basin of the study area drains directly into House Creek. This zone includes the eastern portion of the Lower Meadow and the entirety of the East Woods. House Creek is severely impaired in this area, and the impacts of erosion along the stream banks are very visible from the preserve trails. Channelized stormwater along aggregate paths in the Lower Meadow are also carrying sediment into the stream channel. This basin includes the only FEMA-mapped 100-year floodplain on the site, which is located at the lower-most reach of House Creek within the NCMA property.

A third basin collects runoff from the southwest corner of the Museum property, including portions of the overflow parking area and the maintenance yard. This basin drains into a ditch along the side of Wade Avenue, which eventually meets House Creek as it enters the site from the culvert beneath Wade Avenue.

Wetland indicator species at potential spring near overflow parking area; Photo: Andropogon


WEST BUILDING
EAST BUILDING
Stormwater Pond
DIRECT IMPACTS TO UNNAMED TRIBUTARY WATER QUALITY
Unnamed tributary
Spring
House Creek
WADE AVE
0
300
600
1,200
Feet
N
SITE HYDROLOGY
Stream Channel
Drainage Channel
Significant Drainage Entering Stream
Surveyed Wetland
House Creek Direct Drainage Area
Retention Pond Drainage Area
Unnamed Tributary Drainage Area
Wade Avenue Ditch Drainage Area
100-Year Floodplain

STREAM CONDITIONS: HOUSE CREEK

From past land uses, both House Creek and the unnamed tributary have experienced channel downcutting, steep eroding bank formation, and the degradation of aquatic habitat. The reach of House Creek on the Museum property has a much larger watershed than the unnamed tributary, so the volume of water reaching it is greater, and the effects of disturbance and agriculture are more pronounced.

As shown in the geomorphic studies (Appendix II-D), the channel has eroded downward and cut down into the landscape, isolating larger flows in the deeper channel and not allowing them to access the floodplain. This effect is technically termed *channel incision*.

Channel incision decreases the frequency at which higher stream flows reach the top of the banks and spill into the floodplain, where the flow can be filtered, cleansed, and stored for a slow release.

The reduced access of a stream to its floodplain hampers the stream's natural ability to reduce suspended pollutants and sediment and store potential floodwater.

Fall and spring water quality sampling of House Creek (summarized in Appendix II-D) resulted in a good or fair Biotic Index score (as defined by NC Biotic Index Bioclassification system), depending on the section of stream sampled and the season. Turbidity levels were very high in both streams, especially in House Creek. This indicates substantial negative impacts to water quality caused by sediment entering the stream from adjacent land uses or eroding from the incised banks.

Overall, the Design Team was encouraged by the water quality sampling results, which indicate that once the causes of erosion are remedied, the water quality of House Creek will likely improve steadily.

House Creek entering the NCMA from Wade Ave culvert (May)

Looking upstream (south) from greenway bridge (February)

Sediment in House Creek at confluence with tributary (February)

Erosion below seating area and trail in Lower Meadow (February)

Tree loss due to erosion of stream banks (May)

Invasive plants at 100-year floodplain near I-440 culvert (May)

Photos: Andropogon and Biohabitats

STREAM CONDITIONS: UNNAMED TRIBUTARY

The unnamed tributary's watershed is entirely contained within Museum property, and therefore the existing conditions of the channel and its riparian zone reflect the land use history of what is now the Park. This includes a Civil War training camp, a World War I tank training camp, and agricultural production on and off until the Museum's establishment.

The unnamed tributary bears the scars from these past disturbances. Increased stormwater runoff generated by the areas that were cleared flowed downslope, concentrating in the channel and eroding it. The natural channel bed was scoured during larger precipitation events, removing bed material and lowering the channel bed elevation. This process in turn formed tall, steep, eroding stream banks. It has continued over the past 100 years, creating unstable channel conditions and degrading water quality and aquatic habitat, in addition to worsening downstream water quality offsite.

As with House Creek, the geomorphic studies of the unnamed tributary (Appendix II-D) reveal substantial channel incision, which is preventing water from reaching its natural floodplain. This results in increased suspended solids within the stream and degraded water quality in both the unnamed tributary and House Creek downstream.

Water quality sampling (see Appendix II-D) in the unnamed tributary resulted in a Bioclassification score of good to fair, depending on the season sampled. Turbidity levels were high during both low and high flow conditions, indicating problems with erosion. However, turbidity levels in the unnamed tributary were much lower than those in House Creek during high-flow conditions.

Although the unnamed tributary is small in size, the Museum has an opportunity to make major improvements to its water quality through their land use practices within the watershed.


Headwaters, just below the Blue Loop trail (February)


Sediment deposits just downstream from headwaters (February)


Erosion just downstream from Blue Loop crossing (February)


Blown-out bridge at forest path crossing (February)


Bank reinforcement at greenway trail (February)


Buried culvert near confluence (February)

Photos: Andropogon and Biohabitats

SLOPE

Through an analysis of slopes on the Park preserve site, the Design Team was able to identify specific areas where runoff and erosion are contributing to problems with water quality and steep grades on walking paths are limiting accessibility.

The slope map on the facing page shows that although the site has not been used for grazing in many decades, the impacts of overgrazing on soil and water quality are still very evident today. North and south of the unnamed tributary, ribbons of yellow following the contours reveal where grazing on cleared slopes caused soil to wash into the creek below.

The steep slopes of the stream channel are very apparent, particularly along the lower reach of House Creek, as the stream hits the heavily eroded hillside near the Lower Meadow (note 4, right).

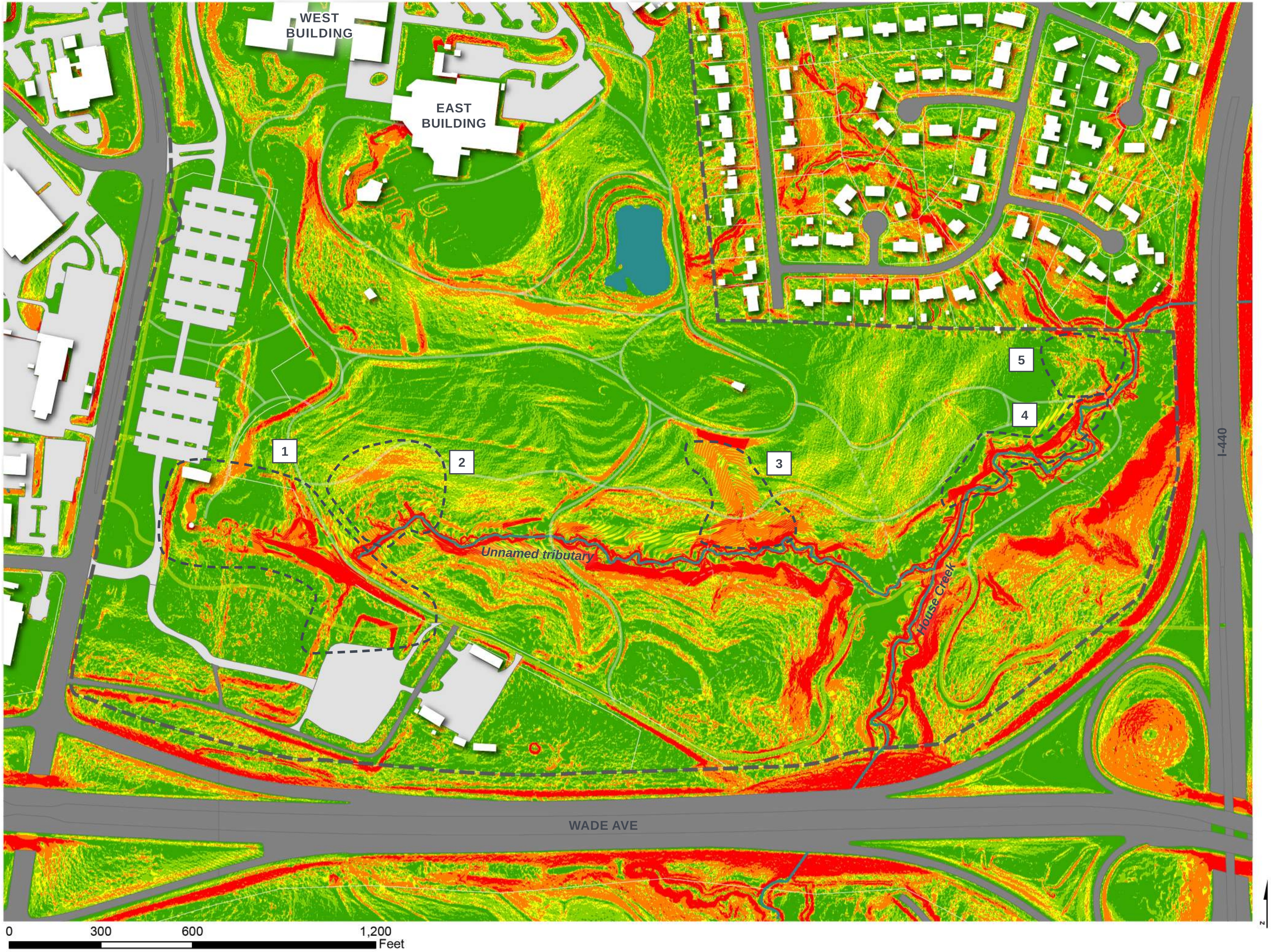
What was once the active floodplain of House Creek is visible as two dark green areas, one west of House Creek surrounding the confluence area, and the other east of House Creek, downstream from the confluence area. The deep channelization and continued erosion of the stream corridor prevents the creek's water from reaching this floodplain as regularly as it should during large storm events.

The slope mapping also shows the channelization of storm water along trails in a number of locations, including the northeast corner of the Lower Meadow (note 5, right) and along a section of the Blue Loop just east of the smokestack (note 1, right).

The change in slope surrounding the draws within the Upper and Lower Meadows is also very visible (notes 2 and 3, right). A lack of biomass in these areas allows stormwater and the sediment it carries to rush into the creeks during large storm events.

Some trails traversing the steep upland areas can pose safety issues, as with the steep curve in the greenway trail near the confluence of the two streams. However, slope can also be an asset, providing interesting views of the different ecosystems and vegetation found on site.

Sloped hillside in Lower Meadow; Photo: Andropogon



1 Runoff from Steep Slopes below Impervious Surfaces at Unnamed Tributary Headwater

2 Runoff from Steep Slopes, Draws in Meadow at Wetland Pockets

3 Runoff from Steep Slopes, Draws through Central Meadow

4 Severe Erosion of Hillside above House Creek

5 Runoff from Channelized Swales Draining Lower Meadow

SLOPE

- 0–5%
- 5–8%
- 8–10%
- 10–20%
- 20% +

STORMWATER

As the Design Team considered the interplay of slopes, hydrology, land cover, and infrastructure within the site, the group was able to identify critical areas where improvements to stormwater treatment would have a major impact on water quality in the unnamed tributary and House Creek.

Large areas of impervious surface, such as the main parking lot, the overflow parking lot, and the maintenance yard, need additional stormwater treatment devices in order to prevent runoff from washing sediment and toxins from paved areas into the creeks during large storm events.

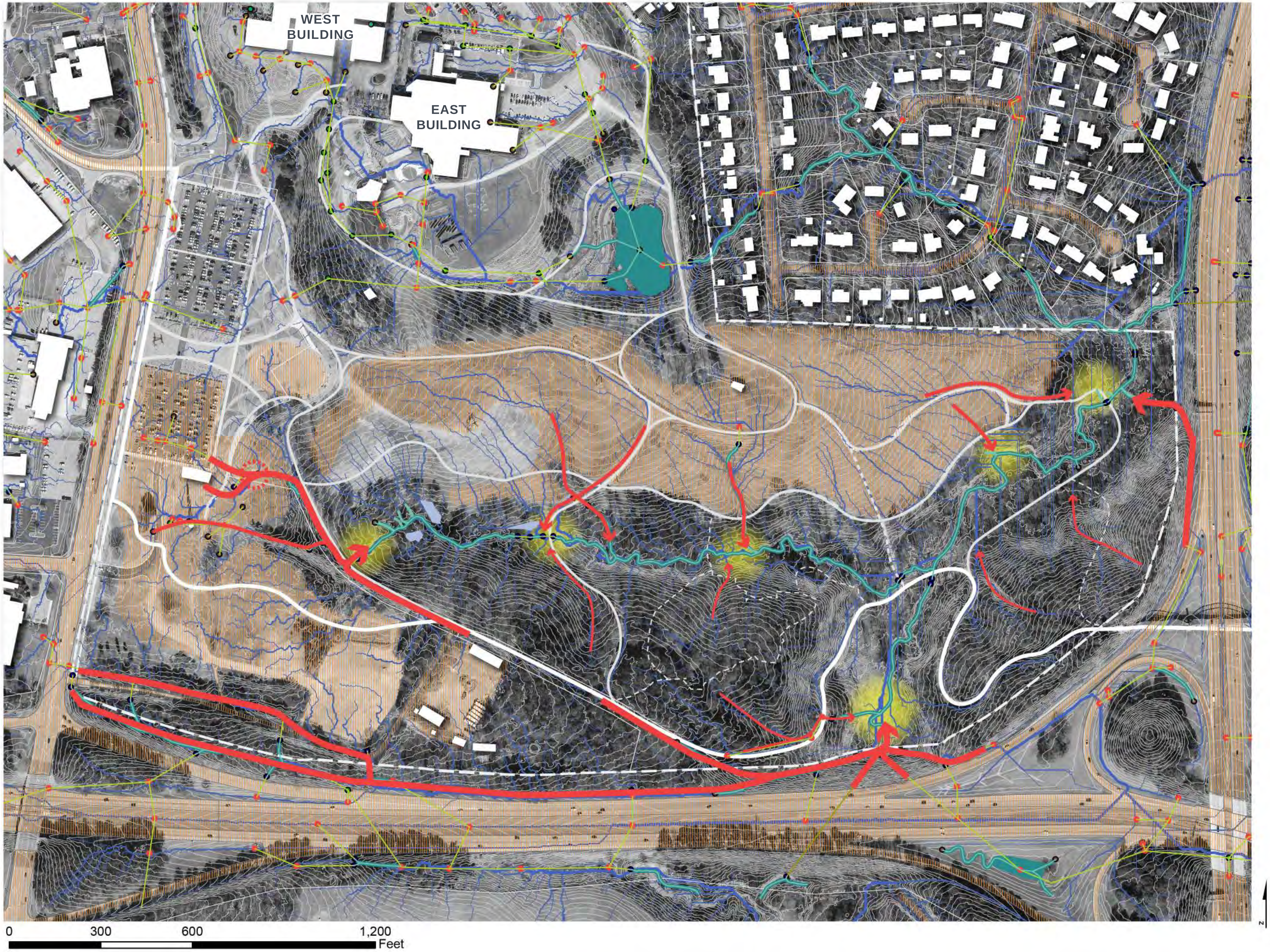
Stormwater management along smaller impervious areas, such as paved trails, is also necessary. This is especially important in steeper areas where water is channelizing along the trails as it makes its way down to lower elevations.

In particular, measures to improve stormwater treatment in areas draining directly into the headwaters of the unnamed tributary will have the greatest impact on the health of both riparian corridors in the preserve.

Although the fescue meadows in the preserve are considered pervious surfaces, the rate at which stormwater flows off these surfaces does not allow for adequate infiltration of water into the soil. A conversion of fescue to more deep-rooted grasses, shrubs, and canopy trees in the Upper and Lower Meadow areas would allow stormwater to soak into the soil and be slowly released back into the creeks after sediments and toxins have been filtered out.

The addition of deep-rooted plant material is especially important in the draws that reach north from the riparian zones into the meadows, connecting them hydrologically to the streams. If soil is stabilized with vegetation in these areas, less sediment will wash into the waterways below. Additional biomass will slow water as it moves through steeper areas, and plant roots will absorb water and help store carbon in the soil.

Erosion caused by concentrated runoff from Lower Meadow; Photo: Andropogon



RUNOFF COEFFICIENTS (HIGH TO LOW):

Roofs: 0.90 - 1.00

Pavement: 0.85 - 0.95

Turf (with heavy soils, average to steep slope): 0.70 - 0.90*

Meadow: 0.10 - 0.50

Wooded Areas: 0.15

Source: NCDEQ

** Turf values adjusted to reflect specific site conditions*

STORMWATER RUNOFF: SOURCES + PROBLEM AREAS

Upland Remediation Needed (Erosion, Sediment Issues)

Surfaces with High Runoff Coefficent (Turf, Pavement)

Surveyed Wetland

Significant Drainage to Stream (Major/Minor)

Significant Drainage Entering Stream

Stream Channel

Drainage Channel

Stormwater Channels

Stormwater Culverts

Stormwater Pipes

Inlets

Junctions/PipeIO/StubPt

CIRCULATION

The team studied circulation patterns in the Park preserve in order (1) to identify ways the trail system can provide users in the periphery of the preserve with easy access to the main NCMA buildings and (2) to ensure that visitors to the main buildings and the Museum's core landscapes can easily explore the natural areas in the Park at whatever distance or duration that is comfortable for them. The trail system should link the formal part of the campus with the Park in a more integrated, seamless way that showcases restored native landscapes as a quintessential part of the NCMA experience.

In order to achieve this, the Design Team identified a number of locations where the following improvements could be made:

- Places where an unofficial path or paths connecting two heavily used spaces should be formalized into a trail (notes 1, 2, and 3, right);
- Places where crossings over House Creek and the unnamed tributary need to be improved for safety, accessibility, and maintenance access (red and pink circles, right);
- Places where trail alignments need to be reconfigured to improve safety, protect infrastructure investments, and improve water quality (note 6, right);
- Places where trail alignments could be slightly adjusted to ease steep slopes and provide an easier walking experience (throughout the Park);
- Places where small paths and creek crossings could provide additional access to the water, especially for children (note 4, right); and
- Places where trail alignments need to be completely redesigned in order to provide a more interesting and enjoyable visitor experience (note 7, right).

Existing "cow paths" between the Welcome Center and Blue Loop; Photo: Andropogon

WEST BUILDING
EAST BUILDING
1
2
3
4
5
6
7
1 Connect Welcome Center, Stack, Ellipse, Greenway
2 Connect Welcome Center, Upper Meadow, Greenway
3 Connect South Woods to Upper Meadow
4 Stabilize Tertiary Path and Crossing
5 Improved Greenway/Meadow Path Connection, Gateway
6 Remove, Realign Ridgeline Path
7 Improve Crossing, Safety, and Increase Vegetative Buffer
CIRCULATION: TRAILS + CROSSINGS
Gateway to Preserve
Damaged/Unusable Crossing
Inadequate Crossing
Proposed Trail Connection
Trail to Be Realigned
Trail to Be Removed
Existing Forest Path
Existing Trail
Proposed Greenway
Existing Greenway, Increased Width Needed
Existing Greenway
Existing Blue Loop
0
300
600
1,200
Feet
N

VIEWS

The design of viewsheds in the Park is incredibly important, not only to define the ways in which artwork is viewed, but also to provide a restorative experience for visitors as they move through the many layers of meadow, forest, and riparian landscapes within the site.

The Museum Park's topography, coupled with the contrast between broad expanses of meadow and densely forested areas, provides ample opportunity to create a rhythm of open and closed spaces that highlight certain features in the landscape. By undertaking improvements that create a sense of surprise and encourage exploration, the Park can provide a wider variety of experiences in the same amount of space.

Views of riparian zones, both from above and at eye level, help educate visitors about the health and value of the Park's ecological communities.

If both views and sounds of the adjacent highways and maintenance areas are screened, visitors can feel more immersed in nature.

The Design Team developed the following strategies to enhance pleasant landscape vistas in the Park:

- Employ the concept of "hide and reveal" within the landscape. (Photo 1, right)
- Create contrasts among simple and complex textures, colors, and light. (Photo 1, right)
- Create opportunities to view the streams from above. (Photo 2, right)
- Highlight the structure of the landscape. (Photo 3, right)
- Create opportunities to see wildlife, especially along the riparian corridors.
- Reduce visibility of the impacts from DOT construction. (Photos 4 and 5, right)

Photos: Andropogon; except bottom left: Google Street View


WEST BUILDING
EAST BUILDING
1
2
3
4
5
0
300
600
1,200
Feet
N
VIEWS
Positive View
Negative View

SPATIAL ECOLOGY

As shown in the data collected by the NCMA on the map to the right, many of the worst invasive plant infestations coincide with the worst areas of erosion in the stream corridor. Soil disturbance along the stream banks during large storm events allows for invasive species to take root and spread, particularly in areas where the tree canopy has been lost. This is especially apparent in the lower sections of the unnamed tributary and House Creek.

A kudzu infestation within the House Creek floodplain adjacent to Wade Avenue is a major challenge for NCMA staff. The Museum will work with the NC DOT to collectively manage the infestation and create a more diverse and resilient floodplain ecosystem.

A healthy and resilient interior forest ecosystem requires a 300-foot minimum diameter of uninterrupted tree cover without trails or other breaks in the canopy.3 This prevents invasive species from colonizing in edge conditions and moving into the deeper forested areas. Existing interior forests of this size in the Park preserve should be preserved, and new or altered trails should be routed accordingly.

Although the forested area south of the sewer line trail has major infestations of invasive species, it also contains a wealth of native ferns, flowering understory trees, and mature canopy trees. Stands of native river cane dotting the banks of House Creek and the unnamed tributary should be protected where feasible, as river cane is a desirable native plant but hard to establish from nursery stock.

The transition areas between forest and meadow play an important role in providing habitat and preventing the spread of invasives. The successional forest edge present on the west side of the preserve should be extended to the east to provide a less abrupt transition from forest to meadow.

Continued conversion of fescue to warm-season grass meadows is also very important, especially in areas where draws create a hydrological connection between meadows and riparian zones.

3. University of Connecticut Center for Land Use Education and Research

Invasive Japanese stiltgrass (Microstegium vimineum) in understory; Photo: Andropogon

SPATIAL ECOLOGY

For Reference: 300' Diameter, Minimum Footprint for Interior Forest Ecosystem

Successional Edge

Major Presence of Invasive Plants

Wetlands, Seeps, Channels

Fescue

Meadow

Mixed Meadow/Turf/Trees

Forest + Canopy Height (Light/High to Dark/Low)

UTILITY ACCESS REQUIREMENTS

Electric and sewer utility easements in the Museum Park limit the size of plant material in some locations, but adding diversity and biomass to the existing plant palette while still meeting height maximums and access requirements is achievable.

The 50-foot-wide Duke Energy easement on the north end of the Lower Meadow restricts taller plant material along the Park's border with the Meredith Woods neighborhood. However, low shrubs and herbaceous plants are allowed in the entirety of the easement, and vegetation under 12 feet in height is allowable within the easement, as long as it is outside of the wire zone.

Access for Duke Energy maintenance vehicles must be maintained at all times, and Duke Energy may remove plantings if deemed necessary. Currently, access is provided via a dirt path through the fescue meadow, which is also used by NCMA security vehicles. A mowed path through more diverse plantings would provide acceptable access as well.

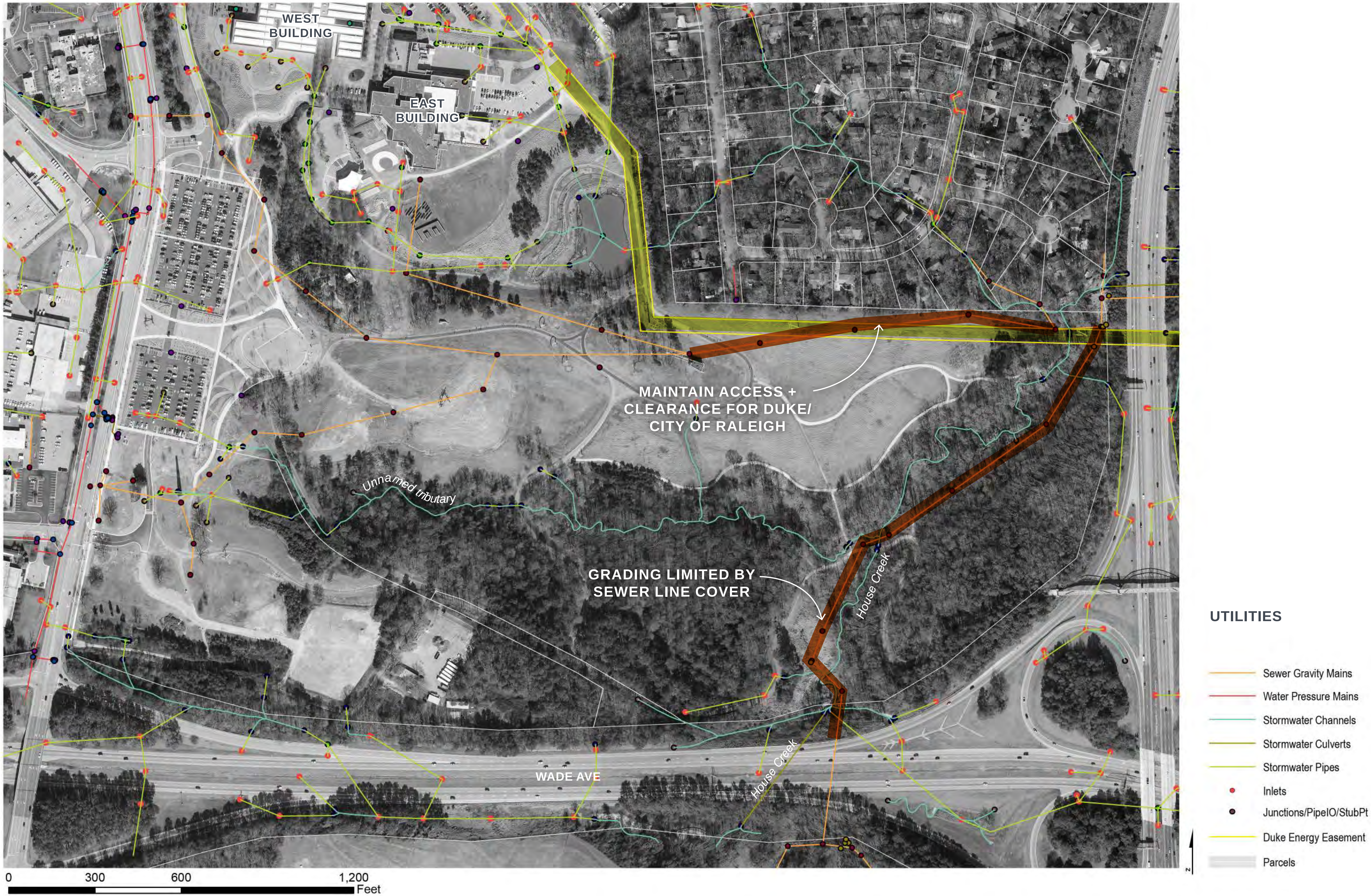
The Design Team recommends continued coordination with Duke Energy to create a landscape of low shrubs, meadow plantings, and small trees (where allowed) that will help buffer the Park from the adjacent neighborhood while meeting safety requirements and maintaining access for maintenance vehicles.

Two sewer lines traverse the Museum Park, one parallel to House Creek and the other in roughly the same location as the Duke Energy easement within the Lower Meadow.

City maintenance vehicles must be able to access the entirety of the sewer line, which means woody vegetation is removed by the City on a regular basis.

As the Museum makes improvements to the floodplain area where House Creek enters the property from Wade Avenue, restrictions on the amount of cover over the sewer line may limit the amount of grading feasible in this area.

Existing power lines through Lower Meadow, looking toward I-440; Photo: Andropogon


WEST BUILDING
EAST BUILDING
MAINTAIN ACCESS + CLEARANCE FOR DUKE/ CITY OF RALEIGH
Unnamed tributary
GRADING LIMITED BY SEWER LINE COVER
House Creek
WADE AVE
House Creek
0
300
600
1,200
Feet
N
UTILITIES
Sewer Gravity Mains
Water Pressure Mains
Stormwater Channels
Stormwater Culverts
Stormwater Pipes
Inlets
Junctions/PipeIO/StubPt
Duke Energy Easement
Parcels

PREVIOUS PLANNING EFFORTS

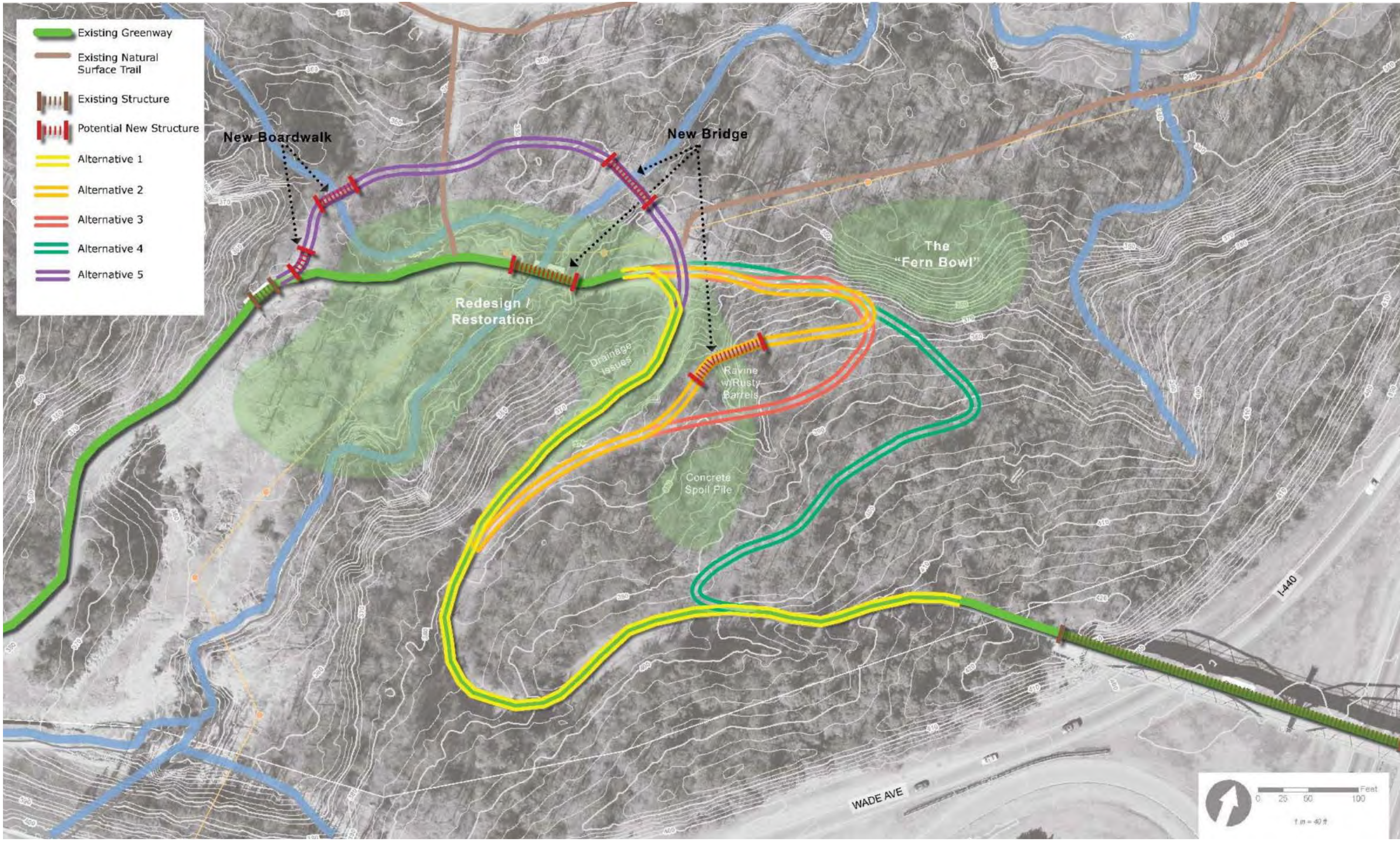
DESIGN STUDIES + PLANS

- 2021 Updated East Lawn Concept Plan (In progress) – Surface 678
- 2020 Welcome Center Plans – In Situ Studio
- 2019 Wade Ave/I-440 Design Documents – NCDOT (See Appendix II-E)
- 2017 Reedy Creek Greenway Realignment and Bridge 70 Replacement Study – Stewart (See Appendix II-E)
- 2017 East Lawn Concept Plan – Sam Reynolds
- 2017 Headwaters Stream Repair Plans – Wildlands Engineering
- 2014 Reforestation and Meadow Planting Concept Plan – Darrel Morrison
- 2007 Park Master Plan – Lappas + Havener
- 1989 Imperfect Utopia Framework– Barbara Kruger, Smith-Miller + Hawkinson, and Nicholas Quennell

MANAGEMENT PLANS + COST ESTIMATES

- 2019 Sustainability Framework Plan – NCMA
- 2018 Invasive Plant Species Management Plan and Data – NCMA
- 2017 House Creek Stabilization Cost Assessment – Wildlands Engineering

2007 Park Master Plan, Lappas + Havener (NCMA)



Trail realignment options from the 2017 Reedy Creek Greenway Realignment and Bridge 70 Replacement Study, Stewart (NCMA)

SUMMARY OF OPPORTUNITIES + CONSTRAINTS

MUSEUM PARK OPPORTUNITIES

- The Museum controls land use, land cover, and operations within the entire watershed of the unnamed tributary.
- The conversion of the existing fescue meadow to warm-season grasses will increase stormwater capture, provide habitat, and store carbon on site.
- Improvements to stabilize stream channel banks and allow the stream to access its floodplain during large storm events will improve water quality.
- Prevention of erosion along trails and steep slopes where stormwater is channelizing will improve water quality.
- Greenway safety can be improved by increasing radii of sharp curves, easing steep slopes, and preventing water collecting on the trail.
- The creation of a gateway into the lower preserve from the greenway trail will improve connections to the East and West Buildings.
- The Museum can leverage partnerships with research institutions to monitor the health of the landscape over time.
- Landscape improvements will increase the Park's resiliency in the face of climate change–related pressures.
- The Museum can develop educational programming and exhibitions related to the ecological restoration process.
- Improvements in the Park can provide additional opportunities to site art within the landscape.
- The Park's landscape can provide a restorative experience in nature within the city's core.

MUSEUM PARK CONSTRAINTS

- Erosion and tree loss in both stream channels is degrading water quality.
- Offsite land use and maintenance practices upstream are degrading water quality on NCMA property.
- The right-of-way expansion and associated construction on I-440 and Wade Avenue could have negative impacts to water quality and landscape views on NCMA property.
- Restrictions on vegetation type and access requirements in utility easements limit plant choices in some areas of the Park.
- The NCMA will work to save existing canopy trees in the stream restoration corridor, where feasible.
- Invasive species are present throughout the Park and on adjacent property.
- Soils on site have been degraded from previous land uses.
- Additional capture of stormwater from impervious surfaces (maintenance yard, overflow parking area, west parking lot) and treatment of that stormwater are needed.
- Abandoned infrastructure from previous agricultural and institutional uses causes drainage problems in the unnamed tributary headwaters area.
- Heavy use patterns on trails are stressing the landscape in some areas.
- Regulatory and permitting requirements of the US Army Corps of Engineers and the NC Department of Environmental Quality will have to be met.

Park visitors sitting in the lawn along the edge of the meadow; Photo: Andropogon

REGULATORY CONSIDERATIONS

Improvements in or near riparian areas of the Park must meet the standards set forth in the Neuse River Buffer Rules. This law was created to increase forest cover in riparian zones, thereby reducing the amount of nitrogen in waterways that flow into the Neuse River. The rules will govern the stream restoration, crossings, and trail construction in a 50-foot buffer of both streams in the Park.

In order to avoid riparian buffer impacts of more than one tenth of an acre (per NCDEQ requirements), the crossings in the preserve must span the entire floodplain, allowing the streams to flow without obstruction during large storm events. Per the US Army Corps of Engineers (USACE) requirements, impacts from crossings must be less than 150 linear feet of stream, or mitigation will be required.

Stream restoration work will also require a USACE Nationwide 27 permit, which prohibits any impacts to floodplain wetlands unless temporary.

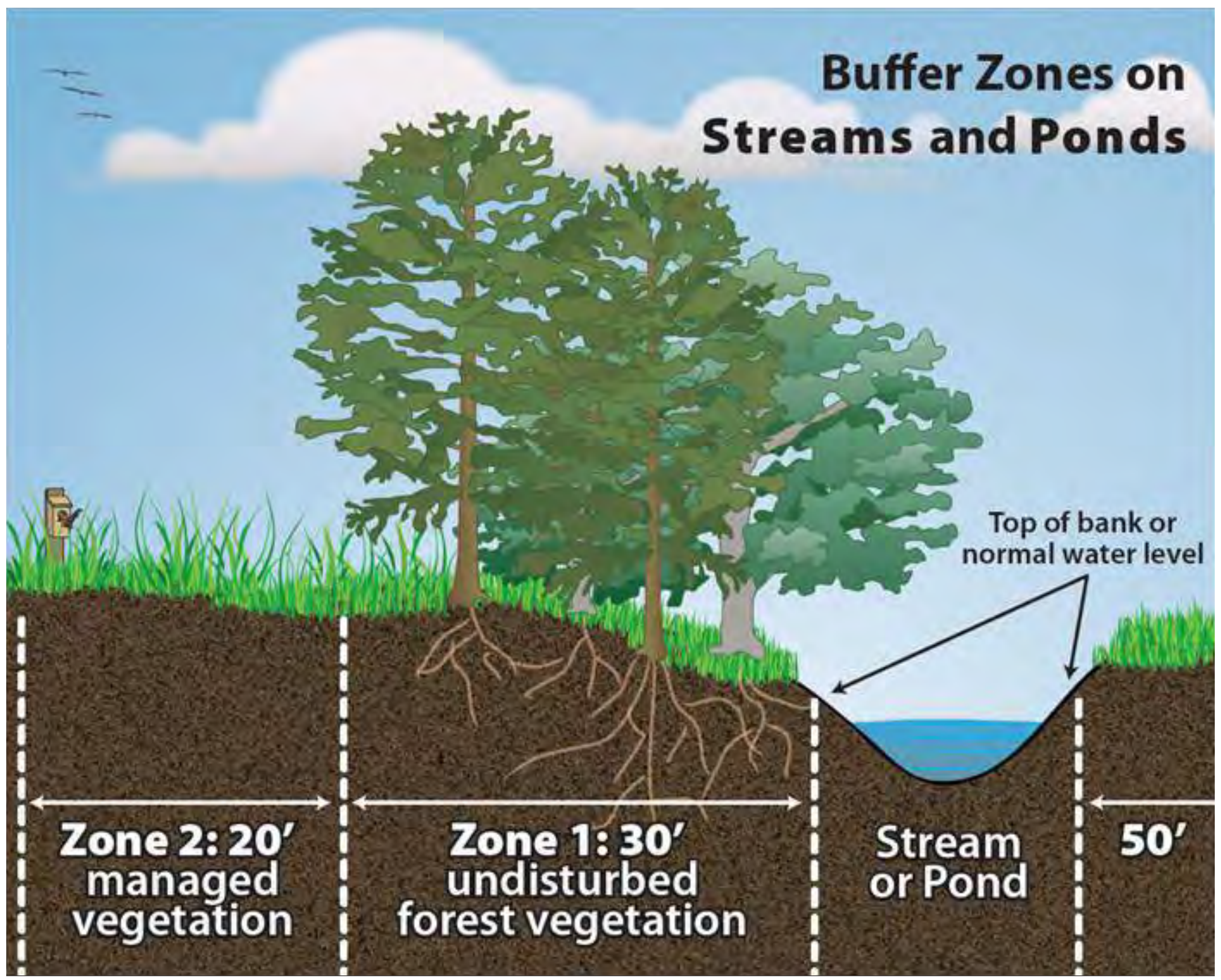
Realigned and additional trails in the Neuse River Buffer zones will also have to be permitted through the NCDEQ. Additional time and effort may be required to receive approval for new crossings, as the NCMA will have to help the agency understand how trees are being protected throughout the riparian corridor and how the proposed improvements are “self-mitigating.”

The American Association of State Highway and Transportation Officials (AASHTO) has developed trail design recommendations for shared-use paths, which although non-binding, are recommended in order to ensure cyclist and pedestrian safety in the Park. The existing grade of the greenway trail as it approaches the confluence area from the west is 8 percent in some areas. According to AASHTO, the grade of a multiuse path designed for 25 mph max speed should be no higher than five percent. Additionally, AASHTO standards recommend a minimum radius of 166 feet for curves on paths with a design speed of 25 mph and grades of six percent or more.[4] The existing curve radius in this area is 53 feet.

4. American Association of State Highway and Transportation Officials (2010)

Greenway slope and curve not in compliance with AASHTO standards; Photo: Andropogon

NEUSE RIVER BUFFER RULES



(North Carolina Division of Water Quality, 2012)

	Deemed Allowable	Allowable Upon Authorization	Allowable with Mitigation Upon Authorization	Prohibited
(j) Greenways, trails, sidewalks or linear pedestrian/bicycle transportation systems:				
(i) In Zone 2 provided that no built upon area is added within the riparian buffer	X			
(ii) In Zone 1 provided that no built upon area is added within the riparian buffer and the installation does not result in the removal of tree(s)	X			
(iii) When built upon area is added to the riparian buffer, equal to or less than 10 feet wide with two foot wide shoulders. Shall be located outside Zone 1 unless there is no practical alternative		X		
(iv) When built upon area is added to the riparian buffer, greater than 10 feet wide with two foot wide shoulders. Shall be located outside Zone 1 unless there is no practical alternative			X	
(c) Bridges:				
(i) Impact equal to or less than one-tenth of an acre of riparian buffer	X			
(ii) Impact greater than one-tenth of an acre of riparian buffer		X		
(w) Restoration or enhancement (wetland, stream) as defined in 33 CFR Part 332 available free of charge on the internet at: http://water.epa.gov/lawsregs/guidance/wetlands/wetlandsmitigation_index.cfm:				
(i) Wetland or stream restoration is part of a compensatory mitigation bank, nutrient offset bank, or the In Lieu Fee program	X			
(ii) Wetland or stream restoration other than those listed above		X		

(NC Legislation 15A NCAC 02b .0714 Neuse River Basin: Nutrient Sensitive Waters Management Strategy: Protection and Maintenance of Existing Riparian Buffers, 2020)

MAPPING A PATH FORWARD

The following strategies for achieving the goals of the Vision Plan were identified at the conclusion of the discovery phase and were meant to guide the design process:

Goal 1: Create a plan to restore and protect the NCMA's stream system and natural areas.

Strategies:

- Prevent further erosion by capturing and slowing additional runoff from the new Welcome Center, parking lots, and maintenance areas.
- Increase biomass to improve infiltration in the Lower Meadow, especially along natural draws, by adding native successional plantings and warm-season grasses.
- Work with the DOT to design Best Management Practices that minimize sediment load and decrease speed of runoff entering the NCMA from offsite.
- Design a high-functioning stream and adjacent riparian system to dissipate erosive flows from heavy-rain events.
- Strategically integrate pedestrian use with restored stream and riparian areas, taking care to protect sensitive zones.
- Improve habitat for native flora and fauna by providing floodplain reconnection in select reaches to enhance or create vernal pools and wetland pockets in the riparian corridor where feasible.

Goal 2: Improve the Park's circulation and visitors' experience with art, nature, and people, broadening the NCMA's appeal to more diverse audiences.

- Connect people to nature by providing access to interact with the streams in defined areas. Provide views of sensitive habitats but restrict public access in these areas to protect these habitats.
- Use the trail system to immerse visitors in a series of rich ecological communities of the North Carolina Piedmont as they navigate through the Park.
- Reroute trails to solve safety issues related to the greenway slope/curve and stream crossings.
- Use plantings and trail realignments to minimize negative views and sound from 440 and Wade Ave.
- Set the stage for art and educational opportunities (both ecological and cultural) in the landscape.
- Link to the other areas of the Museum property to draw visitors from inside out and outside in. The trail network should offer a series of experiences that are distinct but linked.

Goal 3: Build climate resiliency, environmental awareness, and opportunities for future artists' projects that work with both upstream and downstream conditions.

- Further position the NCMA as a leader in sustainability in the Triangle community and Southeast.
- Showcase cutting-edge restoration and maintenance strategies and report on successes and failures.
- Capture carbon onsite (through soils and plants) and communicate the impacts to the public.
- Highlight the Museum's role within its urban watershed and show what it means to be a good upstream and downstream neighbor.
- Heal broken ecological relationships to build the capacity of ecosystem services, enabling the Park to better respond to future challenges related to climate change.

Mowed path in Lower Meadow; Photo: NCMA

3 THE VISION

VISION PLAN SUMMARY

The Museum Park Vision Plan lays the groundwork for the phased restoration and continued stewardship of this treasured landscape over years to come. The plan envisions an enhanced preserve that brings the mission of the NCMA beyond the building walls and out into nature. Here visitors are immersed in a diverse and vibrant ecosystem that celebrates the native ecological communities of the North Carolina Piedmont.

The Plan synthesizes efforts to improve water quality in the unnamed tributary and House Creek, improve access and circulation, expand opportunities to experience nature and art, capture carbon on site, and increase resiliency in the face of a changing climate.

The Museum Park will function as a living laboratory where research partnerships, educational programming, and art installations allow the NCMA to report on the restoration process over time, helping others understand how they can be better upstream and downstream neighbors.


0
300
600
1,200
Feet

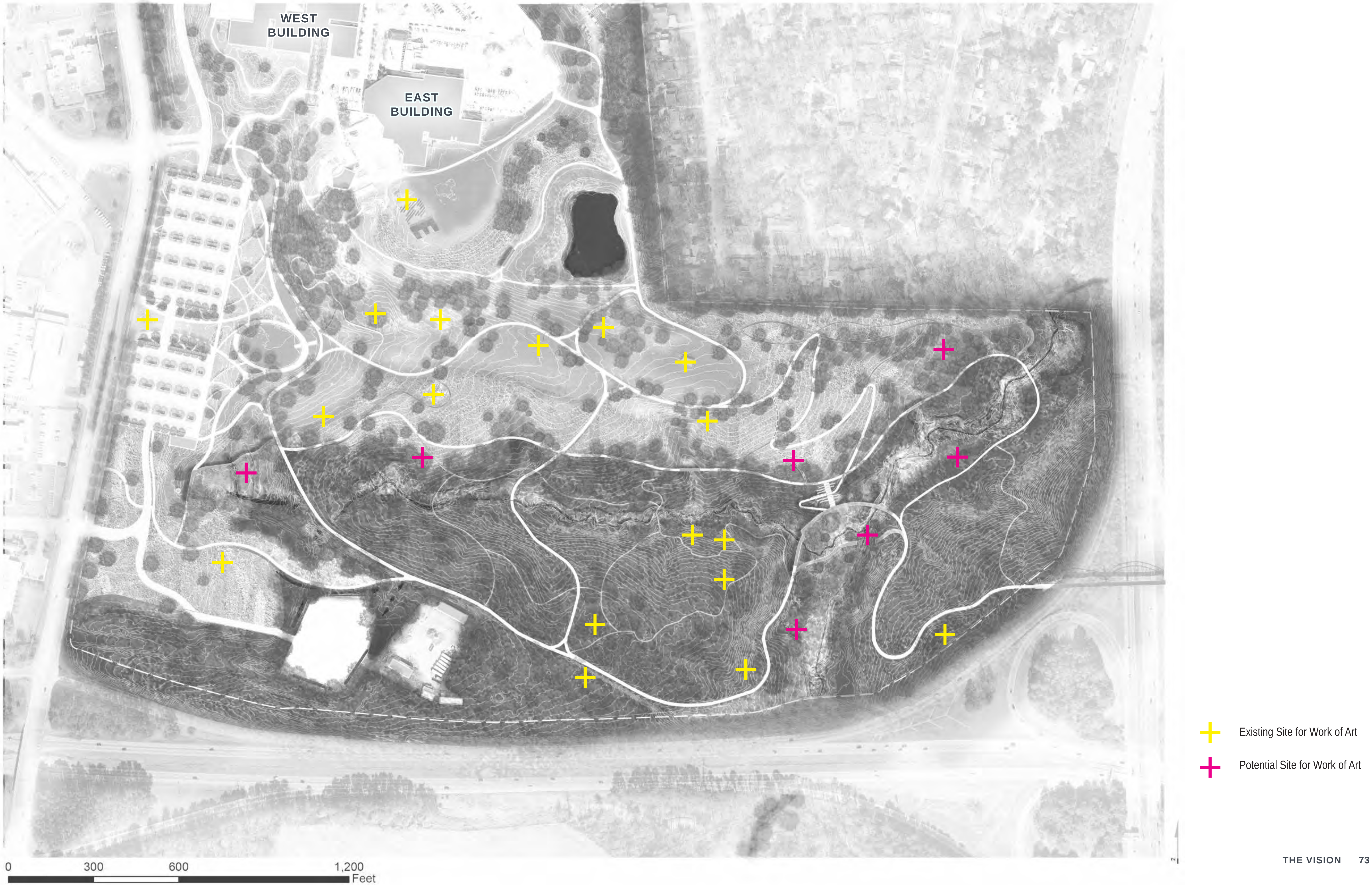
ART OPPORTUNITIES

BACKGROUND

The move of the North Carolina Museum of Art from downtown Raleigh to the Blue Ridge Road location reflected the desire to situate this cultural institution within a natural setting. The 50-acre property logically could have been conceived as a conventional sculpture park, but the Museum sought to develop a plan that would bring together art, nature, and people in more innovative and engaging ways.

