BUFFALO BAYOU PARK

Buffalo Bayou Partnership

Prepared for:

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BUFFALO BAYOU PARK VEGETATION MANAGEMEN PLAN

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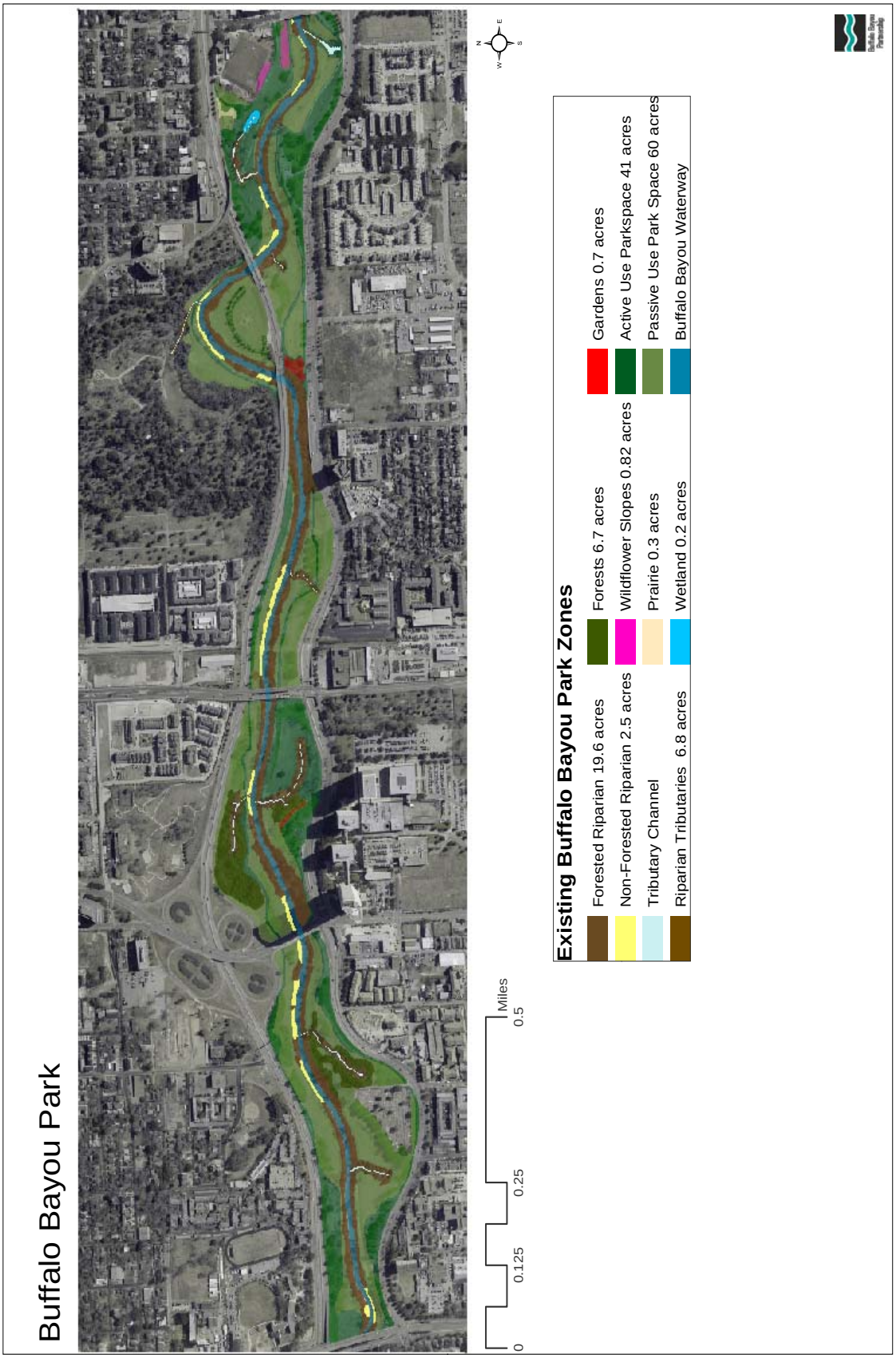


1.2 Plan Summary

Introduction

Buffalo Bayou Park is one of Houston's most popular and visible greenspaces. Located just west of downtown Houston, between Shepherd Drive and Sabine Street, the Park is a linear greenspace created naturally by the Bayou cutting into the substrate and augmented by the City as a floodwater storage corridor during severe storm events. The Park is two miles long and contains approximately 160 acres of mixed-use park space divided equally on both sides of the bayou. Memorial Drive defines the north edge of the park and Allen Parkway defines the south. On either side of the park, land-use includes businesses, historical residential homes and new mixed-use development. Facilities in the Park include recreational trails, pavilions, sculpture gardens, playgrounds, picnic areas, a disc golf course, a dog park, a canoe and kayak boat launch and many other recreational and ecological activities.

Buffalo Bayou Partnership's 20-year Masterplan, *Buffalo Bayou and Beyond*, published in 2002 focused on a ten-mile stretch of Buffalo Bayou from Shepherd Drive to the Port of Houston Authorities Turning Basin. The Plan divided Buffalo Bayou into three sectors: west, downtown and east. Buffalo Bayou Park encompasses almost all the area designated as the West Sector, Shepherd Drive to the Interstate 45 overpass.

Buffalo Bayou Park offers many benefits to the urban complex including its capacity to relieve flooding and to improve Houston's quality of life, air and water. Effective vegetation management policies and practices of this central park offer an opportunity to showcase Houston as a contemporary metropolitan city concerned with maintaining a primary natural resource for social, economic and ecological agendas. Ultimately, restoring and managing West Sector resources will benefit both the City of Houston and park users for years to come.

Site Description

Buffalo Bayou Park encompasses diverse uses, vegetation and conditions. The Park has been broken down into ecological and recreational components to most effectively address the needs of the whole area. It is composed of approximately 26 acres of Bayou and tributary riparian conditions, 7 acres of forest, 2 acres of prairie and wildflower slopes, 0.2 acres of wetlands and 0.7 acres of formal gardens. Approximately 100 acres of the park are maintained as "parkspace" lawn with specimen trees throughout. Most of the maintained parkspace has multiple terraces which manage a steep, 20- to 45-foot grade change from street level, down to the Bayou. The depth and terracing throughout the park function as a floodwater storage basin while also providing rich natural resources and substantial space for recreation. 25 stormwater outfalls flow into the West Sector, 12 of which cut tributaries into the corridor creating wildlife habitat and other natural conditions that currently go unmanaged.

Most tree stand perimeters (or fringes), including Bayou riparian, tributary and forest fringes, are overgrown with vines, un-pruned, low hanging branches and giant ragweed. This condition has developed thick, wall-like conditions that block visual access to these areas and accommodate numerous homeless compounds throughout the Park.

VMP Goals

The City of Houston Parks and Recreation Department (PARD) provide large-scale maintenance in Buffalo Bayou Park. When developing the VMP, Park maintenance provided by PARD was not included except for a brief description. Instead, the VMP focuses on Significant Management Zones, those areas with higher diversity and no existing maintenance. The integration of existing PARD maintenance with natural resource management described in this plan is designed to:

- **protect and enhance existing natural resources;**
- **increase natural resources within the corridor;**
- **stabilize Bayou banks;**
- **reduce maintenance costs;**
- **and, improve the aesthetic and recreational value of the Park.**

1.3 How to Use This Plan

The purpose of the Buffalo Bayou Vegetation Management Plan is to direct vegetation management in significant zones in Buffalo Bayou Park. It is not intended to be used as a technical manual for habitat restoration, rather as basic guidelines for increasing species diversity and wildlife habitat, stabilizing Bayou banks in the Park and increasing the aesthetic value of the Park. Further, the VMP was written to be understood and used for maintenance managers and personnel using basic landscape and restoration principles.

Depending on the intended function, individual sections will apply to individual goals being accomplished. The VMP is meant to be broad enough to apply anywhere along the Bayou and specific enough to guide practical care of Buffalo Bayou Park's natural resources. This section should provide the essential information to move quickly through the document to reach particular sections of interest. The VMP was conceived with flexibility and accessibility in mind.

Chapters 1 – 4 provide basic information on the park, its problems and needs, its history and baseline vegetation information for ten management zones in the park.

Chapter 5 describes each significant management zone. It provides restoration procedures and management recommendations on the three existing significant management zones including the riparian, tributary and forest zones. It also provides establishment procedures and management recommendations for three current pilot projects in the park: wetlands, prairies and wildflower slopes. Each section includes a map of the existing area and offers recommendations for future sites of the pilot projects. A maintenance frequency table, maintenance goals and a plant list appropriate to each zone are at the end of each section.

Chapter 6 provides information on the current maintenance in the Park by the City of Houston Parks and Recreation Department and technical maintenance information including watering, mulching, pruning, fertilizing, disease and pest control, tree removal, invasive species control and herbicide use.

Chapter 7 describes erosion types occurring in the Park. It proposes a particular site that was chosen because the erosion occurring is undercutting the parks hike and bike trail. Finally, it recommends streambank stabilization objectives for the site.

CHAPTER TWO
GOALS AND OBJECTIVES

2.1 Overall Goals of the West Sector

No comprehensive vegetation management plan has been developed and implemented for the ecological functioning of Buffalo Bayou Park. Current vegetation maintenance practices in the corridor include mowing terraced, turf conditions and pruning trees within the turf. Although maintained turf parkspace is an overwhelming portion of the West Sector, areas that go neglected by maintenance can potentially create the most interesting and unique features of the corridor. Some managed parkspace currently requiring intense maintenance can be converted to more sustainable conditions that will decrease maintenance while providing a richer aesthetic and ecological value to the Park.

2.2 Urban Forestry Goals

Urban forestry, "the study of trees and forests in and around towns and cities" is essential to the health of the West Sector trees and forests (EPA). The following goals were developed to guide the Buffalo Bayou Partnership's Urban Forester to begin implementing the VMP. The Texas Forest Service 2004 Partnership Grant Program objectives include:

- **promoting natural conditions within the corridor;**
- **monitoring trees and forests;**
- **implementing a bioengineered streambank protection demonstration project;**
- **enhancement of the riparian buffer by removing invasive species;**
- **enhancement of the riparian buffer by developing planting plans for native species;**
- **managing Forestry Volunteer Program;**
- **and, increase Public Safety.**

2.3 Buffalo Bayou Park Vegetation Management Plan Goals and Objectives

The primary goal for the VMP is to determine the existing conditions and make recommendations on the management for the natural resources within the Sector.

Goal: Use best vegetation management practices for the bayou corridor
Objectives:

- Identify the conditions and needs of the West Sector
- Review city, county and state agencies, and other best management practices (BMP's) for each condition represented or proposed in the West Sector
- Incorporate those BMPs into the maintenance structure of managing agencies

Goal: Protect and enhance native vegetation and natural resources
Objectives:

- Restore forest community with site-specific reforestation projects
- Restore and enhance grasslands, wetlands and wildflower slopes
- Develop and maintain lists of native vegetation for each area
- Increase migratory bird habitat (snags and large native trees)
- Make recommendations for the re-establishment of historically existing conditions (including prairies, vegetated swales, etc.)
- Work toward the possible designation of park habitat areas as wildlife areas

Goal: Develop a streambank restoration plan utilizing erosion control techniques
Objectives:

- Identify a specific location where severe erosion is occurring in the West Sector for a demonstration project
- Upon completion of Harris County Flood Control District's erosion study of the Buffalo Bayou, apply their recommendations to a demonstration project in the West Sector

Goal: Improve the aesthetic value of natural areas
Objectives:

- Provide maintenance procedures for the perimeter of tributaries, riparian and forest zones that will increase the aesthetic value of the corridor
- Recommend locations for re-grading the Bayou banks for greater visual and pedestrian access to the Bayou
- Enable use and enjoyment of Buffalo Bayou Park's natural resources while protecting wildlife and habitat

CHAPTER 3
CONTEXT OF PLAN

3.1 West Sector History

- *1871* The Glenwood Cemetery opened as a park
- *1877* Founding of the Old Sixth Ward, bounded by Memorial Drive, Glenwood Cemetery, Washington Avenue and Houston Avenue
- *1880's* Daniel Shepherd built a dam at present day Shepherd Drive on Buffalo Bayou. In time, floods washed away his dam.
- *1880's* *Beth Yeshurun Cemetery created by the Orthodox Congregation of Adath Yeshurun at* 3500 Allen Parkway.
- *1912* Arthur Coleman Comey's Planning Report for the Houston Park Commission published as 1st proposal for Buffalo Bayou improvements. Comey envisioned a linear park system along the city's waterways.
- *1917* Forty-four acres of land on the north bank of Buffalo Bayou between Studemont Street and Waugh Drive became Vick's Park. This tract included a small oxbow lake, called Vick's Lake. Later, the park was incorporated as a part of Cleveland Park and the Vicks Lake oxbow was filled and contoured during the construction of Memorial Drive and the Waugh Drive cloverleaf. Today, a portion of the former park site remains at Spotts Park.
- *1926* Creation of Buffalo Bayou Park between Taft Street and Sabine Street aimed at linking Downtown with the nearby suburban area of River Oaks and preserving urban waterfront greenspace, including an attractive, lush segment of the Bayou. Buffalo Bayou Park extends from Shepherd Drive along the south side of the bayou to Sam Houston Park.
- *1929* Severe flood causing millions of dollars in damage.
- *1953-58* Channelization of Buffalo Bayou between Shepherd and Sabine by the Army Corps of Engineers to improve floodwater conveyance to Galveston Bay. In conjunction with the construction of Memorial Drive into downtown, the banks of the bayou were cleared of their natural woodland environment. Both sides were scraped, as the process was called, and most of the trees were removed to be replaced by landscaped, grassy banks. Work also removed the northward curving bend in the bayou at Waugh Drive
- *1972* Charles Tapley designed a flowing tributary scheme for a section of the northern banks of the West Sector with granite steps and seating areas.
- *1978* Wortham Fountain built at Allen Parkway and Waugh
- *1978* Two springs were found; one poured 11 lps from Beaumont sand and shell deposits at Stanford Street. The other discharged 0.95 lps at Tirrell Street. Pennywort fringes the flow, shaded by willows. Azaleas bloom in the park in spring. (Springs of Texas 1971).
- *1979* "Large Spindle Piece," a 12-ft. abstract bronze structure by English sculptor Henri Moore was donated to the City of Houston for placement outdoors. It is located a short distance upstream of Tinsley Park, east of Taft Street on the crest of a low hill between Allen Parkway and Memorial Drive. The greenbelt area along Allen Parkway and Buffalo Bayou, where the skyline drops behind fertile foothills of grass, trees, and flowers was selected as the ideal space that combined the sculptural form with the natural environment.
- *1979* Near the Sabine St. bridge, there is a side drainage that enters from the south bank. A small riparian plaza has been built at the base of the Heiner St. storm sewer in which fish, turtles and aquatic fowl are seen frequenting this pleasant oasis. Stairs descend from Allen Parkway to the plaza as part of the hiking trail that continues under the bridge to the Civic Center area near Sam Houston Park and City Hall Annex.
- *1980* Spotts Park, 16.24 acres, (401 South Heights Boulevard) -acquired by the Houston Parks & Recreation Department.
- *1987* The creation of the Buffalo Bayou Art Park by a group of artists who wanted a place to exhibit their masterpieces in downtown open-air arenas.
- *1992* The Police Officers' Memorial was erected across from Memorial Drive. Created by Jesus Bautista Moroles, consisting of a five stepped pyramid in a ziggurat design (each 40 ft square at the base) formed together in a Greek cross shape. A 12.5 ft central pyramid rises from ground to apex. There is a reflecting pool surrounded by four inscribed slabs of Texas pink granite at the apex.

3.2 Previous Plans and Policies

- 1972 Charles Tapley & Associates, *et al*; *General Landscaping & Improvements between Sabine Street and Allen's Landing* [prepared for the City of Houston, 1970.] A preliminary study of bayou redevelopment
- 1980-81 Charles Tapley & Associates; *General Landscape & Improvements between Shepherd Dr. and Allen's Landing* [prepared for the City of Houston, Harris County, Texas, June 1980.] A design development study, their report outlines plans for the redevelopment of the bayou and recommended new public amenities in conjunction with flood and erosion control improvements.
- 1986 Buffalo Bayou Task Force; *The Buffalo Bayou Task Force Report* [prepared for the City of Houston and Harris County, 1986.] The Report outlines recommendations for preservation and improvement of the bayou and consists of a re-evaluation of earlier plans by Charles Tapley.
- 1993 Comprehensive Bikeway Plan (CEC)
- 2002 Jane Thompson, *et al*: *Buffalo Bayou and Beyond, a 20-Year Masterplan* [prepared for the Buffalo Bayou Partnership, the City of Houston, Harris County and Harris County Flood Control, 2002.] An extensive $1.2 million plan encompassing economic, ecologic, recreational, artistic, hydraulic and demographic features of a 10-mile stretch of the bayou. This plan included recommendations for the restoration of many natural features that historically existed in the West Sector.

CHAPTER 4
ASSESSMENT OF EXISTING RESOURCES

4.1 Geology
The Buffalo Bayou watershed is located directly above the Beaumont Formation, the youngest of the Pleistocene age geological formations. This formation is closest to the surface in the Pineywod and Gulf Prairie and Marsh vegetation areas, and consists of clay, silt and fine sand arranged in spatial patterns that reflect the fluvial and coastal, mudflat and marsh origins of the materials. Buffalo Bayou has incised deep into the surface of the underlying Beaumont Formations. 150 years ago, the Bayou surface was closer to the adjacent land surface elevation than today. These changes occurred through recent changes in hydrology due to human engineering and development, Bayou base-level lowering as it readjusts to the Bay, decreased sediment supply to the system, and urban encroachment (Collins, TC&B Environmental Quality and the Ecoregion Report, May 2002).

4.2 Soils
The soils found along the banks of Buffalo Bayou are the result of interactions between five soil-forming factors: 1) climate, 2) parent material, 3) relief, 4) organisms, and 5) time. The general distribution of surface soils indicates that the lower reaches of Buffalo Bayou consist of Ijam-Harris soils (Entisols-Mollisols). To the north and south of the Bayou, soils are composed of Lake Charles, Bernard and Edna soils (Vertisols, Mollisols, Entisols). (Collin, TC&B Environmental Quality and the Ecoregion Report, May 2002).

