5-2014

Increasing Urban Biodiversity in Springfield, MA by Restoring the Native Floodplain Plant Community Along the Connecticut River

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Master's Thesis Project

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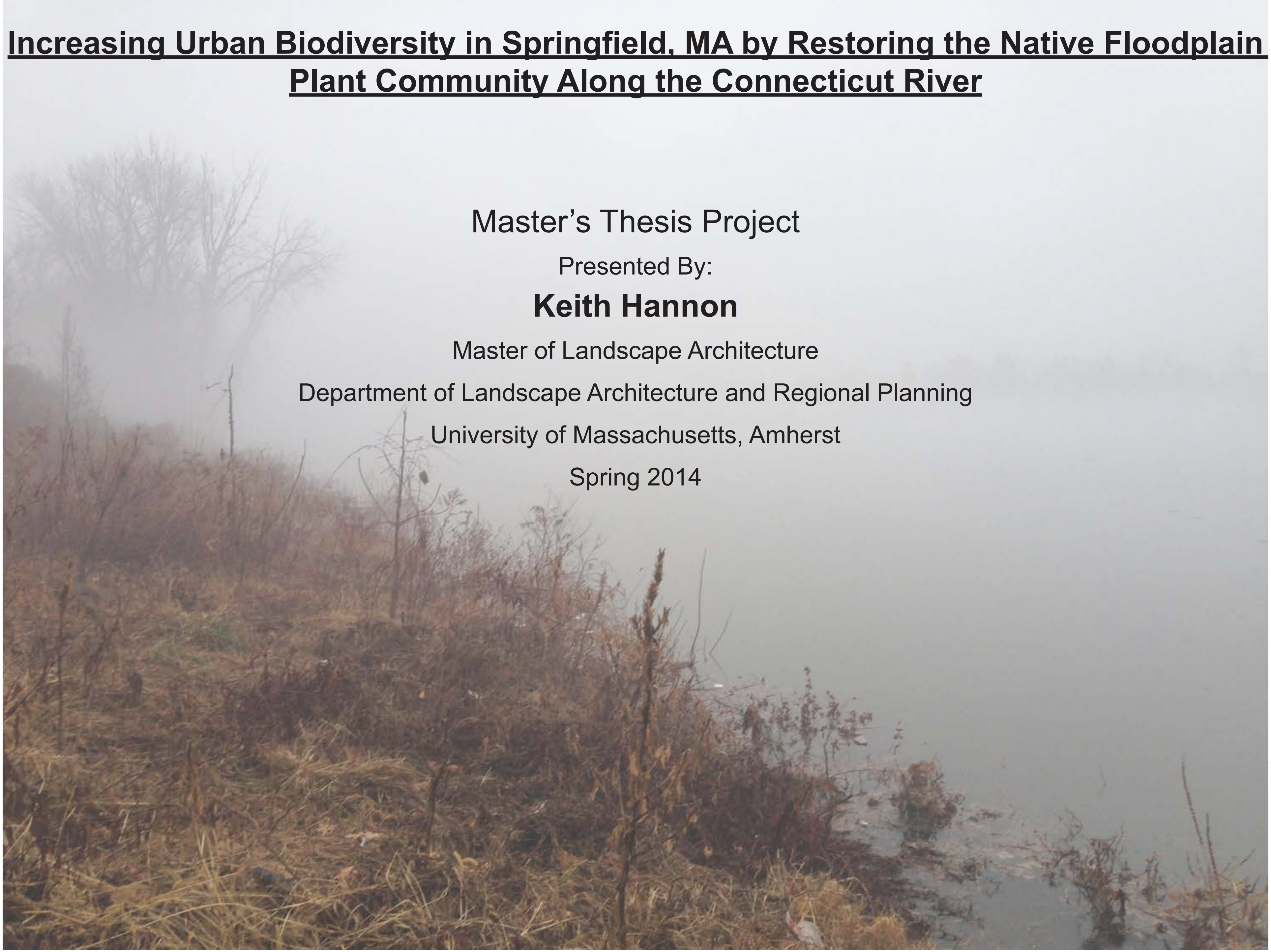

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Abstract

The purpose of this project was to increase urban biodiversity by restoring the native floodplain plant communities along the Connecticut River at the Pioneer Valley Riverfront Club (PVRC). Restoring or designing native plant communities is an important design alternative to the typical design methods of using non-native plant species and mono-culture plant palettes. Restoring a native plant community at the PVRC will allow the landscape to function once more as usable habitat for wildlife and native plants, encourage the natural succession of native plants, and become a more resilient landscape that can better withstand ecological changes caused by various factors including climate change. The project was also intended to be a showcase example for other landscape designers to see how native plant community design can be effectively utilized to not only inform the plant palette for a landscape design proposal, but also effectively show how a native plant community-based design can restore the functionality and environmental resilience of a landscape in a safe, educational, and welcoming manner. In addition, this project bridges the gap and acknowledges the difference between a typical landscape designer's approach to restoration and a restoration ecologist's approach. This was accomplished by re-grading the site of the PVRC in order to reconnect the artificially filled-in and elevated areas of the property with the floodplain. The design creates a series of terraces based on estimated flood levels required to sustain both the Floodplain Forest and High Terrace Floodplain Forest plant communities while utilizing the plants found in those native plant communities, as described by the Classification of the Natural Communities of Massachusetts (Swain & Kearsley, 2001). The designs were informed by extensive research on native plant communities in Massachusetts, previous native plant community restoration projects, and through detailed site analysis and site visits to the researched case studies.

Acknowledgments

I would like to thank my committee members, Mike Davidsohn of the University of Massachusetts and Andy Bohne of New England Environmental, for their guidance and support throughout this project. Their knowledge and expertise has informed many of my design decisions and processes. I would also like to thank Christian Marks from The Nature Conservancy for his guidance and shared knowledge regarding floodplain plant community restoration projects. I extend thanks to Karro Frost from NHESP for informing me about the first steps of performing a plant community restoration project on the site. I would also like to thank Julie Richburg for sharing information and photos of the floodplain forest restoration project that she worked on.

I would also like to thank the faculty and staff of the Department of Landscape Architecture and Regional Planning for support during my graduate school experience and for encouraging me to explore restoration ecology and native plant community design. I would like to thank my classmates for their constant feedback and camaraderie. I would finally like to thank Madeline Jacknin for her support and patience over the course of this project.

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Chapter 1

Introduction

The goal of this project is to increase urban biodiversity by restoring the native plant community in an urban area. While researching the subjects of urban biodiversity and native plant community restoration, it became clear that restoring native plant communities, whether in an urban area or not, had so many positive benefits not only to the environment, but to us as well. It became clear that the design approach of increasing biodiversity should not necessarily be limited to urban areas. Urban areas, however, experiences the maximum transformation through human actions and development – whether it is caused by removing natural plant communities to make room for buildings, paving new roads, filling in wetlands, or cutting down forests – urban areas are hot beds for ecological degradation. This type of degradation tends to be long-term or permanent that does not allow these natural plant communities to ever return.

This project seeks to create a site design for the Pioneer Valley Riverboat Club (PVRC), which is situated in an urban area, along the Connecticut River. The property is owned by the City of Springfield, MA who lease the property out to the PVRC. PVRC is a 501(c)3 nonprofit which operates a recreational facility in the North End of Springfield with the mission to promote river-based sporting activities, to develop river access, and encourage recreation along the Connecticut River. This project site is an excellent location and opportunity to do an urban biodiversity focused design. The site is approximately three acres in size, sits within the Connecticut River floodplain, and is almost completely covered in asphalt. The native plant community has been removed and the hydrologic connections of the floodplain have been altered by significant re-grading of the site in order to elevate a significant portion of the property to sit above the high water levels within the floodplain during flood stages. By converting the large areas of asphalt back to the native plant community and reconnecting the site back to the hydrologic cycles within the floodplain, thereby allowing the natural cycles associated with flooding to occur, this site can positively increase the urban biodiversity within the City of Springfield. It can also function as a highly visible educational resource that promotes the importance of native plant community design as an effective design approach to increases urban biodiversity.

Goal and Objectives

The inspiration for this project is to increase the biodiversity in an urban area (Springfield, MA) by restoring the native plant community, which, over time, has been degraded and covered-over with impermeable asphalt.

Project Goal: The goal of this project is to provide the PVRC with a detailed site design for their property that will guide and inform their own planned future site design.

Objectives:

- Focus on a design that re-establishes the native Major River Floodplain Forest plant community.
- Produce a package of plans that the PVRC could use to present to various foundations in order to raise funds to build a new site design.
- Provide grading alternatives for the site that allows for stormwater infiltration to occur on-site and to divert or minimize stormwater that currently originates in the paved parking areas from flowing into the Connecticut River.
- Integrate restoration ecology with landscape design principles.

Justification

This project will be a showcase example for other professionals who design with the landscape, restoration ecologists, and the general public to show them that native plant community design is not only feasible, but that it also contributes to the biodiversity of an urban area. In regards to the professionals who design the landscape, this type of native plant community restoration project is not likely to be feasible at a private residential property, or at a more typical urban property, which are not located within floodplains of major rivers. Urban properties also tend to be smaller, one acre or less in size, and are isolated from surrounding natural habitat areas. Restoring a native plant community in these properties is possible, but the quality of the restored habitat will be less than a restored plant community that has a connection to surrounding habitat areas or corridors. Restored habitat in these more isolated areas would create patch habitat. The PVRC site is 3.1 acres in size and is part of the extensive Connecticut River greenway corridor. There is existing floodplain forest on the neighboring north and south properties, albeit narrow, that the restored plant community will be able to connect with successfully. The PVRC project is a great opportunity to do a native plant community restoration in an urban area that has high visibility, and that has existing connections to an extensive greenway corridor.

Chapter 2

Literature Review and Case Studies

Literature Review

The Need for Biodiversity

One definition of biodiversity is the" variety of life and its processes. It includes the variety of living organisms, the genetic differences among them, the communities and ecosystems in which they occur, and the ecological and evolutionary processes that keep them functioning, yet ever changing and adapting"(Noss & Cooperrider, 1994). Biodiversity can also be thought of as the biotic basis of plants, animals and microbes on the earth and it is disappearing at an alarming rate just at the time when we need it most for sustaining life (Kim & Weaver, 1994). Biodiversity has become threatened due to population growth and the associated increase in land development required to meet the demands of a growing population. Population growth has resulted in permanently destroying natural systems including grasslands, wetlands, and prime farmland and contributes to excessive runoff of industrial and domestic wastes and increases impervious surfaces (Kim & Weaver, 1994). Human actions may negatively influence biodiversity in three main ways: causing habitat loss or fragmentation, introducing invasive species, and inducing global climate changes (Ahern, Leduc & York, 2006).

> "It all comes down to a decision of ethics- how we value the natural world in which we evolved… the drive toward perpetual expansion… is basic to the human spirit… But to sustain it, we need the most delicate, knowing stewardship of the living world that can be devised. Expansion and stewardship may appear at first to be conflicting goals but the opposite is true. The depth of the conservation ethic will be measured by the extent to which each of the two approaches to nature is used to reshape and reinforce the other." (Wilson & Peter, 1988).

For example, bees are an integral part of pollination and without them, the survival of their host plants will be threatened; consequently humans will also be detrimentally affected. This could cause whole ecosystem collapse (Samways, 1989). "Only 20 crop species provide 90% of the food supply, of which just three species, namely wheat, maize, and rice supply more than half of the global food supply (Kim

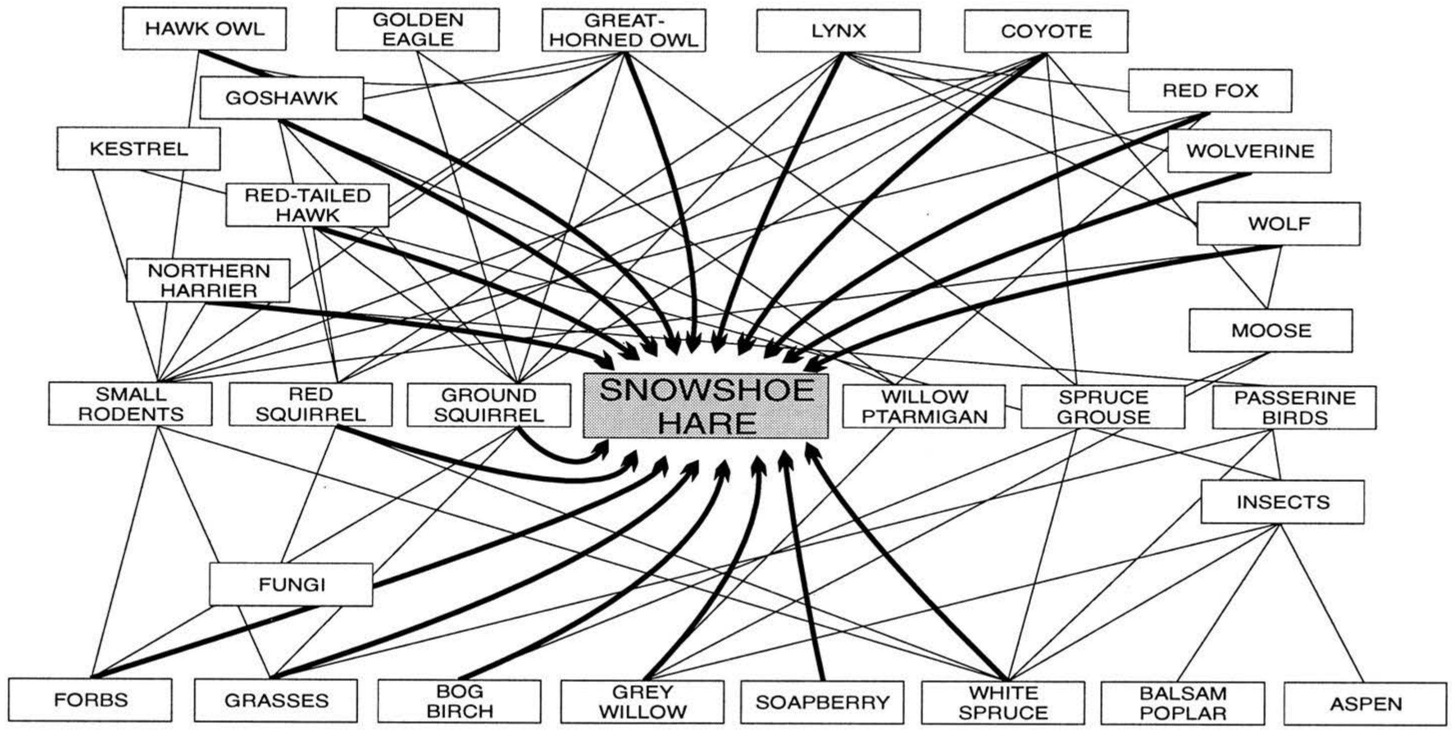
& Weaver, 1994). We are eroding the genetic diversity of the crops we increasingly depend upon by using monocultures, and we are eradicating the wild ancestors of those crops when we destroy wilderness habitats through urbanization.

Designed landscapes that contribute to biodiversity also provide ecosystem services. Ecosystem services are the "conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life. They maintain biodiversity and the production of ecosystem goods, such as seafood, forage, timber, biomass fuels, natural fiber…In addition to the production of goods, ecosystem services are the actual life-support functions, such as cleansing, recycling, and renewal, and they confer many intangible aesthetic and cultural benefits as well"(Daly, 1997). Tilman (1997) describes various field-tests that were done that showed that "many aspects of the stability, functioning, and sustainability of ecosystems depend on biodiversity. This dependence…reflects the increased functional roles that are possible in ecosystems that contain more species. The current evidence shows strong dependence on biodiversity of the resistance of ecosystem functioning to disturbance, indicating that more diverse ecosystems are more stable".

Humans Depend on Biodiversity

Natural systems can be organized such that these systems include both plants and animals. They can also be organized as different plant communities. These communities not only ensure an orderly cycle of material and energy transformations, but also regulate the moisture economy, cushion the earth's surface against violent changes in the land, and make the formation of soil possible. In short, humans are dependent upon other organisms from these communities, both for immediate survival through their production of food, and for maintaining habitat conditions under which human survival is possible. (Platt, Rowntree & Muick, 1994)

Humans also lack the genetic and biological capacity to constantly adapt to rapidly changing environments, so it is in our best interest to maintain or conserve the existing systems and plant communities wherever possible (Kim & Weaver, 1994). We also co-evolved with all of the plants and animals on the planet and we are linked to them, and depend on them in ways we may not ever fully understand. We take this relationship for granted. For example, the image below is a visual representation of all of the connections or relationships that exist with just one rabbit species (the snow shoe hare) within in its food web (there are about thirty connections shown).



Source: http://www.pnas.org/content/94/10/5147/F1.expansion.html

Humans are on the top of the food chain so we are connected in this same way to all the plants and animals on the planet, which includes many more than the thirty shown in the snowshoe hare example. E.O. Wilson wrote that, “we have only a poor grasp of the ecosystem services by which other organisms cleanse the water, turn soils into fertile living cover, and manufacture the very air we breathe. We sense, but do not fully understand what the highly diverse natural world means to our survival” (Wilson, 1998).

One definition of ecological sustainability that was defined in terms of ecosystems relates these concepts to urban biodiversity, where long term ecological sustainability requires the protection of genetic resources and the conservation of biological diversity (Rutherford, Rowntree & Muick, 1994). Using this definition of ecological sustainability, there are few redeeming qualities of cities regarding ecological sustainability; cities are focal points for biodiversity loss. They don't contribute to the protection of genetic resources or the conservation of biological diversity.

The Gap Between Designers and Ecologists

"Restoration ecology is grounded in the functioning of the landscape, particularly the ability of the new plant community to reproduce, to modify the physical environment, and to be acceptable habitat that satisfies the many niche requirements of animals (Handel, 2013). In contrast to this assessment of restoration ecology, many (if not most) gardens or planting plans carried out by professionals who design the landscape are built to remain static or unchanging over time. If any of the plants die after being planted they are replaced in kind. Any successional growth or appearance of new species is removed during routine maintenance of the site or garden (Handel, 2013).

"This typical approach undermines ecological function (e.g., seedling recruitment, successional change, availability of microsites for animal habitats) and is never included in the criteria of success for habitat restoration" (Handel, 2013). Other critical differences exist between the typical approach of a professional who designs the landscape's site design when compared to a restoration ecologist's approach. Attitudes and opinions regarding the tempo of vegetative change, artificial lighting, irrigation, monoculture plantings, and the use of turf grass are examples of some of these differences. When investigating a couple of these differences including the tempo of vegetative change, Handel (2013) summarized that an ecological community of many species includes those with subtle but real physiological differences. Some plants tolerate and need high light intensities; others only succeed in the shade. These differences have well-understood biological bases, such as photosynthetic chemistry and water balance adaptations. For example, many beautiful woodland wildflowers, such as trilliums (Trillium spp.) and mayapple (Podophyllum peltatum), can only survive in the shade. Installing them early in the construction process leads to death. These plants can only be added years after the initial canopy is installed and the woodland surface is suffused with shade. The tempo of a successful woodland restoration is slow and can stretch to over a decade.

Another example of a design goal that differs between a typical professional that designs the landscape and that of a restoration ecologist has to do with the use of artificial lighting. Many design professionals design a site that utilizes artificial lighting as a key component so that the site can be appreciated by humans, or increase their perception of safety at night. Restoration ecologists eschew this approach and would not typically design an artificial lighting system for use at night at a restoration site. The effects of artificial light on plants and animals have been studied, and some effects of artificial light at night to plants and animals are more obvious than others. Artificial lighting does affect plants, but it is not clear yet based on the research, whether artificial lighting poses any short or long term consequences to any particular plant species in nature (Rich & Longcore, 2006). The effect of artificial light on insects and animals is better understood. Constant artificial lighting may disorient organisms accustomed to navigating at night in darkness. “Once a bird is within a lighted zone at night, it will not leave the lighted area. Large numbers of nocturnally migrating birds are therefore imperiled when…conditions bring them close to lights, such as during inclement weather. Within the sphere of lights, birds may collide with each other or with structures, become exhausted, or be taken by predators (Rich & Longcore, 2006). Similar negative effects of artificial night lighting can be found with insects, fish, and terrestrial mammals as well. Reproductive behavior, foraging behavior, and disruption of biological clocks may be altered by artificial night lighting with all of these species (Rich and Longcore, 2006).

Bridging the gap between the professional who designs the landscape’s typical approach and that of the restoration ecologist’s is a simple design approach. This approach is to design a native plant community “likeness”, where there is a high regard for native plants in a landscape design that contributes to the biodiversity of the area and contributes usable habitat for wildlife, but does not re-create a true native plant community. Turf grass could be present, site lighting and monocultures plantings could also be present, as well as irrigation systems. One such example is the site design at the Olympic Sculpture Park in Seattle, Washington. The site design was created by the landscape architect Charles Anderson, whose design imitates natural plant communities on site using different plant communities that exist throughout the State of Washington as a guide (Beck, 2013). “Anderson does not claim that the plantings in the park are native plant communities. He calls them “likenesses”’ (Beck, 2013). This park is part of the Seattle Art Museum, where turf grass, site lighting, and pedestrian pathways are all important aspects of the landscape plan at the museum, which is situated within an urban setting of downtown Seattle.

Another design approach that bridges the gap between professionals who design the landscape and restoration ecologists is called "natural landscaping". "The objective of natural landscaping is to restore the natural beauty of the landscape by utilizing native plants in a community context. Unlike ecological restoration, which attempts the replication of an ecological community with a full complement of species, natural landscaping uses nature as a model for landscape designs" (Harker, 1999). Harker (1999) also described that, "Natural landscaping should be viewed as a long-term process that ultimately results in a self-sustaining landscape, but you are not trying to recreate the complexities and balance of ecological systems." Harker (1999) continues to say that one main goal of the natural landscaping design approach is to reduce the management intensity of a particular landscape, which includes mowing, pruning, irrigating, fertilizing, and pest control. In other words, a natural landscape design can contribute to increasing the biodiversity of a site, but the main goal is not to recreate an undisturbed native plant community. Installing native plants and using nature as a guide has positive effects to the environment and contributes to biodiversity.

A Changing Landscape is a Natural Landscape

In order to successfully restore a native plant community, designers must accept the inevitability of change in their designs (Begon, Townsend & Harper, 2006), and be able to recognize and communicate to the public its role in creating sustainable habitats and the ecosystem services they provide. A successful plant community restoration project may contain completely different species over time than were initially installed. "Ecological systems are, by their nature, dynamic and variable. Management has to be flexible and adaptive and to leave room for future change to occur" (Suding & Gross, 2006). Different reasons exist that help explain how plant composition in a natural design can change over time. Dispersal of seeds by wind or insects are examples of mechanisms some plants rely on for reproduction, which are important factors to understand in restoration ecology. Creating the space to allow the natural disbursement of seeds to occur is very important. Another important factor to understand is the concept of species mutualism. Plants and animals share a symbiotic relationship where the plants feed the animal and the animal helps fertilize and disperse the plant's seed. One such mutualism was studied at the Fresh Kills landfill restoration project in New York City. Within the first year of planting native trees at the site, one study recorded the presence of thousands of seeds brought in by birds. The seeds represented more than 20 species of trees that had not been planted on the site, including other native species (Hoppes, 1988). This type of data is evidence that a landscape design is likely to be strongly influenced by species mutualism after initial planting. New seeds not part of the original design palette will likely be brought in by birds from the surrounding habitats and change the composition of the plant complex on site. Species mutualism is both a source of biodiversity and a sink for the retention of the initial landscape design. This process can only be managed by an understanding of the surrounding vegetation coupled with a long term management plan that controls the seed dispersal dynamics and reduces or eliminates non-native species as a native plant community becomes established and is allowed to change over time (Handel, 2013).