The first significant chapter in this more than thirty-year history began in the late 1980s, when the Museum selected a collaborative Design Team composed of artist Barbara Kruger, architects Henry Smith-Miller and Laurie Hawkinson, and landscape architect Nicholas Quenelle to create a site plan. It was a groundbreaking move to include an artist in the planning of a large-scale museum concept. The plan, *Imperfect Utopia: A Park for the New World* (1989), provided an initial framework for developing a museum park and an outdoor art program. Its physical manifestation in 1996 as a site-specific, conceptual artwork by Kruger comprising text, landscape, and built structure, and encompassing a performing arts venue (the Joseph M. Bryan, Jr., Theater in the Museum Park), signaled the intention to create interactive encounters with the arts across the campus. In the ensuing years, and particularly since 2003, when the Museum Park opened as a defining element of the NCMA visitor experience, the outdoor art program has grown and evolved.

Barbara Kruger's Picture This *and the Joseph M. Bryan, Jr., Theater in the Museum Park; Photo: NCMA*


WEST BUILDING
EAST BUILDING
0
300
600
1,200
Feet
Existing Site for Work of Art
Potential Site for Work of Art

ART OPPORTUNITIES (CONT.)

ART PROGRAM

The art in the Museum Park is both permanent and temporary, made of diverse materials and produced by artists of different generations, nationalities, cultures, and lived experiences. Various works have been placed in relation to points of entry and the Museum buildings to optimize landscape aesthetics and draw people to the galleries. Mark di Suvero's monumental sculpture *Ulalu* (2001), on loan from the artist, on the street-front presentation lawn serves as a visual beacon to the campus. Commissions by Roxy Paine and Ursula von Rydingsvard enliven the lawn around West Building and beckon the public to come see the People's Collection, presented for free. A mirrored labyrinth sculpture by Jeppe Hein—installed along the walkway from the upper parking lot to West Building—similarly greets visitors and offers an interactive encounter with art, nature, and people as visitors see fleeting reflections of themselves and the natural environment displayed across its surface. In other cases, outdoor displays function as an extension of the gallery experience. For example the Auguste Rodin sculptures in the Iris and B. Gerald Cantor Court and Garden are set in direct dialogue with the selection of Rodin sculptures presented in an adjacent interior gallery.

The middle section of the Museum Park receives the largest number of visitors and encompasses a large swathe of land developed between the East Building's green and the smokestack. It serves as a site for temporary projects and collection works that activate and define various routes through the campus. Most notable among the latter is Thomas Sayre's iconic *Gyre* (1999), the first art commission after the Park Theater, which punctuates the path connecting the campus to the greenway used for recreation and exercise. Other works in this part of the Park, such as Daniel Johnson's *Untitled* (2019), echo Sayre's use of natural materials. Several infuse the landscape with a burst of color like Yinka Shonibare's *Wind Sculpture II* (2013), which evokes a piece of patterned cloth caught by the wind, inspired by multiple cultural sources, thus reflecting the ethos of the collection to invite reflection on past histories and present realities.

The Museum presents a variety of public programs in the Park, with many inspired by the artworks on view. Temporarily sited on a hill above the Park Theater, Heather Hart's 2019 *Southern Oracle: We Will Tear the Roof Off*, served as an inviting platform for visitors to encounter daily and to enjoy a series of community programs that welcomed diverse audiences. More recently, in 2020, Leonardo Drew's *City in the Grass*, was installed in the Ellipse, creating a whimsical, community gathering point around art at the height of the pandemic.

The area of the Park most remote from the Museum's buildings and security systems, known as the preserve, offers various sites that are ideal for artists who create works in the landscape and focus on the healing of natural environments. Thus far there have only been a handful of artworks developed there, key among them Chris Drury's *Cloud Chamber for the Trees and Sky* (2003). Future works in the preserve will generally not be permanent. Exceptions may include artworks that either become part of the fabric of the Park—a bridge, for instance—or commissions intended to change over time. The overarching emphasis will be on ephemeral, experimental, and site-conscious commissions. With the knowledge that the Park will undergo a long series of restoration phases, this program will evolve over time to coordinate with phases of work and emphasize artist collaborations with each phase of design, to echo the formative concept of the Park.

Existing art in the Museum Park; Photos: NCMA (top left, bottom left to right), Rachel Woods (top right, center)

EDUCATIONAL OPPORTUNITIES

Through this Vision Plan, the Museum seeks to engage visitors in learning and experiencing the Museum Park and advance an ambitious campus plan to create a cohesive, accessible, and interconnected experience.

Education objectives in the Museum Park will be achieved either through NCMA-facilitated educational events and programs or by self-guided educational opportunities provided to visitors.

The Education, Outreach, and Audience Engagement team will instill a sense of belonging in community spaces through programming and resources that reflect people's diverse lived experiences, offering events that invite connections with art, nature, and other people to create an environment in which people feel welcome.

Audiences will be engaged in topics that focus on the dynamic environmental changes at work in the Museum Park and initiatives being implemented in the Park to ameliorate them. Programs will be developed that stimulate a dialogue between the People's Collection and the Park. The Museum will offer expanded opportunities for public participation that connect visitors on a personal level to their role in land and art conservation and preservation. Interpretation in the Museum Park will also be expanded to engage diverse members of the community on the site's history, native flora and fauna, art conservation, and sustainable design features. Finally, spaces in the Park will be designed to facilitate programming in mindfulness and themes on nature as a work of art and exploration of works of art inspired by nature.

This framework for expanded offerings in the Museum Park will be implemented using methods that are authentic, inclusive, and welcoming to provide experiences that engage a broader audience. Utilizing universal design principles and gradually adding bilingual labels, the NCMA will update and expand existing Park signage to increase visitors' ability to engage with art, nature, and people, improving Park accessibility for diverse audiences and ages. The Museum Park experience will be enhanced for visitors by providing maps of accessible routes and accessible areas available in the Park, as well as by offering like experiences throughout the Park. Technology will be strategically utilized to reach audiences through virtual programs and online educational lectures.

Previous outdoor educational programing; Photos: (left) Rachel Woods, (right) NCMA

WEST BUILDING
EAST BUILDING
0
300
600
1,200
Feet
Potential Site for Educational Feature

SITE ORGANIZATION

The Vision Plan organizes the site into six zones, each offering a unique experience in the Park and a distinct role in the House Creek and unnamed tributary watersheds.

1. Upland Headwaters: encompasses the southwest corner of the NCMA property, including the area south of the main parking lot on Blue Ridge Road, the overflow parking area, and the maintenance and operations area.
2. Unnamed Tributary Corridor: encompasses the stream's riparian corridor, which flows east through the park to meet House Creek; as well as adjacent forested areas to the south of the stream up to the Blue Loop/ greenway trail.
3. House Creek Corridor: encompasses the stream's riparian corridor from the NC DOT property line at Wade Avenue to the northeast corner of the project boundary, where House Creek flows below I-440, as well as the adjacent forested areas in the southeast corner of the property.
4. Confluence: encompasses the area where the unnamed tributary enters House Creek, as well as the surrounding wetland areas.
5. Lower Meadow: encompasses the upland area east of the Blue Loop crossing at the unnamed tributary and south of the property line shared with the Meredith Woods neighborhood.
6. Upper Meadow: encompasses the upland area west of the Blue Loop crossing at the unnamed tributary and south of the section of the Blue Loop trail, which connects the Ellipse and Lowe's Park Pavilion.


WEST
BUILDING
EAST
BUILDING
Upper Meadow
Lower Meadow
House Creek Corridor
Unnamed Tributary Corridor
Confluence
Upland
Headwaters
0
300
600
1,200
Feet

Add sidewalk between parking area and greenway
Connect trail to Welcome Center
Welcome Center
Provide boardwalk connections through wet meadow
Improve water quality above headwaters
Connect trail to greenway
Convert to warm-season grass meadow
Expand forest canopy
Enhance treatment of spring and stormwater in overflow parking area
0
150
300
600
Feet

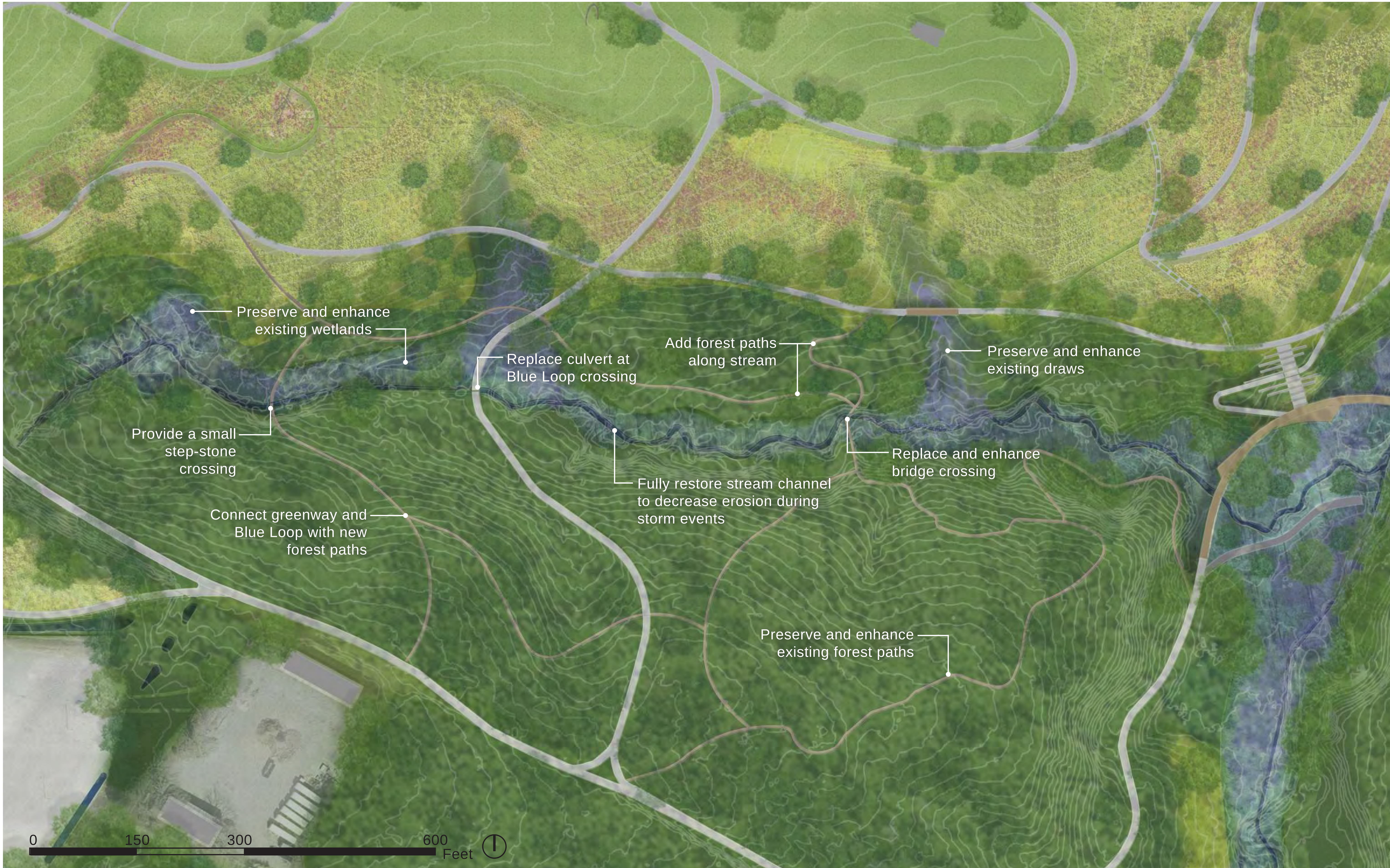
HEALING THE UPLAND HEADWATERS

Proposed improvements in the upland headwaters area will work in concert to capture and clean stormwater runoff before it reaches the headwaters of the unnamed tributary.

A wet meadow will help treat runoff from the main parking area to the north of the Welcome Center, preventing it from channelizing along the trail. Additional stormwater treatment in the areas surrounding the overflow gravel parking lot will help capture and filter water before it flows over the greenway trail, where it currently creates a hazard for cyclists. Water quality improvements in the area near the southwest section of the Blue Loop, above the current headwaters, will help slow runoff and stabilize slopes as the water enters the unnamed tributary channel.

The NCMA's continued conversion of fescue turf areas to warm-season grass meadows west of the overflow parking area will also aid in slowing stormwater while capturing and storing carbon on site to reduce the amount of carbon dioxide in the atmosphere.

Pedestrian and bike traffic circulation improvements will connect the new Welcome Center with the Blue Loop, greenway, and main parking lot.



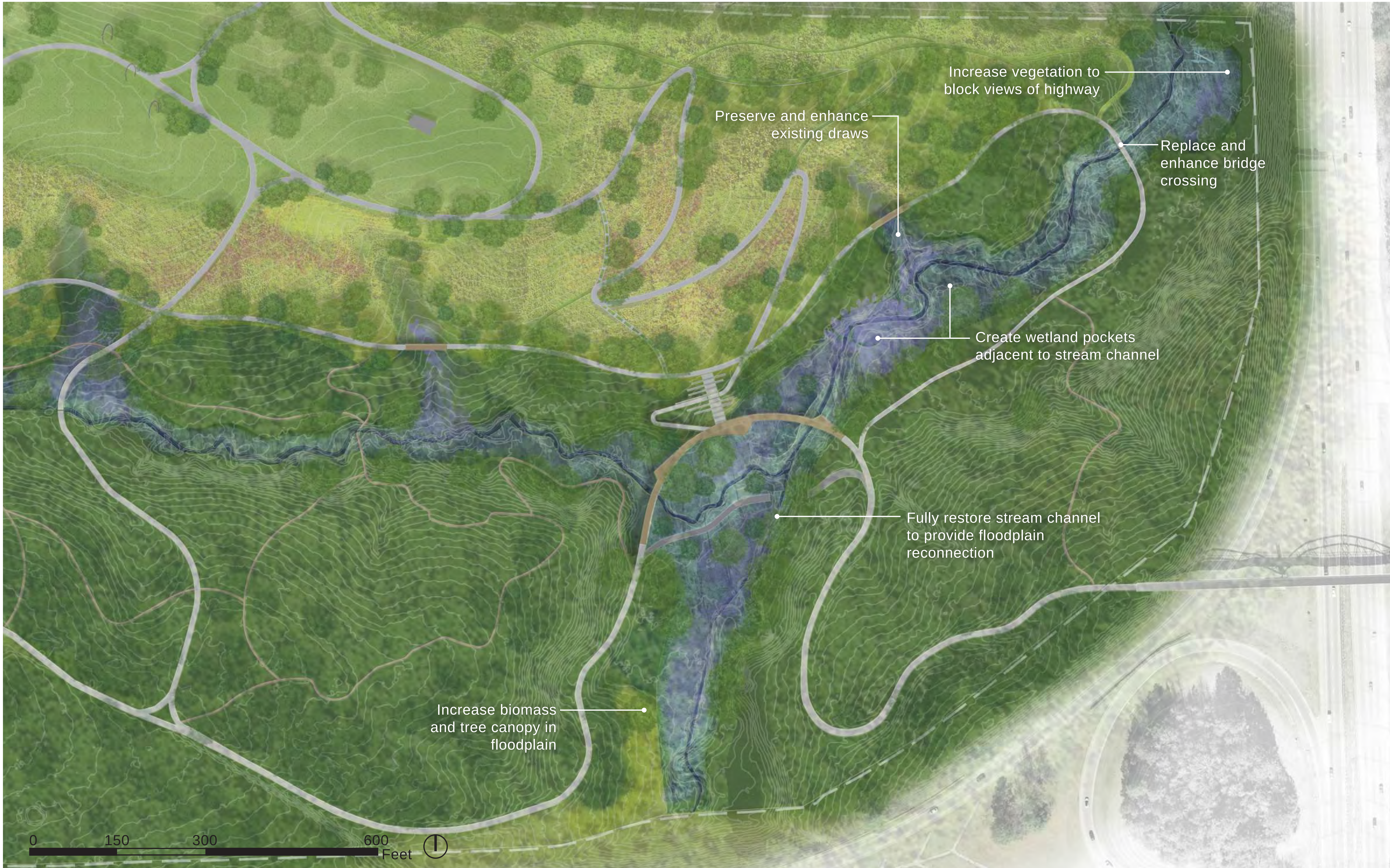
Preserve and enhance existing wetlands
Replace culvert at Blue Loop crossing
Add forest paths along stream
Preserve and enhance existing draws
Provide a small step-stone crossing
Replace and enhance bridge crossing
Fully restore stream channel to decrease erosion during storm events
Connect greenway and Blue Loop with new forest paths
Preserve and enhance existing forest paths
0
150
300
600
Feet

HEALING THE UNNAMED TRIBUTARY CORRIDOR

In addition to the full restoration of the unnamed-tributary stream channel, other restoration efforts in the unnamed tributary corridor will protect and enhance the existing draws and wetlands, which capture and filter runoff from the Upper Meadow into the stream.

Additional forest path connections to the greenway and Blue Loop trail and along the stream will improve existing circulation and provide more options for visitors seeking to be fully immersed in the riparian forest ecosystem. These trails will be constructed and routed in a way that responds to the sensitive conditions surrounding the wetlands and streams. A small step-stone crossing will allow children and other visitors to safely experience the water's edge while avoiding negative impacts on water quality. Replacing the culvert where the Blue Loop trail crosses the unnamed tributary will ensure that water in the stream flows unimpeded beneath the crossing during increasingly common, large storm events, which will prevent damage to the trail.

The wooden bridge leading to the *Cloud Chamber* installation, which was damaged in a hurricane years ago, will be replaced with a durable bridge crossing that spans the entire floodplain.


Increase vegetation to block views of highway
Preserve and enhance existing draws
Replace and enhance bridge crossing
Create wetland pockets adjacent to stream channel
Fully restore stream channel to provide floodplain reconnection
Increase biomass and tree canopy in floodplain
0
150
300
600
Feet

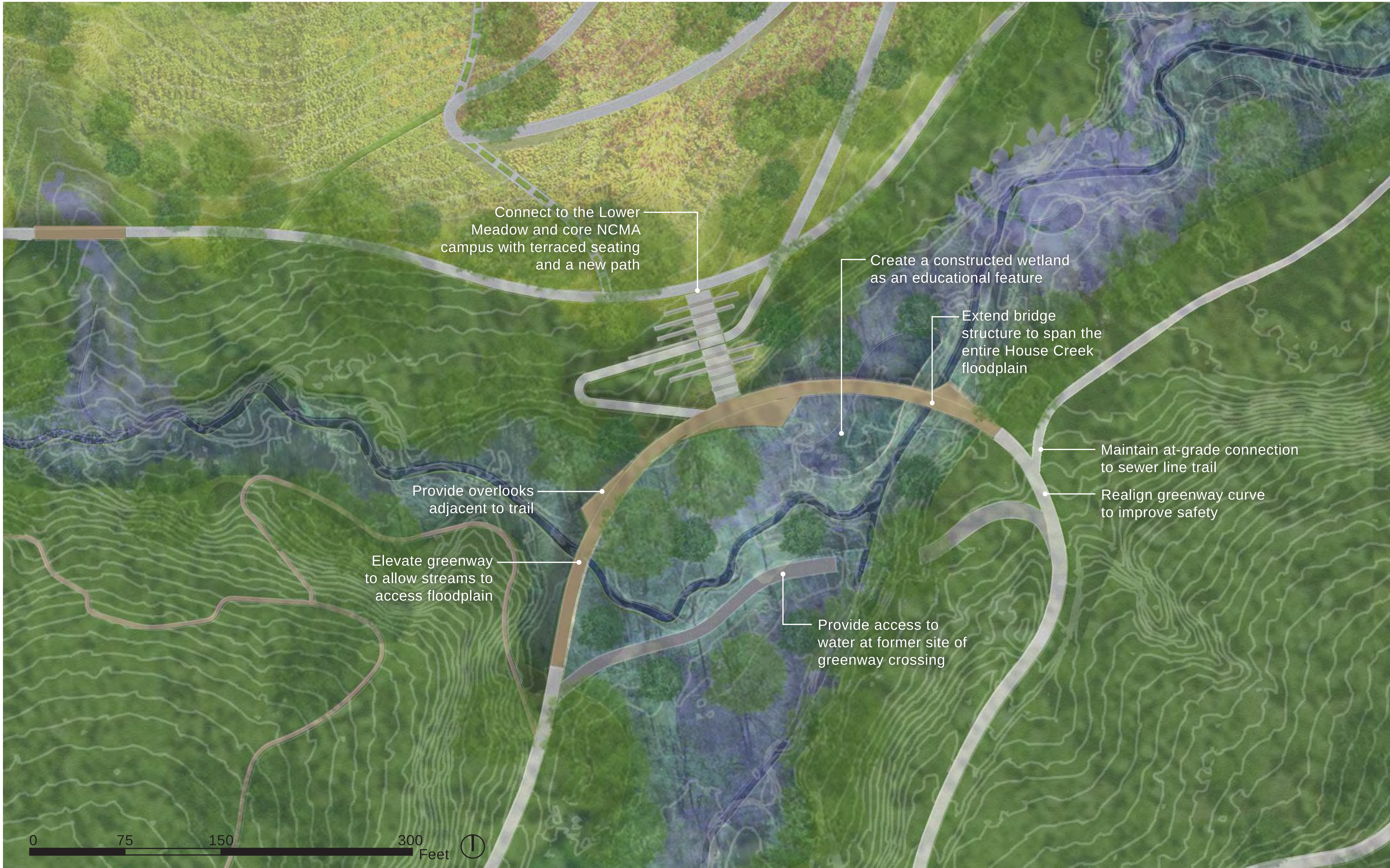
HEALING THE HOUSE CREEK CORRIDOR

A similar approach to watershed restoration will be employed in the House Creek corridor. The plan calls for increasing biomass in existing draws that connect the Lower Meadow with the stream corridor. Elevated trail crossings over these draws will allow visitors to experience this unique ecosystem without negatively impacting water quality.

As part of the full restoration of the stream channel, new wetland pockets will be created along the edges of the stream. These areas will provide habitat, improve the visitor experience, slow stormwater, and capture carbon on site.

An increase in biomass and tree canopy in the floodplain adjacent to Wade Avenue, as well as the expanded right-of-way along I-440, will filter stormwater and block views to the highways from inside the Park.

The lower bridge crossing on House Creek will be replaced with a more adequate structure that spans the entire floodplain, allowing water to pass underneath without obstruction.


Connect to the Lower Meadow and core NCMA campus with terraced seating and a new path
Create a constructed wetland as an educational feature
Extend bridge structure to span the entire House Creek floodplain
Maintain at-grade connection to sewer line trail
Realign greenway curve to improve safety
Provide overlooks adjacent to trail
Elevate greenway to allow streams to access floodplain
Provide access to water at former site of greenway crossing
0
75
150
300
Feet

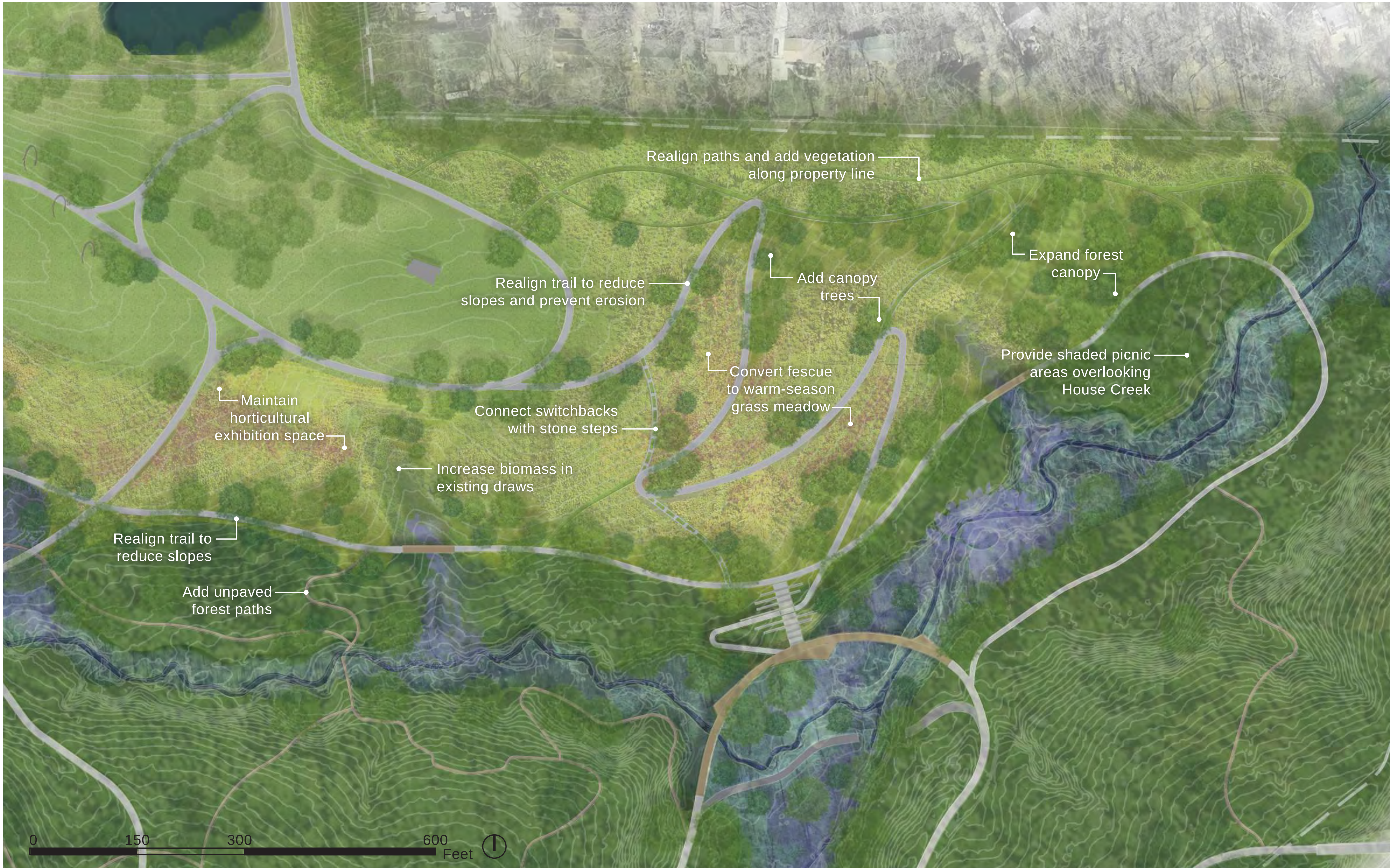
HEALING THE CONFLUENCE

The confluence of the unnamed tributary and House Creek is a focal point of the Vision Plan. This will be a very exciting and special place that serves as a gateway, connecting people entering the NCMA property via the greenway with the rest of the Park and the main buildings.

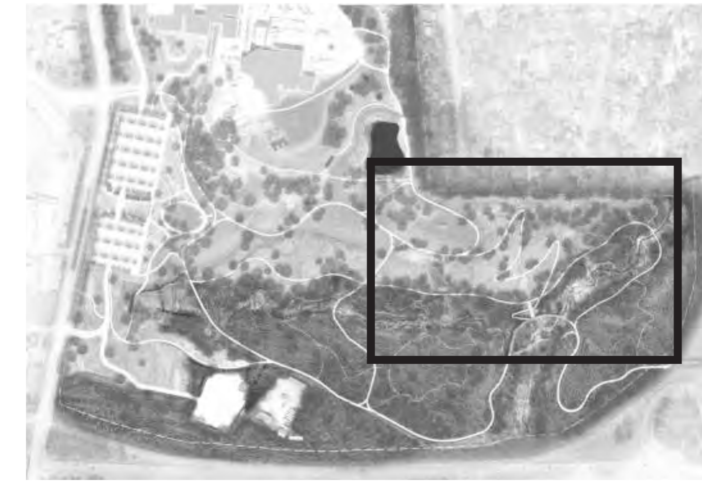
The plan proposes that the NCMA realigns the greenway to help alleviate trail safety issues while improving water quality in both streams. If the trail is elevated out of the floodplain, the streams can reach the floodplain during large storms, creating new wetland areas that are highly visible to those looking down from the greenway trail above.

Pushing the trail north creates an opportunity to tie into the Lower Meadow trail system, where terraced seating and a ramped, ADA-accessible trail connection create a space for gathering and resting before transitioning into a new zone in the preserve.

At the site of the former greenway trail, smaller unpaved paths will provide more secluded access to the water's edge, as well as necessary maintenance access for the sewer line. The existing greenway bridge will be removed.


Realign paths and add vegetation along property line
Expand forest canopy
Add canopy trees
Realign trail to reduce slopes and prevent erosion
Provide shaded picnic areas overlooking House Creek
Convert fescue to warm-season grass meadow
Maintain horticultural exhibition space
Connect switchbacks with stone steps
Increase biomass in existing draws
Realign trail to reduce slopes
Add unpaved forest paths
0
150
300
600
Feet

HEALING THE LOWER MEADOW



The Vision Plan proposes significant changes to the land cover and circulation in the Lower Meadow. The plan envisions a shift from a strictly delineated landscape of fescue meadow and forest into a warm-season grass meadow with a successional forest transition along the lower trail. Additional clusters of canopy trees throughout the Lower Meadow will provide shade, visual interest, and places to rest.

The section of the Meadow Trail that traverses the hillside from Yinka Shonibare's *Wind Sculpture II* to the downstream bridge crossing over House Creek will be dramatically altered to decrease existing slopes and provide a connection to the proposed gateway at the confluence area. The lower section of the Meadow trail will remain is its current location, with slight realignments in key areas to even out grades in steeper sections.

The deep draws within the Lower Meadow will have a more diverse palette of plant material, which will slow stormwater and will add visual interest across the long views in the meadow.

Planting successional vegetation in and adjacent to the Duke Energy power line easement will provide necessary screening of the residential area beyond, and mowing fresh paths will create a new path system with a unique character in a currently underutilized section of the Park.

Pull Blue Loop south to soften slope
Extend unpaved trail connection
Convert fescue to warm-season grass meadow
Increase biomass in existing draws
Expand forest canopy
Add unpaved forest paths
0
150
300
600
Feet

HEALING THE UPPER MEADOW

The proposed restoration within the Upper Meadow will build upon the successful efforts already underway to convert the fescue meadow to warm-season grasses and successional forest plantings. As in the Lower Meadow, increased biomass in the draws connecting the meadow with the stream corridor will aid in slowing and filtering runoff before it enters the unnamed tributary and adjacent wetlands.

Additional unpaved trail connections will provide access to the unnamed tributary and connect the Meadow Trail with the overlook which currently hosts Mark di Suvero's *No Fuss* sculpture.

The Blue Loop trail is shifted off of the ridge line near the Ellipse to ease the grade as the trail dips east into the Park. It will return to its current alignment prior to reaching Thomas Sayre's *Gyre* sculpture in order to maintain the existing relationship between visitor and artwork as the trail passes between the sculptural pieces. This will also create visual interest by employing the concept of "hide and reveal". As visitors enter the Park from the main parking lot along Blue Ridge Road, their sightlines will be more focused on the forested stream corridor, and much of the preserve will be obscured from view. As they make their way deeper into the Park, the rest of the landscape will be slowly revealed.

UPLAND HYDROLOGICAL RESTORATION

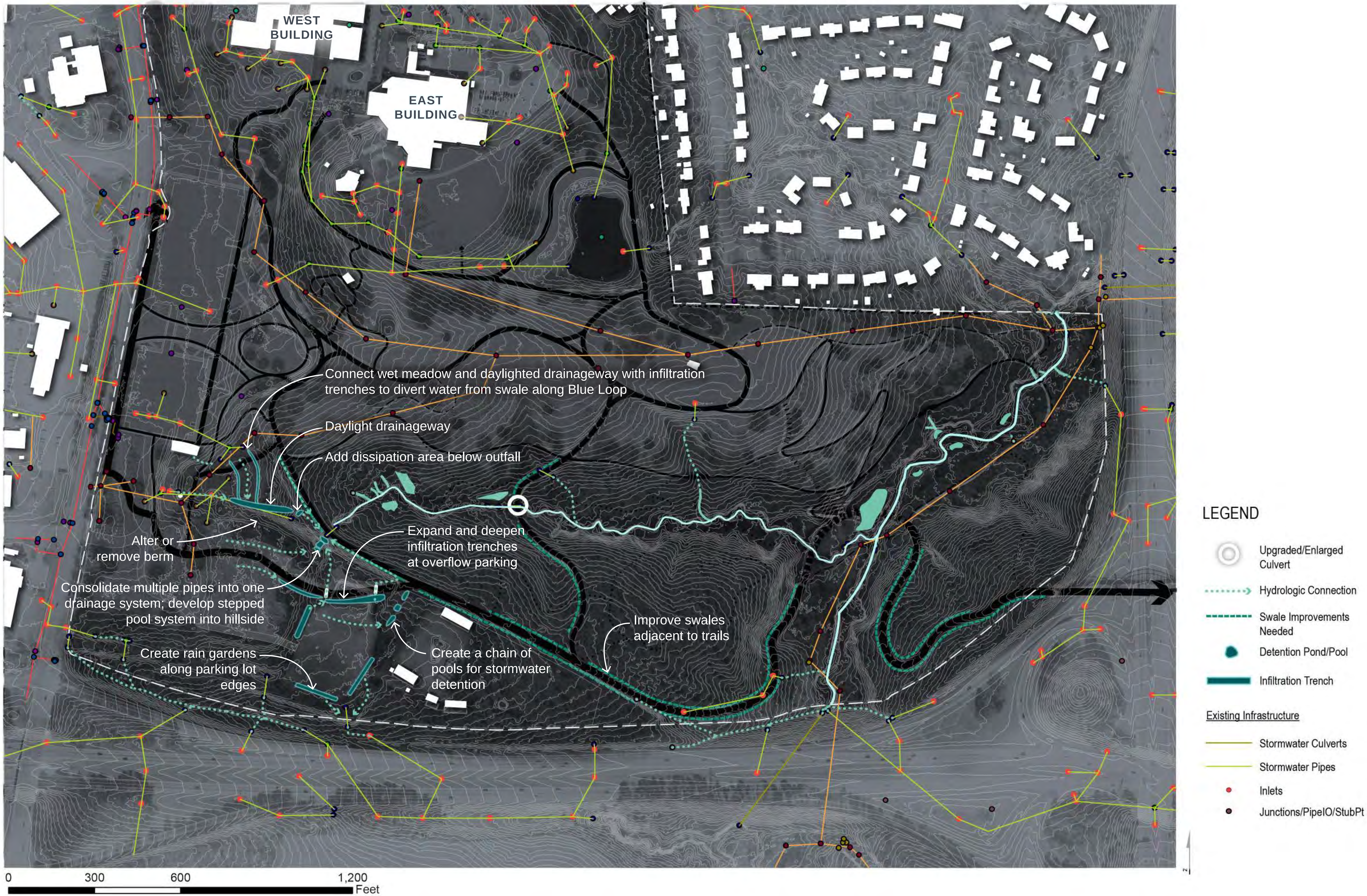
The capture and filtration of stormwater runoff within the area that drains into the unnamed tributary headwaters is a key strategy for improving water quality within both of the streams on NCMA property. Because the Museum controls the entire watershed of the unnamed tributary, improvements in this area will yield measurable and highly visible improvements to water quality as a result of the Museum's stewardship efforts. The significance of the restoration process will be on display to Museum visitors as the stream heals over time.

Stormwater runoff from the southern section of the main parking lot along Blue Ridge Road currently drains into the dissipater ring located just below the new Welcome Center. In order to prevent the water flowing out of the dissipater from re-channeling along the Blue Loop trail during large storms, additional stormwater treatment is needed. The Vision Plan proposes a wet meadow with infiltration trenches leading from the dissipater area to the existing swale to the south. Stormwater currently being piped below this swale could be daylighted and allowed to infiltrate more slowly through the soil before reaching the stream.

Additional dissipation areas should be constructed on the west side of southwest section of the Blue Loop, where water drains into the culvert under the trail prior to forming the headwaters of the unnamed tributary. Relics of agricultural and institutional infrastructure are partially visible in the wooded hillside above the culvert, and the multiple drainageways are likely having negative impacts to water quality. These drainageways will need to be excavated and combined into one channel with additional stormwater treatment features. A stepped pool system constructed with native stone would carry the water down the steepest part of the hillside, slowing the runoff and creating visual interest for trail users.

Stormwater runoff and seepage from what may be a subsurface spring near the overflow parking area are causing safety issues when water pools or freezes on the greenway trail below. The expansion and deepening of infiltration areas surrounding the parking lot will help capture this water before it makes its way to the trail. Future subsurface studies will be needed to better understand the source and flow of the spring. The addition of rain gardens on the south side of the overflow parking area will capture and treat stormwater before it enters the drainage ditch along Wade Avenue, helping to filter sediment and pollutants before they make their way into House Creek.

A series of stepped pools between the maintenance and overflow parking areas will capture stormwater runoff from impervious surfaces, filtering and slowing the water before it enters the headwaters of the unnamed tributary.



WEST BUILDING
EAST BUILDING
Connect wet meadow and daylighted drainageway with infiltration trenches to divert water from swale along Blue Loop
Daylight drainageway
Add dissipation area below outfall
Alter or remove berm
Expand and deepen infiltration trenches at overflow parking
Consolidate multiple pipes into one drainage system; develop stepped pool system into hillside
Improve swales adjacent to trails
Create rain gardens along parking lot edges
Create a chain of pools for stormwater detention
LEGEND
Upgraded/Enlarged Culvert
Hydrologic Connection
Swale Improvements Needed
Detention Pond/Pool
Infiltration Trench
Existing Infrastructure
Stormwater Culverts
Stormwater Pipes
Inlets
Junctions/PipeIO/StubPt
0
300
600
1,200
Feet

Existing swale along path; Photo: Andropogon

Existing draw in fescue meadow; Photo: Andropogon

Example of proposed enhancements to swales along paths; Photo: Sustainable Technologies Evaluation Program's LID SWM Planning and Design Guide

Example of proposed enhancements to draws in meadow ecosystem; Photo: Kyle Lanzer

CAMPUS-WIDE STRATEGIES

A number of stormwater treatment strategies that will improve both water quality and aesthetics can be implemented throughout the entire Museum Park.

Stone check dams and dense perennial plantings should be added to the existing swales along pathways throughout the Park. This is especially important in areas with steep slopes that drain directly into the streams. The check dams will slow runoff and allow sediment and pollutants to filter down through the soil before reaching the stream corridors. Plantings that can withstand extremes of wet and dry conditions will be best suited for these areas, and the added biomass will slow runoff while also capturing carbon. Flowering plant species will provide visual interest for trail users and sustenance for pollinators.

The draws that connect the upland meadows with the riparian corridor play a critical role in improving water quality in the streams. Additional biomass in the form of deep-rooted plants can slow stormwater in these areas, allowing it to soak back into the water table, and preventing sediment from washing into the streams. The contrast in color and texture between plant material in the draws and plant material in the upland meadow will provide visual interest and help convey to visitors the story of how water moves through the preserve.

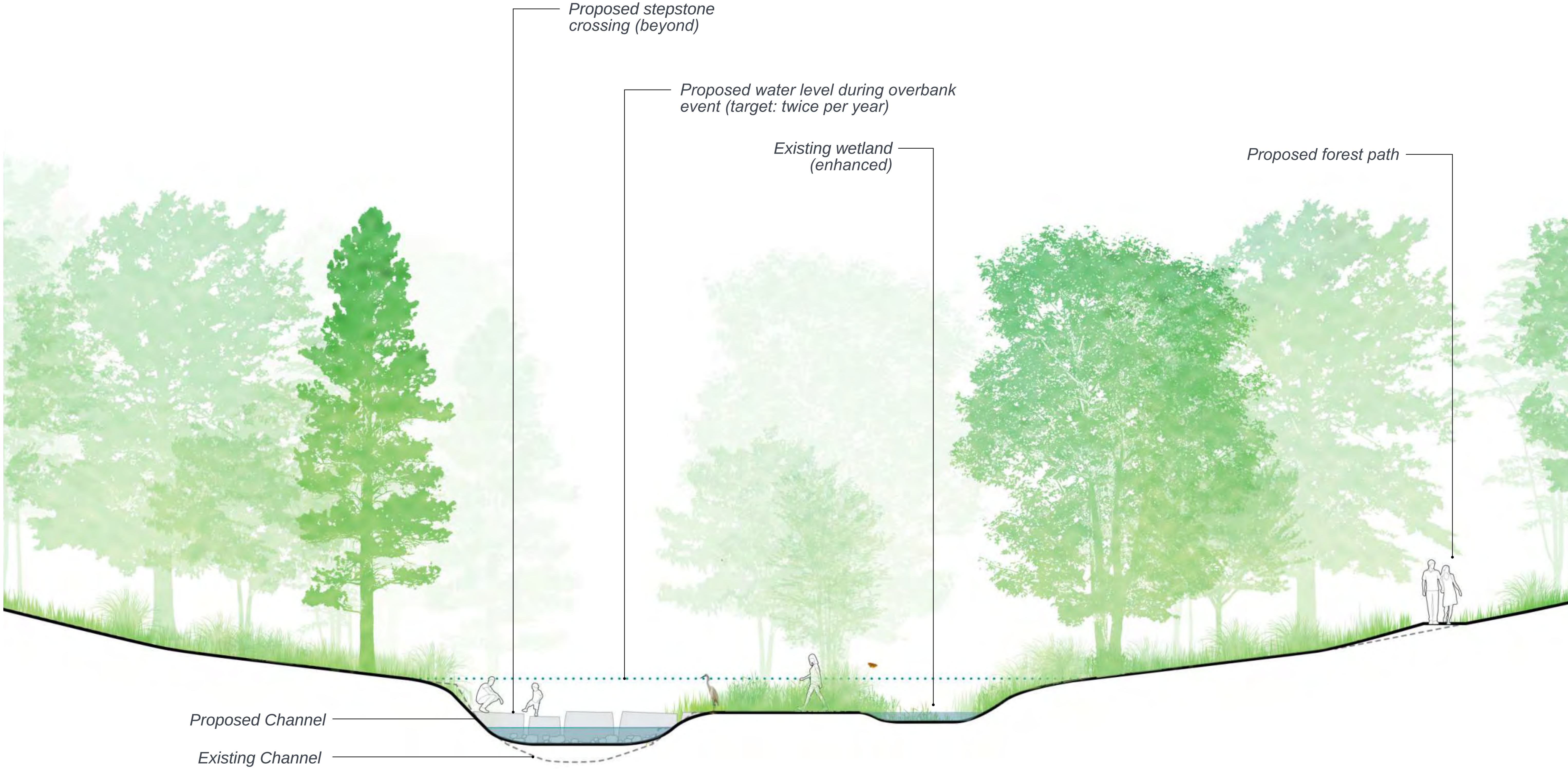
STREAM RESTORATION

In order to formulate an effective stream restoration design approach, it is essential to understand the suite of factors influencing watershed and channel dynamics. As such, awareness of land use history is instrumental in identifying key processes that have contributed to stream and riparian corridor impairment. The NCMA property, as detailed in previous sections, has a legacy of land disturbance activities that have been deleterious to healthy stream system functions. Decades of unsustainable agriculture and other disturbance-intensive land use practices caused widespread erosion of soil from the uplands flanking NCMA stream systems, overwhelming their valleys with a wedge of mobile sediment. As land cover gradually transitioned over the years toward more sustainable uses, this sediment supply was largely eliminated, and the previously deposited sediment was stabilized with naturally recruited vegetation. In order to adjust to this condition, the stream channels in the NCMA property, both House Creek and the unnamed tributary, incised vertically through the sediment, resulting in high stream banks that confine higher flow events in the existing channel cross-section. This combination of factors has resulted in the unhealthy, erosive channel conditions present today.

To arrest the widespread bank erosion and streambed scour present along NCMA stream reaches and achieve functional and ecological improvements, a fundamental element of the proposed stream restoration design is to decrease the size of the existing streams' cross-sectional area by raising the streambed elevation. This cross-sectional size adjustment has multiple benefits, chief among them the elimination of bank erosion and the reintroduction of high-volume flows to adjacent floodplain areas. Other improvements include improving channel planform geometry to avoid overly sharp bends, installation of stone/gravel grade control structures and woody debris habitat elements, and establishment of native plant communities suited to a wetter soil moisture regime that is anticipated upon the completion of restoration activities.

Alger Park Restoration, Washington DC; Photo: Biohabitats

Stepstone crossing at unnamed tributary



Unnamed Tributary Section A - A'

UNNAMED TRIBUTARY RESTORATION

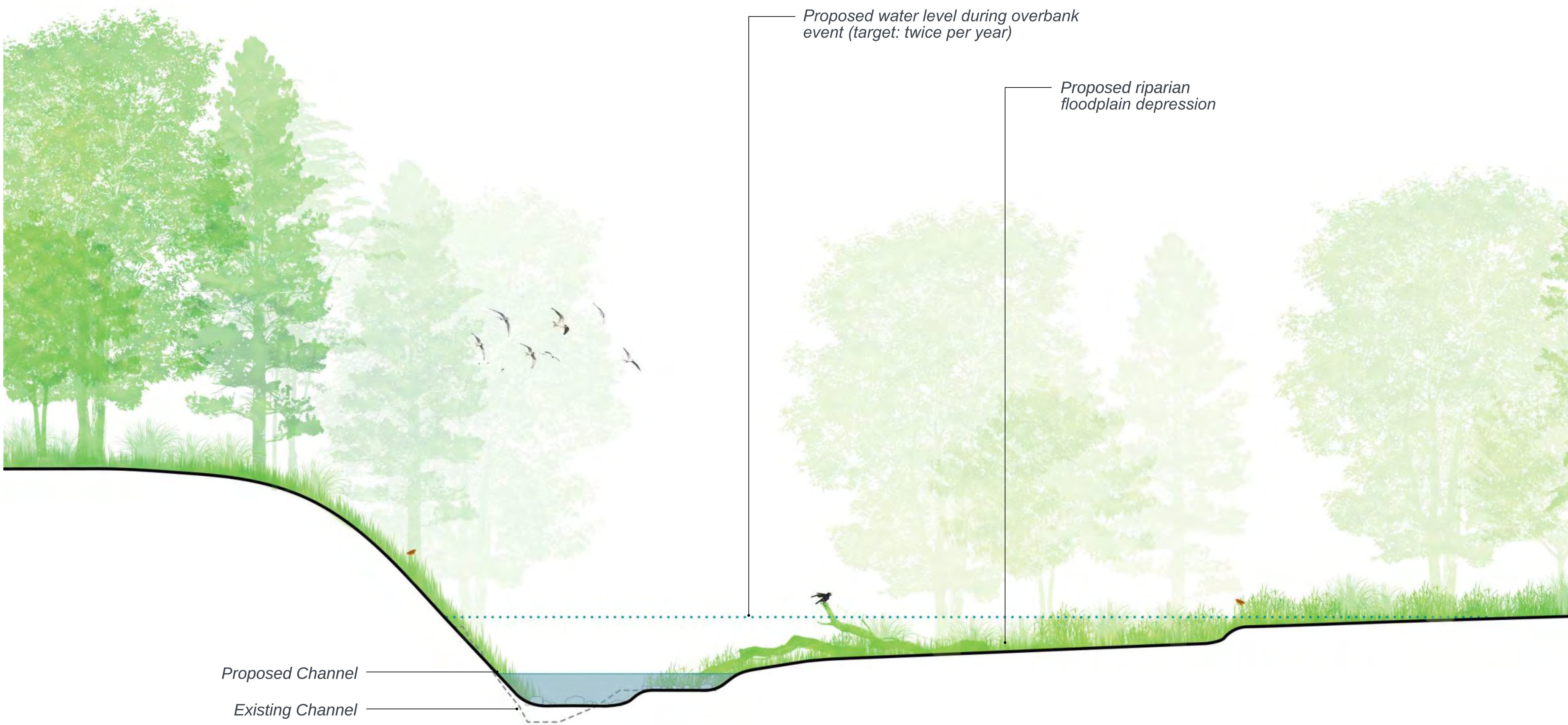
House Creek and the unnamed tributary, while both first-order, headwater streams, differ significantly in terms of channel/ floodplain dynamics. Thus, the design approach is different for each stream. The unnamed tributary occupies a relatively steep gradient valley that is entirely confined in NCMA property. Adjacent grade is concave/U-shaped, and there is minimal flat adjacent to the channel. Thus, it is likely that the unnamed tributary used to resemble a chain-of-pool, beaver influenced stream system that lacked a naturally wide floodplain. Proposed restoration responds to this context by calling for regenerative stormwater conveyance (RSC) design. With this approach, the existing channel is partially backfilled, and stone grade control structures are placed to gradually step the streambed elevation down toward its confluence with House Creek in a rhythmic, stable fashion.

This approach for the unnamed tributary emphasizes reestablishing channel stability, improving water and aquatic habitat quality, and enhancement of the streamside terrestrial forest.

The entire watershed of the unnamed tributary lies in Museum property, which allows for control over the stormwater runoff that reaches the channel and facilitates the stewardship of the stream corridor's ecosystem in the future.

Generally, the size of the upstream watershed is a primary factor in determining the magnitude of flow in a stream. The unnamed tributary is a headwater stream with a relatively small watershed, and therefore the channel and riparian concept design seeks to minimize disturbance and incorporate stream structures that are appropriate for the relatively small stream flow volume. Furthermore, the proposed design seeks to restore presumptive pre-disturbance valley grades to best dissipate intense stormwater flow events.

Opportunities to restore wetland areas along the unnamed tributary are not abundant due to the steepness of the stream valley and its narrow shape; however, creation of smaller depressional wetland "pockets" is possible in the flatter, wider valley locations.



