

A dirt path winds through a lush green park. The path is made of light-colored gravel and dirt, curving gently to the right. On the left side of the path, there is a low stone wall and a fallen log. The right side is bordered by tall grass and a large, leafy tree. In the background, more trees and a house are visible under a bright sky.

San Marcos Natural Areas Land Management Plan

Parks and Recreation Department

ACKNOWLEDGMENTS

The San Marcos Natural Areas Land Management Plan was developed by the City of San Marcos with the technical support and design assistance of Halff. A special thanks goes to the many community members, staff members, and San Marcos Greenbelt Alliance for their insight and support during the duration of this planning process. The following individuals are recognized for their contributions towards the creation of the San Marcos Natural Areas Land Management Plan.

MAYOR AND CITY COUNCIL

Jane Hughson, Mayor
Matthew Mendoza, Council Member
Saul Gonzales, Council Member
Alyssa Garza, Council Member
Shane Scott, Council Member
Mark Gleason, Council Member
Jude Prather, Council Member

KEY CITY STAFF

Jamie Lee Case, Director of Parks and Recreation
Bert Stratemann, Parks Operations Manager

PARKS AND RECREATION BOARD

Amanda Hargrave
John P. Hardy
Hilary A. Taylor
John Thomaidis
Mitchell Lee Hoffman
Amanda D. Fox
Benjamin C. Peck
Peter Tschirhart
Alexandra C. Thompson

PREPARED FOR:

City of San Marcos, Texas

STAKEHOLDERS

San Marcos Greenbelt Alliance
Great Springs Project
San Marcos River Foundation
Emerald Crown Trail Work Group
San Marcos Council of Neighborhood Associations

HALFF

Nathlie Booth, AICP
Matt Bucchin, AICP
Jordan Maddox, AICP
Julian Salas-Porras
Whitney Linder
Brandyn Littleton
Samantha Kaschel
Jeremy Mantooth

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION & PLANNING PURPOSE

Introduction to the Natural Areas.....	2
Purpose of this Plan.....	6

CHAPTER 2: BENEFITS & GOALS

Ecosystem Benefits.....	10
Public Engagement Summary.....	12
Vision Statement and Goals.....	14

CHAPTER 3: ENVIRONMENTAL OVERVIEW

Environmental Features.....	18
Soil Resources.....	18
Geologic Resources.....	22
Biologic Resources.....	25
Protected Species.....	28
Aquatic Resources.....	30
Wildfire Intensity Risk.....	32
Environmental Sensitivity.....	34
Natural Areas Site Ecosystem Descriptions.....	36
Spring Lake.....	36
Sessom Creek.....	37
Schulle Canyon.....	38
Western Loop Unit (Ringtail Ridge, Millican and Early).....	39
Lower Purgatory Creek (including Prospect Park).....	40
Upper Purgatory Creek (including Barker, Wildenthal, and River Recharge).....	41
Retreat on Willow Creek.....	42
Blanco River Unit.....	43
Cottonwood Creek.....	44

CHAPTER 4: STANDARDS & MANAGEMENT RECOMMENDATIONS

Introduction.....	48
Management Goals and Objectives.....	49
Goal 1: Natural Resource Preservation.....	50
Habitat Preservation.....	50
Edwards Aquifer Protection.....	54
Goal 2: Natural Resource Management.....	56
Habitat Restoration and Stabilization.....	56
Invasive Species Control.....	64
Fire Hazard Planning Guidance.....	75
Fire Management.....	79
General Land Management Best Practices.....	86
Goal 3: Use, Safety, and Connectivity.....	88
Safe and Accessible Trail Systems.....	89
User Safety and Education.....	106
Trail Connectivity and Expansion.....	112

CHAPTER 5: IMPLEMENTATION

Introduction.....	116
-------------------	-----

TABLE OF CONTENTS

APPENDIX

MAPS

1.1 Regional Context.....	2
1.2 Citywide Context.....	5
3.1 Soil Resources.....	19
3.2 Geologic Resources.....	23
3.3 Biologic Resources.....	29
3.4 Aquatic Resources.....	31
3.5 Wildfire Intensity Risk.....	33
3.6 Environmental Sensitivity	35
4.1 Fire Hazard Mapping.....	77
4.2 Wildfire Intensity Risk.....	80
4.3 Citywide Trails System.....	114

FIGURES

4.1 Sensitive Lands by Natural Area.....	51
4.2 Rolling Contour Trail Design.....	91
4.3 Trail Loops and Stacking.....	93
4.4 Miscellaneous Trail Design Guidance.....	94
4.5 Specialized Trail Design Features and Sources.....	95
4.6 Single Track Trail Cross-Section.....	96
4.7 Double Track Trail Cross-Section.....	97
4.8 Multi-use Trail Cross-Section.....	98
4.9 Riparian Corridor Trail Cross-Section.....	99
4.10 Vehicle Trail Cross-Section.....	100
4.11 ROW Trail Cross-Section.....	101
4.12 Trail Materials	103
4.13 Suggested Annual Trail Maintenance Schedule.....	105

TABLES

3.1 Soil Types within the Natural Areas.....	20
3.2 Geologic Units within the Natural Areas.....	24
3.3 Natural Area Management Recommendations.....	45
4.1 Natural Area Regulation Applicability.....	55
4.2 Trail Counter Data.....	90
4.3 Golden-Cheeked Warbler Trail Counter Data.....	90
5.1 Implementation and Prioritization.....	119

Introduction & Planning Purpose



INTRODUCTION TO THE NATURAL AREAS

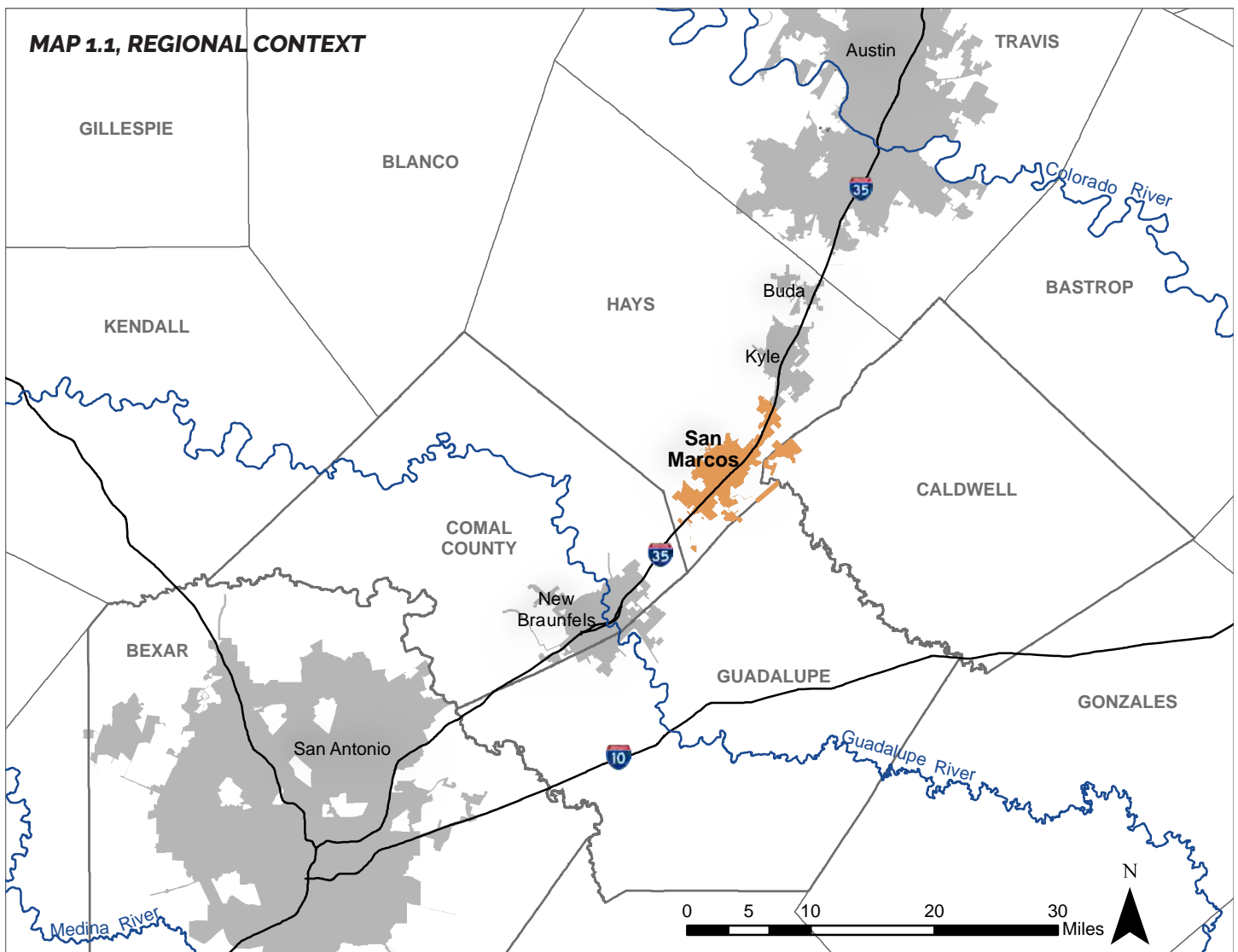
PURPOSES OF THE NATURAL AREAS

The City of San Marcos Parks and Recreation Department manages over 1,500 acres of natural areas. Unlike traditional parks, natural areas are parklands conserved in an undeveloped state. The primary purposes of the San Marcos natural areas are natural resource preservation, protection of water quality and quantity in the Edwards Aquifer and the San Marcos River, and flood mitigation in the watersheds of the San Marcos and Blanco Rivers. A secondary purpose of the natural areas is for passive recreational opportunities to promote human physical and mental health and to foster knowledge and awareness of the importance of proper land conservation.

TERMINOLOGY

The term “natural area” in this plan means a tract of

undeveloped land that is preserved and managed primarily for its ecological value. The ecological value includes protection of water quality and quantity, flood mitigation, and biologic and geologic features, and it also encompasses scenic, archaeological and cultural features. The terms “greenspace” and “natural area” are used somewhat synonymously in the City’s 2019 Parks, Recreation and Open Space Master Plan, but the term “natural area” connotes that the land is not only left undeveloped but is actively managed to restore and enhance the land’s native ecosystems. The City’s natural areas also have recreational and educational value, but their primary value is ecological. Most of the City’s existing natural areas are dedicated parkland, are zoned “P - Public and Institutional District” on the City’s zoning map and are shown on the City’s Preferred Scenario Map as “Park or Natural Area.”



REGIONAL CONTEXT

San Marcos, Texas, found within the Central Texas megaregion, is located 30 miles southwest of Austin and 51 miles northeast of San Antonio. Due to the City's location along the Balcones Fault Zone of the Balcones Escarpment, the City of San Marcos is a unique ecotone, or region of transition between ecosystems.

West of San Marcos is the Edwards Plateau ecoregion, consisting of forested or grassy rolling hills, and to the east of San Marcos is the Blackland Prairie ecoregion. Within the Balcones Fault Zone, the San Marcos Springs Fault is the source of the San Marcos Springs, an artesian outflow from the Edwards Aquifer and the second largest natural cluster of springs in Texas. The San Marcos Springs are the source of Spring Lake and are also the headwaters of the San Marcos River. Both the San Marcos River and the Blanco River flow through the City of San Marcos, which is located within the Guadalupe River Watershed. Into these rivers flow Cottonwood Creek, Purgatory Creek, Sink Creek, Sessom Creek, and Willow Springs Creek.

HISTORY OF INHABITATION OF SAN MARCOS & SPRING LAKE

The rich ecological characteristics of San Marcos are a key reason why San Marcos, and specifically the San Marcos Springs, is known as a "persistent place," meaning humans of varying cultures and technology have been drawn to and inhabited the area repeatedly. Humans have been known to occupy the area of the San Marcos Springs for upwards of 13,500 years making this area one of

the longest continuously occupied areas in North America. The area was home to Paleo-Indians, also known as Clovis People. In fact, they consider the springs to be their source of origin.

In 1848, former Republic of Texas Vice President, Edward Burleson, built a cabin overlooking the headwaters and the first dam across the San Marcos River, thus forming Spring Lake. Burleson, along with William Lindsey and Dr. Eli Merriman, founded the town of San Marcos, which was officially established in 1851.

In 1926, entrepreneur A.B. Rogers purchased the land surrounding the headwaters of the San Marcos River and built the Spring Lake Hotel, which opened in 1929. Twenty years later, Paul Rogers, the son of A.B. Rogers, purchased the land surrounding Spring Lake and developed Aquarena Springs Theme Park. The Park, complete with glass bottom boat tours and an underwater theater, served as a tourist destination for several decades.

In 1994, Texas State University, then known as Southwest Texas State University, came into ownership of the land around Spring Lake and developed the International Institute for Sustainable Water Resources. The site is now known as The Meadows Center for Water and the Environment and focuses on water research, education, and water's relationship with the environment. The university has removed many of the buildings associated with the theme park, installed a wetlands walk in the Sink Creek slough area of Spring Lake, and allowed a portion of the theme park site to revert to a wild state with native plants and wildlife.



THE ECOLOGICAL RICHNESS OF SPRING LAKE HAS MADE THE AREA AROUND SAN MARCOS SPRINGS ONE OF THE LONGEST CONTINUOUSLY OCCUPIED AREAS IN NORTH AMERICA

DESCRIPTION OF NATURAL AREAS

The City of San Marcos has several natural areas, shown in **Map 1.2, Citywide Context**, consisting of more than 1,500 acres of land and more than 22 miles of existing trails. Some of the natural areas in this plan are not yet open to the public. The Spring Lake Natural Area is the second largest natural area in the City, behind the Purgatory Creek Natural Area.

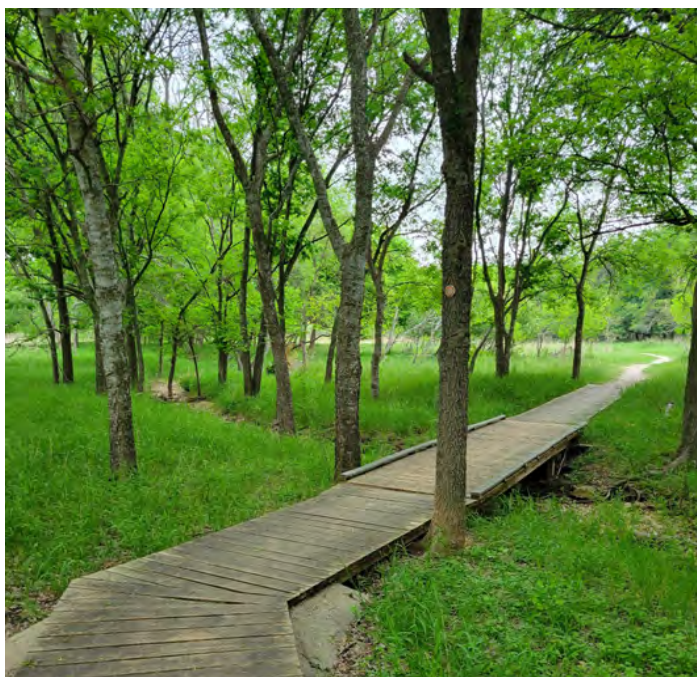
Spring Lake and the San Marcos Springs support several endangered and threatened species, including the Fountain Darter, the San Marcos Salamander, the San Marcos Gambusia, and Texas Wild Rice. The endangered Texas Blind Salamander occurs within the Edwards Aquifer near Spring Lake and at other nearby sites. About half of the Spring Lake Natural Area's 251 acres are found within the Edwards Aquifer Recharge Zone and all of the property is within the Sink Creek watershed.