Challenges to Restoring Native Plant Communities on Previously Developed or Urban Land

It is generally hypothesized that the former plant community that existed on a disturbed site can be reinstated, and this hypothesis can be challenged on many grounds. Urban sites are usually fragmented, small, and distant from any healthy adjacent sites. These characteristics could prevent a site from supporting local populations of plants or animals because they lack a buffer, or neighboring supportive areas that animals could connect to during or after the a site disturbance (Gilbert, 1991). Landscape ecologists have studied the importance and need for connectivity in order for plant and animal species to thrive. Without connectivity to neighboring habitat patches or larger intact habitat areas, the success of species in isolated patches, especially in urban areas, is reduced (Dramstad, Olson & Forman, 1996).

The condition of the soil at a restoration site is another key factor in determining the success of a restoration plan. Urban soils are chemically and physically stressful to plants. They are compacted, which limits the ability of root growth and doesn't allow for drainage of stormwater, and limits the aeration properties of the soil. They also tend to contain construction debris and concrete dust among other pollutants (Mullins, 1991). Urban soils often lack the beneficial microbes or mycorrhizae fungi necessary for effective nutrient cycling (Karpati, Handel, Dighton & Horton, 2011). Addition of new soil that is free of invasive and exotic plant seeds, as well as chemical contaminants must be considered if a new native plant community is to be established at a particular site (Handel, 2013).

A Native Plant Community is a Resilient Plant Community

Climate change and other major changes in ecosystem functions can have a negative effect on the survival of wild plants and animals, as well as the crops and domesticated animals that humans rely on directly for survival. Biodiversity provides a buffer against these major changes, based on the assumption that separate species utilize separate niches, and respond differently to future events. Tilman's study (1996) showed that a more bio-diverse ecosystem offers more options than simpler ones when placed under stress, and that there were less extreme year-to-year fluctuations in above ground biomass in more diverse grassland communities, and faster recovery after drought. If a landscape were composed of a mono-culture planting or non-native and poorly adaptable plant species, environmental changes could have a catastrophic effect on these plants. Designing more resilient landscapes that emphasize biodiversity and native plants ensures that future environmental changes will not be felt as severely by humans and wildlife.

Designing for and creating micro-sites also contribute to a sites resiliency. As in the wild, many animals and insects depend on these micro-sites for cover and forage. Placing a wide array of pebbles or cobbles that create areas of refuge, or placing dead wood on-site creates habitat for many insects, which are the base of terrestrial food webs. “The ability for a landscape to maintain growing populations of native biodiversity requires that these types of organic microhabitats be available” (Handel, 2013). When dead wood decomposes it creates areas of high organic matter soil, which is where many plant species prefer to germinate from seed.

Plant Community Classifications

The native plant community at the PVRC has been altered, but based on vegetation surveys at the site and comparisons to known floodplain plant communities elsewhere in the state and along the Connecticut River, the native plant community at the site would be classified as Major River Floodplain Forest. The Massachusetts Natural Heritage and Endangered Species Program (NHESP) has classified this plant community type and determined the community designation for the State of Massachusetts. “Floodplain forests are deciduous forested wetland communities which develop next to rivers and streams that flood regularly In the spring…Floodplain forests are considered to be among the rarest and most threatened natural communities in Massachusetts. Due to their high soil fertility and scenic qualities, floodplain forests have largely been converted to agriculture or lost to housing and industrial development" (Swain & Kearsley, 2001). As a result, the NHESP also describes these floodplain forests as being imperiled and require active land protection efforts to preserve the few existing examples of these plant communities within the state. The number of days per year of flooding required to sustain a Major River Floodplain Forest is has been found to be, on average, 4.5 days/year (Marks, unpublished).

The primary source used to classify the plant community at the PVRC, was the NHESP Classification of the Natural Plant Communities of Massachusetts by Swain and Kearsley (2001). This is an important resource that describes in detail the composition of the plant communities in the State of Massachusetts, their status, and wildlife associated with each habitat type. The NHESP has classified the Major River Floodplain forest in Massachusetts as a "Silver maple-dominated forest community of alluvial floodplains of the Connecticut, Deerfield, and Housatonic Rivers" (Swain & Kearsley, 2001). The dominant plants that are classified in these plant communities include silver maple (Acer saccharinum) in the overstory, with over 60% cover. It is mixed with lesser amounts of cottonwoods (Populous deltoides), and American Elm (Ulmus americana) and/or slippery elm (Ulmus rubra) occur in the subcanopy. Shrubs are generally lacking and the herbaceous layer is usually dominated by 3-6ft. tall cover of wood nettles (Laportea canadensis). Ostrich fern (Matteuccia struthiopteris) is sometimes abundant, as are Whitegrass (Leersia virginica). Other common plants are woodreed (Cinna arundinacea) and jack-in-the-pulpit (Arisaema triphyllum). Variants of this community type have been described and they have similar species but silver maple is not dominant in the overstory and the understory is typically strongly dominated by ostrich fern. The overstory is a mix of silver maple, cottonwood, sycamore (Platanus occidentalis), and American ash (Fraxinus americana), with box elder (Acer negundo) and hackberry (Celtis occidentalis) in the subcanopy. Bittersweet (Celastrus orbiculata) and the vines, riverbank grape (Vitis riparia) and Virginia creeper (Parthenosis quinquefolia) are also common.

High-terrace Floodplain Forests "are characterized by a tall and diverse canopy of deciduous trees with a species rich herbaceous layer. Occurrences tend to be relatively small narrow forests on high alluvial terraces that flood occasionally or for shorter duration than other types of floodplain forests…As with other types of floodplain forests…the rich soils and moist conditions make disturbed areas in them prone to invasions by exotic plant species” (Swain & Kearsley, 2001). High-terrace Floodplain Forests are designated as NHESP Priority Natural Communitites because of their high species diversity, distinct vegetation assemblage, susceptibility to disturbance, and limited occurrence. The NHESP describes the location of these communities as occurring on high alluvial terraces of large rivers…and raised banks adjacent to high energy, high gradient rivers. These floodplain forests have an assemblage of plant species that also occur in the Major River Floodplain Forest, including red and silver maple (Acer rubrum and Acer saccharinum), but also includes mesic, more upland, deciduous hardwoods including sugar maple (Acer saccharum), Shagbark Hickory (Carya ovata), black cherry (Prunus serotina), and basswood (Tilia Americana). Ironwood (Carpinus caroliniana) typically forms an open subcanopy and is a good indicator species of this community type. The shrub layer varies from sparse to well developed with arrowood (Viburnum dentatum), nannyberry (Viburnum lentago), and winterberry (Ilex verticillata) as the most common with variable amounts of non-native shrubs. The herbaceous layer is a mixture of characteristic floodplain ferns including sensitive fern (Onoclea sensibilis) and ostrich fern (Matteuccia struthiopteris). Upland herbs such as Canada mayflower (Maianthemum canadense), lady fern (Athyrium filix-femina), zigzag goldenrod (Solidago flexicaulis), white snakeroot (Eupatorium rugosum), jack-in-the-pulpit (Arisaema triphyllum) and bellwort (Uvularia sessilifolia).

Other characteristic herbaceous taxa include honewort (Cryptotaenia canadensis), bottlebrush grass (Hystrix patula), floodplain avens (Geum laciniatum), jumpseed (Tovara virginianum), Wiegand 's wild rye (Elymus wiegandii), trilliums (Trillium spp.),trout-lily (Erythronium americanum), and enchanter's nightshade (Circaea lutetiana ssp. canadensis.). Virginia creeper (Parthenocissus quinquefolia) and poison ivy (Toxicodendron radicans) can also be abundant.” The number of days per year of flooding required to sustain a High-terrace Floodplain Forest is has been found to be, on average, 1 day/year (Marks, unpublished).

Most high terraces have been converted to agriculture. Remaining examples are typically small and disturbed by selective logging and trail clearing. The lack of natural vegetated buffers make these communities highly susceptible to non-native plant invasions. Most known examples have non-native plant species comprising a substantial percentage of overall plant cover. Because these communities fall outside of wetland boundaries, they are not subject to wetland regulations making them targets for selective logging and clearing for agriculture" (Swain and Kearsley, 2001). High-terrace floodplain forests can also contain low wet depressions that function as vernal pools that provide important breeding habitats for amphibians.

Benefits of Floodplain Forests

"Floodplain forests occur as an ecotone between aquatic and upland ecosystems but have distinct vegetation and soil characteristics. They are uniquely characterized by the combination of high species diversity, high species densities, and high productivity. They produce large fluxes of energy and materials from upstream systems. Continuous interactions occur between riparian, aquatic, and upland terrestrial ecosystems through exchanges of energy, nutrients, and species" (D. Harker et. al, 1999). The soils of floodplain forests are rich and deep due to the deposition of sediments from upstream sources during flooding events, and the soils of the New England floodplain forests are generally mineral soils. Important characteristics of floodplain soils are that they have good soil aeration (when not flooded), organic and clay content, and nutrient content (D. Harker et. al, 1999).

These forests also play an important role in nutrient cycling. Peterjohn and Correll (1984) found that a fifty-yard-wide riparian forest near the Chesapeake Bay in Maryland, down slope of an agricultural field, removed an estimated 89% of the nitrogen and 80% of the phosphorus from the groundwater, precipitation, and upland runoff that flowed into that riparian forested area.

Floodplain forests occur along river and stream terraces and are directly affected by their actions, whether it be flooding, scouring/erosion soil deposition, and depositing seeds from upstream sources. Their terrain is typically level, although forested floodplains can become established at the lower edge of steeper slopes. As the elevation increases away from the floodplain, more upland tree species become more common (D. Harker et. al). The periodic flooding that the floodplain forests are exposed to every year has been shown to directly contribute to the floodplain forests high productivity in at least three ways (Brinson et al, 1981).

1) Flooding provides an adequate water supply for the vegetation

2) Nutrients are supplied to the plants and favorable alteration of soil chemistry results from the periodic flooding of the river/stream banks.

3) Flowing water during flood stages offers a more oxygenated root zone than if the water were stagnant. The periodic flooding also carries away many waste products of soil and root metabolic processes, such as carbon dioxide and methane.

Forest Restoration Planting Requirements

There is no specific planting density chosen for all forest restoration projects. These density values are very specific to a site location and site conditions. One study by Mohler, Marks, and Sprugel (1978) showed that in natural populations of trees in a balsam fir forest, the older tree stands in the forest were not only larger but were fewer in number. In a three-year-old stand of fir trees 280 individual trees were counted. In a 19-year-old stand there were 159 individual trees, and in a 59-year-old stand there were just 22 individual trees. This concept of a reduced species density over time is known as “self-thinning”. Beck (2013) described that one “ecological approach to designed plantings is to allow self-thinning to maintain the balance between plant density and plant size. Applying self-thinning principles, the number of plants to include depends not on the ultimate number desired but on the size at which they are planted - either fewer larger plants or more smaller plants. In either case, plants should be planted in numbers necessary to fill the desired area, at such spacing that as soon as they are established, they face infraspecific competition. Setting plants at high densities immediately crowds out weeds, as desired plants claim all the resources of the site.” Self-thinning processes occur over time naturally, but to establish a new forest from young saplings, a specific planting plan and planting densities is needed to ensure the forest will regenerate successfully.

Christian Marks, PhD, a floodplain ecologist, from The Nature Conservancy Connecticut River Program summarized the planting density approach he uses (Marks 2014, per. comm.) when working on a floodplain forest restoration project. Typically 250-300 stems per acre are planted, and leaving a three-meter-on-center space between saplings, which are typically between five-to-six feet tall, is an acceptable planting density to allow a floodplain forest to regenerate successfully. Christian Marks also said in an email correspondence that mature natural forests in most ecosystems exhibit about 1000 trees/hectare or 400 trees/acre. For re-forestation purposes such as planting stream buffers, practitioners typically plant somewhat lower densities because of cost (250-300 stems/acre). Natural regeneration can of course be many thousands of seedlings/acre in an old field, but they eventually thin out to about 1000/acre as the forest matures. Karro Frost from NHESP recommended the following planting density. When planting tree saplings, they typically are planted with a density of one per every 100 square feet. Shrubs are planted at a density of one per every 25 to 64 square feet.

An important aspect to any plant community restoration project is the maintenance that is required after the initial planting has been established. "Frederick Law Olmsted's famous dictum 'Plant thick, thin quick' offers one approach. Too often, designers are unable to communicate long-term removal plans to people responsible for maintenance" (Beck, 2013). Depending on the density of trees desired and the need to control invasive species, a multi-year maintenance plan is an important component to any restoration project. "Restoration budgets must fund follow-up vegetation monitoring and maintenance for 3 to 5 years after planting. Monitoring restoration projects is the only way that restoration science and techniques will advance" (Wetzel, 2013). Vegetation monitoring and maintenance not only includes thinning of planted species or removal of invasive species over a period of years post-construction by hand weeding or using a weed-wacker, but it also includes techniques to prevent deer, beaver, or other wildlife damage to the plantings. Christian Marks described one technique he uses to dissuade beavers from damaging newly planted trees. That is to paint the saplings with a latex paint that is mixed with sand, which prevents beavers from biting the trees. Other typical protection measures include spraying a natural irritant like chili spray on the saplings and using metal rodent cages to prevent rodent or beaver damage.

Soils and Soil Sampling

Soil samples were collected at the PVRC and were tested at the University of Massachusetts Soil and Plant Tissue Testing Laboratory. Soil samples were also collected at the Fannie Stebbins Wildlife Refuge in Longmeadow, MA Major River Floodplain plant community, and the Arcadia Wildlife Sanctuary in Easthampton, MA, which is a High-Terrace Floodplain plant community (see soil testing results in the Appendix).

The soils at the PVRC are mapped as Urban land-Hadley-Winooski association, 0-8% slopes, and Rumney fine sandy loam, 0-3% slopes. The urban land classification in this region of the Connecticut River floodplain accounts for the fact that the original soils have been altered significantly due to developments associated with urban areas. The PVRC does show evidence of past berming of large amounts of soil to create the flood protection wall east of the parking lot and to create the level parking area, which sits above the floodplain. The Hadley soil association is found in floodplains, well drained, and is a very fine sandy loam. The Winooski association is also a floodplain soil with a silt loam texture, and is moderately well drained. Rumney fine sandy loam occurs in alluvial flats and has depths of up to 60 inches with stratified loamy sand to sandy loam to fine sandy loam soil textures throughout (NRCS web soil survey). The soil sample from the PVRC was collected outside of the parking lot to the southeast in an unpaved and less disturbed area. The results of the soil test classified the soil as a sandy loam and had lower than optimal nutrient levels for crops. The pH was at a level of 6.0.

The Hampden County Soil survey mapped the soils at the Fannie Stebbins Wildlife Refuge within the Major River Floodplain Forest (where the soil sample was collected) as Limerick Silt Loam 0-3 percent slopes. This soil is classified as a poorly drained silt loam. The results of the soil sample taken at the Fannie Stebbins refuge indicate that the soil texture is a loamy fine sand, has a low pH (4.7), and the soil is low in key nutrients including Phosphorus (P), Potassium (K), Calcium (Ca), and Magnesium (Mg). This is important to note because the plants in this flood plain forest were thriving in what can be considered less than ideal growing conditions for non-native and ornamental plants.

The Hampden County Soil survey mapped the soils at the Arcadia Wildlife Sanctuary as Merrimac fine sandy loam, 15-25 percent slopes. This soil is classified as somewhat excessively drained, and located on stream terraces and outwash terraces. The soil sample collected at the Arcadia Wildlife Sanctuary was determined to be a fine sandy loam with a low pH (4.9). The soil is very low in key nutrients including Potassium (K), Calcium (Ca), and Magnesium (Mg). Phosphorus (P) was found to be higher and in an “optimum” amount for establishing crops.

Native plants are very good at adapting to different soil conditions, and this gives them an advantage over non-native plants. Non-native plants need more fertilizer and a more neutral pH to thrive. When fertilizers are added to amend soils in gardens or other landscapes, it encourages the establishment of non-native plants. Putting the plants under some level of stress with lower pH, and lower nutrient levels, favors the native plants, which are more adaptable to this stress. Crawley's study (2005) analyzed the species richness of various plots as part of the Park Grass Experiment. Beck (2013) described the results, and diversity was highest in the unfertilized control plots (up to 44 species). "Where Phosphorous and nitrogen were added to the plots, biomass increased and diversity decreased. Where nitrogen was added in the form of ammonium sulfate, which acidifies the soil, diversity was lowest (as low as three species). The effect of fertilization was therefore twofold: As some species (grasses) were allowed to grow vigorously, other species were crowded out, and where the soil was acidified, fewer species were adapted to grow in those conditions…The most diverse communities…are those with moderate or even moderately low fertility and productivity. As productivity increases above these levels (or is increased with fertilization), vigorous species exclude others and reduce species richness"(Beck, 2013)

Consultations and Permitting

In order to create a design for an effective floodplain forest restoration in a major river floodplain, there are important representatives the designer should consult with to ensure the design is applying the current best-practices and lessons learned from other similar restoration projects. Representatives from private restoration companies, non-government organizations, and state or federal agencies should all be contacted. There were many professionals that shared their expertise and knowledge for this project. Andy Bohne, a committee member of the project, is from New England Environmental and is a landscape architect. He specializes in ecological design projects, including plant community restorations, and has permitting experience. Karro Frost is from the MA NHESP and works as a Conservation Planning Botanist. Karro is a Conservation Botanist and helped to identify plant species at the PVRC. Christian Marks is from the Connecticut Chapter Staff Division of The Nature Conservancy. Christian is a Floodplain Ecologist and has extensive experience studying and restoring floodplain forests and other plant communities. Christian shared research documents on floodplain forest restoration practices and lessons learned from restoration projects he has designed. Julie Richburg is a Regional Ecologist with The Trustees of Reservations and shared her experience and lessons learned working on the Bartholomew's Cobble floodplain forest restoration project. Peter Hazelton is a representative from The Massachusetts Fish and Wildlife agency, which regulates the protection of state listed endangered species. Peter provided me with information regarding endangered species protection near the PVRC.

The NHESP has also mapped the PVRC water-front as Core Habitat for endangered species, which can be confirmed through the state GIS database (MassGIS). The NHESP BioMap2 database shows where the core habitat areas are within the State of Massachusetts. Discussions with the staff at both the PVRC and Massachusetts Fish and Wildlife have revealed that there is indeed a state listed endangered species in the water of the Connecticut River at the PVRC location. The Massachusetts Fish and Wildlife agency representative, was consulted via telephone for this project. He requested that the exact location and species not be disclosed publicly.

Various permits will need to be filed before the PVRC can begin construction of a new site design. To perform any site construction near any wetland resources, including rivers or streams, in the State of Massachusetts a Notice of Intent (NOI) with the local Conservation Commission must be filed, as well as with the State Department of Environmental Protection. In addition, the federal Army Corps of Engineers (ACOE) will need to be notified of any construction within the floodplain along navigable waterways, such as the Connecticut River, and areas determined to be wetland resources that connect to navigable waterways. In addition, PVRC would need to file with NHESP because the river is mapped as Core Habitat for rare and endangered species. Rare and endangered plant species surveys are likely to be conducted prior to any construction. PVRC may also need to file with the Massachusetts Historical Commission (MHC) depending on if the site is mapped as a possible site for historical artifacts. Massachusetts Fish and Game was also contacted by phone to discuss the potential for endangered species to be located at the PVRC. They confirmed that it is core habitat for state listed endangered species.

Other issues to be aware of when performing the site design at the PVRC include avoiding soil compaction during construction, which prevents stormwater from infiltrating the soil; remove invasive plants species before planting proposed trees; when removing the asphalt at the PVRC the sub-base of the asphalt needs to be removed and disposed of properly. The soil will likely be compacted under these areas that were paved; new soil will need to be brought in to establish native plant communities. A viable source of this soil that is similar to the native flood plain soil or that of other proposed native communities at the PVRC will need to be located; diverting stormwater from directly flowing into the Connecticut River, which is core habitat for endangered species, will be very important with the new site design. A Federal Emergency Management Agency (FEMA) Map was generated for the PVRC to determine the 100 year flood level, which is at approximately 62 ft. Base flow of the Connecticut River was determined to be at an elevation above sea level of approximately 42 feet at the PVRC. The National Oceanic and Atmospheric Administration (NOAA) Weather Center Boston main page was accessed on-line to determine the river level gauges downstream of the Holyoke dam over time to determine the historical recorded flood levels and base flow level.

Conclusion

Restoring or designing native plant communities is an important design alternative to the typical design methods of using non-native plant species and mono-culture plant palettes. Restoring a native plant community at the PVRC will allow the landscape to function once more as usable habitat for wildlife and native plants, increase the biodiversity of the area, encourage the natural succession of native plants, and become a more resilient landscape that can better withstand ecological changes caused by such things as climate change or drought.

Case Studies

The following case studies were selected because two of them had a similar scope of work and similar methods used as the proposed project at the PVRC regarding native plant community restoration. The other two case studies are examples of existing flood plain forest plant communities whose composition informed the plant palette, structure, and layout of the proposed design at the PVRC.

Case Study: Bartholomew's Cobble

Project Summary

Bartholomew's Cobble is a 329 acre property owned by The Trustees of Reservations located in Sheffield, MA, along the Housatonic River. The property was designated a National Natural Landmark by the National Park Service in 1971 because of the diversity of its natural plant communities, and the associated biological diversity in its flora and fauna. There are four natural plant communities located at Bartholomew's Cobble that are considered priority habitat by the Massachusetts Natural Heritage and Endangered Species Program (NHESP). Due to the presence of these communities and the species that exist in them, the property was given the designation of Priority Habitat by the NHESP and also as Core Habitat in the state BioMap2 analysis (Trustees of Reservations, 2013).