House Creek Section B - B’

HOUSE CREEK RESTORATION

In contrast to the unnamed tributary, House Creek's larger watershed size and geomorphic character indicate that it was previously well connected with a relict floodplain prior to land use disturbance. The flat terraces and alluvial soils that flank the channel throughout the Museum property indicate there was once a naturally frequently flooding system. Proposed restoration design will seek to reintroduce natural flood dynamics to the House Creek stream/floodplain complex by raising the streambed elevation such that existing, forested surfaces can function as an active floodplain. This will greatly help to dissipate erosive in-stream forces, eliminate bank erosion, and potentially create adjacent wetlands hydrated by an anticipated higher local groundwater table and overbank events.

The conceptual restoration design for House Creek uses fill from reshaping the banks as well as imported material to raise the elevation of the existing incised stream channel, so that future storm flows can more easily access the floodplain, where potential pollutant loads are reduced. At the confluence of the unnamed tributary, the concept design includes a created wetland/stream complex that will extend across a wide area of the floodplain, serving as a filter for water quality and diversifying wildlife habitat in the stream corridor. The floodplain of House Creek is substantially widened with the restoration, accommodating future flows coming from the upper watershed off site and providing sites for additional floodplain depressions and pocket wetlands downstream of the confluence with the unnamed tributary. These areas will also provide additional habitat diversity, improving site resiliency for the future.

Tributary riffle structure

Tree and woody debris incorporated into stream and riparian wetlands

Floodplain depression wetlands

Cascade drop structure

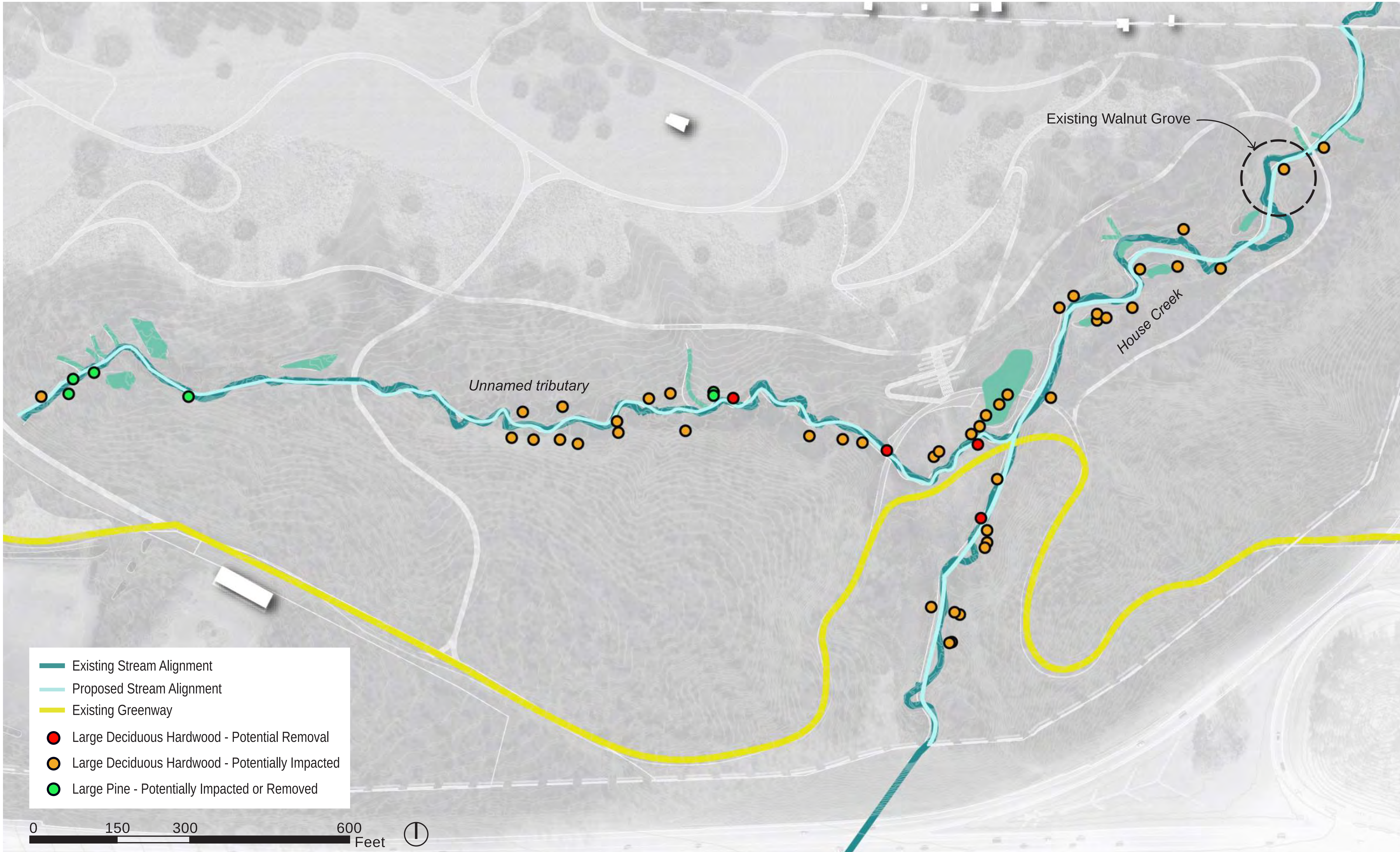
House Creek riffle structure

Floodplain bench with adjacent wetland

Precedent imagery from previous stream restoration efforts: Biohabitats

RESTORATION FEATURES

The most relied-upon restoration channel structure used in the conceptual design is the cobble riffle structure, which stabilizes the channel elevation, preventing future erosion and incision. Pools are created in between the riffle structures, and the combination of the two provides improved aquatic habitat diversity for aquatic insects (macroinvertebrates) and fish species. An at-grade boulder structure is located at the downstream extent of restoration on House Creek, preventing scouring and erosion from proceeding upstream, and protecting the restoration structures. Numerous floodplain depressions will be created in the House Creek floodplain to diversify aquatic and terrestrial habitat. Wood from trees harvested during the construction process with be reused on the site to create habitat such as standing snags for birds and floodplain logs for terrestrial wildlife habitat in the floodplain. The photos on the facing page illustrate the use of these features in previous stream restoration projects of similar scale and character.


Existing Walnut Grove
House Creek
Unnamed tributary
Existing Stream Alignment
Proposed Stream Alignment
Existing Greenway
Large Deciduous Hardwood - Potential Removal
Large Deciduous Hardwood - Potentially Impacted
Large Pine - Potentially Impacted or Removed
0
150
300
600
Feet

EXISTING FOREST RESOURCES MANAGEMENT

Existing oak trees near confluence, damaged by erosion

Existing walnut grove along House Creek; Photos: Andropogon

As part of the process of adjusting grades in the stream corridors to lift the channel closer to its floodplain elevation, some existing trees along the stream will be impacted. However, the substantial tree loss that is currently happening along the banks of the unnamed tributary and House Creek will continue to worsen if restoration does not occur. An increase in volume and speed of water during storm events in both streams is causing the roots of trees along the channel to become exposed, and eventually the trees become so unstable that they fall. Not only does this contribute to erosion and poor water quality, but it poses a safety risk for trail users near the damaged trees. Evidence of this condition, both in terms of fallen trees and trees with heavily damaged root systems, can be seen throughout the stream corridors in the preserve.

Fortunately, grading in the future detailed restoration plans can be adjusted to respond to specific trees that are significant enough and healthy enough to warrant preservation. Care should be taken to minimize impacts to the existing grove of Walnut trees at the lower reaches of House Creek, as they provide critical habitat for many native birds and insects.

In areas where wetland conditions are created or increased in size, some tree species may be lost due to an inability to withstand the wetter soil conditions. In this case, dead or dying trees can be left to remain in areas where they do not pose a threat to nearby trail users. As these trees decompose, they support many different species of native insects and birds. Any hazard trees that need to be removed can be harvested and reused on site. A more extensive list of opportunities for reusing timber on site is included on the following pages.

It is important to understand that although some tree loss may occur in the beginning of the restoration process, the long-term trajectory of the forest ecosystem is one that will be much more stable and supportive of mature native trees and the wealth of benefits that they provide.

CASE STUDY: BACON RIDGE BRANCH STREAM RESTORATION

Floodplain function restoration completed with 100-percent wood harvested on site; Photos: Biohabitats

Construction: placement of a root wad to raise the stream invert level

Prerestoration: substantial tree loss along stream due to erosion

Construction: installation of log check dams

Postrestoration: woody debris and log jams constructed from wood harvested on site

VEGETATION REGENERATION AND REUSE

Living fence constructed from reclaimed wood, Avalon Nature Preserve (Andropogon)

Reclaimed White Oak benches and signage, US Botanical Gardens; Photo: Andropogon

Proposed restoration activities will not result in the widespread clearing of existing trees and other woody vegetation along the House Creek and unnamed tributary stream corridors. However, hazard trees will be removed, and some clearing and tree felling will be required in order to access the channels with heavy construction equipment. In these instances, trees will generally be flush cut with the ground surface to retain valuable root structures that will continue to stabilize soil.

All trees removed to accommodate the stream restoration design will remain on-site and be incorporated as aquatic and terrestrial habitat structures including large woody debris placement in pools and adjacent wetland areas, brush and log placement along the floodplain surface to increase roughness and habitat niche diversity, and potentially as buried floodplain log sills to provide stability for developing planted vegetation.

Any harvested wood that is not suitable for reuse as part of the stream restoration effort may be processed and used for furniture, signage, or other elements, either in the Park preserve or in the Museum buildings. Smaller woody material and limbs of larger trees can be converted to wood chips and used immediately to build soil in upland areas of the Park, or the wood can be ground into mulch and aged on site for use later in more formal planting areas.

Wood harvested on site could also be used to construct movable or permanent fences, which can aid in keeping trail users out of sensitive or hazardous areas. These fences could replace the existing orange construction fencing currently used in the lower preserve, creating a more visually appealing and sustainable way to control foot and bike traffic.

PROPOSED PLANT COMMUNITIES

Improving biodiversity in the Park is a primary objective of the Vision Plan. While a biodiverse landscape is one that supports many different types of organisms, as well as stewardship of the environmental conditions that sustain them, plant communities in particular provide an informative framework for advancing this goal as part of the proposed restoration of the stream corridors and upland areas in the Park.

Plants are but one sector of a local ecology, but their visibility and enduring presence over time, as well as their many contributions to their local environment, make them excellent proxies for understanding conditions of light, moisture, geology, habitat, and pollinator value. While there will always be exceptions to these categories, identifying key plant communities in the Park provides a framework for maximizing plant, and as a result, ecosystem diversity.

The following plant community categories and plant species have been determined through field work and observation, as well as research into the native plant communities of North Carolina. Surveys were conducted by both Museum staff and consultants to review the conditions and plants present on site. The proposed species in the following pages represent the synthesis of that work, with selections from each plant community that should not only be successful in the zones indicated, but also support the goal to maximize biodiversity in that plant community and across the entire site.

Riparian wetland

Stormwater detention

Wet meadow

Mesic warm-season grass meadow

Mesic mixed hardwood forest

Piedmont/alluvial headwater stream forest

Arrested succession zone

See Appendix II-G for photo credits.


WEST BUILDING
EAST BUILDING
1
2
PLANT COMMUNITIES
1 Proposed Bald Cypress Grove
2 Protect/Expand Existing Walnut Grove
Horticultural Exhibition Space
Turf
Arrested Succession Zone
Wet Meadow
Mesic Warm-Season Grass Meadow
Mesic Mixed-Hardwood Forest (Proposed)
Mesic Mixed-Hardwood Forest (Existing)
Piedmont Alluvial/ Headwater Stream Forest
Wetland
Stormwater Detention
0
300
600
1,200
Feet

MESIC MIXED-HARDWOOD FOREST SPECIES


RED OAK
Quercus rubra

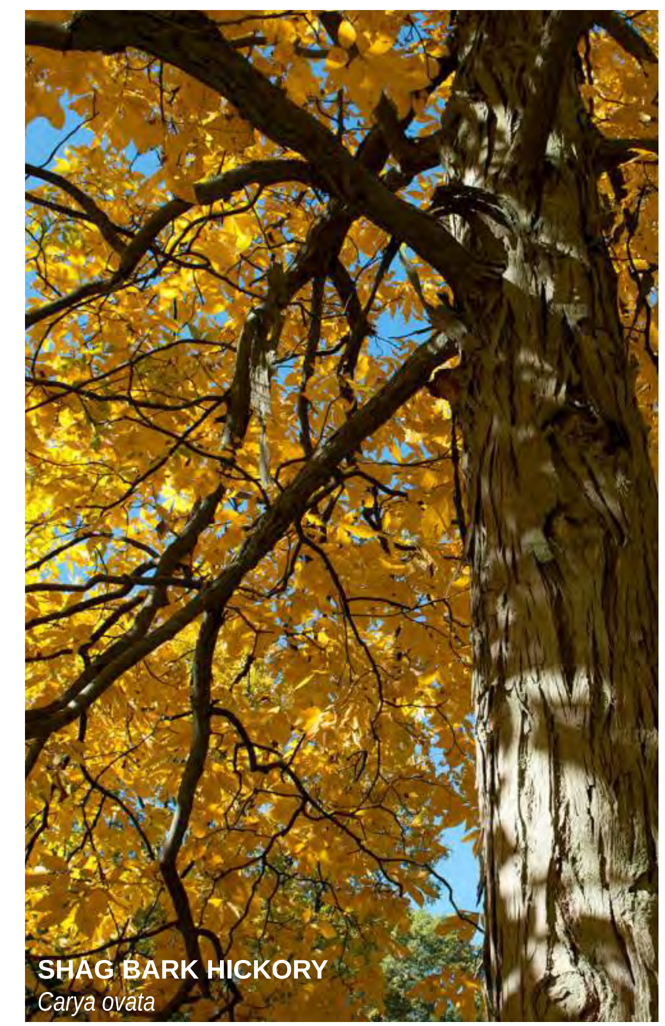

CHRISTMAS FERN
Polystichum acrostichoides


AMERICAN BEECH
Fagus grandifolia


AMERICAN STRAWBERRY BUSH
Euonymus americanus


PERFOLIATE BELLWORT
Uvularia perfoliata


POSSUMHAW
Ilex decidua


SHAG BARK HICKORY
Carya ovata

See Appendix II-G for photo credits.

PIEDMONT ALLUVIAL/HEADWATER STREAM FOREST SPECIES


WITCH HAZEL
Hamamelis virginiana


YELLOWROOT
Xanthoriza simplicissima

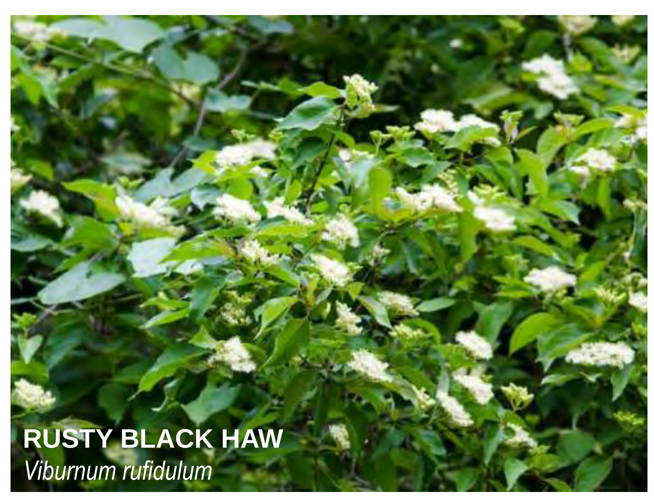

ELDERBERRY
Sambucus canadensis


TULIP POPLAR
Liriodendron tulipifera


PAW PAW
Asimina triloba


SOURWOOD
Oxydendrum arboretum


RED CHOKEBERRY
Aronia arbutifolia


RUSTY BLACK HAW
Viburnum rufidulum

See Appendix II-G for photo credits.

STORMWATER DETENTION SPECIES


SWAMP CYRILLA
Cyrilla racemiflora


BALD SPIKERUSH
Eleocharis erythropoda


WOOL GRASS
Scirpus cyperinus

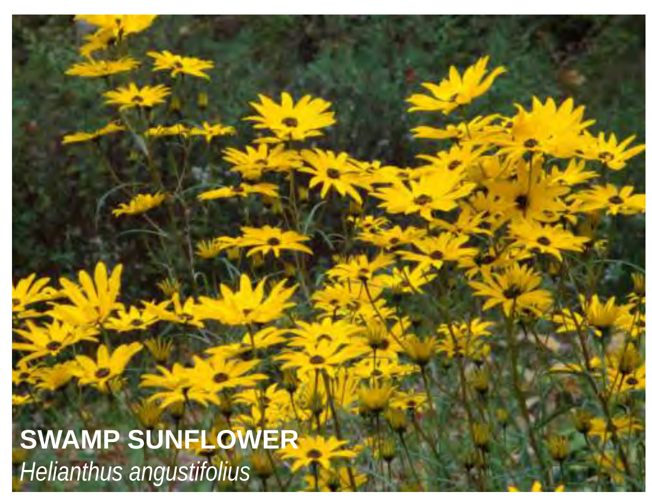

TALL IRONWEED
Vernonia altissima


ARROWHEAD
Sagittaria latifolia


BUTTONBUSH
Cephalanthus occidentalis


RIVER OATS
Chasmanthium latifolium


ROSY SEDGE
Carex rosea


SWAMP SUNFLOWER
Helianthus angustifolius


SHALLOW SEDGE
Carex lurida

See Appendix II-G for photo credits.

RIPARIAN WETLAND SPECIES


RIVER BIRCH
Betula nigra


RED MAPLE
Acer rubrum


WINTERBERRY
Ilex verticillata


PEPPERBUSH
Clethra alnifolia


SILKY DOGWOOD
Cornus amomum


LIZARD'S TAIL
Saururus cernus


ARROW ARUM
Peltnadra virginica


CARDINAL FLOWER
Lobelia cardinalis


BLUE FLAG
Iris versicolor

See Appendix II-G for photo credits.

WET MEADOWS + VEGETATED SWALES SPECIES


SWAMP MILKWEED
Asclepias incarnata


CULVER'S ROOT
Veronicastrum virginicum


FOX SEDGE
Carex vulpinoida


JOE PYE WEED
Eupatorium fistulosum


WILD SENNA
Senna herbecarpa


TORREY'S RUSH
Juncus torreyi


VIRGINIA WILD RYE
Elymus virginicus


COMMON WOOD SEDGE
Carex blanda


BLAZING STAR
Liatris spicata


LANCELEAF COREOPSIS
Coreopsis laceolata

See Appendix II-G for photo credits.

MESIC WARM-SEASON GRASS MEADOW SPECIES

BUTTERFLY MILKWEED
Asclepias tuberosa

OXEYE SUNFLOWER
Heliopsis helianthoides

PRAIRIE DROPSEED
Sporobolus heterolepsis

PURPLE CONEFLOWER
Echinacea purpurea

SWITCHGRASS
Panicum virgatum

BERGAMONT
Monarda fistulosa

SIDE OATS GRAMA
Bouteloa curtipendula

PURPLE TOP
Tridens flavus

PARTRIDGE PEA
Chamaecrista fasciculata

See Appendix II-G for photo credits.

ARRESTED SUCCESSION SPECIES

AMERICAN BEAUTYBERRY
Callicarpa americana

AROMATIC SUMAC
Rhus aromatica

STAGHORN SUMAC
Rhus typhina

SOUTHERN WAX MYRTLE
Morella cerifera

FRINGE TREE
Chionanthus virginicus

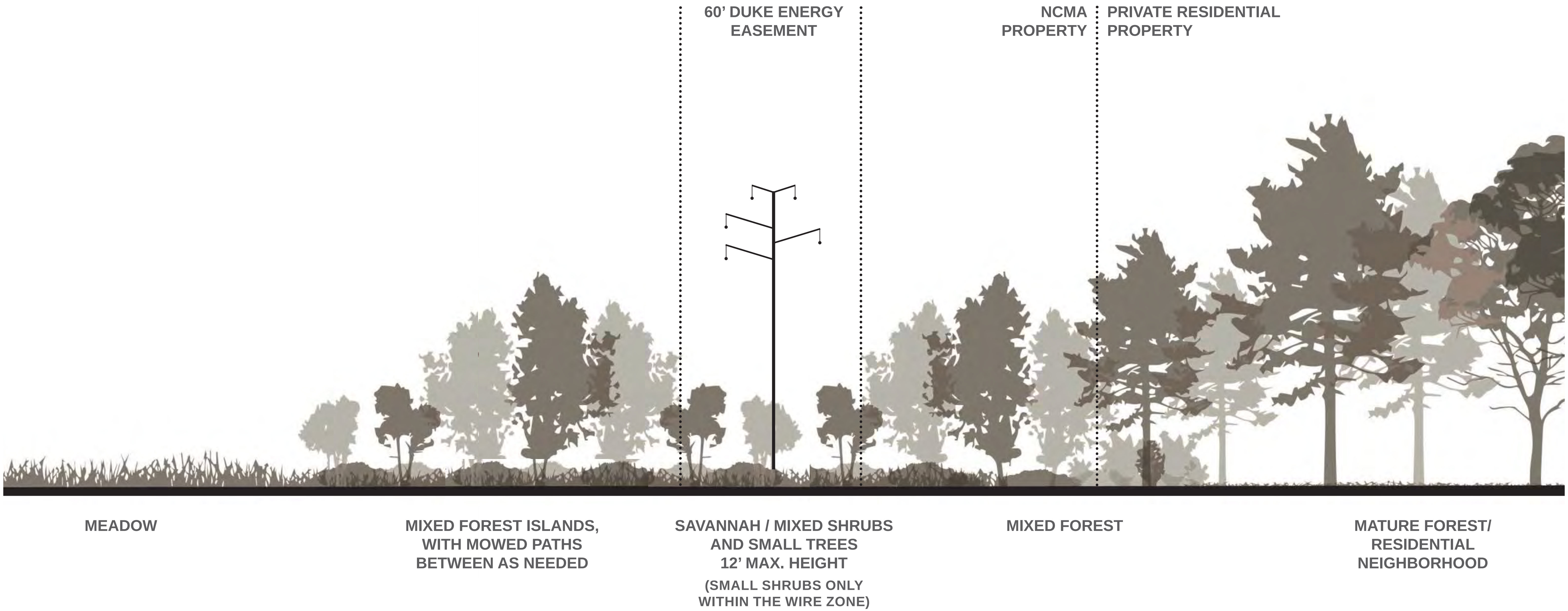
BLACK-EYED SUSAN
Rudbeckia hirta

INDIANGRASS
Sorgahstrum nutans

LITTLE BLUESTEM
Schyzacharium scoparum

VIRGINIA WILD RYE
Elymus virginicus

See Appendix II-G for photo credits.



Typical section, arrested succession zone

TRANSFORMING THE LOWER PRESERVE

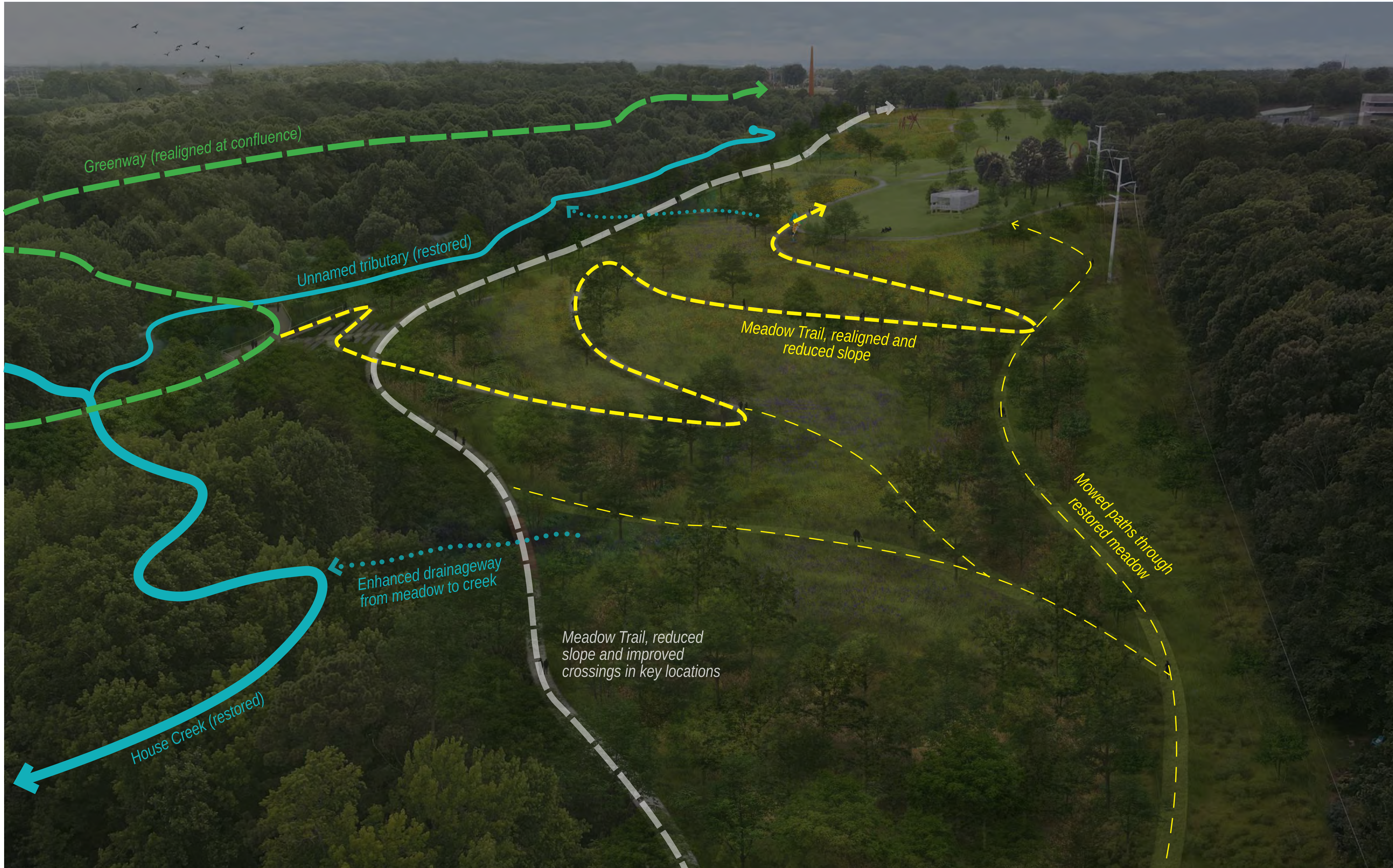
Lower preserve proposed trails and plant communities (facing page) and existing (above); Photo: Luke Mehaffe

Strategic improvements to the lower preserve will engage this area as a critical experiential component of the NCMA visitor experience. The existing fescue meadow will be transformed into a rich, diverse palette of native warm-season grasses dotted with groves of trees and seating where walkers can rest and socialize in the shade, while maintaining long views to the riparian corridor below.

Trail realignments will ease steep slopes and provide visual interest through a rhythm of hide and reveal as visitors move through the landscape.

The new gateway connection to the greenway and confluence area will link the Lower Meadow with the riparian corridor and woods, drawing cyclists and walkers from the greenway trail into the core of the preserve and up to the main Museum buildings.

Key map for views shown to left and on facing page


Greenway (realigned at confluence)
Unnamed tributary (restored)
Meadow Trail, realigned and reduced slope
Mowed paths through restored meadow
Enhanced drainageway from meadow to creek
Meadow Trail, reduced slope and improved crossings in key locations
House Creek (restored)

RESTORING THE WATERSHED

Proposed improvements to the Lower Meadow will work in tandem to improve water quality in both the unnamed tributary and House Creek. The realignment of trails in this area so that they meander more gradually down the slope will help prevent stormwater runoff from channelizing along trails and carrying sediment into the streams below. Infiltration trenches should be installed in key locations along the trail, particularly at switchbacks, to slow and filter runoff. Expanded successional forest areas between the existing forest and meadow, as well as additional pockets of shrubs and trees in the meadow landscape, will also help stormwater infiltrate into the soil.

Increasing biomass in the draws connecting the meadow and riparian zones will filter and slow stormwater runoff while also providing valuable habitat and sequestering carbon. These connections will be a visual reminder for visitors to the Preserve of how land cover and management in upland areas have a direct impact on water quality in the riparian areas they drain into.

Reforestation in the southeast corner of the study area will stabilize eroding slopes, thereby improving water quality in House Creek as it leaves NCMA property and makes its way toward Crabtree Creek. Establishing mature vegetation in this area will help screen the undesirable views and sound from traffic on I-440.

CIRCULATION IMPROVEMENTS

While the Museum Park is very well traveled by visitors, the Design Team identified several locations during the site analysis and inventory where circulation could be revised to improve visibility, accessibility, visitor experience, and landscape performance.

Along the Blue Loop, between the Ellipse and *Gyre*, the path will be realigned slightly to the south (note 2, right). This shift will ease the slope along the route and add curvature to the path, improving visitor experience in this area. The realigned path will rejoin the existing path orientation before reaching *Gyre* to maintain the intended relationship between the path and sculpture.

Additional updates along the Blue Loop should be integrated to connect to the new Welcome Center, as well as connections from the Welcome Center to the smokestack and greenway (note 1, right). Some of these new connections will traverse sensitive areas at the headwaters of the unnamed tributary, where a wet meadow condition is planned. Boardwalks and steps will be needed to cross these areas without having a negative impact on water quality.

Within the existing and proposed forested areas along the unnamed tributary and House Creek, there is the opportunity to create additional trails through the woodland (note 3, right). The design of these trails will respect sensitive slopes and soils while providing visitors with clear direction about how to safely access these areas. Incorporating an additional step stone crossing at the unnamed tributary would allow direct access to the stream. A new crossing will also be needed at the existing footbridge over the unnamed tributary, which is in disrepair (note 4, right).

The most significant realignment of the circulation will occur at the confluence of the two streams (note 5, right). Shifting the trail to the north allows both streams to access the floodplain, while creating a gateway feature that connects the greenway to the Lower Meadow. Increasing the radius of the curve on the greenway as it crosses the streams will help alleviate safety issues posed by the existing sharp turn at the bottom of a very steep hill. The greenway realignment is discussed in more detail in the following sections.

In the Lower Meadow, the current trail alignment follows a steep grade toward the greenway. This straight, direct route will be transformed into a gently sloped path with switchbacks (note 6, right), and small stepped connections will be added along the western edge to ensure a stable path for those who prefer a shorter route. The new path will also allow for additional trail connections along the Lower Meadow trail and trails in the arrested succession zone along the Duke Power easement.

Along the Duke Power easement at the northeastern edge of the study area, mown paths are proposed to allow visitors to access the arrested successional zone (note 7, right). These paths will meander gently down the slope, providing a more comfortable walking experience and added visual interest along the length of the trail.

The existing unpaved trail that follows the sewer easement along the south side of House Creek will maintain its current alignment (note 8, right). However, the bridge crossing at the lowest reach of House Creek will be upgraded so that it spans the entire floodplain, improving water quality and increasing the longevity of the structure.


WEST BUILDING
EAST BUILDING
1
2
3
4
5
6
7
8
1 Add Trail Connections through Wet Meadow
2 Shift Blue Loop Trail Down from Former Ridgeline Location
3 Add and Upgrade Woodland Trails, Stream Crossing
4 Add and Upgrade Woodland Trails, Stream Crossing
5 Realign Greenway Trail at Confluence Area
6 Realign Trail at Lower Meadow Hillside Area
7 Create Mowed Paths through Arrested Succession Zone
8 Maintain Trail Above Sewer Line; Improve Bridge Crossing
CIRCULATION: TRAILS + CROSSINGS
Stepstone Crossing
Improved Crossing (Bridge)
New Crossing (Bridge)
Stairs
Fence (proposed)
Greenway (elevated)
Greenway (at grade) 10' width, 2' shoulders
Paved Trail (Primary) 10' width
Paved Trail (Secondary) 8' width
Trail Elevated Crossing over Drainageway
Mowed/Aggregate Path 6-8' width
Natural Surface Forest Path 5-6' width
Stream (Proposed)
0
300
600
1,200
Feet

SLOPE

Existing Path
Proposed Path

(X%) Existing Path Slope
X% Proposed Path Slope

0–5%
5–8%
8–10%
10–20%
20% +

ACCESSIBILITY IMPROVEMENTS

Accessibility is often one of the highest priorities and greatest challenges in public outdoor spaces such as the Park. Modifying or adding trails to utilize more durable materials and provide gentler slopes can be at odds with other priorities for minimizing impervious surfaces and land disturbance. The Vision Plan proposes a suite of changes to the existing trail network that seeks to balance the desire to provide comfortable access to as much of the Museum Park as possible with the need to protect sensitive areas in the existing landscape.

In general providing a slope of five percent or less will allow most people using a wheelchair or with limited mobility to traverse the Park's terrain comfortably. Five percent is also the maximum slope for an accessible walk (without requiring a handrail and landings) in compliance with the Americans with Disabilities Act. While the paths in the Park are not required to meet this standard, five percent is the target wherever reasonably possible. In particular the main trails that allow visitors to travel around the Park and experience the notable elements of the preserve, such as the proposed confluence area, as well as primary access points to parking and buildings, should strive to meet accessibility standards.

In many locations a slight realignment is enough to bring a path's slope below five percent. Several locations along the southern portion of the Lower Meadow trail can be modified to reduce steep slopes, and in some areas also provide a more direct route or clearer sight lines. In other locations a larger intervention is required. Where the Lower Meadow trail splits off from the Blue Loop just below Lowe's Park Pavilion, the existing path cuts straight down the hillside at a roughly seven-percent slope. The Vision Plan replaces this steep path with a series of gently sloped switchbacks, providing easy access to the confluence area, where the elevated greenway offers an immersive experience in nature.

Along certain areas of the greenway and in the stream corridor, achieving a five percent slope for all trails may not be practical. Where existing slopes exceed five percent and trail realignment would cause significant disturbance in forested areas, there may be other opportunities to improve visibility and safety in spite of the slope, such as improved sightlines, signage, or trail width.

Additional details regarding proposed changes to alleviate safety issues related to steep slopes along the eastern section of the greenway are discussed in the following sections.

The trail alignments proposed in the Vision Plan are based on slope information gathered from available GIS data and surveys of discreet areas in the preserve. As proposed improvements are designed in more detail and implemented, trail alignments may require adjustment to reconcile existing conditions with desired slopes.

PROPOSED RESPITE STOPS

- * Bench Seating
- * Rough-Cut Stone Plinth Seat
- * Open Area for Picnic Blanket, etc

PROVIDING SPACES FOR RESPITE

Comfortable places to pause, sit, and enjoy the Museum Park are a high priority for the proposed improvements in the Vision Plan. Spaces for gathering and respite have been designed in tandem with the paths that connect them to provide visitors with a rich and varied experience in the Park.

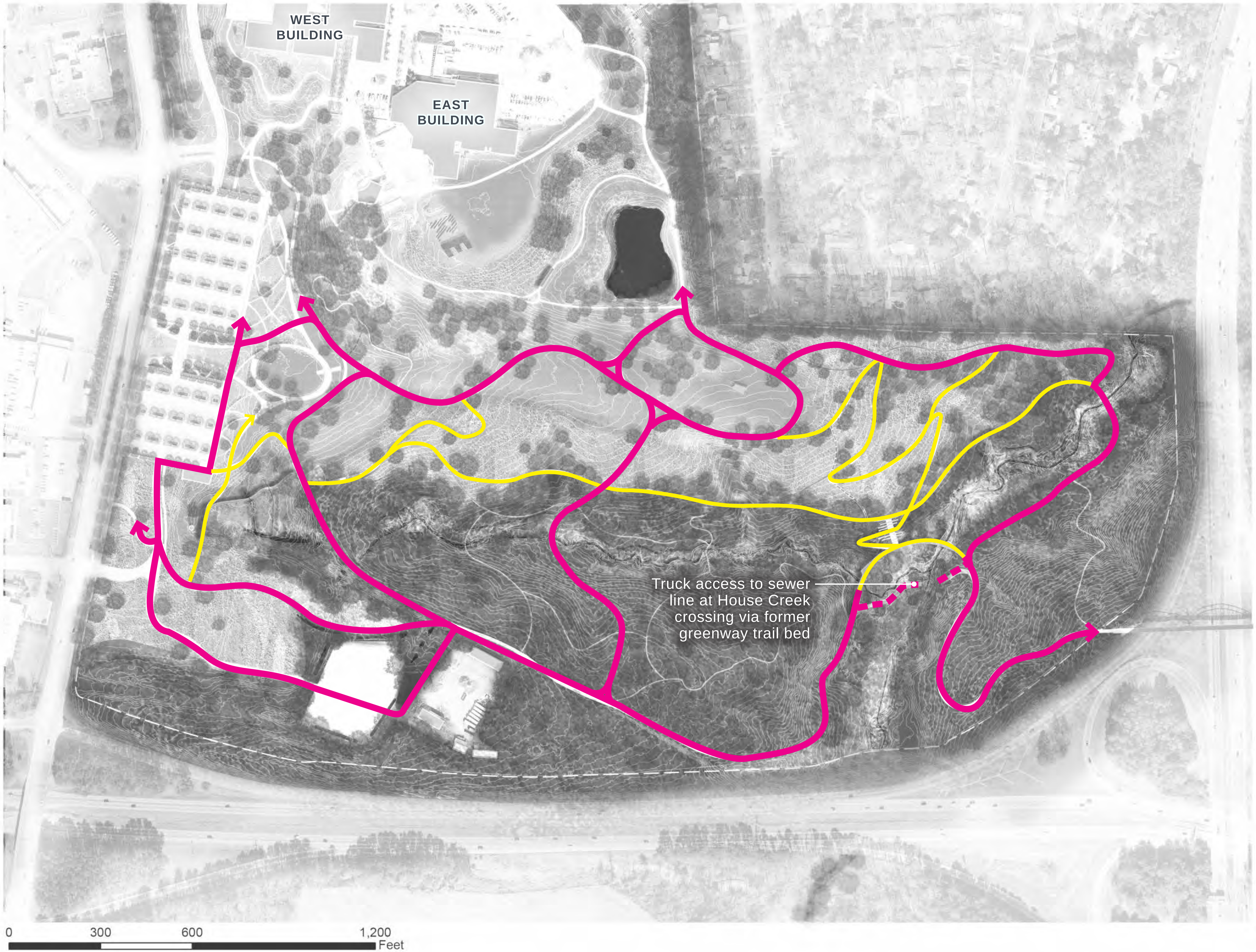
Several proposed seating areas are located at key areas along paths, where visitors may want to take a short break, or where the best views of the Park's artworks and landscape can be appreciated. A few such locations can be found along the top of the hill overlooking the Lower Meadow, where wide views of the diverse native warm-season grass meadows can be enjoyed.

The bends in the switchback path to the confluence area are designed to inspire visitors to pause, reframe their surroundings, and take a moment to reflect. The provision of seating at these locations supports this behavior. Visitors can take in views of the meadows and forest beyond, rest, wait for others in their party, or decide which route they want to take.

The seating areas in the Park also provide spaces for gathering. Sitting on a bench overlooking the landscape or picnicking at the edge of the meadows are already well-loved pastimes in the Park. The Vision Plan identifies additional areas for these uses along both new and existing trails.

Seating and gathering areas are also planned to provide visitors with the best vantage points over the new landscape features of the Museum Park. Terraced stone seating will be integrated into the hill connecting the Lower Meadow with the confluence area, providing an informal gathering area and a space to watch people passing by on the greenway trail. Seating areas along the elevated greenway path will provide opportunities to view wildlife in the stream corridors and fully experience the restored floodplain ecosystem.

Seating areas will also be added along the Blue Loop as it crosses the unnamed tributary to provide views toward the restored stream channel and perched wetland.



PROPOSED MAINTENANCE/ SECURITY VEHICLE ACCESS

Full-Size Truck Access (Paved)

Full-Size Truck Access (Unpaved)

Maintenance/Security ATV Access

IMPROVING MAINTENANCE/SECURITY ACCESS

Adequate, appropriately designed access for security and maintenance operations is essential for the Museum Park to provide the best visitor experience possible. In the Vision Plan, proposed security and maintenance routes were considered both as improvements to the existing conditions and for the integration of security and maintenance in the Park landscape as it evolves over time.

Addressing security and maintenance access at the stream crossings was identified as a high priority for the preserve, as crossings have deteriorated or been damaged by hurricanes in several locations. Some crossings do not provide the needed width or loading capacity for security vehicles, and some do not span the entire floodplain, causing erosion and structural damage during large storm events.

The approach to security and maintenance access is to meet the needs of the Museum, City of Raleigh, and Duke Energy with the lightest footprint possible. While vehicular access with a full-size truck may be necessary along the meadows and primary trails, maintenance access to the elevated boardwalks at the confluence can be achieved with NCMA ATVs. Designing for a smaller vehicle provides adequate access to the elevated walkway at a lower cost, while prioritizing the smaller-scale pedestrian experience. The NCMA's security staff will still be able to complete a full circuit of the Park using ATVs.

At the confluence area, the existing bridge over House Creek will be removed, but the existing trail bed will remain to provide access to the sanitary sewer line from both sides of the creek. Although the primary greenway trail alignment will shift north, these secondary trail beds can also provide visitors access to the water's edge via smaller footpaths.

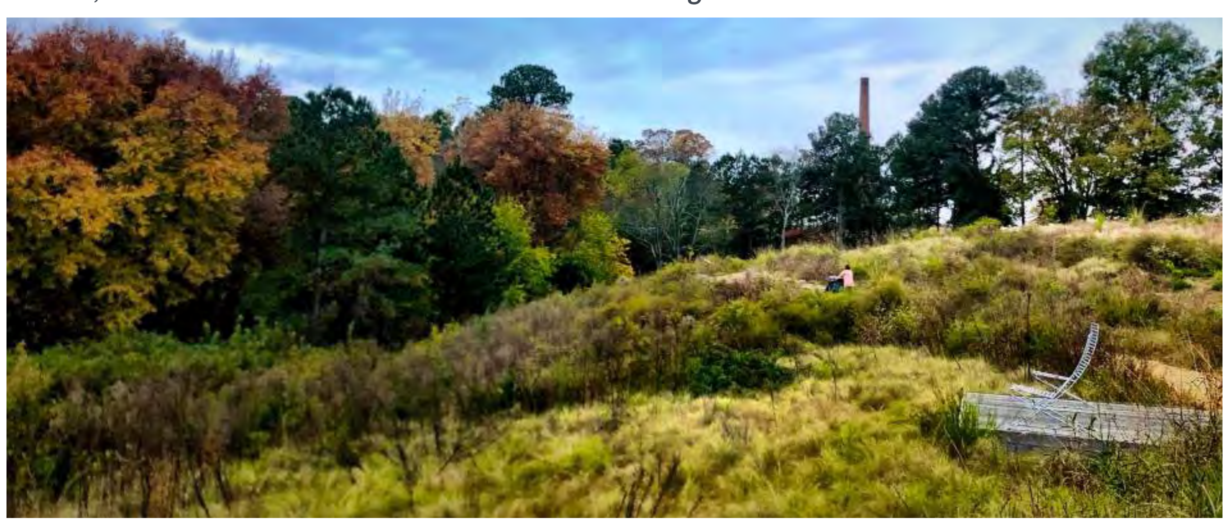
The lower crossing on House Creek will be upgraded to handle the load of a full-size vehicle, ensuring that larger maintenance vehicles can still easily access the sewer lines along House Creek and the western part of the preserve from the greenway.

Along the Duke Energy easement, mowed paths will double as walking paths and maintenance access. While the Museum should be prepared for some regular vegetation removal by Duke Energy, the design for this location provides access and vegetation heights that comply with regulations, and large-scale removal should be minimized. While this approach deviates from a typical maintenance access path under overhead power lines, the hope is that with communication between the NCMA and Duke Energy, this more diverse planted edge can provide a better experience for Museum visitors while maintaining the necessary level of access for the utility company.

WEST BUILDING
EAST BUILDING
SIGHTLINES
Enhanced Sightlines
Undesirable View, to Be Obscured with Plant Material
0
300
600
1,200
Feet

IMPROVING SIGHTLINES + VIEWSHEDS

Longwood Gardens: Mowed paths through meadows provide glimpses without full reveal; Photo: Master Gardeners of Northern Virginia



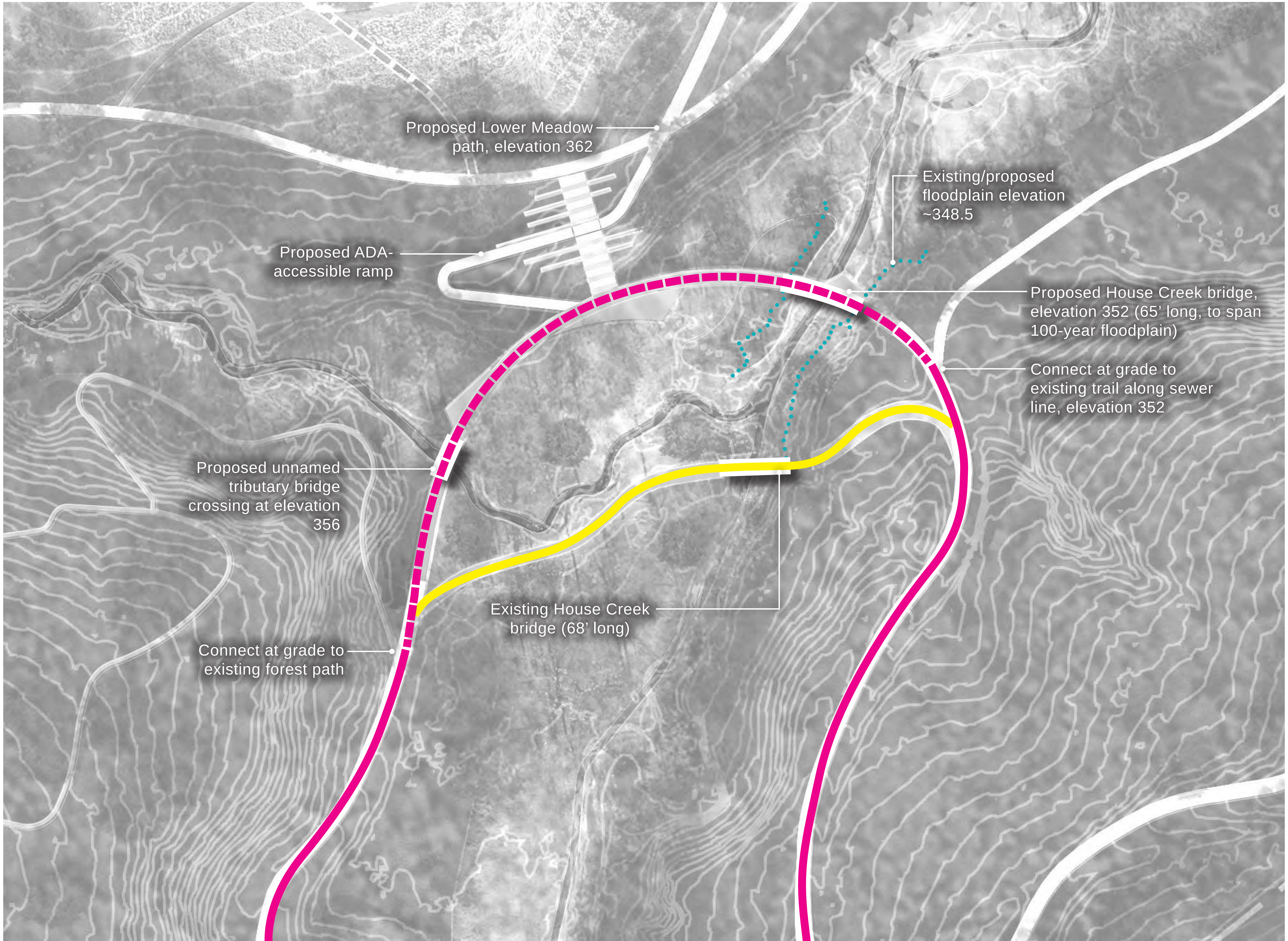
East/west views along the successional forest will highlight texture and color within the landscape; Photo: Andropogon

Intentional and well-designed sightlines and viewsheds maximize the aesthetic experience while also providing important cues for wayfinding and orientation. Throughout the Park, vegetation, topography, and paths are orchestrated to lead visitors from one moment of scenic beauty to the next.

The native warm-season grass meadows will showcase a variety of size, texture, and color with their diverse plant palette. The complexity of the vegetation is complemented with the openness of the sky, as one looks over these spaces, and is anchored by the backdrop of the forest edge. In contrast to the existing monoculture of fescue, the views over the meadow will provide a rich backdrop to the Park's many works of art, with changing character over the different seasons.

Beyond showcasing spaces of natural beauty, framed views will contribute to a sense of wonder and discovery as visitors proceed along the trails. Certain views may narrow and obscure, adding to the drama of an open view around the next corner, or creating emphasis on a particular target such as a sculpture. Sightlines also assist with wayfinding, indicating a destination or providing a moment to orient oneself in the broader landscape. By providing views both intimate and expansive, the NCMA will enable visitors to appreciate a rich series of experiences in the boundary of the Museum Park.

In other cases the importance is not in what is seen but what is not seen. While the Park provides a generous natural area of meadow and forest, totaling over 100 acres, it is bounded by large roads on the east and south, which contribute noise and detract from views through the forest. With additional work planned to increase the NCDOT right of way, planting additional vegetation to screen these areas is a near-term priority for the Museum Park. Other locations, such as the maintenance area, would also benefit from additional screening to improve views from the Park trails.