TRAIL IN SCHULLE CANYON



OPEN SPACE IN FUTURE NATURAL AREA

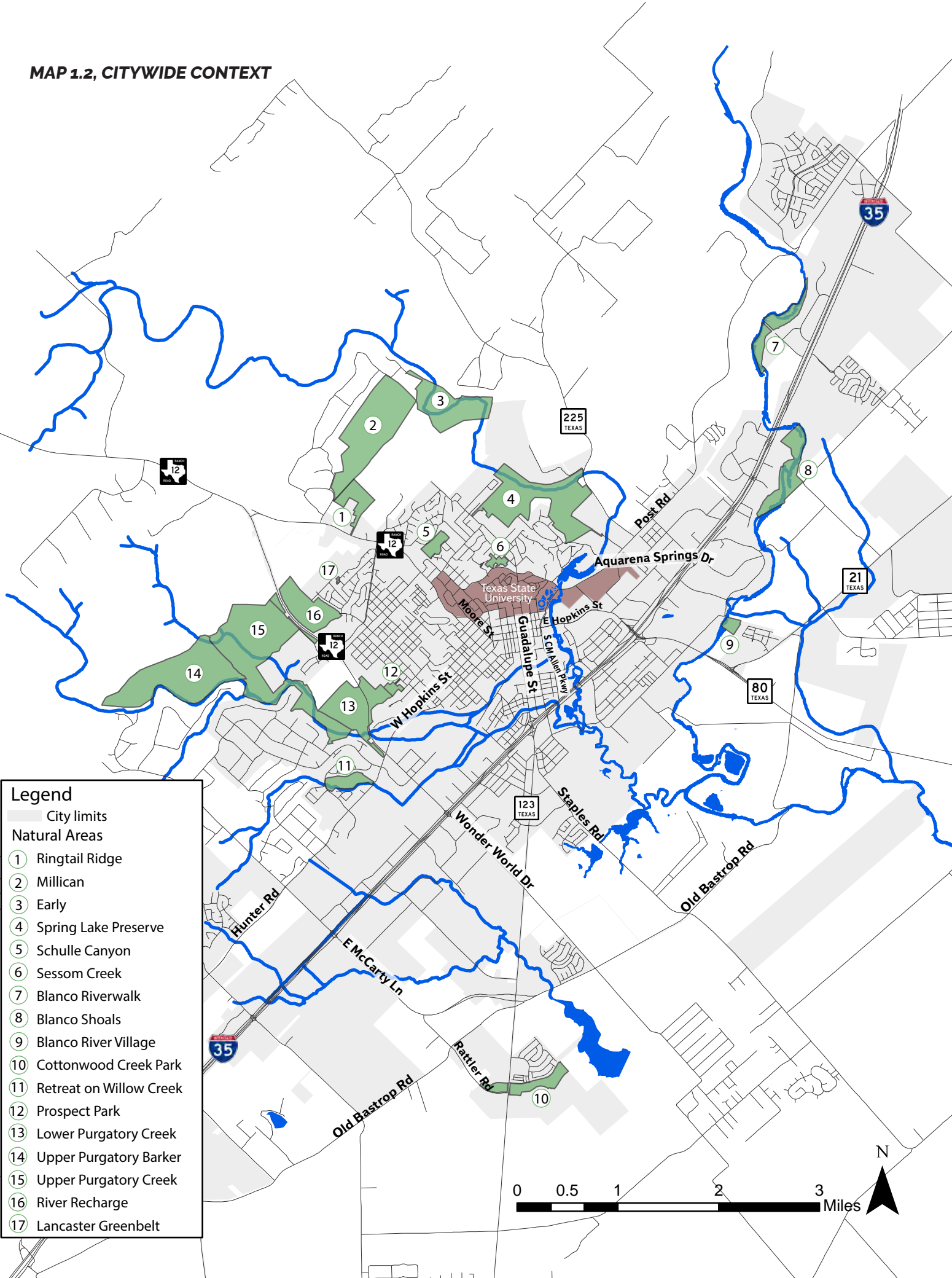


TRAIL IN RINGTAIL RIDGE

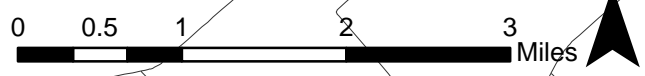


TRAIL IN SPRING LAKE

MAP 1.2, CITYWIDE CONTEXT



- Legend**
- City limits
 - Natural Areas
 - 1 Ringtail Ridge
 - 2 Millican
 - 3 Early
 - 4 Spring Lake Preserve
 - 5 Schulle Canyon
 - 6 Sessom Creek
 - 7 Blanco Riverwalk
 - 8 Blanco Shoals
 - 9 Blanco River Village
 - 10 Cottonwood Creek Park
 - 11 Retreat on Willow Creek
 - 12 Prospect Park
 - 13 Lower Purgatory Creek
 - 14 Upper Purgatory Barker
 - 15 Upper Purgatory Creek
 - 16 River Recharge
 - 17 Lancaster Greenbelt



PURPOSE OF THIS PLAN

In recent years the City of San Marcos Parks and Recreation Department and its partners have realized that a long-term commitment to protect the City’s natural areas is essential to preserving them for future generations. They have also realized that well-planned, thoughtful stewardship is needed to achieve this protection, and to ensure that the natural areas perform all of the functions intended for them. Stakeholders who participated in the public input process for this land management plan asserted that the highest priority of this plan should be to preserve and enhance the natural environment – particularly protecting native habitat and maintaining the water quality and quantity necessary for healthy aquatic ecosystems. The purpose of this San Marcos Natural Areas Land Management Plan is to establish an inventory and framework for the preservation, management, restoration and enhancement of the natural, cultural, visual, archaeological, and recreational resources of the natural areas.

PLAN ORGANIZATION

Chapter 1 provides the context of the San Marcos natural areas and related planning efforts. Chapter 2 introduces the plan goals and identifies objectives that will contribute to achieving the goals. Chapter 3 includes an overview of the environmental features of the natural areas, and ecosystem descriptions and summary management objectives and recommendations for each of the natural areas. Chapter 4 identifies realistic, specific standards and management recommendations for achieving the goals and objectives of this plan based on state, national, and local best practices.

AUTHORITY AND RESPONSIBILITY

The natural areas are the responsibility of the City of San Marcos which has all authority commensurate with any agency holding title to property.

While some aspects of this plan affect the City’s water utility, stormwater management, and firefighting functions, the Parks and Recreation Department is the point of contact for use and the management activities that occur in the natural areas. The Parks Department is responsible for and charged with overseeing general operations in the natural areas including stewardship and recreation activities.

- The Parks Department will prepare and oversee the execution of contracts and memorandums of understanding for materials and services provided in the natural areas
- The Parks Department retains the authority to make decisions in conflict with the guidelines in this land management plan when its agents deem necessary

All participants in stewardship activities must conduct actions with the consent and under the supervision of the parks department.

FUNDING

Funding for improvements to and maintenance and management of the natural areas has primarily been from the City General Fund appropriated to the Parks and Recreation Department. Since the City acquired its first natural area over 20 years ago, the Parks Department has leveraged its funds significantly with efforts of the San Marcos Greenbelt Alliance and other volunteer groups that construct and maintain trails, manage invasive species, and promote use and appreciation of the natural areas. The City should consider use of additional funds from the General Fund and from other City revenue sources to accomplish the purposes of this plan. In addition, larger improvement projects in the natural areas should be considered for inclusion in the City Capital Improvements Plan.

RELATIONSHIP TO OTHER PLANS

There have been multiple planning efforts in the past related to the natural areas in San Marcos. This land management plan is not intended to be a replacement of those plans; rather, it is intended to complement the other plans and ensure that the natural areas are properly managed to ensure their long-term health and sustainability.

Vision SMTX Comprehensive Plan

The City of San Marcos is updating its Comprehensive Plan from 2013. This comprehensive plan rewrite will establish the goals and vision for the future of San Marcos for the next 20 years. Although the plan is only in a draft stage at the completion of this land management plan, many of the goals from the comprehensive plan support the management strategies and recommendations in this land

management plan. The following goals and policies from the 2013 comprehensive plan are specifically furthered by efforts recommended in this plan.

- Goal ENV-1: Protect, restore, and conserve open spaces and natural systems (particularly waterways, floodplains, watersheds, karst, and recharge features) as growth and development occur.
 - ENV-1.5 Establish riparian buffer zones for resource protection of rivers, creeks, retention ponds, and flood mitigation areas.
 - ENV-1.6 Enforce the preservation of trees and native habitats.
 - ENV-1.7 Mitigate erosion along riverbanks through habitat protection and ecological restoration. Protect and restore sensitive natural areas and habitats.
- Goal ENV-2: Ensure adaptability and resilience to natural, climate, and other unexpected events to protect human life and natural resources.
- Goal PPS-1: Provide an accessible, diverse connected network of parks, open spaces, and recreation facilities to serve the entire San Marcos community.
 - PPS-1.1 Create a Greenways Master Plan to improve pedestrian and bicycle access and connections between parks, open spaces and recreation facilities and to encourage active transportation.
 - PPS-1.2 Implement a signage, wayfinding and interpretation system to improve access to and information about parks, recreation facilities, and open spaces.
- Goal PPS-2: Ensure stewardship of the rivers, aquifers, and other sensitive lands and natural resources while providing outdoor recreation opportunities.
 - PPS-2.3 Locate parks, open spaces, and natural areas to protect and benefit the aquifer.
- Goal AC-1: Foster arts and culture citywide to provide enrichment and education opportunities for all residents.
 - AC-1.5 Develop a wayfinding and interpretive system for artistic, historic, and cultural resources.

Several other goals and policies in the Comprehensive Plan align with the goals and objectives of this land management plan, particularly regarding connecting and preserving open space east of Interstate 35. But the goals and policies listed above have the most direct connections to this plan.

San Marcos Parks, Recreation, and Open Space Plan

Adopted in 2019, this plan established the foundation for the creation of this Natural Areas Land Management Plan. The Greenspaces and Resource Protection element identified issues and needs for the natural areas and concluded that a long-range management plan needed to be created to protect these environmentally sensitive areas.

Edwards Aquifer Habitat Conservation Plan

The Edwards Aquifer Habitat Conservation Plan (EAHCP) is the culmination of a decade’s-long conversation on how to best protect the endangered and threatened species in and near the San Marcos Springs and the San Marcos River. The EAHCP has many ongoing projects in and along the San Marcos River and creeks and tributaries that drain to the river, that work together to protect and enhance the river’s water quality and native habitat. These projects include removing invasive, plants like hydrilla from the river, and ligustrum and elephant ears along its banks and planting a diversity of historically native plants. The overall goal is to create a healthier ecosystem that protects not only the protected species, but all of the river’s native animals and plants.

Stormwater Management Plan

The City has a Stormwater Management Plan (SWMP), updated most recently in 2018. This plan, administered by the City Stormwater Management Department, covers drainage infrastructure in the City and ensures compliance with the Municipal Separate Storm Sewer System (MS4) permit issued by the Texas Commission on Environmental Quality (TCEQ) to the City. Under this permit, the City is required to create and implement the SWMP to control the level of pollutants in surface water that enters the City’s drainage system, which includes creeks and tributaries in the natural areas. The SWMP includes a broad range of pollution control measures, one of which is “Pollution Prevention and Good Housekeeping for Municipal Operations.” This measure includes the following commitment by the City: “[The City will have an] operation and

maintenance (O&M) program, including an employee training component, in place or scheduled, to reduce/prevent pollution from municipal activities and municipally owned areas including but not limited to park and open space maintenance... [and] stormwater system maintenance.” Several management objectives and best practices in this land management plan address the protection of water quality in the natural areas, thereby supporting the City’s efforts under the SWMP.

FUTURE PLANNING FOR EACH NATURAL AREA

The character, setting and natural features in each of the natural areas are unique, as illustrated by the Natural Area Site Descriptions included in Chapter 3. The City should consider building on this land management plan by developing a supplemental land management plan for each of the natural areas, so the site-specific aspects of each natural area can be addressed. These plans could include guidance on protection of specific biologic, geologic, and aquatic features and resources, and future trail routing and connectivity planning.



TRAIL IN PROSPECT PARK

Benefits & Statement
of Goals



ECOSYSTEM BENEFITS

Ecosystem services are life-sustaining benefits provided by the natural environment, such as pollination, climate regulation, water purification, decomposition, erosion control and flood mitigation. These services have long been recognized as essential to both environmental and human health.

The ecosystem services provided by preserved natural areas undoubtedly provide a positive impact to society. While there is considerable overlap among these categories, these benefits and ecosystem services can be broadly grouped into three categories: ecological benefits, such as those of climate regulation, water quality protection, flood mitigation, and biodiversity enhancement; social and cultural benefits, such as those of recreational and educational opportunities, and spiritual enrichment; and finally, economic benefits, such as those from ecotourism revenues and costs saved through flood mitigation.

ECOLOGICAL BENEFITS

- **Biodiversity:** Natural areas provide habitats for many species of plants and animals, and these areas help to maintain a high level of biodiversity. Biological diversity is necessary for the provision of many other ecosystem services and processes that flow from natural areas. These services can include, but are not limited to, lowered temperatures, soil formation and conservation, pollination processes, and improved air, water, and soil quality. Each of these then has the ability to influence food systems and the resiliency of the ecosystem.
- **Water Quality and Quantity:** Natural areas help protect the quality and quantity of surface water. Natural areas contribute to the supply of freshwater by recharging groundwater aquifers through the processes of infiltration and percolation. Water that infiltrates the surface within natural areas also has the potential to slowly release into nearby waterbodies, thus contributing to watershed stability.

In areas of high impervious cover, stormwater runoff moves quickly and picks up pollutants that are present such as sediment and motor oil; natural areas, however, contribute to water quality by slowing down stormwater runoff and allowing for sediment, pollutants, and even nutrients, to be absorbed or deposited prior to entering an aquifer or a body of surface water. For the San Marcos natural areas, this ecological benefit is important for the quality and quantity of water that recharges the Edwards Aquifer and for surface water runoff that flows into the San Marcos River and its tributaries.

- **Flood Mitigation:** Natural areas help to reduce flooding by slowing down stormwater runoff and increasing infiltration of rainfall into the soil and into aquifer recharge features. In areas with high amounts of impervious cover, where runoff is unable to be absorbed into the ground, there is a greater likelihood of higher short term peak flows. When these higher peak flows enter local drainage systems, these systems are more likely to become overwhelmed, causing local flooding events. Because of their higher levels of permeability and infiltration, natural areas help to mitigate such events.
- **Climate Regulation:** Natural areas contribute to improved air quality through greenhouse gas mitigation. Trees, dead plant material, and soil capture and store atmospheric carbon and can store these gases for decades, and even centuries. Trees have also been shown to remove particulate matter, pollutants resulting from urban activities such as car exhaust, from the air.

Natural areas further contribute to clean air and climate regulation by mitigating the effects of urban heat islands, a phenomenon in which developed urban areas experience higher average temperatures than their undeveloped counterparts. The presence of trees and other vegetation in natural areas within and near urban areas helps to cool the urban areas, thereby reducing energy demands for cooling purposes.