Beginning in 2011, the Bartholomew's Cobble Floodplain Forest Restoration and Habitat Improvement Project began. This restoration project's goal is to restore 10 acres of Major River Floodplain Forest on three fields along the Housatonic River. These fields are located in areas that were historically forested but were cleared for agricultural use, much like most of the floodplain forests in the area. This historical clearing of floodplain forest to create agricultural land to farm the fertile floodplain soils has made the floodplain forest a rare plant community today (Trustees of Reservations, 2013). Floodplain forests are important natural habitats and the Trustees of Reservations described their value at the Bartholomew's Cobble property in their 2013 report, stating that "Because of the annual and long duration flooding, these habitats contribute to natural flood water storage, they absorb sediments and pollutants, and they contribute to aquatic food webs. When converted to agriculture, these functions are often more than just lost, the soils, fertilizers and other pollutants can get washed into the river degrading in-stream habitats downstream." The Trustees of Reservations also acknowledge that a restored floodplain forest at the site can help mitigate damage from flood events by allowing floodwaters to spread over the area and reduce their velocity. The report continued to describe that the fields where the floodplain forest is being restored "regularly flood when the Housatonic River floods. Floodwaters can be quite deep, up to two feet and can persist for more than a week. Generally the fields flood in the spring and occasionally in a very wet fall and have seen recent increased flooding due to tropical storms such as Irene and Sandy".

Planting Materials

At the end of the floodplain forest restoration project at Bartholomew's Cobble, the three fields (totaling 10 acres) will be on their way to becoming a Major River Floodplain Forest plant community. The trees that were planted to begin this transformation included mostly mainly silver maples (acer saccharinum), with some American Elm (Ulmus americana), American ash (Fraxinus americana), green ash (Fraxinus pennsylvanica), cottonwood (Populus deltoides), and hackberry (Celtis occidentalis). The Trustees of Reservations (2013) stated that "The development of the [floodplain forest] will be the result of succession, flooding events and other processes out of our hands". Another important aspect of the restoration project was to remove invasive plant species and establish a maintenance program to control the spread of invasive species. The details of that program are beyond the scope of this case study analysis and are omitted from this summary.

Table 1: Bartholomew's Cobble Species List

Tree Species	Common Name	Proportions (%)	Number of Plants
*Acer saccharinum	Silver Maple	63	880
*Acer negundo	Boxelder	9	150
*Celtis occidentalis	Hackberry	4	60
Fraxinus Americana	White Ash	5	70
*Fraxinus pennsylvanicsa	Green Ash	4	60
Liriodendron tulipifera	Tulip tree	0.5	5
Platanus occidentalis	American Sycamore	3	35
*Populus deltoides	Eastern Cottonwood	3	40
*Salix nigra	Black Willow	3	40
*Tilia americana	American Basswood	2	30
*Ulmus americana	American Elm	2	30
Various Saplings	Various Species	n/a	300
Total Trees	n/a	n/a	**1,700**

A more detailed planting list used by the Trustees of Reservations (2013) for the Bartholomew's Cobble floodplain forest restoration project is summarized in Table 1. Tree species with an "*" next to them in the table indicate a species that were already present at the project site prior to the restoration project.

Approximately 15% of the trees planted during 2013 were collected at Bartholomew's Cobble in previous years and grown at a nursery to be used as part of the restoration project planting. In addition, 550 trees collected as seedlings from the project site will be grown at the same nursery to be used as a source of replacement trees if any of the newly planted restoration project saplings fail to grow (Trustees of Reservations, 2013).

Planting Methods

Saplings planted for the restoration project were generally planted when they were at a height of 4-6 feet tall (Trustees of Reservations, 2013). The trees planted in each of the three fields at Bartholomew's Cobble will have different planting densities as determined by the need to establish a quick dense shade cover or not depending on the presence of the invasive species reed canary grass, which was commonly found in the fields. Planting densities of tree saplings varied between 280 trees per acre (1 tree every 155 square feet), 173 trees per acre (1 tree per 250 square feet), or 170 trees per acres (1 tree per 300 square feet) (Trustees of Reservations, 2013). Weed mats were placed around their base for moisture retention and to keep weeds to a minimum at the sapling base. Garlic or chili spray was used for deer browsing prevention and rodent cages were installed where deemed necessary to prevent beaver and/or rodent damage to the saplings. Supplemental watering was done daily during the installation and for the first week after installation. During the second week, watering occurred 3-4 times and the third week 2-3 times. After the third week, watering occurred only if adequate rainfall did not occur (Trustees of Reservations, 2013).

Project Monitoring

Each newly planted sapling was monitored closely by restoration workers who were on the lookout for weeds around their base. The presence of weeds at the tree base threaten the success of the sapling and were mowed or weed-wacked when necessary. Saplings will be kept free of tall vegetation for two years or until a height is achieved such that herbaceous vegetation is no longer competing with and inhibiting growth of the sapling. Any debris that washes into the trees following normal spring flooding events will be cleaned up and beaver cage exclosures will be repaired as needed (Trustees of Reservations, 2013). The goal of the restoration project was to achieve an 80% survival rate of the newly planted trees. An annual census of the planted trees was planned to determine their survivability, and to replace dead trees using the external nursery stock that the Trustees of Reservations established (Trustees of Reservations, 2013).

Bartholomew’s Cobble before restoration plantings

Bartholomew’s Cobble after restoration plantings installed

Case Study: Hartwell Farm Wetland Mitigation Project

Project Summary

The Hartwell Farms Wetland Mitigation Project was completed by New England Environmental, Inc (NEE). Hartwell Farms is located in Bedford, MA. Andy Bohne, from NEE, provided all of the project details summarized in this case study analysis. The project’s goal was to increase flood storage and restore lost riparian habitat along Elm Brook by removing two-thirds of an existing parking lot and transforming 3.6 acres into a hydrologically and ecologically functioning wetland ecosystem. The sub-grade soil below the asphalt was a mix of heavily compacted fill material that ranged from four to six feet in depth. These compacted soils prevented any hydrologic connection to the adjacent Elm Brook and surrounding forest watershed.

The design strategy included mimicking natural wetland features such as standing tree snags, brush piles, and laying root-wads throughout the site.

Planting Methods

An invasive plant species management plan was developed prior to construction to limit the presence and establishment of invasive species post-construction. Seven different planting zones were used based on grade and hydrology. Different plant species were used depending on its zone. For this case study analysis, zone five will be studied because it is most similar to a high-terrace floodplain forest. The other zones designed for the project were either different wetland zones with standing water or an upland buffer zone that included hummocks. Zone five is approximately 31,900 square feet in total area.

The areas that received new plantings were seeded and were covered in a hydro-mulch. The hydro-mulch contained a biodegradable glue which kept the mulch in place so that the soil would not become dried out by sun exposure. The mulch also kept invasive plant species propagation to a minimum, but the area was aggressively treated with herbicides and hand pulling of invasives and other unwanted plant species was necessary.

Planting Materials

Table 2 summarizes the plants used, their quantity, and spacing.

Table 2 Hartwell Farms Planting List				
Common Name	**Scientific Name**	**Quantity**	**Height**	**Spacing**
Red Maple	Acer rubrum	4	8’-10’	n/a
Red Maple	Acer rubrum	30	3’-4’	10’ O.C.
Swamp White Oak	Quercus bicolor	34	4’-5’	10’ O.C.
Black Gum	Nyssa sylvatica	34	4’-5’	10’ O.C.
Sycamore	Platanus occidentalis	34	4’-5’	10’ O.C.
Green Ash	Fraxinus pennsylvanica	29	4’-5’	n/a
Bayberry	Morella pennsylvanica	43	2’-3’	10’ O.C.
Common Spicebush	Lindera benzion	44	18”-24”	6’ O.C.
Red-Osier Dogwood	Cornus sericea	43	2'-3'	6’ O.C.
Sillky Dogwood	Cornus amomum	42	2'-3'	6’ O.C.
Sweet Pepperbush	Clethra alnifolia	43	2'-3'	6’ O.C.
Witch Hazel	Hammamelis virginiana	43	2'-3'	6’ O.C.
Meadowsweet	Spirea alba var. latifolia	43	2'	6’ O.C.
Gray Dogwood	Cornus racemosa	43	2'-3'	6’ O.C.
Shadblow Serviceberry	Amelanchier canadensis	43	3'-4'	6’ O.C.
Ironwood	Carpinus carolina	43	2'-3'	6’ O.C.
Virginia Rose	Rosa virginiana	43	2'-3'	6’ O.C.

Asphalt Removal Details

Beneath the asphalt that was used in the parking area was approximately four feet of compacted fill. Two feet of this fill was stripped away over the whole area, and channels were excavated down another two feet to reach the water table in the constructed channels. In the areas that were not channelized, stock-piled top soil from the neighboring housing complex was used as the source for the top soil material in the new wetland areas where the parking lot was removed. The stock-piled top soil was soil taken from areas where there was no known presence of invasive plant species. This limited the presence of invasive plant seeds in the top soil that was used for the new plantings.

Project Monitoring

Five years of post-construction monitoring was proposed to ensure plant establishment and as part of the invasive species management plan. Site inspections will be conducted twice annually (spring and fall) during the first two growing seasons. A separate invasive species inspection will also be conducted twice annually (May & late August) until an issuance of a Certificate of Compliance or three years from the date of the Order of Conditions, whichever comes later. Continued invasive species monitoring will take place annually for an additional three years from the end of the initial monitoring period. Invasive species encountered during any site inspection will be controlled and removed. Hand pulling and herbicide applications will be used to control the growth of invasive species.

View of the parking area at Hartwell Farms

View of the same area after restoration plantings installed

Case Study: Fannie Stebbins Wildlife Refuge

The Fannie Stebbins wildlife refuge is a “non-profit, educational organization that owns approximately 330 acres of land between Interstate 91 and the Connecticut River in Longmeadow, Massachusetts. It is part of a larger area of approximately 1170 acres which includes Conservation and other land owned by the Town of Longmeadow and privately owned land has an existing Major River Floodplain Forest native plant community that has not been disturbed in recent times”(www.massbird.org).

The NHESP also classified this floodplain forest community as good habitat for birds such as warblers, thrushes, and other songbirds. Yellow-throated and warbling vireos, which like to nest in the trees next to rivers, are common. Raptors such as bald eagles and red-shouldered hawks use the riverside trees as perches. Spring floods attract wood ducks and mergansers to the shady edges of the floodplain forest. Eastern comma butterflies feed on elm and nettles, and dragonflies thrive along shady riverbanks. Interior areas of the floodplain forest commonly function as vernal pools, which are important breeding habitat for many frog species and salamanders. Floodplain forests also provide shelter and riverside corridors for deer and migratory songbirds(Swain & Kearsley, 2001).

Observations at the Fannie Stebbins Wildlife Refuge include the following canopy species: red maple (Acer rubrum), american elm, cottonwood, white pine (Pinus strobus), silver maple (Acer saccharinum), pin oak (Quercus palastrus), white ash. Shrubs included: gray dogwood (Cornus racemosa), American whitchazel (Hamemelis virginiana) The herbaceous layer included: sensitive fern (Onoclea sensibilis), ostrich fern, goldenrod.(Solidago spp.), jack in the pulpit, jewel weed (Impatiens capensis), sedges (Carex spp.), grasses (Poa spp.), mosses. The forest has a thick canopy (>60% cover) and the predominant herbaceous plant was the ferns (sensitive and ostrich). There was a vine layer as well, which was mainly riverbank grape and bittersweet.


Photos of Fannie Stebbins' Floodplain Forest - Silver Maples and ferns are dominant species

Mass Audubon Arcadia Sanctuary, Easthampton, MA

Spanning Easthampton and Northampton is the 621 acre Arcadia Wildlife Sanctuary. The sanctuary is a diverse terrain that includes forest, meadows, grasslands, marsh, and wetlands. It attracts an extraordinary variety of wildlife and contains a thriving population of wildflowers, thanks to its rich, loamy soil, which is characteristic of the Connecticut River floodplain (www.massaudubon.org). The Mill River runs through the sanctuary and on the banks of the river is a known example of High-Terrace Floodplain Forest plant community.

The High-Terrace Floodplain forest at the Arcadia Sanctuary contains canopy species that are listed by the NHESP as indicator species, which include: Silver Maple (Acer saccharinum), Red Maple (Acer rubrum), Shagbark Hickory (Carya ovata), and Black Cherry (Prunus serotina). Ironwood was also seen located near the survey area, which is "a good indicator species [of a High-Terrace Floodplain Forest] and typically contributes to an open sub canopy”(Swain & Kearsley, 2001). More herbaceous species that are characteristic of this plant community were not visible during the time of the plant survey because the survey was conducted in early Spring outside of the growing season. Examples of the characteristic herbaceous species include Wood Nettle (Laportea canadensis), Sensitive Fern (Onoclea sensibilis), and Ostrich Fern (Matteuccia struthiopteris). Rich upland herbs such as Lady Fern (Athyrium filix-femina), Zigzag Goldenrdod (Solidago flexicaulis), Jack-in-the-pulpit (Arisaema triphyllum), and Bellwort (Uvularia sessilifolia) among others.

Photos of Arcadia High Terrace Floodplain - Silver Maple and Shagbark Hickory are dominant species

Chapter 3

Methodology

Consult with Experts

An important step in the methodology used when researching a native plant community design for the PVRC was to meet with ecologists and project representatives from previous flood plain forest restoration projects. Their knowledge and practical experience restoring native plant communities, including flood plain forests, was invaluable to this project. Their knowledge and expertise helped identify the necessary permits required and permitting agencies to contact regarding a new site design at the PVRC.

Planting Density

It was necessary to determine a planting density that was appropriate to reestablish a floodplain forest at the PVRC. Research on ecological restoration practices and lessons learned from other similar projects, as part of the literature review and case study analyses, along with consultations with professionals helped inform the planting density required at the site.

Site Survey

A site survey was done twice, once using a traditional theodolite and rod method and other method utilized a Trimble Geo-XH hand-held global positioning satellite (GPS) unit, with sub-meter accuracy. The traditional theodolite and rod method was very time consuming. The PVRC site is a complex landscape with steep slopes, uneven terrain, and a large building to account for. The site survey collected over three hundred elevation points, which needed to be entered into AutoCad one at a time. Once all of the elevation points are entered into AutoCad, then contour lines need to be interpolated by the AutoCad user. This method was determined to be too time consuming and was abandoned for this project. Resurveying the site using the GPS unit was significantly faster, and the elevation points the unit collects can be imported into Geographical Information System (GIS) software and used to create a three-dimensional surface. ArcMap was used to generate a three-dimensional surface for the PVRC. Using this surface, contour lines at one-foot intervals were automatically generated for the PVRC, which can be exported into a .dwg file format and opened and edited in AutoCad to generate site designs and grading plans. After the site surveys were done, a deeper analysis of the available data layers available on the MassGIS website yielded the discovery that Light Detection and Ranging (LiDAR) terrain data for the site was available for free download. LiDAR terrain data is data collected by an airplane that measures distance by illuminating a target with a laser and analyzing the reflected light. Elevation data is collected by the laser through this process. The LiDAR data available for the PVRC was collected in 2004 and has a 10ft resolution. The data is in a geo-tiff format, which is raster based, and from this terrain data a more accurate contour plan for the site was generated using GIS. A similar process was followed as before and one- foot contour intervals were generated using the geo-tiff terrain data. These contours were deemed more accurate than those created by the survey techniques and were used as the base for this proposed design and grading plan.

GIS Analysis

GIS analysis was an important tool when analyzing and assessing the PVRC site. In addition to importing LiDAR terrain data and GPS survey points to generate contour lines GIS was used to determine property abutters, lot line locations, utilize current aerial imagery as a base, NHESP plant community determinations, endangered species habitat locations (NHESP BioMap2 data), and soil classifications. This data was all downloaded from MassGIS, the statewide repository of spatial data.

Soil Sampling

Soil samples were taken at the PVRC, as well as at the two existing floodplain forest plant communities analyzed in the case studies. The samples were tested at the UMass Soil & Plant Tissue Testing Laboratory. Results were compared across the sites to determine the soil characteristics of a floodplain forest plant community. Soil amendments or alterations may be required at the PVRC in order to replicate a functioning and successful floodplain forest.

Vegetation Classification

A general classification of existing vegetation at the site was conducted, including invasive species. The proposed plant palette was based on the Classification of the Natural Communities of Massachusetts by Swain and Kearsley (2001). The two plant communities that were used for this design are Floodplain Forest and High Terrace Floodplain Forest. Each of these plant communities has specific plants growing in them as well as composition. The planting density used for this project was based on Christian Marks' recommendations for restoring a floodplain plant community. Christian Marks works for The Nature Conservancy.

Impervious Surface Assessment

The majority of the PVRC property is covered in asphalt. The extent of the asphalt was studied to understand the role that the asphalt has in relation to stormwater drainage on-site, water quality, and stormwater flow into the Connecticut River. The total area of impervious surface on site was calculated.

Final Document Production

Section drawings, a master plan, and photo renderings were utilized to communicate the proposed restoration design plans. In addition, a proposed grading plan was created to show the change in the topography as part of the proposed site design.

Monitoring Plan

A monitoring and maintenance plan based on the recommendations discussed in the literature review and case studies was created for this project. The monitoring plan for this project focuses on eliminating invasive species, maintaining the areas around planted tree saplings by cutting down tall herbaceous growth to reduce shading, and installing plants that require shade to grow, like ostrich ferns, at least two years post-construction.

Chapter 4

Application and Site Design

Client and Site Users

Organized in 2007, the formation of the PVRC revolved around their mission dedicated to increasing accessibility to the riverfront and river-based activities, most notably rowing, for the community. PVRC was located in Longmeadow, MA between 2007 and 2012. While in Longmeadow the PVRC developed from a private club into a nascent organization prefaced on inclusivity, service to their community, and dedication to the sport of rowing. Their relocation to the city of Springfield placed them in the historic Bassett Boathouse, currently owned by the city and leased to the PVRC. The lease, predicated on their continuing service to the city, solidified their commitment to functioning as a nonprofit rowing organization(UMass Planning Studio Report, 2013).

Overview Map

PVRC is located in Springfield, MA. The Connecticut River travels north to south and flows past Springfield, MA.

Overview Map

Site Location

The town of West Springfield is located across the Connecticut River to the west of the PVRC and the areas around the PVRC are very developed and urbanized with limited green space and usable habitat for wildlife.

Site Location

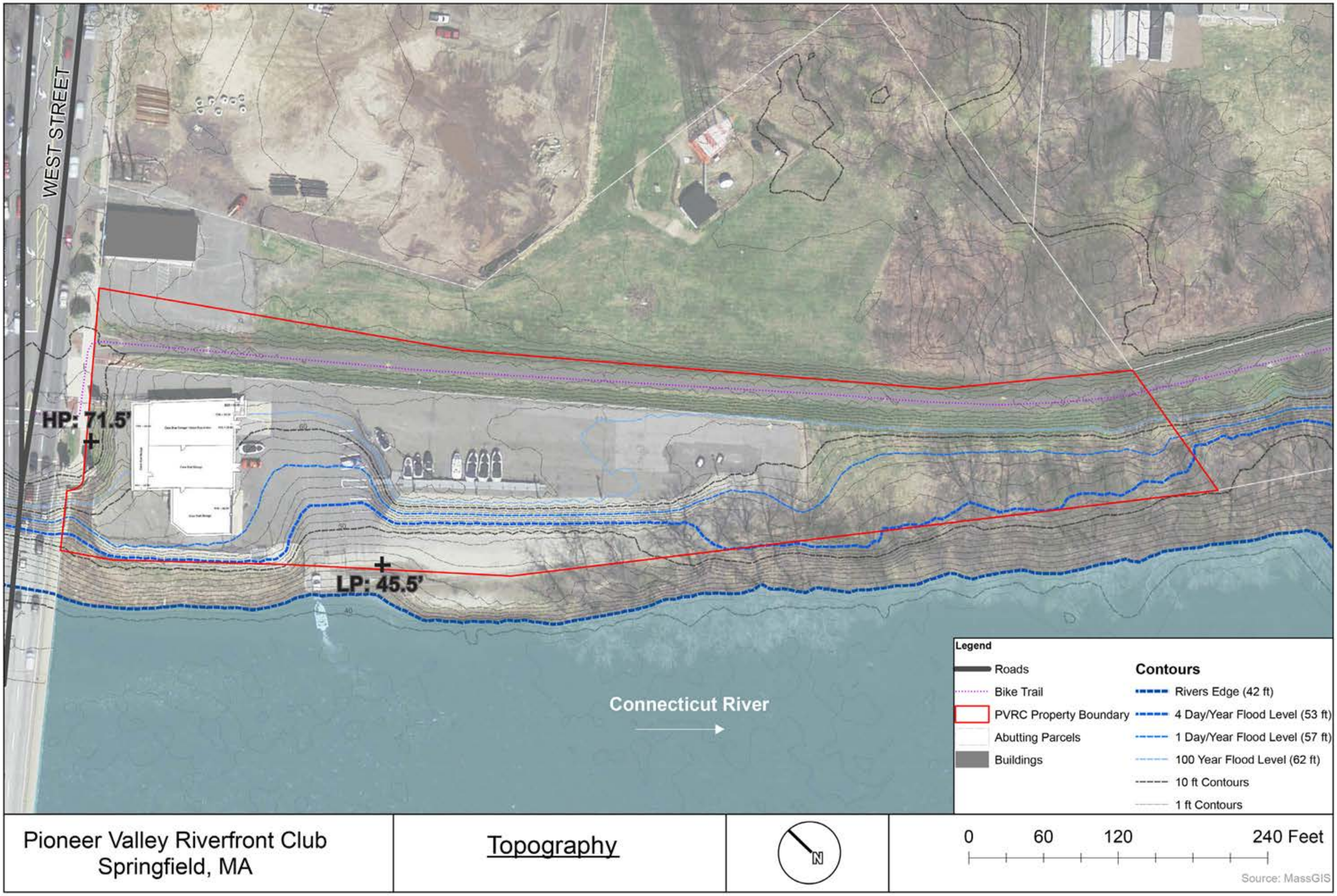
Pioneer Valley Riverfront Club Springfield, MA	Site Location	N	0 0.25 0.5 1 Miles Source: MassGIS

Topography and Site Features

The PVRC property is approximately three acres in size and has a high point of 71.5 ft above sea level. The site's low point within the property boundary has an elevation of 45.5 ft, but the water's edge of the Connecticut River is approximately 42 ft above sea level and is located west of the property boundary. The Connecticut River Walk and Bikeway is a bike path that travels past the PVRC, and is shown as a purple dotted line. This bike path is located on top of the flood protection levee that was installed by the Army Corps of Engineers. The PVRC is also located on south side of the West Street Bridge, in the North End neighborhood of the City of Springfield. It is noted that the boat launch area used by the PVRC for access to the river extends past the mapped property boundary and into the river.

There are three elevations that are highlighted on the site that coincide with different flood levels that have been determined to be significant for a floodplain forest restoration project. These elevations are 42ft, (the river's approximate edge), 53 ft (the four day/year flood minimum flood level), and 57 ft (the one day/year flood minimum level). The four day flood level is the assumed elevation based-on site visits and visual analysis of flood levels and aerial image analysis required to sustain the Major River Floodplain plant community. A more in depth study of the flood levels at the site would be required to determine more accurate flood level elevations at the PVRC in order to determine the native plant community boundaries. The one day flood level is the assumed flood elevation required to sustain the High-Terrace Floodplain Forest plant community.