GREENWAY REALIGNMENT

Proposed Greenway Alignment (At Grade)

Proposed Greenway Alignment (Elevated)

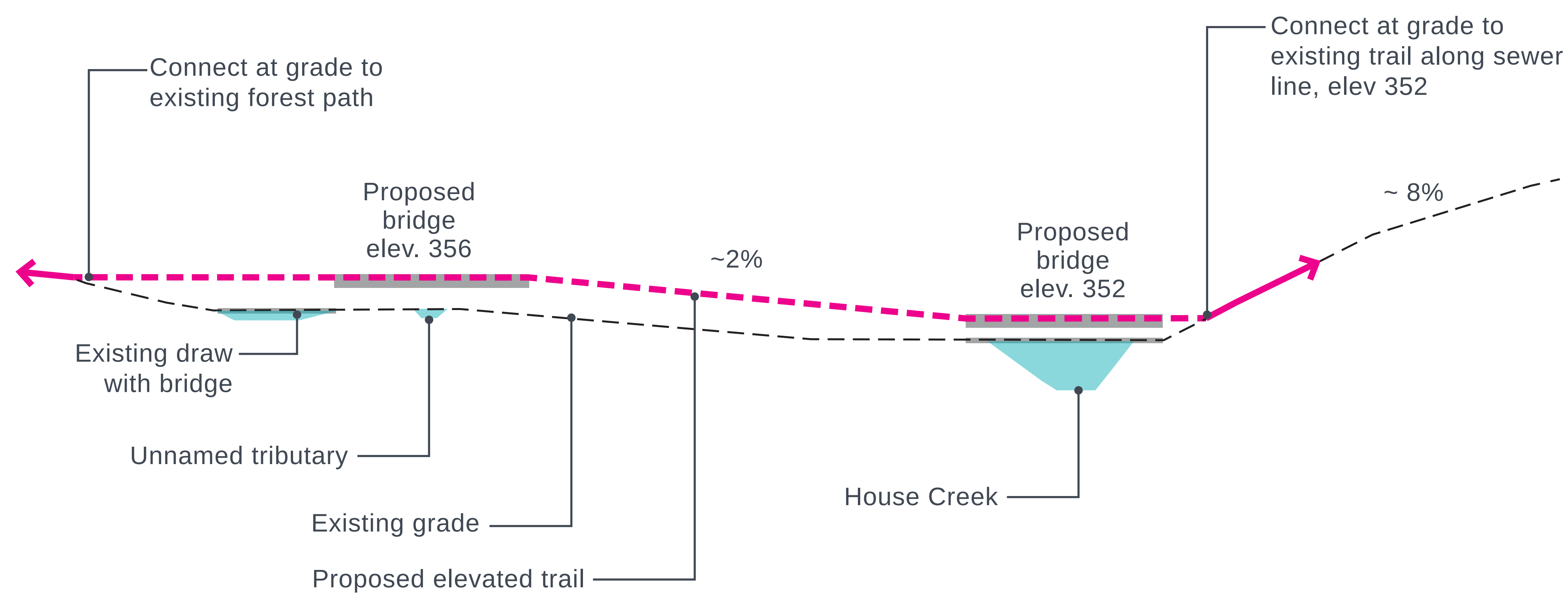
Existing Greenway Alignment (At Grade)

REALIGNING THE GREENWAY

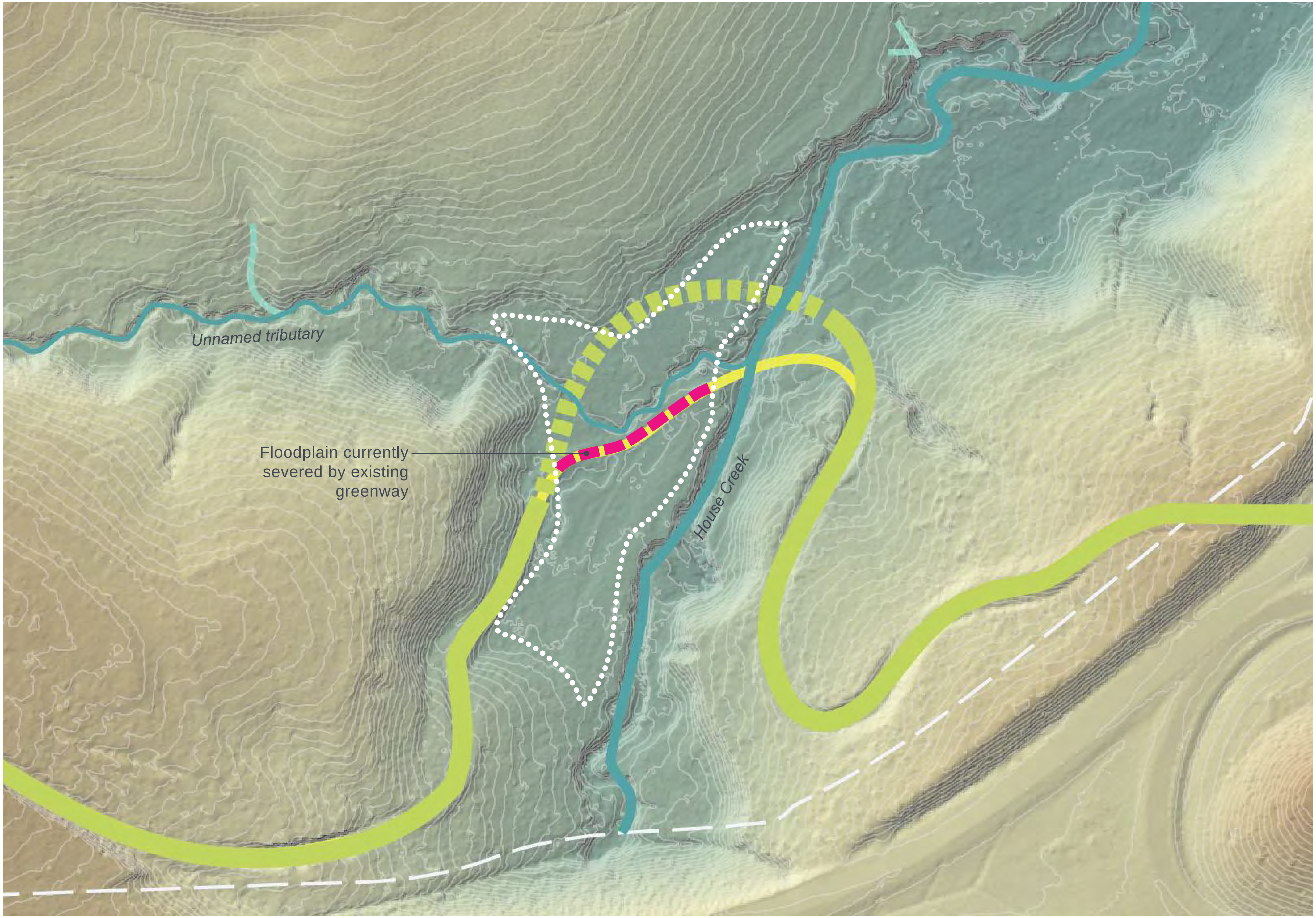
In order to address safety concerns related to the sharp curve and steep slope of the greenway trail at the confluence area, the Vision Plan proposes a realignment of the trail, shifting it further north and elevating it out of the floodplain. This alignment was based on a previous greenway study (see Appendix II-E) and adjusted to meet the needs of the stream restoration.

While the proposed slope of the greenway remains around eight percent, as one approaches the confluence from the west, the new trail alignment follows a more generous curve as it crosses the floodplain. Increased visibility, compared to the existing condition that combines the eight-percent slope with a sharp turn, provides a safer, more enjoyable experience for pedestrians and cyclists alike.

Possibly the Vision Plan's most significant improvement to the Museum Park is the realignment of this section of greenway, in terms of addressing the Museum's three goals for the preserve. It protects and enhances the riparian ecosystem, improves visitor circulation, allows people to better experience nature, and improves resiliency in the face of climate change.



Proposed realigned greenway trail profile



Existing elevation map showing natural floodplain at confluence, currently divided by existing greenway alignment

FLOODPLAIN RECONNECTION

- Existing Floodplain at Confluence
- Existing Trail (At Grade)
- Proposed Trail (At Grade)
- Proposed Trail (Elevated)

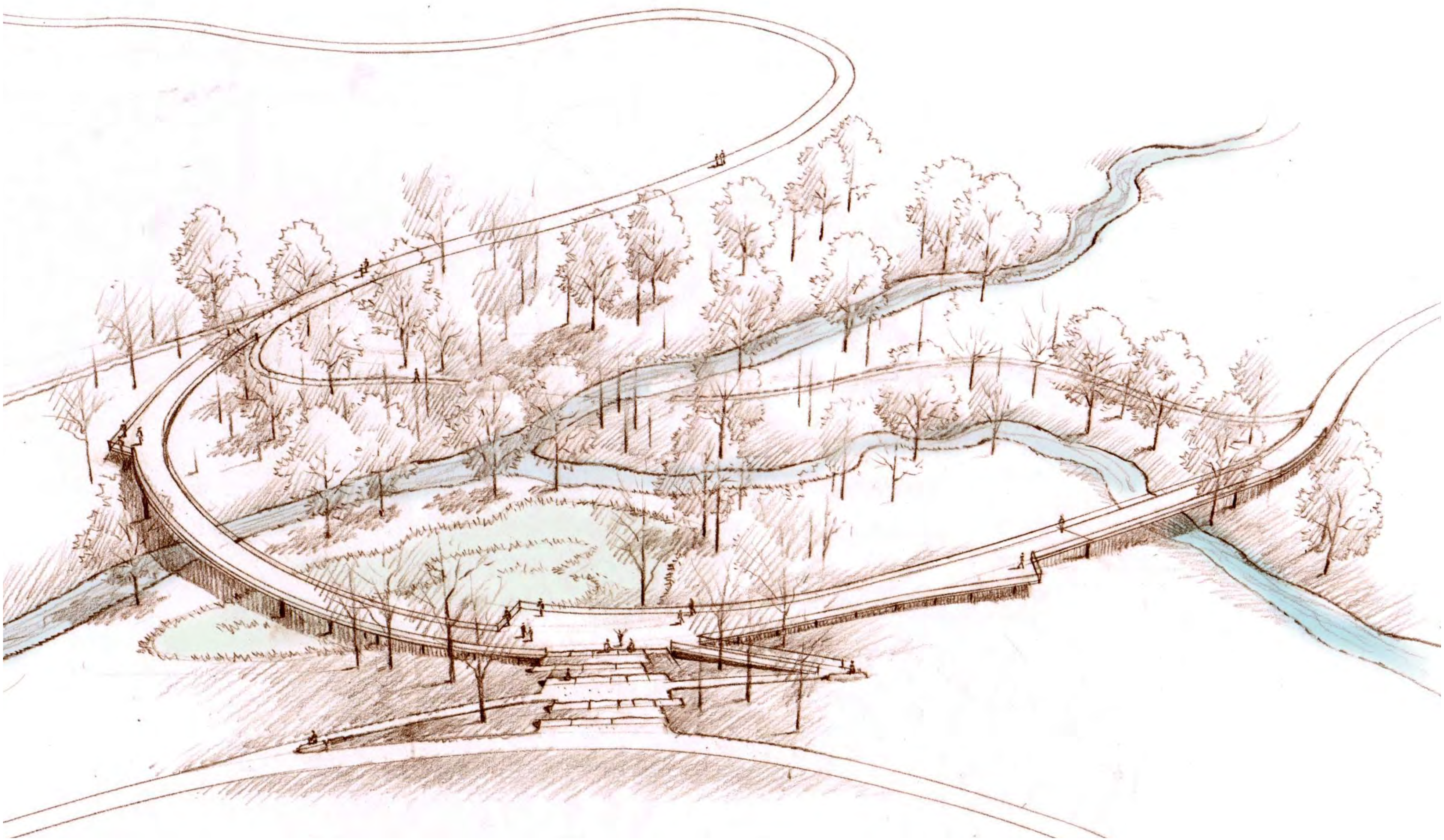
RECONNECTING THE FLOODPLAIN

Unnamed tributary eroding banks and overtopping greenway to reach natural flood-plain; Photo: Andropogon

The existing at-grade greenway trail acts as a barrier to water movement in the confluence area, preventing the unnamed tributary and House Creek from accessing the floodplain during large rain events. Evidence of this is clearly visible along the greenway, where eroded banks must be stabilized with concrete, and water collects on the trail.

If the greenway is elevated completely out of the floodplain, the water from both streams can flow freely below during both light and heavy rains, reducing erosion, improving water quality, and providing habitat for both aquatic and terrestrial species.

Although an additional crossing is required to route the new path over the unnamed tributary, the realigned trail will actually have less impact on the floodplain ecosystem as compared to its current location, where the banks of the unnamed tributary are eroding. Bridges and abutments will be fully clear of the floodplain, and an elevated boardwalk will facilitate the movement of water throughout the entire confluence area.



Bird's-eye view of elevated greenway trail at confluence area, looking south from Lower Meadow

EXPERIENCING THE CONFLUENCE

Transitioning the greenway to an elevated boardwalk at the confluence of the streams will not only improve water quality, but it will also provide a unique opportunity for walkers and cyclists to experience a floodplain ecosystem with views from above as well as provide an immersive experience at the floodplain level. A typical bridge crossing does not allow for close interaction with wetland communities on the periphery of the stream corridor, but the proposed elevated boardwalk will provide access to these areas in a way that is respectful of the sensitive soil and hydrological conditions below.

Seating and gathering areas just off the main path will allow visitors to watch wildlife, study plants, and listen to the sounds of the wetlands and streams. These areas will be prime locations for educational programing, signage, and opportunities to view art.

As bikers and walkers navigate the sweeping curve of the path, their view frame will change, creating a rich and varied but cohesive trail experience as they move through this new feature of the preserve.

If the NCMA draws attention to this special spot in the preserve, it can help visitors understand how the improvements to water quality that the Museum has made in the watershed of the unnamed tributary have impacts far beyond the Museum's boundaries. By revealing the journey of the unnamed tributary's clean water as it meets House Creek and flows downstream toward Crabtree Creek, the Museum can highlight both its successful restoration efforts and the broader imperative to be a good neighbor and land steward.

Key map for view shown on facing page

Eye-level view of elevated greenway trail at confluence area, looking west from House Creek bridge

CONNECTING TO THE LOWER MEADOW

Examples of terraced rough-cut stone retaining walls; Photos: Andropogon (top) and Esch Landscaping (bottom)

In shifting the greenway trail further to the north, a new connection can be made to the Lower Meadow trail system, creating a gateway that draws greenway users into the core of the Park and eventually up to the East and West Buildings. Conversely, visitors from the main buildings will now be able to easily access the rich riparian ecosystems of the confluence area.

At this point in the trail, an elevated overlook space adjacent to the main trail will provide an area for people to gather, socialize, watch wildlife, or sit and rest.

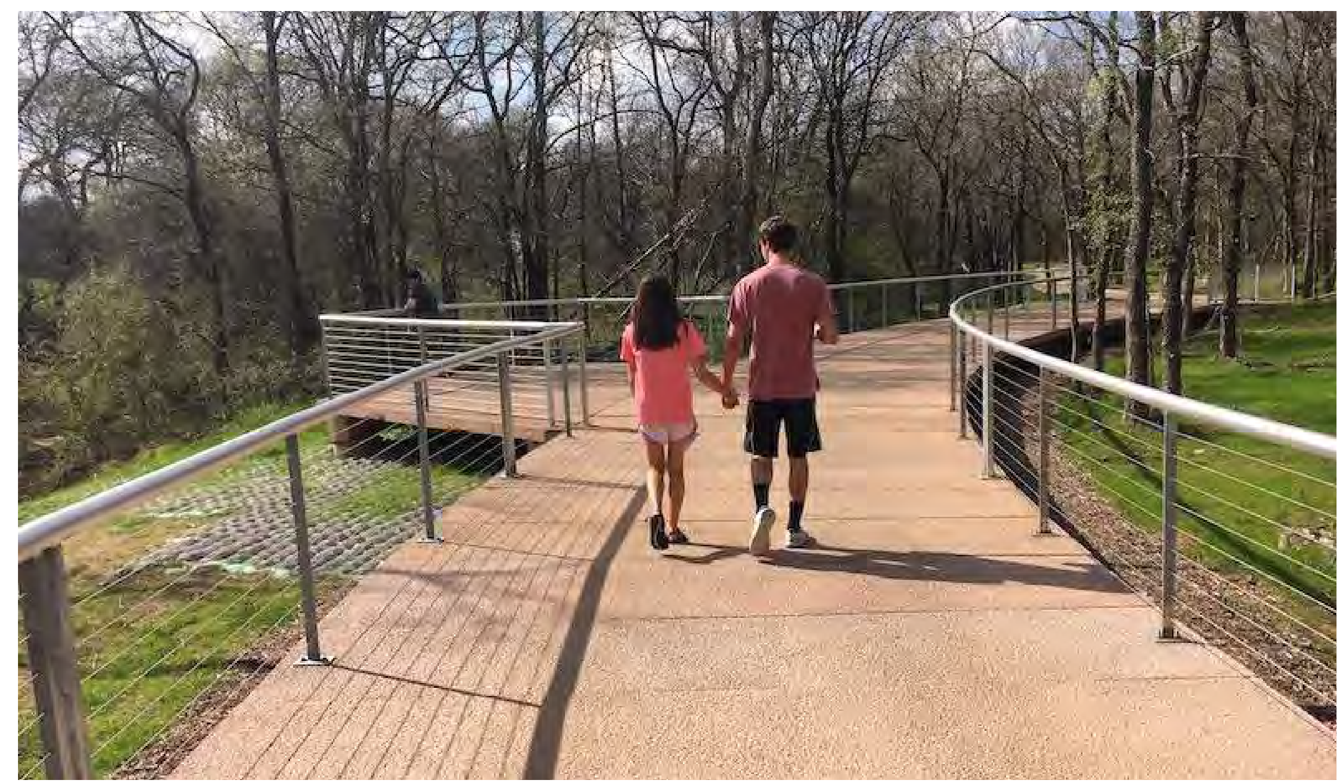
Terraced stone seating and steps to the north of the greenway trail will help stabilize steep slopes leading up to the Lower Meadow path, while providing seating for groups of all sizes and formalizing the existing “cow path” in this location. An ADA-accessible path will traverse the slope via a series of switchbacks that cut through the stone terraces and meet the Lower Meadow trail to the east.

Key map for view shown on facing page

Pervious metal grating and curved span, Torrens Bridge, Australia; Photo: Sam Noonan

Curved span and full floodplain clearance; New York Botanical Gardens; Photo: Synergi

Bridge spanning the entire floodplain, Sanford Creek Greenway, Wake Forest, NC; Photo: PermaTrak



Concrete boardwalk, Walnut Creek Trail, Texas; Photo: PermaTrak

BRIDGE CONSIDERATIONS

There are many important considerations in the design of the bridge and elevated walkways in the Vision Plan. Not only will these spaces be frequently traveled by visitors to the Park, but they will also be located in some of the most sensitive ecological zones. Additionally, these structures will be subject to greater environmental stresses than a walkway on solid ground, due to the fluctuations inherent to a stream corridor.

The bridges and elevated walkways must first and foremost be constructed of highly durable materials. While these materials may initially require a greater fiscal investment, materials that can withstand hurricane damage, such as trees falling, will prove more valuable over time. Choosing higher quality and longer-living materials will also help operations return to normal following extreme weather events, as repairs can be completed more quickly than a full replacement.

Choices in materials for site elements such as bridges can also help support the mission of promoting climate resiliency and reducing net carbon impacts. Many traditional building materials for structures like bridges have a high level of embodied carbon, or the carbon generated through the manufacturing of component materials, final production, and transportation. Wood often has a lower embodied carbon than materials such as steel and concrete, however, specifying certain types of manufacturing procedures or material components can help reduce that toll. Steel produced in plants that utilize renewable energy sources and recycled content, or concrete mixes with fly ash or other carbon capture additives, can offer substantial improvements in the net carbon impact of these structures.

Lastly, there are numerous considerations relative to the flooding potential of the streams that factor into the materials and design of the bridges. While the Vision Plan calls for upgraded bridges that span the entire flood plain below, some flooding may occur on the bridges during extreme weather events. To minimize maintenance effort following large storm events, bridge structures should be permeable enough to allow water and mud to be washed off easily. The texture of the path surface should prevent hazardous, slippery conditions during wet weather and allow for leaves and other debris to be easily swept away.

CARBON SEQUESTRATION OPPORTUNITIES + STRATEGIES

Building climate resiliency will require consideration of how the activities, materials, and organisms in the Park impact net carbon production. Interventions may address carbon impacts through any of the following strategies:

- Reductions in operational carbon, or carbon generated by activities in the Park.
- Reductions in the embodied carbon of materials used in the Park.
- Reduction of carbon expended in the productions and transport of materials.
- Increased capacity for carbon sequestration, or the removal and storage of carbon from the atmosphere in the soil and biomass.

Many of these strategies also support the related goals of fostering biodiversity, creating high-functioning environmental systems, and decreasing maintenance inputs over time.

A first step in reducing carbon and greenhouse gas emissions for the Museum Park will be to identify which equipment and products could be substituted for a lower operational carbon alternative. Replacing gas-powered maintenance vehicles with electric vehicles powered by clean energy sources can be a significant first step. Changes to the overall maintenance practices, such as mowing and leaf removal, and the establishment of the plant communities in the Vision Plan over time will further reduce vehicle emissions. As successional forest zones are established and the routine mowing of fescue areas is replaced by less frequent mowing of warm season grass meadows, operational carbon will decline.[5]

To further increase carbon storage and sequestration in the Park, maintenance activities should shift away from the traditional model of removal and clean-up of dead or excess biomass toward a practice of retention and reuse of the existing biomass on site. Fallen leaves removed from paths can be used as mulch, while woody debris can be stockpiled in mounds using the horticultural technique (see right), which will decompose and build soil, or, where appropriate, be used as lumber for trail materials or furniture. Cover crops, planted to stabilize and aerate soils, may be allowed to decompose back into the soil prior to the next planting. Though carbon is slowly released through the decomposition process, the reuse of on-site material reduces the operational carbon of maintenance activities and the input of additional carbon through the application of chemical fertilizers.

The conversion of large areas of the site from turf lawn to native warm-season grass meadow and forest will further augment the carbon storage capacity of the Park landscape. These higher-diversity and higher-biomass plant communities have been shown to store carbon at much higher rates than lawn[6]. In addition to storing carbon in their above-ground biomass, forests and grasslands have been shown to contribute to greater carbon storage through their deeper and more robust root systems and by supporting the health soil mycelia/fungal networks critical to soil health.

Beyond carbon sequestration, the development of resilient environmental systems as outlined in the Vision Plan will impart many other additional benefits in the Park, known as ecosystem services. The deep-rooted meadow grasses and woody vegetation of the forested areas will slow and absorb more stormwater than the existing fescue, contribute to improvements in water quality, and mitigate the urban heat island effect. The Museum Park will also offer a unique opportunity in the Raleigh area for people to connect with nature, providing a restorative experience and supporting wellness among visitors.

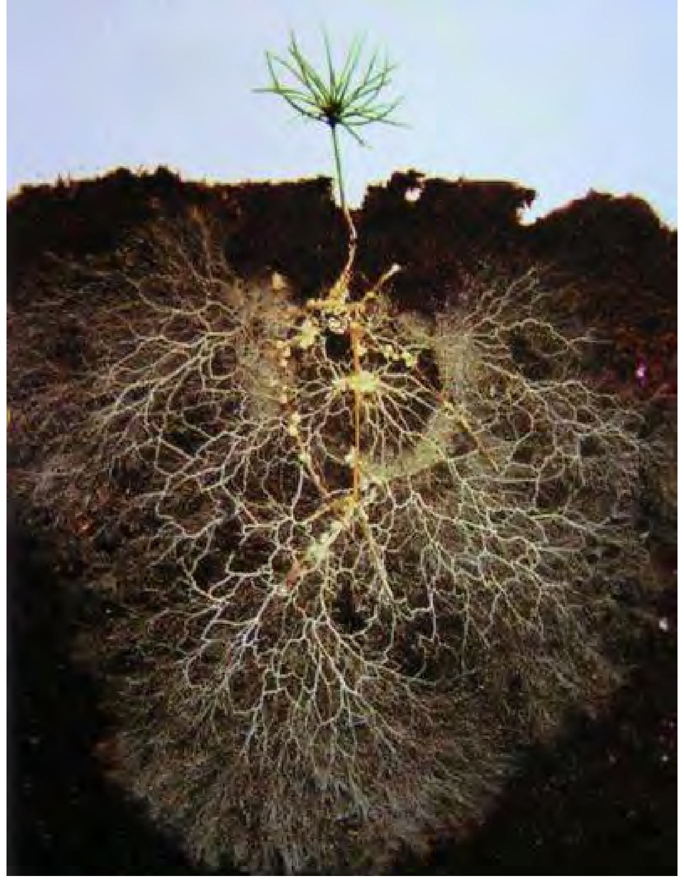
The carbon storage and ecosystem services strategies used in the Park can contribute to climate resiliency beyond the Museum site, serving as a model for management on public lands. With the support of educational programming, visitors can learn about these methods and why they should consider implementing these practices on their own properties. While the climate challenges we face are considerable, a focus toward carbon sequestration, carbon storage, and ecosystem services can have a positive impact, not only at the Museum, but for all that visit.

5. Banks (2015)

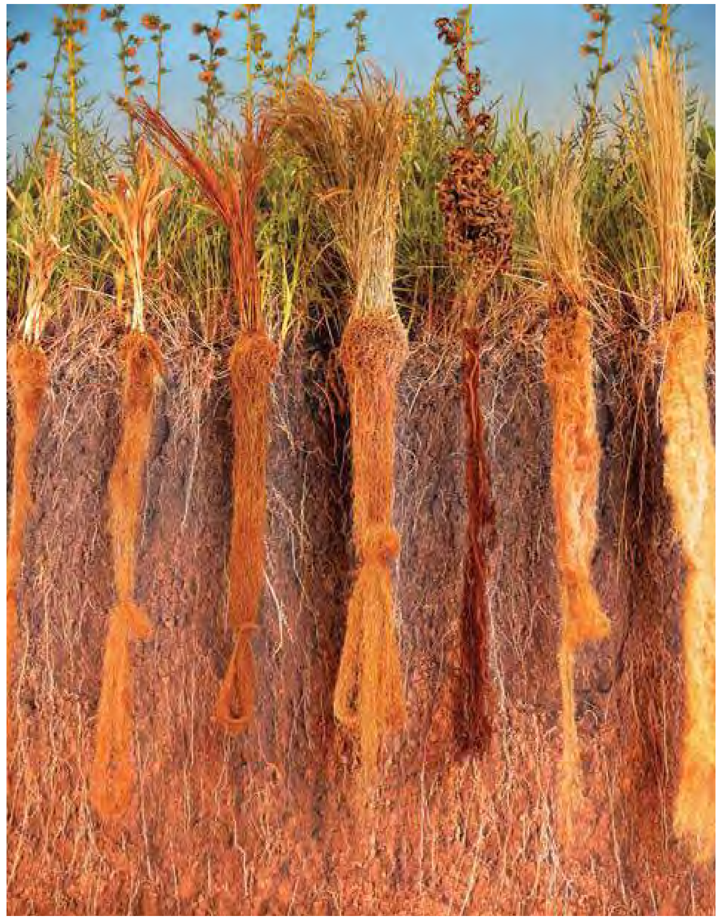
6. Gu, et al. (2015)


Prepping Red Maple logs for reuse on site; Photo: Biohabitats


Leaf mold, made on site from collected leaves; Photo: thisoldhouse.com

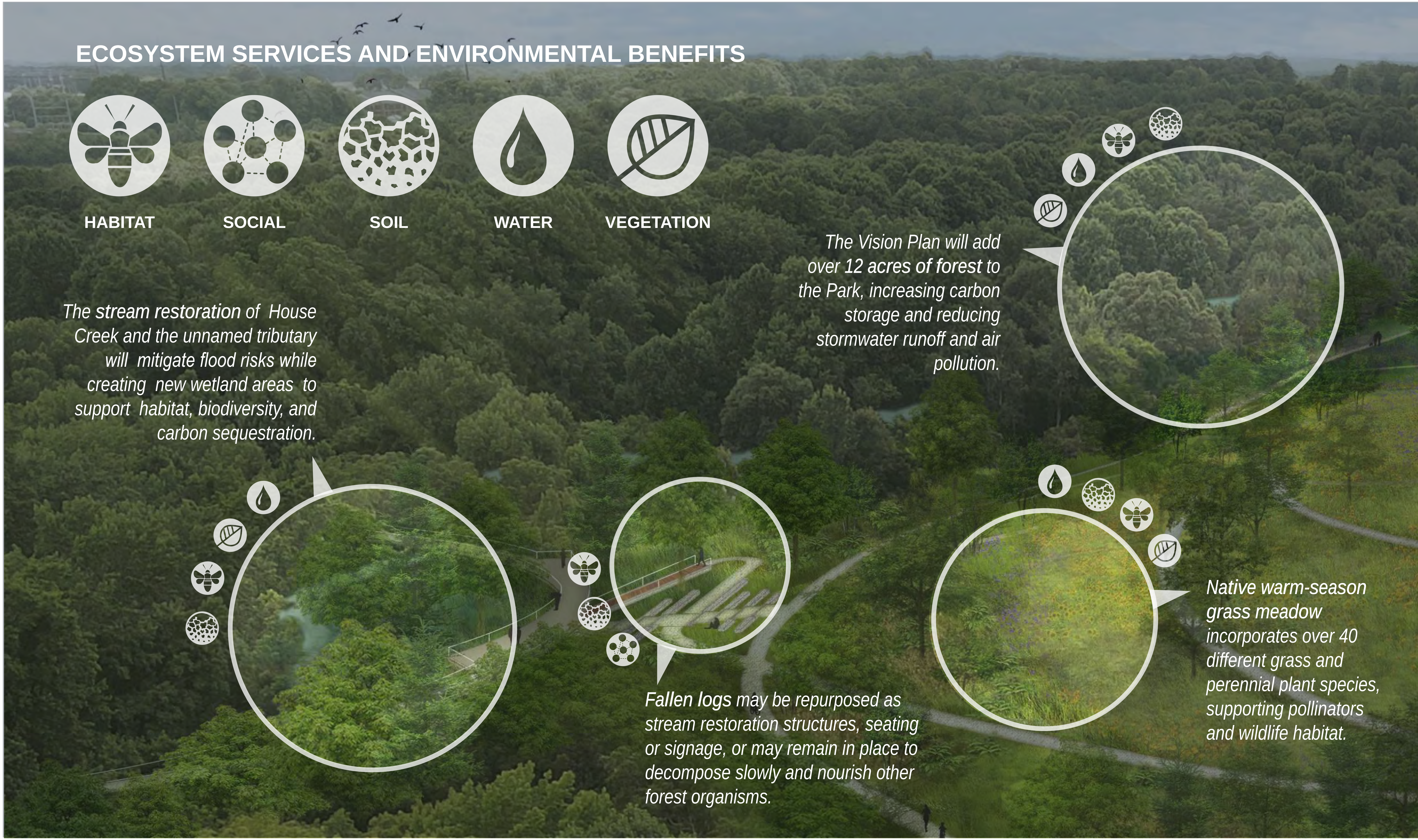

Mycelia in soil; Photo: Rainforest Alliance


Tillage radishes; Photo: directgardening.com


Deep-rooted prairie grasses; Photo: greenbuild-ermedia.com


Hugelkulture construction, Avalon Nature Preserve; Photo: Andropogon

ECOSYSTEM SERVICES AND ENVIRONMENTAL BENEFITS



HABITAT

SOCIAL

SOIL

WATER

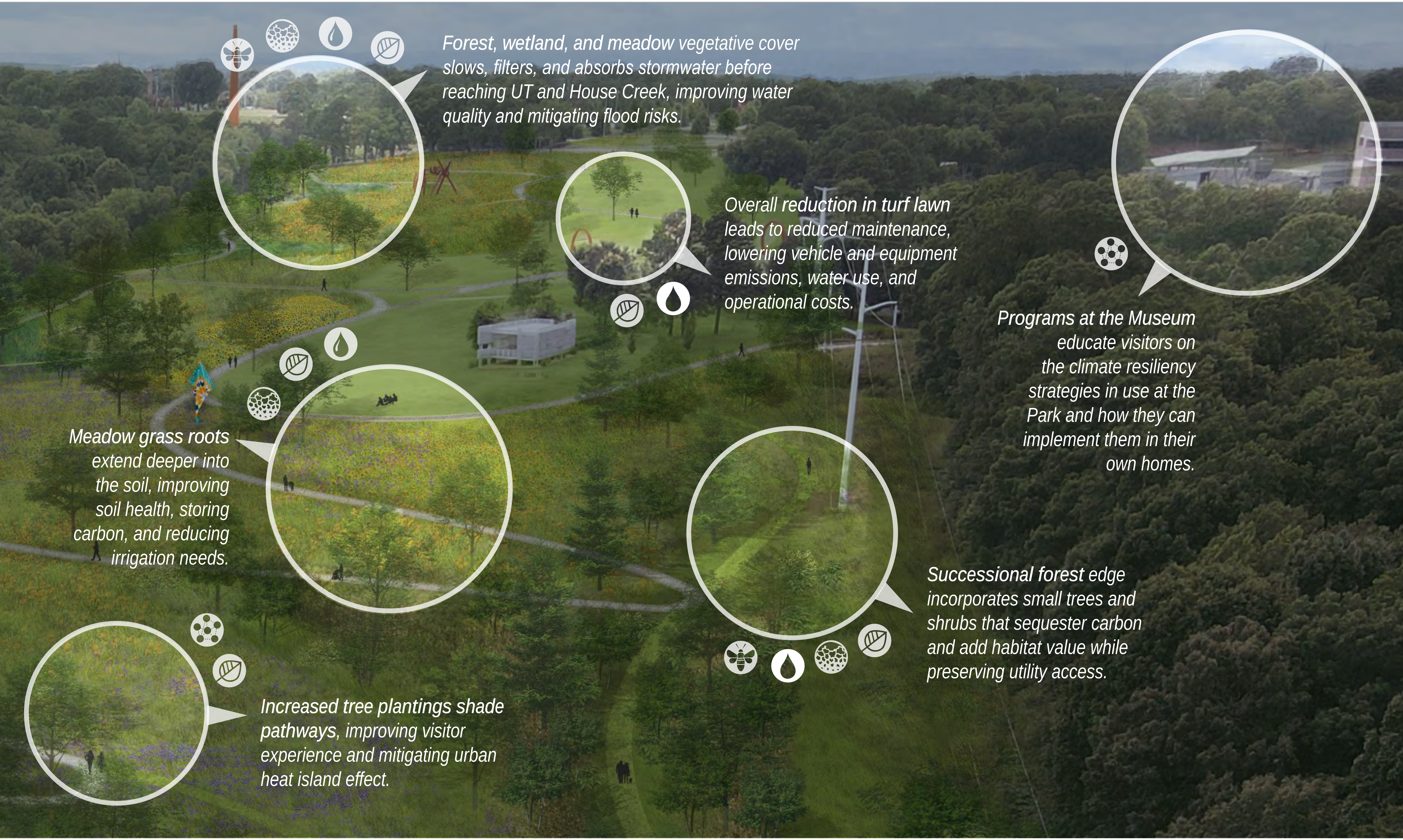
VEGETATION

*The **stream restoration** of House Creek and the unnamed tributary will mitigate flood risks while creating new wetland areas to support habitat, biodiversity, and carbon sequestration.*

*The Vision Plan will add over **12 acres of forest** to the Park, increasing carbon storage and reducing stormwater runoff and air pollution.*

__Fallen logs__ may be repurposed as stream restoration structures, seating or signage, or may remain in place to decompose slowly and nourish other forest organisms.

__Native warm-season grass meadow__ incorporates over 40 different grass and perennial plant species, supporting pollinators and wildlife habitat.


Forest, wetland, and meadow vegetative cover slows, filters, and absorbs stormwater before reaching UT and House Creek, improving water quality and mitigating flood risks.
Overall reduction in turf lawn leads to reduced maintenance, lowering vehicle and equipment emissions, water use, and operational costs.
Programs at the Museum educate visitors on the climate resiliency strategies in use at the Park and how they can implement them in their own homes.
Meadow grass roots extend deeper into the soil, improving soil health, storing carbon, and reducing irrigation needs.
Successional forest edge incorporates small trees and shrubs that sequester carbon and add habitat value while preserving utility access.
Increased tree plantings shade pathways, improving visitor experience and mitigating urban heat island effect.

4 PHASED IMPLEMENTATION

PROPOSED SEQUENCING

The Museum Park Vision Plan is extensive and far reaching, setting a path for an ecologically productive and experientially rich future. However, the implementation of many of these recommendations will need to be phased over time, due to funding and logistical considerations, as well as the nature of many of the proposed improvements, which will require time of their own to mature. Immediate, first, second, third, and long-range priorities have been identified by the design team to guide the Museum in transforming the Park over time.

A few general principles can be applied across the proposed activities for the Park. Interventions higher up in the watershed are almost always a greater priority due to the cumulative impacts they have downstream. In general stream restoration should occur prior to any associated bridge upgrades so that the as-built grades can be accommodated. Grouping the implementation of similar projects may help save on costs related to materials, mobilization, and labor. The seasonal timing of many of the proposed improvements is also critical—whether to ensure plants are installed in the correct season or to coordinate with Museum programs for minimal disruptions. Lastly, engaging Park users with the restoration and conversation processes underway will be key to realizing the full implementation of the Vision Plan.

The items indicated as immediate priorities are focused on removing imminent safety hazards, preventing further damage in already degraded areas, and readying the site for the next phase of work. Damaged bridges and culverts in two locations along the unnamed tributary and House Creek should be removed at the earliest opportunity, as well as any trees designated hazardous by the tree assessment. Drainage improvements along the greenway, north of the maintenance facility, will help prevent stormwater from flowing over the greenway trail and causing safety issues for cyclists. Temporary signage and trail treatments such as striping and lane markers can also be added near the confluence to improve bike and pedestrian safety on the greenway.

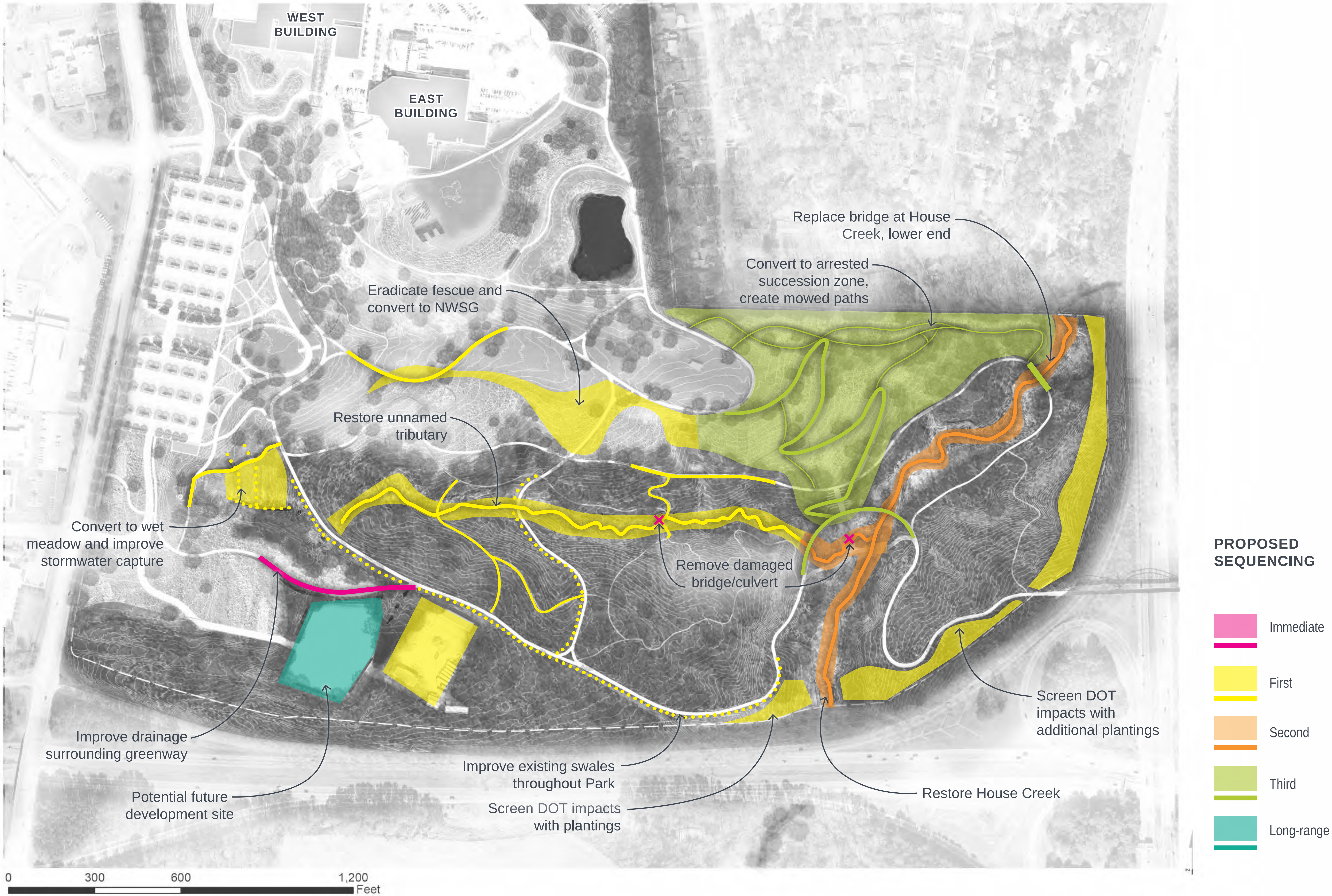
The unnamed tributary stream restoration, up to the future confluence area, and the conversion of the western fescue areas to native warm-season grass meadow are first-phase improvements due to the visibility of this area and proximity to the native meadow previously established by the Museum. The conversion of the wet meadow and stormwater improvements in the headwater area should happen in tandem with the channel restoration. Other stormwater improvements that should be prioritized include deepening swales along the greenway, as well as incorporating rain gardens and infiltration trenches to capture stormwater at the maintenance facility and overflow parking area.

Additional screening plants along the boundary with the planned NCDOT work should proceed as soon as possible in order to get a head start on building back a robust vegetative buffer.

Stream restoration of House Creek will follow. As this section of stream is larger and more degraded than the unnamed tributary, additional coordination related to design, permitting, and mobilization will be required. Lessons learned during the restoration of the unnamed tributary can be applied to the House Creek restoration process.

In the next phase of implementation, the conversion of the northeastern portion of the study area to native warm-season grass meadow and successional forest, along with the path realignments and improvements, can proceed. The bridge replacement at the lower end of House Creek should happen early in this phase so that greenway traffic can be re- routed through this area during construction of the boardwalks, bridges, and seating at the confluence area.

Finally, as part of the longer-range future of the site, the existing maintenance facility has been identified as a potential development site. There are many different possibilities for this location, but any future development should incorporate stormwater infrastructure to address added runoff and utilize green building practices.


WEST BUILDING
EAST BUILDING
Replace bridge at House Creek, lower end
Convert to arrested succession zone, create mowed paths
Eradicate fescue and convert to NWSG
Restore unnamed tributary
Convert to wet meadow and improve stormwater capture
Remove damaged bridge/culvert
Screen DOT impacts with additional plantings
Improve drainage surrounding greenway
Improve existing swales throughout Park
Restore House Creek
Potential future development site
Screen DOT impacts with plantings
0
300
600
1,200
Feet
PROPOSED SEQUENCING
Immediate
First
Second
Third
Long-range

ESTABLISHMENT TRAJECTORIES

For all of the restoration and planting efforts recommended in the Vision Plan, time will be a crucial element. Cultivating an understanding of the different processes occurring as these landscapes mature will contribute to their overall success by informing maintenance efforts and educating visitors on the changes they see happening in the Park. For many visitors the existing areas of lawn may be aesthetically pleasing, and the interim conditions of forest or meadow establishment may seem sparse or messy in the initial years after planting. Communicating the environmental and aesthetic value of the proposed landscapes, as well as the expected trajectory for establishment, will help show why these plant communities are worth the wait.

RIPARIAN CORRIDOR

Both House Creek and the unnamed tributary will undergo substantial restoration and re-engineering to address channel incision and floodplain access. In addition to the reshaping of the stream cross section, vegetation and stone structures will be essential parts of the long-term success of the stream restoration process.

At initial construction the banks will be largely stabilized by seeded grasses, and shrub and tree plantings will be quite small. In areas of greater visibility, larger plant material may be a worthwhile investment. The re-engineered channel will utilize more stone and gravel than is present currently. These will serve to withstand erosive forces in the channel, while also providing important habitat to aquatic macroinvertebrates, which are a primary indicator of water quality.

As the woody species in the stream bank mature, they will for a period of time appear quite shrubby compared to the adjacent forested areas. Over time, as the trees reach their mature height, there will be more visibility to the stream banks and ground cover as understory plant communities transition to more shade-tolerant species over time.

SUCCESSIONAL FOREST

Many areas in the preserve that are currently maintained as fescue meadow will be converted to forest with the implementation of the Vision Plan. These zones will not be planted with large trees and shrubs but will be allowed to undergo succession, the transition of plant communities over time, toward a forested condition. The initial planting will resemble the native warm-season grass meadows more closely than a forest. Small trees and shrubs will be planted in the meadow matrix and allowed to develop and mature, rather than mowed or burned as the meadow will be. These introduced woody plants, along with volunteers from the adjacent existing forest, will initially form a low, dense, and shrubby condition.

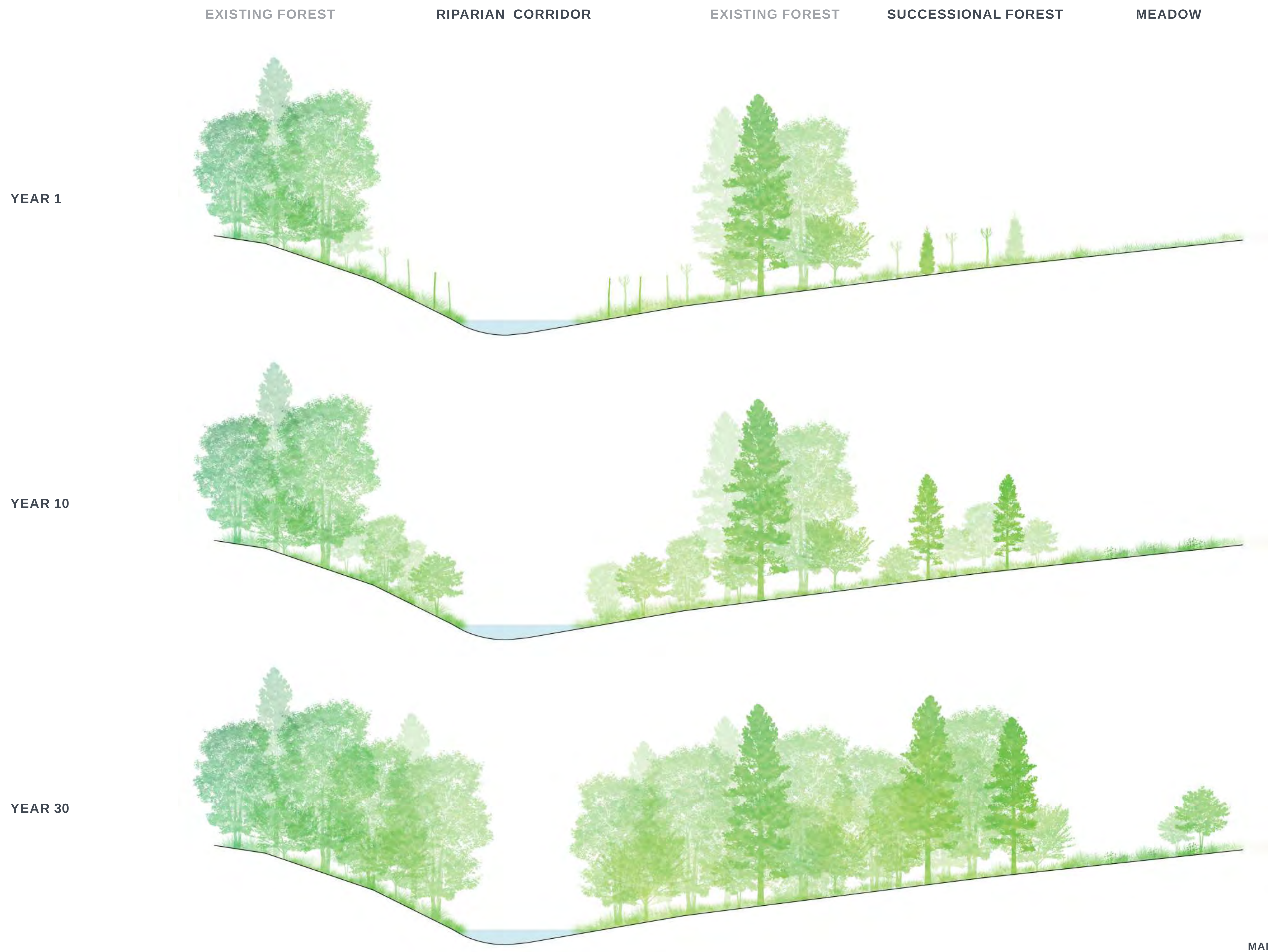
A continuous, layered woodland edge is the goal at the edges of the successional forest. This will provide diverse bird habitat and shade the forest interior. Maintaining a shaded and continuous edge will also help discourage establishment of invasive vegetation and maximize habitat value. Where a large disturbance occurs, replacement vegetation may be required to reestablish a continuous edge. Regular removal of invasive vegetation should proceed as needed. With time the successional forest will merge with the adjacent established forest.