SOCIAL, CULTURAL, & ECONOMIC BENEFITS

- **Health and Exercise:** Outdoor exercise in natural areas offers many health benefits, including improved cholesterol levels and protection against chronic diseases like cardiovascular disease, diabetes, and obesity.
- **Education and Research:** Natural areas can serve as living classrooms for environmental education, biological research, and natural resource management.
- **Ecotourism:** Natural areas can foster tourism connected with nature. San Marcos has a long history of nature-based tourism activities, including the Aquarena Springs resort and amusement park at the San Marcos Springs, and the Wonder World Cave and Adventure Park that showcases a karst cave. The growing inventory of San Marcos' natural areas and trails has given San Marcos a reputation as a hiking and biking destination that contributes significantly to the number of out-of-town visitors.
- **Mental Well-being / Reduced Stress / Social Interaction:** A large body of research has shown that access and exposure to natural areas provides beneficial effects for humans with regards to mental health and wellbeing. Natural areas provide opportunities for recreation and exercise, reducing stress and thus contributing to better physical health. Natural areas also provide opportunities for people to engage and socialize with others, improving mental health and strengthening social networks.
- **Costs Saved from Flood Damage:** Floods in Texas are becoming more frequent and intense, with about 400 floods occurring annually and costing approximately \$254 million per year on average¹. Because natural areas can reduce flooding, these areas can help prevent or reduce damages to property and infrastructure, and disruptions to business and local economies. Additionally, risks associated with increased flooding, either directly or indirectly, have the potential to discourage public or private investment and disrupt a community's tax base.
- **Increased Property Values:** Due in part to the various benefits already described, such as scenery and recreational opportunities, the presence of green spaces and natural areas has been shown to increase property values as homeowners and renters are willing to pay more for proximity to green spaces and natural areas. Increased property taxes and community revenue coincide with this increase of property values.



HOMES LOCATED NEAR NATURAL AREAS, SUCH AS THIS ONE NEAR THE SPRING LAKE NATURAL AREA, MAY HAVE INCREASED VALUES

1. Pew Charitable Trusts. (2016, August 22). Texas: Flood risk and mitigation. <https://www.pewtrusts.org/en/research-and-analysis/fact-sheets/2016/08/texas-flood-risk-and-mitigation>

PUBLIC ENGAGEMENT SUMMARY

STAKEHOLDER MEETINGS

A series of stakeholder meetings was held at the onset of the public engagement process. Information collected during these meetings helped shape the open house questions and generated ideas that could be incorporated later as recommendations. Three stakeholder meetings were conducted, with stakeholders being divided into groups by their area of expertise. The following stakeholder groups were invited: San Marcos Greenbelt Alliance (SMGA), San Marcos River Foundation (SMRF), Trust for Public Land, The Great Springs Project, Emerald Crown Trail Work Group, and the Council of Neighborhood Associations (CONA).

KEY THEMES

- Water quality and quantity, and conservation, flood mitigation, and habitat protection were top priorities
- How do we balance trails and public recreation with ecological sensitivity and conservation?
- Equity is important because there is very little public land in Texas
- Environmental management takes priority; we need to ensure these areas thrive and continue to be ecologically beneficial

PUBLIC OPEN HOUSE

An in-person open house was held in the San Marcos Activity Center to gather community input for the development of the San Marcos Natural Areas Land Management Plan. The public input received during this effort is an important source of information for developing the community vision and priorities of the natural areas within the San Marcos community. The open house was held all-day on Saturday May 14, 2022. The meeting was an open house format so there was no formal presentation, attendants were able to come and go as needed. Individuals were asked to provide feedback on a number of topics which had been identified as key issues during the stakeholder meetings.



CITIZENS OF SAN MARCOS PARTICIPATE IN THE PUBLIC OPEN HOUSE ON MAY 14, 2022

MOST LOVED THINGS ABOUT SAN MARCOS NATURAL AREAS



**TOP THREE WORDS
ECOSYSTEMS | CONSERVATION |
RECHARGE**

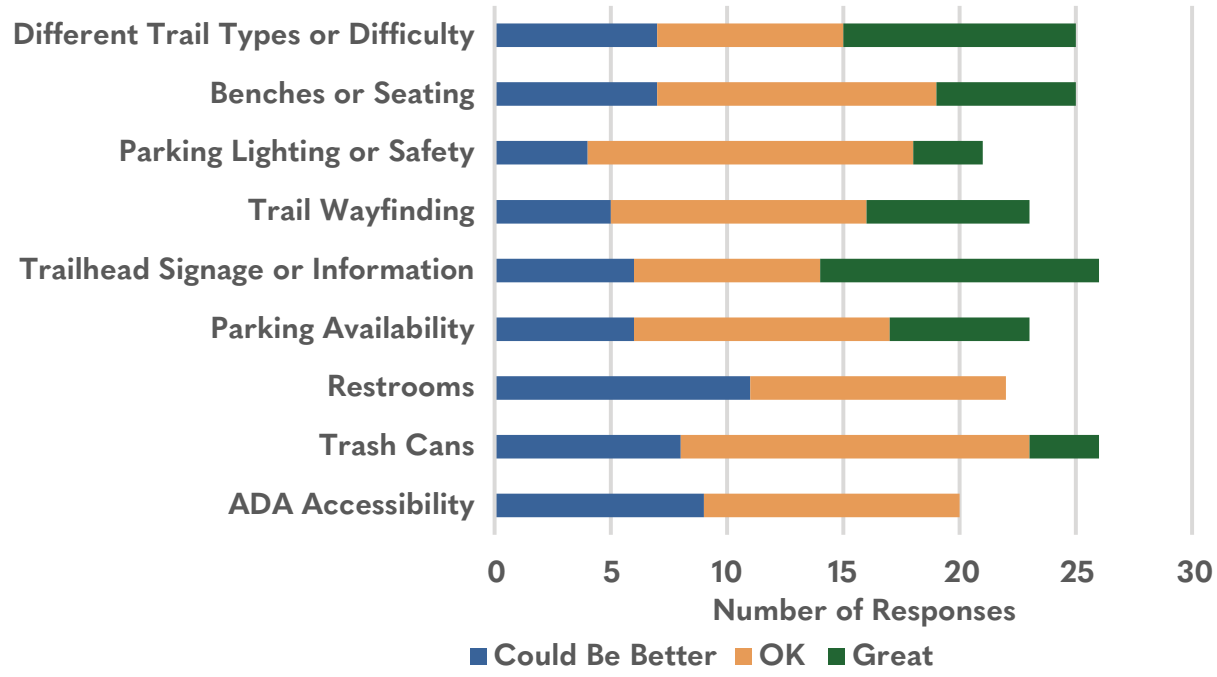
MOST APPRECIATED THINGS ABOUT SAN MARCOS NATURAL AREAS

Ranking	Appreciated Categories
1	That they exist, undeveloped
2	Quality of life, personal enjoyment and peaceful attribute of the space
3	Nearby and accessible
4	Trails and ease of biking/walking/running
5	Beautiful natural scenery

GREATEST BENEFITS OF THE SAN MARCOS NATURAL AREAS

1. HABITAT CONSERVATION
2. HEALTHY ENVIRONMENT
3. CONNECTING WITH NATURE

RATINGS OF QUALITY AND/OR AVAILABILITY OF NATURAL AREA AMENITIES



VISION STATEMENT

The vision statement for the San Marcos natural areas is representative of the community input received during the planning effort. The primary focus of this Natural Area Land Management Plan is to protect the natural environment of the areas, and the plan highlights the community's desire that the natural areas be protected first and foremost. The vision statement is a statement of the desired long-term outcome for the San Marcos natural areas, rather than a statement of existing conditions. It should inform and harmonize the preservation, flood mitigation, restoration, natural resource management, and use and safety efforts to be undertaken for the natural areas.

“The San Marcos natural areas are treasured natural spaces that have thriving ecosystems comprised of diverse communities of native plants and animals, well performing watersheds, and opportunities for people to safely enjoy, connect with, and learn about nature.”



WOODED AREA IN FUTURE NATURAL AREA

GOALS

It is the intention of this land management plan to reflect and support the vision statement by offering recommendations for the ongoing management of San Marcos' treasured natural areas. The three goals illustrated on this page form a framework for that ongoing management.

The three overarching goals of this plan are as follows:



WAYFINDING SIGNAGE IN PURGATORY NATURAL AREA



WAYFINDING SIGNAGE IN RINGTAIL RIDGE NATURAL AREA

This page intentionally left blank.

Environmental
Overview

3

ENVIRONMENTAL FEATURES

Before describing management objectives and recommendations for the natural areas, it is imperative to understand the environmental features of the natural areas so the management practices and techniques best suited to the areas can be identified. This chapter provides an overview of the environmental features of the natural areas, as well as the wildfire risk to the region. The environmental overview is followed by an ecosystem site description summary for each individual natural area. The information outlined here can help determine the best practices, outlined in **Chapter 4**, for each individual natural area.

SOIL RESOURCES

An inventory of the soil resources found in the San Marcos natural areas is useful in determining best management practices and in planning and conducting land management activities. The accepted source for this inventory is the Soil Survey of Comal and Hays Counties, Texas is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture (USDA) and other agencies. The soil survey provides information that can be used in land planning and to identify practices needed to ensure proper performance. References from the soil survey coupled with specific soils obtained from the web soil survey are described below to provide an outline of soil types within each of the natural areas (NRCS, 2023).

The majority of the natural areas to the north and west of the City of San Marcos are located within the Comfort-Rumple-Eckrant map unit. This map unit contains soil depths ranging from very shallow to moderately deep, in undulating to steep hill areas over indurated limestone geologic formations. This map unit occurs in upland vegetation areas of the Edwards Plateau Ecoregion and predominantly consists of well drained soils with one to 30 percent slopes. These soils are located on broad divides intersected by narrow drainage ways such as small streams or rivers. Comfort soils make up 36 percent of the map unit, with Rumple making up 26 percent and Eckrant at eight percent. Comfort soils are undulating on ridge summits and short hillslopes. Rumple soils are also undulating and typically occur on broad interstream divides and short hillslopes. The Eckrant soils are strongly sloping and steep and occur on side slopes of high ridges.

The natural areas along the Blanco River are within the Lewisville-Gruene-Krum map unit. This map unit is characterized as deep, shallow, and very shallow, nearly level to gently sloping soils over loamy, clayey and gravelly sediment on stream terraces and valley

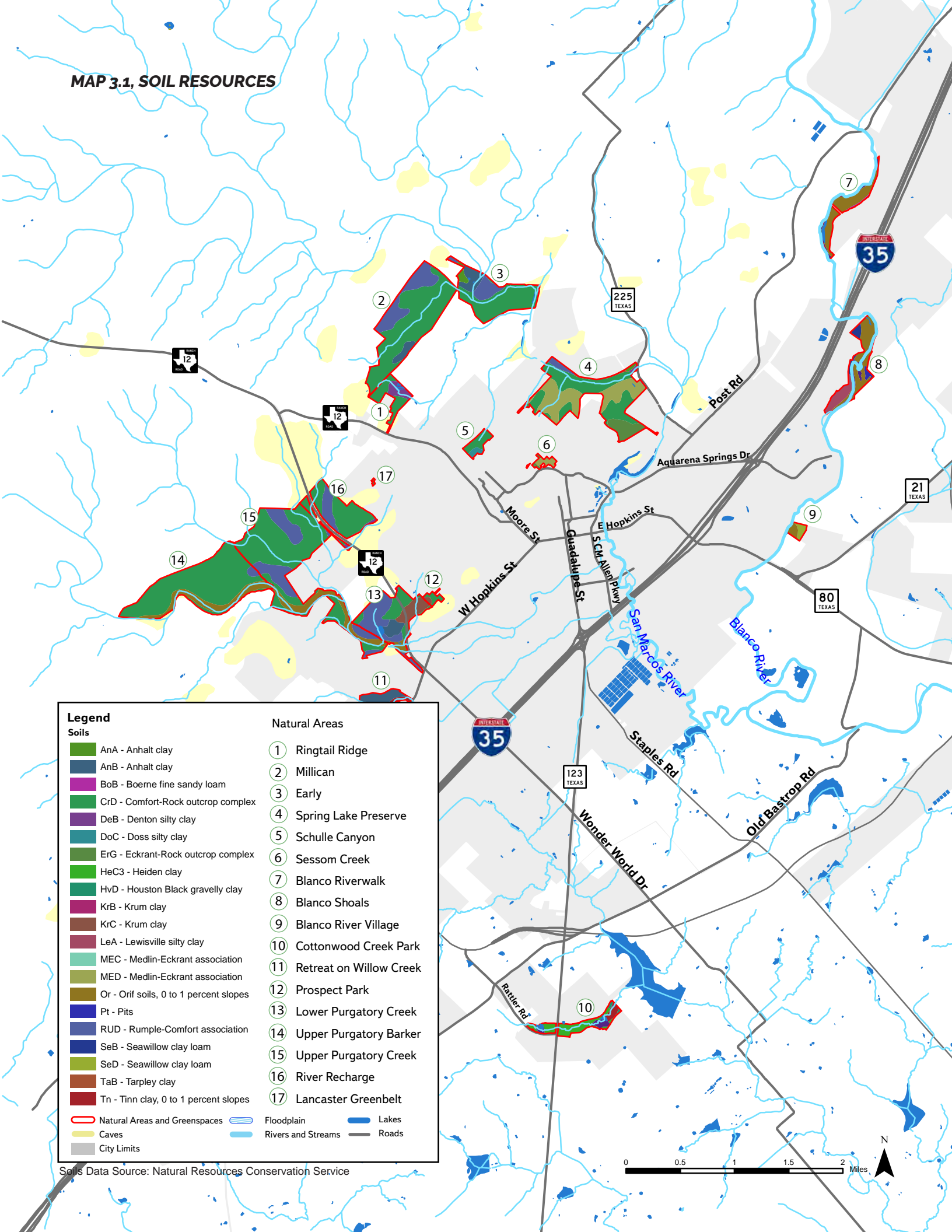
fills of the Blackland Prairie and Edwards Plateau ecoregions.

This map unit predominantly consists of well drained soils that have slopes of zero to five percent. The soils are located on low terraces along rivers and large creeks. The Lewisville soils are nearly level to gently sloping. They are in plane to slightly convex areas that are lower than those of the Gruene soils and slightly higher on the landscape than the areas of the Krum soils. Lewisville soils are moderately permeable. Typically, the surface layer is dark grayish brown silty clay about 17 inches thick. The subsoil to a depth of 36 inches is brown silty clay. The other soils in this map unit are the deep, loamy Boerne, Seawillow, and Sunev soils in convex to plane areas on the lowest stream terraces; and the deep, sandy and gravelly Orif soils on floodplains.

Cottonwood Creek Park is within the Heiden-Houston Black map unit. The Heiden-Houston Black map unit is characterized as deep, gently sloping to sloping soils over clay and shale on uplands of the Blackland Prairie Ecoregion. This map unit predominantly consists of well drained and moderately well drained soils that have slopes of one to eight percent. The Heiden soils are gently sloping to sloping and are mainly located on the more eroded parts of the landscape. Typically, the surface layer is dark grayish brown clay about 13 inches thick. The Houston Black soils are gently sloping to sloping and are located on ridge summits and on long, smooth ridge slopes. The other soils in this map unit are clayey Tinn soils on floodplains.

Within each of the general soil complexes described above are more specific soil types, which are displayed on **Map 3.1, Soil Resources** and described further in **Table 3.1, Soil Types within the Natural Areas**. The map also includes natural areas and greenspaces, caves, floodplains, rivers and streams, lakes and roadways.