4.3 Slope Stability and Erosion
The banks of the Buffalo Bayou are extremely susceptible to erosion. The velocities of storm flows, the controlled release of Barkers Reservoir and the resulting water table fluctuations continue to degrade the Bayou banks. In doing so, clay particles remain or re-suspend maintaining a murky and turbid condition. Erosion types found in the West Sector include slumping, toe erosion, bank and bed scour, and runoff.

4.4 Flooding
Due to the topographic relief of the West Sector, the entire park is designed for, and susceptible to, severe flooding and high water velocity during storm events. Numerous times a year, Bayou waters rise over its banks and flood the Park and most of the surrounding corridor sections east and west of the park. The Bayou's corridor slopes provide storage capacity for the surrounding metropolitan areas with 25 functioning outfalls which transport stormwater from nearby streets into the park corridor.

4.5 Line-Intercept Transect Vegetation analysis
Eleven random Line-intercept transect samplings were completed in the unmaintained areas of Buffalo Bayou Park. Data were tabulated on the basis of plants lying on a straight line. Sampling locations are identified in Appendix I.

Procedure
For line-intercept sampling in the West Sector, 20-meter transects were defined with a tape measure, identified by steel stakes and numbered. Transects were randomly acquired using a random number table within significant management zones. Sampling began at one end of the transect and data was recorded moving down the transect. All plants that fell within a 1-cm strip of the line were counted, including plants whose aerial foliage overlay the transects. In the event where individual plants were difficult to distinguish and count, clumps were counted rather than individual stems, stalks, or shoots.

For each zone sampled, species, measurements of intercept length, latitude/longitude, and dbh (diameter at breast height) were recorded. Field summaries of temporal and spatial data were also logged. Where several strata existed, each stratum was surveyed separately.

4.6 Vegetation Inventory Analysis
On the basis of dominant vegetation, location, use and maintenance regimen, Buffalo Bayou Park has been divided into ten management zones. Buffalo Bayou Parks existing Vegetation Zones include:

Zone 1	Riparian
Zone 2	Tributaries
Zone 3	Forests
Zone 4	Wildflower Slopes
Zone 5	Prairie
Zone 6	Wetlands
Zone 7	Maintained Active-use Parkspace
Zone 8	Maintained Passive-use Parkspace
Zone 9	Ornamental Gardens

Subsequent to channelization in the 1950's, portions of the West Sector were turned into usable park space planted with specimen trees and Bermuda grass turf establishing vast lawn-like space. Other areas, where the ground depressed and held water, or areas that contained a relatively constant source of running water were allowed to reseed with the deposition of seeds from birds, wind and flooding. Leaving these areas alone allowed them to succeed under semi-natural conditions enabling both native and invasive vegetation to establish and flourish. Park zones vary in composition from highly managed landscape and lawn areas containing controlled species growth, to natural conditions of native riparian and forest remnants. Other natural areas such as prairies and wildflower slopes have been carved from the existing maintained areas of the park.

In wooded zones, the most common, oldest and significant tree species are noted as the "dominant tree species", while shrub species covering over 10% of area are recorded as "dominant shrub species." Common grasses and forbs are recorded as "dominant non-woody." Invasive species, covering large portions of zones are recorded as "dominant invasive spp." For maintained landscapes, groundcover and canopy were recorded.

4.7 Vegetation Zones

Zone 1 Riparian Edge of Buffalo Bayou

Acreage:	19.6 acres
Slope:	North and South
Soils Present:	Sediment
Canopy Closure:	60-75%
Dominant Trees:	black willow, elderberry, cottonwood, red mulberry, rough-leaf dogwood
Dominant Shrubs:	yaupon holly
Dominant Non-Woody:	romerillo, Philadelphia fleabane, Paspallum spp.
Dominant Vines:	morning glory, mustang grape
Dominant Invasive Spp:	giant ragweed, love in a puff, Johnson grass, Chinaberry, Chinese tallow

The riparian zone of Buffalo Bayou contains both heavily woody conditions and bare slopes of exposed sediment with relatively few native herbaceous plants. Approximately one-quarter mile of bank has been stabilized using brick, and another 870 feet with gabion baskets and riprap. No restoration work using bioengineering techniques or managed succession is known to have occurred within the Park. Because riparian conditions are largely limited by swaled or sloped maintained park space, pioneer species have little or no room to establish after the existing vegetation is gone. Areas that are wide enough are typically overwhelmed by invasive plants that have poor stabilization capabilities.

Zone 2 Tributaries

Acreage:	6.8 acres
Soils:	Sediment
Canopy:	80-90%
Dominant Trees:	bald cypress, black willow, river birch, roughleaf dogwood, elderberry,
Dominant Shrubs:	wax myrtle
Dominant Non-Woody:	turk's cap, Philadelphia fleabane, lantana
Dominant Vines	morning glory, poison ivy, passion flower
Dominant Invasive Spp:	giant ragweed, Johnson grass, giant reed, Chinese tallow, Chinaberry
Down Woody Debris (ave/acre)	n/a
Snags/acre	3

Tributaries contain a mixture of native, non-native and invasive plants. Three tributaries have had initial restoration work done to them including plantings native trees and various native groundcover for stabilization after invasive plants have been weeded. Much of this work has been done on a volunteer basis typically involving weeding, litter removal and tree planting. For the most part, these small tributaries in the Park have gone unmaintained and unnoticed for decades.

Zone 3 Forest

Acreage:	6.7 acres
Soils:	Clay and fill material
Canopy:	70-85%
Dominant Trees:	cottonwood, sycamore, water oak, elderberry
Dominant Shrubs:	n/a
Dominant Non-Woody:	Philadelphia fleabane, lantana
Dominant Vines	mustang grape, morning glory, poison ivy, passion flower
Dominant Invasive Spp:	giant ragweed, Chinaberry, Chinese tallow

Forests, existing around tributaries and small pools on the West end of the park have been allowed to grow without interference from PARD maintenance. The largest forest on the southwest side of the park is seasonally flooding acting as a green tree reservoir (although it is currently unknown if it functions ecologically as a green tree reservoir) while the other forest areas on the southside are expanded regions of tributaries. These areas have tremendous potential to become accessible native tree stands with the establishment of hiking trails. Currently they have little to no access due to dense stands of invasive species that block their perimeter. Leaving the forest neglected creates numerous problems including safety issues, homeless shelters and storehouses for invasive species that are allowed to reseed the forest year after year.

Zone 4 Wildflower slopes

Acreage:	1.5 acres
Soils:	Clay fill
Canopy:	n/a
Dominant Trees:	n/a
Dominant Shrubs:	n/a
Dominant Non-Woody:	bee-balm, black-eyed Susan, phlox, clasping-leaf coneflower, skullcap, Texas vervain, Indian blanket, bluebonnet, lance-leaf loosestrife
Dominant Invasive Spp:	Bermuda grass, giant ragweed

Two slopes in the West Sector are currently classified as wildflower slopes. Established in the fall of 2003 they have done very well for their first year blooming all spring and summer. The slopes were mowed by the Parks Department in July. A second annual seeding will be performed in November 2004.

Zone 5 Prairie

Acreage:	0.5 acres
Soils:	Alluvial, clay fill material
Canopy:	n/a
Dominant Trees:	n/a
Dominant Shrubs:	n/a
Dominant Non-Woody:	bee-balm, common sunflower, clasping-leaf coneflower, foxtail, little bluestem, *Paspallum floridanum*
Dominant Invasive Spp:	giant ragweed, bermuda grass

One half-acre prairie exists in the West Sector. It started as a demonstration project in 2003 to determine establishment procedures, maintenance and long-term management of prairies. The area was mowed by the Parks Department in July and has since been mowed on a 14-day cycle, possibly causing summer and fall forbs and grasses to be lost. Before mowing, maintenance for the prairie included removing invasive giant ragweed three times during the spring and summer.

Future sites for more prairie restoration projects will be limited to level areas between the riparian zone and the first sideslope. These surfaces are the least used as recreational space and offer better growing conditions than higher terraces. Criteria for selected areas for the establishment of prairies included location, pedestrian access, pedestrian visibility, prior use and environmental conditions.

Zone 6 Wetlands

Acreage:	0.25 acres
Soils:	Clay
Canopy:	20-30%
Dominant Trees:	bald cypress, black willow, sweet-bay magnolia
Dominant Shrubs:	yaupon holly
Dominant Non-Woody:	spikerush, pickerel weed, grassy arrowhead, southern blue-flag iris, spiderwort, white-topped sedge
Dominant Invasive Spp:	alligatorweed, wedilia

Only one wetland has been established in the West Sector. Located at the head of the Tapley Tributary at the northeast end of the park, this man-made wetland created by combined community effort contains over 20 species of native wetland plants.

Zone 8 Maintained Active-Use Park Space

Acreage:	41 Acres
Slope	Variable
Soils Present:	Clay fill material, alluvial
Canopy Closure	20%
Dominant Trees:	live oak, Chinese elm, shumard oak, red maple, crape myrtle
Dominant Shrubs:	n/a
Significant Non-woody:	Bermuda grass
Significant Invasive Species:	n/a
Down Woody Debris:	n/a

Terraced active use park space describes turf areas that are mowed and maintained regularly by PARD and receives more use than zone 9.

Zone 9 Maintained Passive-Use Park Space

Acreage:	60 acres
Slope	Variable
Soils Present:	Clay fill material, alluvial
Canopy Closure	30%
Dominant Trees:	live oak, Chinese elm, shumard Oak, red Maple, crape myrtle
Dominant Shrubs:	n/a
Significant Non-woody:	Bermuda grass
Significant Invasive Species:	n/a
Down Woody Debris:	n/a

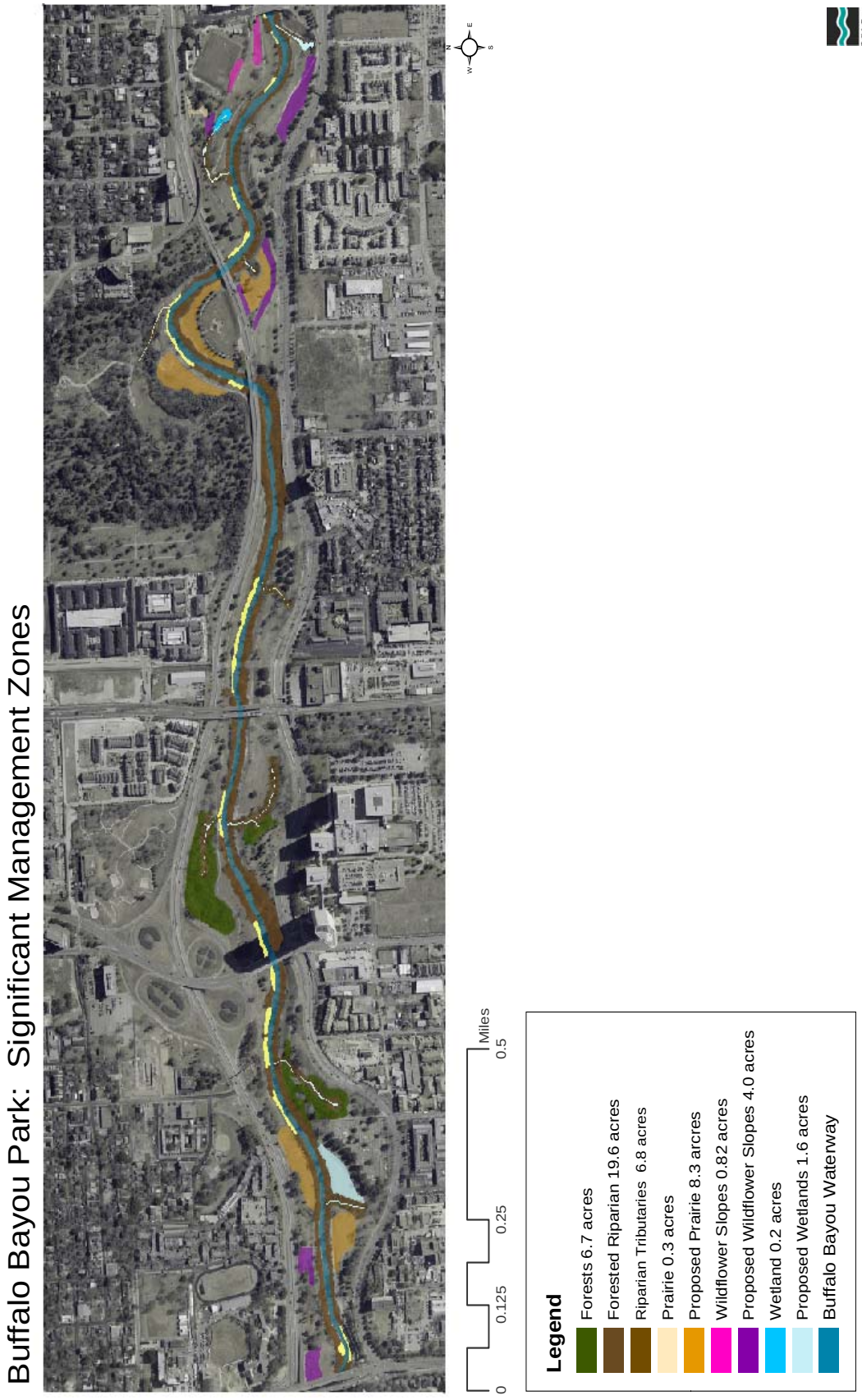
Maintained passive-use park space is the area mowed and maintained regularly by PARD receiving the least amount of traffic of the maintained park space. Zone 9 offers the greatest potential to expand and restore the riparian, tributary and forest zones and establish wildflower slopes and prairies.

Terraced turf conditions (active and passive) primarily receive full-sun. Bermuda grass forming a lawn like appearance serves as a closely cropped ground cover for most of the year. Winter rye overseeding occurs on an irregular basis. Native and non-native trees, such as live oak, American sycamore and Chinese elm have been dispersed throughout to stand as specimens that grow in 360 degrees of turf. They provide shade along trails and throughout the turf. Active and passive turf areas are mowed and pruned on a 14-day summer cycle. Trees along the trail are generally pruned to 8 feet high; along the road 14 feet; and those trees that are neither along trails and roads are pruned high enough for PARD mowers to move under their canopy.

Zone 10 Ornamental Gardens

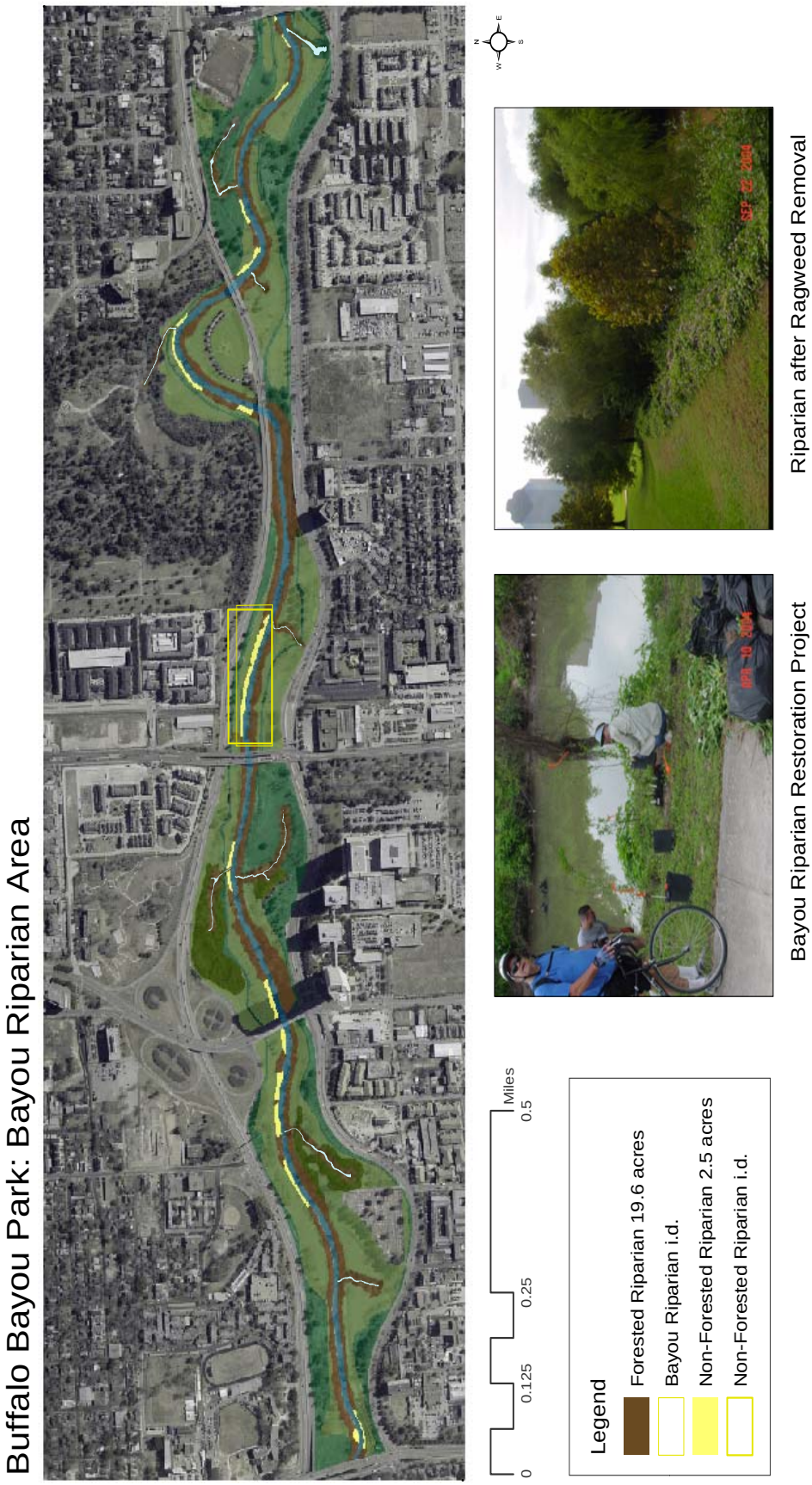
Count:	2
Acreage:	0.7 acres
Soils Present:	Transplanted Top Soil with clay-fill base
Canopy Closure:	75-85%
Dominant Trees:	live oak
Dominant Shrubs:	azaleas,
Dominant non-woody:	Rotating showy forbs
Dominant Invasive Spp:	giant cane

The Jane Gregory Garden and the Wortham Fountain Garden are more formal gardens containing a mix of showy native and non-native herbaceous plants backed by stands of trees and shrubs. Tree canopy above the gardens are pruned back to allow sunlight to penetrate to the gardens and allow pedestrian access. The Jane Gregory Garden has a path winding through it and a bench to sit under the trees. Gardens are mulched annually and receive spring plantings by PARD.