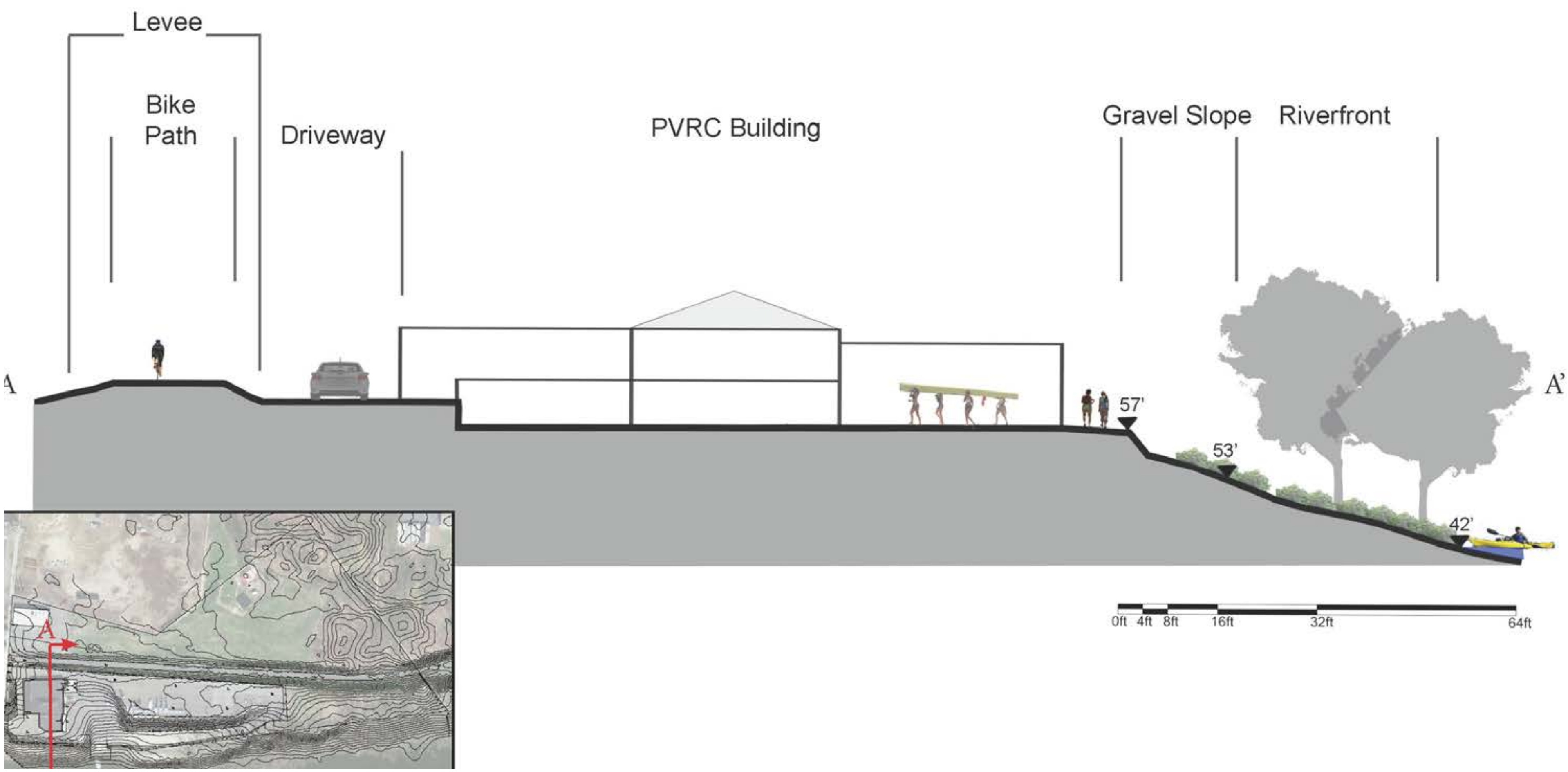
Topography and Site Features



Section View: Existing Conditions A-A’

Section view of existing condition.

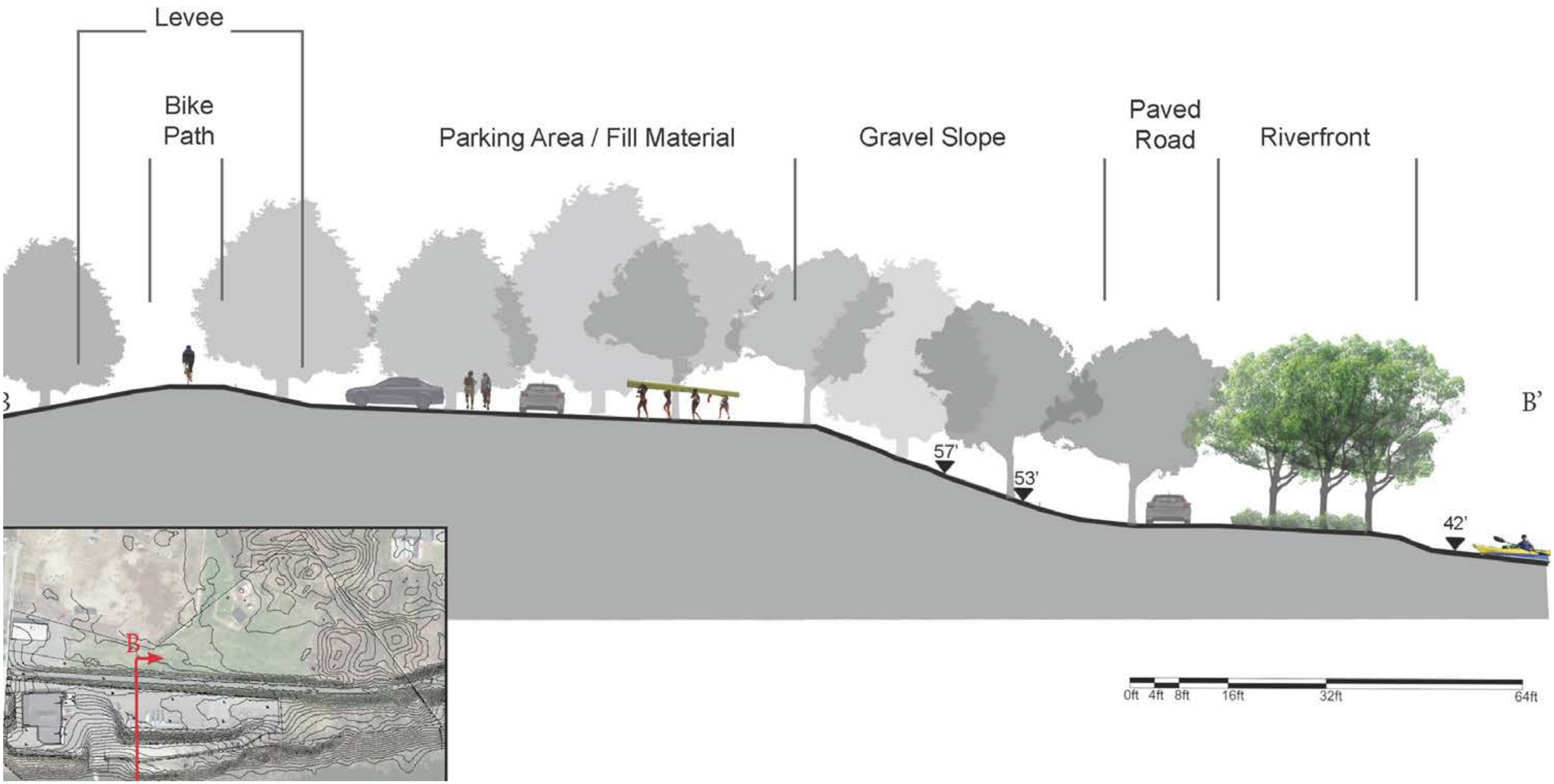
Section View: Existing Conditions A-A’



Section View: Existing Conditions B-B’

Section view of existing condition.

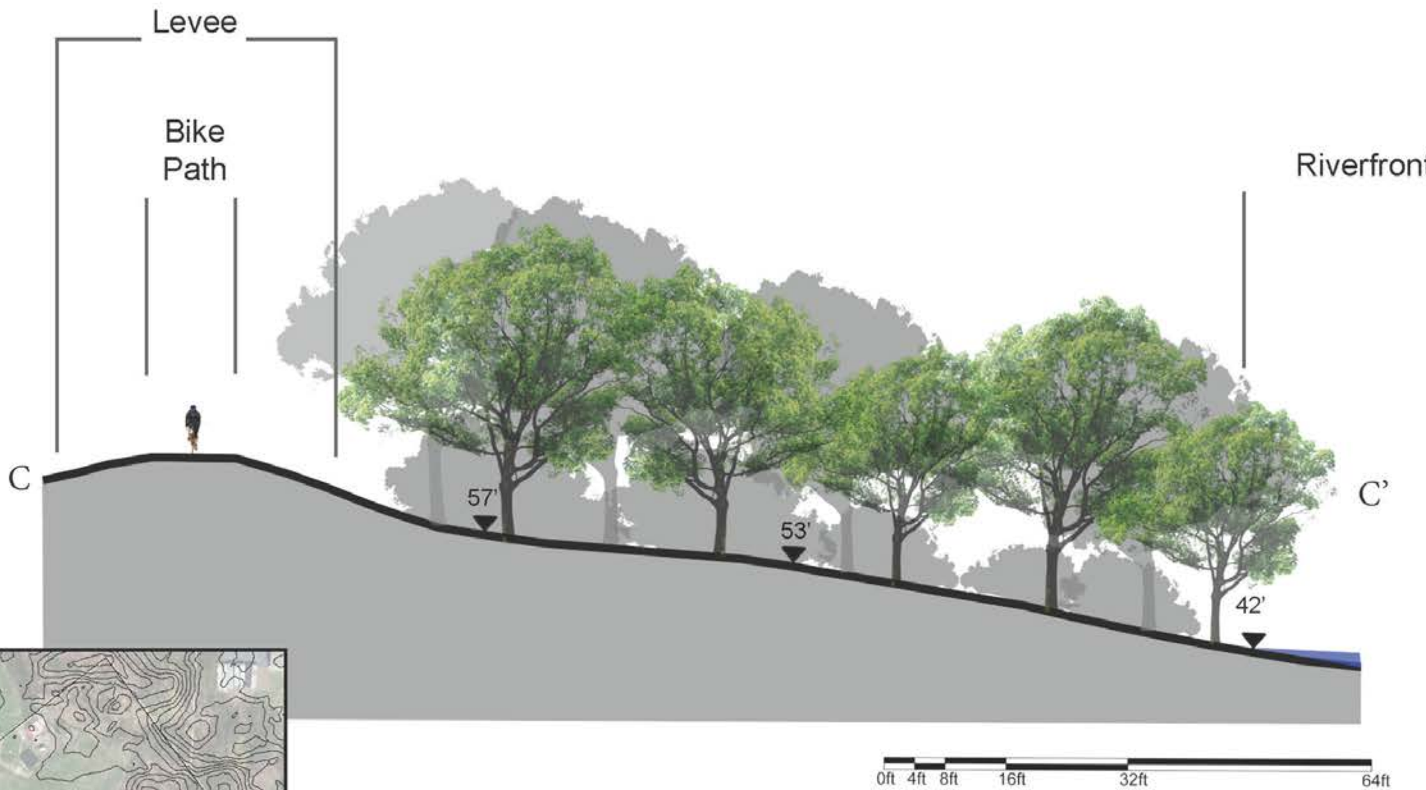
Section View: Existing Conditions B-B'



Section View: Existing Conditions C-C’

Section view of existing condition.

Section View: Existing Conditions C-C’



Slope Analysis

Slopes vary greatly at the site ranging from 0-3% in the flatter regions and exceed 20% in the areas that were bermed up with fill material, or along the steep cut bank of the river (Figure 5). The fill material was used to elevate both the parking areas and PVRC building to sit at an elevation that is higher than the normal seasonal flood levels. Additionally, more areas of steeply sloped fill can be found along the flood-levee that runs parallel to the Connecticut Rive through the eastern portion of the site.

Slope Analysis

Pioneer Valley Riverfront Club Springfield, MA	Slope Analysis	N	0 60 120 240 Feet Source: MassGIS

FEMA Flood Map

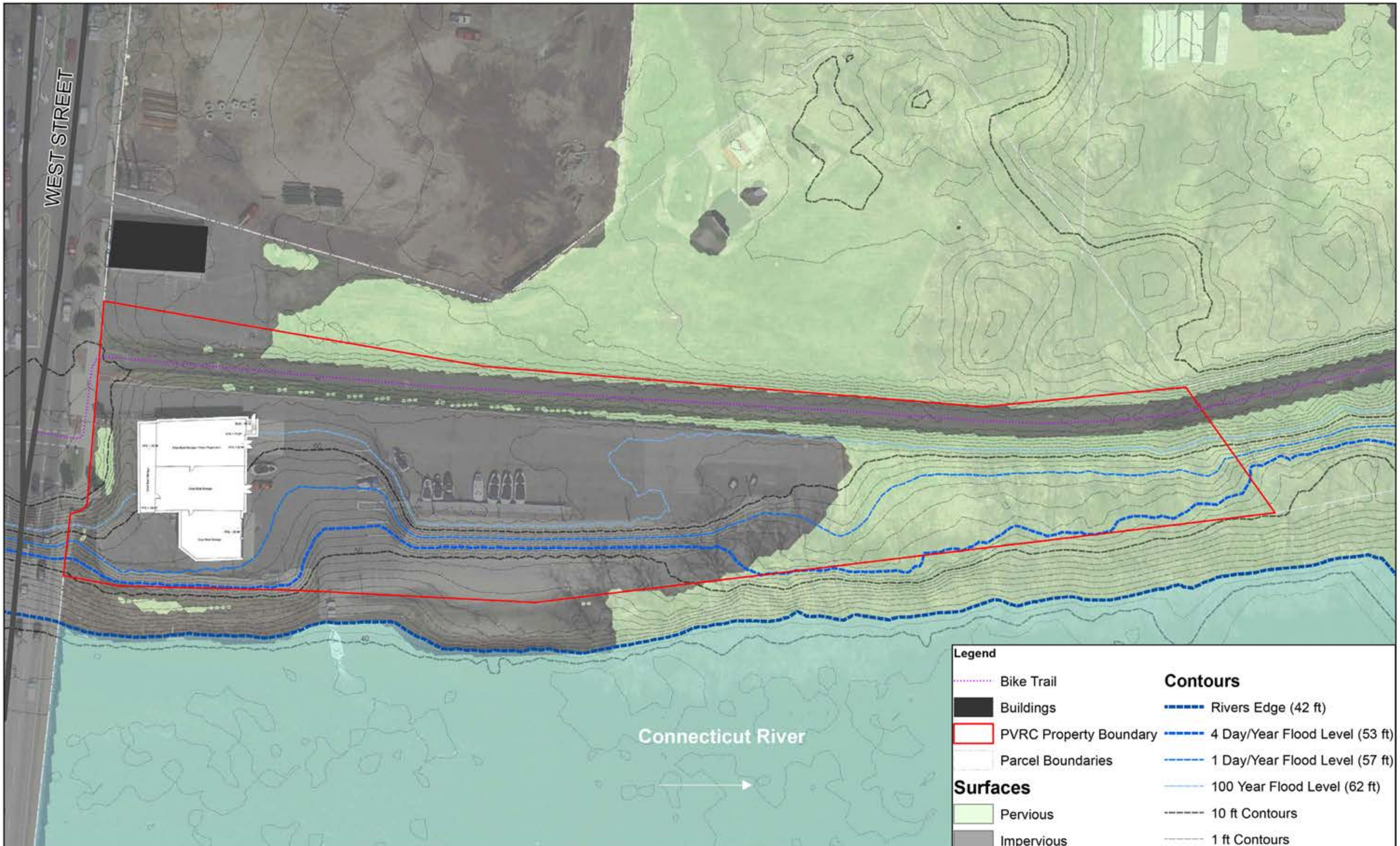
The Federal Emergency Management Agency (FEMA) flood maps show that the 1% annual chance flood hazard level (i.e., 100 year storm) elevation is approximately 62 feet. The finished floor elevation of the PVRC is approximately 58 feet, so the elevated or filled-in areas, do not fully protect the boathouse from the potential of flooding during major flood events.

FEMA Flood Map

Impervious Surfaces

Approximately 75% of the site, or 2.3 acres, is covered in impervious asphalt. There is no on-site stormwater collection system, so any stormwater that collects on these impervious surfaces ultimately flows into the Connecticut River, untreated. Engine fluids from cars commonly drip onto the ground when parked, and they are likely flowing as pollution into the Connecticut River when it rains.

Impervious Surfaces

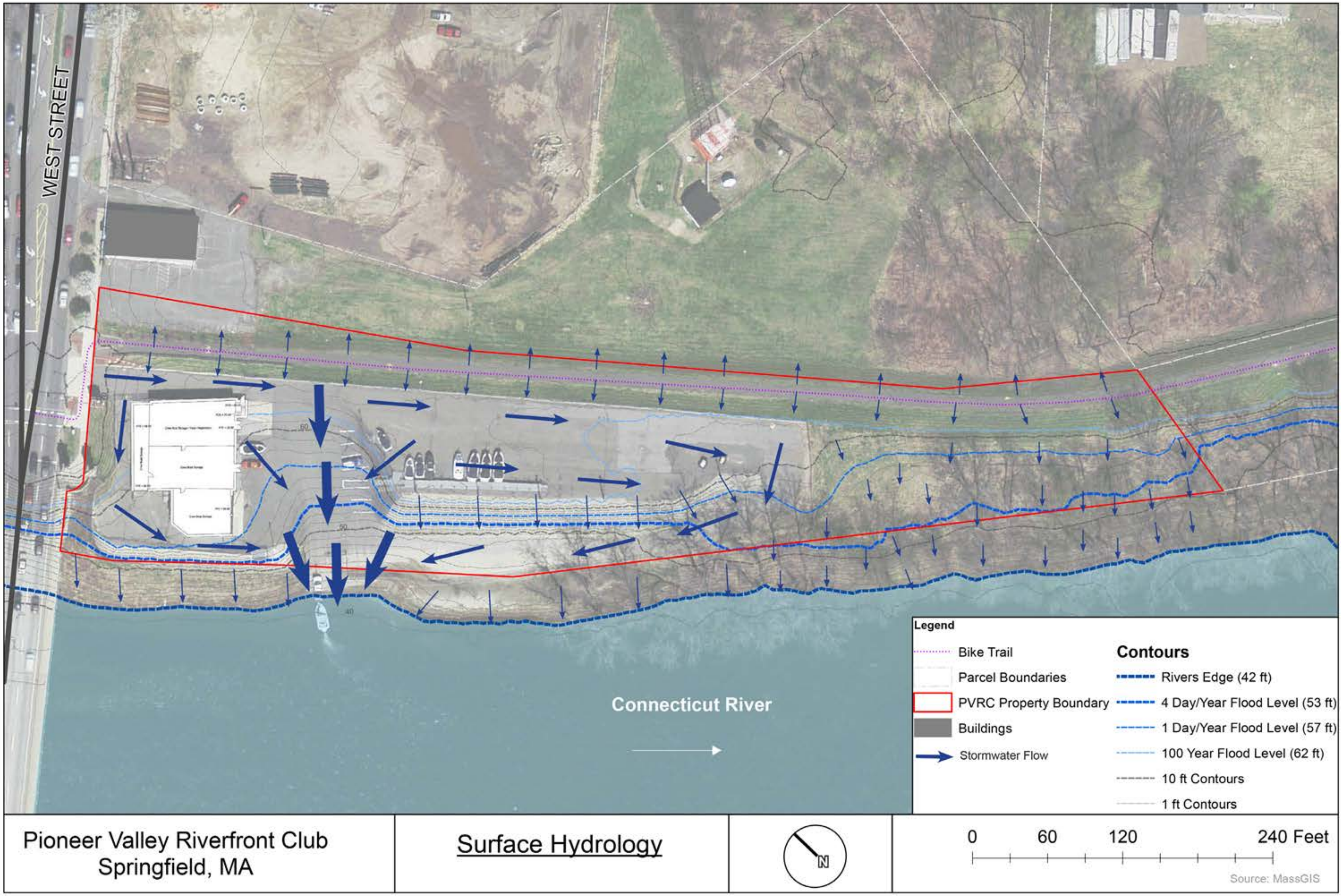


Pioneer Valley Riverfront Club Springfield, MA	Impervious Surfaces	N	0 60 120 240 Feet Source: MassGIS

Surface Hydrology

This figure shows the general flow of stormwater at the PVRC currently, with a thicker arrows indicating impervious surface flow, and the thickest arrows representing flow from impervious surfaces directly into the Connecticut River. As the storm water collects in the more elevated and impervious areas near the PVRC building, it can be seen that the stormwater flows into the boat ramp south of the building. A large portion of the site drains directly into the Connecticut River as a result.