NATIVE WARM-SEASON GRASS MEADOW

Prior to any meadow planting, the eradication of the existing fescue lawn will be necessary (see Maintenance and Management Plan, Appendix I-B). Following fescue eradication and soil prep, the planting of the meadow will be accomplished with plugs (small live plants) in combination with meadow seed. Within the first year of planting, the plugs will have an especially high growth rate. Seeded areas should be stable, but the rate of germination and amount of vegetation may be less.

Native warm-season grasses may take two to three years to become established, at which point they can be mowed once a year or burned with controlled burns every three to five years. Along with annual removal of invasive species, mowing, grazing, controlled burns, or other management will be required to preserve the meadow state. Woody vegetation will begin to grow if the meadow is not maintained, eventually becoming a successional forest.

All of the new plantings in the preserve will benefit from monitoring, which should occur at more frequent intervals during early stages of establishment and can decline over time. In addition to preventing the establishment of invasive vegetation, monitoring presents an opportunity to understand which plants in which areas are more or less successful, which will inform planting and maintenance activities throughout the site.


EXISTING FOREST
RIPARIAN CORRIDOR
EXISTING FOREST
SUCCESSIONAL FOREST
MEADOW
YEAR 1
YEAR 10
YEAR 30

MANAGEMENT INPUTS + BIODIVERSITY

RESILIENCY

The proposed plant communities in the preserve will not only increase biodiversity and carbon sequestration, but they will also require less maintenance over time. Efforts devoted to management activities in the Park will decrease as maturing habitats become increasingly established and resilient. As vegetation matures and self-propagates, improved habitat structure and function will increasingly attract wildlife over time. With proper stewardship, the relationship between land management and biodiversity is therefore inversely proportional over time.

For more details on management needs, see the full Maintenance and Management Plan in Appendix I-B.

WILDLIFE BIODIVERSITY

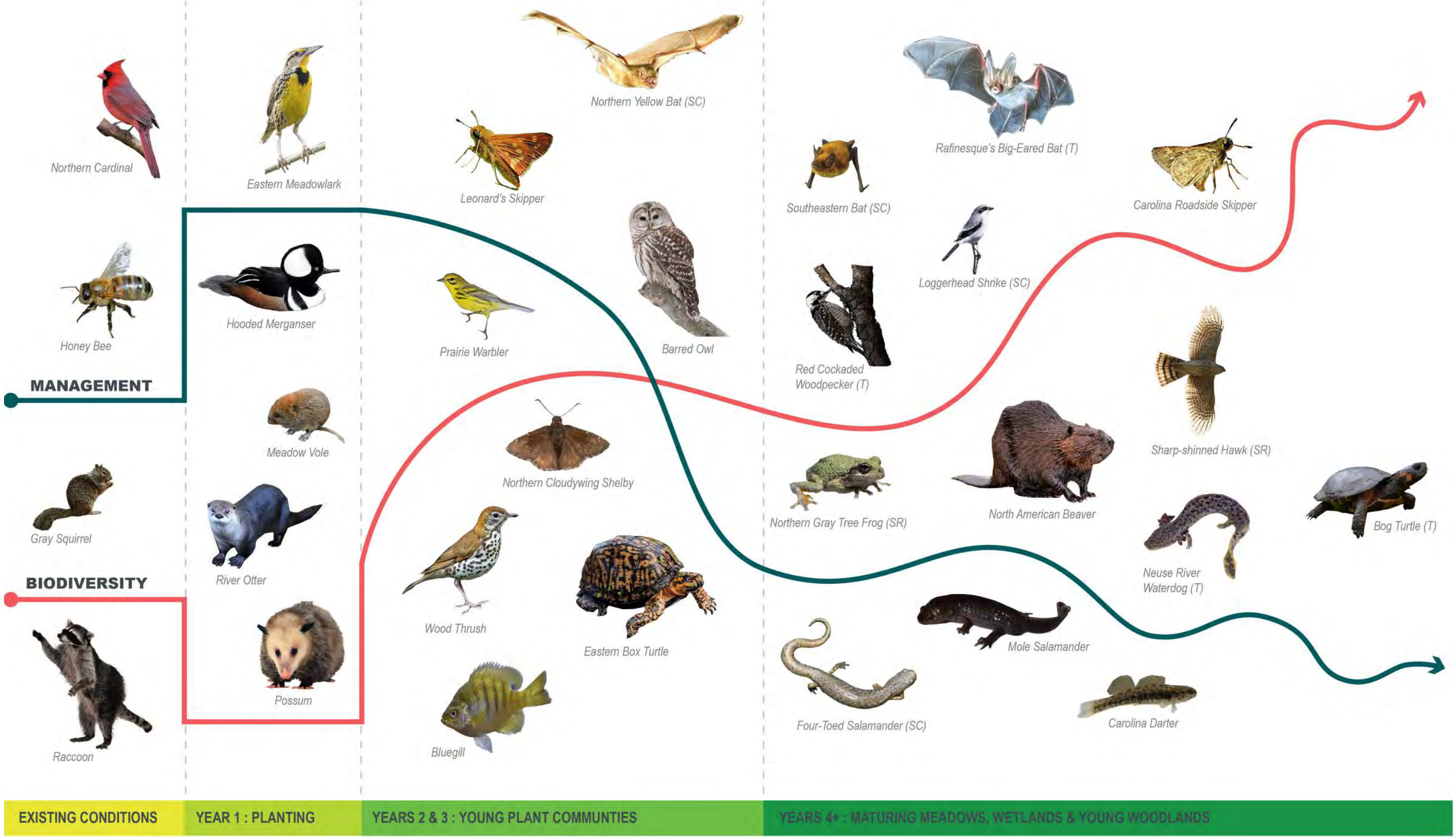
Promoting wildlife diversity is also integral to establishing functional ecosystems in the Park. Globally, and here in the Piedmont region, habitat fragmentation and degradation are rapidly reducing the space available to our native wildlife. Awareness and appreciation of our native flora and fauna are important first steps toward increasing conservation efforts throughout the region.

The species shown at right are representative of a diversity of habitats and species groups found in North Carolina's Outer Piedmont ecoregion. Many are already present in the Park, while others may be rare or endangered. Monitoring wildlife is recommended to track the presence of these species, and to better understand the wildlife potential of the existing and proposed habitats in the Park. An awareness of the species on site can also inform design and management of the Park moving forward.

The Museum Park includes meadow, upland forest, wetland, and stream habitats. Each has a unique potential to support animal species assemblages, and the variety of habitats in a relatively small site could create a significant amount of biodiversity in the Park. However, each habitat represented will be relatively small in acreage, and surrounding development creates a barrier to mobility for many species. Thus, area-sensitive species, and species intolerant of moving through urban or suburban conditions to reach the site, will not likely be supported. Additionally, stream water quality and hydraulics are a major factor in habitat-fauna relationships, and they are dependent on watershed-wide conditions, which can only be partially influenced by actions taken on site.

Wetland and native warm-season grass habitats are very rare in this ecoregion, as development activities have skyrocketed in the previous decade. Therefore, these habitats, and the wildlife that they might support, will be an important restoration opportunity and unique recreation experience. Numerous songbird species occupy native warm-season grass meadows, while wetlands support a host of amphibians, such as salamanders and frogs that are highly sensitive to water quality. The presence of these species in the Park would show significant steps not only toward improving wildlife diversity but also toward successful environmental restoration.

The level of interaction between Park visitors and wildlife will require thoughtful design throughout the Vision Plan implementation. It is important that visitors are able to see and appreciate the biodiversity possible in the Park, without damaging sensitive wildlife habitat. In addition to the expected decrease over time in maintenance activities, which can be a primary deterrent to wildlife establishment and diversity, visitor access points, such as paths and gathering spaces, should be carefully considered to preserve the largest contiguous areas of habitat possible. Educational signage and Museum programs should be provided to educate visitors on the wildlife of the Park and the steps taken to support a more diverse ecosystem.



T = Threatened Species
SR = Significantly Rare Species
SC = Species of Concern

5 APPENDICES I

APPENDIX I-A—MANAGEMENT + MAINTENANCE PLAN

Prepared By: Andropogon Associates and Biohabitats, in association with the NCMA Stream Restoration Design and Museum Park Vision Plan

September 20, 2021

Management Goals

The Maintenance and Management Plan will provide guidance for the North Carolina Museum of Art (NCMA) leadership and maintenance staff to ensure that the investments made in the Museum Park are protected as patterns of use, climate conditions, and available resources change over time.

The primary goal of this plan is to develop a watershed-based approach to site and landscape management activities that will support the proposed rehabilitation efforts in the House Creek and unnamed tributary stream corridors. Because the entire project site drains into one of these two streams, it is of utmost importance that every maintenance activity helps to improve the water quality in these water bodies.

The management recommendations in this document are meant to support the establishment and promotion of ecological systems that will require fewer inputs over time. This runs contrary to traditional maintenance strategies, such as the use of synthetic fertilizers and unsuitable plant choices, which over time contribute to unbalanced relationships in the ecosystem, requiring more and more inputs in order to achieve the desired result. The Museum can build strong ecosystems by increasing biodiversity and creating high-quality habitats which will be able to better withstand climate change-related environmental stresses such as severe storms, drought, and invasive species. Consistent monitoring and adaptive management strategies will play a vital role in the successful management of the Park.

While many of the following recommendations call for a change in current maintenance practices, it is important to understand and work in the constraints of the NCMA operations budget, staff availability, and staff training in order to ensure that the long-term vision is achievable. Specific recommendations and strategies to succeed in these constraints are as follows:

- Conduct further staff development with training programs through the US Forest Service, NC State Extension, NC Botanical Garden, and other agencies.
- Bring in experts for targeted training sessions as well as general updates on best practices and current technology.
- Designate one or more staff members as the manager(s) of the Park's data collection and database updates. Strive for consistency in this position.
- Develop partnerships with students and teachers in related fields (NC State's Department of Landscape Architecture and Environmental Planning or the Parks, Recreation, and Tourism Management Department, Duke University's Nicholas School of the Environment, and NC Central University, for example).
- Develop community partnerships that utilize the expertise of volunteers.
- Develop partnerships with other institutions and participate in interagency groups such as the Wake Nature Preserves partnership to foster synergy and support for similarly aligned agencies.

Management Zones

The following sections identify specific strategies for the variety of ecological communities currently found on site, as well as those proposed in the 2021 Museum Park Vision Plan.

Riparian Corridor and Stream Restoration

Long-term monitoring of stream health on both the unnamed tributary and House Creek will allow the Museum staff to better understand what maintenance strategies are most effective and identify problems areas in need of additional attention. This data will also aid in communicating to funding partners and the general public the water quality impacts of the Museum's restoration efforts in both riparian and upland areas.

Short-term (postconstruction years one through five), success for stream restoration projects will be measured by the stability of the constructed channel structures and banks and the survival of planted vegetation. Five or more years following construction, success will be measured by channel stability and vegetation survival and growth remain primary objectives, but additional ecological responses can also be used to measure ecological functional uplift. These features vary in practice, but a commonly used measurement of aquatic ecosystem health is the size and diversity of the macroinvertebrate population.

This is because macroinvertebrate populations integrate stream conditions over an extended period of time and their species compositions reflect the water and habitat quality of the streams where they occur. The North Carolina Department of Environmental Quality, Division of Water Resources (NCDEQ/DWR) uses this metric as one of the quantitative evaluators of stream water quality in North Carolina. There are five bioclassifications: Excellent, Good, Good/Fair, Fair, and Poor, which indicate water quality and aquatic habitat conditions. Sampling macroinvertebrates is a relatively cost-effective way to ascertain trends and can be done periodically (every five to ten years) to monitor stream aquatic health.

To monitor stream channel stability during the first two years following construction, the NCMA should visually inspect the entirety of the restored channel reaches every three to four months and after major storm events. Any evidence of stream structure degradation or bank erosion should be documented. If degradation occurs and is severe enough, repairs should be made to prevent unstable conditions from increasing in severity and extent. After the first two years, if the stream channel and banks are stable, then periodic monitoring every six months is recommended. Planted vegetation should be monitored for survival at the end of the growing season for at least two years after the plant warranty expires, to ensure mortality is at acceptable levels (generally less than 10 percent) and the stems per acre count is on a trajectory to attain 250–300 stems (trees and shrubs) per acre after four years. If mortality rates are outside of accepted levels, then replanting should be implemented where necessary. The target for replanting efforts should be to meet at least 90 percent of the density of the original planting. Due to the adjacent forests, volunteer species will also help make up for any losses in planted material. The riparian corridor should be monitored for invasive species and controlled on an annual basis.

With the proper, calibrated water quality sampling equipment, additional water quality parameters can be periodically measured, and trends can be determined. Measurements listed in Table 2 of the tabulated water quality parameters were taken during the master planning process and can be used to build a database of site measurements to track trends over time to determine if and how water quality trends are changing. It should be noted that dissolved oxygen, turbidity, and to a lesser degree, conductivity readings, can be highly variable over time, depending on temperature, precipitation, and season. Therefore, it is recommended that if any of these parameters are measured to determine trends over time, a sufficient number of data points should be collected to help dampen the variability in readings that may occur. This can be accomplished by collecting data multiple times over a single day or several days. Regardless of the protocol, consistency over time is important.

Baseline survey data for macroinvertebrates, fish, and vegetation was collected in the fall of 2020 and spring of 2021. The full reports are available through NCMA staff, and a summary of fall and spring data can be found in the Appendix section of the Museum Park Vision Plan (2021).

Table 2

Data Measurement	**Indicator of success**	**Target**	**Source**
Turbidity	Stable or decreasing	≤50 NTU	NCDEQ/DWR
pH	Stable	6.0–9.0	NCDEQ/DWR
Conductivity	Stable or decreasing	<115 Us/cm	Susan Gale's *Explorations of Relationships Between Specific Conductance Values and Benthic Macroinvertebrate Community*[1] Bioclassifications in North Carolina-NCDWQ
Dissolved oxygen	Increase over time	For non-trout waters, not less than a daily average of 5.0 mg/l with an instantaneous value of not less than 4.0 mg/l	NCDEQ/DWR
Macroinvertebrates	Increase in natives over time	NCIBI score of Good/Fair or higher	NCDEQ/DWR
Fish	Increase in natives over time	NCIBI score of Good/Fair or higher	NCDEQ/DWR

Meadows

The conversion of the meadows in the upper and lower preserves from fescue to native warm-season grasses (nwsg) will aid in building soils and increasing infiltration rates, which will, in turn, improve the health of the streams in the riparian zones below. These native grasses are also critical in sequestering carbon. These desired native warm-season grasses (nwsg) and other herbaceous plants may already be present in the existing fescue-dominated landscape, and the timing and sequence of the fescue eradication can help to preserve those species while creating the conditions for successful establishment of additional plants through seeding and plugs.

The first three years of the conversion process is a critical time frame for eradicating the fescue to a point where major infestations do not recur and regrowth can be controlled with targeted treatments.

The sequence for fescue eradication should ideally begin in the fall or early winter with a controlled burn of the fescue area. Heavy grazing or mowing may also be used, with a goal of removing as much of the fescue vegetation as possible. If mowing is used, cuttings should be removed so they do not impede herbicide application, which is often a necessary next step to eradicating the fescue. Herbicide use should

[1] Gale, Susan. (2011)

be minimized, but if deemed necessary, application should occur following burning/grazing/mowing, when plants reach a height of six to eight inches. Additional spot treatments or hand weeding of any additional regrowth of the fescue will likely be needed following the initial treatment. The monitoring and maintenance of recurrence are critical to the successful eradication of the fescue and subsequent establishment of seeded and plugs of native warm season meadow species.

After the fescue has been eradicated, seeding a cover crop will aid in stabilizing the soil and accumulating nutrients ahead of the spring planting of the warm season species. Species selected as the cover crop should be appropriate for the current season and for their ability to fix nitrogen in the soil, such as tillage radish or partridge pea. The cover crop may also be an opportunity to highlight the agricultural history of the site and traditions of the region with selections such as hemp, oats, rye or millet, or for a commodity crop when harvested.

By killing off the fescue in the fall, when any native warm-season grass species present in the area are dormant, the desired species present in the area will be unharmed and should continue with their growth cycle the following spring. Interseeding, or seeding directly into the matrix of existing vegetation, can occur in early spring to build upon the existing warm season species that remain following the fescue eradication. Seeding nwsg species with a no-till drill will ensure the variety of seed species are installed at the correct depth and minimize erosion. Strategic use of live plugs will also aid in the more rapid establishment of the meadow plants as part of a combination planting strategy with seeding.

The first three years will be spent establishing the meadow and controlling any regrowth of the fescue or other undesired species. Many of the nwsg species may not emerge in the first year of planting, and so patience is paramount while these plant communities establish themselves in the meadow. Once established, however, the management regime must shift toward maintaining the meadow and controlling the successional processes that would otherwise eventually transition the area toward a forested condition. The management practices listed below may be deployed to preserve the meadow condition, foster the continued growth of a diverse warm season community, and prevent the incursion of invasive exotics and weeds.

- Controlled burning—A controlled burn in early spring is optimal to remove any cool-season vegetation that has developed in the meadow and set an ideal seed bed for the nwsg meadow species[2]. Burning in sections, with mown paths around burn areas as firebreaks, can help to preserve wildlife habitat where a burning maintenance regime is utilized. Phasing the burn may help to minimize impacts to adjacent properties. Controlled burning has been shown to benefit native species, as it recreates the natural conditions of many native grassland communities, and also reduces reliance on chemical herbicides. Advance planning is required for a year-long regeneration cycle in burned areas, as well as any permits needed and logistical impacts on the site. The Museum can partner with the NC Forest Service to develop the burn plan, conduct the burn, and coordinate with the City of Raleigh Fire Department to ensure that all necessary permits are obtained and all burning regulations are obeyed. The City of Raleigh Fire Chief can assist in coordinating burn locations and times with adjacent property owners.

- Mowing—Whereas controlled burning is preferable to mowing, mowing can also be used to manage growth of weeds and woody plant species in the meadow. Late winter, after at least two hard frosts, is the best time to mow the nwsg meadow to ensure that the seed bank has been set for the following spring. Mowing is most advantageous in locations where the growth of woody vegetation cannot be managed with burning alone, and it is more effective when used just before the species to be removed sets seed. The meadow should never be mowed when wet, and the height of the mower should be set 12 inches, with eight inches the minimum height to remain after

[2] Sauer, Leslie Jones and Andropogon Associates. (1998)

a mowing. Mowing also does not need to be an annual practice and can be used on an as-needed basis, skipping years when the development of woody vegetation is slower.

- Hand weeding—While it requires the highest human time and labor input, hand weeding is the lowest impact method of maintenance that can be used in especially sensitive and hard to access areas, or in areas that are not suitable for controlled burns. Training of staff to identify which plants should be pulled and which should be protected is essential.
- Spot herbicide treatment – Where needed, spot treatment with herbicides may be needed to control any unwanted infestations. A watershed-labelled selective herbicide application should be completed before the seed of the species to be removed has set and to minimize impacts to the nwsg nearby.
- Grazing—Grazing by animals, such as goats, is another option in lieu of mowing or weeding. While the NCMA should take care to prevent overgrazing, animals can be a very effective way to remove vegetation, stimulate nwsg species, and add beneficial inputs back into the meadow with manure.When vegetation is actively growing in the spring and summer, grazing should preserve a minimum of 12 inches in height.
- Disking—Light rotational or strip disking can be used as a strategy to prevent successional forest species from moving into the meadow. This technique may be especially helpful in areas where establishment of annual meadow species, particularly those which support specific native bird species, is desired. Disking is most effective for establishment of broomsedge (Andropogon virginicus) and other native grasses, but it is most beneficial as a management technique following the eradication of fescue.[3]

In select areas where woody vegetation or tree cover is desired, allowing succession to proceed past the point of a meadow can produce a “savannah”-type landscape. Pockets of shrubby vegetation or trees can add greater habitat diversity to the meadow zone, while providing vertical interest and shade. Left to their own devices, these savannah areas, as well as the edges of the adjacent wooded areas, will eventually expand into the meadow zone, so the boundary between these conditions should be established early, monitored, and intentionally maintained to preserve the desired meadow extents.

Following meadow establishment, annual monitoring should be performed to find and eradicated any invasive exotics or regrowth of the fescue. Every three to five years, a full vegetation survey should be completed to track the species composition of the meadow as it changes over time.[4]

Guided Forest Succession (Ecotone) Areas

As the meadows meet the existing forested areas of the preserve, a transition zone of guided forest succession will develop. While the longer-term goal for these areas is to transition to forest, management of the ecotone between the meadow and forest will be needed in the interim to cultivate the desired plant species and conditions for forest succession.

In these areas, restoration stock trees should be introduced to develop the canopy and seed bank of native woody vegetation. Mowing and burning should not be used in these areas, and if mowing is unavoidable, clippings should be removed so they do not shade out seedlings of woody species. Familiarity of staff with the desirable species will be important to preserving the native seedlings and removing the invasive vegetation that can come to dominate these transition zones if not carefully maintained.

[3] Burger, Dr. L. Wes, and Kirk Greenfield. (2005)
[4] Virginia Department of Wildlife Resources. (2021)

The guided forest succession zone should be maintained as a continuous zone at the woodland edge to maximize the diversity of habitat, especially for birds, and to provide a shady buffer for the forest core. The integrity of this zone is especially important to habitat preservation and preventing the intrusion of invasive species. Where a significant disturbance occurs that interrupts this zone, prioritize replacement plantings to maintain canopy cover and continuity of the guided forest successional zone.[5]

Forests

Management in the forested areas should be geared toward building and maintaining 300 foot–diameter zones as the minimum spatial unit for promoting biodiversity and watershed improvement.[6] The highest priority zones for active management in forested areas occur at the wetland headwaters and in drainageways where the impact of a healthy forest on habitat and water quality is the greatest. The continued removal of invasive species should be paired with replacement plantings of native canopy trees, understory trees, and shrubs. In addition to the species identified in the Museum Park Vision Plan’s “Plant Communities” section, restoration efforts underway for native species such as the long leaf pine present an opportunity for additional community partners and funding sources.

Preservation of the existing, established native plants in the Park’s forested areas must be coordinated in parallel with other maintenance efforts. Undesired plant material should be removed using the cut stump method of mechanical removal with the use of selective herbicide to minimize off-target damage. Alternative methods of vegetation control such as Integrative Pest Management (IPM) take a systemic approach, while other targeted and lower-impact removal techniques such as the use of vices and weed wrenches, are strategies that may be used to minimize adverse impacts on any desirable nearby vegetation and avoid soil disturbance.

Arrested Succession Areas

An arrested succession strategy will allow for a functional balance between promoting biodiversity and maintaining the access needed for utility maintenance in areas where a full restoration approach is not suitable. In the Duke Energy easement, selective pruning of taller trees will allow shrubs and smaller understory trees to become more dominant. Over time an initial maintenance cycle of removal every one to three years may be reduced to every 12 to 15 years.[7] Grouped placement of shrubby vegetation will also allow space in between for annual mowing to maintain herbaceous zones that will permit vehicle and equipment passage. In contrast to the typical approach of clear-cutting in these areas, working with utility partners to establish acceptable heights of vegetation for their operations can allow for the coexistence of habitat areas and the utility operations.

In addition to diversifying the vegetation types in the arrested succession areas, strategies for management of invasive species should be transitioned away from regular herbicide treatments whereever possible. Herbicides may be necessary to control certain aggressive invasive species such as vines, but a first-line approach of mowing will support the transition toward a more diverse habitat in these areas. Targeted herbicide treatment may be needed to eradicate particularly vigorous invasive plant species, but routine application should be discontinued. Invasive species removal should be scheduled in the spring, on an annual basis, with a follow-up inspection in summer to ensure additional regrowth has not occurred.[8]

The success of the arrested succession areas will hinge on the coordination between the Museum and utility partners that access the easement areas. Clear expectations for the height and density of the vegetation through this corridor will need to be agreed upon with the utility company. Currently, Duke Energy allows for mixed shrubs and small trees under 12 feet in height in the 60-foot easement zone.

[5] Sauer, Leslie Jones and Andropogon Associates. (1998)
[6] University of Connecticut Center for Land Use Education and Research (n.d.)
[7] Niering, W. A., and G. D. Dreyer. (1989)
[8] Niering, W. A., and G. D. Dreyer. (1989)

While coordinating maintenance and vegetation removal with Duke to ensure that this occurs at the preferred time of year is optimal, plant selection for the arrested succession area should also take into account the possibility of damage due to clear cutting for maintenance access. Native species that can better withstand that stress and regenerate rapidly should be prioritized in this area. Museum staff should communicate its management strategies with Duke Energy prior to beginning the conversion process in order to establish agreed-upon management strategies and approve plant selections. The Museum should establish schedules for COR and Duke Energy for maintenance activities in the Park.

Mowed Turf

In some areas of the Park, mowed turf will be necessary for circulation, gathering, or to define the edge of the meadow. There are a number of strategies that can be employed to reduce the use of fossil fuels and decrease maintenance demands for turf. Grass should be cut to a height of five to seven inches (not lower), and the height should never be reduced by more than half during one cutting. Blades should be kept sharp in order to be most effective. The Museum should explore potential conversion to battery-powered mowers, which could be charged with solar panels mounted on the roofs of maintenance buildings. If this is not feasible, conversion to biodiesel and propane-powered equipment should be considered. If gasoline-powered equipment must be used, four-cycle motors should be used in lieu of two-cycle motors.[9]

In order to decrease and eventually eliminate the use of chemical fertilizers, grass clippings should be left in situ so that they can help build soil health. Maintaining the proper pH will also reduce the need for fertilizers. Where necessary, turf areas can be amended by top dressing with compost or other fully decomposed organic matter. Turf should be top dressed only in the fall, well before winter, when nutrients would quickly wash away into streams before being absorbed. Avoid top dressing in the spring and summer, as the nutrients will feed the weeds in the turf.[10]

General Management Strategies

In addition to management practices specific to the ecological communities identified in the Vision Plan, several general management strategies can be applied across the Park to support the mission of ecological restoration and increased biodiversity.

The reduction of the use of chemicals in all landscape management is a goal throughout the Park. While this transition may require additional staff time in the early phases, maintenance and labor input should decrease over time as the site's ecological systems attain a balance of biodiversity and nutrients that should be largely self-sustaining. In lieu of chemical fertilizer inputs, leaves should be shredded and used to amend soils and promote healthy macroinvertebrate communities. The Museum should develop a system to collect compost tea from the existing leaf mulch storage pile in the maintenance and operations yard. Fallen branches or tree trunks should remain in place in areas where they won't pose a safety concern to serve as habitat for other forest organisms before decomposing and building healthy soil. Wherever possible, the existing biomass of the site should remain in place and cycle back through the ecosystem, rather than being removed as waste and replaced with imported fertilizers and mulch.

The transition to an all-organic maintenance regime will most likely have to be phased over time according to available resources and the level of public acceptance for herbicide use. Some strategies to phase out non-organic herbicides over time include:

- Avoid using herbicides for widespread eradication of fescue in meadow areas if possible; instead use them exclusively to spot-treat invasive species, with the reduction of non-organic herbicides over time.

[9] Sauer, Leslie Jones and Andropogon Associates. (1998)
[10] Sauer, Leslie Jones and Andropogon Associates. (1998)

- Shift to the exclusive use of organic herbicides in areas near walking paths, with the use of non-organic herbicides in areas that are not close to paths reduced over time.
- Immediately discontinue use of broad-spectrum herbicides containing glyphosate, and instead use products that are free of glyphosate and targeted to specific plant types where possible. During the period of transition to an all-organic maintenance regime, products with triclopyr as the active ingredient can be used for broadleaf invasive species, and products with imidazoline can be used where broad-spectrum treatment is needed, such as fescue eradication. However, over time, the use of all non-organic herbicides should be phased out.
- Set a target date by which the Museum seeks to achieve a 100-percent organic maintenance regime, and develop funding targets for additional staff and resources to meet this goal.

The most important element of any invasive species removal program is consistency. This is especially important during the transition to an all-organic maintenance regime, as even one season where maintenance is reduced or delayed can set back the entire program by many years.

In order to repair the ecological damage that the site has sustained over the past two centuries, all management activities must aim to build healthy, stable soils. The establishment of deep root systems as part of the conversion from fescue to native warm-season grass species, along with the continued recycling of all existing biomass on the site, will increase water infiltration rates and soil holding capacity while also reducing watering needs. These changes will lead to the establishment of more diverse and resilient plant communities with a greater capacity to provide carbon sequestration in the Park grounds, and this capacity will increase as these newly established ecosystems mature over time.

Increased care and maintenance of newly installed plant material is another area where greater initial investment will contribute to higher success rates and lower maintenance in the longer term. While the external inputs needed for mature plants are minimal, a recently installed tree or shrub without an established root system is far more vulnerable to fluctuations in moisture, temperature, and other variables. The critical window for plant success is typically three to five years following planting.[11] During this time, the provision of temporary irrigation for all woody plant species planted in the Park will contribute to a higher rate of establishment of these essential plants.

The use of temporary irrigation, especially in high-visibility areas, will help to minimize the staff time needed for watering from a mobile tank, which is the current method of watering new plantings. Where the use of irrigation hose or bags is not feasible, time for watering from the mobile tank must be accounted for in staff scheduling projections, particularly in the hottest parts of the year. If temporary irrigation or additional staff time is not feasible throughout all newly planted areas, efforts may be focused on high-priority areas, as identified based on impacts to water quality and the visitor experience. Again, while initial maintenance and labor inputs may be greater during the temporary irrigation phase, the success of these plantings will contribute to the development of the desired plant and ecological communities that should be far lower maintenance over their lifespan.

Deer mitigation strategies are also needed to protect newly planted wood vegetation from browsing. Currently, a deer herd typically moves through the Park on a daily basis. Fencing can be integrated to protect new plantings and any existing rare species present that are threatened by deer. Deer deterrents have not been shown to be very effective, and they work best when reapplied frequently and when overall deer populations are low.[12] Where deterrents such as urine are used, reapplication is needed after rain. In high priority areas, such as at donor trees, tree protection fencing can continue to be implemented only

[11] Sauer, Leslie Jones and Andropogon Associates. (1998)
[12] Sauer, Leslie Jones and Andropogon Associates. (1998)

during the rut season, if this provides adequate protection. Additional staff hours should be accounted for during times when additional deer protection is needed.

Maintenance Moving Forward

The maintenance regimes for the Park should be an evolving set of practices that respond to the changes of the site over time. Each season, and each success or failure, is an opportunity to reassess and calibrate the methods in use. While new plantings will be selected for their suitability for the site and contribution to overall biodiversity, certain species will succeed and others will not. Resources for maintenance and monitoring for the Museum may fluctuate, as will the climate trends over the coming decades.

In addition to the adjustment of maintenance over time as plant communities grow and develop, maintenance should also account for the interactions of the landscape with human visitors, which is the source of greatest impacts, both positive and negative, for the Park. Considering the visitor as part of the Park maintenance not only improves experience, but it also presents an opportunity for observation and experimentation by engaging visitors for participation and feedback. For example, where new paths are proposed, a mown path will invite visitors to test the new alignment while maintaining flexibility for future adjustments. A standard for temporary trail wayfinding can also be developed for temporary trail closures or barriers in order to replace orange construction fencing. This will improve aesthetics for visitors and contribute to more legible site circulation. Increasing visibility of maintenance activities in an attractive way not only allows visitors to know where they should and should not go, but it also promotes awareness of the efforts required to cultivate this “natural” area.

Monitoring visitation as part of Park maintenance can also inform where to direct resources. As with any beloved landscape, “well used” can quickly become “over used”, with consequences for visitor experience, maintenance needs, and the ecological health of the site. Observations of plant community health and water quality metrics should be assessed alongside the number of visitors to understand where the human impact is becoming too intense in the Park.

Works Cited

Burger, Dr. L. Wes, and Kirk Greenfield. (2005). *Light Disking to Enhance Early Succesional Wildlife Habitat in Grasslands and Old Fields.* Technical Note No. 190-32. Washington, DC: US Department of Agriculture Natural Resources Conservation Service.

Gale, Susan. (2011). *Explorations of Relationships between Specific Conductance Values and Benthic Macroinvertebrate Community Bioclassifications in North Carolina*. Raleigh, NC: NC Division of Water Quality, Wetlands Program Development Unit.

Miller, James H., Manning, Steven T., and Enloe, Stephen F. (2013). *A Management Guide for Invasive Plants in Southern Forests*. General Technical Report SRS–131. Asheville, NC: US Department of Agriculture Forest Service, Southern Research Station.

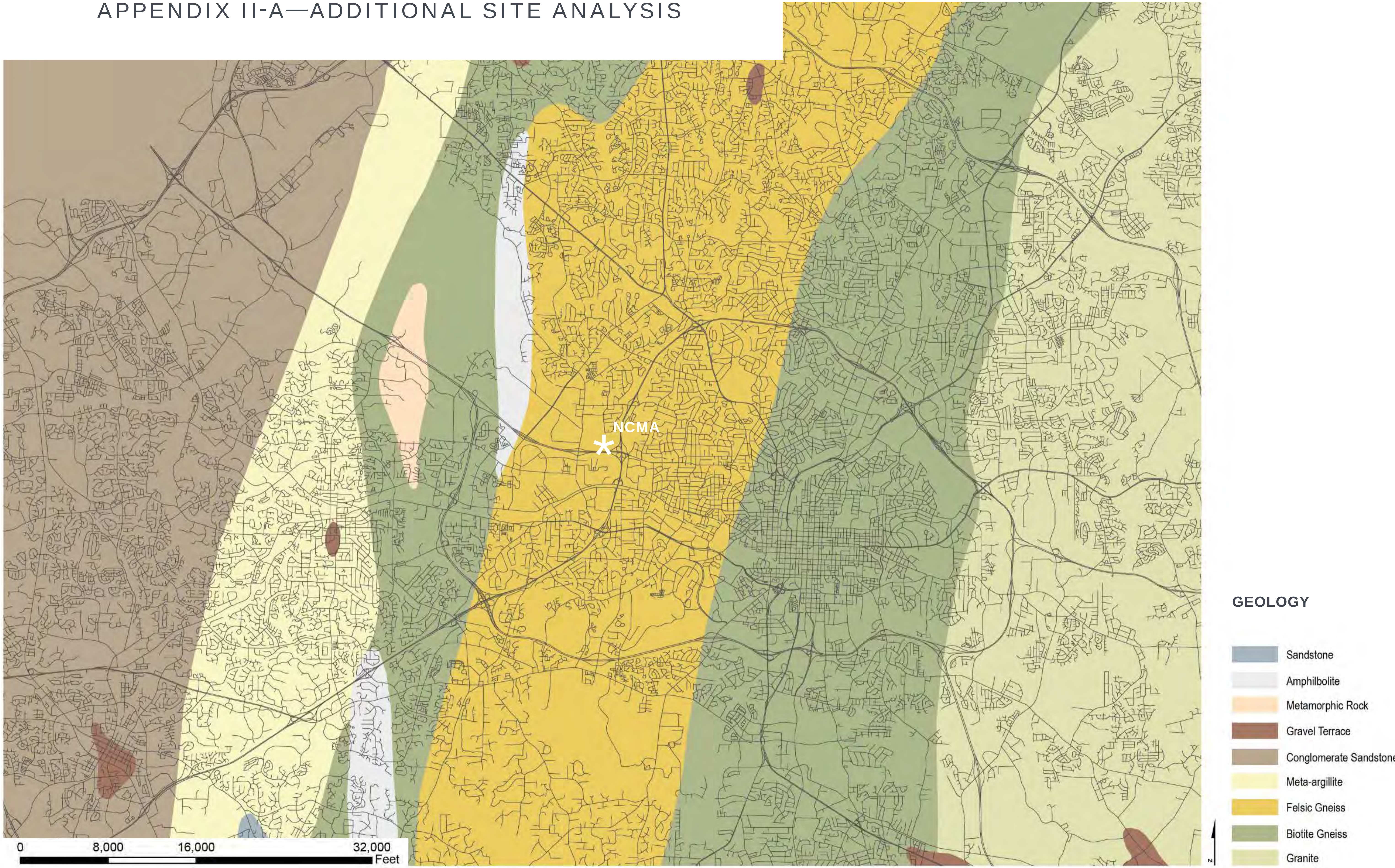
Niering, W.A., and G. D. Dreyer. (1989). Effects of prescribed burning on *Andropogon scoparius* in postagricultural grasslands in Connecticut. *American Midland Naturalist, 122*, 88–102.

Sauer, Leslie Jones and Andropogon Associates. (1998). *The Once and Future Forest: A Guide to Forest Restoration Strategies.* Washington, DC: Island Press.

University of Connecticut Center for Land Use Education and Research. (n.d.). Retrieved from https://clear.uconn.edu/%5C/projects/landscape/v2/forestfrag/measuring/categories_explained.htm

Virginia Department of Wildlife Resources. (2021). Native Warm Season Grass. Retrieved from https://dwr.virginia.gov/quail/managing-your-land/old-field-management/nwsg/

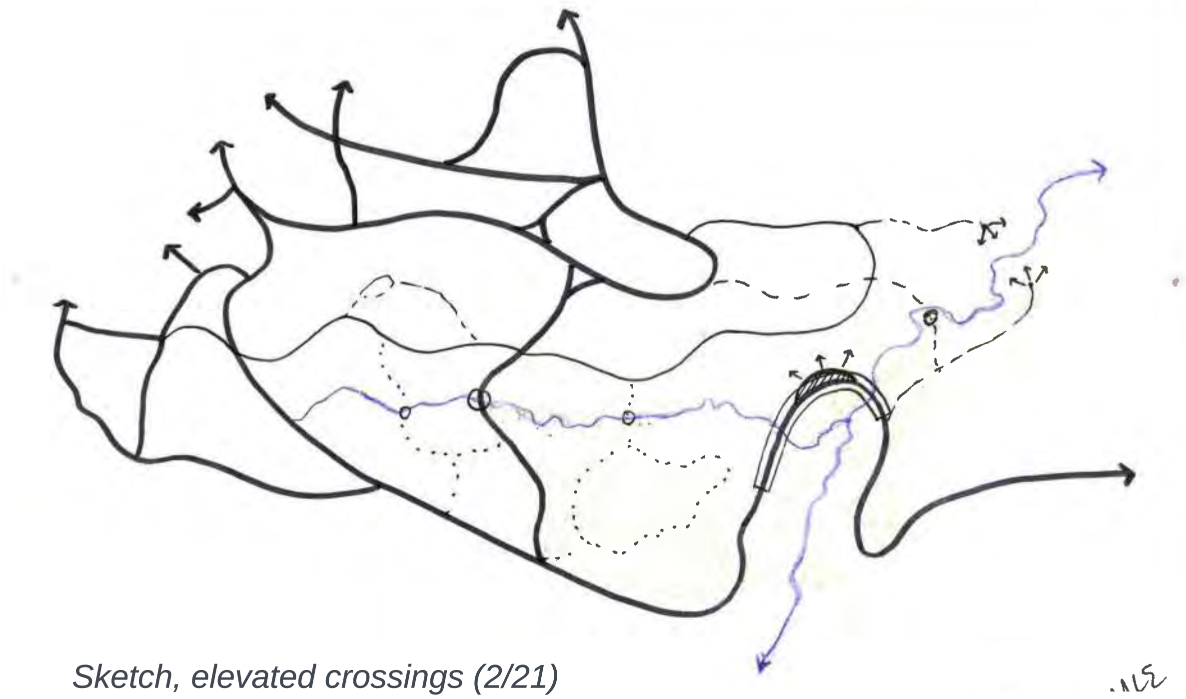
6 APPENDICES II


NCMA
0
8,000
16,000
32,000
Feet
N
GEOLOGY
Sandstone
Amphibolite
Metamorphic Rock
Gravel Terrace
Conglomerate Sandstone
Meta-argillite
Felsic Gneiss
Biotite Gneiss
Granite

SOILS

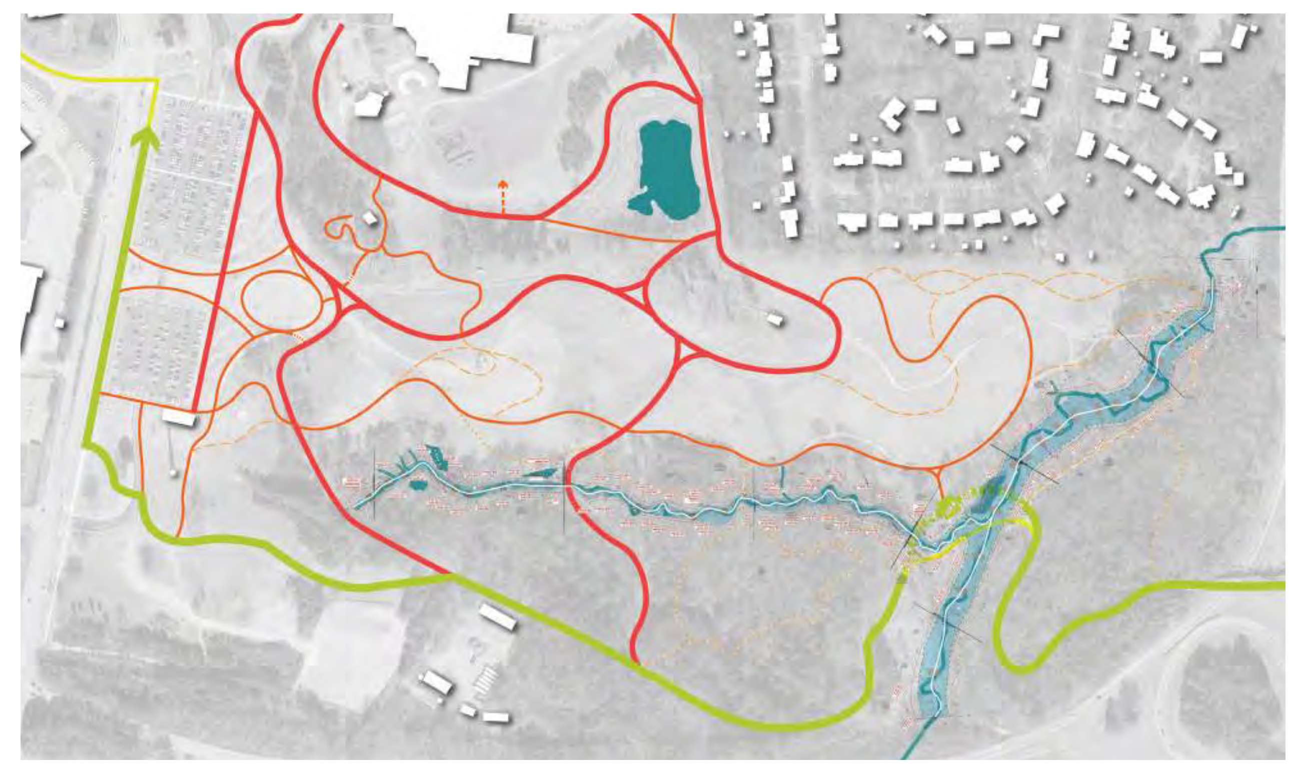
Hydric Soils

CIRCULATION ALTERNATIVES

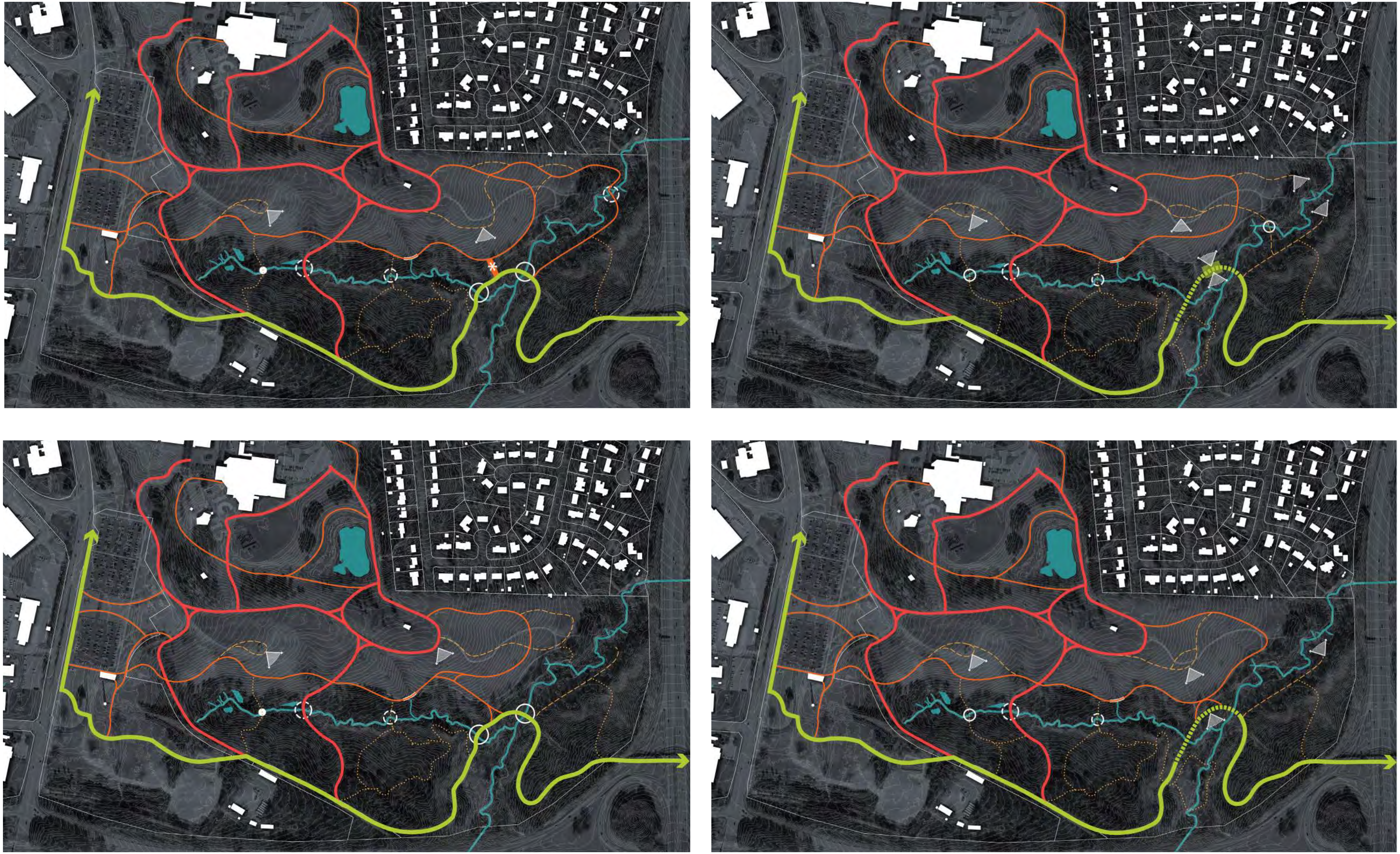


Sketch, elevated crossings (2/21)

Sketch, crossings at grade (2/21)