Buffalo Bayou Park: Significant Management Zones
Legend
Forests 6.7 acres
Forested Riparian 19.6 acres
Riparian Tributaries 6.8 acres
Prairie 0.3 acres
Proposed Prairie 8.3 arcres
Wildflower Slopes 0.82 acres
Proposed Wildflower Slopes 4.0 acres
Wetland 0.2 acres
Proposed Wetlands 1.6 acres
Buffalo Bayou Waterway
0
0.125
0.25
0.5
Miles

Significant Management Zones (SMZ) are those areas in the Park that require maintenance beyond the current practices of the PARD, the Buffalo Bayou Partnership and other groups that work in the park. Six of the ten vegetative zones have been classified as significant management zones. They were classified as such because they offer the greatest potential to preserve and protect aquatic resources, restore ecological integrity, restore natural structure, restore natural function, address ongoing causes of degradation and restore self-sustainability (EPA: River Corridor and Wetland Restoration). They also contain unique features such as upper canopy forest and small, flowing streams that, with proper management, add interest and aesthetic value to the Bayou.

Sections 5.1, 5.2 and 5.3 SMZ's are already established throughout the Park. These areas need to be restored and managed for them to provide greater benefits to the Park. Sections 5.4, 5.5 and 5.6 SMZ's exist in the park only as pilot projects. These zones are included here because of the success of the pilot projects for increasing species diversity, wildlife habitat and park interest. Procedures for establishment are recommended here on the basis of the lessons learned in the pilot project.


Buffalo Bayou Park: Bayou Riparian Area
Legend
Forested Riparian 19.6 acres
Bayou Riparian i.d.
Non-Forested Riparian 2.5 acres
Non-Forested Riparian i.d.
0
0.125
0.25
0.5
Miles
Bayou Riparian Restoration Project
Riparian after Ragweed Removal

Riparian areas, also known as riparian zones, streamside zones, stream protection zones and buffer strips, are the transitional boundaries between aquatic and terrestrial ecosystems. This unique condition contributes to water quality by removing pollutants, nutrients and sediment, reducing sheetflow maintaining lower water temperatures and creating aquatic habitat. The riparian ecosystem also enhances wildlife habitat on land and greatly increases biological diversity of a region. In addition to their ecological importance, riparian conditions provide a range of functions with economic and social value. (Kilgore,4).

In the West Sector, the riparian zone is generally the area between the bayou channel and the point at which PARD stops mowing managed parkspace, or the transition from the Bayou to a tributary. Numerous studies report that potential contributions of riparian vegetation to the ecological functions within a stream are present within the first 15 to 100 feet from the stream bank. "RMZ widths in that range typically provide at least 50 percent of potential effectiveness and often 75 percent or greater effectiveness at protecting various stream functions" (Castelle and Johnson 2000).

The riparian zone of the West Sector varies greatly in size and condition. Some portions contain overgrown understories consisting of tall invasive plants such as giant ragweed with an upper canopy engrossed in vines; a vegetative condition typical of riparian transitioning into a forested tributary. Other portions are barren eroding banks. Eroding banks with no upper canopy are dominated by giant ragweed leaving them susceptible to further erosion requiring streambank stabilization intervention to restabilize an eroding bank. Other sections of the riparian zone are over 20 feet wide with a strong bank composed of adequate species diversity.

Restoration and Management Recommendations

Objectives:
- Establish section boundaries and needs
- Remove invasive and noxious vegetation
- Re-establish native riparian vegetation
- Prune hazardous trees and specific visual obstructions
- Develop a maintenance schedule

Area: 20 acres corresponding to Vegetation Zone 1

Restoration:
When restoring the riparian zone, divide the area into manageable plots to restore sections at a time. Where possible, use natural breaks and begin with sections that offer the most to the corridor in both appearance and function. After assessing the boundary and condition of the site, outline the steps needed for restoration. Restoration of 20 foot wide and greater thriving natural riparian sections will only involve routine fringe maintenance of ragweed, pruning hazard branches, cut-treat herbicide applications to invasive trees and planting native understory vegetation. Under 20 to 30 feet wide, native woody and herbaceous riparian vegetation should be planted through managed parkspace to increase the width of the section with desired species. Sections of severe erosion will require streambank stabilization and the establishment of a minimum 20 foot riparian zone planted with native riparian vegetation.

Canopy: Dominant trees throughout the RMZ include black willow (*Salix nigra*), cottonwood (*Populus deltoids*), elderberry (*Sambucus canadensis*), American sycamore (*Plantanus occidentalis*), rough-leaf dogwood (*Cornus drummondii*).

Understory: Along the tree line, dominant vegetation includes rough-leaf dogwood (*Cornus drummondii*), elderberry (*Sambucus canadensis*), romerillo (*Bidens alba*), morning glory (*Ipomoea cordatortriloba*), Philadelphia fleabane (*Erigeron philadelphicus*), wood sorrel (*Dryopteris marginalis*), and common sunflower (*Helianthus annuus*).

Invasive plants: Giant ragweed (*Ambrosia trifida*) dominates canopy fringes along the bank and in treeless areas. Woody invasive species include Chinaberry (*Melia azedarach*) and Chinese tallow (*Sapium sebiferum*). On the western end, dense stands of Chinaberry cover the south banks.

RIPARIAN MAINTENANCE FREQUENCY SCHEDULE:

Month																									
Maintenance Management Practices	Jan		Feb		Mar		Apr		May		June		July		Aug		Sept		Oct		Nov		Dec		Total
Weeding & Invasive spp																									
Trees																x									**1**
Shrubs	x	x																							**2**
Herbs						x		x		x		x		X											**5**
Tree Pruning	x	x																					x	x	**4**
Plantings																									
Trees																									
Shrubs																									
Herbs																									
Fringe Mowing								x			x		x			x									**4**

Indicates range of time to perform maintenance
x Indicates specific times to perform maintenance

WEEDING AND INVASIVE SPECIES CONTROL
Weeding in the riparian zone should be done in sections, beginning with the most visible areas. Weeding the east and west ends, Eleanor Tinsley Park and Bayou edges around tributaries will visually expose the waterway to park users and vehicular traffic on Allen Parkway and Memorial Drive. Because the Bayou is a virtual seed highway, rising water consistently delivers new seeds that must be addressed during the summer months. Weed as needed during the growing season and should be done monthly in newly planted areas. Manage woody invasive species in July and August before the tree goes dormant. To prohibit coppicing re-growth of woody species a systemic herbicide will be used. A complete list of acceptable herbicides used for invasive species control is located in Appendix III.

REMOVING PLANTS
Unlike invasive species, the removal of native trees should be conducted only under the following conditions:

- To relieve conditions where floatable materials caught in foliage and unnatural eddies cause flooding or danger on the waterway,
- To remove hazardous trees threatening the safety of maintenance personnel or park users,
- To allow for more desired trees during the restoration of a site.

PRUNING TREES
Limit tree pruning within the riparian zone to limbs blocking visual access to specific areas and to overhanging limbs that back up floatables in the waterway. Procedures for pruning are located in section 6.2.

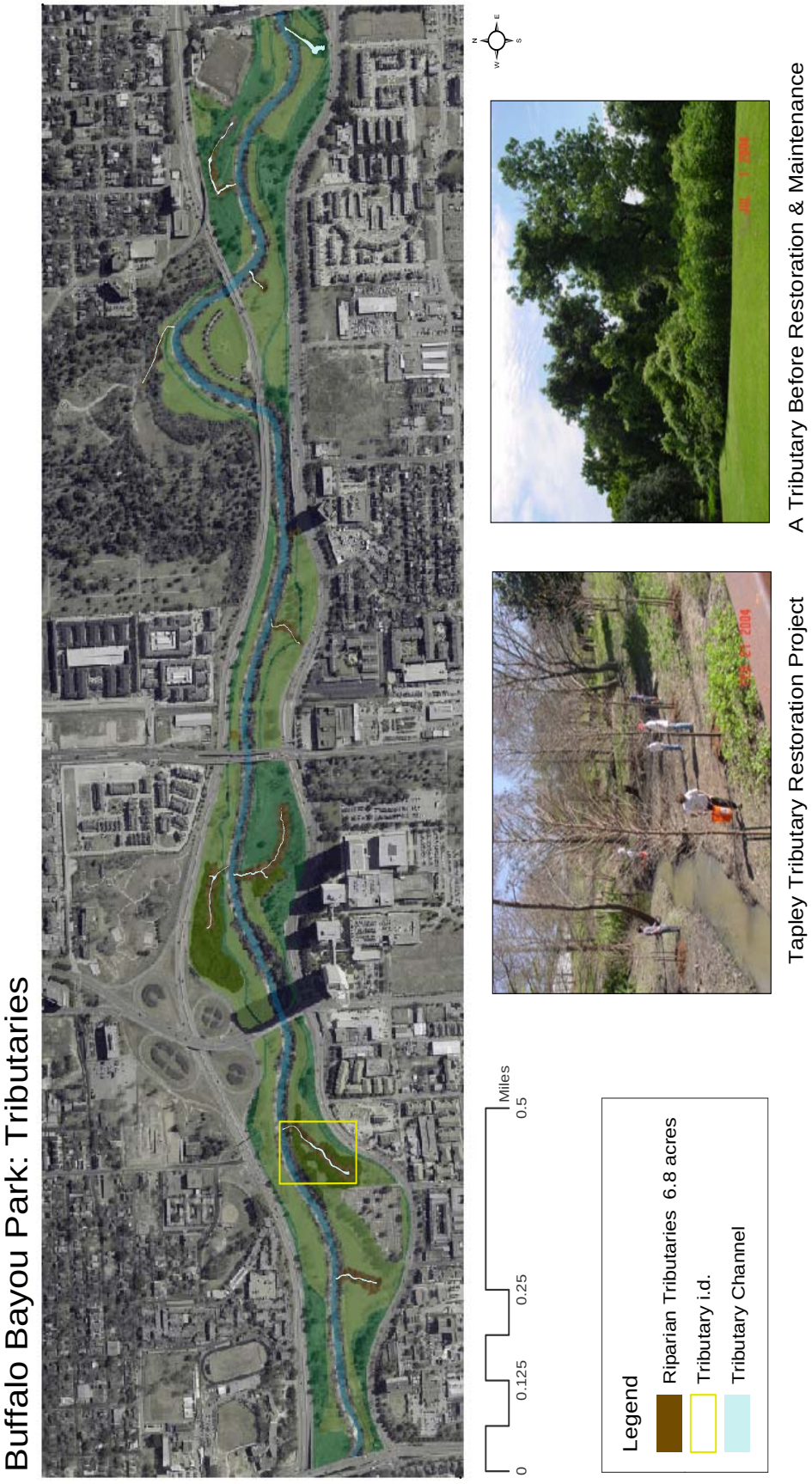
PLANTING RIPARIAN VEGETATION
Tree and herbaceous planting should primarily occur when widening the riparian zone for bank stabilization and improving ecological integrity. When choosing native plants, those best adapted to the riparian zone for bank stabilization and for water treatment purposes are preferred. A complete list of riparian vegetation is located at the end of this section. Follow mulching procedures in section 6.2 for any tree installations performed in the riparian zone

MOWING
Mow riparian fringes in conjunction with hand weeding and power weeding at least four times per year to prohibit giant ragweed from going to seed and to maintain a clear view of the bayou and native riparian conditions.

TWO YEAR CARE
Riparian care for new plantings is limited to minor pruning and removing invasive species where they may overtake the natives before they are established.

Riparian Restoration Plant List

Scientific Name	Common Name	Type	Status
Acer negundo	Box Elder	Tree	
Betula nigra	River Birch	Tree	
Catalpa bignonioides	Southern Catalpa	Tree	
Cornus drummondii	Rough-leaf Dogwood	Tree	
Fraxinus pennsylcanica	Green Ash	Tree	
Liquidamber styraciflua	Sweetgum	Tree	
Morus rubra	Red Mulberry	Tree	
Pinus taeda	Loblolly Pine	Tree	
Plantanus occidentalis	American Sycamore	Tree	
Populus deltoids	Eastern Cottonwood	Tree	
Quercus nigra	Water Oak	Tree	
Quercus phellos	Willow Oak	Tree	
Quercus prinus	Swamp Chestnut Oak	Tree	
Salix nigra	Black Willow	Tree	
Sambucus canadensis	Elderberry	Tree	
Taxodium distichum	Bald Cypress	Tree	
Ilex vomitoria	Yaupon Holly	Shrub	
Chasmanthium latifolia	Inland Sea Oats	Grass	
Schizachyrium scoparium	Little Bluestem	Grass	
Tridens strictus	Long-Spike Tridens	Grass	
Bidens Alba	Romerillo	Forb	
Cassia fasciculata	Partridge Pea	Forb	
Erigeron philadelphicus	Daisy Fleabane	Forb	
Melocactus intortus	Turk's Cap	Forb	
Passiflora incarnata	Passion Flower	Forb	


Buffalo Bayou Park: Tributaries
Legend
Riparian Tributaries 6.8 acres
Tributary i.d.
Tributary Channel
0
0.125
0.25
0.5
Miles
A Tributary Before Restoration & Maintenance
Tapley Tributary Restoration Project

Tributaries play an important role to the health of stream systems. Buffalo Bayou Park tributaries are formed by stormwater outfalls ending somewhere in the corridor, instead of reaching the actual waterway. The riparian zone of tributaries provides increased opportunities for wildlife habitat, and can function as a treatment zone for effluent, when treatment vegetation is established. Preliminary water tests should be run on the effluent to help determine types of vegetation best suited for each tributary before beginning restoration. Tributaries also offer a natural aesthetic that park users enjoy seeing and interacting with.

Tributary management zones (TMZ) are similar to the Bayou's riparian management zone but include a more diverse topography with intermittent flow. Typically in TMZ's, the entire channel has an upper tree canopy and the channel itself is between 6 inches and 5 feet wide. Many tributary management zones have had deliberate tree and herbaceous vegetation plantings of both native and non-native plants to decrease erosion and for beautification. Maintenance procedures for TMZ's will follow the same procedures as RMZ's. During restoration some added plant material may vary slightly to increase diversity of the corridor but should be restricted to the TMZ plant list.

Restoration and Management Recommendations

Area: 6.8 acres corresponding to vegetation zone 2.

Objectives:
- Increase the riparian width with trees,
- Remove invasive species,
- Re-establish herbaceous riparian vegetation,
- Prune hazard trees and specific visual obstructions.

RESTORATION
The Bayou banks once hosted dozens of natural tributaries. Today, these streams have been channelized and the water arrives at the Park from neighboring areas through storm drains. While the origins of the tributaries are unlikely to be restored to pre-development conditions, the small areas between stormwater outfalls and the Bayou itself can improve some ecological benefits to the Bayou and the Park.

Restoration should begin by removing herbaceous invasive species like ragweed and love in a puff. Mulch the banks after removing large sections of invasives to stabilize the banks and to deter re-growth of invasives. Next, use a systemic herbicide to remove invasive trees such as Chinese tallow and chinaberry. Replanting should follow with native trees and understory plants. To provide a dense canopy, trees should be planted throughout the tributaries riparian area and should be extended laterally through turf parkspace to widen the forest canopy when applicable. This will not only increase wildlife habitat but will also decrease park maintenance. Additionally, adding rocks and boulders, grading slopes and excavating pools to establish pool, riffle and run conditions will increase ecological integrity and the aesthetic value of the channel.

Canopy: The majority of the native tree canopy is composed of black willow (*Salix nigra*), bald cypress (*Taxodium distichum*), water oak (*Quercus nigra*), elderberry (*Sambucus canadensis*), red mulberry (*Morus rubra*), American sycamore (*Plantanus occidentalis*) and eastern cottonwood (*Populus deltoids*).

Understory: The understory consists of herbaceous plants including Turk's cap (*Melocactus intortus*), wedilia (*Wedilia trilobata*), passion flower (*Passiflora incarnata*), *Paspallum spp*., morning glory (*Ipomoea cordatortriloba*) and mustang grape (*Vitis mustangensis*).

Invasive plants: Invasive species include woody species such as Chinese tallow (*Sapium sebiferum*), Chinaberry (*Melia azedarach*); herbaceous plants including giant ragweed (*Ambrosia trifida*), love in a purr (*Cardiospermum halicacabum*), Johnson grass (*Sorghum halepense*) and giant reed (*Arundo donax*).

TRIBUTARY MAINTENANCE FREQUENCY SCHEDULE:

	Month																								
Maintenance Management Practices	Jan		Feb		Mar		Apr		May		June		July		Aug		Sept		Oct		Nov		Dec		Total
Weeding & Invasive spp																									
Trees																	x								1
Shrubs																									
Herbs						x			x			x			x							x			4
Tree Pruning	x	x		x		x		x														x			2
Plantings																									
Trees					x		x		x										x						4
Shrubs					x																				1
Herbs					x														x						2
Selective Weed Cutting on Parameter					x			x				x													3
Vine Removal	x	x			x															x	x				5

Indicates range of time to perform maintenance

x Indicates specific times to perform maintenance

WEEDING AND INVASIVE SPECIES CONTROL

Weeding tributaries should occur primarily around the perimeter of the tree canopy and within the tributary where light penetrates. Relieving the perimeter of tall invasive species allows light into the interior of the tributary including the waterway to the Bayou exposing small rippling falls and pools that have naturally formed.

REMOVING PLANTS

Removal of trees should be conducted with sensitivity to the goals. Most often, the only native trees that should be removed are hazardous trees and trees that block access into the tributary and cannot be pruned accordingly. In rare cases, a tree can be removed to allow for more desirable native species. Leave at least 5-10% of the cut woody material inside the tributary to add decomposing wood to the soil system.

PRUNING TREES

Trees along the perimeter should be pruned for two reasons. First, removing low branches around the perimeter enables much easier maintenance of the area. Secondly, it enhances the view into and around tributaries and the overall appearance of the tributary. It is also necessary to cut down any hazardous tree limbs in or around the tributary. Because the interior of tributaries often already have a high canopy, little pruning will be necessary inside the riparian zone unless the area has never been pruned or it is a young system. In such cases, initial interior pruning may be extensive. Leave at least 5-10% of the cut woody material inside the tributary. Standard pruning procedures are located in section 6.2.