Surface Hydrology

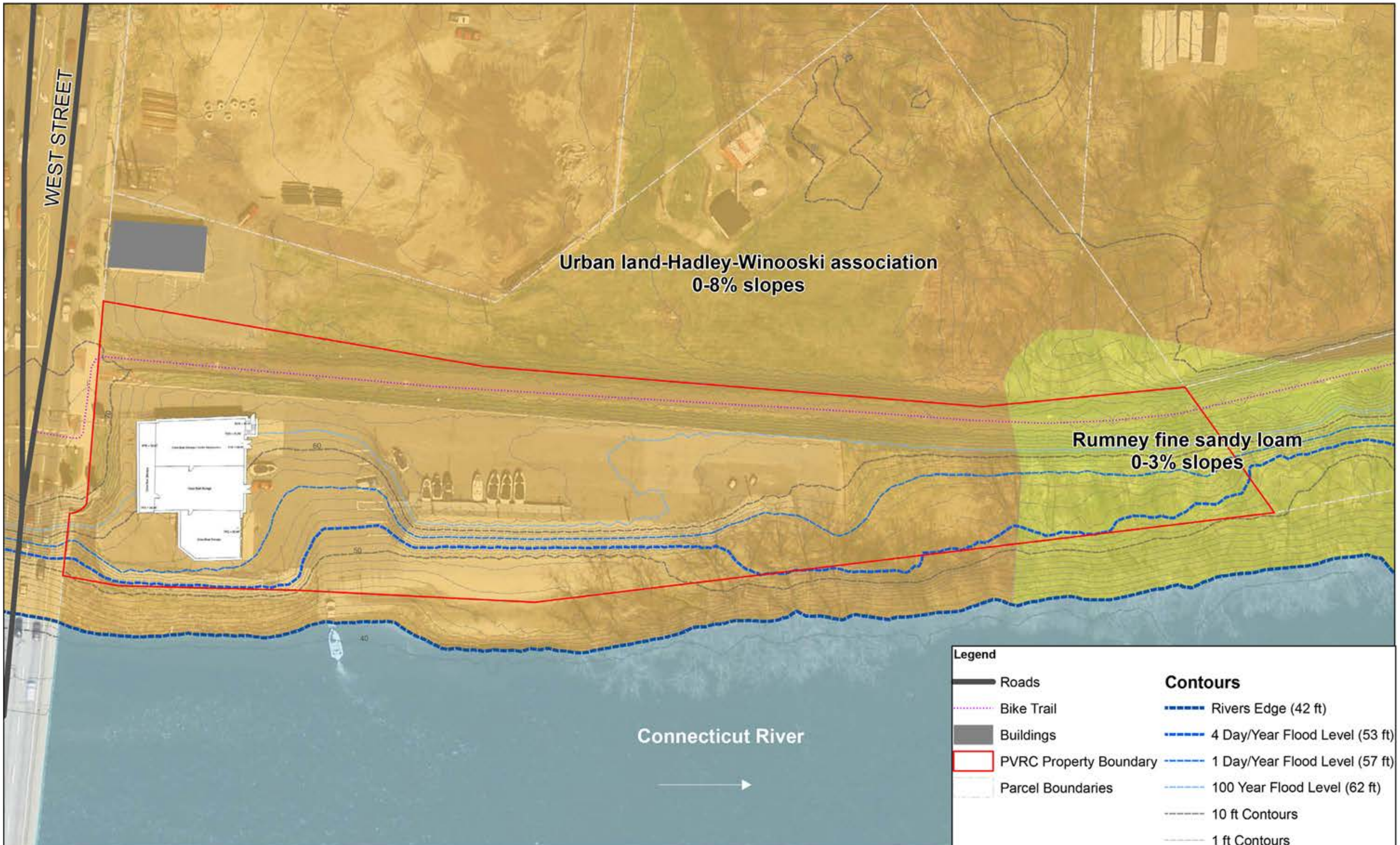


NRCS Soil Survey

The NRCS Soil Survey for Hampden County shows the two mapped soil types at the PVRC are Urban land-Hadley-Winooski association and Rumney fine sandy loam (Figure 9). The NRCS soil survey describes Urban land as “so covered by urban works and structures that identification of the soils is not possible” (NRCS, 1975). Both of the Hadley and Winooksi soils are well drained and located on broad nearly level and gently sloping areas. Slopes range from 0 to 8 percent. They have a friable medium textured substratum. They are subject to flooding by stream overflow (NRCS, 1975). This soil association is more general in its description since there is likely a lot of variability in the soil characteristics within this soil association.

Rumney soils are described in more detail by the NRCS as nearly level, poorly drained soil on flood plains. Slopes range from 0 to 3 percent. Typically the surface layer is very dark grayish brown fine sandy loam about 5 inches thick. The subsoil is dark grayish brown, mottled fine sandy loam 17 inches thick. The substratum is gray and dark grayish brown sand to a depth of 60 inches or more. The permeability of this soil is moderately rapid in the surface layer and subsoil and rapid or very rapid in the substratum. Available water capacity is moderate, and runoff is slow. The soil has a seasonal high water table at a depth of about 6 inches from late fall through spring and is subject to frequent flooding. The soil is very strongly acid through slightly acid.

NRCS Soil Survey

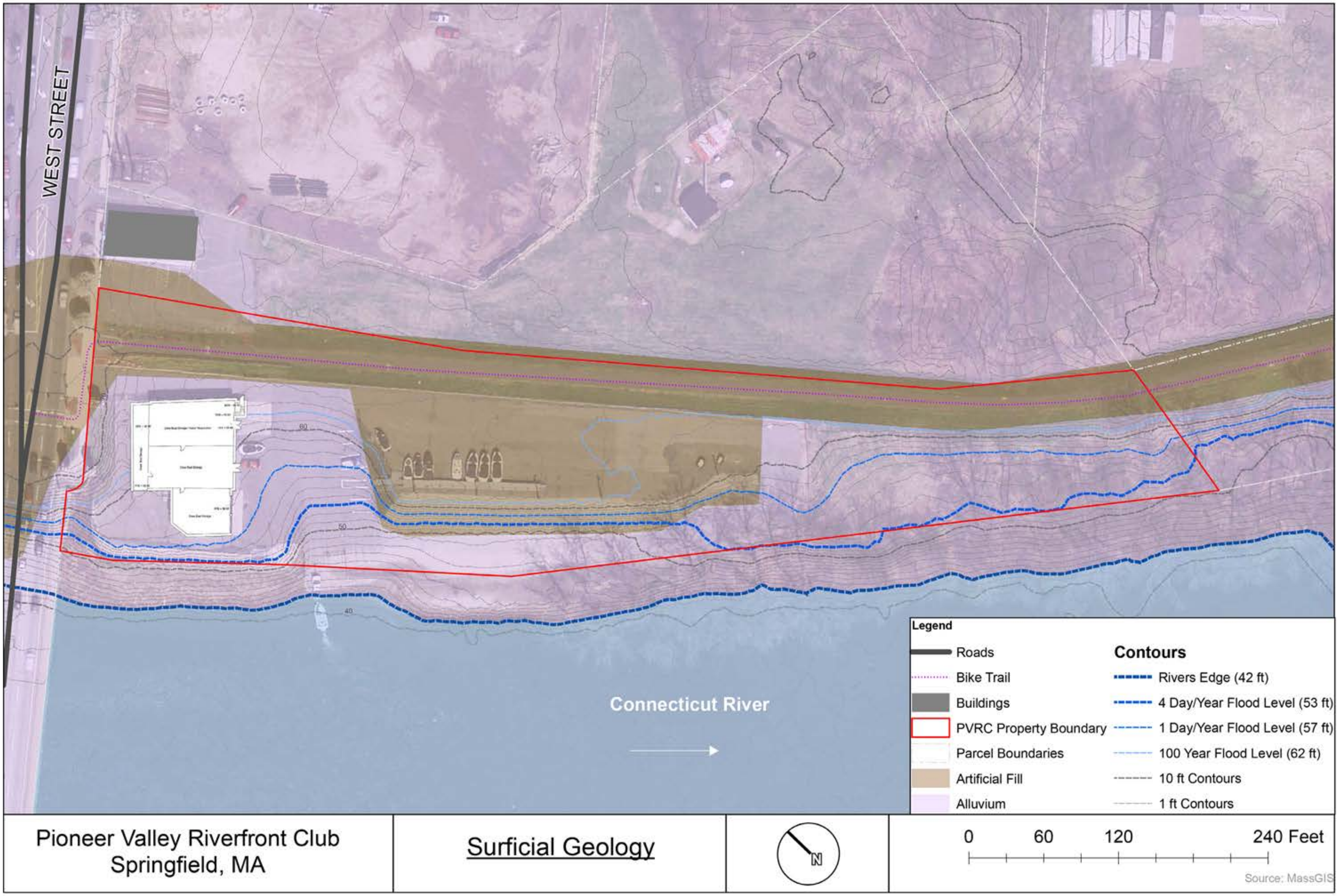


Pioneer Valley Riverfront Club Springfield, MA	NRCS Soil Survey	N	0 60 120 240 Feet Source: MassGIS

Surficial Geology

Analyzing the surgical geology of the PVRC, it can be seen that there are significant areas of artificial fill that have been added to raise the ground to sit above the floodplain of the river. The linear flood protection levee is mapped as artificial fill as well, which runs through the eastern area of the PVRC property, parallel to the Connecticut River.

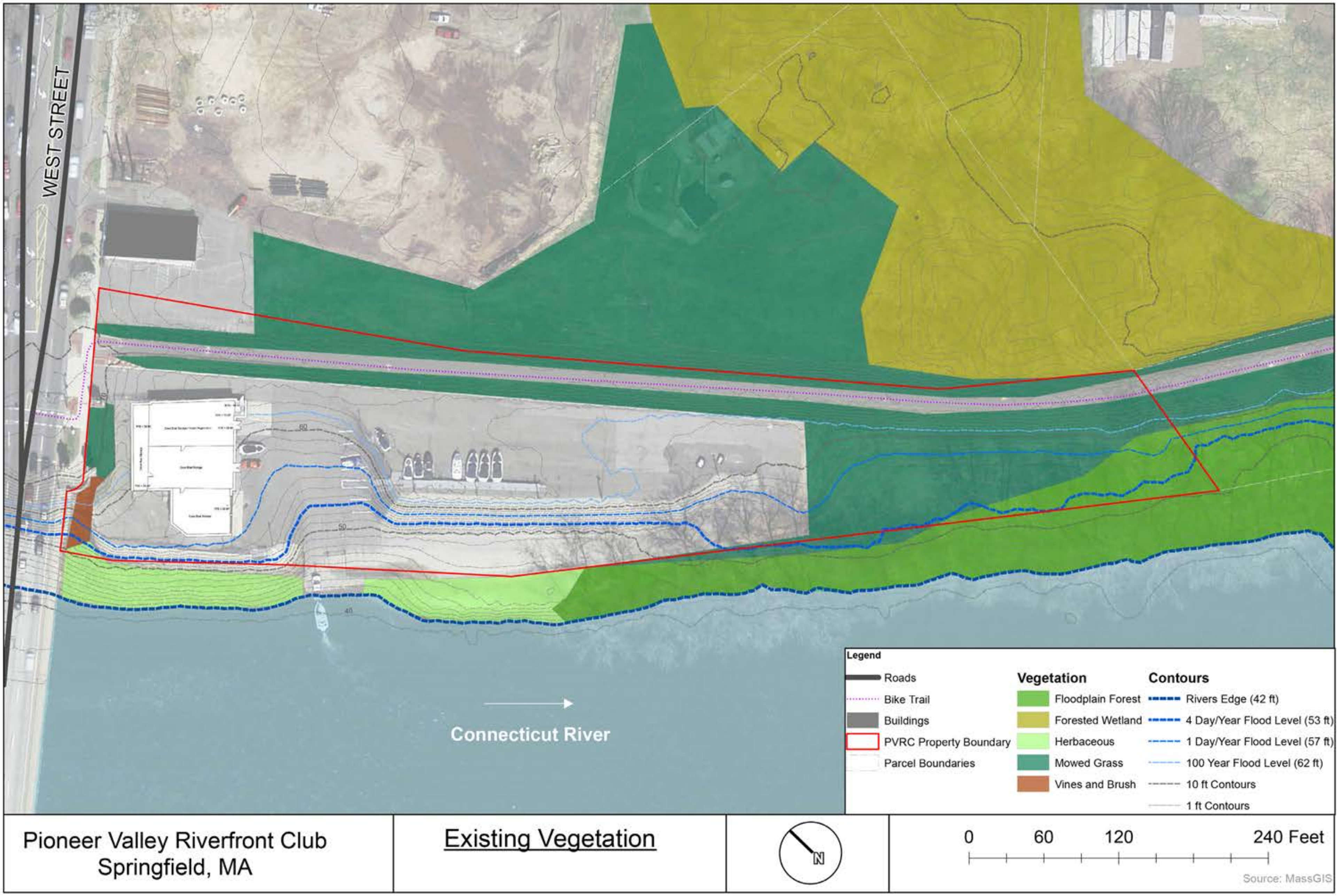
Surficial Geology



Existing Vegetation

The majority of the PVRC property is paved over with asphalt and not vegetated. The southern portion of the property is largely maintained as mowed grass, and a small area of floodplain forest exists on the property in this southern area, but most of the floodplain forest is found outside of the mapped property boundary to the south and west. Existing vegetation observations at the PVRC include mature cottonwoods and silver maples along the bank of the river, as expected when comparing to the NHESP classification of trees in a major river floodplain forest. There is a diverse herbaceous layer along the river shoreline. These native plants include grasses (Poa spp.), dogbane or Indian hemp (Apocynum cannabinum.), Beach clotbur (Xanthium echinatum), Evening primrose (Oenothera sp.), Foxtail grass (Setaria sp.). No ferns are growing. There is an area of Oriental bittersweet (Celastrus orbiculatus) in between the PVRC building at the West Street bridge. This will have to be removed and closely monitored to control future spreading of the plant, which spreads quickly via bird driven seed dispersal. Japanese Knotweed (Fallopia japonica) is present in the southern portion of the property that extends beyond the property line. This invasive plant will also need to be removed and heavily managed to prevent further spreading of the plant into the property in the future.

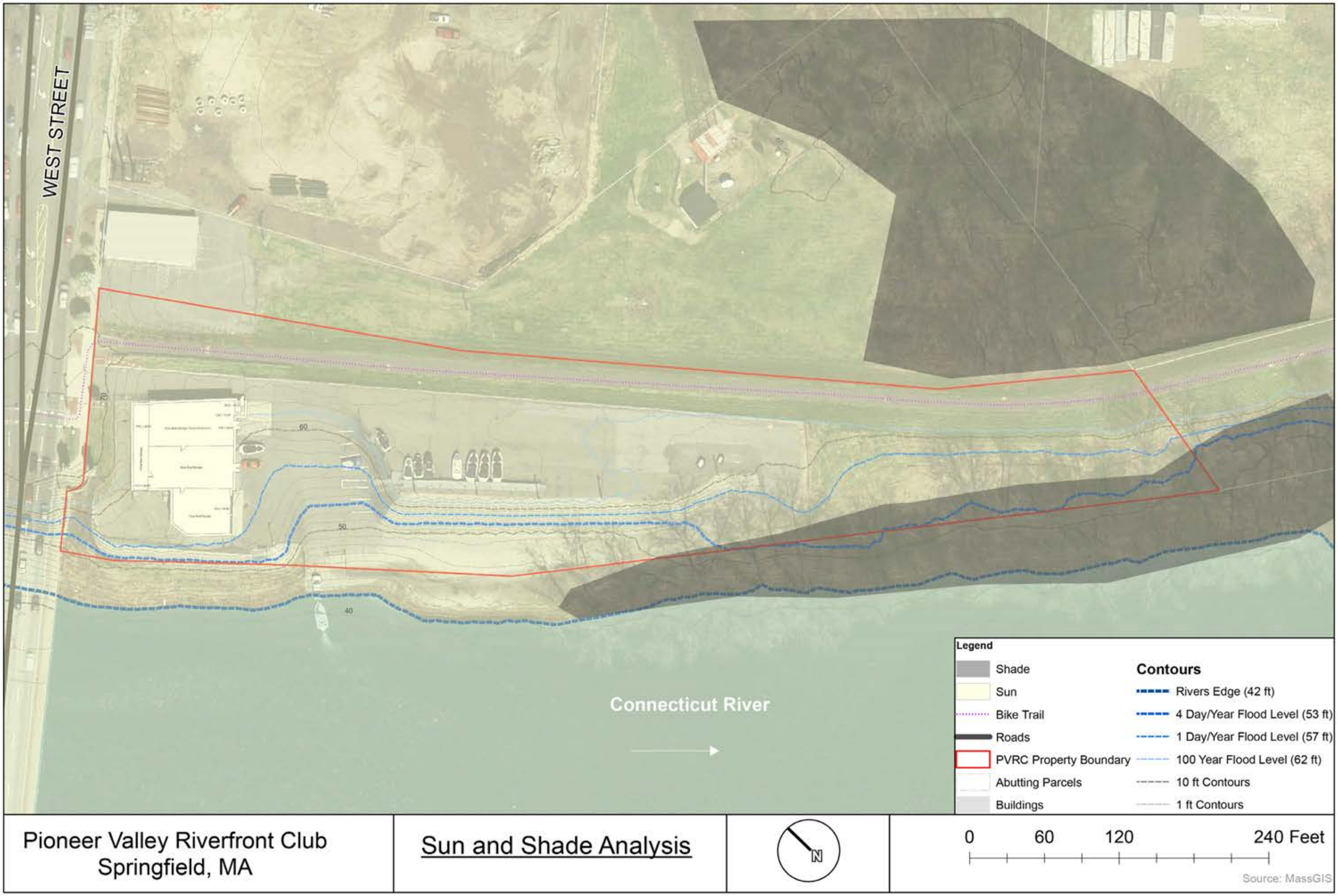
Existing Vegetation



Sun and Shade Analysis

The PVRC is in an area that lacks significant tree cover, therefore, there is much more sun than shade on-site. The small area in the southern and southwestern areas of the property do have an existing mature tree canopy, but there are no walking paths or easy access to these areas. The people who use the PVRC are either in the large parking areas, near the PVRC building, or utilizing the boat ramp area all of which are very exposed to the sun and have no tree cover.

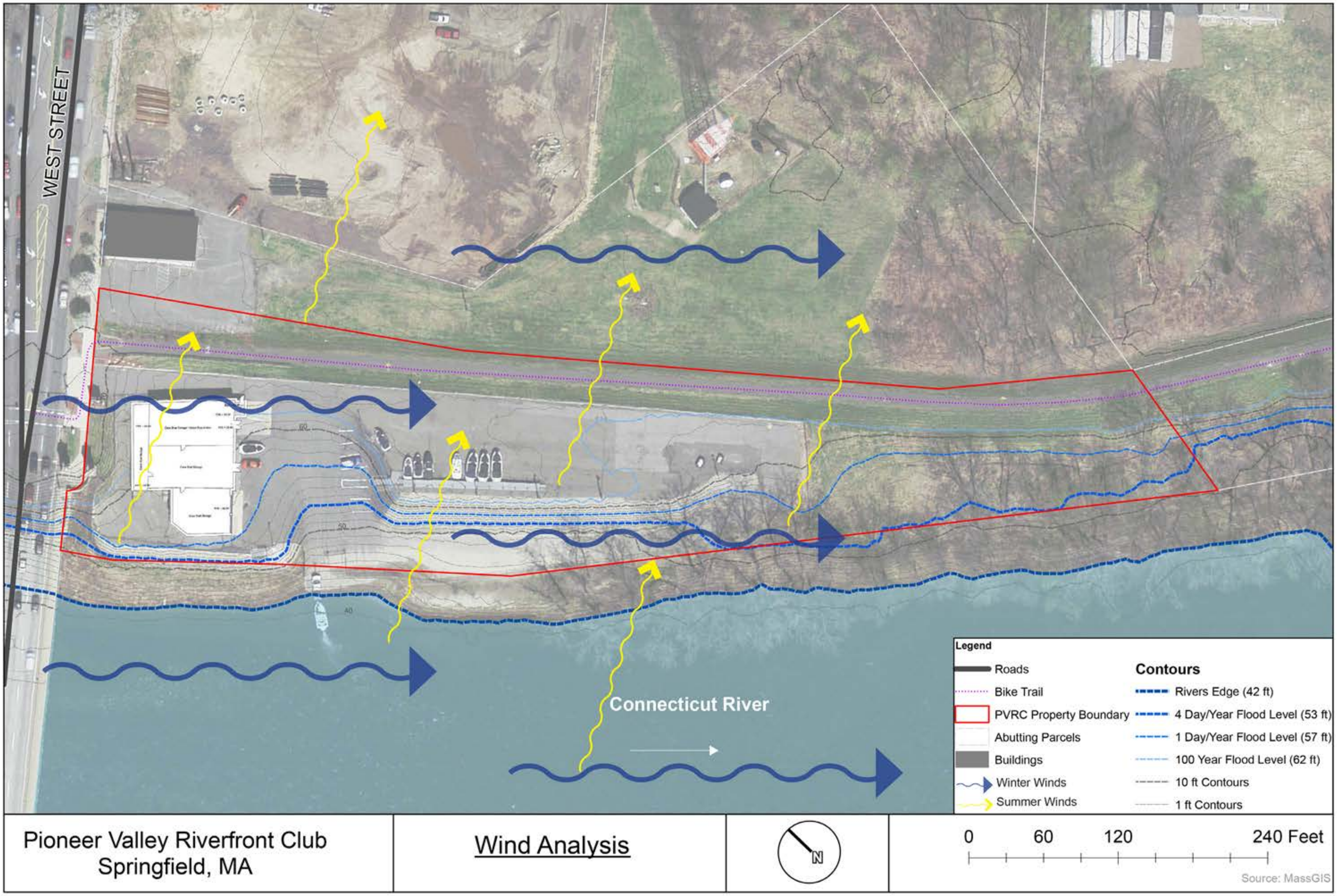
Sun and Shade Analysis



Wind Analysis

In addition to being exposed to the sun, the PVRC is also exposed to the wind. Strong and cold northwest winds in the winter come down from Canada generally parallel to the Connecticut River. The only potential wind block for these cold winter winds is the West Springfield bridge, which is located along the northern property boundary of the PVRC (i.e., West Street). In addition, the light and welcomed summer breezes from the southwest come across the river and blow through the site, also unimpeded.

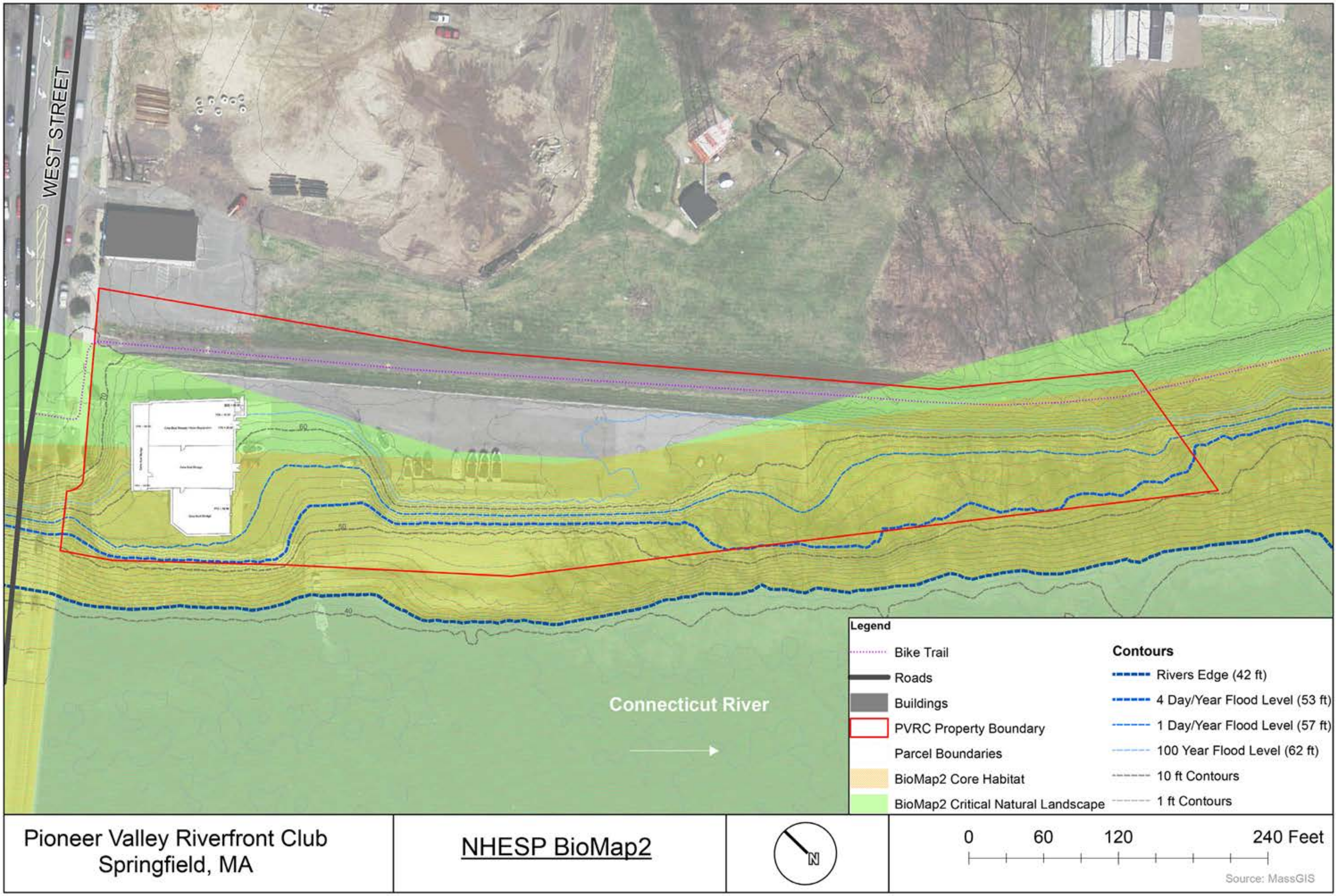
Wind Analysis



NHESP BioMap2

The majority of the PVRC property is mapped as either Core Habitat or Critical Natural Landscape by the NHESP. “Core Habitat identifies key areas to ensure the long-term persistence of species of conservation concern, exemplary natural communities, and intact ecosystems across the Commonwealth. Critical Natural Landscape identifies larger landscape areas that are better able to support ecological processes, disturbances, and wide-ranging species” (NHESP, Biomap2). The areas directly abutting the Connecticut River are mapped as Core Habitat and Critical landscape primarily for the protection of roosting areas/trees used by Bald Eagles. The PVRC is also known habitat for an aquatic endangered state-listed species, which the BioMap2 takes into account.