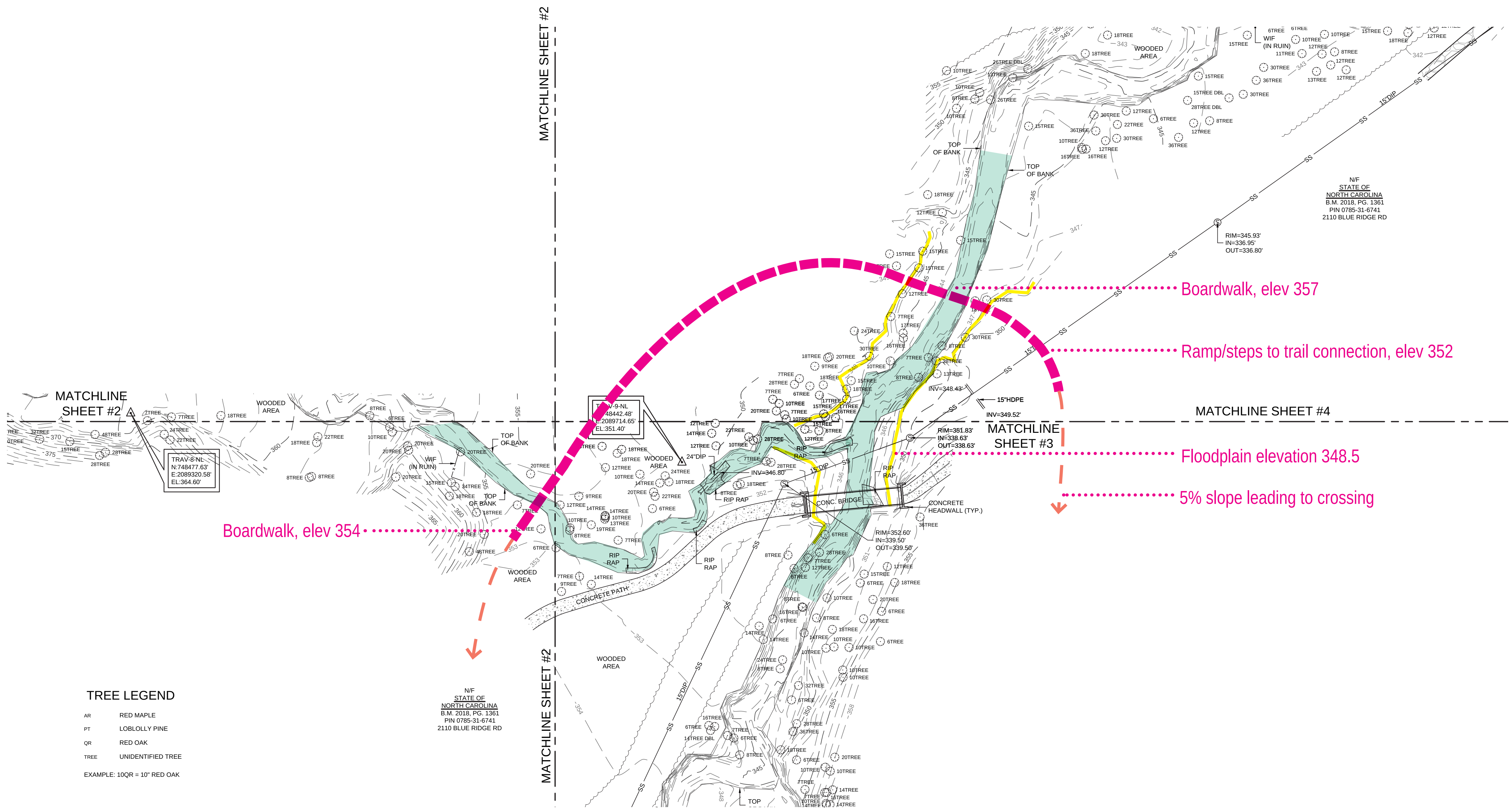


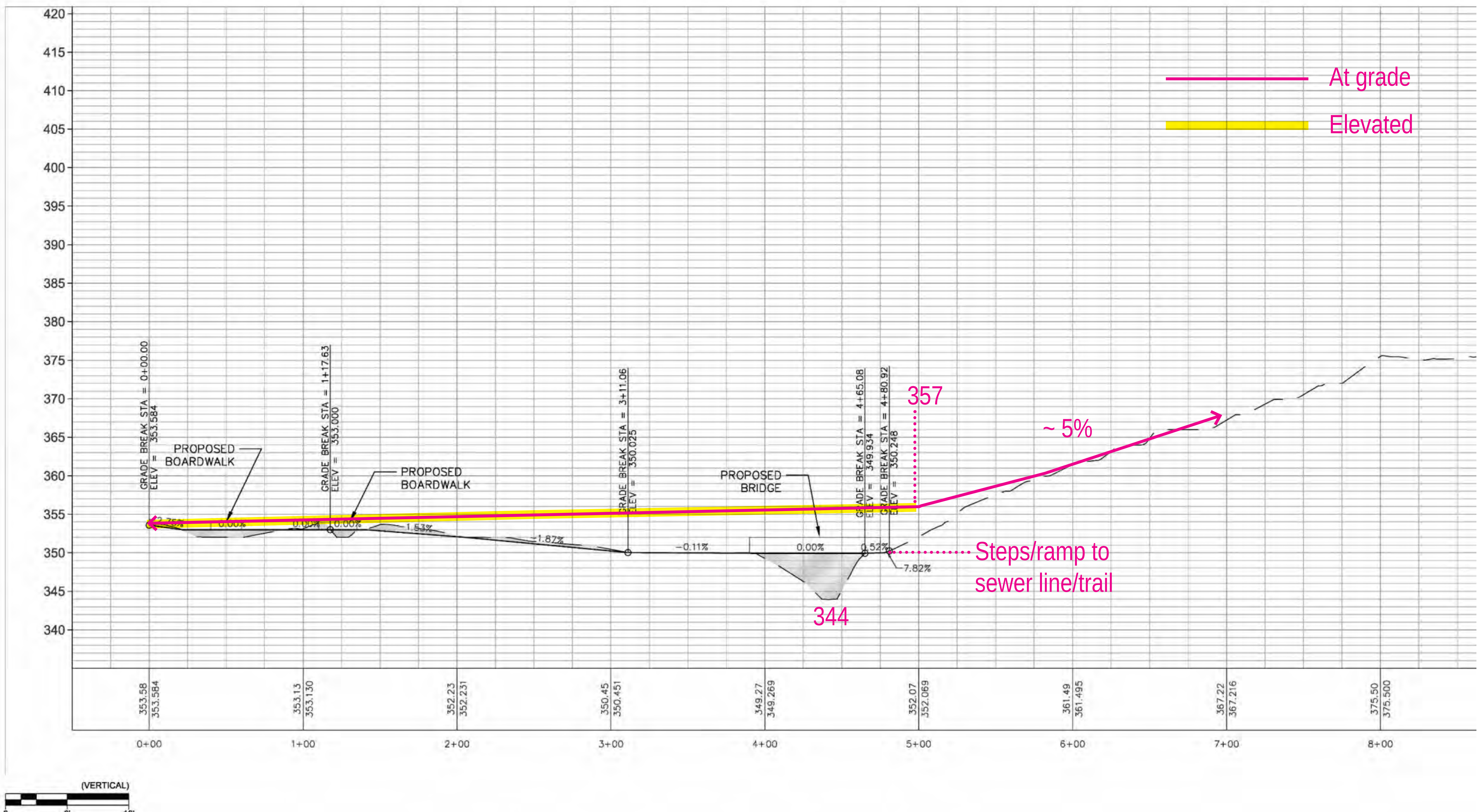
Blue Loop and Lower Meadow Trail alignments (3/21)



Confluence gateway/Lower Meadow connection alternatives (2/21)

GREENWAY REALIGNMENT ALTERNATIVE: HIGHER ELEVATION OF BOARDWALK



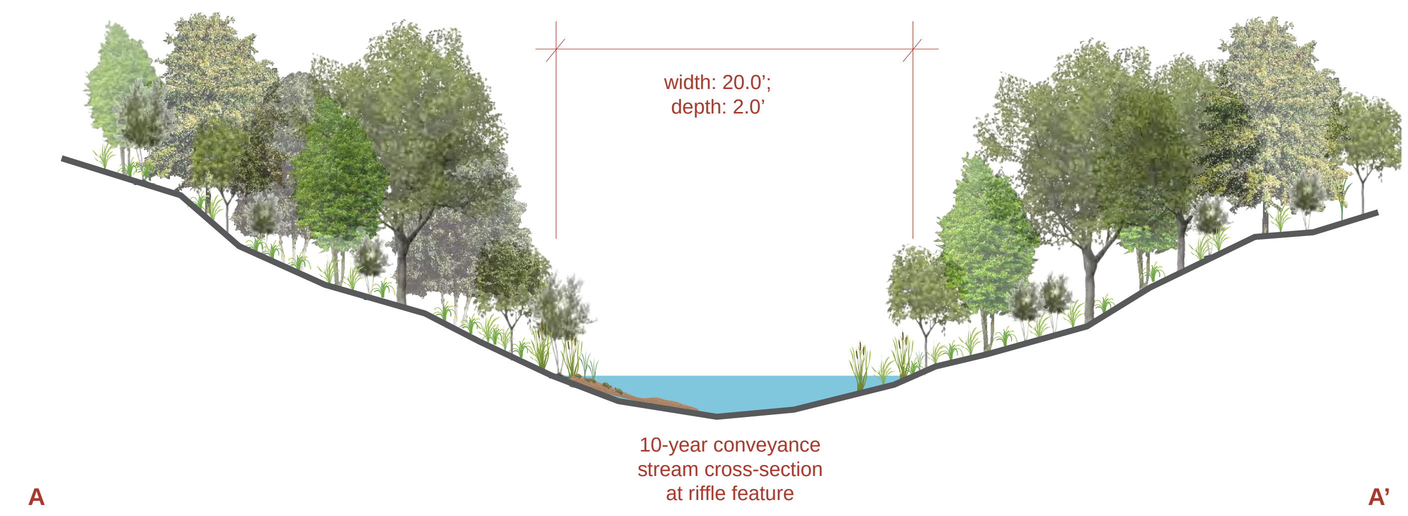


At grade
Elevated
PROPOSED BOARDWALK
PROPOSED BOARDWALK
PROPOSED BRIDGE
GRADE BREAK STA = 0+00.00
ELEV = 353.584
GRADE BREAK STA = 1+17.63
ELEV = 353.000
GRADE BREAK STA = 3+11.06
ELEV = 350.025
GRADE BREAK STA = 4+65.08
ELEV = 349.934
GRADE BREAK STA = 4+80.92
ELEV = 350.248
357
~ 5%
344
Steps/ramp to sewer line/trail
-1.53%
-1.87%
-0.11%
0.00%
0.52%
-7.82%
420
415
410
405
400
395
390
385
380
375
370
365
360
355
350
345
340
353.58 353.584
353.13 353.130
352.23 352.231
350.45 350.451
349.27 349.269
352.07 352.069
361.49 361.495
367.22 367.216
375.50 375.500
0+00
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
(VERTICAL)
0
8'
16'

STREAM RESTORATION ALTERNATIVE 1 (PREFERRED)

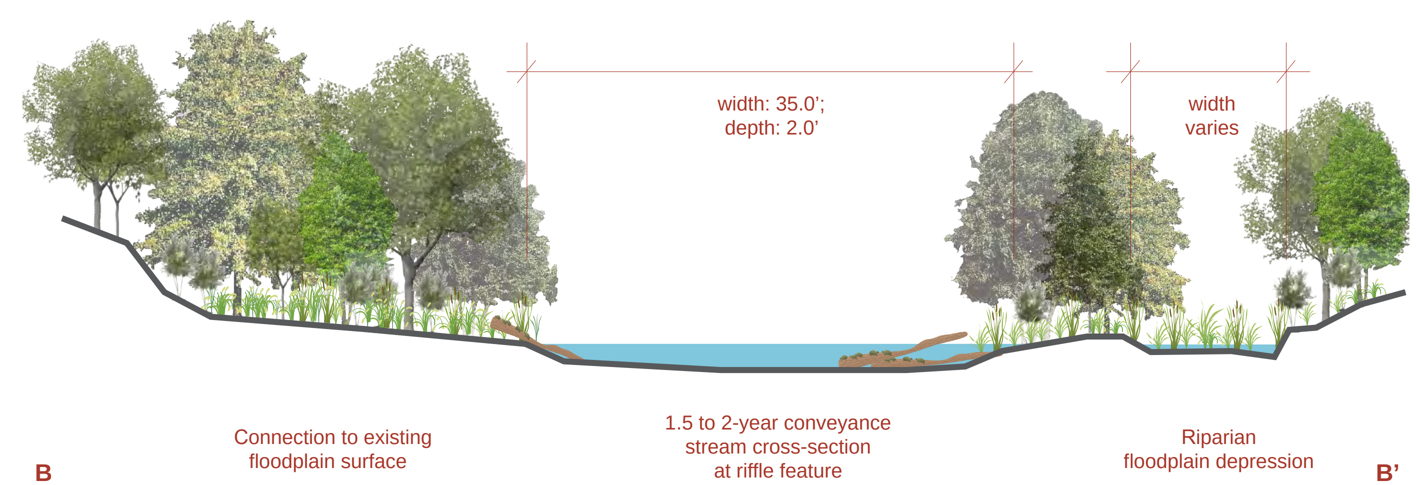
UNNAMED TRIBUTARY

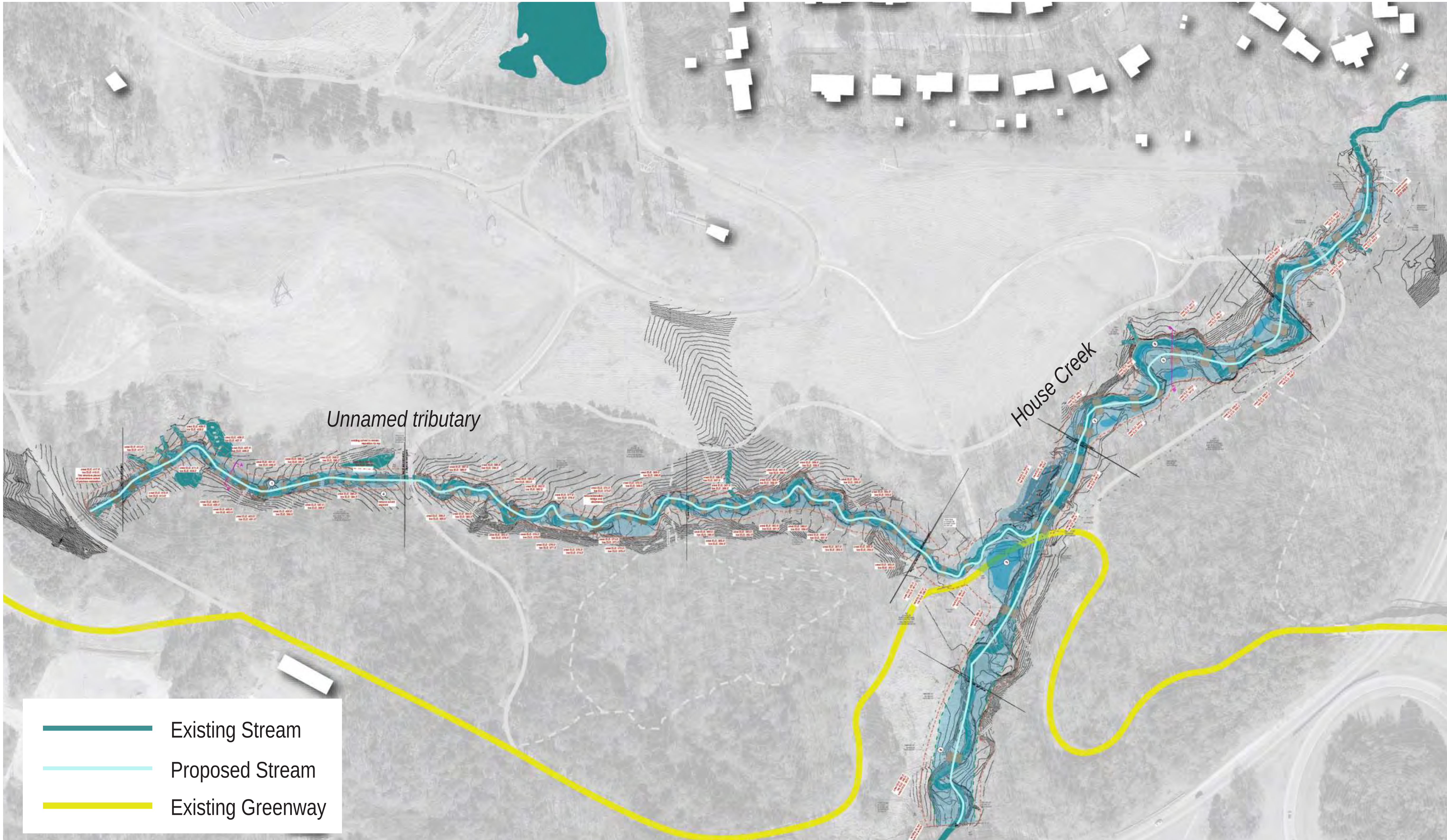
- Minimize disturbance to existing headwater forest and riparian zones
- Riffle/pool pattern as the stream channel drops
- Wetlands in floodplain depression at confluence



HOUSE CREEK

- Streambed elevation raised to allow water access to existing floodplain
- Reuse of excavated material for channel fill material (potentially lower cost)



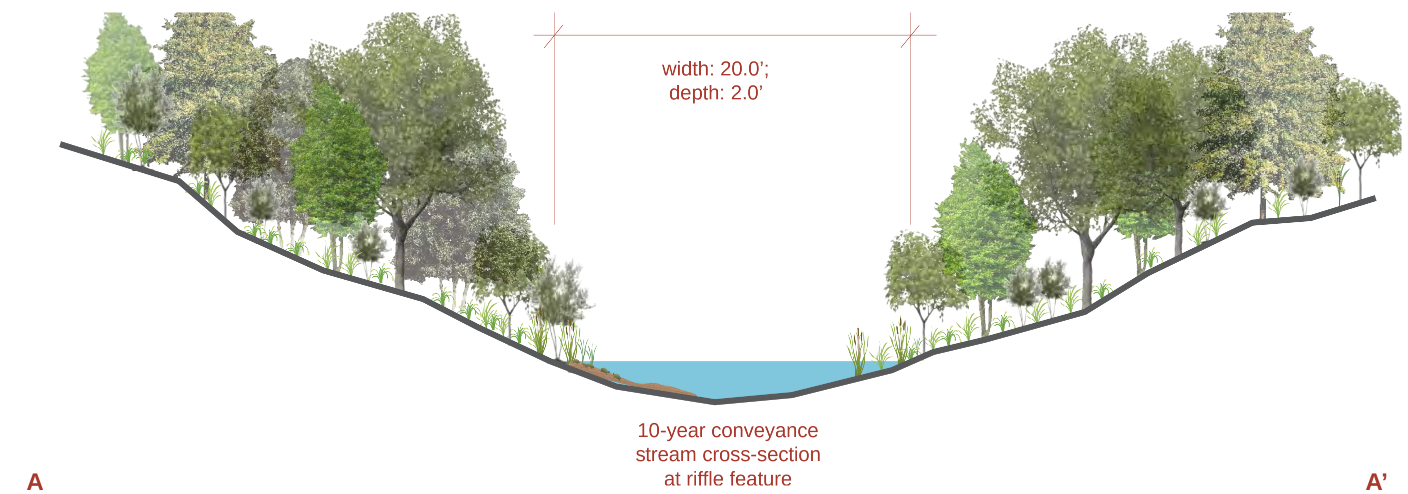


Stream Restoration Alternative 1

STREAM RESTORATION ALTERNATIVE 2

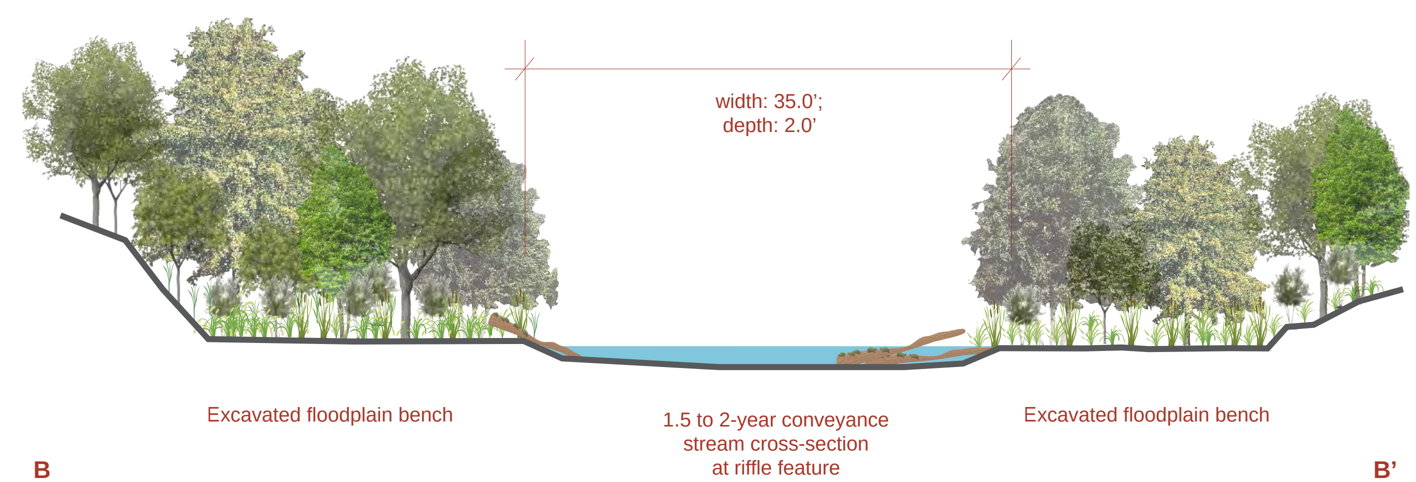
UNNAMED TRIBUTARY

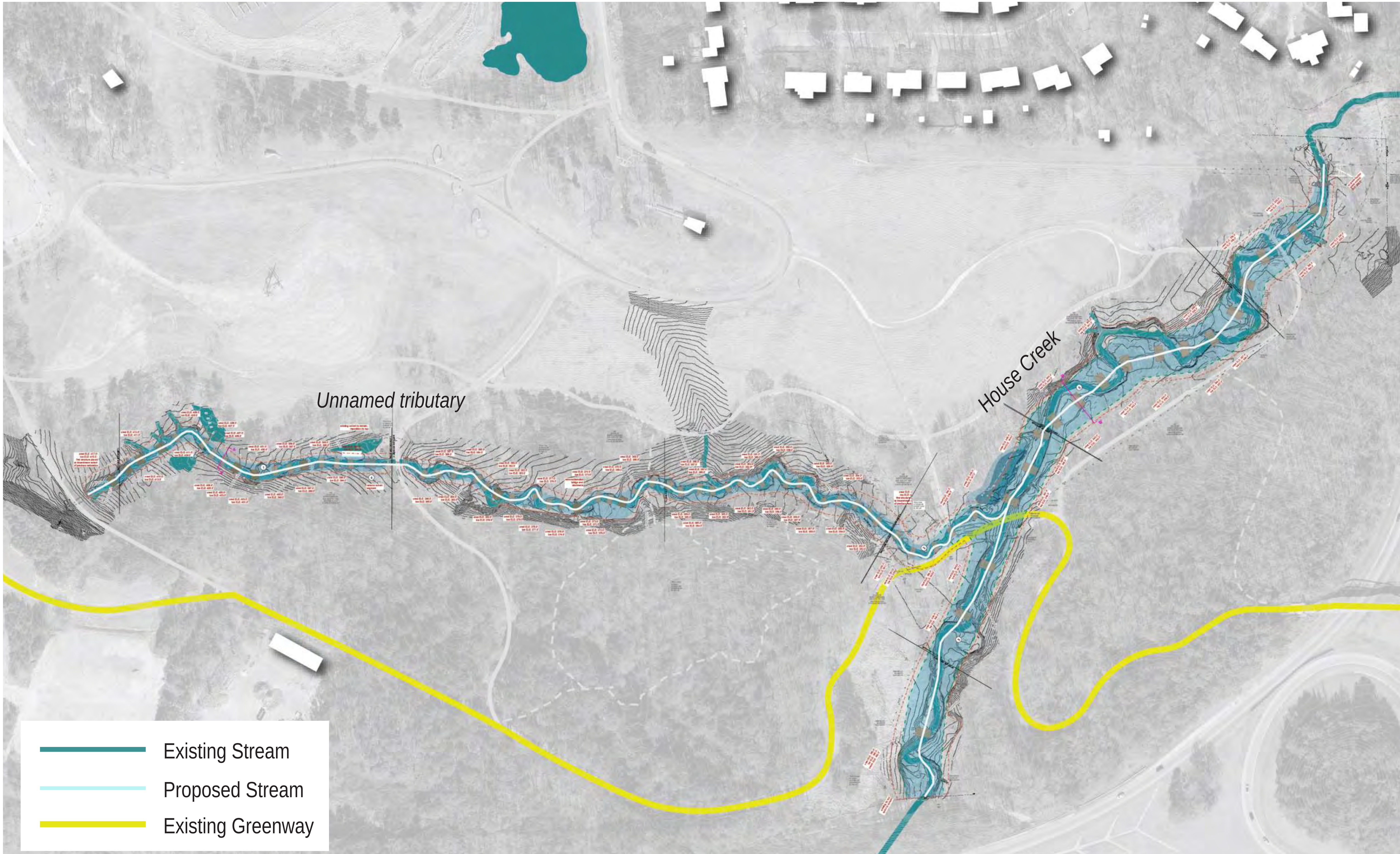
- Minimize disturbance to existing headwater forest and riparian zones
- Riffle/pool pattern as the stream channel drops
- Wetlands in floodplain depression at confluence



HOUSE CREEK

- Streambed elevation remains closer to existing grades
- Requires excavation and removal of floodplain bench material (potentially higher cost)





Stream Restoration Alternative 2

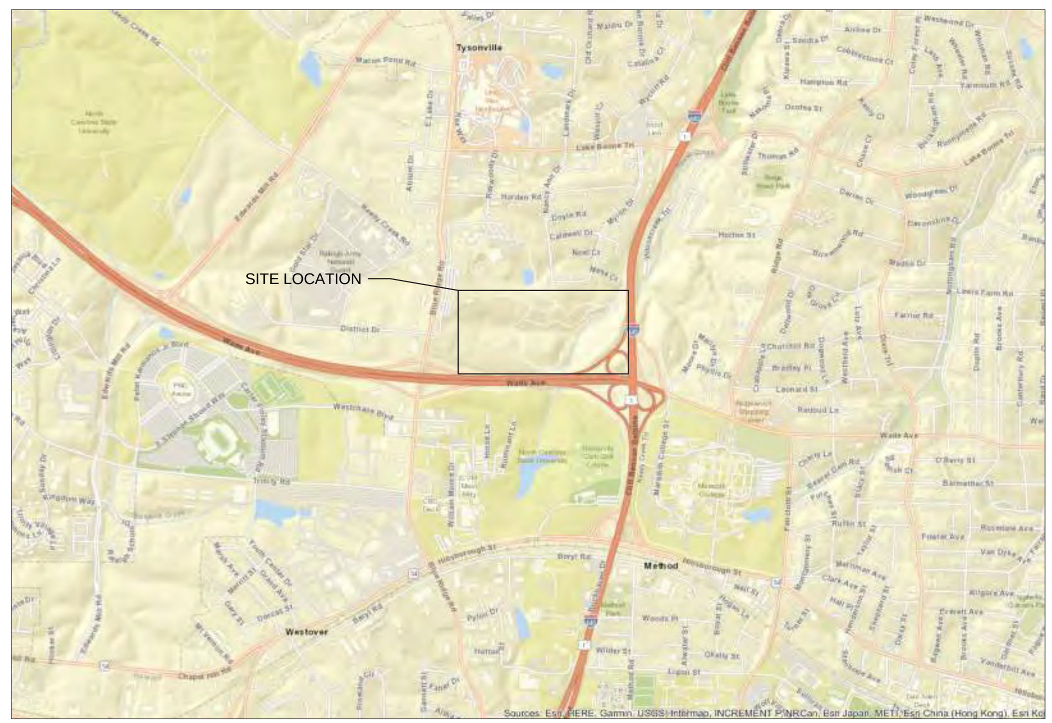
APPENDIX II-C—
STREAM RESTORATION
CONCEPTUAL PLANS

NORTH CAROLINA MUSEUM OF ART

FINAL STREAM RESTORATION CONCEPTUAL PLANS
JUNE 2021

2110 BLUE RIDGE RD
RALEIGH, NC 27607

VICINITY MAP



LIMIT OF DISTURBANCE = XX ACRES

SCALE: 1" = 2,000'

Legend

- Proposed channel alignment
- 1-ft. drop riffle structure
- 2-ft. drop riffle structure
- Presumptive riparian wetland extents
- Stone cascade structure
- At-grade boulder grade control structure
- Riparian floodplain depression
- Approximate grading extents/limits of disturbance (LOD)
- Floodplain bench extents
- Section line (A A')
- (1) Photographic precedent

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DATE | ISSUES / REVISIONS

andropogon

WK DICKSON
community infrastructure consultants

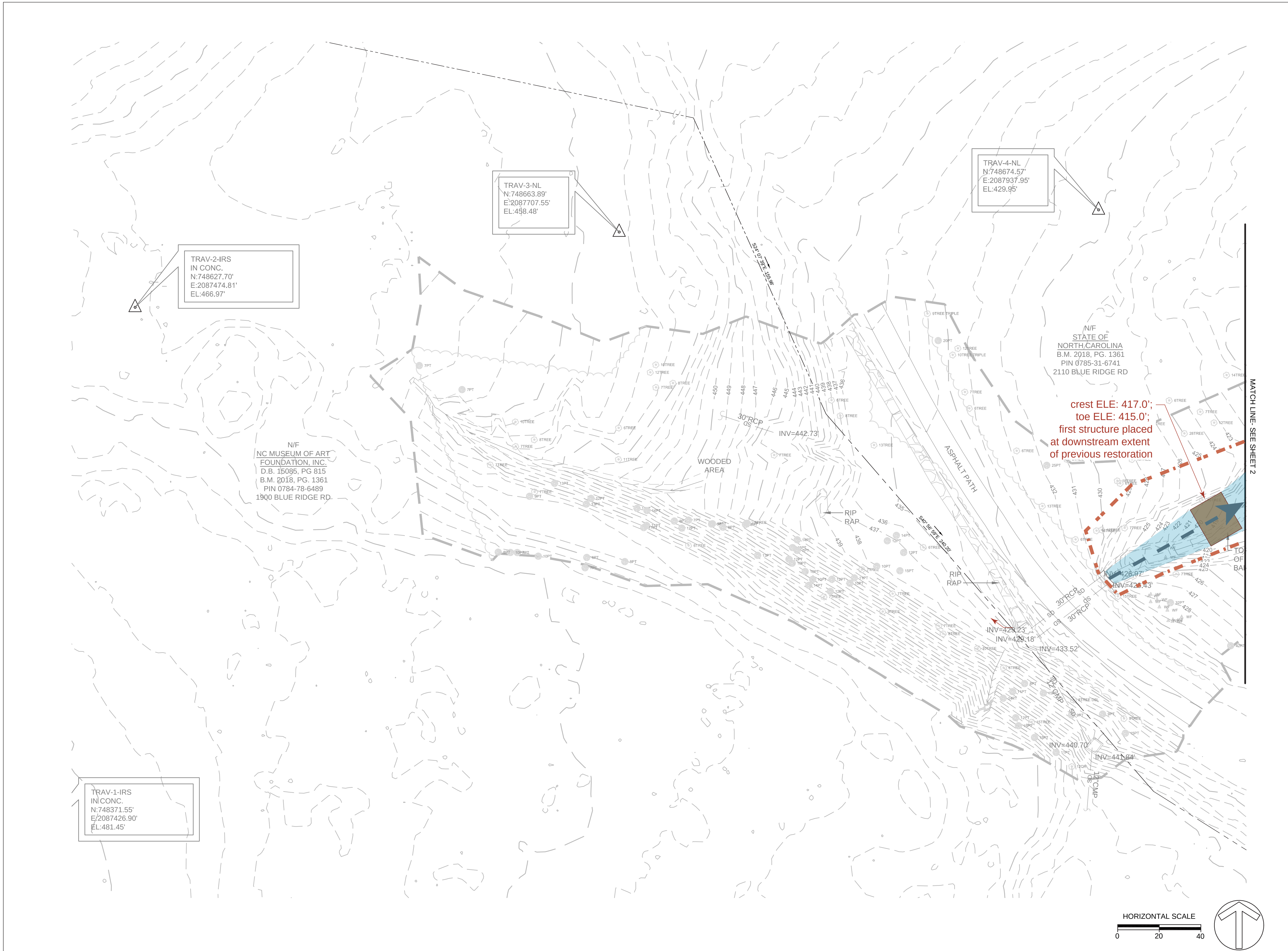
CONCEPTUAL PLAN

NC MUSEUM OF ART VISION PLAN AND STREAM RESTORATION

TITLE: ALTERNATIVE 1

PROJECT NO.: 20024.01
SCALE: AS SHOWN
SEAL:
BY: GB
CHECK: JC
DWG. NO.: CVR

3/9/2021 I:\Projects\20024.01 NC Museum of Art Master Plan and Stream\CAD\Plans\cv01ncma.dwg



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community infrastructure consultants

CONCEPTUAL PLAN

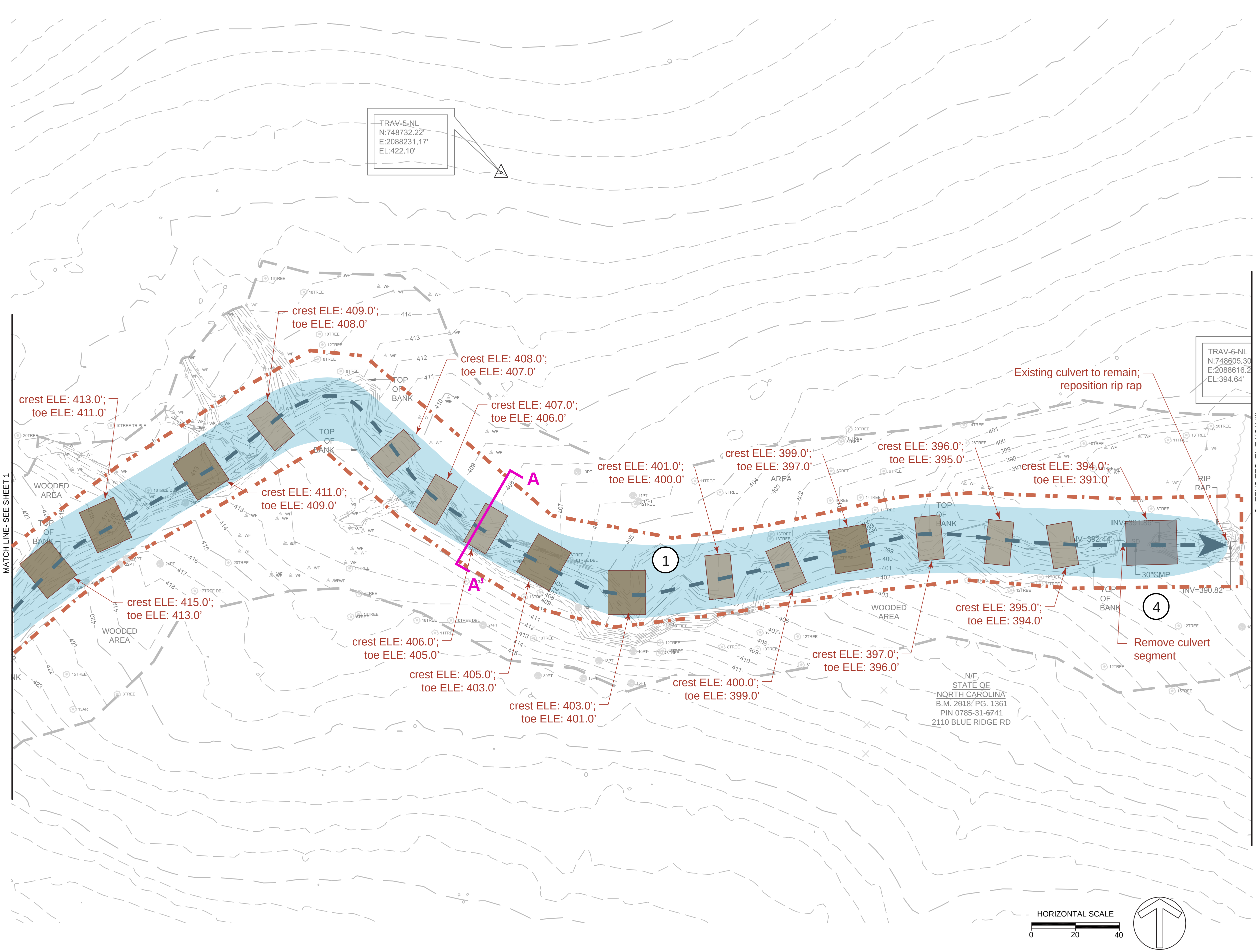
NC MUSEUM OF ART VISION PLAN AND STREAM RESTORATION

TITLE:

ALTERNATIVE 1

PROJECT NO.: 20024.01
SCALE: 1" = 20'
SEAL:
BY: GB
CHECK: JC
DWG. NO.:

1 OF 8



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community infrastructure consultants

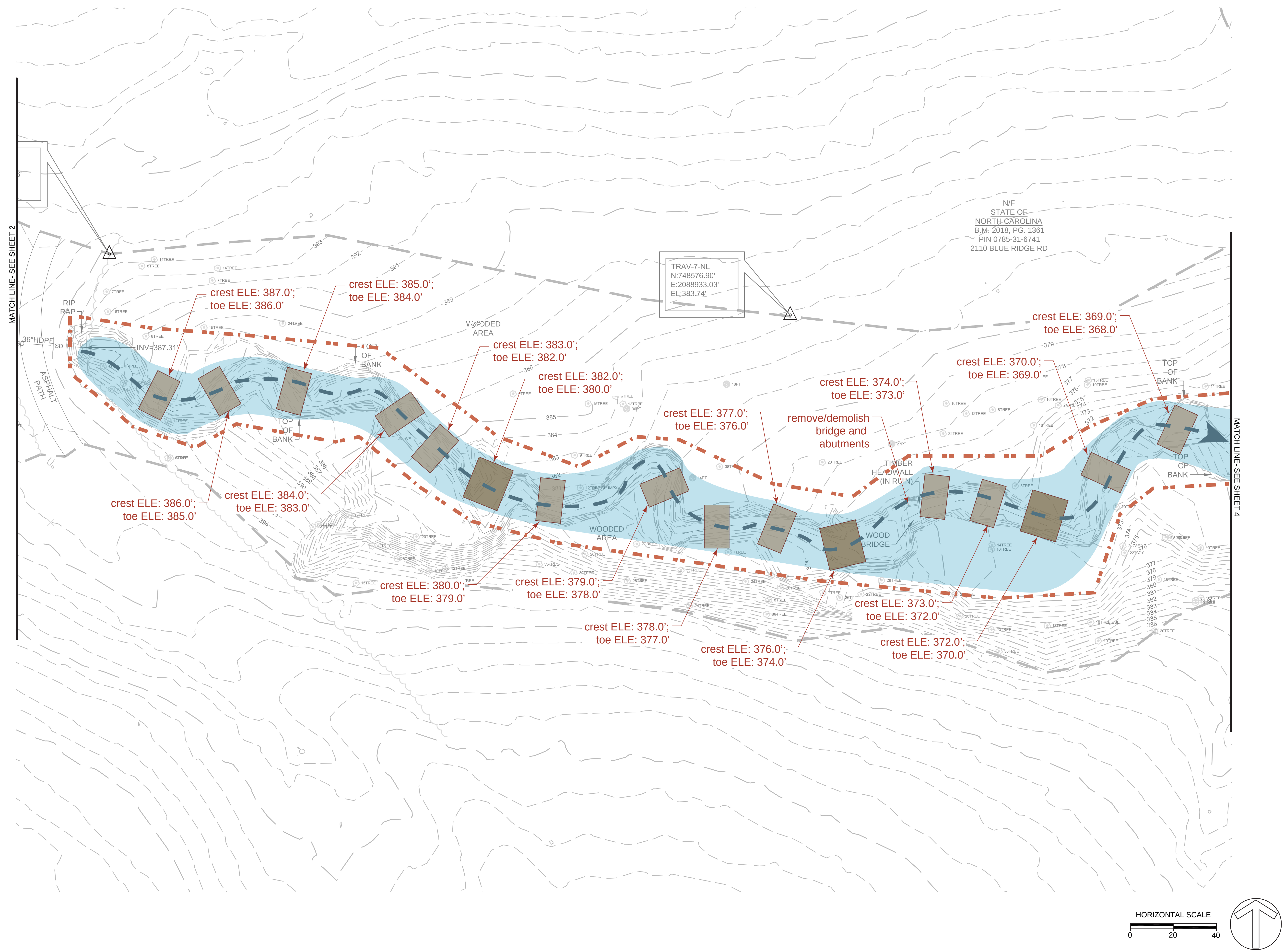
CONCEPTUAL PLAN

NC MUSEUM OF ART VISION PLAN AND STREAM RESTORATION

TITLE:

ALTERNATIVE 1

PROJECT NO.: 20024.01
SCALE: 1" = 20'
SEAL:
BY: GB
CHECK: JC
DWG. NO.:
2 OF 8



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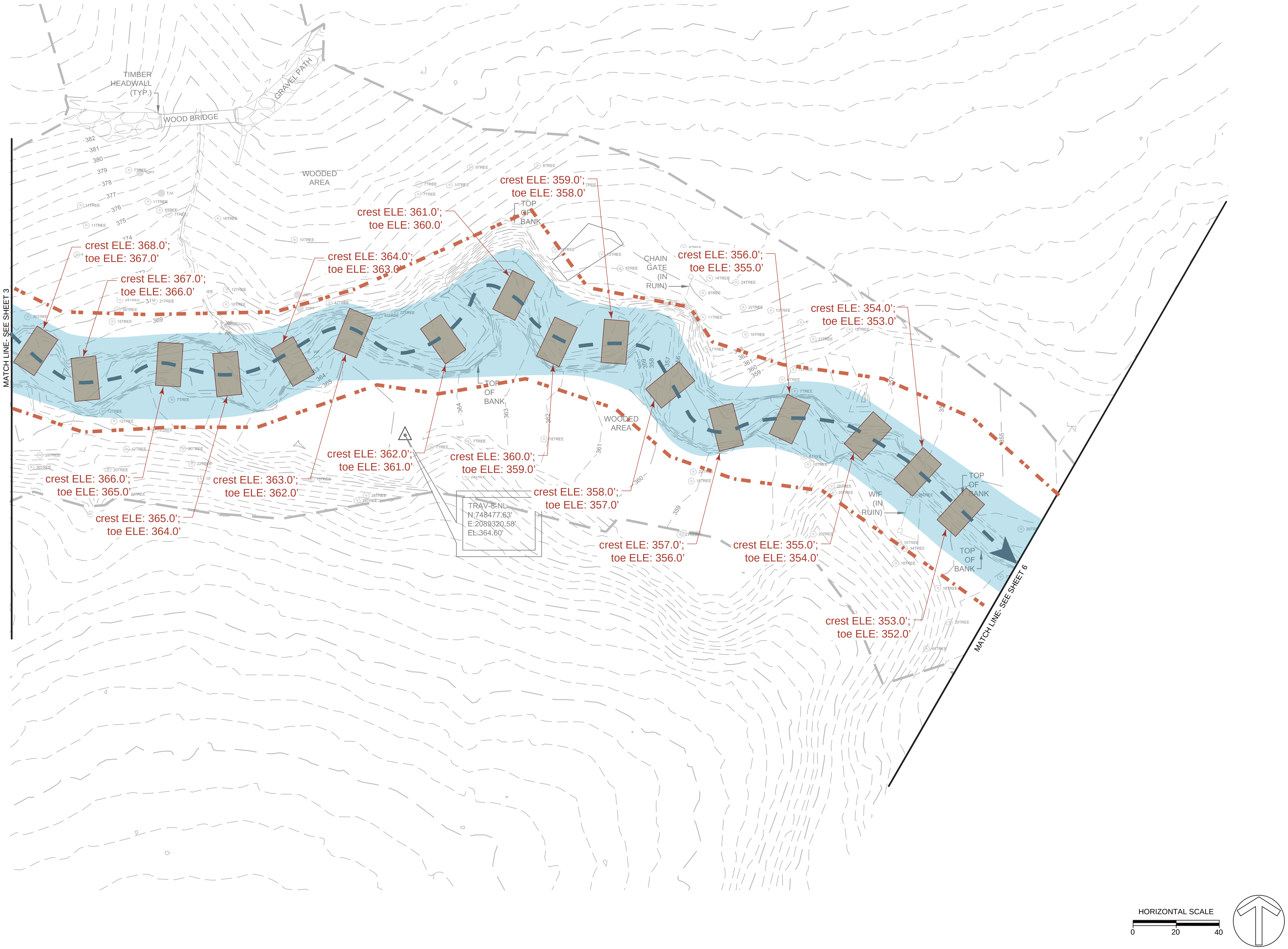

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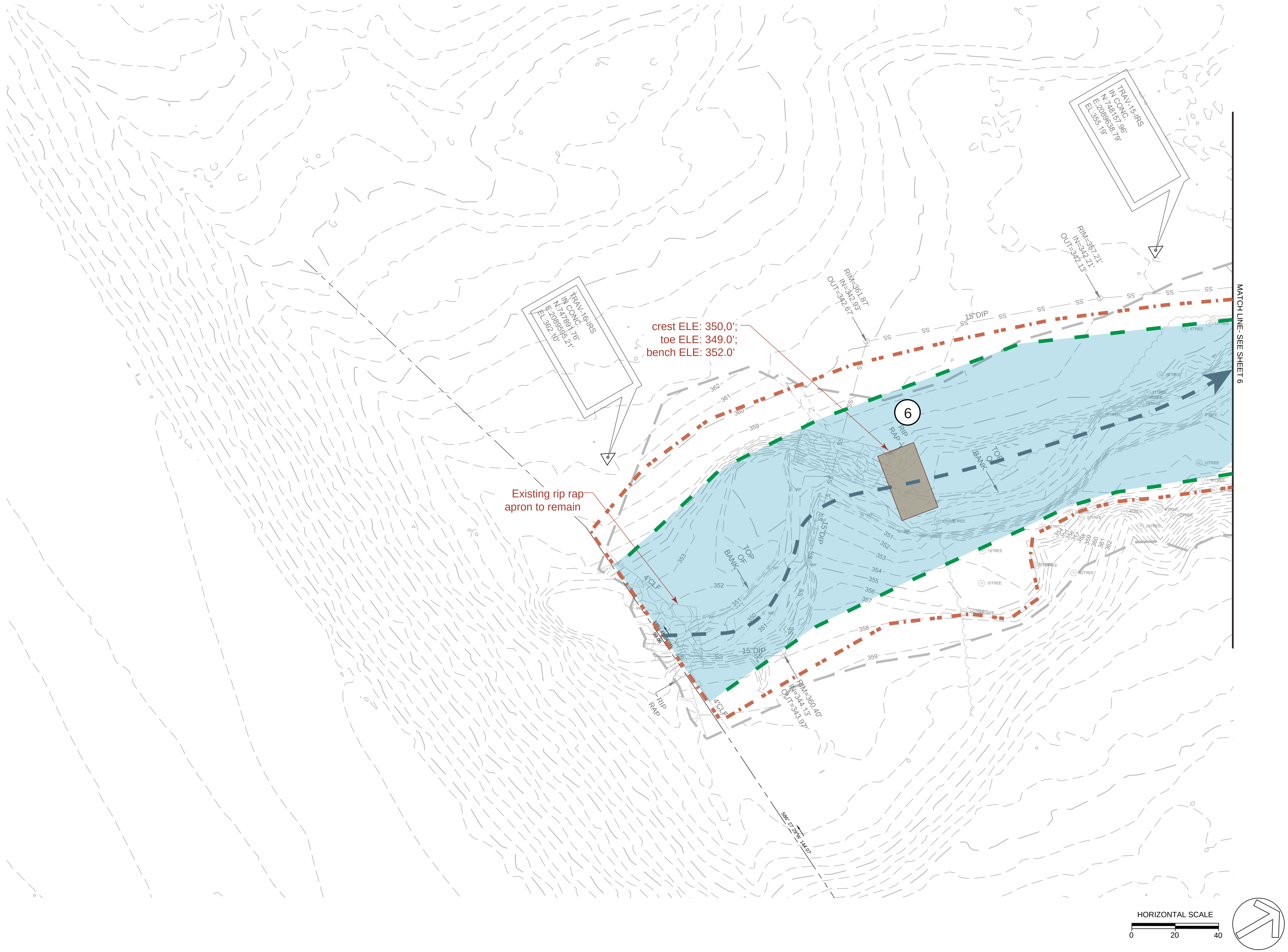

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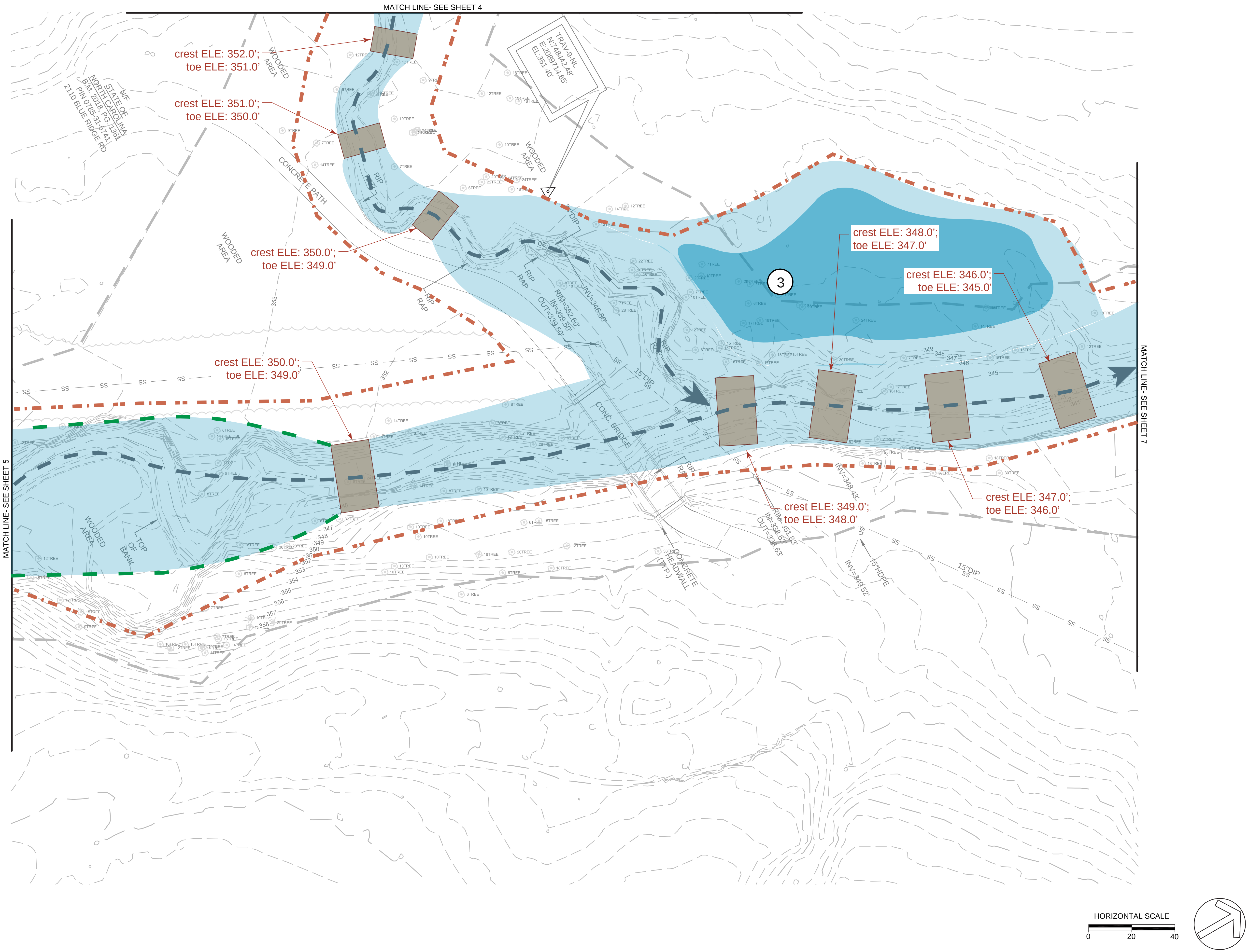