PLANTING RIPARIAN VEGETATION

Tree planting can be done either within the tributary when more desirable trees are needed or around the perimeter of the tributary to increase its area and push back ragweed fringes. Understory herbaceous material should be planted to increase diversity and to stabilize tributary banks. Follow mulching procedures for any tree installations performed. Establish a 2 inch layer of mulch around herbaceous installations.

VINE REMOVAL

Vines are often a problem around the perimeter of tributaries. Removing vines is part of the initial maintenance done around perimeter and from around tree trunks.

TWO YEAR CARE

Continued removal of giant ragweed will be necessary for the first two years to allow for native plants to become established and to maintain its appearance. Watering and periodic stake adjustments and stake removal will be necessary to establish new plants. Tree stakes should be removed no earlier than one year after planting and no later than two years.

Tributary Restoration Plant List

Scientific Name	Common Name	Type	Status
Betula nigra	River Birch	Tree	
Cornus drummondii	Rough-leaf Dogwood	Tree	
Crataegus marshallii	Parsley Hawthorne	Tree	
Fraxinus pennsylcanica	Green Ash	Tree	
Liquidamber styraciflua	Sweetgum	Tree	
Morus rubra	Red Mulberry	Tree	
Pinus taeda	Loblolly Pine	Tree	
Plantanus occidentalis	American Sycamore	Tree	
Populus deltoids	Eastern Cottonwood	Tree	
Quercus nigra	Water Oak	Tree	
Quercus phellos	Willow Oak	Tree	
Quercus prinus	Swamp Chestnut Oak	Tree	
Salix nigra	Black Willow	Tree	
Sambucus canadensis	Elderberry	Tree	
Taxodium distichum	Bald Cypress	Tree	
Tilia caroliniana	Carolina Basswood	Tree	
Ulmus crassifolia	Cedar Elm	Tree	
Ilex vomitoria	Yaupon Holly	Shrub	
Symphoricarpos orbiculatus	Coral Berry	Shrub	
Chasmanthium latifolia	Inland Sea Oats	Grass	
Schizachyrium scoparium	Little Bluestem	Grass	
Tridens strictus	Long-Spike Tridens	Grass	
Iris virginica	Southern Blue Iris	Forb	
Bidens Alba	Romerillo	Forb	
Hymenocallis liriosme	Spider Lilly	Forb	
Melocactus intortus	Turk's Cap	Forb	
Passiflora incarnata	Passion Flower	Forb	
Dryopteris marginalis	Common Wood Fern	Fern	
Lorinseria areolata	Chain Fern	Fern	
Onoclea sensibilis	Sensitive Fern	Fern	
Parthenocissus quinquefolia	Virginia Creeper	Vine	


Buffalo Bayou Park: Forests
Legend
Forests 6.7 acres
Forest example
Riparian Tributaries 6.8 acres
0
0.125
0.25
0.5
Miles
Forest Condition From the Trail
Interior Conditions of Corridor Forests

The importance of forests within urban areas cannot be underestimated. Forests provide many functions to cities including "the absorption of carbon dioxide by trees, reduction in temperature and provision of habitat for urban wildlife, they act as natural storm water management areas filtering particulate matter (pollutants, some nutrients, and sediment) and by the absorption of water, and they reduce noise levels, provide recreational benefits and increase property value" (EPA Office of Water).

Forest management zones (FMZ's) between Shepherd Drive and Sabine Street are extended riparian zones of the Bayou or its tributaries, or surround ephemeral pools with an average tree canopy at least 30 feet beyond the center of the reservoir. These conditions make them difficult to maintain within the framework of PARD maintenance policy. Because there is little or no fringe maintenance of forest', perimeters form a thick vegetative barrier that discourages accessibility to their interior atmosphere while also decreasing the aesthetic value, safety and overall experience of the corridor. Maintenance of forests will create a substantial aesthetic boost to the area with minimal effort.

Objectives:

- Increase fringe maintenance
- Increase the forest acreage through perimeter tree plantings
- Remove invasive species
- Increase native forest species abundances
- Prune hazard trees and specific visual obstructions

Actual Area: 6.7 acres corresponding to vegetation zone 3

Canopy: Dominant mature trees in forest zones include cottonwood (*Populus dactyloides*), American sycamore (*Plantanus occidentalis*), loblolly pine (*Pinus taeda*), water oak (*Quercus nigra*), cedar elm (*Ulmus crassifolia*), red mulberry (*Morus rubra*) and green ash (*Fraxinus pennsylvanica*).

Understory: The interior of forest understory receives almost no direct sunlight, allowing few plant species to grow. The dominant understory plants found in West Sector forest' include elderberry (*Sambucus canadensis*), flowering dogwood (*Cornus florida*), southern dewberry (*Rubus trivialis*) passion flower (*Passiflora incarnata*), mustang grape (*Vitis mustangensis*) and poison ivy (*Rhus toxicodendron*).

Invasive species: Invasive species include woody species in the interior such as Chinese tallow (*Sapium sebiferum*), chinaberry (*Melia axedarach*), herbaceous plants on the forest fringe including giant ragweed (*Ambrosia trifida*), Johnson grass (*Sorghum halepense*)

FOREST MAINTENANCE FREQUENCY SCHEDULE:

	Month																								
Maintenance Management Practices	Jan		Feb		Mar		Apr		May		June		July		Aug		Sept		Oct		Nov		Dec		Total
Weeding & Invasive spp																									
Trees																	x	x							2
Shrubs																	x	x							2
Herbs						x		x																	2
Tree Pruning			x		x		x																	x	4
Plantings																									
Trees					x			x											x						3
Shrubs					x			x																	2
Herbaceous					x			x																	2
Vine Removal																		x		x		x			3
Fringe Maintenance						x		x			x		x			x		x							6

Indicates range of time to perform maintenance
x Indicates specific times to perform maintenance

INVASIVE SPECIES CONTROL
Dense stands of giant ragweed and vines are well established along the fringe which needs to be maintained throughout the spring and summer by bush hogging. Sensitivity should be taken to insure any native vegetation doesn't get lost which may require site specific hand weeding. Chinese tallow and chinaberry have established periodically throughout the forest interior, as well as along forest perimeter. Once a year trees and saplings should be cut and treated with herbicide to insure complete removal. Procedures for invasive species control are described in section 6.4.

REMOVING PLANTS
Tree removal should be limited to hazard trees. If a falling tree does not pose a threat to human safety, girdling or trimming to provide snag habitat is preferred to complete removal.

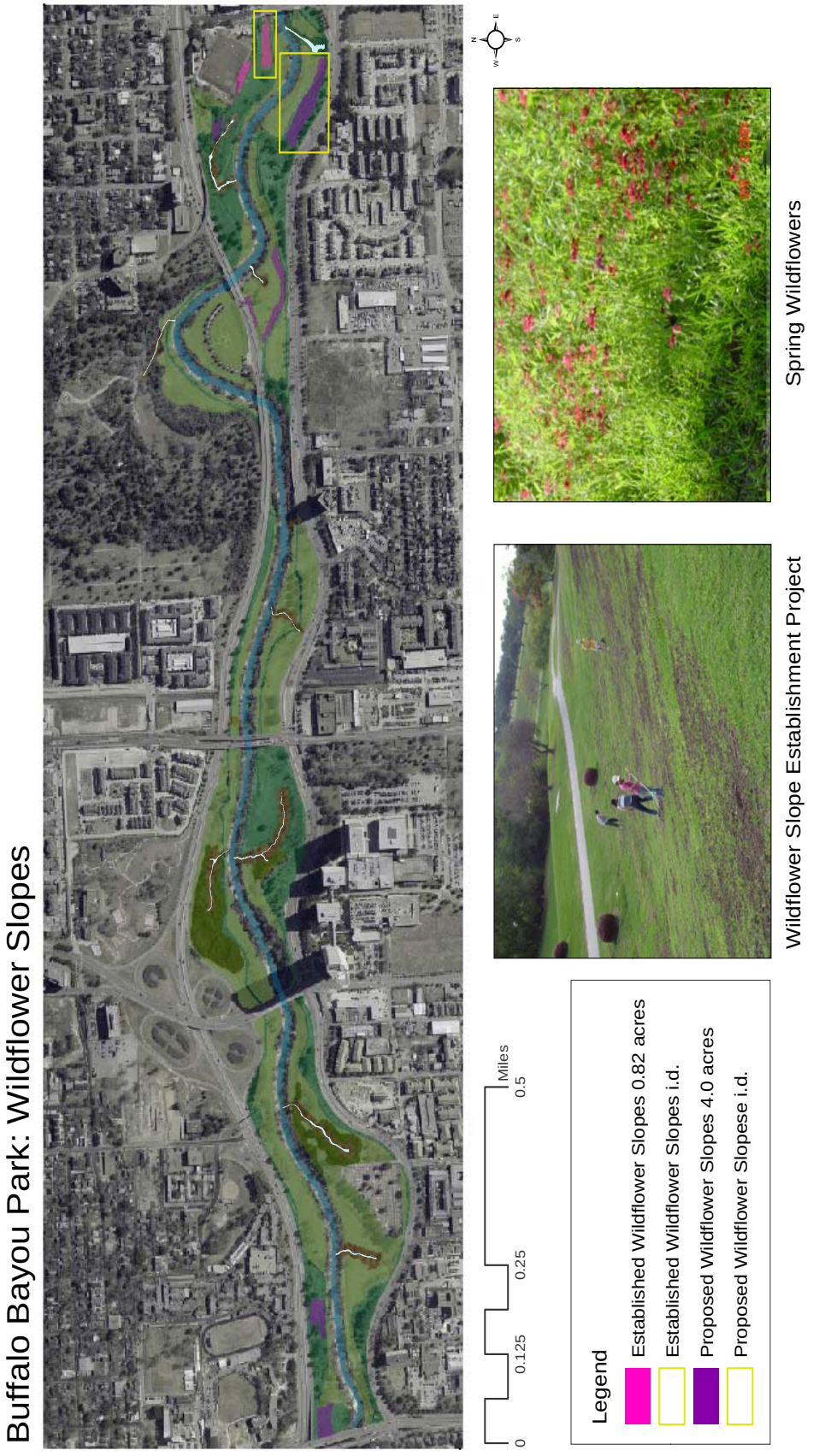
PRUNING TREES
Tree pruning should be limited to low hanging perimeter limbs that prohibit ease of maintenance to the vines and invasive species along the forest fringe. If a trail exists, hazardous tree limbs should be removed and placed along side the trail to provide a distinct boundary in conjunction with routine monitoring for new hazards. Large limbs removed during pruning should never be placed directly on tree root crowns. Standard pruning maintenance is detailed in section 6.2.

PLANTING FOREST VEGETATION
As in any forest, when a tree dies, falls or is removed, pioneer species move in and begin succession. In an area with little natural habitat such as the West Sector, these locations present an opportunity to plant both understory and desired saplings to out-compete less desirable species likely to grow, thus increasing diversity and improving the health of the system from the interior. With any new installation of trees mulch the base according to mulching procedures in section 6.2.

TWO YEAR CARE
Perimeter removal of invasive species and low hanging limbs through an establish maintenance program will enable forests to be viewed, increase safety and reduce homeless shelters. Planting herbaceous species and trees should be monitored on a quarterly basis to ensure the development of natives and watering, in some cases, may be necessary. If so, a bi-weekly, two year watering schedule should be developed at the time of planting.

Forest Restoration Plant List

Scientific Name	Common Name	Type	Status
Acer negundo	Box Elder	Tree	
Betula nigra	River Birch	Tree	
Carya illinoensis	Pecan	Tree	
Celtis occidentalis	Hackberry	Tree	
Cornus drummondii	Rough-leaf Dogwood	Tree	
Cornus florida	Flowering Dogwood	Tree	
Fraxinus pennsylvanica	Green Ash	Tree	
Liquidamber styraciflua	Sweetgum	Tree	
Magnolia grandiflora	Southern magnolia	Tree	
Morus rubra	Red Mulberry	Tree	
Pinus taeda	Loblolly Pine	Tree	
Plantanus occidentalis	American Sycamore	Tree	
Populus deltoids	Eastern Cottonwood	Tree	
Prunus caroliniana	Cherry-laurel	Tree	
Quercus alba	White Oak	Tree	
Quercus falcate	Souther Red Oak	Tree	
Quercus laurifolia	Laurel Oak	Tree	
Quercus lyrata	Overcup Oak	Tree	
Quercus macrocarpa	Bur Oak	Tree	
Quercus nigra	Water Oak	Tree	
Quercus phellos	Willow Oak	Tree	
Quercus prinus	Swamp Chestnut Oak	Tree	
Quercus shumardii	Shumard Oak	Tree	
Sambucus canadensis	Elderberry	Tree	
Taxodium distichum	Bald Cypress	Tree	
Tilia caroliniana	Carolina Basswood	Tree	
Ulmus crassifolia	Cedar Elm	Tree	
Illicuim floridanum	Florida Anise	Shrub	
Ilex vomitoria	Yaupon Holly	Shrub	
Itea virginica	Virginia Sweetspire	Shrub	
Leucothoe axilliaris	Coast Leucothoe	Shrub	
Leucothoe populifolia	Florida Leucothoe	Shrub	
Symphoricarpos orbiculatus	Coral Berry	Shrub	
Bidens Alba	Romerillo	Forb	
Oxalis stricta	Yellow Wood Sorrel	Forb	
Passiflora incarnata	Passion Flower	Forb	
Physla incise	Frog Fruit	Forb	
Physostegia spp.	Obedient Plant	Forb	
Rivina humilis	Pigeonberry	Forb	
Rubus trivialis	Southern Dewberry	Forb	
Stachys coccinea	Texas Betony	Forb	
Carex cherokeensis	Cherokee Sedge	Sedge	
Carex leavenworthii	Little Sedge	Sedge	
Chasmanthium latifolia	Inland Sea Oats	Grass	
Chasmanthium sessiliflora	Small Flowered Chasmanthium	Grass	
Muhlenbergia capillaris	Gulf Muhley	Grass	
Tridens strictus	Long-spike Tridens	Grass	
Tripsacum dactyloides	Eastern Gama Grass	Grass	
Dryopteris marginalis	Common Wood Fern	Fern	
Lorinseria areolata	Chain Fern	Fern	
Onoclea sensibilis	Sensitive Fern	Fern	


Buffalo Bayou Park: Wildflower Slopes
Legend
Established Wildflower Slopes 0.82 acres
Established Wildflower Slopes i.d.
Proposed Wildflower Slopes 4.0 acres
Proposed Wildflower Slopese i.d.
0
0.125
0.25
0.5
Miles
Spring Wildflowers
Wildflower Slope Establishment Project

Wildflower Slopes

Wildflower management zones (WMZ's) are areas where native forbs and grasses have been established to increase diversity, butterfly habitat and improve the overall appearance and enjoyment of Buffalo Bayou Park. Wildflower slopes also reduce annual maintenance costs, reduce cut organic debris into the Bayou and have no impact on floodwater conveyance (HCFCD). North and south facing sideslopes offer numerous locations throughout the Park to establish wildflowers. Existing wildflower slopes were established within active and passive use parkspace because few, if any, trees were growing on them and they enabled high visibility with low through traffic. Both existing and other recommended sites for future wildflower slopes are identified in map 5.4.

Area: 1.5 acres. Boundary corresponds with vegetation zone 4 consisting of two wildflower slopes. The areas were established in 2003 as a pilot project for Buffalo Bayou Park. They are located just west of Sabine Street on the top two north facing slopes. The largest of the two lies within the Buffalo Bayou artpark while the second, smaller one is just up the hill. Both can be observed from the Sabine Street Bridge throughout spring and early summer.

Groundcover: Dominant forbs include spotted bee balm (*Monarda punctata*), common sunflower (*Helianthus annuus*), Drummond's phlox (*Phlox drummondii*), skullcap (*Scutellaria drummondii*), Texas vervain (*Verbena halei*), brown-eyed Susan (*Rudbeckia hirta*) and Indian Blanket (*Gaillardia pulchella*).

Invasive and undesired plants: Dominant invasives include giant ragweed (*Ambrosia trifida*), Bermuda grass (*Cynodon dactylon*) and Johnson grass (*Sorghum halepense*).

Wildflower Slope Establishment and Management Recommendations

Objectives:

- Increase wildflower slope acreage (establishment)
- Maintain existing wildflower slopes
- Re-establish native wildflowers and grasses to Buffalo Bayou Park

Establishing a Wildflower Slope in Buffalo Bayou Park

The establishment of wildflower slopes begins by choosing an appropriate location that takes into account land use, visual accessibility, stormwater run-off filtering and erosion control. Recommended slopes are shown in Map 5.4, but there are many other slopes available that will work equally well to establish wildflowers.

Step 1: The entire slope being utilized for wildflowers should be mowed as low as possible to expose the ground below, 1 to 3 days before being seeded.
Step 2: Spread a layer of organic compost over the whole slope at least 1 inch thick. This will suppress the current groundcover, give the seeds a good soil to establish in and provide nutrients for the seeds.
Step 3: Spread seeds at approximately 20 lbs. per acres. The seed mix will determine the exact quantity of seed per acre.
Step 4: Rake the seeds in lightly over the area so that they are covered by the compost. This will hold seed in place and better protect them over the winter.

WILDFLOWER SLOPE MAINTENANCE FREQUENCY SCHEDULE:

	Month																								
Maintenance & Management Practices	Jan		Feb		Mar		Apr		May		June		July		Aug		Sept		Oct		Nov		Dec		Total
Weeding & Invasive spp																									
Shrubs																									
Herbs					x		x			x			x												**4**
Tree Pruning					x	x																			**2**
Plantings																									
Trees																									
Shrubs																									
Herbs							x																		**1**
Seeding																				x	x				**2**
Mowing				x										x		x									**3**

■ Indicates range of time to perform maintenance
x Indicates specific times perform maintenance

WEEDING AND INVASIVE SPECIES CONTROL
Invasive species control will be limited to hand pulling weeds. In rare cases, it may be necessary to apply a selective herbicide after a site has been seeded with wildflowers. In cases such as the presence of poison ivy, herbicides shall be applied following the procedures outlined in Section 6.5.

REMOVING PLANTS
Other than invasives, removing plants from a site should be performed on a case by case basis.

PRUNING TREES
Currently, no trees are established on wildflower slopes. Trees along the fringe of wildflower slopes should be pruned following procedures in section 6.3.