MAP 3.1, SOIL RESOURCES



Legend	
Soils	
	AnA - Anhalt clay
	AnB - Anhalt clay
	BoB - Boerne fine sandy loam
	CrD - Comfort-Rock outcrop complex
	DeB - Denton silty clay
	DoC - Doss silty clay
	ErG - Eckrant-Rock outcrop complex
	HeC3 - Heiden clay
	HvD - Houston Black gravelly clay
	KrB - Krum clay
	KrC - Krum clay
	LeA - Lewisville silty clay
	MEC - Medlin-Eckrant association
	MED - Medlin-Eckrant association
	Or - Orif soils, 0 to 1 percent slopes
	Pt - Pits
	RUD - Rumble-Comfort association
	SeB - Seawillow clay loam
	SeD - Seawillow clay loam
	Tab - Tarpley clay
	Tn - Tinn clay, 0 to 1 percent slopes
	Natural Areas and Greenspaces
	Floodplain
	Caves
	Rivers and Streams
	Lakes
	Roads
	City Limits
Natural Areas	
①	Ringtail Ridge
②	Millican
③	Early
④	Spring Lake Preserve
⑤	Schulle Canyon
⑥	Sessom Creek
⑦	Blanco Riverwalk
⑧	Blanco Shoals
⑨	Blanco River Village
⑩	Cottonwood Creek Park
⑪	Retreat on Willow Creek
⑫	Prospect Park
⑬	Lower Purgatory Creek
⑭	Upper Purgatory Barker
⑮	Upper Purgatory Creek
⑯	River Recharge
⑰	Lancaster Greenbelt

Soils Data Source: Natural Resources Conservation Service

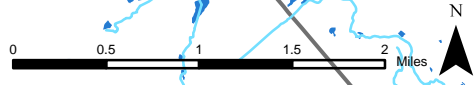


TABLE 3.1, SOIL TYPES WITHIN THE NATURAL AREAS

Soil ID	Soil Series	Topography	Available Water Capacity	Drainage Class	Flooding Frequency	Ponding Frequency	Hydric Components
Comfort-Rumple-Eckrant							
AnA	Anhalt clay	0-2% slopes	Low	Well drained	None	None	None
AnB	Anhalt clay	1-3% slopes	Low	Well drained	None	None	None
CrD	Comfort-Rock outcrop complex	1-8% slopes	Very low	Well drained	None	None	None
DeB	Denton silty clay	1-3% slopes	Low	Well drained	None	None	None
DoC	Doss silty clay	1-5% slopes	Very low	Well drained	None	None	None
ErG	Eckrant-Rock outcrop association	8-30% slopes	Very low	Well drained	None	None	None
KrB	Krum clay	1-3% slopes	High	Well drained	None	None	None
KrC	Krum clay	3-5% slopes	Moderate	Well drained	None	None	None
MEC	Medlin warm-Eckrant association	1-8% slopes	Low	Well drained	None	None	None
MED	Medlin warm-Eckrant association	8-30% slopes	Moderate	Well drained	None	None	None
RUD	Rumple-Comfort rubly association	1-8% slopes	Very low	Well drained	None	None	None
TaB	Tarpley clay	1-3% slopes	Very low	Well drained	None	None	None

TABLE 3.1, SOIL TYPES WITHIN THE NATURAL AREAS (CONTINUED)

Soil ID	Soil Series	Topography	Available Water Capacity	Drainage Class	Flooding Frequency	Ponding Frequency	Hydric Components
Lewisville-Gruene-Krum							
BoB	Boerne fine sandy loam	1-3% slopes	Moderate	Well drained	None, Rare	None	None
LeA	Lewisville silty clay	0-1% slopes	High	Well drained	None	None	None
Or	Orif soils	0-3% slopes	Very low	Well drained	None	Frequent, None	None
Pt	Pits	None	None	None	None	None	None
SeB	Seawillow clay loam	1-3% slopes	Moderate	Well drained	None	None	None
SeD	Seawillow clay loam	3-8% slopes	Moderate	Well drained	None	None	None
Heiden-Houston Black							
HeC3	Heiden clay	3-5% slopes	High	Well drained	None	None	None
HvD	Houston Black gravelly clay	3-8% slopes	High	Moderately well drained	None	None	None
Tn	Tinn clay	0-1% slopes	Moderate	Moderately well drained	Frequent, none	None	None

Soils Data Source: Natural Resources Conservation Service

GEOLOGIC RESOURCES

The natural areas on the northwest side of San Marcos are dominated by various limestone geologic formations that include the Edwards Limestone (Ked), Eagle Ford formation and Buda Limestone undivided (Keb), Austin Chalk (Kau), Pecan Gap Chalk (Kpg) and the Del Rio Clay and Georgetown Limestone (Kdg) formations. Limestone geologic formations are important to aquifers due to their high porosity and permeability and associations with karst formations.

The Edwards Limestone (Ked) formation is an early Cretaceous Gulfian series unit made up of limestone, dolostone and chert. This unit is massive to thin bedded with fine to very fine grains and is very porous. The Eagle Ford and Buda Limestone undivided (Keb) formation is made up of shale, siltstone and limestone with the upper layer dominated by limestone. This unit is very fine grained with thickness values ranging from 75 to 200 feet. The upper limestone layer is a fine grained bioclastic limestone with interbeds of pyrite with thickness values ranging from 45-100 feet.

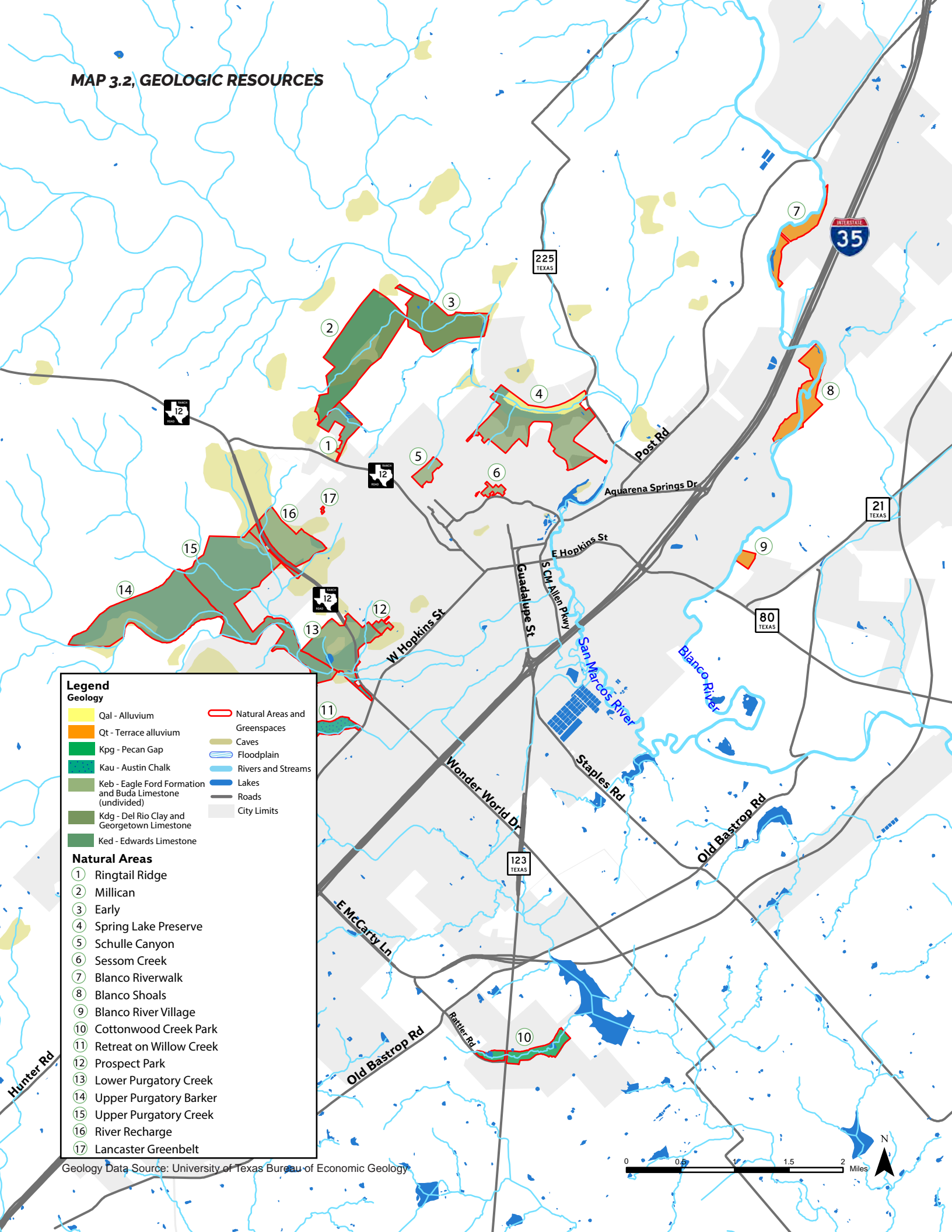
The Austin Chalk (Kau) formation is a late Cretaceous Gulfian series made up of chalk with microgranular calcite and calcium carbonate formations. This formation occurs on ledges with massive interbed thickness ranging from 325 to 420 feet. The Pecan Gap Chalk (Kpg) formation is also a Late Cretaceous Gulfian series made up of chalk, limestone and limestone sands. This formation has thickness values ranging from 50 to 70 feet and is fine to very fine grained.

The Del Rio Clay and Georgetown Limestone (Kdg) formation is a late Cretaceous Gulfian Series geologic unit. The Del Rio Clay layer is a calcareous, blocky siltstone with marine mega fossils known to occur in its upper reaches. This layer's thickness values range from 40 to 70 feet. The Georgetown Limestone layer is a chalky, fine-grained limestone associated with karst formations with thickness values ranging from 30 to 80 feet. This layer is thick bedded; some shale formations and marine mega fossils are known to occur in its upper reaches.

The remainder of the natural areas are dominated by alluvial and deposit formations including the Quaternary Alluvium (Qal) and Terrace Deposit (QT) formations. The Quaternary Alluvium (Qal) formation is a Holocene unit that occur along streams and rivers. This formation is made up of silt, sand, clay and gravel with grain size ranging from coarse to fine. This formation also contains deposits of clay and silty fine to very fine-grained quartz sands on alternately dry and flooded barren flats one meter above sea level. The Terrace Deposit (QT) formation includes sand, silt and gravel grains of various proportions from very coarse to very fine. This formation occurs on higher terrace deposits along streams and is locally inundated with calcium carbonate.

Geologic units within the natural areas are displayed on **Map 3.2, Geologic Resources**, and **Table 3.2, Geologic Units within the Natural Areas** describes each of the mapped geologic units and their locations relative to the natural areas. The map also includes natural areas and green spaces, caves, floodplains, rivers and streams, lakes and roadways.

MAP 3.2, GEOLOGIC RESOURCES



Legend

Geology

 Qal - Alluvium	 Natural Areas and Greenspaces
 Qt - Terrace alluvium	 Caves
 Kpg - Pecan Gap	 Floodplain
 Kau - Austin Chalk	 Rivers and Streams
 Keb - Eagle Ford Formation and Buda Limestone (undivided)	 Lakes
 Kdg - Del Rio Clay and Georgetown Limestone	 Roads
 Ked - Edwards Limestone	 City Limits

Natural Areas

- ① Ringtail Ridge
- ② Millican
- ③ Early
- ④ Spring Lake Preserve
- ⑤ Schulle Canyon
- ⑥ Sessom Creek
- ⑦ Blanco Riverwalk
- ⑧ Blanco Shoals
- ⑨ Blanco River Village
- ⑩ Cottonwood Creek Park
- ⑪ Retreat on Willow Creek
- ⑫ Prospect Park
- ⑬ Lower Purgatory Creek
- ⑭ Upper Purgatory Barker
- ⑮ Upper Purgatory Creek
- ⑯ River Recharge
- ⑰ Lancaster Greenbelt

Geology Data Source: University of Texas Bureau of Economic Geology



TABLE 3.2, GEOLOGIC UNITS WITHIN THE NATURAL AREAS

Geologic Unit Name	Description	Natural Areas
Quaternary (Qal)	Holocene with silt, sand, clay and gravel as primary rock types	Spring Lake Natural Area
Quaternary (Qt)	Plesitocene and Holocene with sand, silt, clay and gravel as primary rock types	Blanco Riverwalk, Blanco Shoals, Blanco River Village
Pecan Gap Chalk (Kpg)	Early Cretaceous; Gulfian Series with chalk, limestone and dolostone as primary rock types	Cottonwood Creek Park
Austin Chalk (Kau)	Early Cretaceous; Gulfian Series with chalk, limestone and dolostone as primary rock types	Retreat on Willow Creek
Eagle Ford Formation and Buda Limestone, undivided (Keb)	Early Cretaceous with limestone, dolostone, clay and mud as primary rock types	Spring Lake Natural Area, Schulle Canyon, Sessom Creek, Lower Purgatory Creek
Del Rio Clay and Georgetown Limestone. Undivided (Kdg)	Late Cretaceous with limestone, clay and mud as primary rock types	Millican, Early, Spring Lake Natural Area
Edwards Limestone (Ked)	Early Cretaceous; Gulfian Series with limestone and dolostone as primary rock types	Ringtail Ridge, Millican, Spring Lake Natural Area, Prospect Park, Lower Purgatory Creek, Upper Purgatory Barker, Upper Purgatory Creek, River Recharge, Lancaster Greenbelt

Geology Data Source: University of Texas Bureau of Economic Geology

BIOLOGIC RESOURCES

Vegetation

The Texas Parks and Wildlife Department's (TPWD's) Ecological Mapping System of Texas (EMST) is a detailed land classification map for the State of Texas. The map data includes numerous ecological classes (i.e., systems) and subclasses (i.e., vegetation types) based on existing vegetation communities.

The San Marcos natural areas occur within seven EMST systems: Edwards Plateau Dry-Mesic Slope Forest and Woodland, Edwards Plateau Floodplain, Edwards Plateau Limestone Savannah and Woodland, Edwards Plateau Limestone Shrubland, Edwards Plateau Riparian, Southeastern Great Plains Floodplain Forest, Southeastern Great Plains Riparian Forest. Two additional classes/systems occur within the natural areas: Azonal and Agricultural and other Human-related Mapped Types.

The Barren, Native Invasive: Deciduous Woodland, Native Invasive: Juniper Woodland, and Native Invasive: Mesquite Shrubland vegetation types are widespread and considered azonal (i.e., they are not particularly characteristic of any region or system of naturally occurring vegetation types). This may be due to disturbance of anthropogenic or invasive species actions.

The Agricultural and other Human-related Mapped Types include lands that are disturbed or occupied by human structures. Mapped sub-classes within the natural areas of this class include Open Water, Urban High Intensity, and Urban Low Intensity.

Edwards Plateau Dry-Mesic Slope Forest and Woodland

The Edwards Plateau Dry-Mesic Slope Forest and Woodland system is generally found on limestone (primarily Cretaceous or Pennsylvanian) slopes within the Edwards Plateau and adjacent ecoregions, including the Carbonate Cross Timbers in the Palo Pinto County area and the Callahan Divide. This system may also occupy the cuestas of Cretaceous chalk in the Blackland Prairie and calcareous slopes of the Crosstimbers ecoregions. Landforms usually contain slopes greater than 20 percent. Stones and boulders are conspicuous on the soil surface and soils are generally dark clay to clay loam and shallow. This system occurs on dry to mesic, middle slopes of the rolling uplands and escarpments of the Edwards Plateau. The tree canopy is typically dominated or codominated by deciduous trees, including Texas oak (*Quercus buckleyi*), Lacey oak (*Quercus laceyi*),

white shin oak (*Quercus sinuata* var. *breviloba*), Texas ash (*Fraxinus texensis*), cedar elm (*Ulmus crassifolia*), plateau live oak (*Quercus fusiformis*) and Ashe juniper (*Juniperus ashei*). The shrub layer may be well-represented, especially where the overstory canopy is discontinuous. Species such as red buckeye (*Aesculus pavia* var. *flavescens*), Texas redbud (*Cercis canadensis* var. *texensis*), elbowbush (*Forestiera pubescens*), Mexican buckeye (*Ungnadia speciosa*), and Texas mountain-laurel (*Ophora secundiflora*) may be present in the shrub layer. Vegetation types within this system that are present within the natural areas include Edwards Plateau: Ashe Juniper Slope Forest, Edwards Plateau: Live Oak Slope Forest, Edwards Plateau: Live Oak Slope Forest, Edwards Plateau: Oak - Hardwood Slope Forest, Edwards Plateau: Oak - Ashe Juniper Slope Forest, and Edwards Plateau: Oak - Hardwood Slope Forest.