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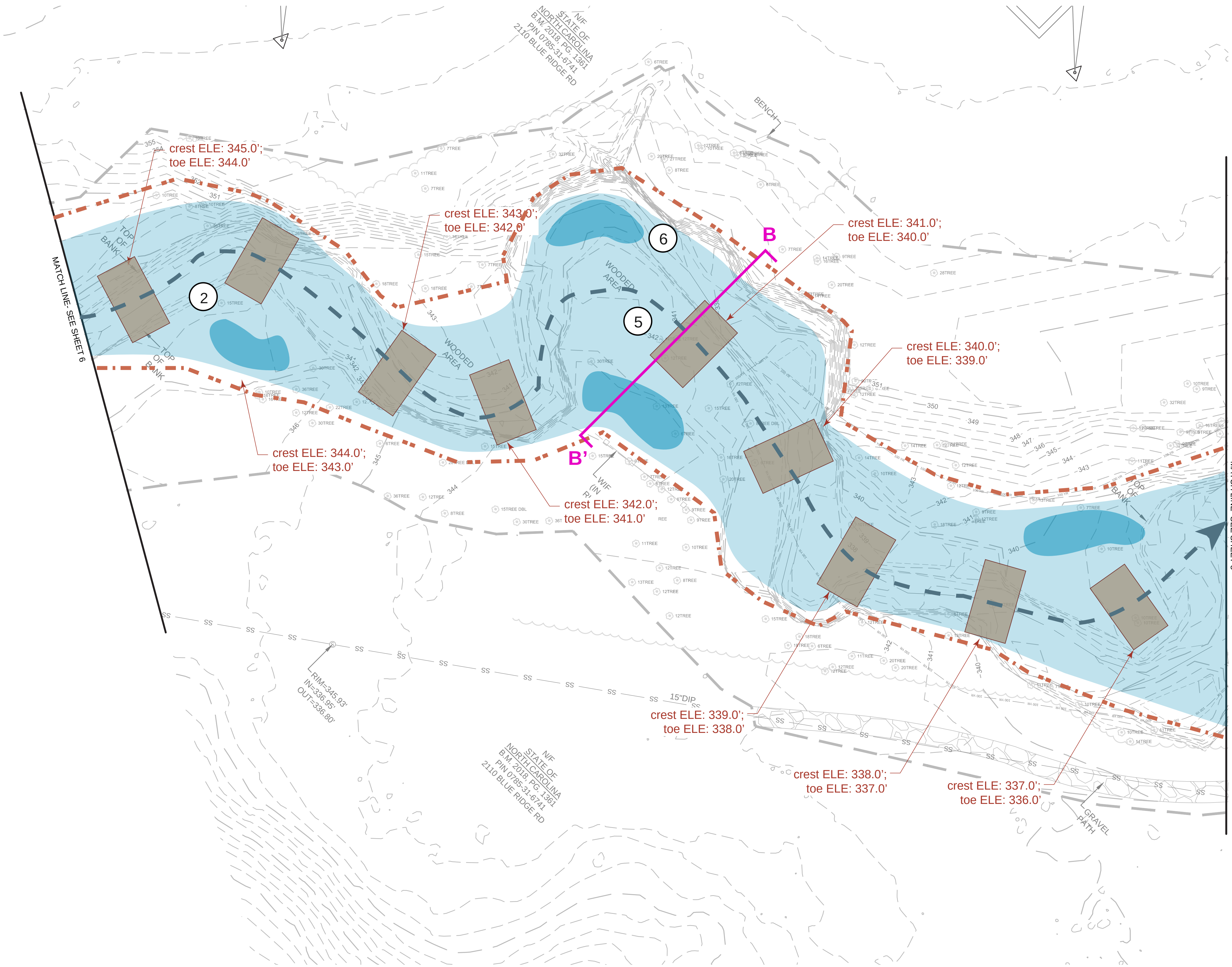

HORIZONTAL SCALE
0 20 40

CONCEPTUAL PLAN

NC MUSEUM OF ART VISION PLAN AND STREAM RESTORATION

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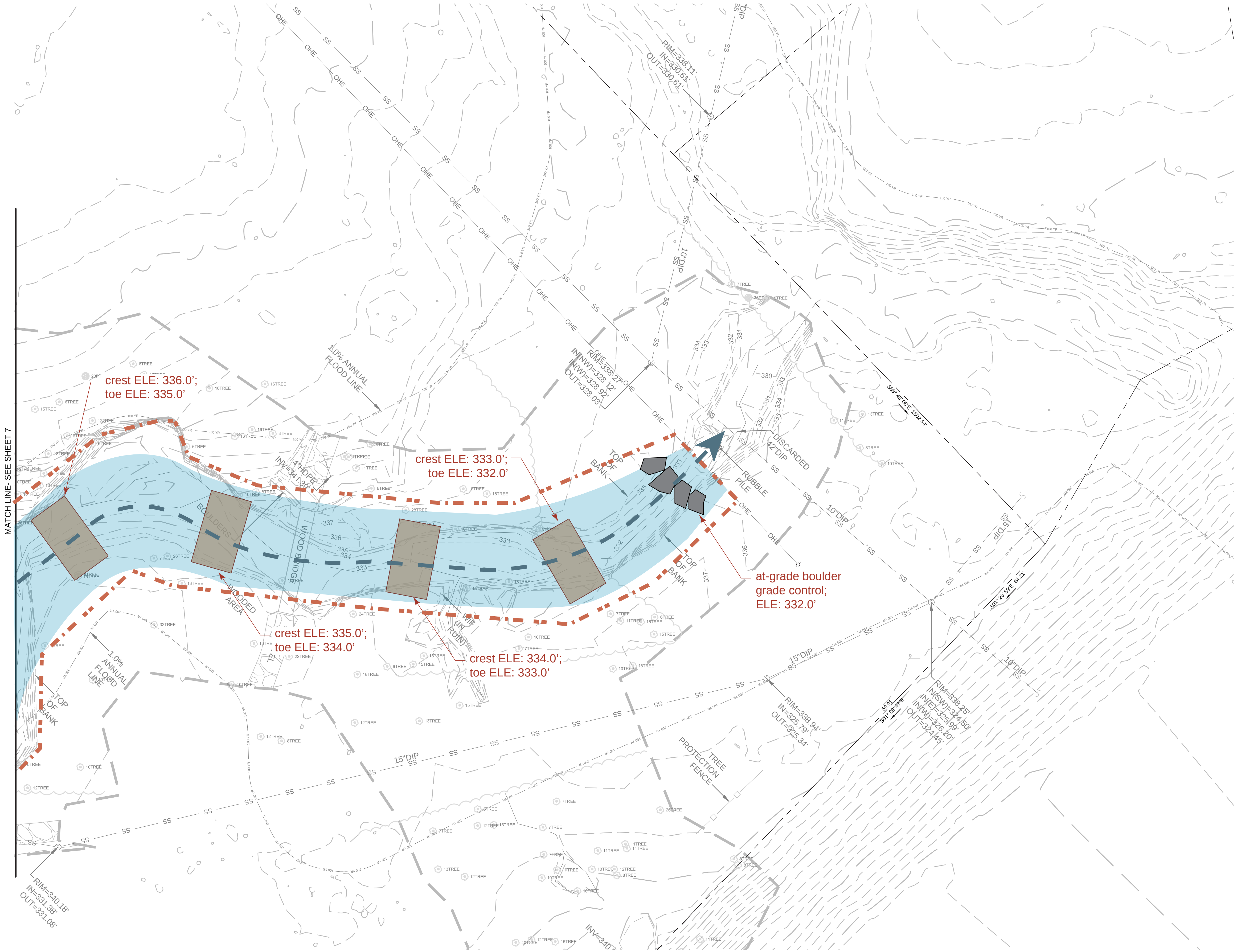
7 OF 8



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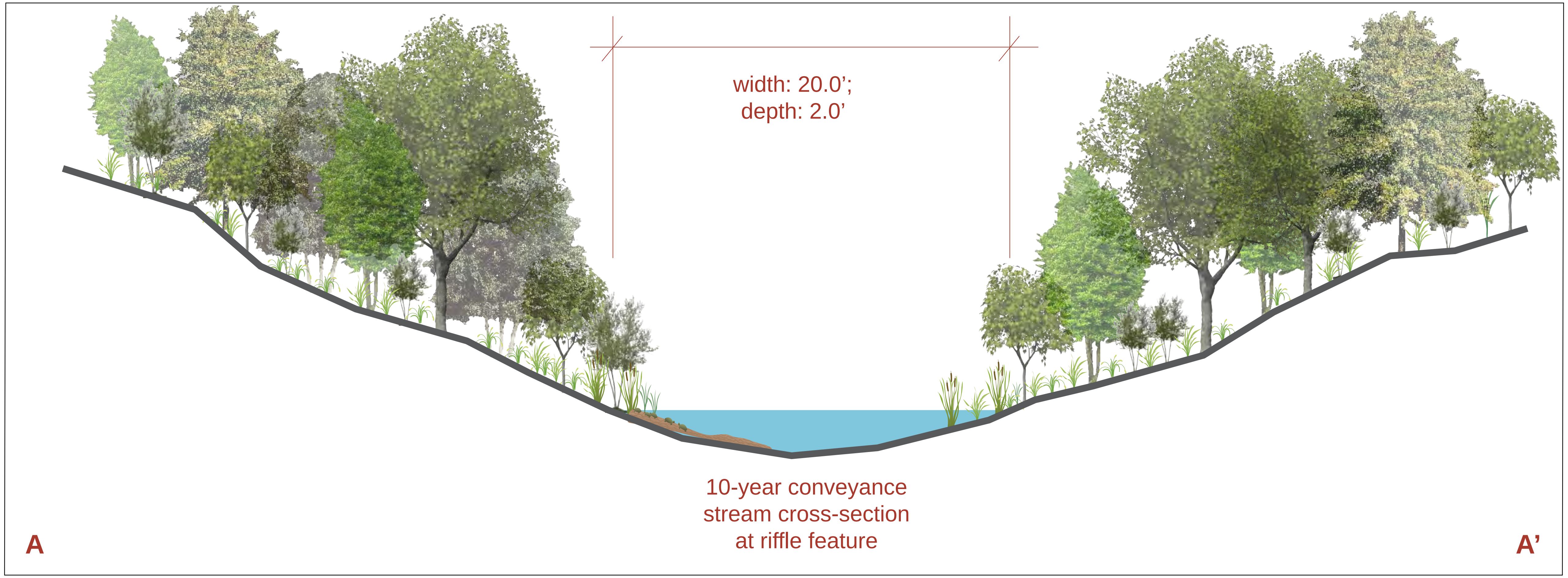

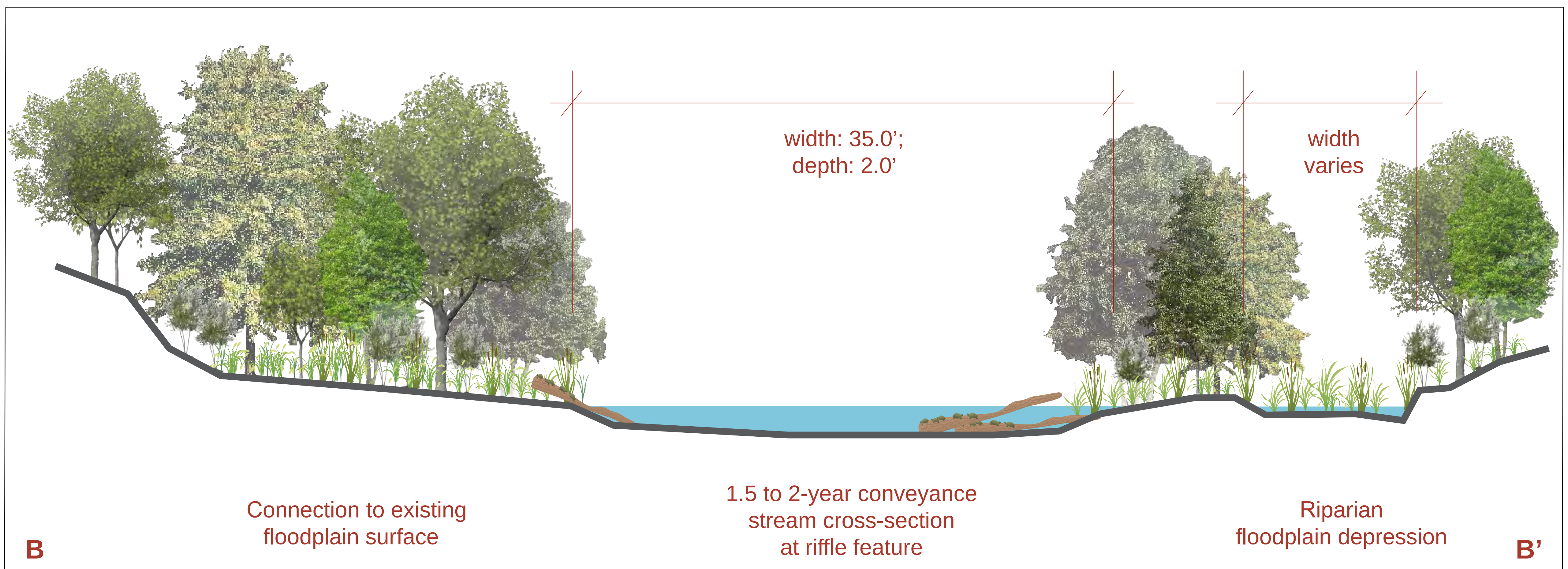

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ALTERNATIVE 1

PROJECT NO. : 20024.01		SCALE: AS SHOWN	
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		DWG. NO. : XS	

APPEN ... 35

3/9/2021 I:\Projects\20024.01 NC Museum of Art Master Plan and Stream\CAD\Plans\cv01ncma.dwg

1 Tributary riffle structure

2 Trees and woody debris incorporated into stream and riparian wetland areas

3 Floodplain depression wetlands

4 Cascade drop structure

5 House Creek riffle structure

6 Floodplain bench with adjacent wetland

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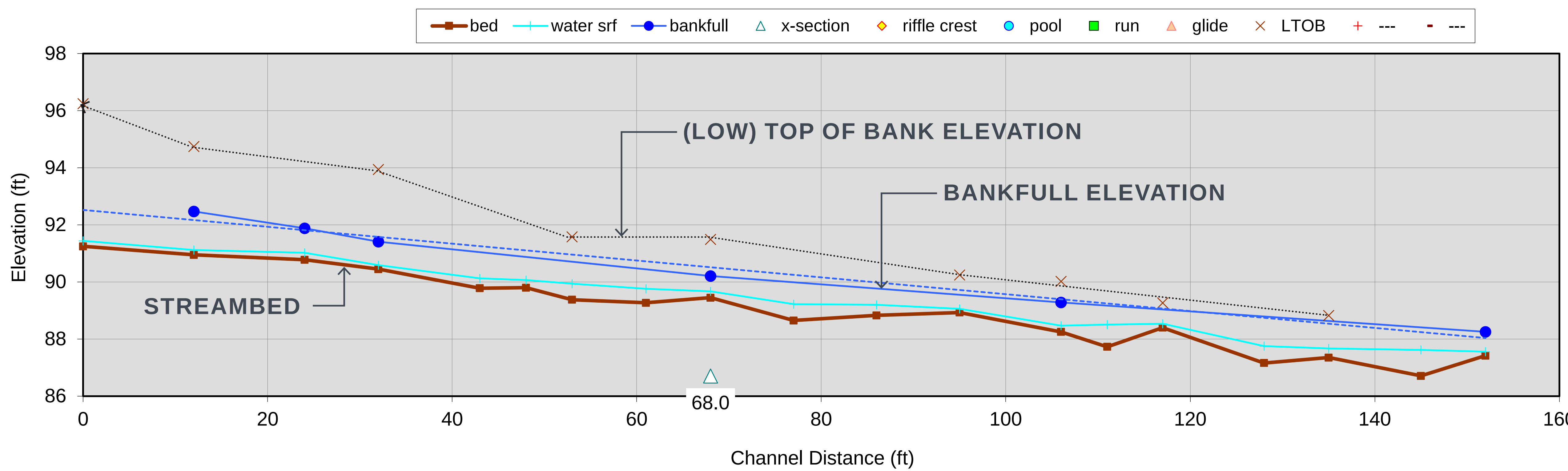
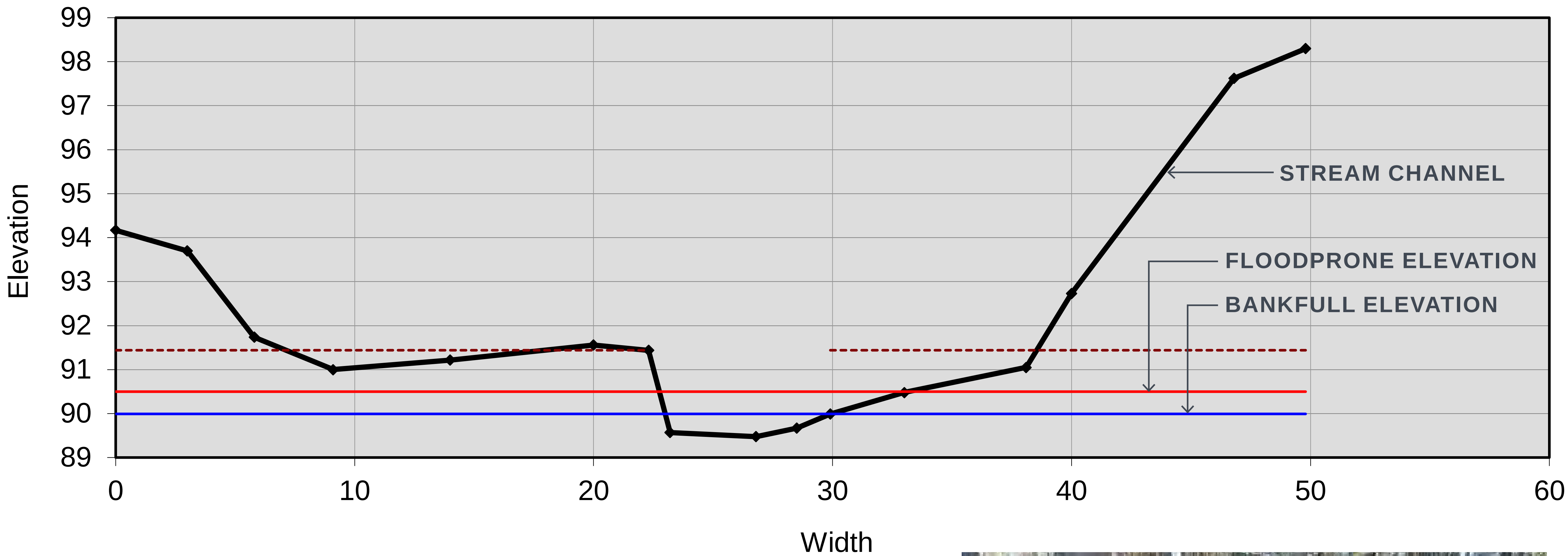
PROJECT NO.: 20024.01 | SCALE: AS SHOWN
SEAL: | BY: GB | CHECK: JC
DWG. NO.: PP

PROFILE OF FULL-REACH, UNNAMED TRIBUTARY TO HOUSE CREEK



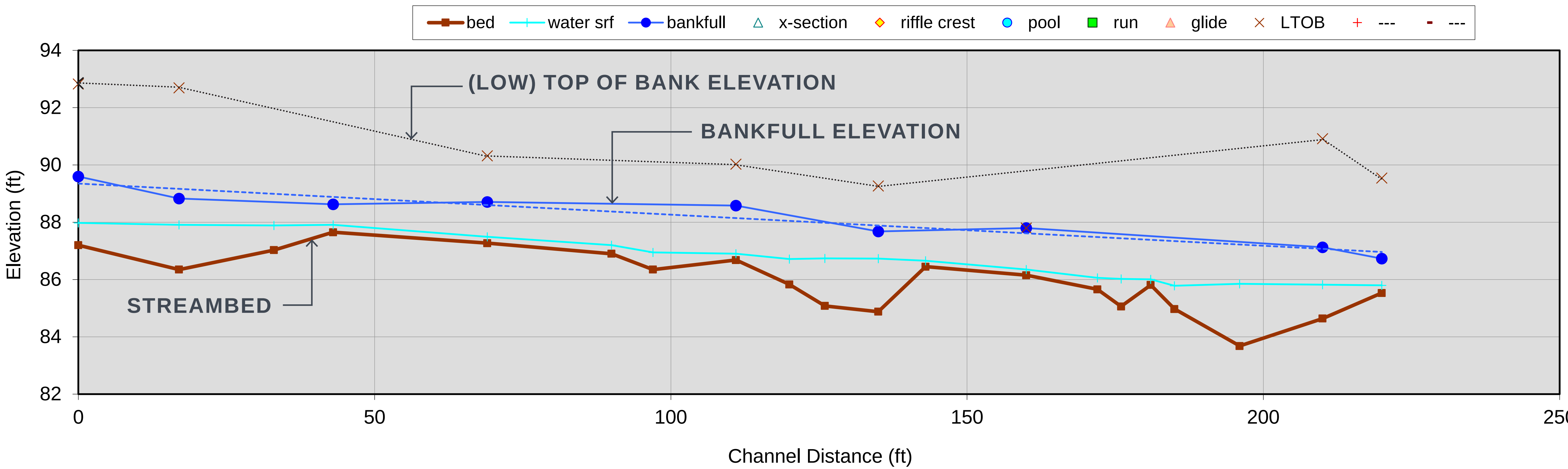
- Bankfull, or the level of frequently occurring peak flow, does not reach the top of the bank, causing erosion within the stream channel.
- Highly incised/entrenched system
- Evidence of continually rejuvenated bank erosion
- Poor streambed pattern (riffles, pools) diversity
- Predominately gravel substrate

SECTION OF RIFFLE, UNNAMED TRIBUTARY TO HOUSE CREEK



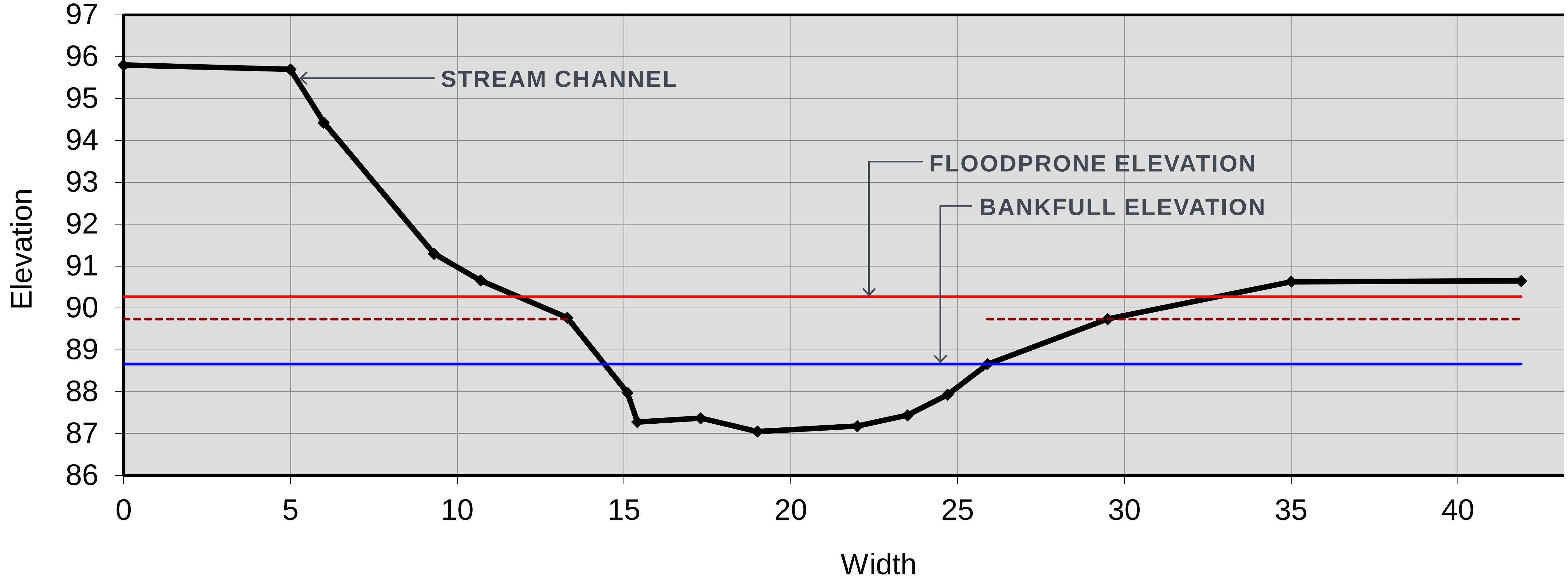
- Floodprone elevation resides within channel cross-section
- Lack of floodplain connectivity

PROFILE OF FULL REACH, HOUSE CREEK



- Bankfull, or the level of frequently occurring peak flow, does not reach the top of the bank, causing erosion within the stream channel.
- Highly incised/entrenched system
- Evidence of continually rejuvenated bank erosion
- Hydraulically influenced by NCDOT structures
- Predominately gravel substrate

SECTION OF RIFFLE, HOUSE CREEK



- Floodprone elevation within channel cross-section
- Lack of floodplain connectivity
- Significantly high bank heights

GEOMORPHIC STUDY SUMMARY

- All NCMA stream reaches are laterally eroding as a result of past land use and fluvial dynamics.
- Tree loss along stream banks will continue, absent restoration activities.
- Bank erosion is significantly contributing to adverse downstream water quality, resulting in high turbidity under storm flow events.
- NCDOT structures (culverts) may present constraints to House Creek design.

FALL 2020 SURVEYS MEMO + DATA SUMMARY

Biohabitats
SOUTHEAST ATLANTIC BIOREGION
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MEMORANDUM

Date: 2/23/2021

To: Rachel Woods, NCMA

From: Kevin Nunnery, Biohabitats, Inc.

RE: Preserve Water Quality and Vegetation Investigations

Subject: Results and Discussion

This memo is intended as a discussion of the vegetation survey and water quality data collected in the fall of 2020 from the project area and unnamed tributary to House Creek and House Creek proper. Contributors to the discussion include Dr. Alexander Krings, who led the vegetation survey in the Fall of 2020 and Larry Eaton who led the macroinvertebrate/water quality sampling. Their comments in this memo are extracted from emails to me.

The vegetation survey was conducted on October 19, 2020. The report from the vegetation survey indicated "the vascular flora comprises 237 species, representing 81 families and 176 genera (Table 2; Appendix A). Non-native species represented 15% of the species encountered (n=36 spp.; Appendix B). The checklist includes (1) species encountered in the course of our survey on 19 Oct 2020 (Appendix C), (2) species seeded into the Upper Meadow (Table 3), and (3) species encountered in a survey of the Upper Meadow by Rachel Woods in Summer 2020 (Table 4). Ten species remain known only from the seed mix, not having been encountered in areas surveyed by Rachel Woods or the present authors (*Baptisia alba*, *B. tinctoria*, *Echinacea purpurea*, *Geum canadense*, *Liatris spicata*, *Penstemon digitalis*, *P. hirsutus*, *Pycnanthemum tenuifolium*, *Solidago juncea*, and *Symphyotrichum laeve*)."

It was beyond the scope of the vegetation survey to create plots, quantify species and abundance, and calculate a quantitative vegetative diversity value. However, Dr. Krings has stated his impression that the individual sites they divided the project area into and surveyed "are not particularly diverse, and suffer from an abundance of non-native species, like many urbanized Piedmont sites." Dr. Krings also noted "Many of the species planted in the "upper meadow" are presently not typically found in similar slope/hillside positions over Ultisols in the Piedmont or at best uncommonly so (e.g., *Asclepias incarnata, Bouteloua curtipendula, Pycnanthemum tenuifolium, Ratibida pinnata, Rhus aromatica, Sporobolus heterolepis, Symphyotrichum oblongifolium, S. prenanthoides*). Thus, one might say that, due to the plantings, compared to other Piedmont hillside sites over Ultisols, the "upper meadow" appears richer in species otherwise currently more common over mafic/calcareous substrates or moister soils."

In summary, the species found on site are typical of an urban Piedmont site. <u>There is opportunity to improve plant species diversity and the abundance of desired species with future upland management strategies and stream restoration plantings.</u>

The macroinvertebrate sampling was conducted on October 17, 2020. The NC Biotic Index Bioclassification scores for the samples were:

Unnamed Tributary (UT)	House Creek upstream (u/s)	House Creek downstream (d/s)
Good	Fair	Good/Fair

House Creek's NC Surface Water Classification is C;NSW. Class C is defined as "Waters protected for uses such as secondary recreation, fishing, wildlife, fish consumption, aquatic life including propagation, survival and maintenance of biological integrity, and agriculture. Secondary recreation includes wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent, unorganized, or incidental manner." NSW denotes nutrient sensitive waters, defined as "Supplemental classification intended for waters needing additional nutrient management due to being subject to excessive growth of microscopic or macroscopic vegetation." NSW is assigned to streams where buffer rules apply, in this case the Neuse buffer rules. The UT flows into House Creek and isn't mapped by the State but can be assumed to have the same classification.

Water Quality Data Summary

Low Flow Conditions Collected 10-17-20	UT Horse Cr	Horse Cr u/s	Horse Cr d/s
Dissolved Oxygen (mg/l)	8.1	8.9	7.9
Temperature (° C)	15.2	15.6	15.9
Conductivity (µS/cm)	79	157	142
pH	7	6.8	6.8
Turbidity (NTU)	4.6	2.4	2.2

High Flow Conditions Collected 12/15/20	UT Horse Cr	Horse Cr u/s	Horse Cr d/s
Dissolved Oxygen (mg/l)	10.2	10.1	10.1
Temperature (° C)	8.9	9.0	9.2
Conductivity (µS/cm)	60	86	84
pH	7.0	7.6	7.3
Turbidity (NTU)	58.3	145	101.7

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Two samples only provide snapshots of water quality conditions. Certainly trends or long-term health assessments require many more samples over a range of conditions. However, a few statements can be made, based on information that is known about NC Piedmont streams.

The NC Stream Assessment Method was developed over a four-year period by State and Federal agencies to determine the level of stream condition relative to reference conditions for 28 stream types based on valley shape, watershed size, and physiographic region. Appendix I in the Method contains research conducted by the NC Division of Water Quality (DEQ), Wetlands Program Development Unit, entitled “Explorations of Relationships Between Specific Conductance Values and Benthic Macroinvertebrate Community Bioclassifications in North Carolina.” Below is information from that research.

Table 4 Piedmont ecoregion, log10 annual median specific conductance distributions by bioclassification (uS/cm at 25°C)

Bioclassification	Min	10%	25%	Median	75%	90%	Max
Poor	2.0086	2.152964	2.359835	2.503791	2.680336	2.826745	2.939519
Fair	1.531479	1.821831	2.018043	2.225955	2.490418	2.615976	2.822168
Good-Fair	1.39794	1.659346	1.872146	2.058805	2.253364	2.412964	2.71265
Good	1.332438	1.501407	1.653213	1.845087	2.013855	2.204112	2.404834
Excellent	1.20412	1.338429	1.469822	1.732394	1.889302	1.974966	2.173186

The following table contains the converted non-logarithmic values (uS/cm at 25°C)

Bioclassification	Min	10%	25%	Median	75%	90%	Max
Poor	102	142	229	319	479	671	870
Fair	34	66	104	168	309	413	664
Good-Fair	25	46	74	114	179	259	516
Good	21	32	45	70	103	160	254
Excellent	16	22	29	54	78	94	149

The conductivity values recorded under normal flow conditions for the UT, House Cr u/s and House Cr d/s agree well with the statistical values reported by DEQ. Also note the turbidity values for each, 4.6, 2.4 and 2.2 NTU’s respectively.

During the high flow event (approximately 0.9 inches of rain over 3 days, 0.6 inches the day of sampling, prior to sampling), conductivity values were lower than during normal flow. The value for the UT was 19 uS/cm lower, the value for House Cr u/s was 71 uS/cm lower and for House Cr d/s it was 58 uS/cm lower. These lower conductivity values may be explained by the dilution of conductance by higher flow. The turbidity values showed a marked increase during high flow. The value for the UT was 58.3 NTU, a 53.7 NTU increase, the value for House Cr u/s was 145 NTU, a 142.6 NTU increase, and the value for House Cr d/s was 101.7 NTU, a 99.5 NTU increase. All these values exceed the North Carolina surface water standard for compliance of ≤50 NTU, and indicate a substantial sediment load in the water column.

Stream restoration likely will not reduce conductivity concentrations, which can often be elevated by factors such as local geology. However stream bank stabilization accomplished during the restoration process will certainly reduce channel sediment loads, turbidity, and sedimentation impacts to aquatic habitat and organisms.

References

Gale, Susan. 2013. *Explorations of Relationships Between Specific Conductance Values and Benthic Macroinvertebrate Community Bioclassifications in North Carolina*. NC Division of Water Quality, Wetlands Program Development Unit.

SUMMARY OF FALL VEGETATION SURVEY RESULTS:

- Trees: 34 species
- Shrubs: 16 species
- Grasses/forbs: 151 species

SUMMARY OF WATER QUALITY MONITORING RESULTS:

- Dissolved oxygen concentrations: 8-10 mg/l (Good)
- Conductivity: UT - Good; House Creek upstream - Fair; House Creek downstream - Good/Fair
- Macroinvertebrate (NC Bioclassification Score): UT - Good; House Creek upstream - Fair; House Creek downstream - Good/Fair
- Turbidity (high flow event): UT - 58 NTU; House Creek upstream: 145 NTU; House Creek downstream: 102 NTU **(NC Standard is ≤50 NTU)**

SPRING 2021 SURVEYS MEMO + DATA SUMMARY

Biohabitats
SOUTHEAST ATLANTIC BIOREGION
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MEMORANDUM

Date: 9/17/2021

To: Rachel Woods, NCMA

From: Kevin Nunnery, Biohabitats, Inc.

RE: Preserve Macroinvertebrate, Fish and Vegetation Investigations

Subject: Results and Discussion

This memo is a brief summary of the findings of the 2020-2021 surveys in the Museum Preserve area, for macroinvertebrates, fish and vegetation.

The Qual-4 method macroinvertebrate survey information is relatively consistent between the two sampling dates of October 17, 2020 and April 28, 2021 (see below). The Bioclassification rating categories are Excellent, Good, Good/Fair, Fair or Poor for this method, based on both EPT taxa richness and the biotic index values, which are computed from the collected species and species abundance.

Summary of Macroinvertebrate Survey Information- Biotic Index Scores			
	Unnamed Tributary	**House Creek Upstream**	**House Creek Downstream**
Bioclassification			
Fall 2020	***Good***	***Fair***	***Good/Fair***
Spring 2021	***Good/Fair***	***Fair***	***Fair***
Biotic Index			
Fall 2020	5.09	6.69	5.75
Spring 2021	5.27	6.77	6.52
EPT Taxa			
Fall 2020	6	5	7
Spring 2021	7	4	5
EPT Abundance			
Fall 2020	51	18	38
Spring 2021	36	19	18

The unnamed tributary Bioclassification ratings are higher than House Creek, and the downstream reach of House Creek, near the pedestrian bridge, scored slightly higher than the upstream reach, upstream of the current greenway crossing.

The fish survey was conducted on May 3, 2021. The sampling was done consistent with the N.C. Division of Water Quality protocol, the N.C. Index of Biological Integrity. The Bioclassification rating categories are Excellent, Good, Good/Fair, Fair or Poor Fish collected in the unnamed tributary are listed below.

Scientific name	Common name	Number of Individuals
Clinostomus funduloides	Rosyside Dace	3
Nocomis leptocephalus	Bluehead Chub	5
Semotilus atromaculatus	Creek Chub	33

Fish collected in House Creek are listed below

Scientific name	Common name	Number of Individuals
Clinostomus funduloides	Rosyside Dace	66
Lepomis machochirus	Bluegill	5
Micropterus salmoides	Largemouth Bass	1
Nocomis leptocephalus	Bluehead Chub	86
Semotilus atromaculatus	Creek Chub	53

Species Name	Common Name	Tolerance Rating	Adult Trophic Status	House Creek	UT House Creek
Clinostomus funduloides	Rosyside Dace	Intermediate	Insectivore	66	3
Lepomis machochirus	Bluegill	Intermediate	Insectivore	5	~
Micropterus salmoides	Largemouth	Intermediate	Piscivore	1	~
Nocomis leptocephalus	Bluehead Chub	Intermediate	Omnivore	86	5
Semotilus atromaculatus	Creek Chub	Tolerant	Insectivore	53	33

The Bioclassification Ratings for the streams are below.

	House Creek	Unnamed Tributary
Total NCIBI Score	32	28
NCIBI Rating	**Poor**	**Poor**

The Poor Bioclassification ratings are not uncommon for streams located in urban, developed watersheds. Stream restoration presents an opportunity to create better structural fish habitat. House Creek originates off the Museum property, and the water quality of it as it flows onto the Museum property reflects land management practices of the watershed upstream of the Museum, which is not under Museum control. However, the unnamed tributary originates on the Museum

property and its watershed is under Museum management. Although small in size, the opportunity exists to maintain or improve water quality and improve aquatic habitat in it.

For the spring vegetation survey, 78 taxa not previously documented in the fall of 202 were reported. Updated checklist of the vascular flora comprises 314 species, representing 92 families and 220 genera. Non-native species represented 20% of the species encountered. Twenty-five rare vascular plant species (i.e., state- or federally-listed) are currently or historically known from Wake County, including federally-listed *Rhus michauxii*. None of these species were encountered.

The species found on site are typical of an urban Piedmont site. There is opportunity to improve plant species diversity and the abundance of desired species with future upland management strategies and stream restoration plantings.

HYDROLOGY AND HYDRAULICS STUDY

MEMORANDUM

WK DICKSON
community infrastructure consultants

720 Corporate Center Drive Raleigh, North Carolina 27607 919.782.0495 tel. 919.782.9672 fax

TO: Andropogon Associates, Ltd.

FROM: Tom Murray, PE;
Alex McMillan, PE

DATE: June 21, 2021

NORTH CAROLINA PROFESSIONAL SEAL 031455 ENGINEER THOMAS L. MURRAY

Jun 21 2021 1:46 PM

RE: NC Museum of Art Project -
Tributary to House Creek Existing Conditions Hydrology and Hydraulics Technical Memorandum

Project Description

The North Carolina Museum of Art (NCMA) project is in Raleigh, NC, and is located within the House Creek watershed as shown in Figure 1. This technical memorandum focuses on the existing conditions analysis of the tributary to House Creek – the main hydraulic feature draining the Museum park area. This analysis is in support of the greater NCMA Museum Park Preserve Master Plan and Stream Restoration project. The goals and vision of that project are as follows:

- Heal the Streams and Wetlands
- Improve Visitor Experience
- Build Resiliency

The goals of this memorandum are to evaluate and discuss the existing site hydrology and hydraulics to determine critical improvement areas along the channel. This analysis will also develop flow rates to be used in support of proposed improvement design in the next project phase. Hydraulic modeling was performed on approximately 2,500 linear feet of open stream for the tributary to House Creek. The Figure 2: Watershed Map illustrates the tributary's 51-acre drainage area and other existing site drainage features. A HEC-RAS model was used to simulate water surface elevations for the 2-, 10-, 25-, and 100-year storm events.

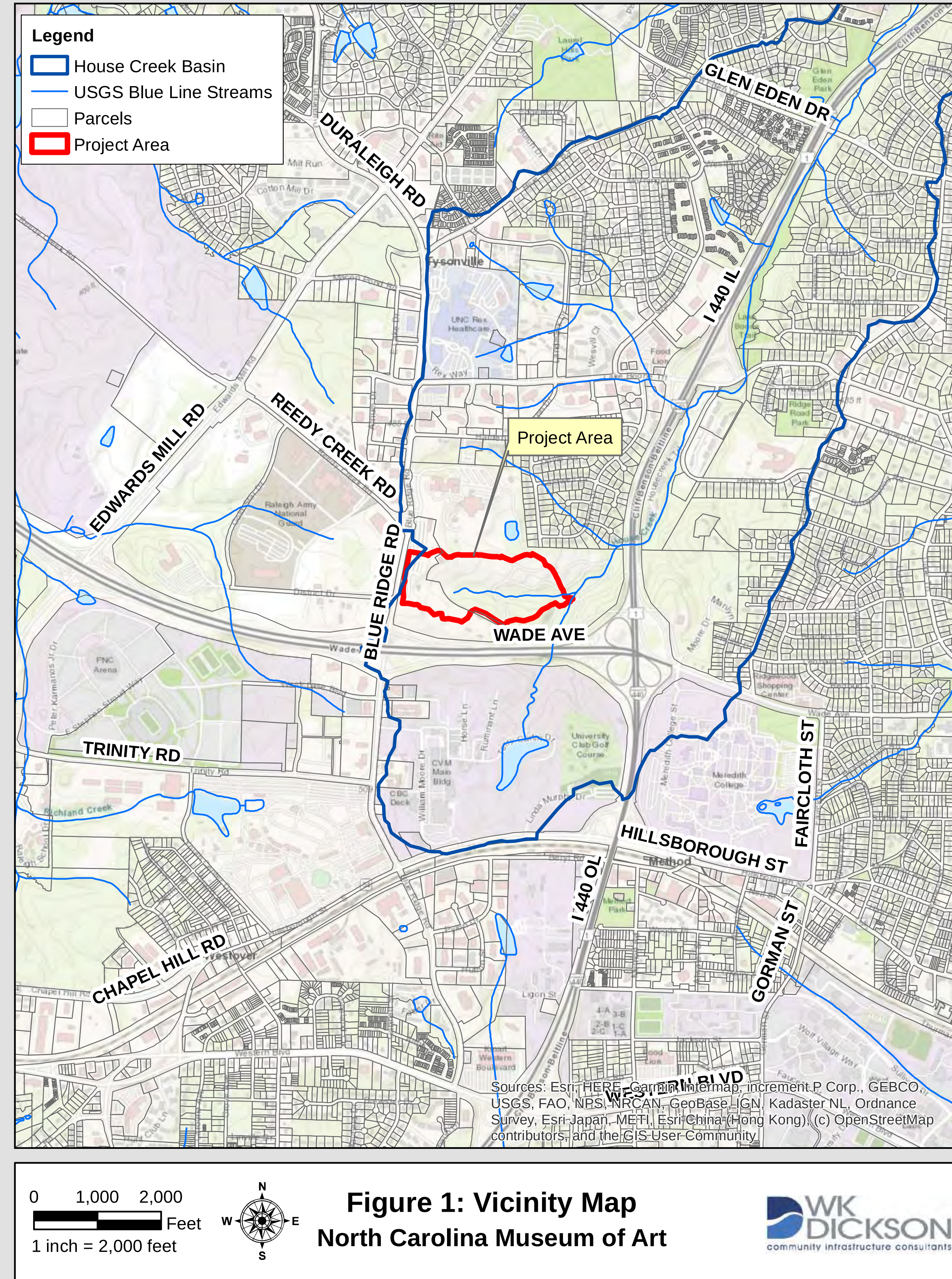

Figure 1: Vicinity Map
North Carolina Museum of Art

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community infrastructure consultants

0 100 200 Feet
1 inch = 200 feet

Figure 2: Watershed Map
North Carolina Museum of Art

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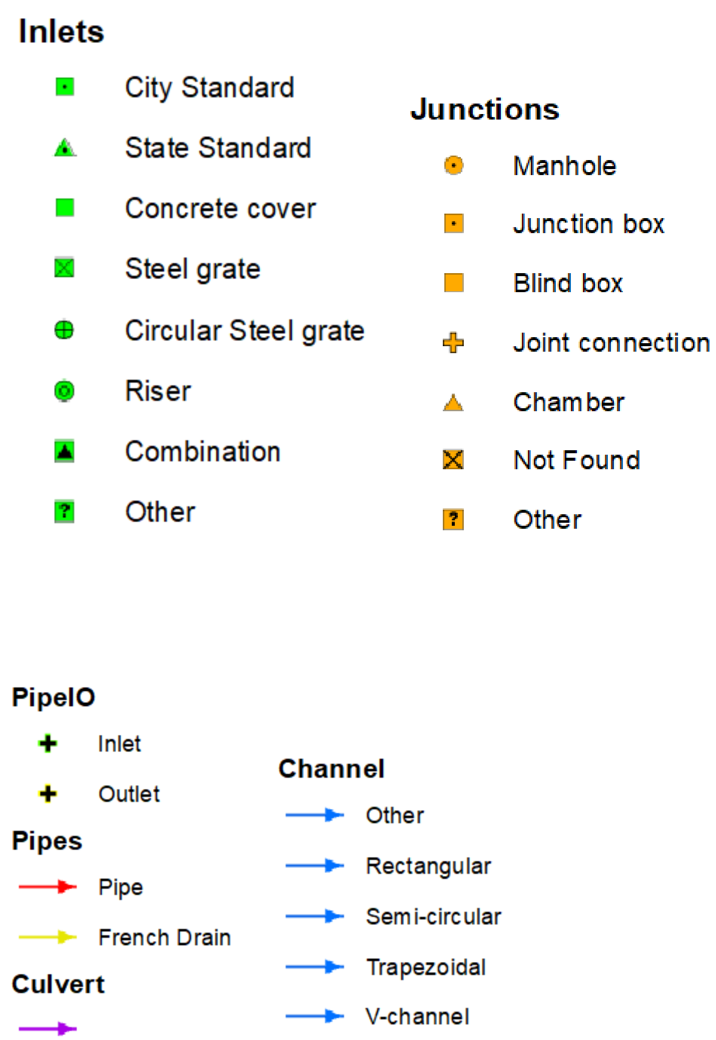
Figure 2 Legend Continued

City of Raleigh Stormwater GIS Features:



Hydrology Summary

The tributary to House Creek collects runoff from approximately 51 acres of grassland, forest, and some impervious parking areas and trails. The hydrology for the tributary's watershed was evaluated using the Rational method approach. The site's time of concentration was determined using the Kirpich equation. The overall tributary drainage area, as shown in Figure 2, was broken up into three sub-watersheds as shown in Figure 3. Sub-watersheds allow flow-splits to be used in the HEC-RAS model to capture stream flow conditions more accurately. Appendix A contains a full description of each hydrological assumption and source as well as the calculations for each sub-watershed.