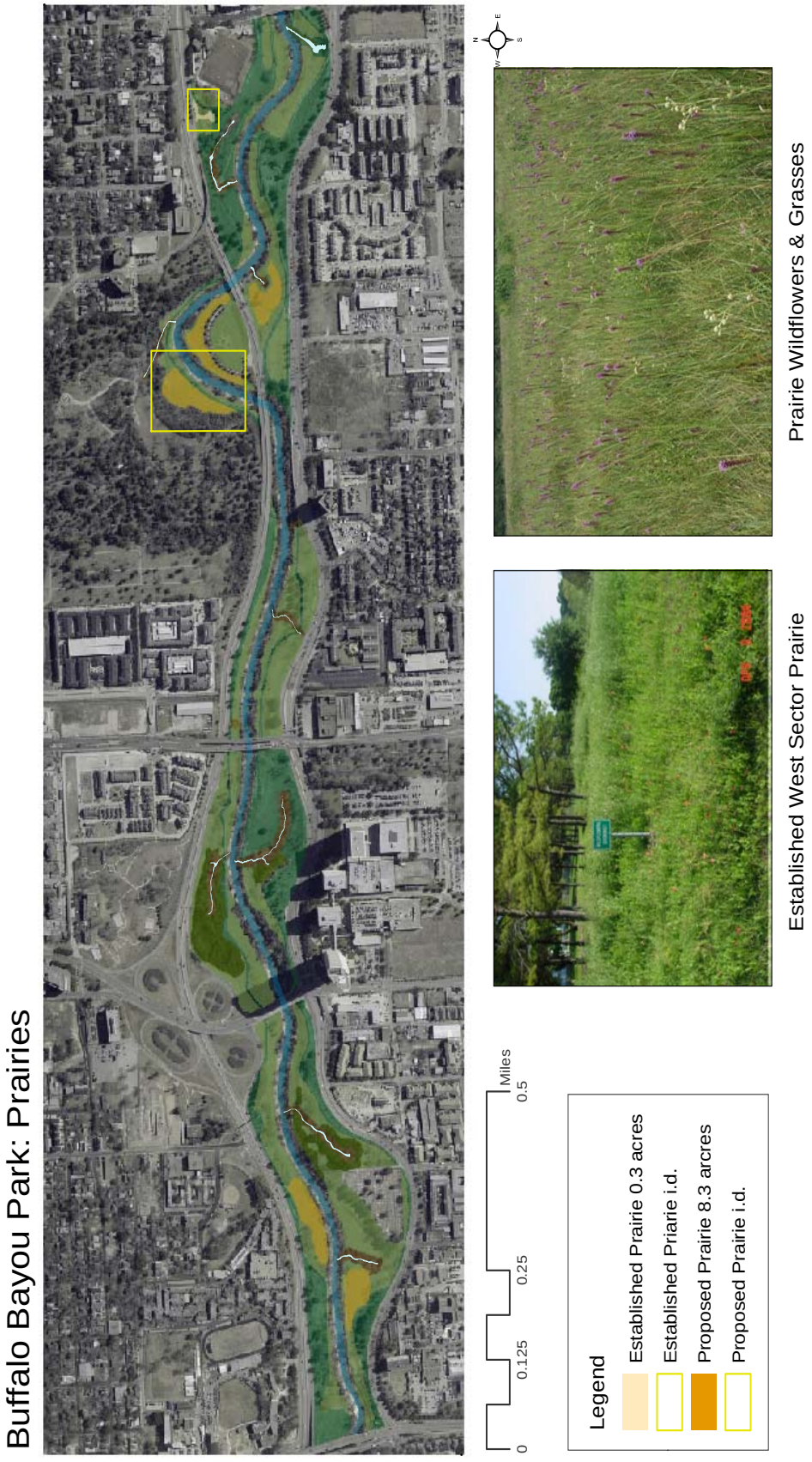
MOWING
Mowing should be performed using a brush hog following the wildflower slope frequency table. Cut material should be left on the slope to restore the area and increase slope stability.

SEEDING:
Seeding occurs between mid October and mid November for best results and, when possible, seeds should be harvested naturally. Otherwise, insure the seeds purchased are from a source that supplies seeds native to this region.

THREE YEAR CARE:
Weeding, mowing and re-seeding are essential in the first three years to establish wildflower slopes.

Wildflower Establishment Plant List

Scientific Name	Common Name	Type	Status
Amsonia illustris	Showy Blue Star	Forb	
Asclepias longiflora	Florida Milkweed	Forb	
Asclepias verticillata	Whorled Milkweed	Forb	
Asclepias viridis	Green Milkweed	Forb	
Cacalia lanceolata	Prairie Plantain	Forb	
Cassia fasciculata	Partridge Pea	Forb	
Centella erecta	Erect Centella	Forb	
Cooperia drummondi	Rain Lilly	Forb	
Cracopis amplexicaulis	Clasping-leaved Coneflower	Forb	
Erigeron philadelphicus	Philadelphia Fleabane	Forb	
Eryngium yucciflora	Rattlesnake Master	Forb	
Eupatorium serotinum	Boneset	Forb	
Euphorbia bicolor	Snow on the Prairie	Forb	
Eustoma exaltatum	Bluebells	Forb	
Euthamia leptocephala	Slender-headed Euthemia	Forb	
Gaillardia pulchella	Indian Blanket	Forb	
Guara lindheimeri	White Guara	Forb	
Helianthus angustifolia	Swamp Sunflower	Forb	
Helianthus maximiliani	Maximilian Sunflower	Forb	
Ipomoea sagittata	Morning Glory	Forb	
Liatris acidota	Sharp Blazing-Star	Forb	
Liatris bracteata	Coastal Gay-feather	Forb	
Liatris pycnostachya	Prairie Blazing-Star	Forb	
Lobelia puberula	Downy Lobelia	Forb	
Lupinus texensis	Bluebonnet	Forb	
Lythrum lanceolatum	Lance-leaf Loosestrife	Forb	
Manfreda virginica	Prairie Agave (American Aloe)	Forb	
Mimosa strigillosa	Powderpuff	Forb	
Monarda punctata	Spotted-Beebalm	Forb	
Oenothera speciosa	Showy Primrose	Forb	
Oxalis stricta	Yellow Wood Sorrel	Forb	
Oxalis violacea	Violet Wood Sorrel	Forb	
Passiflora incarnata	Passion Flower	Forb	
Penstemon murrayanus	Red Penstemon	Forb	
Petalostemum decumbens	Prairie Clover	Forb	
Prunella vulgaris	Self Heal	Forb	
Rudbeckia hirta	Brown-eyed Susan	Forb	
Rudbeckia nitida	Shining Coneflower	Forb	
Ruellia humilus	Low Ruellia	Forb	
Ruellia nudiflora	Violet Ruellia	Forb	
Sabatia campestris	Meadow Pink	Forb	
Salvia azrea	Blue Sage	Forb	
Scutellaria drummundii	Skullcap	Forb	
Sisyrinchium langloisii	Dotted Blue-eyed Grass	Forb	
Solidago canadensis	Common Goldenrod	Forb	
Solidago sempervirens	Mexican Goldenrod	Forb	
Verbena canadensis	Rose Verbena	Forb	
Verbena halei	Texas Vervain	Forb	


Buffalo Bayou Park: Prairies
Legend
Established Prairie 0.3 acres
Established Priarie i.d.
Proposed Prairie 8.3 arcres
Proposed Prairie i.d.
0
0.125
0.25
0.5
Miles
Established West Sector Prairie
Prairie Wildflowers & Grasses

Small pocket prairies and numerous species related to prairie ecology have historically been found along the Bayou. Establishing pocket prairies in underutilized parkspace throughout the West Sector will reduce annual maintenance costs; improve habitat conditions for birds, butterflies and other wildlife; enable interpretive recreation; disrupt floodwater sheetflow; improve soil permeability and floodwater capacity; and create a higher aesthetic value when management needs are met.

Area: 0.5 acres. Boundary corresponds to vegetation zone 7. One small prairie has been established on in a street level field just of Sawyer Drive. It was seeded with native prairie and wildflower mixes in November 2003 in conjunction with the wildflower slopes.

Groundcover: Dominant groundcover includes spotted bee balm (*Monarda punctata*), common sunflower (*Helianthus annuus*), Maximilian Sunflower (*Helianthus maximiliani*), foxtail (*Setaria geniculata*), *Paspallum* spp. and Drummond Phlox (*Phlox drummondii*).

Invasive and Unwanted Plants: Invasives species that were present in the first year have been giant ragweed (*Ambrosia trifida*) and Bermuda grass (*Cynodon dactylon*) and dallisgrass (*Paspallum dilatatum*).

Prairie Establishment and Management Recommendations

Objectives:
- Increase prairie acreage
- Maintain existing pilot prairie
- Re-establish native vegetation
- Prune hazard trees and specific visual obstructions

Establishing a Prairie

Choosing a Location:
With approximately 100 acres of mowed, unused parkspace the Park provides ample opportunities to establish pocket prairies. Generally, these are relatively level, open areas away from the trail and near the waterway. Map 5.5 shows several potential locations for prairie establishment.

Step 1: Choosing a location
- a turf-maintained area under-utilized by park-users
- receives direct solar radiation
- sandy soil with good drainage
- A level surface with depressions, when possible

Step 2: Scalp and treat the existing vegetation to prepare the site for the new prairie. The entire area should be mowed as low as possible and tilled if possible. If known vegetation problems exist, it may be beneficial to treat some areas with an appropriate herbicide to prepare the site. With any chosen site, a 10 foot wide, mowed border should be established around the prairie between zone transitions such as a forests or trails. This will help clearly define the prairie and prevent invasive species from encroaching.

Step 3: Spread a 1 – 3 inch layer of organic compost throughout the site to stabilize and replenish the existing soil.

Step 4: Select and acquire local seeds harvested within 100 miles of the site when possible. In some cases seedlings may be available to plant directly into the prairie.

Step 5: Seed area between October and November

Prairie Maintenance:

- Hand-weed giant ragweed (Ambrosia trifida) bi-monthly for the first summer. Decrease maintenance according to monitoring reports.
- Treat woody invasive species with herbicide using the cut-treat method
- Monitor other herbaceous species like vines and poison ivy which may need herbicide applications

PRAIRIE MAINTENANCE FREQUENCY SCHEDULE:

	Month																								
Maintenance Management Practices	Jan		Feb		Mar		Apr		May		June		July		Aug		Sept		Oct		Nov		Dec		Total
Weeding & Invasive spp																									
Trees															x		x								**2**
Shrubs															x		x								**2**
Herbs																									
Tree Pruning	x		x		x																				**3**
Plantings																									
Trees																									
Shrubs																									
Herbs																									
Seeding																					x				**1**
Bush Hog					x								x												**2**

■ Indicates range of time to perform maintenance
x Indicates specific time to perform maintenance

WEEDING AND INVASIVE SPECIES CONTROL
Herbaceous vegetation such as Giant Ragweed should be pulled by hand. Systemic herbicides should be used to control invasive woody species. Encroaching poison ivy should be avoided when hand pulling other weeds and treated with herbicides. Woody invasives should be treated with cut-treat herbicide applications described in section 6.5.

CONTROLLING WILD SAPLINGS
Desired native shrubs, such as Yaupon holly, that grow in established prairies should be transplanted or left to let prairie succession occur.

PRUNING TREES
Prairie perimeters should be clearly defined. If a prairie butts up to a row or stand of trees, the trees should be pruned and maintained to identify the area as maintained and intentional. Native woody prairie species including Baccharis (*Baccharis halimifolia)*, Yaupon holly *(Ilex vomitoria)*, and Wax myrtle *(Myrica cerifera*) established in the prairie should be left to provide habitat for birds and insects.

MOWING
Bush hogging shall occur annually in the spring between February and March. The cutting will remove old growth, disperse seeds, manage woody plants and help control invasives. It also simulates natural disturbances such as grazing, and to a lesser degree, fires.

Boundaries should be maintained around the entire perimeter of each prairie. A 10-foot mowed swath between prairies and trails or wooded areas should be maintained during regular park mowing.

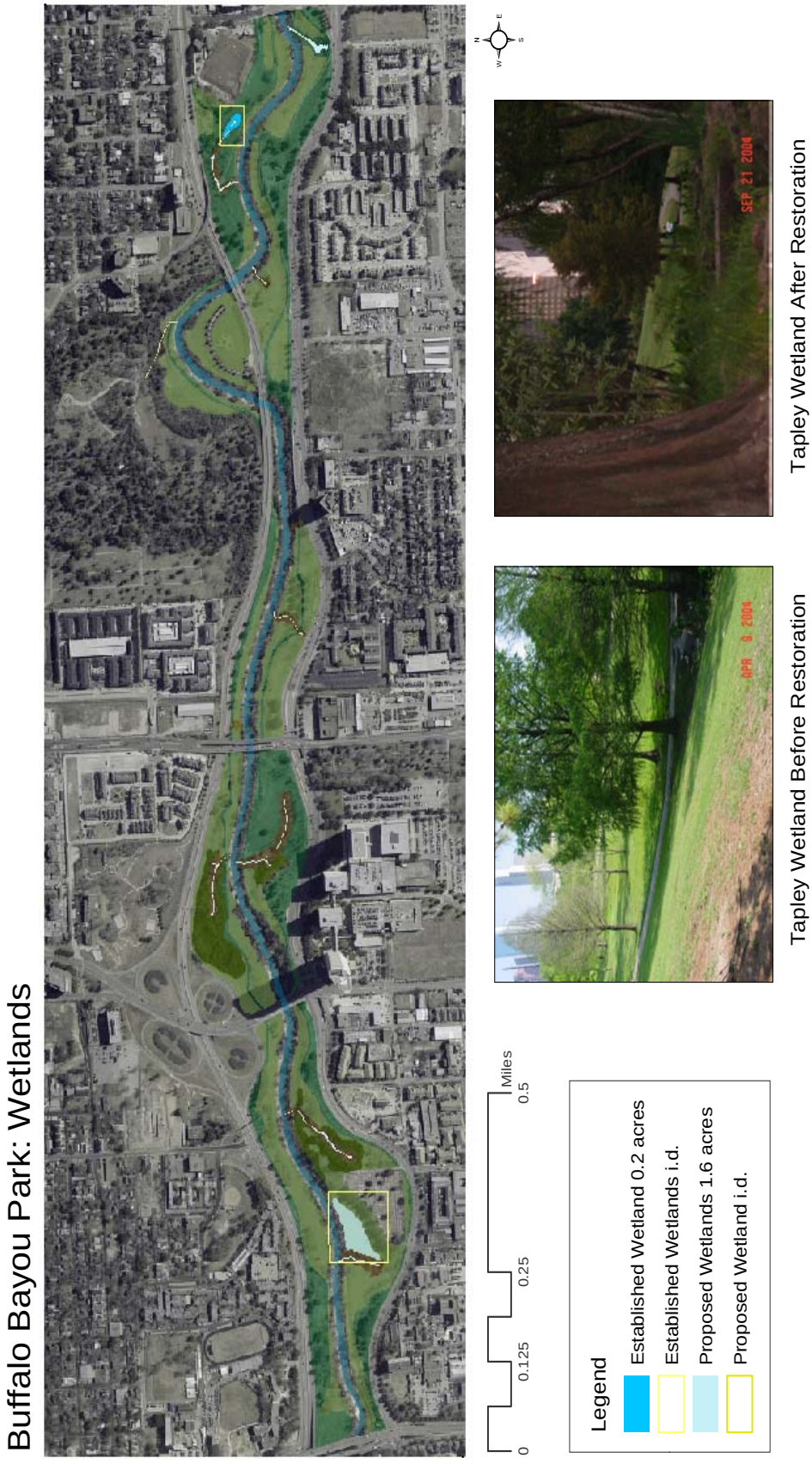
SEEDING
After the initial establishment of a prairie, re-seeding shall occur as needed.

THREE YEAR CARE
Prairies will need brush hogging, weeding, plantings and re-seeding for the first three years to ensure proper establishment. Maintenance may drop to annual brush hogging after three years with reduced weeding beyond three years.

Prairie Restoration and Establishment Plant List

Scientific Name	Common Name	Type	Status
Agrostis hyemalis	Spring Bentgrass	Grass	
Andropogon gerardii	Big Bluestem	Grass	
Andropogon glomeratus	Bushy Bluestem	Grass	
Bothriochloa exaristata	Silver Bluestem	Grass	
Briza minor	Quaking Grass	Grass	
Coelorachis cylindrica	Carolina Jointtail	Grass	
Cyperus digitatus	Flat Sedge	Sedge	
Eleocharis montana	Knotty Spike-Rush	Sedge	
Eleocharis verrucosa	Slender Spike-Rush	Sedge	
Eragrostis spectabilis	Purple Lovegrass	Grass	
Fimbristylis puberula	Chestnut Sedge	Sedge	
Muhlenbergia capillaris	Gulf Muhley	Grass	
Panicum virgatum	Switch Grass	Grass	
Paspallum floridanum	Florida Paspallum	Grass	
Rhynchospora caduca	Anglestem Beaksedge	Sedge	
Rhynchospora colorata	White-topped Sedge	Sedge	
Rhynchospora corniculata	Shortbristle Horned Beaksedge	Sedge	
Schizachyrium scoparium	Little Bluestem	Grass	
Scleria ciliate	Fringed Nutrush	Sedge	
Setaria geniculata	Knotroot Bristlegrass	Grass	
Sorghastrum nutans	Indiangrass	Grass	
Tridens strictus	Long-Spike Tridens	Grass	
Tripsacum dactyloides	Eastern Gama Grass	Grass	
Amsonia illustris	Showy Blue Star	Forb	
Asclepias longiflora	Florida Milkweed	Forb	
Asclepias verticillata	Whorled Milkweed	Forb	
Asclepias viridis	Green Milkweed	Forb	
Cacalia lanceolata	Prairie Plantain	Forb	
Cassia fasciculata	Partridge Pea	Forb	
Centella erecta	Erect Centella	Forb	
Cooperia drummondi	Rain Lilly	Forb	
Cracopis amplexicaulis	Clasping-leaved Coneflower	Forb	
Erigeron philadepphicus	Philadelphia Fleabane	Forb	
Eryngium yucciflora	Rattlesnake Master	Forb	
Eupatorium serotinum	Boneset	Forb	
Euphorbia bicolor	Snow on the Prairie	Forb	
Eustoma exaltatum	Bluebells	Forb	
Euthamia leptocephala	Slender-headed Euthemia	Forb	
Gaillardia pulchella	Indian Blanket	Forb	
Guara lindheimeri	White Guara	Forb	
Helianthus angustifolia	Swamp Sunflower	Forb	
Helianthus maximiliani	Maximilian Sunflower	Forb	
Ipomoea sagittata	Morning Glory	Forb	
Liatris acidota	Sharp Blazing-Star	Forb	
Liatris bracteata	Coastal Gay-feather	Forb	
Liatris pycnostachya	Prairie Blazing-Star	Forb	
Lobelia puberula	Downy Lobelia	Forb	
Lythrum lanceolatum	Lance-leaf Loosestrife	Forb	
Manfreda virginica	Prairie Agave (American Aloe)	Forb	
Mimosa strigillosa	Powderpuff	Forb	
Monarda punctat	Spotted-Beebalm	Forb	
Oenothera speciosa	Showy Primrose	Forb	
Passiflora incarnata	Passion Flower	Forb	
Petalostemum decumbens	Prairie Clover	Forb	
Phlox drummondii	Drummond's Phlox	Forb	
Prunella vulgaris	Self Heal	Forb	
Rudbeckia hirta	Brown-eyed Susan	Forb	

Rudbeckia nitida	Shining Coneflower	Forb
Ruellia humilus	Low Ruellia	Forb
Ruellia nudiflora	Violet Ruellia	Forb
Sabatia campestris	Meadow Pink	Forb
Salvia azrea	Blue Sage	Forb
Scutellaria drummundii	Skullcap	Forb
Sisyrinchium langloisii	Dotted Blue-eyed Grass	Forb
Solidago canadensis	Common Goldenrod	Forb
Solidago sempervirens	Mexican Goldenrod	Forb
Baccharis halimifolia	Baccharis	Shrub
Myrica cerifera	Wax Myrtle	Shrub
Ilex vomitoria	Yaupon Holly	Shrub


Buffalo Bayou Park: Wetlands
Legend
Established Wetland 0.2 acres
Established Wetlands i.d.
Proposed Wetlands 1.6 acres
Proposed Wetland i.d.
0
0.125
0.25
0.5
Miles
Tapley Wetland Before Restoration
Tapley Wetland After Restoration

Wetlands

One small wetland exists in the West Sector and one other is proposed in the VMP. The existing wetland was established in 2003 and 2004 as a community effort involving Eagle Scout, Corporate and other volunteers. It currently contains over 20 species of native wetland plant species and hosts breeding of numerous dragonfly species. Mosquito fish (*Gambusia affinis*) and sunfish (*lepomis spp.*) currently inhabit the standing water along with red-eared sliders (*Trachemys scripta elegans*) and toads (*Bufonidae spp.*).