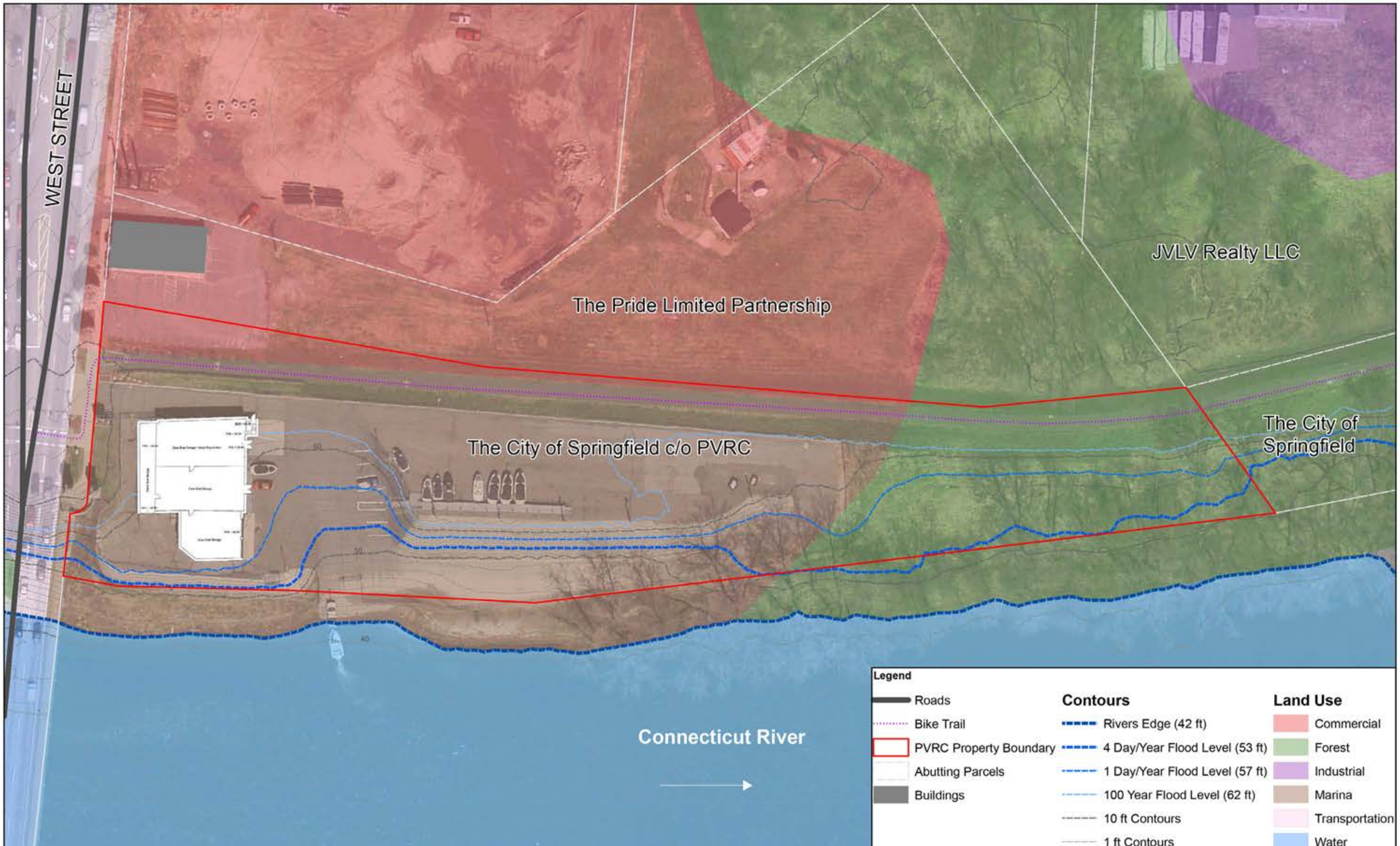
NHESP BioMap2



Land Use & Property Abutters

The PVRC is mapped as “marina” in the land use database for the state. Surrounding land uses include “forest” to the south (owned by the City of Springfield), “commercial” to the east (owned by the Pride Gas Station Limited Partnership), and Transportation to the north (West Street and West Springfield Bridge).

Land Use & Property Abutters

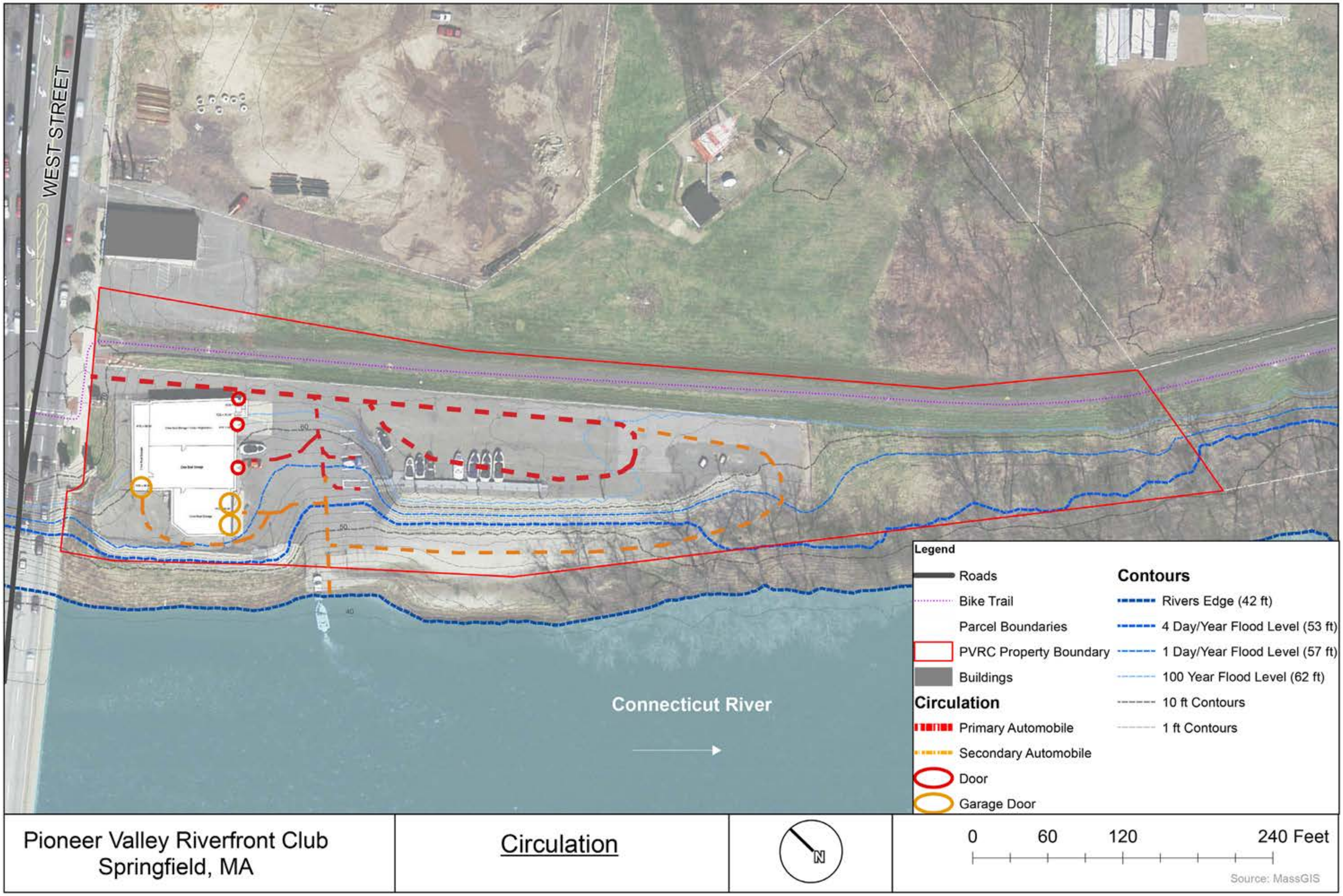


Pioneer Valley Riverfront Club Springfield, MA	Landuse & Property Abutters	N	0 60 120 240 Feet Source: MassGIS

Circulation

Circulation at the site is primarily designed for automobile traffic. Cars enter the site from West Street and either park in the elevated fill parking area or park closer to the PVRC building. These circulation routes are primary circulation routes. Secondary circulation routes are also designed for automobile access. The secondary routes include a loop access road that connects the elevated parking area to the boat ramp area, and provide access to additional storage areas on the north side of the PVRC.

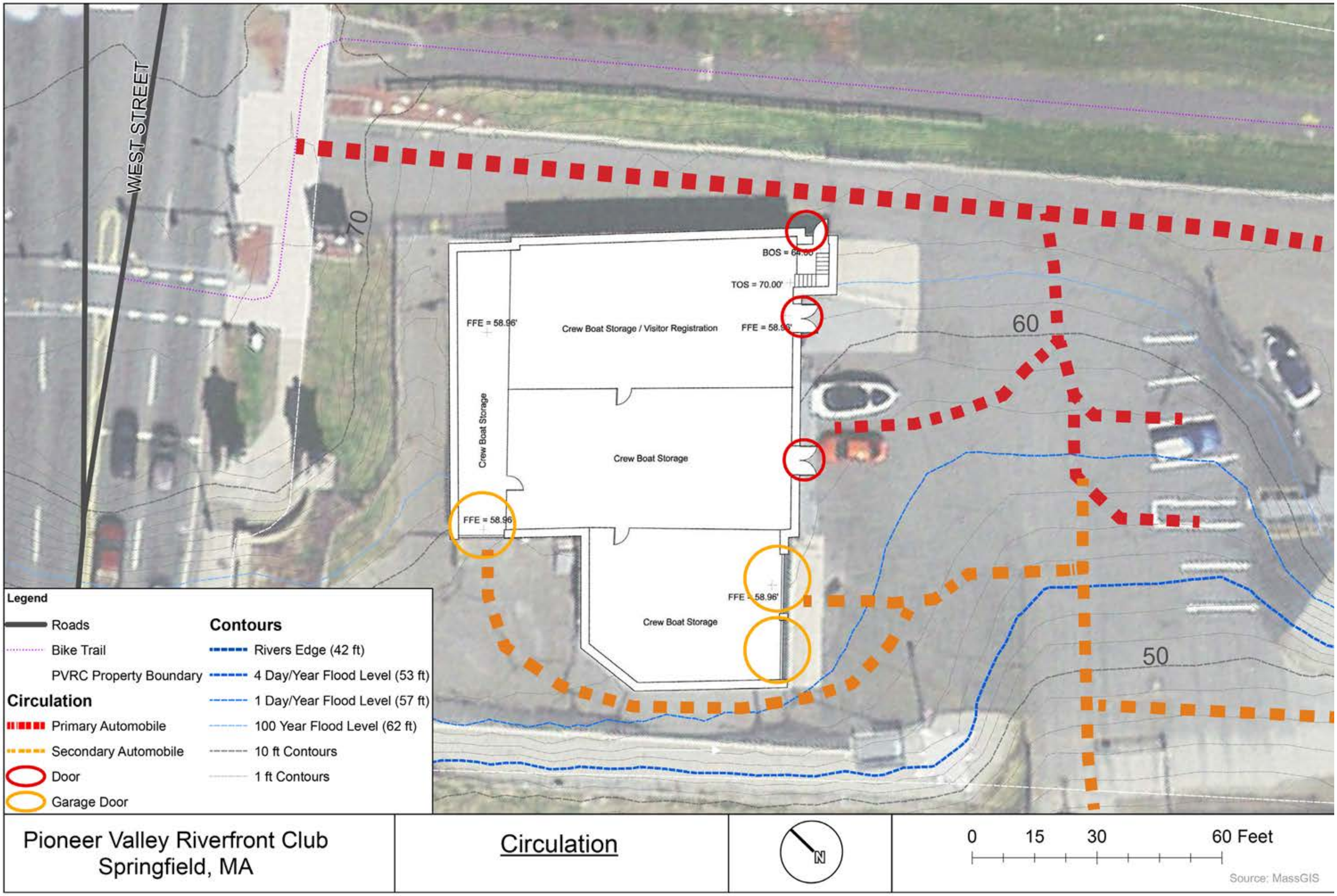
Circulation



Circulation Detail

There are three main doors used to access the PVRC offices and indoor practice facilities. There are also three garage doors used for access to storage of equipment, crew boats, and a small tractor used to transport boats to and from the boat launch if needed. Crew boats are usually carried by the crew overhead with no need for assistance by the tractor.

Circulation Detail



Final Assessment Map

A final site assessment was compiled to summarize the key factors determined in the site analysis The areas of steep slopes, mostly located in the areas of artificial fill, are important to note as a potential constraint to designing the site as they currently are limiting those areas from easily being reconnected to the floodplain. The flood protection levee is also comprised of artificial fill, but this is a permanent feature and cannot be altered, or removed. The parcel to the south of the PVRC is also owned by the City of Springfield, so there is a potential opportunity to link the two parcels together as part of a restoration project. In addition, the site has a large percentage of pavement and no on-site storm water treatment system to collect the surface runoff during rain events. The cold winter winds are a constraint because there is no effective wind block at the site, but the openness to the west of the site is an opportunity to allow the cooling summer breezes to blow through the site unimpeded. The areas of the parcel that are not paved over are mostly maintained as mowed grass, which is an opportunity to restore the native plant community in those locations. There is a lack of pedestrian focused circulation at the site, so there is an opportunity to create a network of walking paths for visitors so that they can access the site, especially along the river and its floodplain, which could become more forested and shaded.

Final Assessment Map

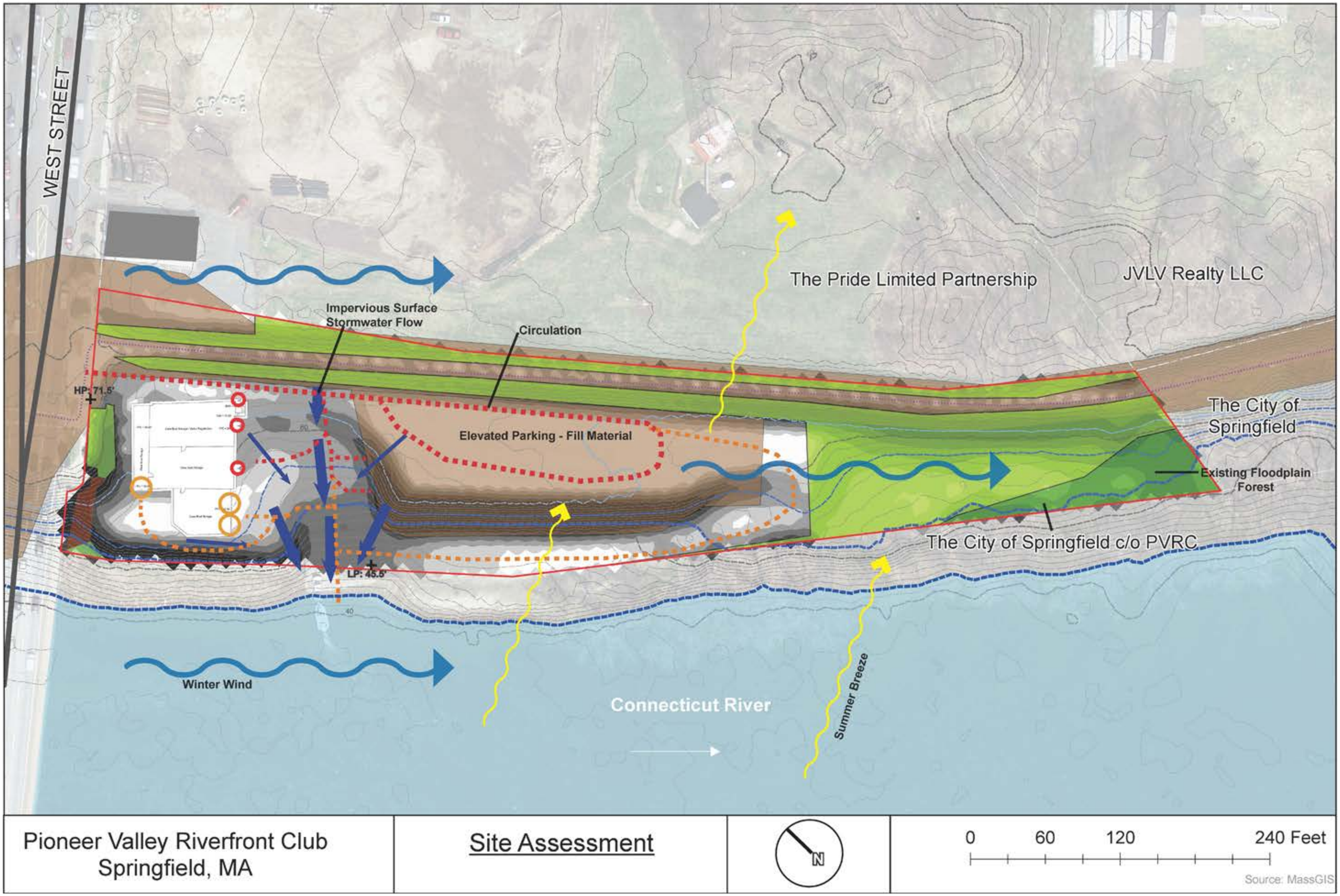


Photo Tour

View of boathouse looking north

Photo Tour

View from boathouse of Connecticut River looking south

Photo Tour

View from boathouse of the elevated fill area looking south-east

Photo Tour

View of elevated fill area and flood levee/bike path in the background

Photo Tour

View of loop road looking north-west

Photo Tour

View looking up the boat ramp and the steep slope

Photo Tour

View on top of the flood wall looking north-west at the PVRC boathouse

Site Program

The boathouse and surrounding property was constructed in 1901. The PVRC feels that they have outgrown the building and would like a landscape design that reduces the amount of asphalt pavement that currently exists there today. The main site programming elements requested by the PVRC include having more shade available outdoors, as well as, reducing the available parking to accommodate thirty cars, and to have an outdoor gathering space or classroom.

Increasing stormwater infiltration and detention and reducing stormwater runoff from the PVRC parking areas and other impervious surfaces into the river is an important objective of the proposed design. This will have a positive effect on the water quality of the Connecticut River at the PVRC by trapping or eliminating pollutants from cars, reducing excess sediment and nutrients, and reducing the stormwater that is heated by the sun when flowing over black asphalt from flowing into the Connecticut River.

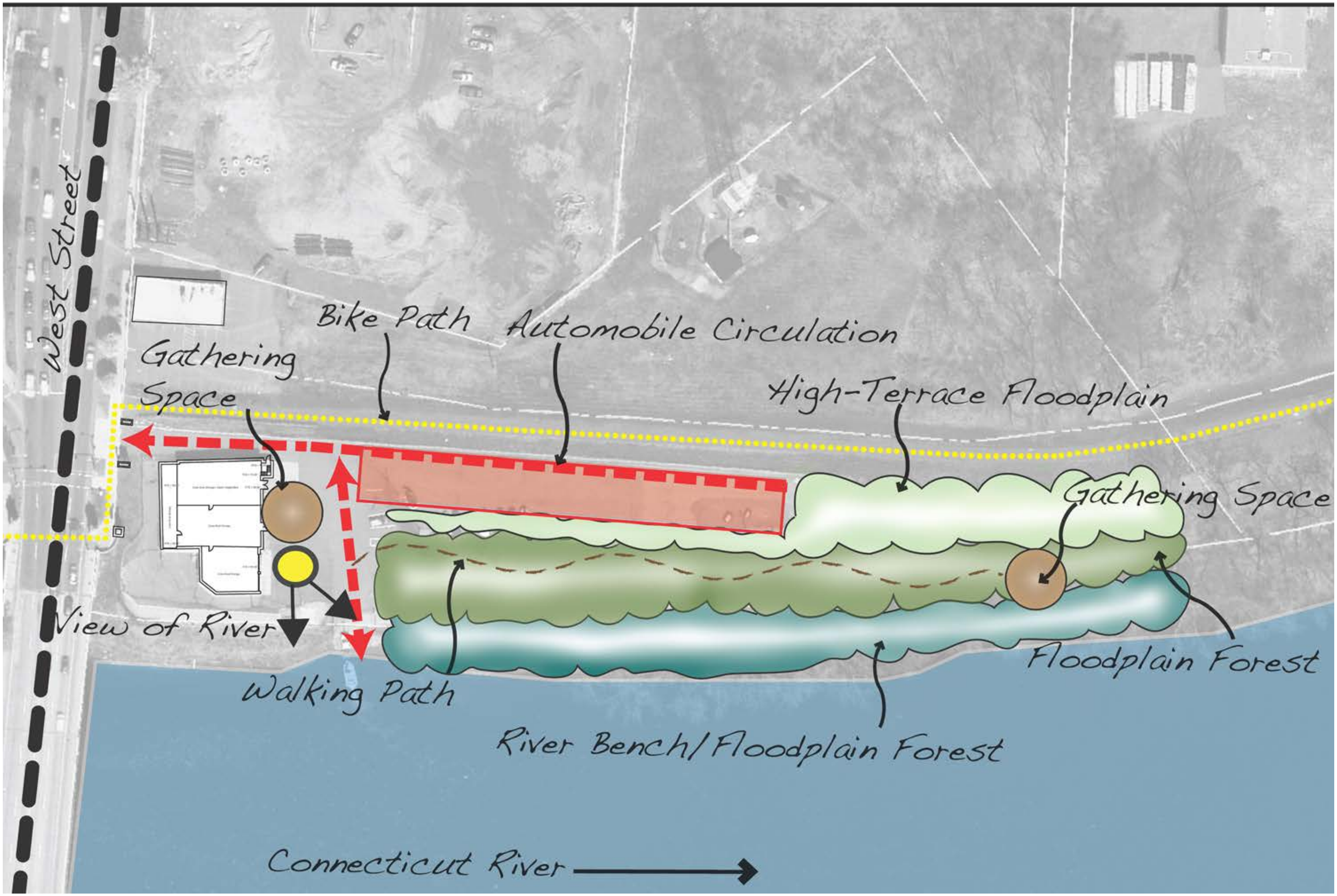
The proposed design would focus on reconnecting the site to the Connecticut River and its floodplain by removing large quantities of paved surfaces and the fill material that currently keeps the paved parking area above the floodplain. By dropping these raised areas back down into the floodplain, and using native plants found specifically in floodplain forests throughout Massachusetts, the native Major River Floodplain Forest plant community will be reestablished. The use of deadwood or tree snags will be installed, such as at the Hartwell Farm project. This will contribute to increasing the urban biodiversity in the area. This new landscape will also include new walking paths that will help connect the visitors to the river.