Edwards Plateau Floodplain

The Edwards Plateau Floodplain system typically occupies Quaternary alluvial deposits often within drainages largely underlain by Cretaceous limestones or drainages that receive outwash from landscapes dominated by these limestones. Landforms usually include valley floors of large rivers and perennial streams. This system contains forests and woodlands dominated or codominated by deciduous trees, including pecan (*Carya illinoensis*), cedar elm (*Ulmus crassifolia*), American elm (*Ulmus americana*), sugar hackberry (*Celtis laevigata*), netleaf hackberry (*Celtis laevigata* var. *reticulata*), and/or plateau live oak (*Quercus fusiformis*). Woody species in the subcanopy may include gum bumelia (*Sideroxylon lanuginosum*), wafer-ash (*Ptelea trifoliata*), roughleaf dogwood (*Cornus drummondii*), red mulberry (*Morus rubra*), Texas persimmon (*Diospyros texana*), grape (*Vitis* spp.), and greenbrier (*Smilax bona-nox*). The herbaceous layer may be continuous, though relatively sparse, with species such as Virginia wildrye (*Elymus virginicus*), creekoats (*Chasmanthium latifolium*), Texas wintergrass (*Nassella leucotricha*), frostweed (*Verbesina virginica*), and carices (*Carex* spp.). Vegetation types within this system that are present within the natural areas include Edwards Plateau: Floodplain Hardwood / Ashe Juniper Forest, Edwards Plateau: Floodplain Hardwood Forest, Edwards Plateau: Floodplain Live Oak Forest.

Edwards Plateau Limestone Savannah and Woodland

The Edwards Plateau Limestone Savannah and Woodland EMST system primarily occurs on Cretaceous limestones of the Edwards Plateau and Limestone Cutplain along rolling to level topography, often on plateau tops. The vegetation consists of a mosaic of evergreen oak and juniper forests, woodlands, and savannahs over shallow loamy soils of rolling uplands. Plateau live oak (*Quercus fusiformis*) and Ashe juniper (*Juniperus ashei*) commonly dominate the canopy. Texas persimmon (*Diospyros texana*), Texas mountain-laurel (*Sophora secundiflora*), honey mesquite (*Prosopis glandulosa*), Lindheimer pricklypear (*Opuntia engelmannii* var. *lindheimeri*), and tasajillo (*Cylindropuntia leptocaulis*) may dominate the understory. Various graminoid species, including little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), cane bluestem (*Bothriochloa barbinodis*), silver bluestem (*Bothriochloa laguroides* ssp. *torreyana*), Texas wintergrass (*Nassella leucotricha*), Indiangrass (*Sorghastrum nutans*), and curlymesquite (*Hilaria belangeri*), may also occur in the understory. Vegetation types within this system that are present within the natural areas include Edwards Plateau: Ashe Juniper Motte and Woodland, Edwards Plateau: Deciduous Oak - Evergreen Motte and Woodland, Edwards Plateau: Oak - Hardwood Motte and Woodland, Edwards Plateau: Post Oak Motte and Woodland, and Edwards Plateau: Savannah Grassland.

Edwards Plateau Limestone Shrubland

The Edwards Plateau Limestone Shrubland EMST system often occurs on massive limestone such as the Edwards on plateaus and may often form a discontinuous band around a plateau edge as it breaks into the adjacent slope. The vegetation is represented by extensive continuous shrub cover, with scattered emergent overstory trees. White shin oak (*Quercus sinuata* var. *breviloba*), plateau live oak (*Quercus fusiformis*), and Ashe juniper (*Juniperus ashei*) are important components of the system. Shrub cover may be dominated by these species, or may be represented as an assemblage of a rather diverse array of species including evergreen sumac (*Rhus virens*), prairie sumac (*Rhus lanceolata*), Texas redbud (*Cercis canadensis* var. *texensis*), elbowbush (*Forestiera pubescens*), Texas mountain-laurel (*Sophora secundiflora*), Texas persimmon (*Diospyros*

texana), and Lindheimer pricklypear (*Opuntia engelmannii* var. *lindheimeri*). Herbaceous cover may be patchy and is generally graminoid with species including little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), Texas grama (*Bouteloua rigidisetata*), Texas wintergrass (*Nassella leucotricha*), hairy tridens (*Erioneuron pilosum*), threeawn (*Aristida* spp.), and others. Vegetation types within this system that are present within the natural areas include Edwards Plateau: Ashe Juniper / Live Oak Shrubland.

Edwards Plateau Riparian

The Edwards Plateau Riparian EMST system usually occupies Quaternary deposits along headwater streams. These may be alluvial or gravel deposits and are often within drainages dominated by limestone or other calcareous substrates on the Edwards Plateau or where substrate is influenced by outwash from the Edwards Plateau. The riparian areas within this EMST system occupy small streams that tend to be in erosional situations, as opposed to broad alluvial depositional sites. These erosional sites may be gravelly, cobbly, or rocky, and generally occupy the upper reaches of streams. Woodlands may have plateau live oak (*Quercus fusiformis*), American sycamore (*Platanus occidentalis*), baldcypress (*Taxodium distichum*), green ash (*Fraxinus pennsylvanica*), cedar elm (*Ulmus crassifolia*), and sugar hackberry (*Celtis laevigata*) (including var. *reticulata*). Shrub species that may be encountered in the understory of these woodlands, or, in some cases, may form shrublands lacking a significant overstory canopy include little walnut (*Juglans microcarpa*), and black willow (*Salix nigra*). Substantial patches of herbaceous cover may be present and often include species such as bushy bluestem (*Andropogon glomeratus*), switchgrass (*Panicum virgatum*), eastern gamagrass (*Tripsacum dactyloides*), Texas wintergrass (*Nassella leucotricha*), spikerush (*Eleocharis* spp.), water penny (*Hydrocotyle* spp.), and/or Lindheimer muhly (*Muhlenbergia lindheimeri*). Johnson grass (*Sorghum halepense*) is also a commonly encountered non-native grass. Vegetation types within this system that are present within the natural areas include Edwards Plateau: Riparian Ashe Juniper Forest, Edwards Plateau: Riparian Deciduous Shrubland, Edwards Plateau: Riparian Hardwood / Ashe Juniper Forest, Edwards Plateau: Riparian Hardwood Forest, Edwards Plateau: Riparian Herbaceous Vegetation, and Edwards Plateau: Riparian Live Oak Forest.

Southeastern Great Plains Floodplain Forest

The Southeastern Great Plains Floodplain Forest EMST system generally occupies Quaternary alluvium geologic formations and relatively broad flats at low topographic positions along large streams where alluvial deposition dominates. Dominant vegetation communities within this system range from floodplain forests to wet meadows to gravel/sand flats linked by underlying soils and flooding regimes. Dominant tree species within the canopy include pecan (*Carya illinoensis*), white ash (*Fraxinus americana*), cedar elm (*Ulmus crassifolia*), sugar hackberry (*Celtis laevigata*), and American elm (*Ulmus americana*). Shrub species include American beautyberry (*Callicarpa americana*), common buttonbush (*Cephalanthus occidentalis*), possumhaw (*Ilex decidua*), yaupon (*Ilex vomitoria*) and common persimmon (*Diospyros virginiana*). Herbaceous cover includes Virginia wildrye (*Elymus virginicus*), frostweed (*Verbesina virginica*), creek oats (*Chasmanthium latifolium*), narrowleaf woodoats (*Chasmanthium sessiliflorum*), Cherokee sedge (*Carex cherokeensis*), switchgrass (*Panicum virgatum*) and sedges (*Carex* spp.). Vegetation types within this system that are present within the natural areas include Central Texas: Floodplain Deciduous Shrubland, Central Texas: Floodplain Hardwood Forest, and Central Texas: Floodplain Herbaceous Vegetation.

Southeastern Great Plains Riparian Forest

The Southeastern Great Plains Riparian Forest EMST system occupies buffer zones of headwater streams, and soils develop in place over a variety of geologic surfaces. This system occurs in valleys and drainages along headwater streams typically in areas with erosional processes dominating over alluvial deposition. Trees that may be present in stands of this system include sugar hackberry (*Celtis laevigata*), cedar elm (*Ulmus crassifolia*), plateau live oak (*Quercus fusiformis*), and green ash (*Fraxinus pennsylvanica*). The shrub layer development is variable, sometimes with species such as yaupon (*Ilex vomitoria*), and roughleaf dogwood (*Cornus drummondii*). Herbaceous cover is also variable, depending on overstory and shrub canopies and recent flooding history. Herbaceous species may include Virginia wildrye (*Elymus virginicus*), creek oats (*Chasmanthium latifolium*), eastern gamagrass (*Tripsacum dactyloides*), western ragweed (*Ambrosia*

psilostachya), switchgrass (*Panicum virgatum*), bedstraw (*Galium* spp.), and caric sedges (*Carex* spp.). Upland species such as little bluestem (*Schizachyrium scoparium*), Texas wintergrass (*Nassella leucotricha*), and Indiangrass (*Sorghastrum nutans*) may be common. Non-native grass species that may be common to dominant on these sites include giant reed (*Arundo donax*) and bermudagrass (*Cynodon dactylon*) and Johnsongrass (*Sorghum halepense*). The non-native species, such as privets (*Ligustrum* spp.) and Chinese tallow (*Triadica sebifera*), may be commonly encountered. Vegetation types within this system that are present within the natural areas include Central Texas: Riparian Herbaceous Vegetation.

Protected Species

Golden-Cheeked Warbler

The Golden-cheeked Warbler is a small migratory bird whose nesting range is currently confined to habitat in 33 counties in Central Texas, including Hays County. This bird species is known for its unique golden cheek patch and is considered one of the rarest birds in North America, with an estimated population of fewer than 30,000 individuals. It was placed upon the endangered species list in 1990 due to habitat loss and fragmentation caused by urbanization, fragmentation, and improper land management practices. The ideal habitat for the Golden-cheeked Warbler is characterized by a dense canopy of mature oak-juniper woodlands, where they utilize the peeling bark of mature Ashe juniper trees to build their nests, and forage for insects and spiders in the understory and midstory layers of shorter trees and shrubs. These oak-juniper woodlands are typically found on rocky slopes and hilltops throughout the natural areas.

Golden-cheeked Warblers migrate to Central Texas in the spring to breed and raise their young before returning to their wintering grounds in Central America. The oak-juniper woodlands provide an ideal nesting and foraging habitat and the surrounding area provides suitable migration grounds. Occurrences of the Golden-cheeked Warbler have been documented within several of the natural areas within the Edwards Plateau. Continued habitat loss and fragmentation due to human activities threaten the survival of these birds. Conservation efforts aimed at protecting and restoring the habitat of the Golden-cheeked Warbler are crucial to ensure their survival in San Marcos and throughout Central Texas.

Other Protected Species

Several protected species occur in and near the San Marcos springs and river in San Marcos. Texas wild rice (*Zizania texana*), the Comal Springs drypoid beetle (*Sypgoparnus comalensis*), the fountain darter (*Etheostoma fonticola*), and the Comal Springs riffle beetle (*Heterelmis comalensis*) are all federally-listed endangered species. The San Marcos

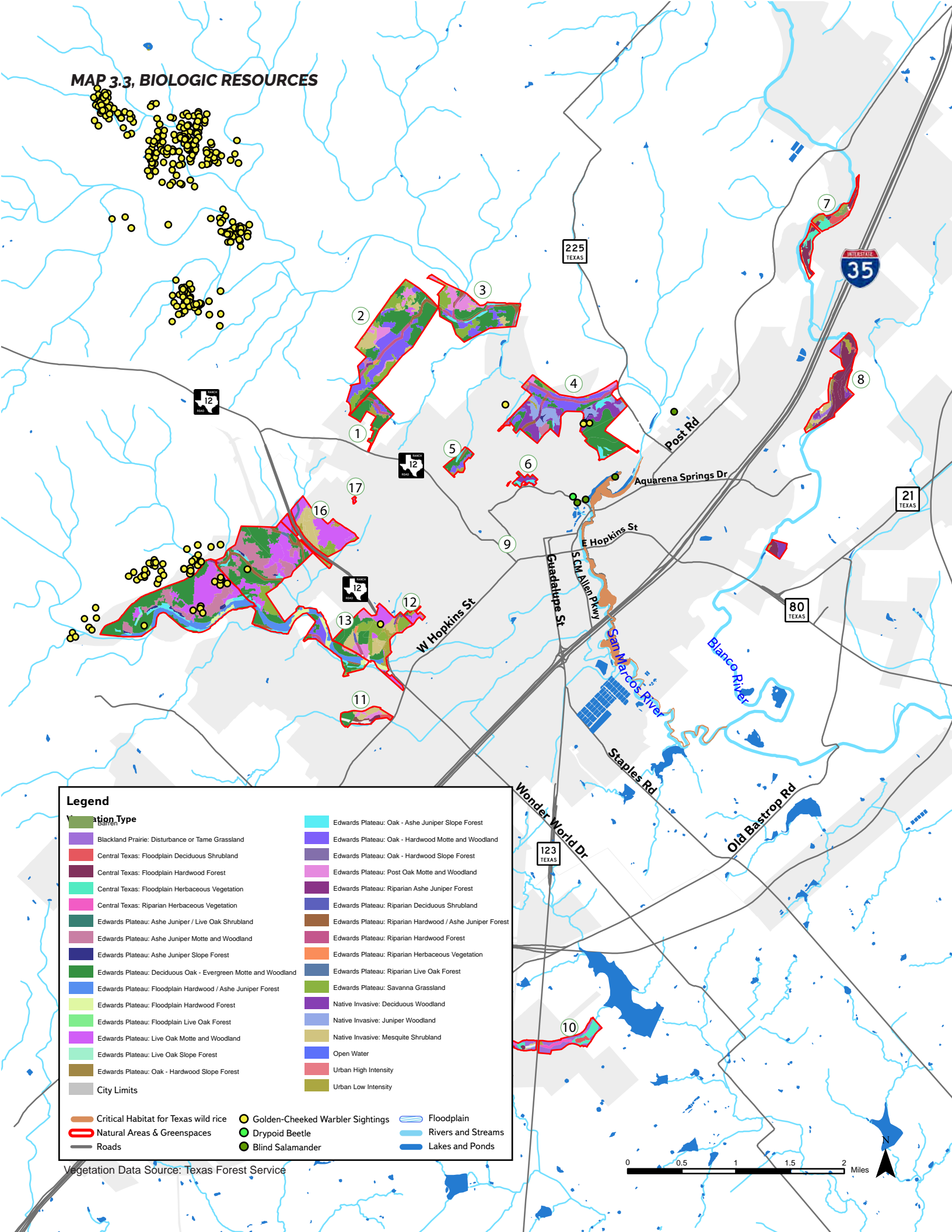
salamander (*Eurycea nana*) is a federally-listed threatened species that occurs in and near the San Marcos River. The Texas blind salamander (*Eurycea rathbuni*) is an endangered species that occurs within the Edwards Aquifer near the San Marcos Springs and at other nearby locations.

These species are all endangered due to habitat destruction caused by human activities, including groundwater pumping, pollution, and urbanization, and also because they are endemic to the San Marcos springs and river, the Edwards Aquifer near San Marcos, and the Comal springs and river in nearby New Braunfels.