Area: 0.25 acres. Boundary corresponding to zone 6.

Canopy: Dominant canopy species cover 35% of the established wetland composed of Bald Cypress (*Taxodium distichum*), black willow (*Salix nigra*), and Swamp Red Maple (*Acer rubrum*).

Understory: Dominant herbaceous vegetation includes horned beakrush (*Rhynchospora corniculata*), Long-lobed arrowhead (*Sagittaria logniloba*), rush (*Juncus nodatus*), American bulrush (*Scirpus pungens*), thin-scale sedge (*Carex hyalinolepsis*) and white-topped sedge (*Dichromena colorata*)

Invasive Plants: Dominant invasive plants in existing wetland include alligatorweed (*Alternanthera philoxeroides*), Bermudagrass (*Cynodon dactylon*) and wedilia (*Wedilia trilobata*).

Wetland Establishment and Maintenance Recommendations

Objectives:

- Increase wetland acreage
- Remove invasive species
- Prune hazard trees and specific visual obstructions

Establishing a Wetland in Buffalo Bayou Park

Choosing a Location:

There are only a few locations to establish wetlands in Buffalo Bayou Park without major grading and land work. This Plan only proposes one additional site behind the Jewish Cemetery because it is a cleared and maintained site that holds water, has a tributary that can easily be diverted into it and is far enough away from trails to pose no threat to safety.

Step 1: Site Selection: When selecting a site it is essential to choose a site that will receive and hold water sufficient to support wetland indicator vegetation and be at least 20 feet away from any hike and bike trail segment. If unsure, soil samples should be taken to ensure that a site will retain water.

Step 2: Design a planting and landscape plan to best suite the desired goals of the wetland. For instance, if you want it to be a full sun marsh condition, include appropriate plants for marsh. A general list of wetland plants is located at the end of this section.

Step 3: Remove unwanted vegetation and perform earthwork to develop pools and other features incorporated into the design.

Step 4: Vegetation installation.

Step 5: Monitor this site to ensure that the wetland plants are receiving the appropriate conditions. Water sampling may be included if the wetland is being used to treat effluent.

WETLAND MAINTENANCE FREQUENCY SCHEDULE:

	Month																								
Maintenance Management Practices	Jan		Feb		Mar		Apr		May		June		July		Aug		Sept		Oct		Nov		Dec		Total
Weeding & Invasive spp																									
Trees																	x								
Shrubs																	x								
Herbs						x			x		x				x										
Tree Pruning						x											x								
Plantings																									
Trees						x													x						
Shrubs						x													x						
Herbs						x		x		x															
Mowing																									
Seeding																					x				

Indicates range of time to perform maintenance

x Indicates specific times to perform maintenance

INVASIVE SPECIES CONTROL

The biggest problem in the Tapley Wetland is alligator weed and Bermudagrass. Controlling alligatorweed is to periodically rake clumps of it out of the area. Bermudagrass is being controlled through using a power weeder (weedeater) to cut the grass down.

CONTROLLING WILD SAPLINGS

Wild Saplings such as black willow should be pulled out when they are spotted. If the entire plant cannot be pulled out, then a cut-tree herbicide application should be applied to control all woody species as described in section 6.5.

PRUNING TREES

Prune trees to increase solar radiation into the wetland and to improve the Parks appearance. Prune desired trees according to maintenance procedures in section 6.3.

TWO YEAR CARE

Over the first two years, controlling invasive species will be the most laborious maintenance and should be accomplished according to the frequency schedule. Unwanted woody plants should be controlled using herbicides. Procedures for herbicide use are located in section 6.5. Other care may include digging the area out if it fills with sediment, installing more plants and controlling wild saplings.

Wetland Restoration and Establishment Plant list

Scientific Name	Common Name	Type	Status
Bacopa monnieri	Coastal Water Hissop	Forb	
Canna glauca	Canna	Forb	
Carex hyalinolepsis	Thinscale Sedge	Sedge	
Ceratophyllum demersum	Coontail	Sedge	
Cladium famaicense	Jamaica Sawgrass	Forb	
Crinum americanum	Swamp Lilly	Forb	
Eleocharis Montana	Spikerush	Sedge	
Eleocharis quadrangulata	Square-stemmed Spikerush	Sedge	
Heteranthera dubia	Water Stargrass	Forb	
Hymenocallis liriosme	Spider Lilly	Forb	
Iris virginica	Southern Blue Iris	Forb	
Juncus rowmerianus	Black Needlerush	Sedge	
Ludwigia pepliodes	Floating Seedbox	Forb	
Najas guadalupensis	Souther Naiad	Forb	
Nymphaea mexicana	Yellow Water Lilly	Forb	
Nymphaea odorata	White Water Lilly	Forb	
Panicum hemitomon	Maidencane	Grass	
Panicum virgatum	Switchgrass	Grass	
Pontederia cordata	Pickerel Weed	Forb	
Potamogton spp.	Pondweed	Forb	
Sagittaria graminea	Grassy Arrowhead	Forb	
Sagittaria lancifolia	Bull Tongue	Forb	
Sagittaria logniloba	Narrow-leaf Arrowhead	Forb	
Sagittaria platyphylla	Delta Duck Potato	Forb	
Schizachyrum scoparium	Little Bluestem	Grass	
Scirpus pungens	American Bulrush	Sedge	
Scirpus robustus	Saltmarsh Bulrush	Sedge	
Scirpus validus	Soft-stem Bulrush	Sedge	
Taxodium distichum	Bald Cypress	Tree	
Thalia dealbata	Powdery Thalia	Forb	
Ulmus crassifolia	Cedar Elm	Tree	
Zizaniopsis miliacea	Cutgrass	Grass	

CHAPTER SIX
MAINTENANCE PROCEDURES

6.1 Current Management Practices in Buffalo Bayou Park

The City of Houston's Parks and Recreation Department maintains the usable park space in the West Sector. Their maintenance practices include mowing the open-terraced lawn space, the scattered landscape tree conditions, swales that meet the riparian edge, and the upper terrace near the trails and roadways. PARD mows monthly during the summer months, shifting to a bi-monthly schedule in fall and winter. Scattered landscape trees, trees along the trails and trees on the upper terrace whose canopy extends over roadways are pruned annually according to PARD and TxDOT specifications (8 ft. over hike and bike trails and 13 ft. over roadways). Ornamental garden areas are maintained by the Parks Department. These areas have some annuals incorporated into perennial beds. The beds are pruned and mulched annually and have irrigation systems installed for watering. Ornamental gardens are also weeded regularly.

BBP Board Member, Mike Garver and his field crew donate their time to perform Bayou riparian maintenance in Buffalo Bayou Park to clear giant ragweed. Four times a year the crew clears the ragweed with a tractor and machetes.

The Buffalo Bayou Partnership has numerous volunteer plantings, invasive species removal and litter pick up work days. A two man crew also maintains the Tapley tributary once a month removing ragweed, cutting hazard limbs, and performs maintenance to new plantings.

6.2 TREE MAINTENANCE GUIDELINES (USDA Urban Forestry Manual, Summary)

Tree Installation

Determine the Size of the Hole
The planting area should be dug the depth of the rootball or slightly less, and 3 to 5 times wider than the rootball. This will allow the tree roots to spread and discourage competing vegetation.

Installation of the Tree
Install the tree by removing it from its container and loosen any bound roots that may have formed. Place the tree in the center of the planting area and backfill the area with organic compost.

Stake the Tree
Drive stakes on either side of the tree near the edge of the planting area. Be sure to install them parallel with the Bayou channel to decrease any obstructions and strengthen the tree where it will need it most during flooding event. Fasten plastic chain or other form of approved guy wire making sure that the tree is as straight as possible from all directions. Some adjustments to the guy wire may be required to get the tree straight up.

Initial Watering
Once the tree has been staked, apply approximately 5-10 gallons of water to ensure that the rootball and surrounding planting area has been fully saturated.

Mulch
Spread a 3 inch layer of mulch from the trunk of the tree to the canopy's dripline. Make sure no bark is touching the base of the tree. Form a saucer with the mulch to ensure that any available water will stay within the saucer. On slopes build the saucer up on the downward side to prevent runoff.

Watering

Watering, especially the first two years after a tree is planted, is essential to a maintenance program. Trees that do not receive enough water during the first few years of establishment have an increased risk for dieback, development of weak, multi-trunks, and possible death (Gilman 1997). Because every planting situation is unique, it is difficult to prescribe a rule of thumb for watering trees; however, keeping the soil in the root ball moist (but not wet) will promote rapid root growth (Gilman 1997).

Young and Established Trees

Young trees need adequate water to become established. For recently planted trees, apply the water directly on the root ball where the absorbing roots are located. When watering 2 or 3 years after establishment, determine by inspection the location and extent of the root system and apply water accordingly.

Timing of Irrigation Systems

Irrigation systems that are timed for watering turf or other groundcover plants typically do not adequately water trees. These systems are generally designed to provide 1 inch of water each week in daily applications of 1/7 inch. This watering regime does not penetrate soil deep enough for tree roots.

Mulching

Guidelines

The mulch area should cover as much of the root system as practical. Ideally, it should extend well beyond the drip line of the canopy. Gilman (1997) uses the rule-of-thumb, "…mulch at least 2 feet in diameter for each inch of trunk diameter." The mulch area should therefore increase as the tree grows. Whenever possible, trees should be mulched in groups to provide a "shared" mulch and rooting area.

Determine Mulch Depth

Organic mulches should be applied 4 to 6 inches deep except for pine straw mulch which should be applied to a depth of 8 inches. Because pine straw decomposes faster than wood chips and bark, it typically needs to be replenished annually. Pine straw may be used in conjunction with wood chips as a top covering for aesthetic purposes.

Check Source and Composition of Mulch

The source and composition of the mulch are important, as contaminants in the mulch may leach into the soil, reduce aesthetic characteristics, or require additional maintenance. Examples of contaminants include: non-composted mulch that contains herbicides, acorns and other weed seed, litter, plastic bags, insects, oil from chippers and chainsaws, and soil. Ideally, composted mulch is best.

Expose Root Collar

Mulch should not be placed against the trunk of the tree. Leave an un-mulched area 6-12 inches in radius around the trunk. The root collar needs adequate air circulation. Use non-metallic hand tools when working near the root collar to prevent damaging the trunk and roots.

Pruning

Pruning is the selective removal of plant parts, typically shoots and branches. Knowledge of a tree's development pattern, including the importance of the apical bud in the growth and structure of a branch, is necessary for understanding how pruning affects a tree. Trees may need pruning to:

- Improve and maintain health
- Eliminate and reduce risks, such as limbs falling and electrical line interference
- Enhance appearance
- Improve views

When and How Often to Prune

- Winter is often the best time to prune, except for those trees that flower in the spring (e.g. magnolia). Branch removal is easier during dormancy because the structure of the tree is more visible and physiological activity is lowest. Trees that flower in the summer can be pruned during the winter (e.g. crapemyrtle, vitex)
- Spring is the primary growth and flowering period for many trees. To maximize flowering and fruiting, trees that bloom in spring should be pruned soon after flowers have faded.
- Summer pruning can be done to remove hazard limbs, diseased leaves and/or limbs, and storm or construction damage although it may slow the growth of the tree.
- Do not prune in the fall. The tree needs to conserve energy for it's dormant period.

Pruning Tools

- A by-pass (or hook and blade) pruning tool should be used for small branches and limbs (usu. ½ to ¾ inch diameter)
- Loppers can be used to reduce the weight of a limb before making the final pruning cut at the branch collar and bark ridge. Use of loppers on small limbs may preclude cuts 1 and 2 in a 3-cut pruning operation (see following section on "How to Prune").
- Saws with fine teeth and narrow, curved blades are recommended for most pruning jobs. Saws are available in a variety of blade lengths (6 to 13 inches) and can be easily used in close areas (i.e. acute or narrow branch angles) with minimum damage to the tree trunk or parent limb. Chainsaws should not be used to prune limbs less than 6 inches in diameter and should be used by someone who is trained and experienced.

Training and Pruning Young Trees

Proper training of trees begins with the selection of tree stock in the nursery. Using structural pruning (discussed later in this section) to shape the tree early avoids the necessity for severe pruning later and limiting subsequent hazards. Training has several goals:

- Developing a strong vertical leader and eliminating co-dominant stems
- Establishing well-spaced branches
- Removing branches that rub other branches

Pruning your trees requires an understanding of the site and purpose of the tree as well as the growth pattern of the species itself.

First and second growing season

Pruning a young tree during the first growing season should be limited to removing dead or problem branches. Early arboricultural practices assumed that top pruning would compensate for the loss of roots when trees were transplanted, but this not true. Reducing the leaf area available for photosynthesis reduces the amount of energy available for growth, reproduction, defense and maintenance. Moreover, pruning apical buds in newly planted trees decreases a growth regulator needed to stimulate root growth.

Third through fifth growing seasons

Beginning in the 3rd year, pruning can promote strong structural growth and prevent future problems. The goal of structural pruning is to develop a strong dominant vertical stem with well-attached alternate branches.

Types of Pruning

- Structural pruning encourages the development of one strong leader
- Cleaning removes dead, diseased, broken, and weakly attached branches. This type of pruning helps maintain tree health, prevents tree limbs from falling, and other hazardous conditions.
- Reducing decreases height and/or spread. Reducing is primarily used to provide clearance for utilities and structures and to minimize potential for failure. (overhead utility line pruning)
- Thinning reduces the density of live branches. Trees may need thinning if branches are too heavy or if there is a foliar disease problem. Thinning can increase airflow and light within the canopy, enhance the appearance of the tree and increase its storm resistance.
- Raising provides vertical clearance so people and vehicles can move easily under a tree. Raising is best done by reducing the length of the branch (cutting back to a lateral branch) instead of completely removing the branch.

Pruning Cuts

Visible branch collar
At the base of the branch, where it meets the trunk, there is often an enlarged area call the branch collar. The raised bark that develops at the angle of attachment between the branch and the trunk is the branch bark ridge. It is best to cut as close as possible to the branch bark ridge and branch collar at the base of the branch without damaging either one. Cutting just outside the branch collar offers several advantages:

- Prevents damage to the trunk tissue
- Limits possibility of trunk tissue decay
- Retains branch collar as natural protective area
- Creates a smaller wound

How to Make the Pruning Cut
How the cut is made is as important as where it is made. Removing a limb larger than 1 inch in diameter should be done with three cuts.

1 A partial undercut to keep the branch from tearing bark as it is removed.
2 A cut through the entire branch slightly farther out than the undercut to remove the branch. On small limbs (less than 1 ¾ inch) a lopper may be used to do this.
3 A cut just beyond the branch collar and branch bark ridge to remove the stub.

Fertilizing

Determining if a Tree Needs Fertilizer
Examining the tree and the site and conducting foliar and soil analysis will help determine fertilization needs. Fertilizing trees that are under stress, such as newly planted, root damaged, or diseased trees, is not recommended because the tree usually does not have the energy reserves necessary for the increased growth that will occur due to fertilization. Gilman (1997) recommends that during the establishment period, maintenance resources should be restricted to watering, mulching and weed control.

Examine the Tree
Examine the tree for any abnormalities in leaf color, leaf size, and twig growth rate, which may be symptomatic of a nutrient imbalance. For example, a lack of nitrogen will turn foliage yellow, but it is not the only cause of yellow leaves.

Examine the Site
Site conditions can also hint at nutrient imbalances. If nearby turf and shrubs are being fertilized, there is typically no need to fertilize the trees (Yeager and Gilman 1991). Also, too much of any nutrient in the soil, which is often the result of over-fertilization in an urban area, may cause stress in a tree.

Establish Nutrient Level Standards
Based on literature and local monitoring, acceptable nutrient and pH levels should be established. For example, a national arboricultural firm has established a 2% leaf nitrogen level for most tree species and recommends soil pH in the 5.5 to 6.5 range. Locally, you can select "healthy" trees that represent the predominant species and age-classes and analyze foliage and associated soil samples. The foliage analyses from these "healthy" trees can be used to establish acceptable nutrient levels for nitrogen, phosphorus, and potassium (and other nutrients). Dr. Kim D Coder (2001) recommends 1.5% as an acceptable nitrogen target for urban forest management until further regional research is completed.