Design Process

The natural flow of the river overlapping the natural terracing on a riverbank influenced the concept of this design. Various site design concepts were developed taking into consideration the site assessment and the site program. Concepts included retaining the existing circulation patterns for automobiles, removing the existing circulation patterns, and altering the existing circulation patterns. Additional concepts explored developing floodplain terraces and reducing the size of elevated parking area to allow for terracing and river flooding onto these terraces. This is the final concept selected as the basis for the proposed site design. The existing circulation was altered and the loop road that connected the lower elevations by the river to the elevated parking area was removed. Parking for cars is reduced to a long parking lot wide enough to include room for 30 cars and one main access road/driveway. Three main flood terraces are located at the predetermined flood elevations of 57 feet, 53 feet, and at various existing river bench elevations below 53 feet. Gathering spaces or outdoor classrooms were drawn near the PVRC building and out in the floodplain forest on one of the terraces. Walking paths connecting the building to the gathering spaces are included.

Concept Sketch

Design Process



Grading Plan

This is the proposed grading plan for the PVRC property. This plan includes the following:

-The existing elevated parking was significantly reduced in size and area to allow for 30 cars to park.

-Using the 57 ft. and 53 ft. estimated flood levels, three main terraces were created within the natural floodplain of the Connecticut River.

-The proposed high terrace floodplain begins at the 53 ft. contour and ends at 57 ft.

-The proposed floodplain forest begins at the river's edge and extends to the 53 ft. contour.

-Impervious surfaces were reduced from 2.3 acres or 75% of the property to 0.4 acres or 13% of the property.

-There is a handicapped ramp that was added from the upper parking area at 62 ft. down to the main entrance elevation of 58.95 ft.

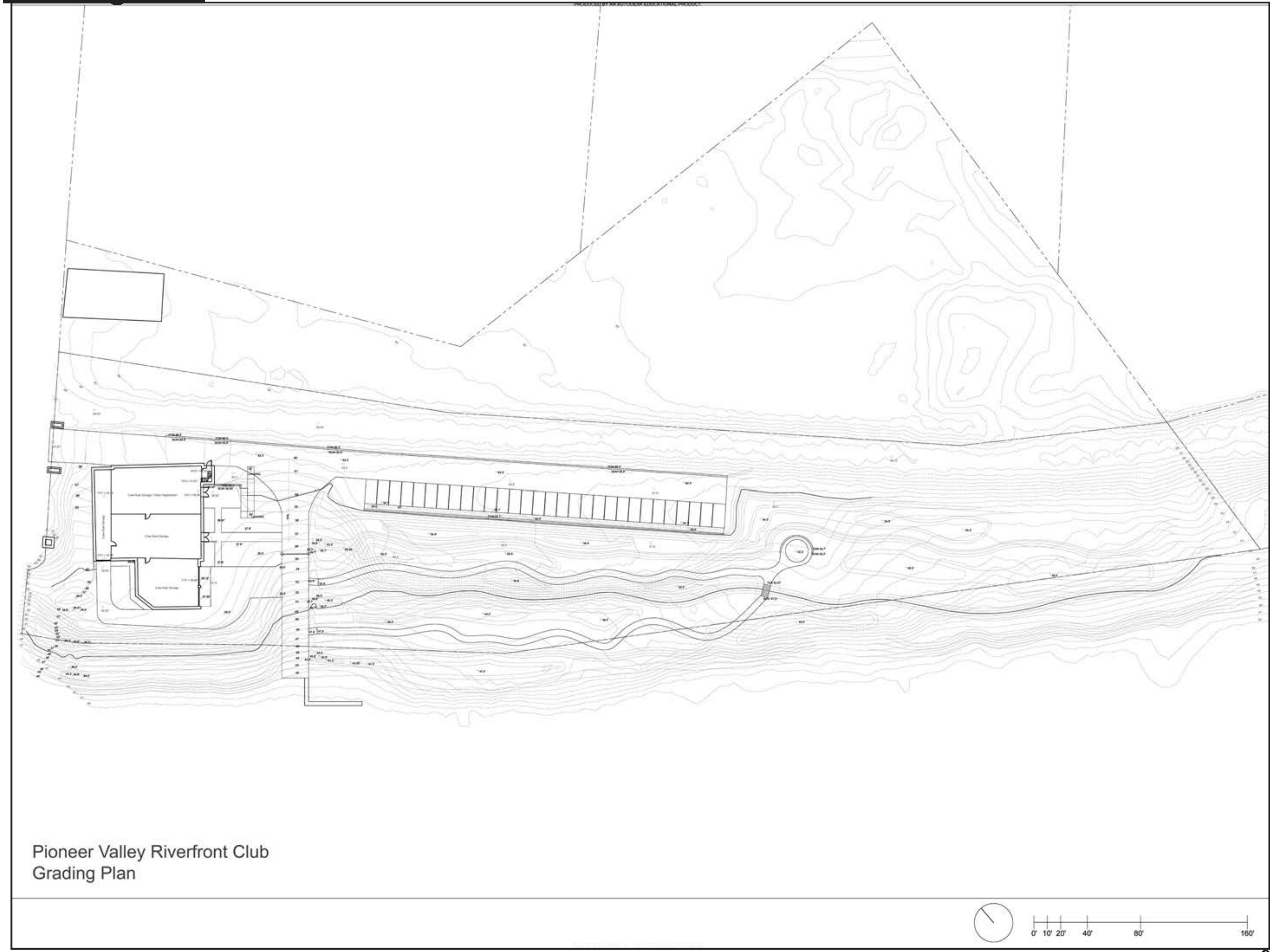
-The top of the boat ramp area was re-graded to be a 10% slope to function as a three-point turn around to allow for fire truck access to the PVRC building.

-The boat ramp was re-graded with a cross-slope so that stormwater drains to the south side into a series of detention basins which also then flows south into larger detention basins in the floodplain terraced area.

-A circular outdoor classroom is designed within the floodplain forest plant community. It is south of the parking area which acts as a windblock from the cold northwest winds. There is a semi-circular sandstone bench on the edge that faces the Connecticut River.

-Two wooden boardwalks are designed to lead people to the outdoor classroom through the floodplain forest plant community. They meander to follow the flow pattern of the Connecticut River. The boardwalk sits on helical piers to prevent corrosion of the wooden pathway. Wood is used to prevent erosion of the pathway during flood events.

Grading Plan

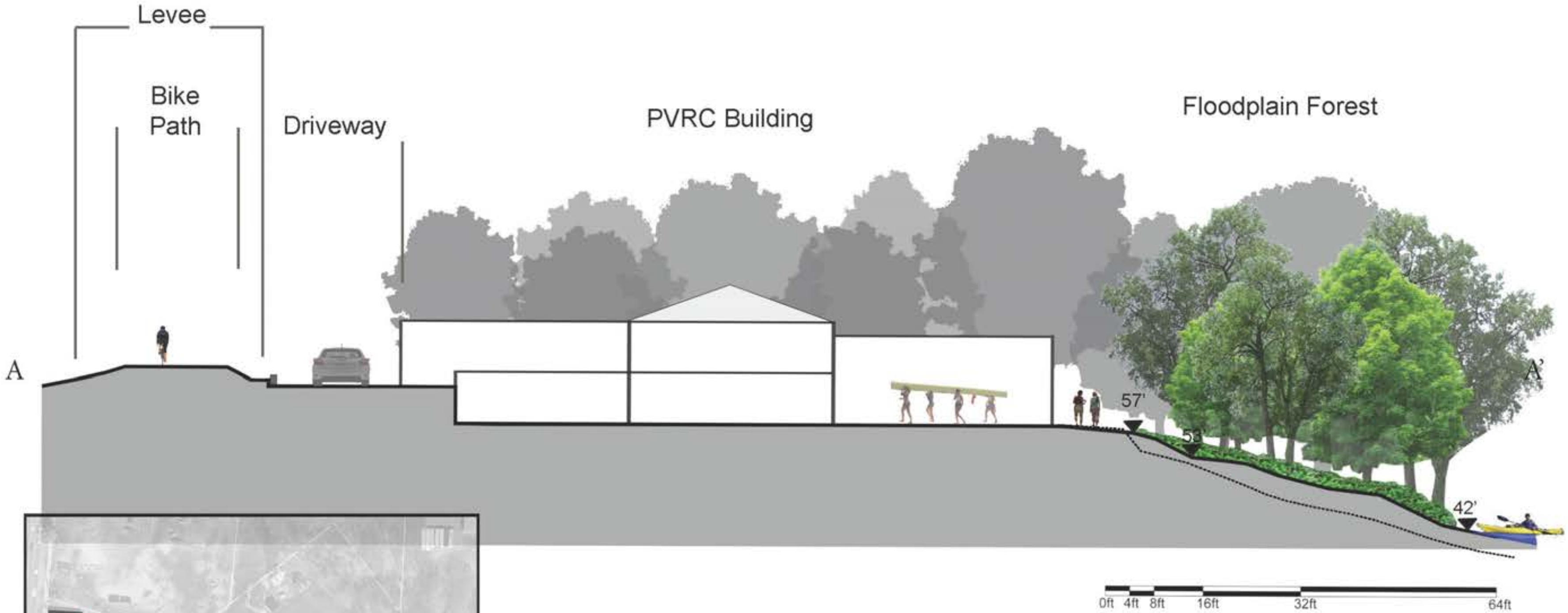


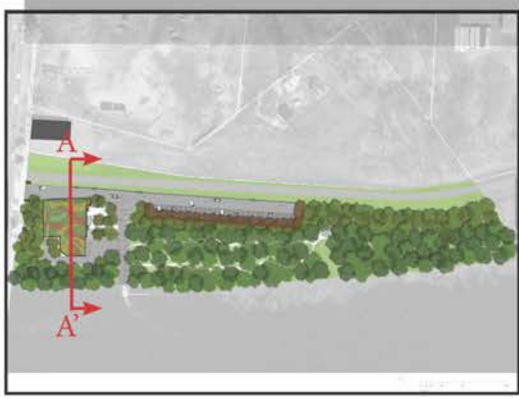
Pioneer Valley Riverfront Club
Grading Plan

Section Views: Proposed Designs

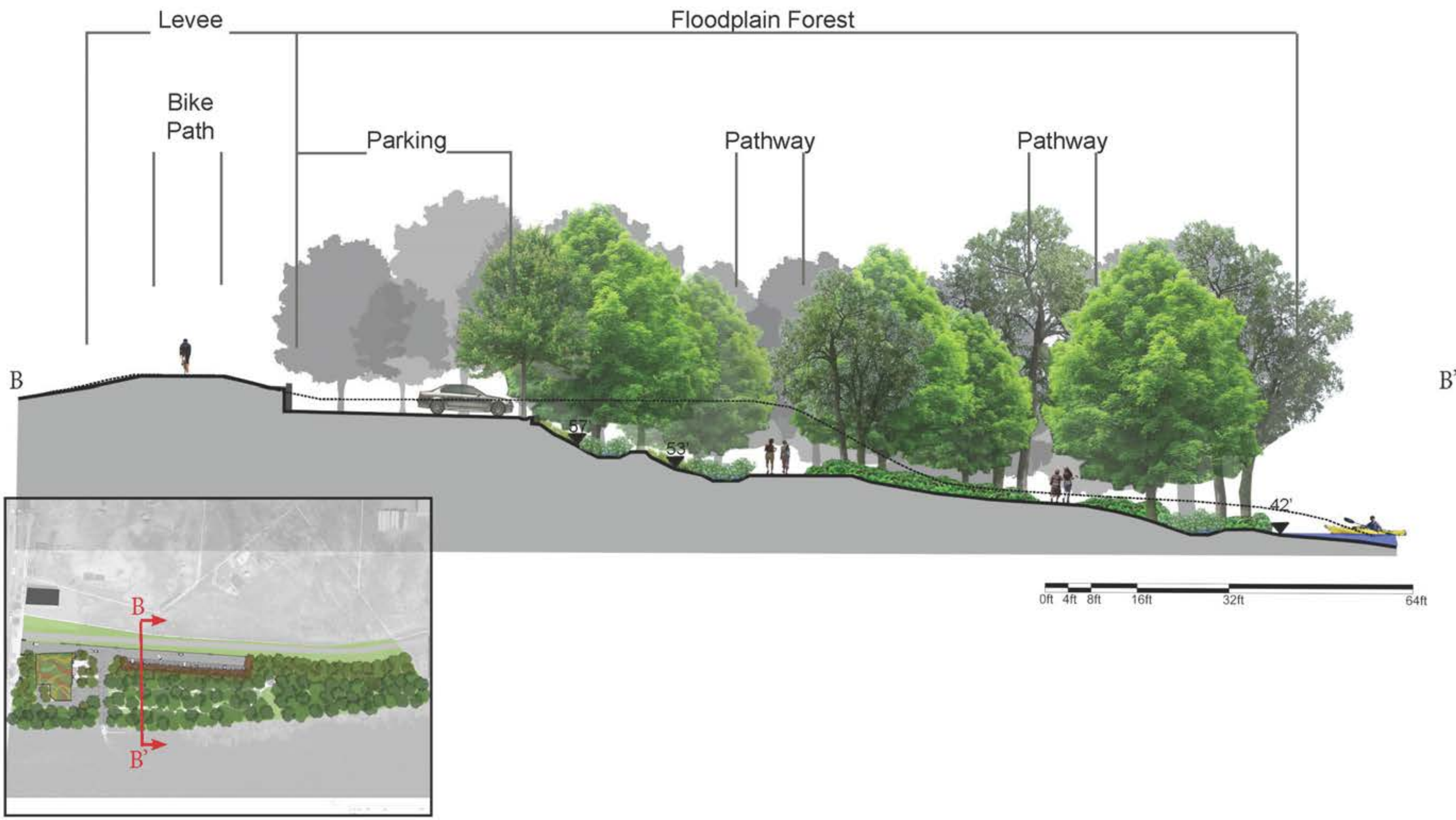
The following section views show the proposed design at A-A’, B-B’, and C-C’.

Section Views: Proposed Design A-A'

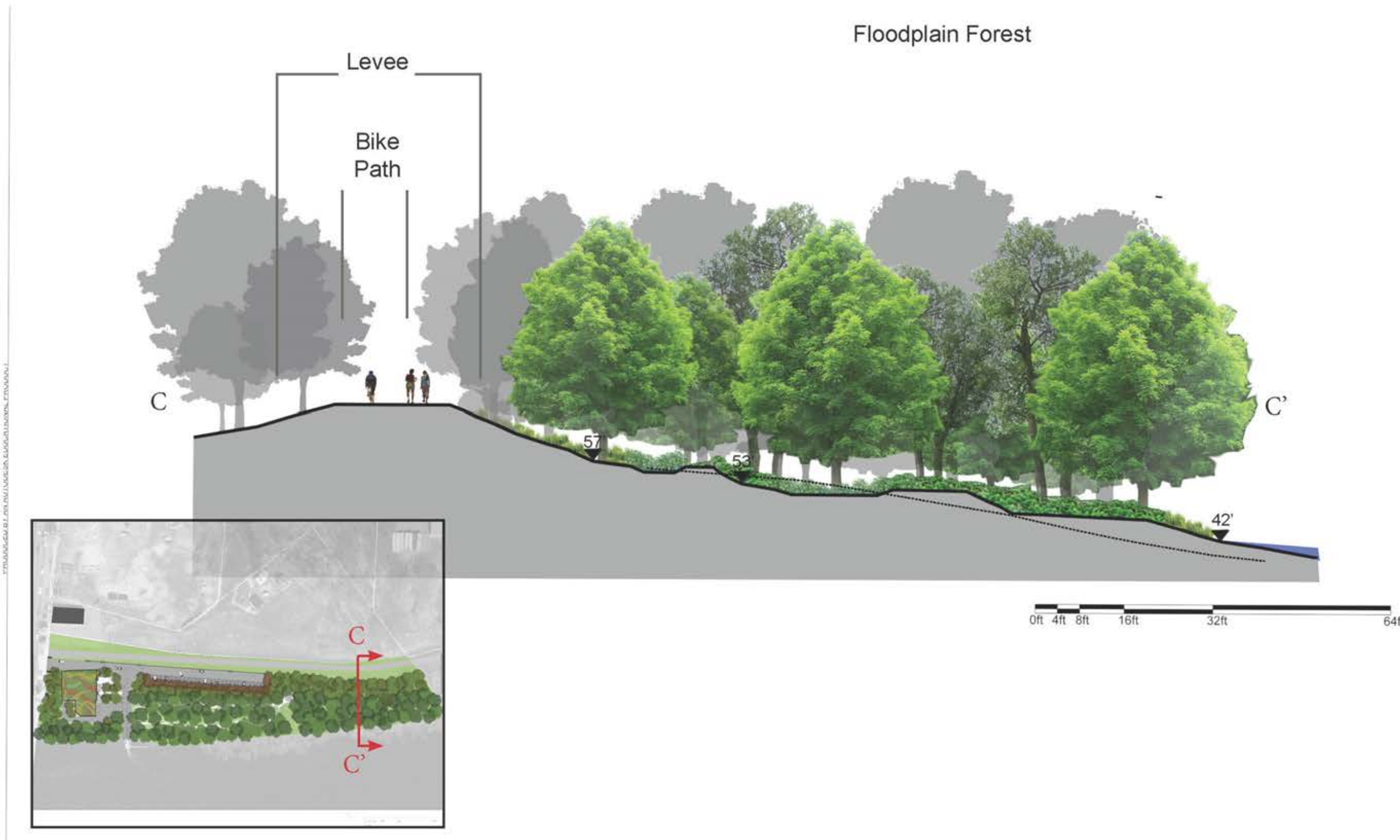




Section Views: Proposed Design B-B’



Section Views: Proposed Design C-C’



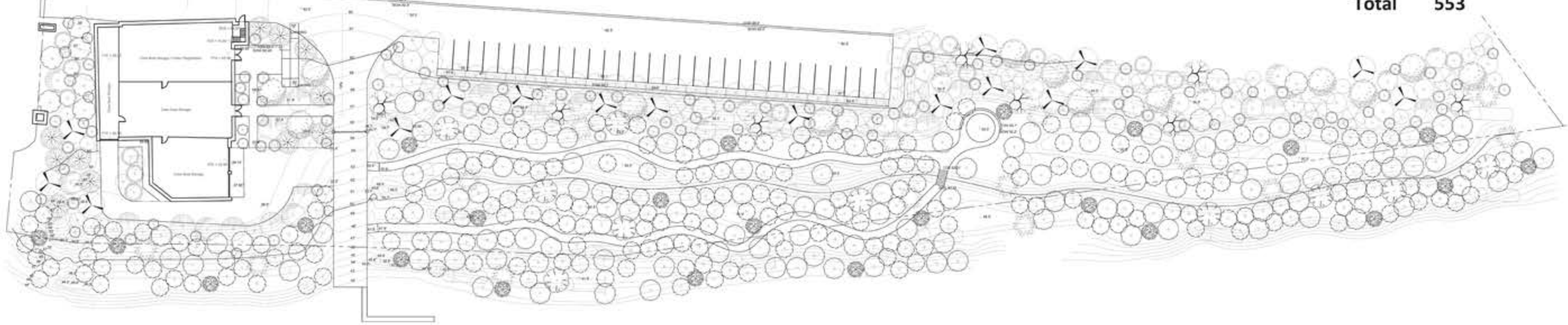
Planting Plan - Trees and Shrubs

There are two zones of trees based on the proposed floodplain terraces. The trees and shrubs included in the high terrace floodplain forest plant community are summarized in the planting plan table. The planting density used for the planting plan was 10 ft. on center for each tree sapling that is proposed to be planted. The total number of trees in the floodplain forest is 60% silver maple, which is what the naturally occurring composition of a floodplain forest is expected to be, as described by the NHESP Plant Community description. The total number of floodplain forest trees planted is 553 and the total number of shrubs planted is 97. There is a row of Red Maple trees along the parking area to give that area a sense of order overlooking the more naturalistic look of the floodplain forest below the elevated parking area. Tree snags and deadwood are placed throughout the floodplain to encourage the presence of wildlife, which use these features as both habitat and food sources.