The ideal habitat for the Texas wild rice, Comal Springs drypoid beetle, and Texas blind salamander are all characterized by clear, clean water, and a stable environment. The Texas wild rice grows in shallow, slow-moving water that is rich in nutrients, while the Comal Springs drypoid beetle lives in the sand beds of rivers and streams with clear water and stable water levels. The Texas blind salamander is fully aquatic and lives in the underground streams and aquifers with clear water and a stable environment. Other than the Golden-cheeked Warblers, there are no documented occurrences of these species within the natural areas, however habitat for these species occur within the San Marcos River and surrounding waterways. Proper land management practices within the natural areas that are within the San Marcos River watershed are crucial to ensure the survival of the Texas wild rice, Comal Springs drypoid beetle, and Texas blind salamander in Hays County.

Biological resources mapped within the natural areas are displayed in **Map 3.3, Biologic Resources** and include EMST vegetation types, critical habitat mapped by the U.S. Fish and Wildlife Service, known colony locations of the Comal Springs drypoid beetle and Texas blind salamander (*Eurycea rathbuni*), natural areas and greenspaces, floodplains, rivers and streams, lakes and roadways.

MAP 3.3, BIOLOGIC RESOURCES



Legend

Barren	Edwards Plateau: Oak - Ashe Juniper Slope Forest
Blackland Prairie: Disturbance or Tame Grassland	Edwards Plateau: Oak - Hardwood Motte and Woodland
Central Texas: Floodplain Deciduous Shrubland	Edwards Plateau: Oak - Hardwood Slope Forest
Central Texas: Floodplain Hardwood Forest	Edwards Plateau: Post Oak Motte and Woodland
Central Texas: Floodplain Herbaceous Vegetation	Edwards Plateau: Riparian Ashe Juniper Forest
Central Texas: Riparian Herbaceous Vegetation	Edwards Plateau: Riparian Deciduous Shrubland
Edwards Plateau: Ashe Juniper / Live Oak Shrubland	Edwards Plateau: Riparian Hardwood / Ashe Juniper Forest
Edwards Plateau: Ashe Juniper Motte and Woodland	Edwards Plateau: Riparian Hardwood Forest
Edwards Plateau: Ashe Juniper Slope Forest	Edwards Plateau: Riparian Herbaceous Vegetation
Edwards Plateau: Deciduous Oak - Evergreen Motte and Woodland	Edwards Plateau: Riparian Live Oak Forest
Edwards Plateau: Floodplain Hardwood / Ashe Juniper Forest	Edwards Plateau: Savanna Grassland
Edwards Plateau: Floodplain Hardwood Forest	Native Invasive: Deciduous Woodland
Edwards Plateau: Floodplain Live Oak Forest	Native Invasive: Juniper Woodland
Edwards Plateau: Live Oak Motte and Woodland	Native Invasive: Mesquite Shrubland
Edwards Plateau: Live Oak Slope Forest	Open Water
Edwards Plateau: Oak - Hardwood Slope Forest	Urban High Intensity
City Limits	Urban Low Intensity

Critical Habitat for Texas wild rice	Golden-Cheeked Warbler Sightings	Floodplain
Natural Areas & Greenspaces	Drypoid Beetle	Rivers and Streams
Roads	Blind Salamander	Lakes and Ponds

Vegetation Data Source: Texas Forest Service



AQUATIC RESOURCES

The Edwards Aquifer is a karst aquifer characterized by sinkholes, sinking streams, caves, large springs and highly productive water wells. Karst aquifers are considered triple permeability aquifers which allow water to be contained within the rock matrix, fractures and faults, with caves and conduits that give rise to distinct biological species and unique ecosystems.

Several of the mapped natural areas are located within the areas that are protected under TCEQ's Edwards Aquifer Protection Program, described under Objective 1.2.1. These include the Transition Zone, the Recharge Zone, the Contributing Zone, and the Contributing Zone Within the Transition Zone.

The contributing zone is defined as the drainage area of the Edwards Plateau which contributes surface water to the recharge zone via perennial and intermittent streams. Spring Lake Natural Area and Schulle Canyon occur within the contributing zone. The transition zone is defined as a thin strip of land where limestones that overlie the Edwards Aquifer are faulted and fractured with caves and sinkholes which allows surface water to enter the aquifer directly. Sessom Creek, Retreat on Willow Creek, and the southernmost portion of Lower Purgatory Creek occur within this zone.

Finally, the recharge zone is defined as a 1,250 square mile area where highly faulted and fractured limestone beds outcrop at the surface. This allows large quantities of water to permeate into the aquifer as ground water or surface water drainage. Ringtail Ridge, Millican, Early, Spring Lake Preserve, Prospect Park, Lower Purgatory, all of Upper Purgatory, River Recharge, and Lancaster Greenbelt occur within the recharge zone. Blanco Riverwalk, Blanco Shoals, Blanco River Village, and Cottonwood Creek Park are to the south and east of the Edwards Aquifer and do not occur within the boundaries of any of the aquifer zones.

The Edwards Aquifer is also a karst aquifer characterized by sinkholes, sinking streams, caves, large springs and highly productive water wells. Karst

aquifers are considered triple permeability aquifers which allows water to be contained within the rock matrix, fractures and faults, as well as caves and conduits which gives rise to distinct biological species and ecosystems that are unique to the aquifer.

Floodplains are mapped based on the Federal Emergency Management Agency's (FEMA) National Flood Hazard Layer (NFHL) and are typically located adjacent to perennial streams. Floodplains occur in Early, Spring Lake Preserve, Blanco Riverwalk, Blanco Shoals, Blanco River Village, Lower Purgatory Creek, Upper Purgatory Barker, and Upper Purgatory Creek. Riverine streams occur in all natural areas except for Sessom Creek and Lancaster Greenbelt. No lakes occur within any of the natural areas. The major drainage areas within the natural areas include Purgatory Creek, Sink Creek, San Marcos River, and the Blanco River drainages. Purgatory Creek is a perennial tributary to the San Marcos River. Purgatory Creek forms the southern boundary of Lower Purgatory Creek and Upper Purgatory Barker. Tributaries of Purgatory Creek flow through Prospect Park, Lower Purgatory Creek, Upper Purgatory Creek, and River Recharge. Sink Creek is a perennial tributary to the San Marcos River that flows through Early and Spring Lake Preserve. Mapped streams in Ringtail Ridge, Millican, and Schulle Canyon are unnamed tributaries to Sink Creek. Sink Creek flows into the San Marcos River east of Spring Lake Preserve. The San Marcos River continues through the City of San Marcos until its confluence with the Blanco River east of Interstate 35. The Blanco River is a perennial stream that flows in a southeasterly direction to the north and east of the City of San Marcos. Blanco Riverwalk, Blanco Shoals, Blanco River Village occur along the Blanco River. Near the confluence of the San Marcos River with the Blanco River is a large floodplain east of Interstate 35.

Aquatic resources mapped within the natural areas are displayed on **Map 3.4, Aquatic Resources**. The map includes wetlands, Edwards Aquifer protection zones, floodplains, natural areas, and roadways.

MAP 3.4, AQUATIC RESOURCES

Legend

Texas Wetlands

- Freshwater Pond
- Lake
- Riverine

Edwards Aquifer

- Recharge Zone
- Contributing Zone
- Transition Zone

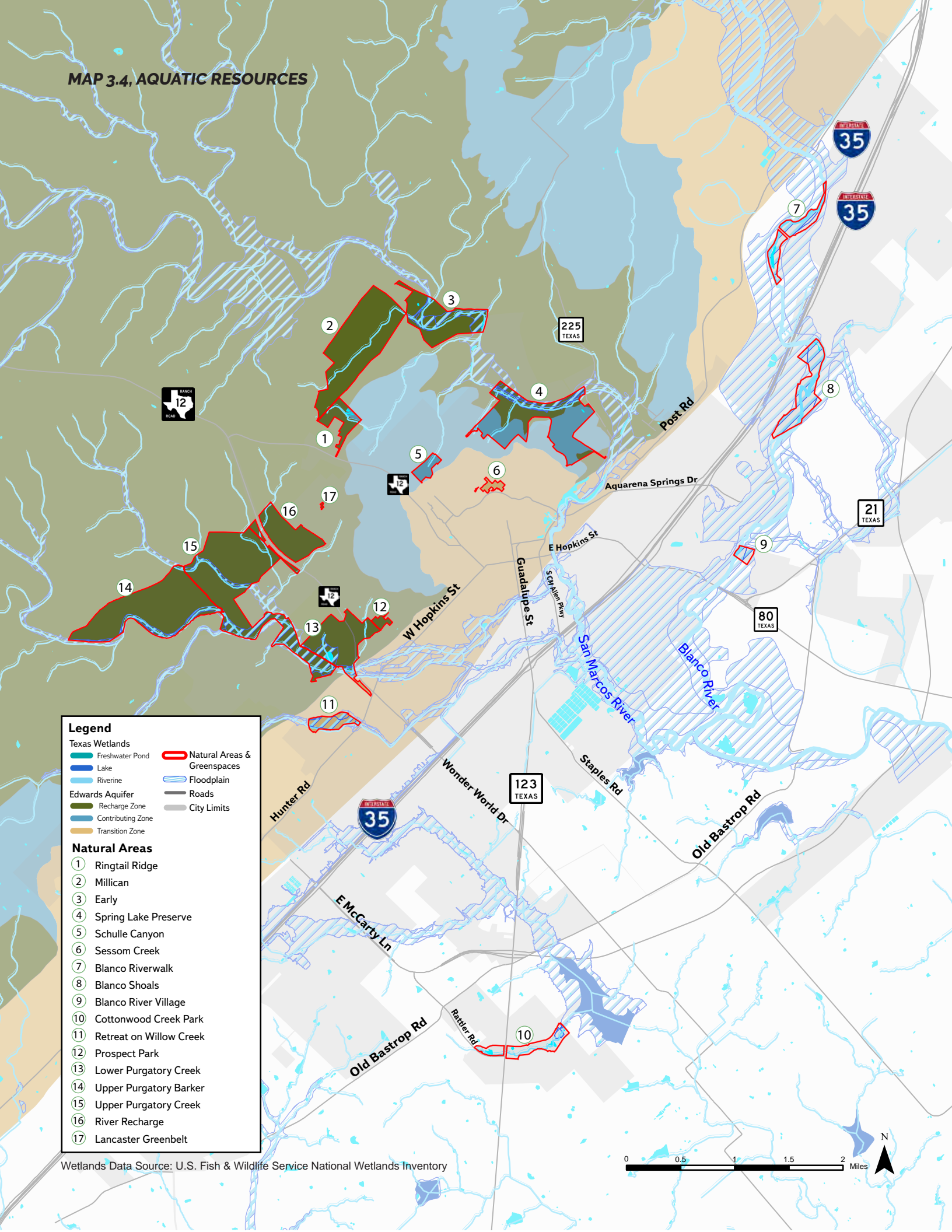
Natural Areas

- Natural Areas & Greenspaces
- Floodplain
- Roads
- City Limits

Natural Areas

- ① Ringtail Ridge
- ② Millican
- ③ Early
- ④ Spring Lake Preserve
- ⑤ Schulle Canyon
- ⑥ Sessom Creek
- ⑦ Blanco Riverwalk
- ⑧ Blanco Shoals
- ⑨ Blanco River Village
- ⑩ Cottonwood Creek Park
- ⑪ Retreat on Willow Creek
- ⑫ Prospect Park
- ⑬ Lower Purgatory Creek
- ⑭ Upper Purgatory Barker
- ⑮ Upper Purgatory Creek
- ⑯ River Recharge
- ⑰ Lancaster Greenbelt

Wetlands Data Source: U.S. Fish & Wildlife Service National Wetlands Inventory



WILDFIRE INTENSITY RISK

The wildfire threat in an area is the likelihood of a wildfire occurring or burning into an area. This threat is an environmental feature of each natural area. The threat is determined by combining a number of landscape characteristics including surface and canopy fuels, resultant fire behavior, historical fire occurrence, historical weather observations, slope and other terrain conditions. The Characteristic Fire Intensity Scale, shown in **Map 3.5, Wildfire Intensity Risk** on the next page, specifically identifies areas where the factors associated with dangerous fire behavior exist. The Fire Intensity Scale includes five classes to measure potential wildfire intensity. The classes, which range from Class 1, Very Low, to Class 5, Very High, have a 10-fold order of magnitude between classes. The classes are shown in one-half increments on the map for more detailed viewing. The specific classes of fire intensity are as follows:

- **Class 1, Very Low:** Very small, discontinuous flames, usually less than 1 foot in length; very low rate of spread; no spotting. Fires are typically easy to suppress by firefighters with basic training and non-specialized equipment.
- **Class 2, Low:** Small flames, usually less than two feet long; small amount of very short range spotting possible. Fires are easy to suppress by trained firefighters with protective equipment and specialized tools.
- **Class 3, Moderate:** Flames up to eight feet in length; short-range spotting is possible. Trained firefighters will find these fires difficult to suppress without support from aircraft or engines, but dozer and plows are generally effective. Increasing potential for harm or damage to life and property.

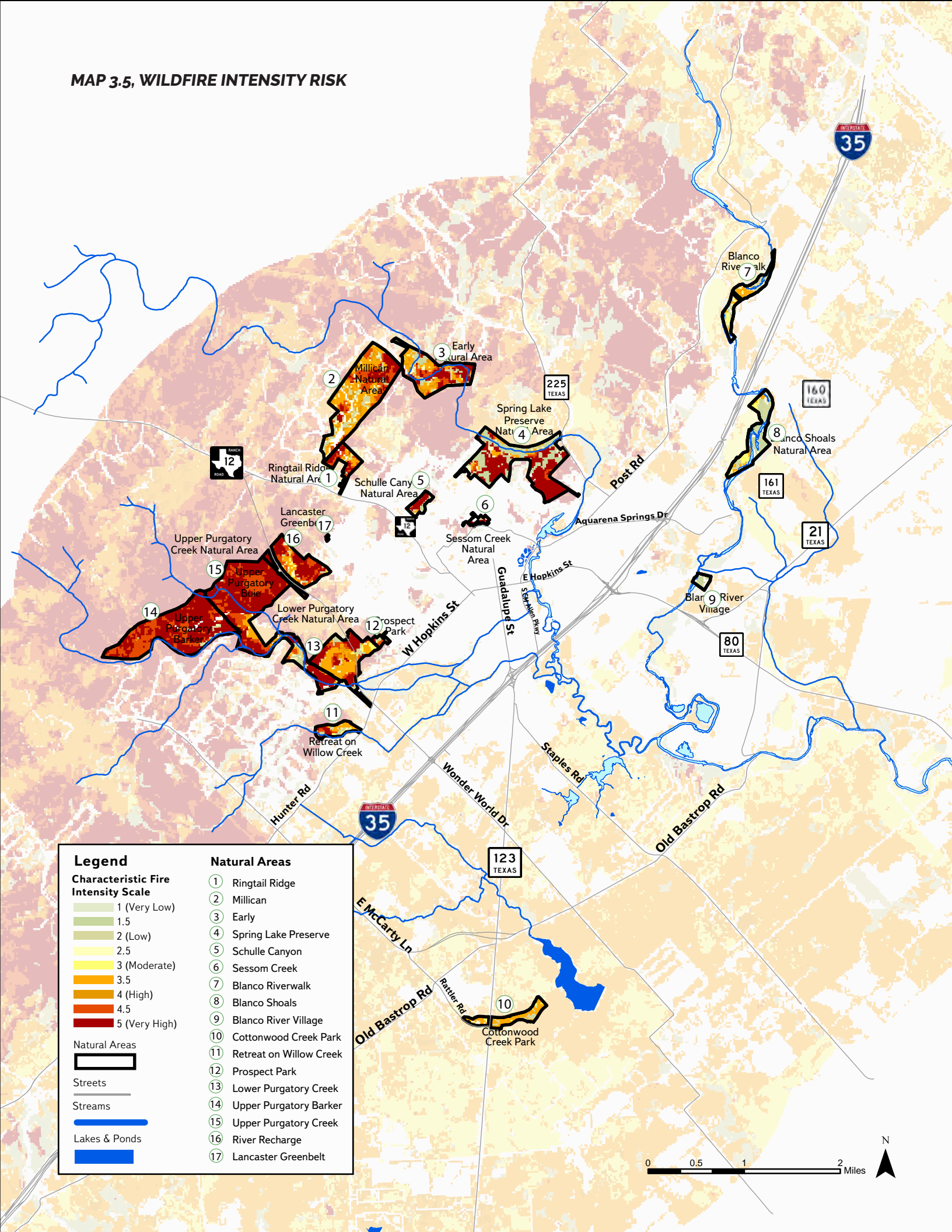
- **Class 4, High:** Large Flames, up to 30 feet in length; short-range spotting common; medium range spotting possible. Direct attack by trained firefighters, engines, and dozers is generally ineffective, indirect attack may be effective. Significant potential for harm or damage to life and property.
- **Class 5, Very High:** Very large flames up to 150 feet in length; profuse short-range spotting, frequent long-range spotting; strong fire-induced winds. Indirect attack marginally effective at the head of the fire. Great potential for harm or damage to life and property.