Send Samples to a Lab for Testing
To reveal a nutrient imbalance, estimate fertilization needs, or detect how the tree is responding to a fertilizer program, send leaf (tissue) and soil samples to a Texas A&M for testing.

Application
Fertilizers should be used according to the manufacturer's instructions, which are usually provided on the packaging. The application method depends on the type of fertilizer, equipment needed, soil composition, site location, environmental concerns and the tree itself. Refer to the manufacturers label and MSDS for rates of application and safety precautions.

Fertilizers can be applied in various ways; slow-release nitrogen fertilizers are the preferred over quick-release. Fertilizers may be applied in granular (dry) or in liquid form. Both of these forms are available as quick-release or slow-release formulations. Fertilizers are also rated for salt index; a rating of 50 or less is preferred.

Disease and Pest Control

Devastating damage from disease and insects can occur in any urban forest. The long-term health of the forest depends on protecting trees from harmful diseases and pests. Keeping trees healthy by establishing and following a maintenance plan can prevent many diseases and pest problems.

Most pests do minimal damage and can remain untreated and others can be kept in control (suppressed) with attention to the health of the tree. A monitoring program, where trees are examined regularly is important to any tree management plan. This is also the first line of defense when dealing with disease and pest problems that can become critical.

Removal

Tree removal is an option in managing the urban forest. Trees of all ages and conditions may be candidates for removal according to the desired management plan for a particular area. Trees for potential removal should be evaluated according to current arboricultural standards for condition and hazard. Refer to the publications *Guide for Plant Appraisal (2000*) and *A Photographic Guide to the Evaluation of Hazard Trees in Urban Areas (1994)* for more information. Factors to be considered when evaluating a tree for removal include tree biology (e.g. an evaluation of growing space), other applicable standards (e.g. adopted engineering safety standards), or local policy (e.g. hazard tree standards, recommended tree species, site selection standards, and long-term objectives).

In urban areas, trees may be removed for a number of reasons:

- The tree is in poor condition and is in a stage of decline.
- A hazard has been identified and removing the entire tree is the best option.
- The tree is diseased or the host to a pest that may spread to adjacent trees in the urban forest.
- The tree may be interfering (i.e. competing) with other trees considered to be more valuable or more important in meeting long-term objectives.
- The tree is located in the path of infrastructure development.
- The tree is obstructing a view or interfering with pedestrian or vehicular traffic.
- The tree is an invasive species.

Removal Guidelines
During tree removal, the possibility for damage to the site (e.g. soil compaction), adjacent trees, or infrastructure always needs to be considered. Only people who are properly trained in safety issues and procedures for reducing or eliminating potential for damage should remove trees. Liability is also an issue and, in some cases, a written contract specifying penalties for damage to landscape and infrastructure would be recommended.

For greater detail on tree maintenance refer to: USDA Forest Service Southern, Southern Research Station, and the Southern Group of state Foresters. 2001. *The Urban Forestry Manual*

6.3 NON-HERBICIDE INVASIVE SPECIES CONTROL

Because of the coppicing ability of woody vegetation maintenance should include herbicide applications for complete removal. Specifications for herbicide use are found in section 6.5. A list of approved herbicides, application procedures and species specs are located in Appendix III. Other invasive species can be controlled in small areas through other forms of control including hand weeding and cutting in sensitive areas such as in the wetland, and mechanical methods of mowing, brush-hogging and power weeding (weedeater) in less sensitive areas such as forest fringes.

6.4 HERBICIDE INVASIVE SPECIES CONTROL (USDA SRS-62, Summary)

The best defense against nonnative plant takeovers is constant monitoring followed by effective control measures at the first appearance of new arrivals. Early detection and treatment will minimize efforts and costs that come with treating well-established plants or full-blown infestations. More effort is required for successful eradication of established infestations. In severe cases, large-scale conversion of existing infestations is the only solution, involving eradication procedures that incorporate integrated management treatments and reestablishment of native plants. Fortunately, in southern-forest native plants in the soil seed bank and plants from surrounding areas will naturally reestablish once the invaders are eliminated.

The application of herbicide makes up a small part of the overall management program. It is used when necessary as part of a sustainable approach to managing noxious species by combining biological, cultural, physical, and chemical tools to minimize economic, health and environmental risks (HCFCD). A sustainable method includes the application of species- specific herbicide products, timely mowing operations that correspond to herbicide application, and wick applications that eliminate over-spray effects

Effective Treatments

If an infestation of an invasive species is spotted, then proper and aggressive eradication measures should be undertaken quickly to avoid the inevitable spread of the species. Continued treatment and re-treatment will be necessary. Most nonnative invasive plants are perennials, having extensive tough roots and runners. This means that effective herbicide applications offer the best means of containment or eradication, because herbicides can kill roots and do so without baring soil for reinvasion or erosion. To be successful with herbicide treatments:

- Use the most effective herbicide for the species.
- Follow the application methods prescribed on the label.
- Choose an optimum time period to apply treatments; for foliar-applied herbicides this is late-summer to early fall and not later than a month before expected frost.
- Adhere to all label prohibitions, precautions, and Best Management Practices (BMP) during herbicide transport, storage, mixing and application.
- Remember that some herbicides require up to a month before herbicidal activity is detectable as yellowing of foliage or leaves with dead spots or margins. Thus, after application, be patient; allow herbicides to work before resorting to other treatment options.

Selective Herbicide Application Methods
Although treating extensive inaccessible infestations may require broadcast treatments of herbicide sprays or pellets by helicopter or tractor-mounted application systems, the best approach is usually selective applications of herbicides to target non-native plants while avoiding or minimizing application to desirable plants. The selective methods described are directed foliar sprays, stem injection, cut-treat, basal sprays, and soil spots.

Directed Foliar Sprays
Directed foliar sprays are herbicide-water sprays aimed at target plant foliage and covering all leaves to the point of run off. Herbicide application by directed foliar spray is the most cost-effective method for treating most types of invasive plant species. With this method, herbicides are thoroughly mixed in water with a non-ionic surfactant and applied either to the foliage and growing tips of woody plants or to the entire herbaceous plant.

Directed sprays are usually applied either with a backpack sprayer or with spray systems mounted on all-terrain vehicles, trucks or tractors with a spray wand equipped with a full cone, flat fan, or adjustable cone spray tip. To minimize drift, use a spray shield, wand extensions or drift retardants.

Foliar sprays are usually most effective when applied from midsummer to late fall, although spring and winter applications can be used on specific plants and situations. Selective treatment is possible because the applicator directs the spray towards target plants and away from desirable plants.

Stem Injection
Stem injection (including hack-and-squirt) involves applying herbicide concentrate or herbicide-water mixtures into downward incision cuts spaced around woody stems made by an ax, hatchet, machete, brush ax, or tree injector.

Tree injection, including the hack-and-squirt technique, is a selective method of controlling larger trees and shrubs (more than 2 inches in diameter) with minimum damage to surrounding plants. It requires cuplike downward incisions spaced around the stem with a measured amount of herbicide applied into each of the incisions. Special tree injectors are available to perform this operation, or a narrow-bit ax, hatchet, or machete along with a spray bottle can be used in sequence to perform the hack-and-squirt method.

Completely frilling the stem with edge-to-edge cuts or injections is required for very large stems or difficult-to-control species. The herbicide should remain in the injection cut to avoid wasting herbicide on the bark and to prevent damage of surrounding plants. All injected herbicides can be transferred to untreated plants by root grafts and uptake of root exudates. Herbicides with soil activity can damage nearby plants when washed from incisions into the soil by unexpected rainfall soon after application. For that reason, avoid injection treatments if rainfall is predicted within 48 hours.

Tree injection treatments are most effective when applied in late winter and throughout the summer. However, heavy spring sap flow can wash herbicide from incision cuts, making spring an ineffective period.

Cut-Treat
Cut-treat involves herbicide concentrates or herbicide-water mixtures applied to the outer circumference of freshly cut stumps or the entire top surface of cut stems, applied with a backpack sprayer, spray bottle, wick, or paint brush. Freshly cut stems and stumps of woody stems, including canes and bamboo, can be treated with herbicide mixtures to prevent re-sprouting and to kill roots. Cutting is usually accomplished using a chainsaw, but can be accomplished by handsaws or cutting blades. To minimize deactivation of the herbicide, remove sawdust from stumps before treatment. Treat large stems and stumps as quickly as possible after cutting with a backpack sprayer or utility spray bottle. Use a wick applicator, lab wash bottle, or paintbrush for small stems. Add a non-ionic surfactant to the mix to aid in penetration, if permitted by the label.

For stumps over 3 inches in diameter, completely wet the outer edge with the herbicide mixture. Completely wet the tops of smaller stumps and all cut stems in a clump. Apply a basal spray mixture of herbicide, oil and penetrate the stumps that have remained untreated for over 2 hours.

The most effective time for the stump spray method is late winter and summer. Although winter treatments are slightly less effective than growing season applications, the absence of foliage on cut stems and branches produces some offsetting gains in application efficiency.

Basal Sprays
Basal sprays are herbicide-oil-penetrant mixtures sprayed or daubed onto the lower portion of woody stems, usually applied with a backpack sprayer or wick applicator. Full basal treatments require that the lower 12 to 20 inches of target woody stems be completely wetted on all sides with an oil-based spray mixture.

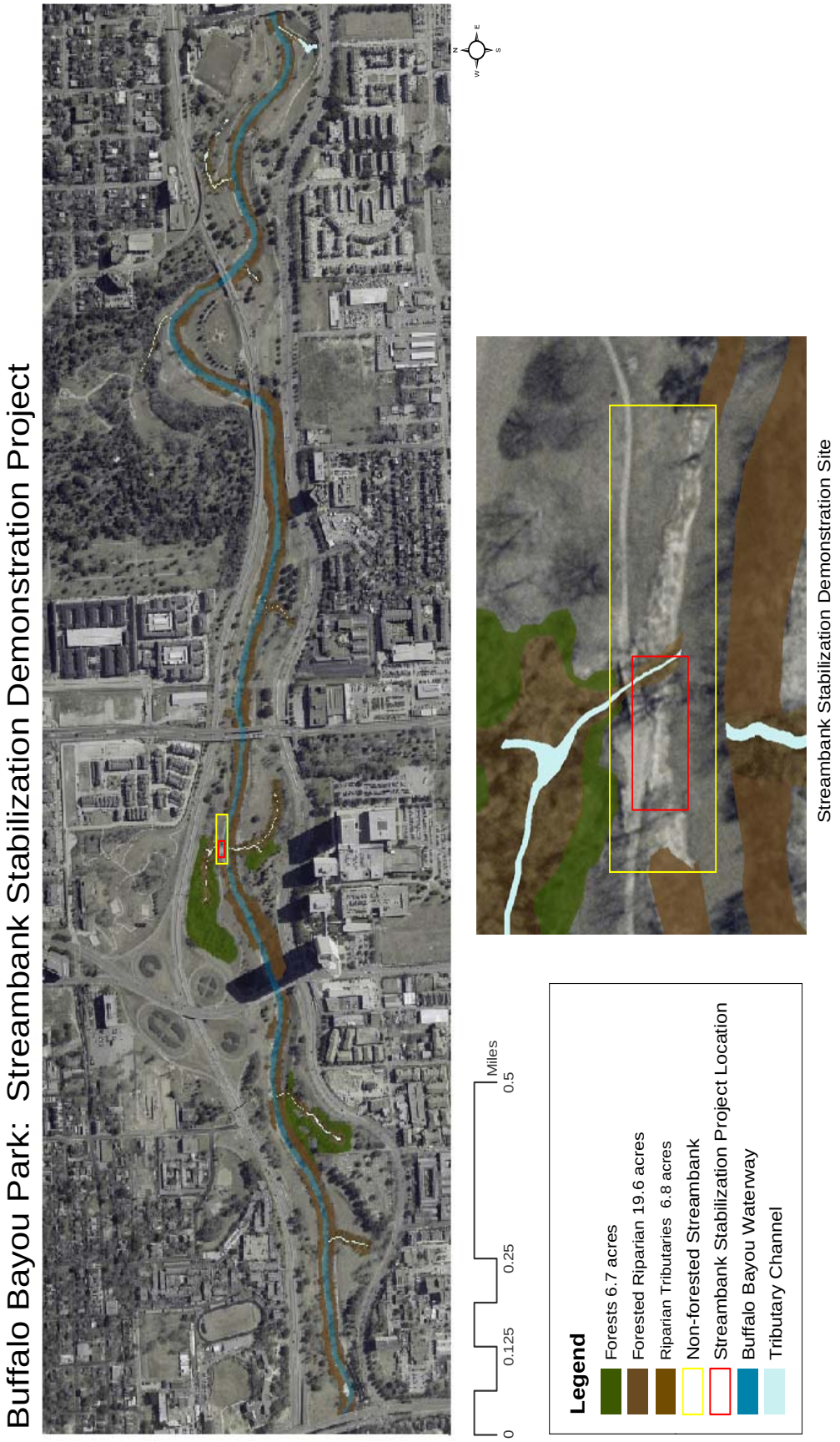
Sprays should be applied to smooth juvenile bark. Full basal sprays are usually effective in controlling woody stems less than 6 inches in diameter or larger diameters of susceptible species, before bark becomes thick, corky, and furrowed. The appropriate equipment for this treatment is a backpack sprayer with a wand or spray gun fitted with a narrow-angle flat fan, cone, or adjustable tip. A wick applicator can also be used.

Herbicides that are soluble in oil (mainly Garlon 4) are mixed with a commercially available basal oil, diesel fuel, or kerosene often adding a special penetrant. Some herbicides, such as Pathfinder II and Pathway, are sold ready-to-use with these ingredients.

The Rehabilitation Phase
Rehabilitation is the most important final phase of an integrated invasive plant eradication and reclamation program. The rehabilitation phase requires establishment and/or release of fast-growing native plants that can out-compete and outlast any surviving nonnative plants while stabilizing and protecting the soil. If the soil seed bank remains intact, native plant communities may naturally reinitiate succession after eradication of nonnative plants. Lightly-seeded native species are usually present in the seed bank while heavier seeded plants will gradually be deposited on a site by birds and other animals.

Often it is necessary to establish fast-growing tree species during the later control phase to hinder reestablishment of shade intolerant nonnative invasive plants. Reestablishing native grasses and forbs is equally important. Tree nurseries operated by State forestry agencies are a good source of many species of native trees and shrubs. Native plant seeds will require proper treatments to assure timely germination. Seedling native plants can be also collected and transplanted from suitable field sites. Their establishment will be more challenging than the commonly available nonnative plants so often used for soil stabilization and wildlife food plots. Monitoring and maintaining forest vigor with minimal disturbance, treating new unwanted arrivals, and rehabilitating the area following invasive eradication are critical to preventing and controlling invasions on a specific site.

Summary of “Nonnative Invasive Plants of Souther Forests: A Field Guide for Identification and Control”. USDA Forest Service Southern Research Station General Technical Report SRS-62.


Buffalo Bayou Park: Streambank Stabilization Demonstration Project
Legend
Forests 6.7 acres
Forested Riparian 19.6 acres
Riparian Tributaries 6.8 acres
Non-forested Streambank
Streambank Stabilization Project Location
Buffalo Bayou Waterway
Tributary Channel
0
0.125
0.25
0.5
Miles
Streambank Stabilization Demonstration Site

7.1 Project Objectives

A principle objective of the Vegetation Management is to determine a strategy to implement Best Management Practices (BMP's) for an embankment stabilization demonstration project along an eroding bank section of Buffalo Bayou Park. The pilot project will test efficacy of re-vegetation through soil bioengineering in the riparian management zone. "Soil bioengineering is an integrated technology that uses sound engineering practices in conjunction with integrated ecological practices. It is a means to assess, design, construct and maintain living vegetation systems, to repair damage caused by erosion and land failures and to protect and enhance functioning systems"(Sotir, 2002). The primary purpose of this pilot project is to minimize erosion, protect Park infrastructure, increase safety and improve instream and downstream water quality within the Buffalo Bayou watershed.

7.2 Streambank Erosion

Stream bank erosion is a natural process that results in the formation of productive floodplains, habitat and other unique characteristics of waterways. "Erosion rates vary due to many factors including: the forces due to flowing water, the embankment soil composition, slope geometry and the type and density of vegetation along the bank" (Erosion Control Along Buffalo Bayou (ECABB), 3). Stable rivers experience some erosion, however, "the rate at which erosion is occurring in stable systems is generally much slower and of a smaller scale than that which occurs in unstable systems" (NRM, 2002). Bank scour and mass failure are two primary mechanisms of erosion in the Park. Bank scour "occurs when the force applied to a bank by flowing water exceeds the resistance of the bank surface to withstand those forces," causing direct removal of bank materials (Rutherfurd, 2002). One obvious form of scour is undercutting of the bank toe. Common strategies for improving scour are aimed at "reducing flow speed through revegetation" (NRM, 2002). Mass failure, including bank collapse and slumping, "occurs when large chunks of bank material become unstable and topple into the stream or river in a single event" (NRM, 2002). Mass failure often occurs after the banks have been saturated from flooding. As the bank dries, heavier, saturated portions shear off. Flooding also deposits sediment throughout the park. A single flood event can deposit over a foot of sediment along the Parks lower terrace.

7.3 Types of Streambank Stabilization

There are many types of streambank stabilization techniques. When determining the type of stabilization for a particular site it is important to consider the location and condition of the site to determine the best type of erosion control for the site. Streambank stabilization techniques fall into three general categories including "(1) conventional vegetative treatments (usually grass, alone or in conjunction with erosion mats, geotextiles, or riprap); (2) conventional bank armoring with riprap, gabions, concrete, or other hard materials; and (3) soil bioengineering" (Sotir, 2002). Both conventional vegetative treatments and bank armoring have been used in the Park with limited success.

There are many locations in Buffalo Bayou Park where conventional vegetation treatments have been installed that are now eroding severely. Conventional bank armoring with stone stabilizes the bank for a boat launch site at the base of Eleanor Tinsley Park. Although the bank has been stabilized by the structure, severe sedimentation occurs on the boat launch and large sand bars have formed in the waterway often obstructing boat access upstream during low tide. Where gabion baskets have been installed, the baskets have almost completely sedimented over and native trees and forbs have begun growing their root systems into the baskets. The banks have stabilized at the gabion, but slumping has been recorded on either end. "No one action can be described as best for the whole bayou since each section is distinctive, with different needs" (ECABB, 5). Soil bioengineering has not been used specifically to stop erosion in the Park although there are many streambank sites that are stable due to a native riparian edge. The demonstration project proposed will use one form of soil bioengineering to demonstrate its effectiveness.