Planting Plan- Trees and Shrubs

Shrub Plan			
Common Name	Botanical Name	Count	Size
Viburnum	*Viburnum spp.*	45	2-3' HT
Bladdernut	*Staphylea trifolia*	23	2-3' HT
Dogwoods	Cornus spp.	29	2-3' HT
	Total	**97**	

Tree Plan			
Common Name	Botanical Name	Count	Size
Red Maple	*Acer rubrum*	45	5-6' HT
Silver Maple	*Acer saccharinum*	202	5-6' HT
Sugar Maple	*Acer saccharum*	14	5-6' HT
River Birch	*Betula nigra*	11	5-6' HT
Ironwood	*Carpinus caroliniana*	16	5-6' HT
Shagbark Hickory	*Carya ovata*	16	5-6' HT
Green Ash	*Fraxinus pennsylvanica*	14	5-6' HT
American Sycamore	*Platanus occidentalis*	8	5-6' HT
Eastern Cottonwood	*Populus deltoides*	118	5-6' HT
Black Cherry	*Prunus serotina*	13	5-6' HT
Swamp White Oak	*Quercus bicolor*	8	5-6' HT
Pink Oak	*Quercus palustris*	10	5-6' HT
American Linden	*Tilia americana*	12	5-6' HT
American Elm "Valley Forge"	*Ulmus americana 'Valley Forge'*	23	5-6' HT
Slippery Elm	*Ulmus rubra*	11	5-6' HT
Ground Logs	n/a	18	Varies
Erect Tree Snags	n/a	14	Varies
	Total	**553**	



Pioneer Valley Riverfront Club:
Tree Planting Plan with Tables

Planting Plan- Herbaceous

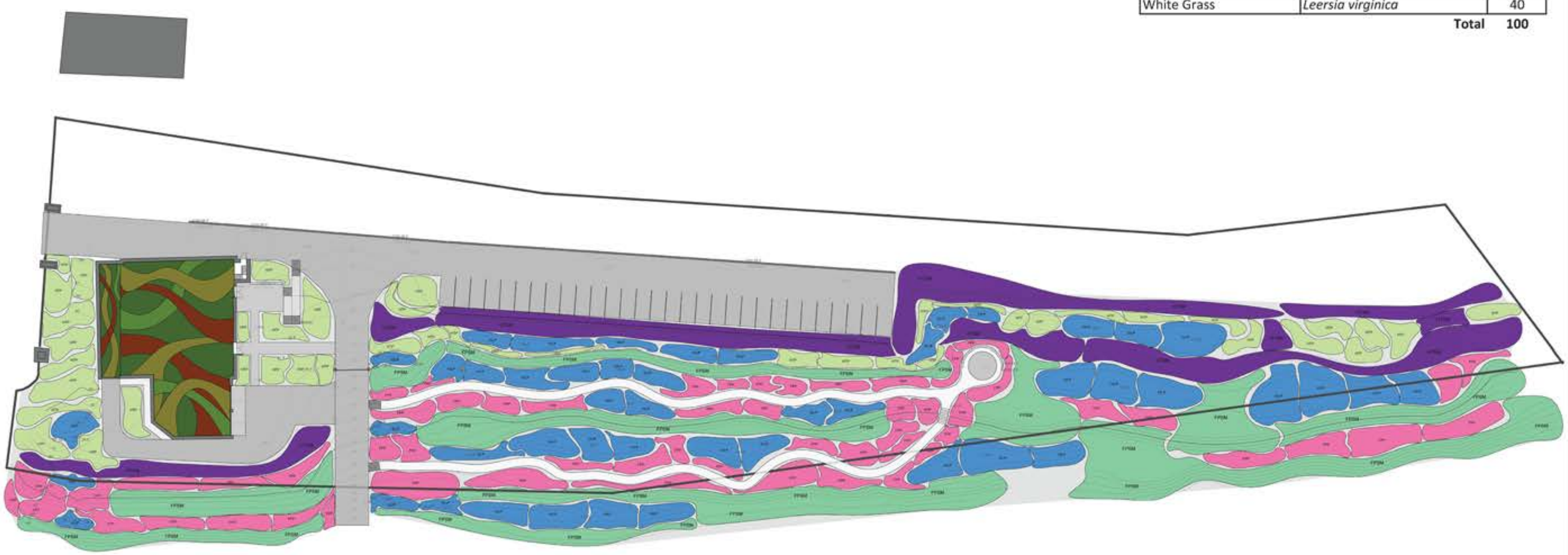
There are five planting zones included in the herbaceous planting plan. The zones are titled: Floodplain Plantings, High Terrace Plantings, Wetland Plantings, Seed Mix Floodplain and Seed Mix High- Terrace. The green roof is proposed but the planting details are not included in the planting plan and design. The total number of plants in the High Terrace Planting is 660. The total number of plants in the Flooplain Plantings is 885. The total number of plants in the Wetland Plantings is 705. Summary of the species types can be viewed in the tables on the planting plan.

Planting Plan- Herbaceous

Pioneer Valley Riverfront Club: Herbaceous Planting Plan with Tables

Seed Mix Floodplain (FPSM)		
Common Name	Botanical Name	Percent
Wood Nettle	*Laportea canadensis*	50
White Grass	*Leersia virginica*	50
	Total	100

Seed Mix High-Terrace (HTSM)		
Common Name	Botanical Name	Percent
Asters	*Aster spp.*	5
Honewort	*Cryptotaenia canadensis*	5
Wiegand's Wild Rye	*Elymus wiegandii*	20
Floodplain Avens	*Geum laciniatum*	5
Bottlebrush Grass	*Hystrix patula*	5
Wood Nettle	*Laportea canadensis*	10
Canada Mayflower	*Maianthemum canadense*	5
Zigzag Goldenrod	*Solidago flexicaulis*	5
White Grass	*Leersia virginica*	40
	Total	100



High Terrace Planting (HTP)	
Common Name	Botanical Name
Jack in the Pulpit *	*Arisaema triphyllum*
Lady Fern	*Athyrium filix-femina*
Trout-lily	*Erythronium americanum*
white snakeroot	*Eupatorium rugosum*
Ostrich Fern *	*Matteuccia struthiopteris*
Sensitive Fern	*Onoclea sensibilis*
Trillium	*Trillium spp.*
	Plant 15 of each per zone * 44 zones
Total of Each	660

'*'= plant two years post construction

Floodplain Plantings (FPP)	
Common Name	Botanical Name
Jack in the Pulpit	*Arisaema triphyllum*
Wild Yellow Lilly	*Lilium canadense*
Ostrich Fern *	*Matteuccia struthiopteris*
Sensitive Fern	*Onoclea sensibilis*
	Plant 15 of each per zone * 59 zones
Total of Each	885

'*'= plant two years post construction

Wetland Plantings (WLP)	
Common Name	Botanical Name
Sedges	*Carex Spp.*
Buttonbush	*Cephalanthus occidentalis*
Winterberry	*Ilex verticillata*
Rushes	*Juncus Spp.*
Spice Bush	*Lindera benzoin*
Cinammon Fern	*Osmundastrum cinnamomeum*
	Plant 15 of each per zone * 47 zones
Total of Each	705

Master Plan

This image shows the final proposed master plan and design.

Master Plan


West Street
PVRC Building
With Green Roof
Main Entrance with Handicap
access Ramp
Thirty Car Parking with
Permeable Pavement
Red Maple Trees
Restored High-Terrace
Floodplain Forest
Bike Path
Outdoor Classroom
Gate
Wood Plank Walkways
View Corridor
Restored Floodplain
Forest
Dock
Pioneer Valley Riverfront Club - Springfield, MA
0' 10' 20' 40' 80' 160'

Floodplain Walkway Perspective

This perspective shows the floodplain forest plant community as one would walk up the wooden pathway toward the outdoor classroom.

Floodplain Walkway Perspective

Floodplain Outdoor Classroom Perspective

This perspective shows the outdoor classroom within the floodplain forest plant community as one would walk from the upper pathway.

The sandstone bench is shown.

Floodplain Outdoor Classroom Perspective

Floodwall/ Bike Path Perspective

This perspective shows the proposed 30-car parking area from the bike path looking south with the restored floodplain forest in the background.

Floodwall/ Bike Path Perspective

Maintenance Plan

To maintain the vegetation plantings proposed at the PVRC, a maintenance plan has been created. Similar to the plans referenced in the case studies. Five years of post-construction monitoring is proposed to ensure plant establishment and to monitor and remove invasive species. Site inspections will be conducted twice annually (spring and fall) during the first two growing seasons. A separate invasive species inspection will also be conducted twice annually (May & late August). Continued invasive species monitoring will take place annually for an additional three years from the end of the initial monitoring period. Invasive species encountered during any site inspection will be controlled and removed. Hand pulling and herbicide applications will be used to control the growth of invasive species.

The presence of weeds at the tree base of each sapling will be mowed or weed-wacked when necessary. Saplings will be kept free of tall vegetation for two years or until a height is achieved such that herbaceous vegetation is no longer competing with and inhibiting growth of the sapling. Any debris that washes into the trees following normal spring flooding events will be cleaned up and beaver cage exclosures will be repaired as needed. Ostrich ferns are to be planted two to three years post construction, or when sufficient shade has been created by the proposed planted trees.

Chapter 5

Conclusion

The purpose of this project was to increase urban biodiversity by restoring the native floodplain plant communities along the Connecticut River at the PVRC. Restoring or designing native plant communities is an important design alternative to the typical design methods of using non-native plant species and mono-culture plant palettes. Restoring a native plant community at the PVRC will allow the landscape to function once more as usable habitat for wildlife and native plants, encourage the natural succession of native plants, and become a more resilient landscape that can better withstand ecological changes caused by such things as climate change. The project was also intended to bridge the gap between a typical landscape design approach to restoration and a restoration ecology perspective to create a welcoming and ecologically diverse design. This was accomplished by re-grading the site of the PVRC to create a series of terraces based on estimated flood levels required to sustain both the Floodplain Forest and High Terrace Floodplain Forest plant communities. These terraces will provide the elevations required to establish floodplain forest plant communities to help increase biodiversity on the site. The designs were informed by extensive research on native plant communities in Massachusetts, previous native plant community restoration projects and through detailed site analysis and site visits to the researched case studies.

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GIS data:
-http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/layerlist.html

http://www.mass.gov/eea/agencies/dfg/dfw/natural-heritage/natural-communities/classification-of-natural-communities.html#

Appendix

Locations for Soil Samples:

A1: PVRC Mowed Grass Area in Floodplain

B1: Fannie Stebbins Floodplain Forest

S3A: Arcadia Mass Audubon High Terrace

A1: PVRC Mowed Grass Area in Floodplain Texture

UMass Extension
CENTER FOR AGRICULTURE

Agriculture and Landscape Program
Soil and Plant Tissue Testing Laboratory
West Experiment Station
682 North Pleasant Street
University of Massachusetts
Amherst, MA 01003-9302
Phone: 413.545.2311
Fax: 413.545.1931
soiltest.umass.edu

11/06/13

TEXTURAL ANALYSIS RESULTS

Customer Name:
Keith Hannon
610 E Pleasant St
Amherst, MA 01002

Sample ID: S131031-219

Customer Designation: A1

USDA SIZE FRACTIONS

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	68.0
Silt	0.002-0.05	27.2
Clay	< 0.002	4.8
Total	< 2.0	100.0

Sand Fractions	Size (mm)	Percent
Very Coarse	1.0-2.0	7.8
Coarse	0.5-1.0	10.9
Medium	0.25-0.5	12.6
Fine	0.10-0.25	20.2
Very Fine	0.05-0.10	16.5
		68.0

Silt Fractions	Size (mm)	Percent
Coarse	0.02-0.05	15.0
Medium	0.005-0.02	9.8
Fine	0.002-0.005	2.4
		27.2

PERCENT OF WHOLE SAMPLE PASSING

Size (mm)	Sieve #	%
2.00	#10	87.4
1.00	#18	80.6
0.50	#35	71.0
0.25	#60	60.1
0.10	#140	42.4
0.05	#270	27.9
0.02	20 um	14.8
0.005	5 um	6.3
0.002	2 um	4.2

USDA Textural Class = sandy loam

Gravel Content = 12.6%

COMMENTS: keith.hannon@gmail.com

B1: Fannie Stebbins Floodplain Forest Texture

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TEXTURAL ANALYSIS RESULTS

Customer Name:
Keith Hannon
610 E Pleasant St
Amherst, MA 01002

Sample ID: S131031-222

Customer Designation: B1

USDA SIZE FRACTIONS

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	82.4
Silt	0.002-0.05	14.5
Clay	< 0.002	3.1
Total	< 2.0	100.0

Sand Fractions	Size (mm)	Percent
Very Coarse	1.0-2.0	1.3
Coarse	0.5-1.0	1.9
Medium	0.25-0.5	10.8
Fine	0.10-0.25	41.1
Very Fine	0.05-0.10	27.3
		82.4

Silt Fractions	Size (mm)	Percent
Coarse	0.02-0.05	8.2
Medium	0.005-0.02	5.6
Fine	0.002-0.005	0.6
		14.5

PERCENT OF WHOLE SAMPLE PASSING

Size (mm)	Sieve #	%
2.00	#10	100
1.00	#18	98.7
0.50	#35	96.7
0.25	#60	86.0
0.10	#140	44.8
0.05	#270	17.6
0.02	20 um	9.3
0.005	5 um	3.7
0.002	2 um	3.1

USDA Textural Class = loamy fine sand

Gravel Content = 0.0%

COMMENTS: keith.hannon@gmail.com

S3A: Arcadia Mass Audubon High Terrace Texture

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TEXTURAL ANALYSIS RESULTS

Customer Name:
Keith Hannon
610 East Pleasant St
Amherst, MA 01002

Sample ID: S140407-703

Customer Designation: S3A

USDA SIZE FRACTIONS

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	75.2
Silt	0.002-0.05	15.9
Clay	< 0.002	8.9
Total	< 2.0	100.0

Sand Fractions	Size (mm)	Percent
Very Coarse	1.0-2.0	5.4
Coarse	0.5-1.0	8.5
Medium	0.25-0.5	15.1
Fine	0.10-0.25	35.9
Very Fine	0.05-0.10	10.3
		75.2

Silt Fractions	Size (mm)	Percent
Coarse	0.02-0.05	3.6
Medium	0.005-0.02	9.4
Fine	0.002-0.005	3.0
		15.9

PERCENT OF WHOLE SAMPLE PASSING

Size (mm)	Sieve #	%
2.00	#10	93.3
1.00	#18	88.2
0.50	#35	80.3
0.25	#60	66.2
0.10	#140	32.8
0.05	#270	23.1
0.02	20 um	19.8
0.005	5 um	11.0
0.002	2 um	8.3

USDA Textural Class = fine sandy loam

Gravel Content = 6.7%

COMMENTS: keith.hannon@gmail.com

A1: PVRC Mowed Grass Area in Floodplain
Soil Test Report

UMass Extension
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682 North Pleasant Street
University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Soil Test Report

Prepared For:
Keith Hannon
610 E Pleasant St
Amherst, MA 01002

keith.hannon@gmail.com
978-397-0274

Sample Information:
Sample ID: A1

Order Number: 2733
Lab Number: S131031-219
Area Sampled:
Received: 10/31/2013
Reported: 11/5/2013

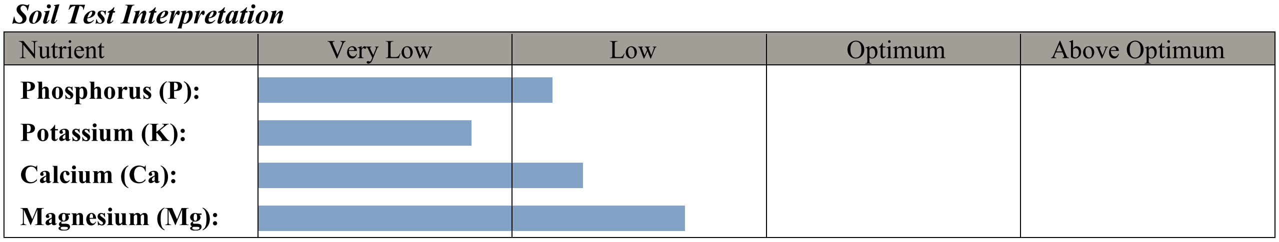
Results

Analysis	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.0	
Modified Morgan extractable, ppm		
Macronutrients		
Phosphorus (P)	2.3	4-14
Potassium (K)	42	100-160
Calcium (Ca)	638	1000-1500
Magnesium (Mg)	42	50-120
Sulfur (S)	11.3	>10
Micronutrients *		
Boron	0.2	0.1-0.5
Manganese (Mn)	5.4	1.1-6.3
Zinc (Zn)	9.5	1.0-7.6
Copper (Cu)	7.3	0.3-0.6
Iron (Fe)	16.0	2.7-9.4
Aluminum (Al)	34	<75
Lead (Pb)	28.7	<22

Analysis	*Value Found*	*Optimum Range*
Cation Exch. Capacity, meq/100g	7.4	
Exch. Acidity, meq/100g	3.8	
Base Saturation, %		
Calcium Base Saturation	43	50-80
Magnesium Base Saturation	5	10-30
Potassium Base Saturation	1	2.0-7.0
Scoop Density, g/cc	1.12	
Optional tests		
Soil Organic Matter (LOI), %	3.6	

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



A1: PVRC Mowed Grass Area in Floodplain
Soil Test Report

UMass Extension
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682 North Pleasant Street
University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Recommendations for Conservation Planting-Warm Season Grasses-Establishment

Limestone (Target pH of 6.5)	Nitrogen, N	Phosphorus, P2O5	Potassium, K2O
lbs / acre			
2000	40	20	60

Comments:

Recommendations for Conservation Planting-Warm Season Grasses-Maintenance

Limestone (Target pH of 6.5)	Nitrogen, N	Phosphorus, P2O5	Potassium, K2O
lbs / acre			
2000	40	20	60

Comments:

Recommendations for Conservation Planting-Wildlife Food Plot-Establishment

Limestone (Target pH of 6.5)	Nitrogen, N	Phosphorus, P2O5	Potassium, K2O
lbs / acre			
2000	40	20	60

Comments:

Recommendations for Conservation Planting-Wildlife Food Plot-Maintenance

Limestone (Target pH of 6.5)	Nitrogen, N	Phosphorus, P2O5	Potassium, K2O
lbs / acre			
2000	40	20	60

Comments:

General References:

Interpreting Your Soil Test Results http://soiltest.umass.edu/fact-sheets/interpreting-your-soil-test-results

B1: Fannie Stebbins Floodplain Forest
Soil Test Results

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Soil Test Report

Prepared For:
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keith.hannon@gmail.com
978-397-0274

Sample Information:
Sample ID: B1

Order Number: 2733
Lab Number: S131031-222
Area Sampled:
Received: 10/31/2013
Reported: 11/5/2013

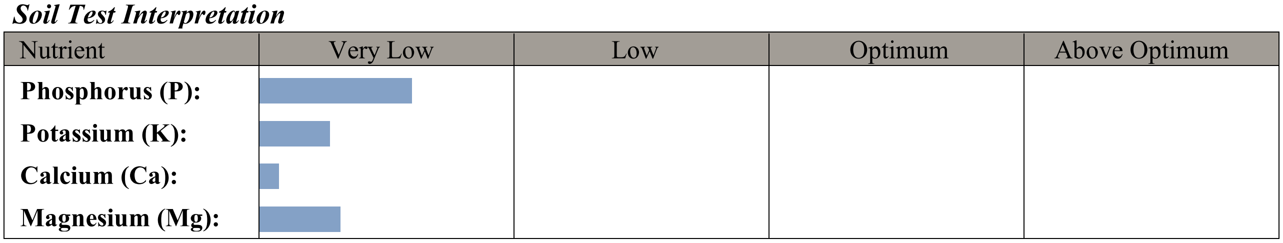
Results

Analysis	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	4.7	
Modified Morgan extractable, ppm		
Macronutrients		
Phosphorus (P)	1.2	4-14
Potassium (K)	13	100-160
Calcium (Ca)	33	1000-1500
Magnesium (Mg)	8	50-120
Sulfur (S)	4.6	>10
Micronutrients *		
Boron	0.0	0.1-0.5
Manganese (Mn)	2.3	1.1-6.3
Zinc (Zn)	0.4	1.0-7.6
Copper (Cu)	0.2	0.3-0.6
Iron (Fe)	27.8	2.7-9.4
Aluminum (Al)	96	<75
Lead (Pb)	1.4	<22

Analysis	*Value Found*	*Optimum Range*
Cation Exch. Capacity, meq/100g	7.3	
Exch. Acidity, meq/100g	7.0	
Base Saturation, %		
Calcium Base Saturation	2	50-80
Magnesium Base Saturation	1	10-30
Potassium Base Saturation	0	2.0-7.0
Scoop Density, g/cc	1.21	
Optional tests		
Soil Organic Matter (LOI), %	1.4	

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



B1: Fannie Stebbins Floodplain Forest
Soil Test Results

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website: soiltest.umass.edu

Recommendations for Conservation Planting-Warm Season Grasses-Establishment

Limestone (Target pH of 6.5)	Nitrogen, N	Phosphorus, P2O5	Potassium, K2O
	lbs / acre		
5000	40	95	80

Comments:

Recommendations for Conservation Planting-Warm Season Grasses-Maintenance

Limestone (Target pH of 6.5)	Nitrogen, N	Phosphorus, P2O5	Potassium, K2O
	lbs / acre		
5000	40	95	80

Comments:

Recommendations for Conservation Planting-Wildlife Food Plot-Establishment

Limestone (Target pH of 6.5)	Nitrogen, N	Phosphorus, P2O5	Potassium, K2O
	lbs / acre		
5000	40	95	80

Comments:

Recommendations for Conservation Planting-Wildlife Food Plot-Maintenance

Limestone (Target pH of 6.5)	Nitrogen, N	Phosphorus, P2O5	Potassium, K2O
	lbs / acre		
5000	40	95	80

Comments:

General References:

Interpreting Your Soil Test Results http://soiltest.umass.edu/fact-sheets/interpreting-your-soil-test-results

S3A: Arcadia Mass Audubon High Terrace
Soil Test Results

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Soil Test Report

Prepared For:
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610 E Pleasant St
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keith.hannon@gmail.com
978-397-0274

Sample Information:
Sample ID: S3A

Order Number: 4780
Lab Number: S140407-703
Area Sampled: 1 acres
Received: 4/7/2014
Reported: 4/11/2014

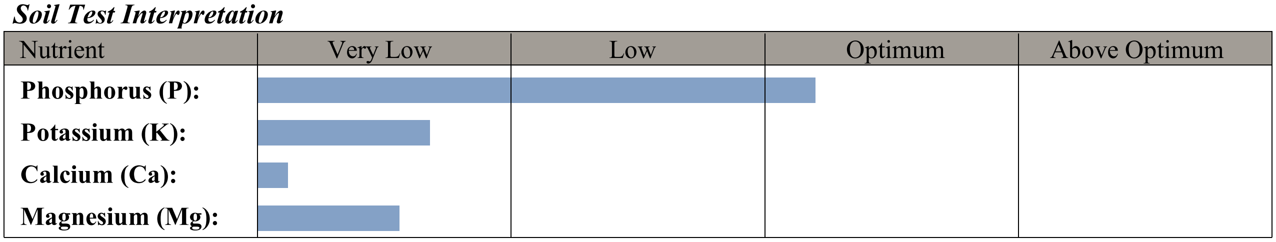
Results

Analysis	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	4.9	
Modified Morgan extractable, ppm		
Macronutrients		
Phosphorus (P)	5.9	4-14
Potassium (K)	33	100-160
Calcium (Ca)	58	1000-1500
Magnesium (Mg)	14	50-120
Sulfur (S)	31.5	>10
Micronutrients *		
Boron	0.1	0.1-0.5
Manganese (Mn)	1.4	1.1-6.3
Zinc (Zn)	0.3	1.0-7.6
Copper (Cu)	0.6	0.3-0.6
Iron (Fe)	111.7	2.7-9.4
Aluminum (Al)	203	<75
Lead (Pb)	5.6	<22

Analysis	*Value Found*	*Optimum Range*
Cation Exch. Capacity, meq/100g	11.1	
Exch. Acidity, meq/100g	10.6	
Base Saturation, %		
Calcium Base Saturation	3	50-80
Magnesium Base Saturation	1	10-30
Potassium Base Saturation	1	2.0-7.0
Scoop Density, g/cc	1.04	

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



S3A: Arcadia Mass Audubon High Terrace Soil Test Results

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e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Recommendations for Data only (including micronutrients)

Comments:

General References:

Interpreting Your Soil Test Results http://soiltest.umass.edu/fact-sheets/interpreting-your-soil-test-results