The Wildfire Intensity Scale does not incorporate historical occurrence data and only evaluates the potential fire behavior for an area. Knowledge of historical fire occurrence data may help natural area managers have a greater understanding of areas where dangerous fire potential exists in relation to nearby homes or other valued assets.

Wildfire intensity is influenced by fuels, weather, and topography. Fuels are anything that can burn in a wildfire and can include grasses, shrubs, trees, and dead leaves. The accumulation of fuel increases the potential for wildfires and allows fires to burn hotter, larger, longer, and faster, making them more difficult and dangerous to manage.

Naturally-occurring wildfires thin out fuels in natural areas; however, historical fire suppression activities have disrupted these natural processes. Consequently, many natural areas have become overgrown and contain greater intensity of fuels leading to more damaging wildfire activity when wildfires occur. Effectively managing fuel loads, and reducing loads when and where appropriate, helps to reduce the risk of fires and maintain functioning ecosystems.

MAP 3.5, WILDFIRE INTENSITY RISK



Legend

Characteristic Fire Intensity Scale

- 1 (Very Low)
- 1.5
- 2 (Low)
- 2.5
- 3 (Moderate)
- 3.5
- 4 (High)
- 4.5
- 5 (Very High)

Natural Areas

Natural Areas

Streets

Streams

Lakes & Ponds

Natural Areas

- ① Ringtail Ridge
- ② Millican
- ③ Early
- ④ Spring Lake Preserve
- ⑤ Schulle Canyon
- ⑥ Sessom Creek
- ⑦ Blanco Riverwalk
- ⑧ Blanco Shoals
- ⑨ Blanco River Village
- ⑩ Cottonwood Creek Park
- ⑪ Retreat on Willow Creek
- ⑫ Prospect Park
- ⑬ Lower Purgatory Creek
- ⑭ Upper Purgatory Barker
- ⑮ Upper Purgatory Creek
- ⑯ River Recharge
- ⑰ Lancaster Greenbelt

0 0.5 1 2 Miles



ENVIRONMENTAL SENSITIVITY

Though all of the natural areas should be protected and preserved, there are areas of increased environmental sensitivity where special precautions should be taken. It is important to ensure that the most environmentally sensitive lands are preserved and protected over time. **Map 3.6, Environmental Sensitivity**, on the next page, highlights the most sensitive areas which need to be protected. Within the areas identified as high or very high on the map, human activities should be strictly limited or perhaps avoided all together. It is not advisable to put trails in these areas due to their increased sensitivity.

Areas of special concern or increased environmental sensitivity were calculated using the following sets of data as indicators:

- Protected species habitat (presence of endangered or threatened species)
- Presence of caves or recharge features
- Aquifer protection zones (special consideration given to the Edwards Aquifer Recharge zone)
- Wildfire Intensity (special consideration given to a rating of 4 or 5 from **Map 3.5 Wildfire Intensity Risk**)
- Floodplains (special consideration given to the 100-year floodplain and floodway)

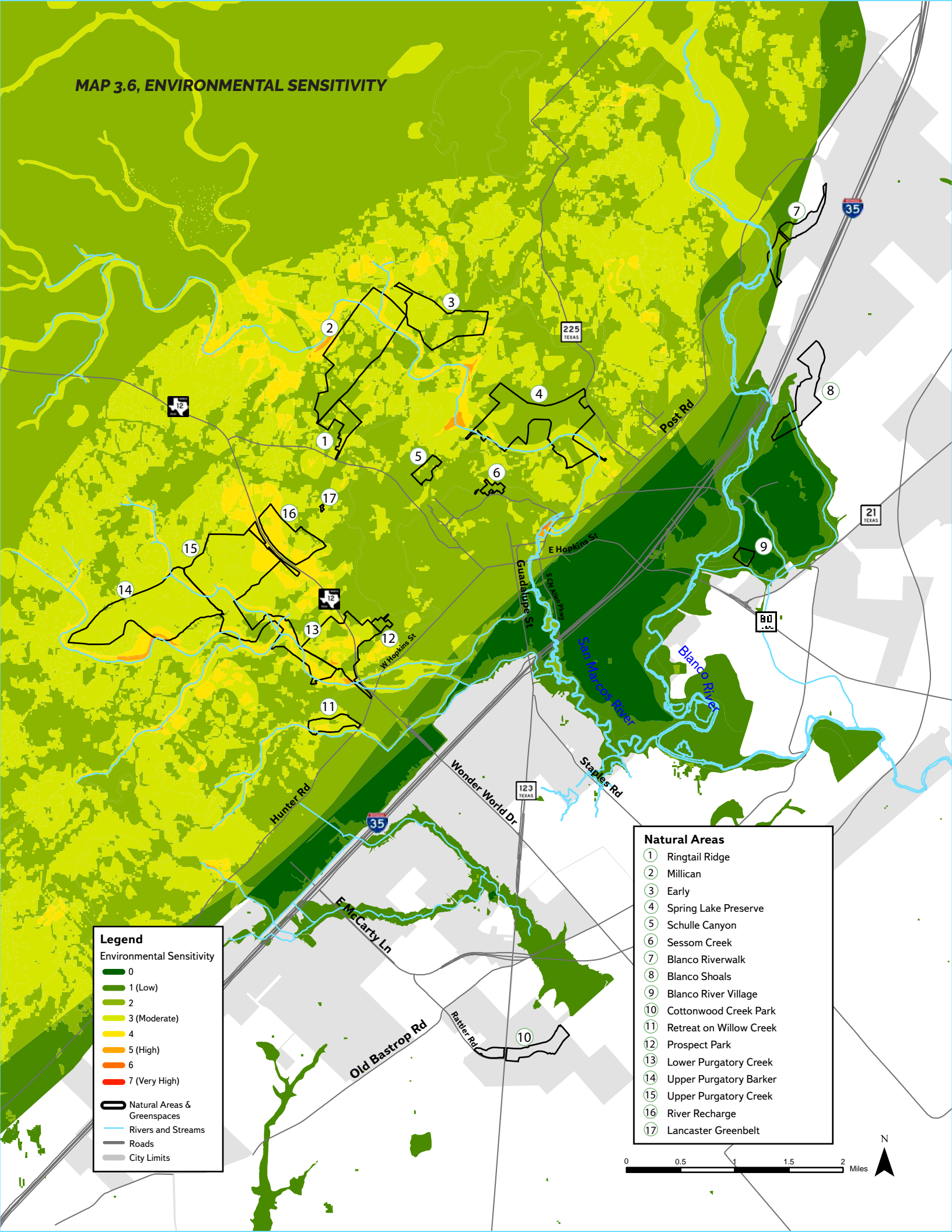
These indicators were weighted to determine the overall environmental sensitivity of a given area. Multiple occurrences of an indicator of environmental sensitivity in a given area show higher overall environmental sensitivity for the site. For example, sightings of endangered species in a floodplain where there are known caves would rank as more environmentally sensitive compared to an area with only the presence of caves.

The environmental sensitivities shown in **Map 3.6, Environmental Sensitivity** on the next page demonstrate areas in which special care should be taken due to a convergence of multiple indicators of environmental sensitivity.



GOLDEN-CHEEKED WARBLER

MAP 3.6, ENVIRONMENTAL SENSITIVITY



Legend

Environmental Sensitivity

- 0
- 1 (Low)
- 2
- 3 (Moderate)
- 4
- 5 (High)
- 6
- 7 (Very High)

 Natural Areas & Greenspaces
— Rivers and Streams
— Roads
 City Limits

Natural Areas

- ① Ringtail Ridge
- ② Millican
- ③ Early
- ④ Spring Lake Preserve
- ⑤ Schulle Canyon
- ⑥ Sessom Creek
- ⑦ Blanco Riverwalk
- ⑧ Blanco Shoals
- ⑨ Blanco River Village
- ⑩ Cottonwood Creek Park
- ⑪ Retreat on Willow Creek
- ⑫ Prospect Park
- ⑬ Lower Purgatory Creek
- ⑭ Upper Purgatory Barker
- ⑮ Upper Purgatory Creek
- ⑯ River Recharge
- ⑰ Lancaster Greenbelt



NATURAL AREA SITE ECOSYSTEM DESCRIPTIONS

SPRING LAKE NATURAL AREA

Spring Lake Natural Area is approximately 251.5 acres of land in northwest San Marcos situated just above Spring Lake, the headwaters of the San Marcos River. The natural area encompasses portions of the San Marcos River and Sink Creek watersheds, and about half of the natural area is in the Edwards Aquifer Recharge Zone. There is approximately 140 feet of elevation change across the natural area with underlying geology including Cretaceous-era limestone deposits in the upland areas and Quaternary alluvium along the riparian zone. Karst features are likely present throughout the natural area and several mapped caves are present in the surrounding area; however, no caves or sensitive habitats have been mapped within the natural area itself.

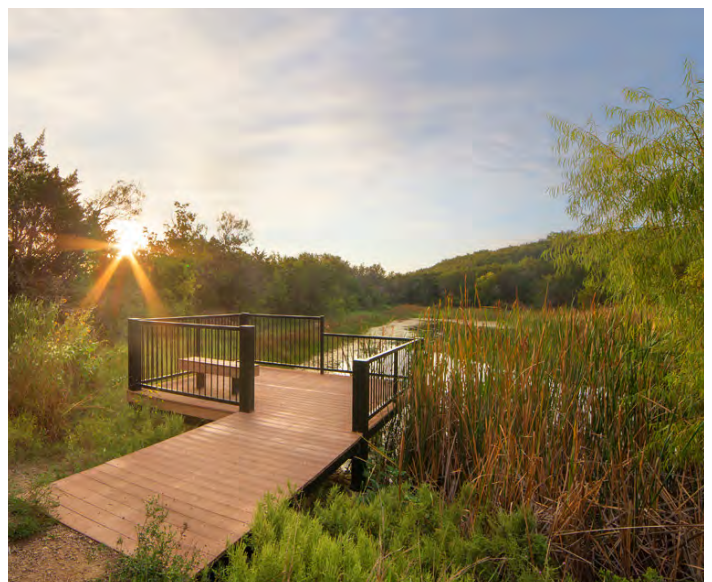
Water features within the natural area include Sink Creek, an ephemeral drainage with a wide riparian corridor that eventually flows into Spring Lake, running parallel with the northern boundary, two unnamed tributaries to Sink Creek moving south through the natural area, and one pond located on the northeast side. The FEMA 100-year floodplain is present through the northern section of Spring Lake Natural Area, surrounding Sink Creek. Soils within the Spring Lake Natural Area include Eckrant and Comfort series soils, which are shallow clay loam or clay soils that typically occur on ridges and

dissected plateaus. Typical land use for these soil series includes rangeland and wildlife habitat and the native climax plant community is tall grass savannah with motts of live oak. Climax community graminoid species include Texas wintergrass, threeawns, sideoats grama, little bluestem, and Indiangrass with woody vegetation including Texas oak, shin oak, plateau live oak, and Texas persimmon.

Present-day vegetation within the Spring Lake Natural Area includes the live oak mott/Savannah communities typical of the Edwards Plateau, along with areas of mature Ashe juniper woodlands which provide nesting and foraging habitat for the Golden-cheeked Warbler, an endangered bird species with federal protection under the Endangered Species Act. The Spring Lake Natural Area remains undeveloped, aside from the presence of surface trails for hiking, biking and recreational uses, such as birding and photography. In 2022, a survey was conducted in Spring Lake Natural Area and three locations of Golden-cheeked Warbler habitat was detected. Selected trails are closed from March 1st to May 31st to support the nesting season for the bird. While the majority of the Spring Lake Natural Area is composed of native vegetation, nonnative/invasive species are present including Ligustrum. Past efforts to remove these invasive species have included herbicide use and manual removal.

Management Objectives

- Invasive species control
- Habitat protection and/or improvement for Golden-cheeked Warbler
- Data collection and record keeping
 - Invasive species surveys
 - Erosion problems
 - Karst feature surveys
- Riparian zone protection
- Fire hazard mitigation
- Native habitat restoration
- Increase native species diversification and abundance
- Natural resource interpretation and education



SUNRISE IN SPRING LAKE NATURAL AREA

SESSOM CREEK

Sessom Creek Natural Area is approximately 14.2 acres, located in northwest San Marcos, within the Sessom Creek watershed. The Edwards Aquifer Transition Zone encompasses the entire natural area. There is approximately 80 feet of elevation change across Sessom Creek, with steepest areas in the southwest corner. Underlying geology is consistent throughout the natural area, including Cretaceous-era limestone deposits. Karst features are likely present within the natural area; however, no caves or sensitive habitats have been mapped within the area.

Sessom Creek and associated tributaries, including Windmill and Gulch tributaries, run throughout the extent of the natural area. The FEMA 100-year floodplain is not mapped within the natural area, and the entire area is within an area of minimal flood hazard. Soils within the natural area include Comfort, Eckrant, and Medlin series soils. Comfort and Eckrant soils are typically shallow, clay soils occurring on ridges or dissected plateaus. Medlin series soils are deep, slowly permeable soils, occurring on narrow stream divides and slopes along drainage ways. Typical use for these soil series

includes rangeland and wildlife habitat and the native climax vegetation is tall grass Savanna with motts of live oak and mesquites. Climax community graminoid species include Texas wintergrass, threeawns, sideoats grama, little bluestem, and Indiangrass with woody vegetation including Texas oak, shin oak, plateau live oak, scattered elm, hackberry and Texas persimmon.

Vegetation in Sessom Creek Natural Area today includes oak and Ashe juniper, with deciduous oak and evergreen motte, consistent with vegetation for the Edwards Plateau ecoregion. Though a formal survey has not been conducted for the presence or absence of the Golden-cheeked Warbler, Ashe juniper is a known nesting and foraging habitat for the endangered species. The natural area remains primarily undeveloped, with two surface trails that traverse throughout the area. The natural area was the site for work under an EPA/TCEQ Water Quality Grant in 2016 which funded efforts to manage invasive trees and grass species, native seedings, and install vegetation for stormwater management. Work under this grant and under the Edwards Aquifer HCP, together with City utility improvements, has resulted in a comprehensive habitat restoration in the natural area. Targeted invasive species within the Sessom Creek include Ligustrum, Chinese tallow, tree of heaven chinaberry, King Ranch bluestem, and Johnson grass.