7.4 Soil Bioengineering

Numerous soil bioengineering techniques exist to use to stabilize streambanks. What follows are a few general types of soil bioengineering techniques. Each technique has multiple variation depending on site conditions and desired effect. The appropriate technique will be determined upon review by the team established to complete the project. Descriptions were taken from Guidelines for Streambank Restoration, by Robbin Sotir.

1. Live Stakes
   Live stakes are living, woody stems capable of rooting. Black willow work best along the Bayou for live staking projects. The cuttings should be long enough (2 to 3 feet) and wide enough (0.5 – 2 inches) to be hammered into the slope until approximately 4/5 of the stake is left exposed. They will quickly root and mature into shrubs that will stabilize the slope and restore the riparian habitat zone. The live materials should be freshly harvested and side branches clipped so as to not damage the bark on the stake. The end being driven into the ground should be cut at an angle for ease of installation with a flat top, similar to a standard wooden stake. The stakes should be driven in perpendicular to the slope and angled downstream. Generally, there should be 2 – 4 stakes per square yard. Other steps that may be required for the project includes bank grading and installing natural geotextiles mats that can be held in place by the stakes.

2. Joint Planting
   Joint planting includes the installation of live willow stakes (as previously discussed) between a rock laden streambank. Combining a rocky slope and live staking improves stabilization other either technique alone. When developing a joint planting, the type and size of rock is important for a successful project.

3. Live Fascine
   Live fascines are long, live branches tied together to form bundles that can be used to stabilize streambanks.. Like live staking, fascines are best constructed of willow tree branches. The difference between them is that instead of driving them perpendicular to the slope, the roll is placed along the slope perpendicular to the waterway in a shallow trenches. The fascines are held in place with dead stakes driven through them at 3 foot intervals to secure them to the slope. Installation should occur on a 3 to 1 or flatter foot slope with bundles set 3 to 7 feet apart depending on soil type. If the slope is steeper than a 3 to 1 foot slope, place the fascines 3 to 5 feet apart. Finally, live stakes should be driven in on the downslope of each fascine.

There are many other techniques of soil bioengineering that can be used alone or in combination with gabion baskets or riprap when needed. At this time it is not known if the banks, particularly cutbanks, will require the combination of soil bioengineering and other treatment to permanently stop erosion.

7.5 Streambank Stabilization Demonstration Project

Bank scour on the outside of a meander bend (cut bank) is apparent throughout Buffalo Bayou Park. “Over eighty percent of the bank failures studied along Buffalo Bayou were located at cutbanks” (ECABB, 3). In developing a streambank demonstration project, a number of factors determined where and what type of erosion should be stabilized for the pilot project including:

- Type of erosion (scour)
  Bank scour was chosen for the pilot project because scour is a dominant form of erosion in the Park. Refining a technique to treat scour will allow the techniques to be reproduced throughout the park.

- Location of erosion (cutbank)
  A large percent of bank scour is occurring on the cut bank of a meander bend. By installing the pilot project on a dominant condition occurring in the Park, the procedures can be used and improved upon numerous times.

- Impact to hike and bike trail (encroachment on trail system)
  Erosion is a problem throughout the riparian section of the Bayou, decreasing habitat and encroaching on parkspace. Threats to public safety, like when erosion creates high, steep and week shoulders and when it begins cutting into a trail segment, were both criteria for determining the best location to perform the pilot project.

- Visibility (ability to be demonstrated to park users)
  To increase public awareness about erosion in the park and display alternate methods for embankment stabilization to bulk heading or other forms of hard banks, a high visibility location was preferred.

The site chosen for the Demonstration Project is located on the north bank, just east of the Waugh Street overpass. Here, the trail slopes toward the bayou to reach an intersection of dense tributary forest and the riparian edge of Buffalo Bayou. Bank erosion of the riparian zone immediately west of the mouth of the tributary has begun undercutting the trail exposing layers of the trail's base material, cracking off the edge of the blacktop. The Streambank Stabilization Demonstration Project Map on Page 49 shows the location proposed for the project within the Park.


University of St. Thomas professor and students setting erosion pins at the SSD site.


Streambank Stabilization Demonstration site from the trail.

Project Team

For a successful project, a project team will be assembled to ensure that all the necessary steps have been taken for a successful project. The team will consist of the following:

- Project Manager:
  The project manager will be the Buffalo Bayou Partnership's Urban Forester. They will be responsible for organizing the rest of the team, scheduling, acquiring permits, monitoring costs and keeping the project on target. They will also be responsible for keeping all records of work done on the project for the agency funding the project.

- Surveyor
  The surveyor will perform a geological survey of the site. This information will be given to the rest of the project team to determine engineering and soil bioengineering needs.

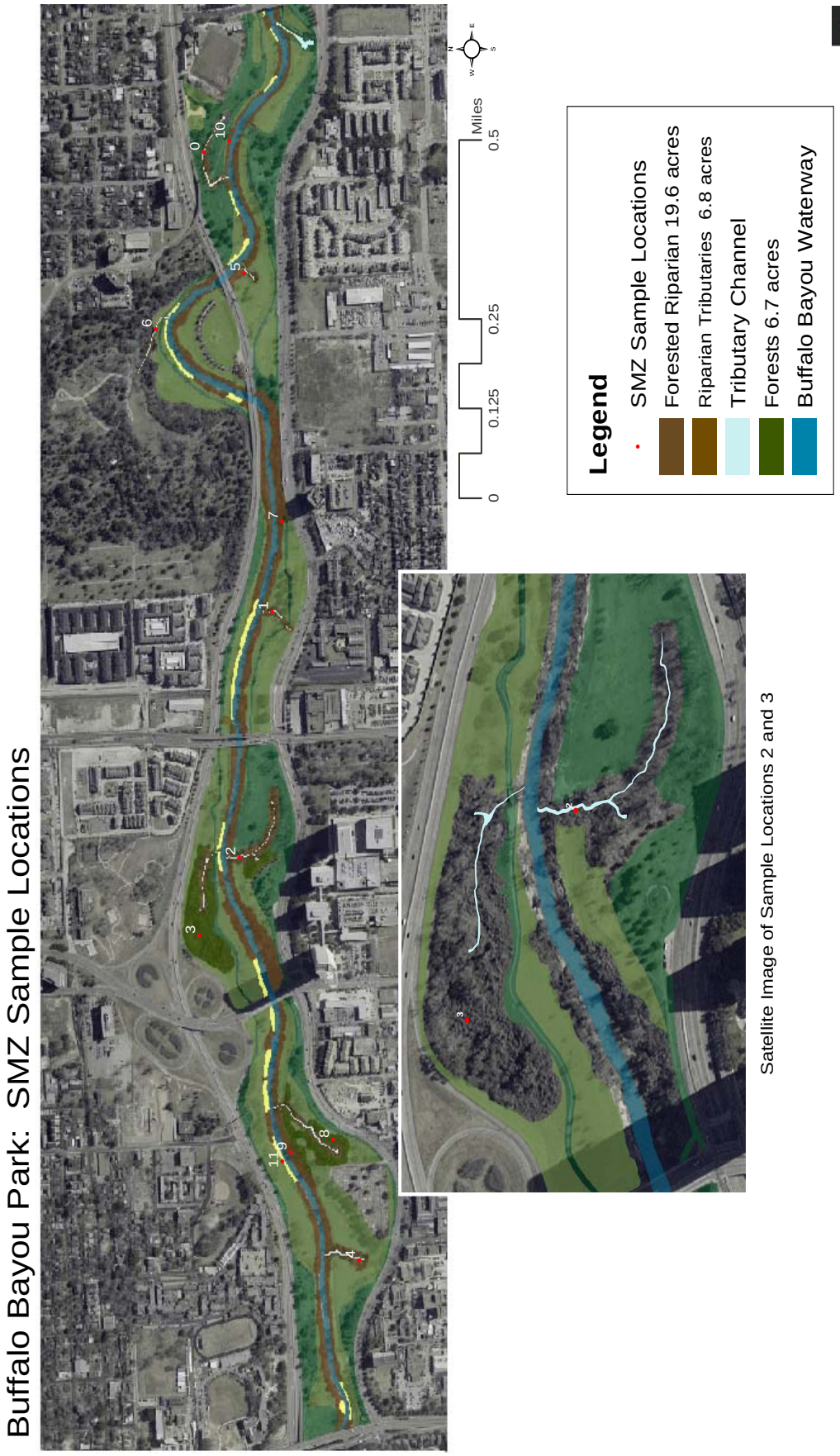
- Civil Engineer
  The civil engineer will be responsible for ensuring that the proposed project has the necessary permits and will sign off on engineering drawings for project approval.

- Biologist
  The biologist will perform a habitat assessment before and after the installation of the stabilization procedures.

- Soil Bioengineer
  Working with the engineer, the soil bioengineer will determine the best soil bioengineering strategy to stabilize the streambank and perform the streambank stabilization installation.

Regulatory Agencies
Regulatory agencies including Harris County Flood Control District, the City of Houston Parks and Recreations and the US Army Corps of Engineers require survey information and Engineering drawings for approval. It will be the responsibility of the project manager to acquire permits necessary for the project to move forward.

Once the project has acquired the appropriate funding to perform the demonstration project and the project team has been assembled, an accurate assessment of the site by the project team will determine the specific method of bioengineering to stabilization and restore the bank. Site monitoring and maintenance should be clearly defined in the initial project description.


Buffalo Bayou Park: SMZ Sample Locations
Legend
SMZ Sample Locations
Forested Riparian 19.6 acres
Riparian Tributaries 6.8 acres
Tributary Channel
Forests 6.7 acres
Buffalo Bayou Waterway
0
0.125
0.25
0.5
Miles
Satellite Image of Sample Locations 2 and 3

Appendix II: Invasive and Non-native Plant List

Scientific Name	*Common Name*	*Type*	*Status*	*Location*
Alternanthera philoxeroides	Alligatorweed	Forb	Invasive	Wetland
Ambrosia trifida	Giant Ragweed	Forb	Invasive	Wooded edges
Arundo donax	Giant Reed	Grass	Invasive	Tributary
Cardiospermum halicacabum	Love in a Puff	Vine / Forb	Invasive	Throughout
Cynodon dactylon	Bermudagrass	Grass	Invasive	Wildflower & Prairie
Melia azedarach	Chinaberry	Tree	Invasive	Wooded Areas
Pueraria montana	Kudzu	Vine	Invasive	Wooded Edges
Sapium sebiferum	Chinese Tallow	Tree	Invasive	Wooded Areas
Sorghum halepense	Johnson Grass	Grass	Invasive	Riparian
Wedelia trilobite	Wedelia	Forb, Ground Cover	Non-native	Wooded Areas
Trachelospermum asiaticum	Asian Jasmine	Forb, Ground Cover	Non-native	Wooded Areas
Ulmus parvifolia	Chinese Elm	Tree	Non-native	Active-use parkspace
Koelreuteria bipinnata	Goldenrain Tree	Tree	Non-native	Tributaries, Active-use parkspace

Appendix III: Herbicide List

Herbicide	*Target Species*	*Application Type*	*Application Time*	*Note*
Aqua-king				Surfactant additive
Arsenal (Imazapyr)		Foliar		Pre-emergent effect used early in the spring
Garlon 3A (Triclopyr)		Foliar		Controls large areas of ragweed, applied to wet vegetation
Grazon p+d	Sapium sebiferum and other woody species	Cut-treat	June - October	Treat individual coppicing stems on cut stumps
Outrider (Sulfosulfuron)		Foliar		Selective herbicide for annual and perennial grass and broadleaf weeds
Plateau (Imazapic)	Sorghum halepense	Foliar		Selective
Rodeo (Glyphosate)		Foliar		Approved for aquatic applications
Roundup Pro (Glyphosate)		Foliar		Selective broad-leaf

Habitat Assessment

Appendix IV

This activity is performed post Vegetation Management Plan to monitor restoration progress.

The site description is easy to do and consists of observing, measuring and noting the main features of your site. It is useful for

- learning about the natural areas within the bayou corridor and
- identifying degraded conditions for future restoration.

Things to do at the site

Take a walk.

Determine the extent of the area to be assessed. Pace 10m upstream and 10m downstream from a point of reference such as a tree or rock. Walk the 20m area along the stream bank and become familiar with the features of the site and surrounding land.

Fill in the details of the top portion of the Site Description Sheets.

You must identify the portion of the corridor you are in with latitude and longitude points along with the name if it has one. For instance, when assessing the Taft Tributary, name it such.

Make a sketch or take a photograph

Make a sketch or take photographs of the area on your Site Description Sheet. Sketches and photographs are useful means of keeping a visual record of the site.

RATING THE HEALTH OF THE SITE HABITAT

This section describes how you can reate the health of the habitat on a scale of excellent , good, fair or poor. This survey is designed for assessing the health of stream habitats but can be used for wetlands, lakes and ponds.

Riparian vegetation

The riparian zone is an area up to about 30m wide directly adjoining the waterway and can include vegetation such as trees, shrubs, forbs and grasses.

Instream Cover

In-stream cover includes overhanging banks and aquatic vegetations, snags, fallen trees, logs and rocks. Streams with a rich diversity of in-stream cover allow fish and macro-invertebrates to shelter from the current, feed and reproduce. Aquatic plants provide food and oxygen, and protruding snags provide roosting and preening sites for birds.

Bank Erosion and Stability

Streams naturally erode on the outside of bends (meanders) and deposit sediment on the inside of the bend. However, changes in nearby land uses can cause a stream to become unstable, resulting in continuous erosion along its channels. You may find steep walled gullies, bank collapse, slumping and hanging roots from riparian vegetation.

Riffles, Pools and Runs

A *riffle* is a section of a flowing waterway where shallow water flows over rocks in rapid turbulent flow. As the water flows downstream the stream bed may deepen and form a quiet *pool* or the water may deepen and *run* smoothly.

Steams that contain a number of pools and riffles are able to support a greater variety of species that those that do not vary in character at all.

To obtain an overall assessment of the site, add each score to obtain a total. The total gives an overall indication of habitat conditions.

Description of Habitat Ratings

Habitat Categories	Excellent = 8	Good = 6	Fair = 4	Poor = 2
Riparian Vegetation (examine vegetation from the water to about 30m back)	Mainly undisturbed native plants on both sides of the bayou or tributary. Introduced species are absent or insignificant. Riparian zone up to 30m wide	Native vegetation on both sides of the bayou or tributary in generally good condition. Some intrusion of introduced species. Wide riparian zone.	Mixture of native and non-native on either or both sides of the bayou or tributary.	Any native vegetation present is severly modified on both sides. Cleared land on both sides. Species present are virtually all exotics.
In-steam cover (aquatic plants, snags, logs, bank overhangs and overhanging vegetation	High cover on banks. Abundant in-stream and overhanging vegetation. Abundant snags and logs or boulders.	Good coverage on the banks, moderate areas of in-stream and overhanging vegetation. Some snags and logs.	Some cover. Some areas of in-stream or overhanging vegetation. Invasion of by terrestrial grasses. Few snags and logs.	Little or no cover. No overhanging vegetation or in-stream plants. The stream is largely cleared with rare or no snags and logs.
Bank erosion & stability (roots, bare soil, slumping, fall-ins, cracking on banks	Stable. No erosion or deposition evident. No slumping or banks. Lower banks completely covered with root mat, grasses, reeds or shrubs.	Very occasional and very localized erosion. Little slumping or undercutting of bank. No significant damage to the bank. Good vegetation cover.	Some erosion evident but not localized. No continuous damage to bank structure. Moderated vegetation cover.	Extensive areas of erosion. Unstable, extensive areas of bare ground, bank failure, such as cracks and fall-ins. Little vegetation cover.
Riffles, Pools and Runs	Wide variety of habitats. Riffles and pools of varying depths present. Bends present.	Good variety of habitat eg. riffles and runs or riffles and pools. Variation in depth of riffle and pool.	Some variety of habitats eg. occasional riffle or bend. Some variation in depth.	Uniform or only slight variety of habitat. All riffles or pools with uniform or only slight variation in depth.

Site Description

For each site you will need to complete this sheet, in the future it will be used to assess if there have been any changes in or around the site and to help assess restoration efforts. Describe the area 10m upstream and 10m downstream from where you are standing.

Investigators:

_____

Name of Water Body: _____

Latitude: _____ **Longitude:** _____

Date: _____ **Time:** _____

Zone Type: ☐ Bayou Riparian ☐ Tributary Riparian ☐ Forest

☐ Wetland

Bank Side: ☐ North ☐ South

Brief Description of the Site:

Birds Eye View of Site:
Sketch the site showing bends, adjacent land use on both sides. Mark areas of vegetation, eroded banks, fences, roads, drains, etc. Try to draw 20m of stream length. Label sketch where possible. Mark and number any photos and draw an arrow to show the direction from which each photograph was taken. Show direction of streamflow.

Bird's Eye View of Survey Site

General Features of Waterway

1. Appearance of Water

☐ Clear ☐ Muddy ☐ Milky ☐ Stained Green ☐ Foamy/Frothy ☐ Oily Sheen

☐ Stained Brown ☐ Reddish

OTHER (describe) _____

2. Smell of Water

☐ Sewage ☐ Fishy ☐ Chlorine ☐ Rotten Egg ☐ None

OTHER (describe) _____

Habitat Rating

Circle the appropriate score for each part of the habitat below:

Habitat Rating	Riparian Vegetation	In-Stream Cover	Erosion and Stability	Pools, Riffles & Runs
Excellent	8	8	8	8
Good	6	6	6	6
Fair	4	4	4	4
Poor	2	2	2	2

How to get an overall assessment of the site
If you wish to get a general rating for the site then add up each condition rating for a total score. The ninimum total score is 6 and the maximum is 24. Compare the total score with the range of scores to find a description of the general condition of the stream habitat.

HABITAT RATING

TOTAL SCORE	RATING	CONDITION OF HABITAT
21 – 24	**Excellent**	Site in natural or virtually natural condition; excellent habitat condition.
16 – 20	**Good**	Some alteration from natural state; good habitat conditions.
11 – 15	**Fair**	Significant alterations from the natural state but still offering moderate habitat; stable.
6 – 10	**Poor**	Significant alterations from the natural state to very degraded. May have moderate to sever erosion or sedimentation problems.

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