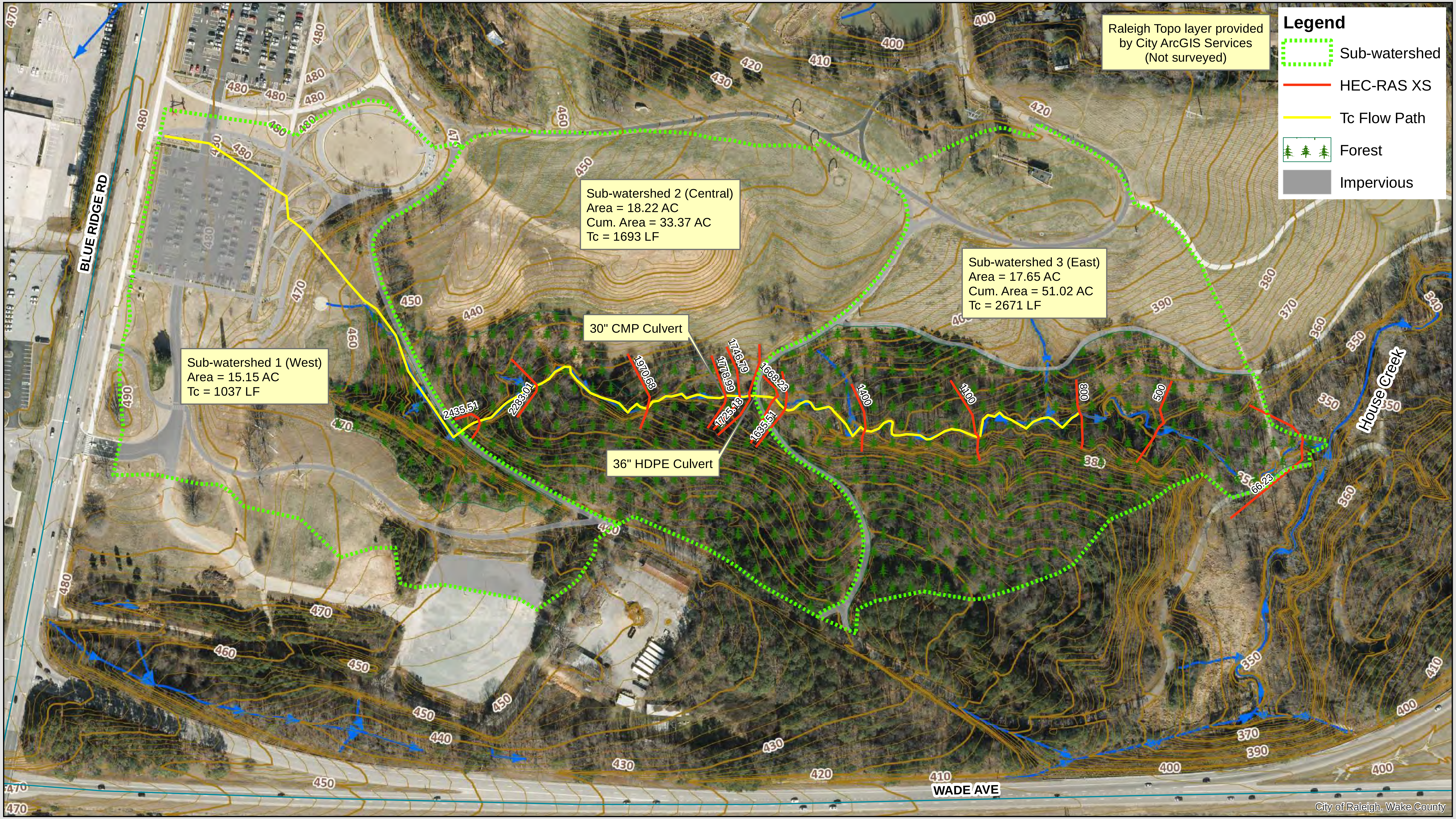
Photo 1. Grassy uplands north of tributary (Google Earth 2018)

Photo 1 illustrates the typical grassland land cover used in hydrologic calculations for the composite rational coefficient. Comprehensive land cover calculations are detailed in Appendix A on a per sub-watershed basis. Peak flows were calculated for each sub-watershed and are shown below in Table 1. Flow values for sub-watersheds 2 and 3 are cumulative flows based on the in-line condition of the sub-watershed delineation.

Table 1. Sub-watershed Runoff Values

Sub-watershed	Flow (cfs)			
	2-Year Event	10-Year Event	25-Year Event	100-Year Event
1	36.85	46.19	52.39	62.18
2*	54.85	69.66	79.25	94.48
3*	65.24	84.03	96.17	115.38

*The flows for Sub-watersheds 2 and 3 are cumulative flow values.



0 100 200 Feet

1 inch = 200 feet

Figure 3: H&H Workmap

North Carolina Museum of Art

WK DICKSON community infrastructure consultants

Hydraulics Summary

The tributary was modeled using the US Army Corps of Engineers developed HEC-RAS version 5.0.7 to evaluate if the system during the 2-year, 10-year, 25-year, and the 100-year storm events using field survey and Wake county LiDAR data. Figure 3 displays the HEC-RAS cross-sections used for evaluation. Appendix B contains the complete HEC-RAS results including water surface elevations, channel shear stress, velocity, channel flow, and total cross-sectional flow.

The existing culvert Level-of-Service (LOS) was determined by the pipe capacity shown in the model. If the modeled flow through the cross-section exceeded the main channel limits (surveyed Top-of-Bank (TOB) to TOB), then the cross-section was considered unable to pass that storm event. Both existing culverts along the tributary are unable to provide a 2-year LOS. Downstream of the 36" HDPE culvert, the 100-year storm is conveyed in the channel potentially contributing to incised channel banks. The HEC-RAS cross-sections and corresponding LOS provided by the cross-section is shown below in Table 2.

Table 2. Level of Service (LOS)

XS	LOS*
2435.51	100-Year
2283.01	2-Year
1778.99	< 2-Year
30" CMP Culvert	< 2-Year
1746.79	2-Year
1725.18	2-Year
36" HDPE Culvert	< 2-Year
1668.23	100-Year
1635.51	100-Year
1400	100-Year
1100	100-Year
800	100-Year
500	100-Year
66.23	100-Year

*Note: LOS for channel XS was determined contingent upon containing all event flow within the main channel.

Photo 2. Typical stream conditions (WKD 2020-11-29)

Modeling Assumptions:

The following modeling assumptions were used in the analysis of this tributary:

- The Existing Conditions analysis assumed that the existing culvert systems are in adequate condition to provide the expected hydraulic capacity. No CCTV or pipe inspection effort was performed as part of this analysis.
- The Hydrology calculations were performed using the Rational Method approach to determine peak flows.
- The Kirpich equation was used to determine the time of concentration for each sub-watershed.
- The Normal Slope Method was used to determine the starting water surface elevation at House Creek.
- Any time of concentration less than 5 minutes was assumed to be 5 minutes.
- A Manning's n-value of 0.024 was assumed for the existing CMP pipe.
- A Manning's n-value of 0.02 was assumed for the existing HDPE pipe.
- A Manning's n-value of 0.07 was assigned to the main channel and an overbank n-value of 0.12 was used. See Photo 2 for typical stream conditions.

Photo 3. Abandoned footbridge at Sta. 11+75 (WKD 2020-11-29)

An abandoned footbridge crossing the tributary at station 11+75 was encountered in the field and was chosen not to be evaluated with the existing conditions HEC-RAS model. This exclusion assumes that this structure would be removed in a future phase of stream improvement regardless of other proposed improvements. Please refer to Photo 3 containing the derelict bridge looking downstream.

Photo 4. Failed 24″ DIP culvert at Sta. ~1+30 (WKD 2020-11-29)

A failed 24″ Ductile Iron Pipe (DIP) culvert was discovered at the downstream portion of the tributary at approximately station 1+30. The upstream invert of this pipe is completely buried and filled-in with several feet of depositional material. The current site conditions require streamflow to pass across some cobble cover on top of the buried culvert as shown in Photo 4.

Shear stresses along the channel were calculated and cross-sections that experience high shear stress are tabulated below in Table 3. For the purposes of this report, elevated shear stress was defined as greater than 3.5 pounds per square foot of channel surface area. Higher stresses were largely encountered at the cross-sections immediately downstream of the 36″ HDPE culvert. Complete hydraulic results for all cross-sections can be found in Appendix B.

Table 3. HEC-RAS Cross-Sections with Elevated Shear Stresses

XS	Storm Event	Shear Stress (psf)
2435.51	2-Year	3.93
2435.51	10-Year	4.28
2435.51	25-Year	4.52
2435.51	100-Year	4.84
1668.23	2-Year	6.63
1668.23	10-Year	7.45
1668.23	25-Year	7.74
1668.23	100-Year	8.41
1635.51	2-Year	5.77
1635.51	10-Year	6.31
1635.51	25-Year	6.61
1635.51	100-Year	7.03
1100	2-Year	5.01
1100	10-Year	5.44
1100	25-Year	5.7
1100	100-Year	6.04
500	2-Year	3.56
500	10-Year	3.96
500	25-Year	4.2
500	100-Year	4.54

Conclusions

The existing hydrologic and hydraulic conditions for the tributary to House Creek were evaluated and summarized in this memorandum. WK Dickson performed site visits over the course of this effort to field verify hydraulic features. The existing channel was found to have extensive erosion along both banks throughout the reach. In some cases, the stream banks were vertical and had root exposure as shown in Photos 2, 3, and 4. Both functioning culverts (30″ CMP and 36″ HDPE) along the tributary were evaluated and found to be performing at a less than 2-year LOS. The 24″ culvert downstream has completely failed, and the channel flow is bypassing overtop as shown in Photo 4. This is likely causing the neighboring asphalt footpath to flood in minor storm events.

WK Dickson looks forward to providing support services to the Andropogon team for developing 60% design plans for the proposed improvements including the proposed stream plan and profile, proposed trail and bridge locations, potential stormwater treatment locations, and proposed utility conflicts.

Hydrologic Analysis

The purpose of this hydrologic analysis is to determine the peak flows for the 2-, 10-, 25-, and 100-year storm events. Initially, a USGS regression method of hydrological analysis was selected to evaluate this site. However, the total site drainage area came in under the minimum applicable acreage for use in USGS methodology. The Rational method of determining peak flows was then selected as a more applicable substitute.

Watershed Delineation and Connectivity

A total drainage area was delineated for the tributary to House Creek utilizing digital LiDAR data available from the State of North Carolina and survey data collected by Stewart Inc. This overall drainage area was field verified by WK Dickson staff. Sub-watersheds were chosen to split up the drainage basin using existing site features including walking paths and ridgelines. Three (3) sub-watersheds were delineated with similar acreage each. The H&H Workmap included in the body of the report illustrates the sub-watersheds and hydrologic connectivity for the project area.

Rational Method

Peak flows were calculated using the Rational Method per the City of Raleigh Stormwater Design Manual. These calculations and supporting data are listed in Tables A-1 through A-3.

Kirpich Equation

Time of concentration was calculated using the Kirpich equation per the City of Raleigh Stormwater Design Manual. The flow path is shown on Figure 3 and lengths are listed in Tables A-1 through A-3.

Land Cover

Land cover influences the runoff characteristics of a watershed is used to determine the rational coefficient for the basin. The museum park property consists of impervious parking and path areas, forested areas, and open grasslands. Each of the sub-watersheds were broken into these three land covers and a composite rational coefficient was calculated.

Rainfall

Rainfall intensities for Raleigh were found and interpolated from "Table 2.3 Intensity – Duration – Frequency Table, City of Raleigh, NC" within the City of Raleigh Stormwater Design Manual. For use in the Rational equation, intensity values were interpolated based on the time of concentration calculation.

Summary of Hydrologic Model Results

The Rational method was used to compute peak runoff for the 2-, 10-, 25-, and 100-year design storms for the existing site conditions. These results will be used to determine applicable design improvements in the next phase of this project. The results of the hydrologic calculations are summarized in Tables A-1 through A-3. The HEC-RAS hydraulic model results are included in Appendix B.

Table A-1: Sub-watershed 1 (West) Hydrologic Calculations

Land Type	Area (AC)	Coeff. Value	
Impervious Area	3.38	0.95	
Forest Area	1.74	0.1	
Grassland	10.03	0.3	
Total Area	**15.15**	**0.42**	**Weighted C Value**

Tc (Kirpich Method)		
Length of Flow Path	1037	ft
Start Elev	482	
End Elev	421	
	4.9	**Tc (min) (Assume 5 min)**

Rational Q = C * i * A	Rainfall Intensity (in/hr)	Q (CFS)
2-Year Event	5.76	**36.85**
10-Year Event	7.22	**46.19**
25-Year Event	8.19	**52.39**
100-Year Event	9.72	**62.18**

Table A-2: Sub-watershed 2 (Central) Hydrologic Calculations

Land Type	Area (AC)	Cumulative Area (AC)	Coeff. Value	
Impervious Area	0.04	3.43	0.95	
Forest Area	7.31	9.05	0.1	
Grassland	10.87	20.90	0.3	
Total Area	**18.22**	**33.37**	**0.31**	**Weighted C Value**

Tc (Kirpich Method)		
Length of Flow Path	1693	ft
Start Elev	482	
End Elev	393	
	7.44	**Tc (min)**

Rational Q = C * i * A	Rainfall Intensity (in/hr)	Q (CFS)
2-Year Event	5.26	**54.85**
10-Year Event	6.68	**69.66**
25-Year Event	7.60	**79.25**
100-Year Event	9.06	**94.48**

Table A-3: Sub-watershed 3 (East) Hydrologic Calculations

Land Type	Area (AC)	Cumulative Area (AC)	Coeff. Value	
Impervious Area	0.77	4.20	0.95	
Forest Area	10.52	19.57	0.1	
Grassland	6.35	27.25	0.3	
Total Area	**17.65**	**51.02**	**0.28**	**Weighted C Value**

Tc (Kirpich Method)		
Length of Flow Path	2671	
Start Elev	482	
End Elev	355	
	11	**Tc (min)**

Rational Q = C * i * A	Rainfall Intensity (in/hr)	Q (CFS)
2-Year Event	4.62	**65.24**
10-Year Event	5.95	**84.03**
25-Year Event	6.81	**96.17**
100-Year Event	8.17	**115.38**

HEC-RAS Output

Table B-1: HEC-RAS Output for Tributary to House Creek

River Sta	Profile	W.S. Elev	Vel Chnl	Shear Chan	Q Channel	Q Total
		(ft)	(ft/s)	(lb/sq ft)	(cfs)	(cfs)
2435.51	2-Year	422.59	5.07	3.93	36.85	36.85
2435.51	10-Year	422.73	5.4	4.28	46.19	46.19
2435.51	25-Year	422.81	5.61	4.52	52.39	52.39
2435.51	100-Year	422.93	5.89	4.84	62.18	62.18
2283.01	2-Year	412.48	3.42	1.51	36.85	36.85
2283.01	10-Year	412.77	3.7	1.72	46.17	46.19
2283.01	25-Year	412.94	3.88	1.85	52.3	52.39
2283.01	100-Year	413.13	4.18	2.11	61.57	62.18
1970.68	2-Year	400.65	3.54	2.4	36.85	36.85
1970.68	10-Year	400.71	3.84	2.69	46.19	46.19
1970.68	25-Year	400.75	4.02	2.88	52.39	52.39
1970.68	100-Year	400.82	4.15	2.93	62.18	62.18
1778.99	2-Year	396.51	1.65	0.3	52.69	54.85
1778.99	10-Year	396.66	1.93	0.39	64.41	69.66
1778.99	25-Year	396.72	2.1	0.46	71.8	79.25
1778.99	100-Year	396.82	2.36	0.58	83.09	94.48
1767.39		Culvert				
1746.79	2-Year	395.73	2.46	0.54	54.85	54.85
1746.79	10-Year	396.07	1.42	0.2	61.85	69.66
1746.79	25-Year	396.22	1.48	0.22	67.64	79.25
1746.79	100-Year	396.4	1.6	0.25	77	94.48
1725.18	2-Year	395.54	2.45	0.55	54.85	54.85
1725.18	10-Year	395.93	1.67	0.3	69.2	69.66
1725.18	25-Year	396.07	1.79	0.34	78.31	79.25
1725.18	100-Year	396.22	2	0.42	92.51	94.48
1703.72		Culvert				

River Sta	Profile	W.S. Elev	Vel Chnl	Shear Chan	Q Channel	Q Total
		(ft)	(ft/s)	(lb/sq ft)	(cfs)	(cfs)
1668.23	2-Year	388.61	7.63	6.63	54.85	54.85
1668.23	10-Year	388.91	8.3	7.45	69.66	69.66
1668.23	25-Year	389.12	8.59	7.74	79.25	79.25
1668.23	100-Year	389.4	9.13	8.41	94.48	94.48
1635.51	2-Year	385.53	6.51	5.77	54.85	54.85
1635.51	10-Year	385.78	6.93	6.31	69.66	69.66
1635.51	25-Year	385.93	7.15	6.61	79.25	79.25
1635.51	100-Year	386.14	7.46	7.03	94.48	94.48
1400	2-Year	378.64	3.23	1.25	54.85	54.85
1400	10-Year	379.02	3.48	1.41	69.66	69.66
1400	25-Year	379.24	3.62	1.5	79.25	79.25
1400	100-Year	379.57	3.83	1.65	94.48	94.48
1100	2-Year	370.13	5.93	5.01	54.85	54.85
1100	10-Year	370.33	6.3	5.44	69.66	69.66
1100	25-Year	370.45	6.52	5.7	79.25	79.25
1100	100-Year	370.63	6.8	6.04	94.48	94.48
800	2-Year	363.26	2.87	1.01	65.24	65.24
800	10-Year	363.54	3.15	1.17	84.03	84.03
800	25-Year	363.7	3.3	1.26	96.17	96.17
800	100-Year	363.94	3.53	1.41	115.38	115.38
500	2-Year	355.79	4.73	3.56	65.24	65.24
500	10-Year	355.92	5.13	3.96	84.03	84.03
500	25-Year	356	5.35	4.2	96.17	96.17
500	100-Year	356.11	5.67	4.54	115.38	115.38
66.23	2-Year	347.73	2.17	0.56	65.24	65.24
66.23	10-Year	348.06	2.34	0.63	84.03	84.03
66.23	25-Year	348.25	2.45	0.67	96.17	96.17
66.23	100-Year	348.53	2.59	0.73	115.38	115.38

Figure 2 Legend Continued

City of Raleigh Stormwater GIS Features:

Inlets

- City Standard
- State Standard
- Concrete cover
- Steel grate
- Circular Steel grate
- Riser
- Combination
- Other

Junctions

- Manhole
- Junction box
- Blind box
- Joint connection
- Chamber
- Not Found
- Other

PipeIO

- Inlet
- Outlet

Pipes

- Pipe
- French Drain

Culvert

Channel

- Other
- Rectangular
- Semi-circular
- Trapezoidal
- V-channel

APPENDIX II-E—RELEVANT STUDIES

NC DOT RIGHT-OF-WAY EXPANSION IMPACTS


EAST BUILDING
House Creek
I-440
Unnamed tributary
WADE AVE
House Creek
DOT IMPACTS
Existing Channel to Remain
DOT ROW Expansion
Riprap Channel
Stormwater Impacts
Clearing Impacts
100-Year Floodplain
0
300
600
1,200
Feet
N

APPENDIX II-E—RELEVANT STUDIES

TRIANGLE BIKEWAY FEASIBILITY STUDY (EXCERPTS)

STEWART

TECHNICAL MEMORANDUM

Date: 11/17/2017
To: Kris Morley-Nikfar, AICP
City of Raleigh Parks, Recreation and Cultural Resources Department
From: Jake Petrosky, AICP
Stewart Inc.

Subject: Reedy Creek Greenway Realignment and Bridge 70 Replacement

Executive Summary

The purpose of this evaluation is to determine the feasibility, surveying and design requirements, and cost estimates for realigning the Reedy Creek Greenway from the I-440 Pedestrian Bridge to Bridge 70 over a tributary of House Creek. The goal is to help the City of Raleigh and the NC Art Museum address the planned replacement of Bridge 70 over the tributary of House Creek and determine a preferred alternative to realign or improve the existing 1,300-foot (0.25-mile) trail segment in order to improve safety and user experience on the greenway. This document provides a summary of existing conditions/need, the alternatives analysis and provides preliminary recommendations.

The existing conditions on the trail has led to several crashes and therefore raised safety concerns relating to the trail's design (steep grade, width of trail, curvature), speed of cyclists, and user volumes. The recommended realignment alternative includes the following:

- Replacement and relocation of the existing bridge structure (Bridge 70). This includes approximately 60 feet of bridge structure
- 560 feet of new, 12-foot asphalt greenway, that removes the sharp curve from the trail that currently exists just east of Bridge 70
- 50-60 feet of boardwalk along the new trail alignment on the north side of House Creek
- Removal of the existing greenway and bridge structure to facilitate the reconnection of the floodplains and a potential stream restoration along the mainstem of House Creek and the tributary that extends south under the current greenway.
- Widening a portion of or all the trail from I-440 Bridge to Bridge 70.

Interim improvements to increase safety and reduce conflicts prior to construction are also recommended.

The recommended alternative and interim improvements are meant to be used by the City to appropriate project funding for survey, full design, preparation of the construction documents, and future construction of the project.

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Recommendations

Summary of Recommendations

Based on the performance of alternatives relative to project goals including safety, user experience, aesthetics and cost effectiveness, it is recommended that the City and/or the NC Museum of Art pursue Alternative 5 which includes a bridge replacement and relocation of the existing trail. It is also recommended that they also consider interim safety solutions and the widening of a portion of the existing trail.

Recommended Alternative

Alternative 5 includes 560 ft of new trail and approximately 60 feet of bridge structure and 60 feet of boardwalk. The existing greenway and bridge structure should be demolished and re-graded to facilitate the reconnection of the floodplains along the mainstem of House Creek and the tributary that extends south under the current greenway. The realignment will allow for new plantings with stream restoration activities that could create a wet meadow, improve riffle and pool structure, and add one or more meanders. The City and Museum should consider widening the existing trail as it ascends the slope south of the junction with the natural surface trail east of the existing bridge (Bridge 70).

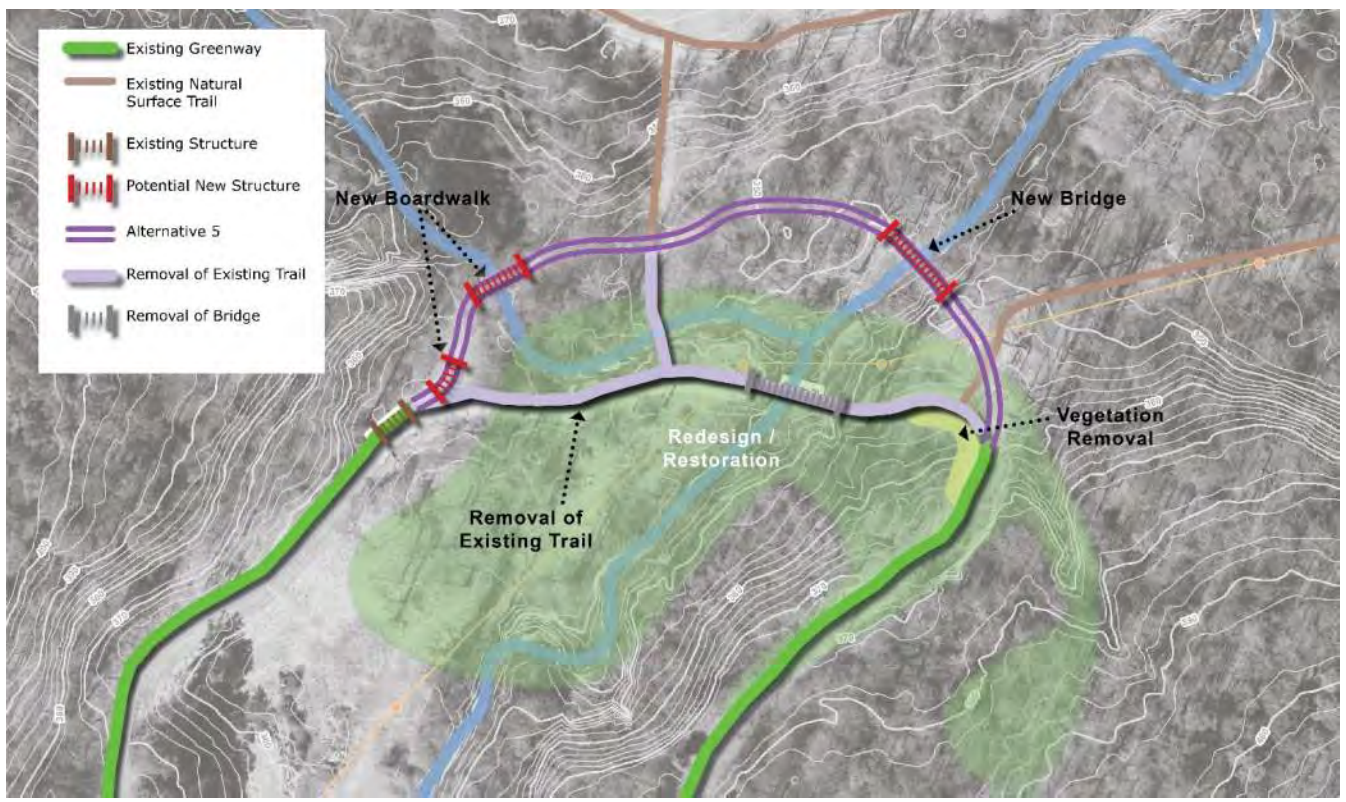


Figure 8. *Recommended Alternative (Alternative 5) for Reedy Creek Greenway Realignment*

Next Steps

The City and Museum are encouraged to use this recommended alternative to help identify appropriate project funding and provide guidance for survey, full design, preparation of the construction documents, and future construction of the project.

STEWART Reedy Creek Greenway Realignment and Bridge 70 Replacement

Interim Safety Improvements

Interim safety improvements including vegetation removal, replacing signage, installing flexible delineators and striping, installing transverse rumble strips, and enhancing the surface textures on the bridge and trail are recommended in order to improve safety in the near term.

A menu of interim safety improvements is provided below to assist with immediate safety concerns on the trail. If implemented, these features would increase safety on the trail by alerting trail users and affecting behavior. Appendix B provides additional information on safety strategies, purpose and installation cost estimates.

A **Vegetation Removal**

Removal of vegetation on the inside of the curve as you are descending to existing Bridge 70 would allow for better sight lines for users of the trail. Extent of vegetation removal would be minimal. Removing the existing stump closest to the trail along with some underbrush and/or pruning or "limbing" select trees could be considered. It is suggested that City Staff coordinate with the NC Museum of Art to discuss the range of options that would accomplish the goal of improving sight lines.

Figure 9. *Limited sight lines (Source: Google Maps)*

B **Replace Warning Signage**

Standard MUTCD trail signage to indicate the direct messaging desired to different user types on the trail cannot occur without excessive sign clutter. Custom signage is recommended. Overhead signage is recommended over post-mounted signage or for cyclists.

Cyclists:
- 8% GRADE
- APPLY BRAKES
- STAY IN LANE
- PASSING RESTRICTED IN CURVE

Pedestrians:
- STEEP HILL
- BE ALERT
- PASSING RESTRICTED IN CURVE

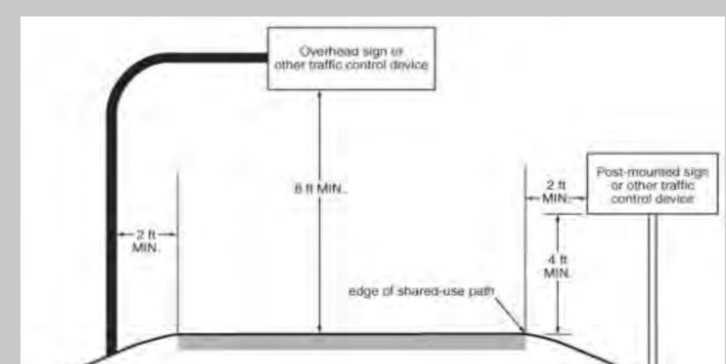


Figure 10. *MUTCD Sign placement guidance for Shared-Use Paths*

C Flexible Delineators and Striping

Delineators are used on solid lines to discourage or prohibit crossing. They have the negative impact of narrowing trail users' operating space and limiting passing maneuvers. However, this option is recommended in the interim to keep cyclists in their lane and give a visual narrowing cue to slow down. It is recommended flexible delineators be placed on the center stripe in advance of the curve on the downgrade but not in the curve for safety reasons. Lane striping should be refreshed and extended back prior to the first curve. Delineators must match the color of the striping and should be placed at a consistent spacing, with 10-foot intervals recommended.

Figure 11. *An illustration of delineator posts on the Reedy Creek Greenway*

D Transverse Rumble Strips

Rumble strips are commonly used on rural roads to provide a tactile and audible warning of an upcoming intersection or horizontal curve. The strips typically consist of depressed grooves crossing the lane surface. It is recommended that rumble strips be placed on the trail prior the downslope. Rumble strips can be hazardous for cyclists, so care should be exercised and best practices consulted when determining size and placement.

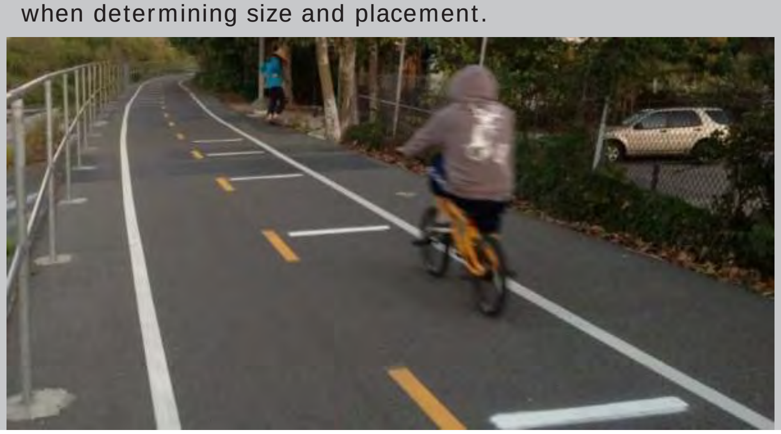


Figure 12*. Rumble Strips on L.A.'s Riverwalk Bike Path*

STEWART
Reedy Creek Greenway Realignment and Bridge 70 Replacement

E Texturization

Expanded metal grating or non-skid metal tread is recommended to add texture and prevent slipping on the bridge surface. Chicken wire, hardware cloth, or non-galvanized metal coverings are not recommended due to the potential for accelerated wear in high-use areas and potential for punctures to bicycle tires. Urethane coatings with grit such as sand are an inexpensive substitute, though may not wear as well.

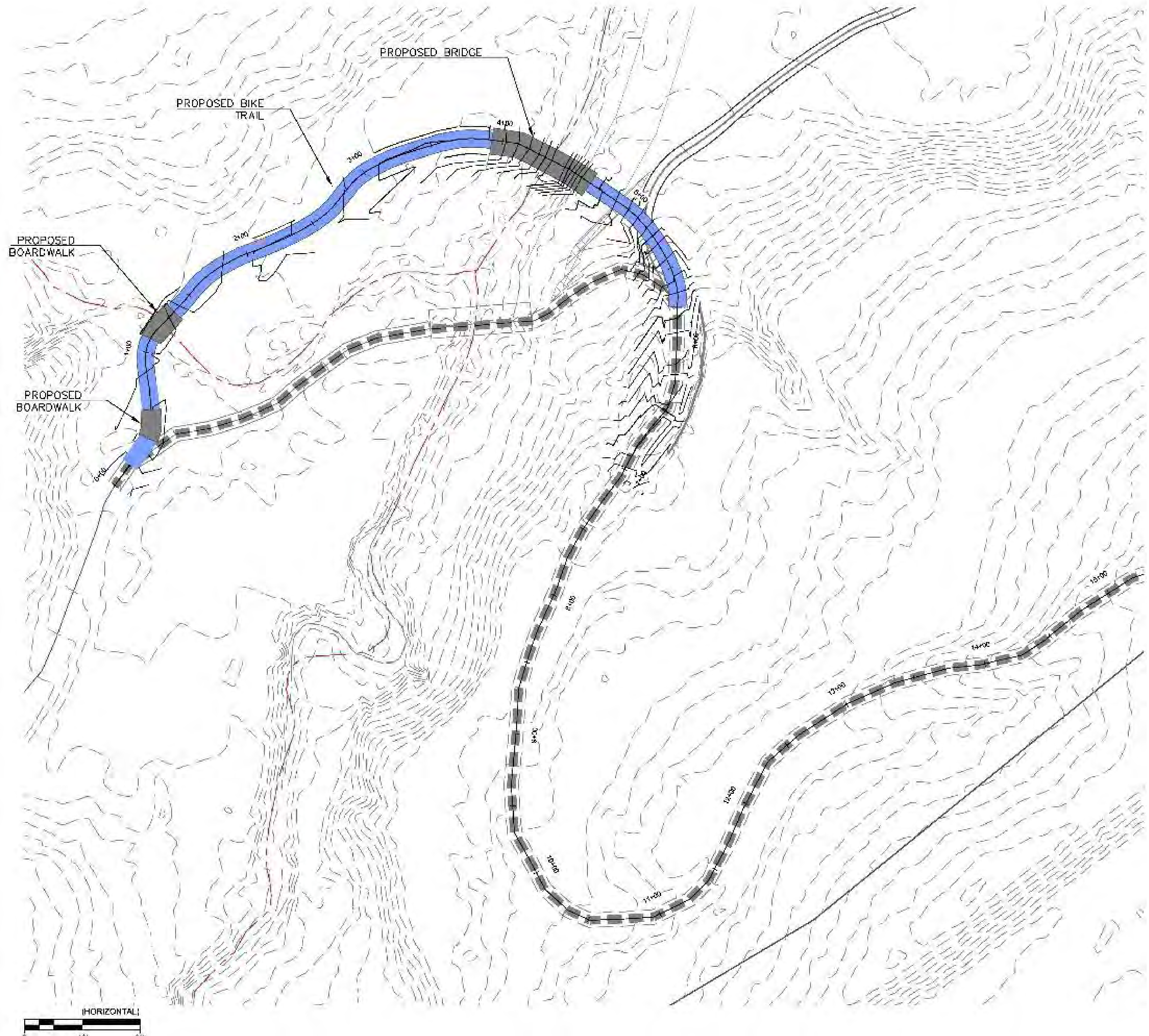
Figure 13. *An example of metal tread used on boardwalk in wet/icy conditions*

F Pavement Markings

Existing pavement markings that read "Slow Curve Slippery When Wet" could be removed, refreshed or revised. Warnings as pavement markings are less effective than overhead signs, but could be included in an overall interim improvement. Farther up the trail towards the top of the hill, before the steepest part of the descent and in the curve at the bottom of the trail, art murals can be installed that include a visual effect to alert and slow cyclists. The location and design of the mural should be carefully selected to be skid resistant and minimize conflicts.

Figure 14. *The "Magic Carpet" art installation on the Charlotte Rail Trail (top left) and example of a speed reduction markings (bottom left). Existing pavement markings (right).*

Alternative 5 - Alignment



RESTORATION STRATEGIES IN ELECTRIC AND SEWER CORRIDORS

(Notes reference plan on facing page)

1. Convert fescue meadow to arrested succession planting with mowed paths to maintain clear height and maintenance access beneath power lines

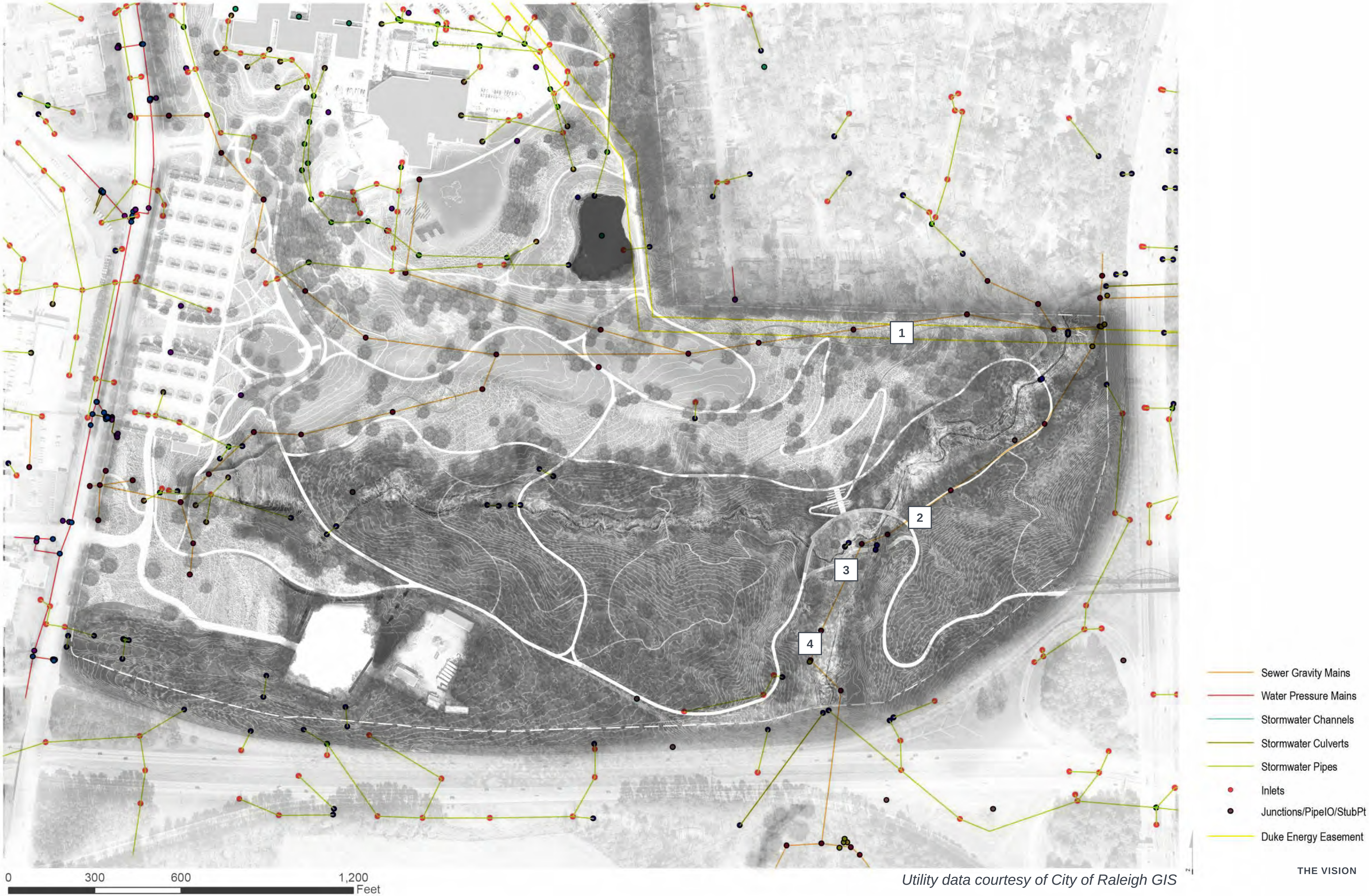
2. Maintain an at-grade connection between greenway and trail over sewer line

3. Provide maintenance access to sewer line at House Creek crossing via former greenway trail bed

4. Minimize grade changes in House Creek floodplain above sewer line

Meadow planting within power line easement, Finland; Photo: Jussi Lampinen, Kalle Ruokolainen, Ari-Pekka Huhta

Mowed meadow paths at Longwood Gardens; Photo: Claire Tekacs



Utility data courtesy of City of Raleigh GIS

APPENDIX II-G—WORKS CITED AND PHOTO CREDITS

Works Cited

American Association of State Highway and Transportation Officials. (2010). *AASHTO Guide for the Planning, Design, and Operation of Bicycle Facilities*.

American Rivers. (2021). *Neuse River: North Carolina*. https://www.americanrivers.org/river/neuse-river/

Ashe County Historical Society. (2021). *Company A of the 34th North Carolina: A Narrative History, Part 1*. Retrieved from: https://www.ashehistoricalsociety.org/company-a-of-the-34th-north-carolina-a-narrative-history-part-1/

Banks, J. L., and McConnell, R. (2015, April). National Emissions from Lawn and Garden Equipment. In International Emissions Inventory Conference, San Diego.

Burger, Dr. L. Wes, and Kirk Greenfield. (2005). Light Disking to Enhance Early Successional Wildlife Habitat in Grasslands and Old Fields. Technical Note No. 190-32. Washington, DC: U.S. Department of Agriculture Natural Resources Conservation Service.

Daniels, Dennis F. (2001). *Historical Research Report: Polk Prison Property.* North Carolina Department of Cultural Resources.

Gale, Susan. (2011). *Explorations of Relationships between Specific Conductance Values and Benthic Macroinvertebrate Community Bioclassifications in North Carolina*. Raleigh, NC: N.C. Division of Water Quality, Wetlands Program Development Unit.

Gu, C., Crane, J., Hornberger, G., and Carrico, A. (2015). The Effects of Household Management Practices on the Global Warming Potential of Urban Lawns. *Journal of Environmental Management*, 151, 233–242.

Miller, James H., Manning, Steven T., and Enloe, Stephen F. (2013). *A Management Guide for Invasive Plants in Southern Forests*. General Technical Report SRS–131. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station.

Neuse River Basin: Nutrient Sensitive Waters Management Strategy: Protection and Maintenance of Existing Riparian Buffers. Public Law No. 15A NCAC 02B .0714 (1997, Readopted 2020).

Niering, W. A., and G. D. Dreyer. (1989). Effects of prescribed burning on Andropogon scoparius in post-agricultural grasslands in Connecticut. *American Midland Naturalist*, 122, 88–102.

North Carolina Division of Water Quality. (2012). *Neuse & Tar-Pamlico Riparian Buffer Rule Changes 2012.*

Peek, Matthew M. (2021). *Camp Polk: When Tanks Were in a WWI State Capital.* NC Department of Natural and Cultural Resources, NC Stories of Service Blog. Retrieved from: https://medium.com/nc-stories-of-service/camp-polk-when-tanks-were-in-a-wwi-state-capital-6a23325f1af1

Sauer, Leslie Jones and Andropogon Associates. (1998). *The Once and Future Forest: A Guide to Forest Restoration Strategies*. Washington, DC: Island Press.

University of Connecticut Center for Land Use Education and Research. (n.d.). *Forest Fragmentation: Category Descriptions.* Retrieved from https://clear.uconn.edu/%5C/projects/landscape/v2/forestfrag/measuring/categories_explained.htm

Virginia Department of Wildlife Resources. (2021). *Native Warm Season Grass*. Retrieved from https://dwr.virginia.gov/quail/managing-your-land/old-field-management/nwsg/

Woods, Alan J., James M. Omernik, and Douglas D. Brown. (1999). *Level III and IV Ecoregions of Delaware, Maryland, Pennsylvania, Virginia, and West Virginia*. Environmental Protection Agency National Health and Environmental Effects Research Laboratory. Retrieved from https://meridian.allenpress.com/jfwm/article-supplement/416031/pdf/10_3996022017-jfwm-017_s11

Photo Credits

Page 108

Mixed Mesic Hardwood Forest: https://commons.wikimedia.org/w/index.php?curid=11025755

Riparian Wetland: https://www.pejraleighnc.org/about-gallery/i5i91k2ioq17athmcfhv6abbycwqhp

Wet Meadow: https://hoffmannursery.com/blog/article/sedges-for-meadow-and-prairie-plantings

Piedmont/Alluvial Headwater Stream Forest: https://auth1.dpr.ncparks.gov/habitat/view.php?combined_code=401.0

Stormwater Detention: https://www.platinumlakemanagement.com/blog/why-choose-a-stormwater-wetland-in-charlotte-nc

Mesic Warm-Season Grass Meadow: https://auth1.dpr.ncparks.gov/habitat/view.php?combined_code=1402.0

Arrested Succession Zone: https://www.flyingtrillium.com/nature_preserves/successional-shrubland/

Page 110

Red Oak: https://en.wikipedia.org/wiki/File:Quercus_rubra_@_Tortworth_Court.jpg

Christmas Fern: https://www.tnnursery.net/christmas-fern-for-sale?gclid=CjwKCAiA78aNBhAlEiwA7B76p8x7Iz3IPNOIDtEPv8RWpLh6ul2uX18gvmoV9hJBFVJFdZqQeSAlgxoCQc0QAvD_BwE

American Beech: https://en.wikipedia.org/wiki/Beech

American Strawberry Bush: https://www.curenursery.com/plants/euonymus-americanus-l/

Perfoliate Bellwort: http://www.namethatplant.net/picpage.shtml?path=/Images/ImagesFire/jkm19/jkm190414_7415.jpg&plant=1573&photo=31968; Credit: JK Marlow

Possumhaw: https://www.plantsfordallas.com/deciduous-holly

Shag Bark Hickory: https://commons.wikimedia.org/wiki/File:Carya_ovata_(Shagbark_Hickory)_(26470328789).jpg

Page 111

Witch Hazel: https://plants.ces.ncsu.edu/plants/hamamelis-virginiana/

Red Chokeberry: https://commons.wikimedia.org/wiki/File:Choke-Berries-IMG_2431_051013_121714.jpg

Yellowroot: http://chestnutherbs.com/wp-content/uploads/2011/09/IMG_3329.jpg

Paw Paw: https://sciotogardens.com/product/paw-paw-3-asimina-triloba/

Rusty Black Haw: https://www.gardenia.net/plant/viburnum-rufidulum

Elderberry: https://www.fs.fed.us/wildflowers/plant-of-the-week/sambucus_nigra_l.shtml

Sourwood: https://www.russelltreeexperts.com/arbor-ed/2020/3/20/at-home-on-the-blue-ridge-parkway

Tulip Poplar: https://mortonarb.org/plant-and-protect/trees-and-plants/tuliptree/#!

Photo Credits (Cont.)

Page 112

Swamp Cyrilla: https://bwwellsassociation.files.wordpress.com/2015/07/img_3150-cyrilla-racemiflora.jpg

Rosy Sedge: https://stonehousenursery.com/plant/carex-rosea/

Bald Spikerush: https://www.prairiemoon.com/eleocharis-obtusa-blunt-spike-rush-prairie-moon-nursery.html

Arrowhead: https://commons.wikimedia.org/wiki/File:Broadleaf_Arrowhead_(Sagittaria_latifolia)_-_Thunder_Bay,_Ontario_02.jpg

Swamp Sunflower: https://worldofflowering plants.com/helianthus-angustifolius-swamp-sunflower/

Wool Grass: http://www.kgnaturephotography.com/photos-wetland-plants/wetland-plant-species/Sedges-and-Rushes/slides/Scirpus-cyperinus-~-woolgrass-bulrush.html

Buttonbush: https://springmeadownursery.com/plantfinder/sugar-shack-09290

Tall Ironweed: http://amberastrophil.blogspot.com/2014/09/giant-ironweed-tall-ironweed-vernonia.html

River Oats: https://bellepiante.it/chasmanthium-latifolium/

Shallow Sedge: https://hoffmannursery.com/plants/details/carex-lurida

Page 113

River Birch: https://www.wildflower.org/plants/result.php?id_plant=BENI

Lizard's Tail: https://arkansasnativeplant.files.wordpress.com/2015/06/photo-3-21.jpg

Red Maple: http://usinggeorgianativeplants.blogspot.com/2016/

Arrow Arum: https://www.gardenia.net/plant/peltandra-virginica

Winterberry: https://www.gardenia.net/plant/ilex-verticillata

Pepperbush: https://www.maine.gov/dacf/mnap/features/cletaln.htm

Cardinal Flower: https://www.nativewildflowers.net/red-cardinal-flower/

Silky Dogwood: https://www.tennesseenaturescapes.com/all-plants-in-stock-mail-order/silky-dogwood-cornus-amomum

Blue Flag: https://www.splashplants.com/product/blue-flag-iris-iris-versicolor/

Page 114

Swamp Milkweed: https://www.amandasnativeplants.com/product-page/wet-or-moist-soil-collection-fall-2018

Common Wood Sedge: https://tuesdaysinthetallgrass.wordpress.com/tag/common-wood-sedge/

Culver's Root: https://stonehousenursery.com/plant/veronicastrum-virginicum/

Wild Senna: https://commons.wikimedia.org/wiki/File:Senna_hebecarpa_(19994539134).jpg

Blazing Star: https://www.michiganwildflowerfarm.com/product/liatris-spicata-marsh-blazing-star-per-oz/

Fox Sedge: https://www.wilsonbrosgardens.com/carex-vulpinoidea-fox-sedge-plant-6pk-1-gallon.html

Torrey's Rush: https://commons.wikimedia.org/wiki/File:2015.08.22_10.24.56_IMG_0238_-_Flickr_-_andrey_zharkikh.jpg

Joe Pye Weed: https://sylvangardenslandscape.com/product/joe-pye-weed-little-joe-plant-profile/

Virginia Wild Rye: https://prairiegardentrust.org/explore/nature-areas/the-savanna/

Lanceleaf Coreopsis: https://servescape.net/products/coreopsis-lanceolata-lanceleaf-coreopsis

Page 115

Butterfly Milkweed: https://commons.wikimedia.org/wiki/File:Asclepias_tuberosa_interior.jpg

Purple Top: https://alchetron.com/Tridens-flavus#tridens-flavus-9b004f0a-1895-43c1-8b02-1cde9ec1ce2-resize-750.jpeg

Oxeye Sunflower: https://www.americanmeadows.com/wildflower-seeds/sunflower-seeds/early-sunflower-seeds

Switchgrass: https://sciotogardens.com/product/north-wind-2-switchgrass-panicum-virgatum/

Prairie Dropseed: https://hoffmannursery.com/plants/details/sporobolus-heterolepis

Bergamont: https://www.applewoodseed.com/product/bergamot/

Purple Coneflower: https://www.gardendesign.com/flowers/coneflower.html

Side Oats Grama: https://www.cityrootsnursery.com/grassessedges-for-sale/bouteloua-curtipendula-side-oats-grama

Partridge Pea: https://www.clayandlimestone.com/2017/07/wildflower-wednesday-partridge-pea.html

Page 116

American Beautyberry: http://fnpsblog.blogspot.com/2010/09/american-beautyberry-purple-now.html

Indiangrass: https://www.everwilde.com/store/Sorghastrum-nutans-Seed.html

Aromatic Sumac: https://commons.wikimedia.org/wiki/File:Rhus_aromatica_2016-07-19_3275.jpg

Fringe Tree: https://piedmontmastergardeners.org/article/fringetree-slow-to-bloom-but-worth-the-wait/

Staghorn Sumac: https://goodwitcheshomestead.files.wordpress.com/2020/07/staghorn2.jpg

Black-Eyed Susan: https://www.tnnursery.net/rudbeckia-for-sale

Little Bluestem: https://www.gertens.com/carousel-little-bluestem.html

Southern Wax Myrtle: https://www.plantant.com/supplierimages/image.php/myrica-cerifera-wax-myrtle-1000052647-1392913168.jpg?height=1000&image=/public/supplierimages/plants/1000052647-1392913168.jpg&width=1000

Virginia Wild Rye: https://prairiegardentrust.org/explore/nature-areas/the-savanna/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