Management Objectives

- Invasive species control
- Data collection and record keeping
 - Golden-cheeked Warbler habitat surveys
 - Invasive species surveys
 - Karst feature surveys
 - Erosion problems
- Riparian zone protection
- Native habitat restoration
- Increase native species diversification and abundance
- Natural resource interpretation and education



TRAIL MARKER IN SESSOM CREEK NATURAL AREA

SCHULLE CANYON

Located in northwest San Marcos, Schulle Canyon is approximately 21 acres and is located within the Schulle Canyon watershed leading to Sink Creek. The natural area has approximately 70 feet of elevation change and is located within the Edwards Aquifer Contributing Zone within the Transition Zone. Underlying geology is consistent throughout Schulle Canyon, including Cretaceous-era limestone deposits. Karst features are likely present within the natural area; however, no caves or sensitive habitats have been mapped within Schulle Canyon.

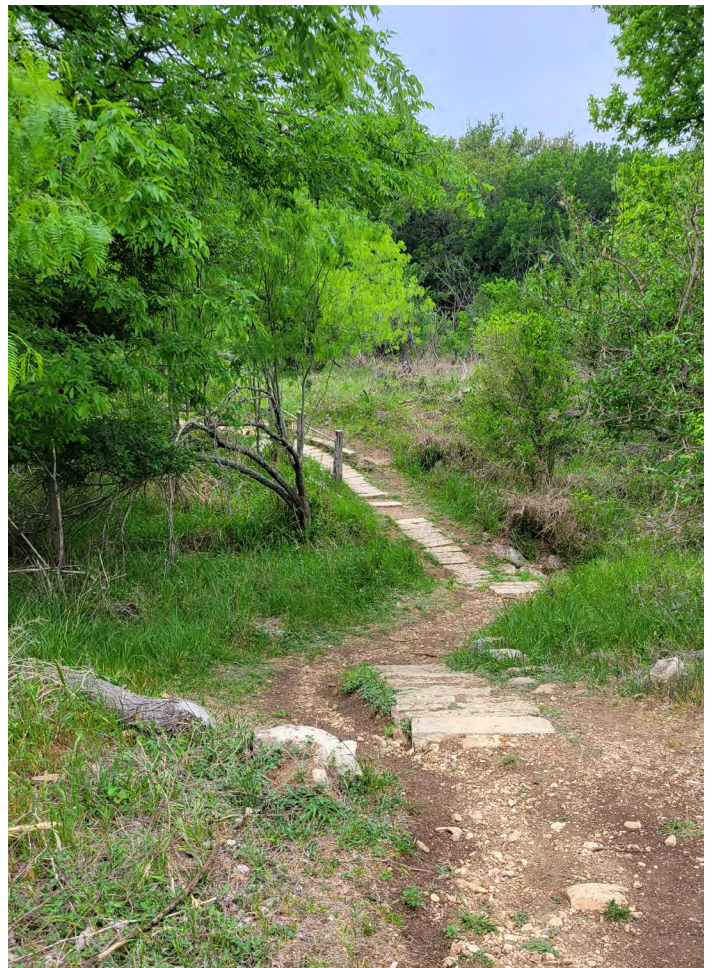
Water features within Schulle Canyon Natural Area consist of a small unnamed stream that runs through the extent of the natural area. The FEMA 100-year floodplain is not mapped within the natural area, and the entire area is within an area of minimal flood hazard. Soils in Schulle Canyon consist of Comfort and Doss series. Comfort and Doss soils are shallow, slow permeable clay and silty clay soils occurring in

dissected plateaus and moderately sloping hills. The primary use of these soils is rangeland with small occurrences of small grains. Native climax vegetation consists mostly of tallgrass Savannah with scattered presence of live oak. Climax community species include little bluestem, sideoats grama, and Texas intergrass, with woody vegetation including live oak and cedar elm trees.

The natural area is primarily undeveloped, with one accessible trail and several single-track trails. Present-day vegetation within the natural area are primarily oak and hardwood motte, consistent with the Edwards Plateau. Though most vegetation in the natural area consists of native species, invasive species such as chinaberry, King Ranch bluestem, and Johnson grass are present with the natural area. Management of these invasive species has been ongoing since 2020. Efforts to remove these species have included herbicide use and manual removal.

Management Objectives

- Invasive species control
- Fire hazard mitigation
- Data collection and record keeping
 - Invasive species surveys
 - Karst feature surveys
 - Erosion problems
 - Vegetation and species area profiles
 - Wildlife and insect surveys
 - Soil biota; soil loss or gain
- Re-align or remove trails not consistent with these objectives
- Provide interpretation and experiential opportunities for visitors in support of the vision and values of this plan
- Increase native species diversification and abundance
- Natural resource interpretation and education



NATURAL TRAIL IN SCHULLE CANYON NATURAL AREA

WESTERN LOOP UNIT (INCLUDING RINGTAIL RIDGE NATURAL AREA, EARLY AND MILLICAN TRACTS)

The Western Loop Unit includes the Ringtail Ridge Natural Area and the Early and Millican tracts. Collectively, these properties are approximately 450.3 acres, within the Sink Creek watershed, and Edwards Aquifer Recharge Zone. Across the Western Loop Unit there is approximately 120 feet of elevation change, with the steepest change occurring in the riparian zone of Sink Creek. Underlying geology includes Cretaceous-era limestone deposits in the upland areas. Karst features are likely present throughout the preserve and several mapped caves are present within the Western Loop Unit, mainly in the Early tract.

Sink Creek and associated tributaries are throughout the Western Loop Unit. A small unnamed tributary is located within Ringtail Ridge Natural Area. One pond is located in the northwest corner of the Millican tract, while three ponds are located in Ringtail Ridge. The FEMA 100-year floodplain is limited to the

Millican tract, encompassing the majority of the tract around Sink Creek. The Western Loop Unit includes Comfort, Denton, Medlin, Rumble and Anhalt series soils. These soils range from fine, silty soils to clay soils. Typical land uses for these soil types vary for cropland, pasture and rangeland. Sorghums are associated with croplands in these soil types. Native vegetation includes post oak savannah, in addition to live oak, scattered elm, hackberry, and mesquite trees in some areas.

Vegetation throughout the Western Loop Unit today primarily includes savannah grassland, riparian hardwood, and live oak. Efforts to manage invasive species have taken place in the Ringtail Ridge Natural Area of the Western Loop Unit, targeting species such as chinaberry, ligustrum, and bastard cabbage. The manual removal of Ashe juniper trees in the Early tract has also occurred.

Management Objectives

- Invasive species control
- Fire hazard mitigation
- Data collection and record keeping
 - Golden-cheeked Warbler habitat surveys
 - Invasive species surveys
 - Karst feature surveys
- Native habitat restoration
- Increase native species diversification and abundance
- Natural resource interpretation and education



KIOSK AT RINGTAIL RIDGE NATURAL AREA



BOARDWALK TRAIL IN RINGTAIL RIDGE NATURAL AREA

LOWER PURGATORY CREEK (INCLUDING PROSPECT PARK)

The Lower Purgatory Creek Natural Area, which includes Prospect Park, is approximately 151 acres, situated in southwest San Marcos. The natural area is primarily within the Purgatory Creek watershed, with a small area in the southeast corner of the boundary in the Willow Springs Creek watershed. Within the natural area approximately 60 feet of elevation change occurs, with steep changes surrounding Purgatory Creek. Underlying geology includes Cretaceous-era limestone deposits in the upland areas. Karst features are present throughout the preserve and several caves are mapped within the natural area.

Purgatory Creek and associated tributaries run throughout the southern portion of the natural area. There are two pond features within this area in the southwest and southeast corners. Upper San Marcos Watershed Reclamation and Flood Control District Dam No. 5 is located here to retain flood flows. The dam has a bypass channel that flows only during extreme rainfall events. Water retained by the dam can cause large piles of duff to accumulate above the dam that require cleaning to maintain trails. The southern portion of the natural area is within the FEMA 100-year floodplain. Soils in the natural area consist of Comfort, Denton, Krum, Rumble, Anhalt,

and Orif series. In general, these soils range from fine clayey soils, with the exception of Orif series soils, that come across as more sandy. These soils appear on dissected plains and plateaus, as well as gently sloping floodplains. Typical land uses, include rangeland, cropland and native pasture. Orif series soils also serve as a source of sand and gravel. Native grasses commonly consist of hooded windmillgrass, fall witchgrass, Hall's panicum, threeawn grass, grassbur, sideoats grama, Texastridens, and bristlegrass. Woody plants are live oak, Texas persimmon, Texas colubrina, catclaw, mesquite, whitebrush, and agarita.

Present-day vegetation in Lower Purgatory Creek Natural Area includes savannah grasslands with oak and Ashe juniper. Riparian hardwood and shrubland also surround Purgatory Creek. Invasive species management in the natural area has been ongoing since 2021. Invasive tree management and prairie restorations have been initiated to target known invasive species. Targeted invasive species include, Ligustrum, chinaberry, bamboo, red tip photinia, Chinese pistache, King Ranch bluestem, and Johnson grass. In 2018, a survey was conducted in Prospect Park and one location of Golden-cheeked Warbler habitat was detected.

Management Objectives

- Invasive species control
- Habitat protection and/or improvement for Golden-cheeked Warbler
- Data collection and record keeping
 - Invasive species surveys
 - Karst feature surveys
 - Additional Golden-cheeked Warbler habitat surveys
- Fire hazard mitigation
- Riparian zone protection
- Native habitat restoration
- Increase native species diversification and abundance
- Natural resource interpretation and education



NATURAL TRAIL IN PURGATORY CREEK NATURAL AREA

UPPER PURGATORY CREEK (INCLUDING BARKER, WILDENTHAL, RIVER RECHARGE TRACTS)

Connecting to the Lower Purgatory Creek Natural Area is Upper Purgatory Creek Natural Area, which includes the Barker, Wildenthal, and Buie tracts. This natural area is approximately 760.2 acres, and spans across the Purgatory Creek and associated tributaries watershed system. This natural area displays approximately 120 feet of elevation change, with the steepest changes occurring around the water features in the natural area. Underlying geology is limited to Cretaceous-era limestone deposits throughout the area. Karst features are likely present throughout the natural area and several caves are mapped within the natural area.

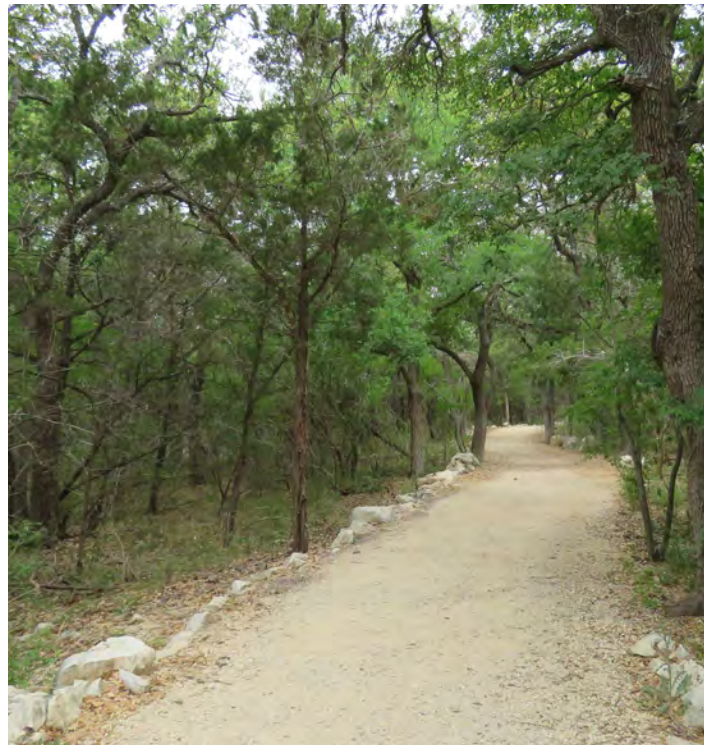
Purgatory Creek and associated tributaries are the main water features throughout the natural area. The easternmost section of the natural area, where there is a shared boundary with Lower Purgatory Creek Natural Area, is fully encompassed by the FEMA 100-year floodplain. The 100-year floodplain is also throughout the center of the natural area to the northwest, and the southeastern boundary of the Barker tract. Soils within the Upper Purgatory Creek include Comfort, Rumpel, Denton, Orif and Tarpley series soils. These soils are typically clay and sandy

and found on dissected plateaus and sloping ridges. Land uses consist of rangeland and crop production of small grains. Native vegetation is typically Texas wintergrass, sideoats grama, little bluestem, and Indiangrass. Woody vegetation is white shin oak, live oak, post oak, and mesquite.

Vegetation in the natural area today is a mix of Savannah grassland, riparian hardwood, live oak, and Ashe juniper. Field habitat surveys for the USFWS endangered golden-cheeked warbler (*Setophaga chrysoparia*) have been conducted in areas throughout the natural area. Habitat surveys for the Barker and Wildenthal tracts in 2013-2014 recorded more than 10 observations of Golden-cheeked Warblers in these tracts. Known and potential habitat areas are also mapped throughout the natural area. During the Golden-cheeked Warbler nesting season March 1-May 30, the Paraiso Trail in the natural area is closed to the public. Invasive species management in the natural area has generally mirrored the efforts done in Lower Purgatory Creek Natural Area.

Management Objectives

- Invasive species control
- Habitat protection and/or improvement for Golden-cheeked Warbler
- Data collection and record keeping
 - Invasive species surveys
 - Karst feature surveys
 - Golden-cheeked Warbler habitat surveys
 - Erosion problems
- Fire hazard mitigation
- Riparian zone protection
- Native habitat restoration
- Increase native species diversification and abundance
- Natural resource interpretation and education



IMPROVED TRAIL IN UPPER PURGATORY CREEK NATURAL AREA

RETREAT ON WILLOW CREEK

The Retreat on Willow Creek Natural Area is located just southeast of the Upper and Lower Purgatory Creek Natural Areas. The Retreat on Willow Creek Natural Area is approximately 33.0 acres and located within the Willow Springs Creek watershed. Across the natural area is approximately 20 feet of elevation change. Underlying geology within the natural area is limited to Cretaceous-era limestone deposits.

Willow Springs Creek is the primary water feature within the natural area. The FEMA 100-year floodplain encompasses the entire natural area. Soils within the natural area include Tinn, Rumble, Comfort and Anhalt series. These series vary in erodibility and typically have clay characteristics. These soils occur

on dissected plains and plateaus. Common uses of these soils include rangeland, pasture and in some instances cultivated crops. Native vegetation consists mostly of Texas wintergrass, threeawns, sideoats grama, little bluestem, and indiagrass. Woody vegetation includes cedar elm, hackberry, live oak, persimmon, bee brush, and Ashe juniper.

Present-day vegetation within the natural area is a combination of post oak, cedar elm, live oak, persimmon, hackberry, bee brush, Ashe juniper, mesquite, deciduous oak, and floodplain hardwood. Efforts to manage invasive species such as Chinaberry, Chinese tallow, KR bluestem, and Johnson grass have not occurred in the Willow Creek Natural Area.

Management Objectives

- Data Collection and record keeping
- Invasive species surveys
- Karst feature surveys
- Golden-cheeked Warbler habitat surveys
- Native habitat restoration
- Increase native species diversification and abundance
- Natural resource interpretation and education

RIGHT: POND AT THE RETREAT ON WILLOW CREEK NATURAL AREA



ACCESS POINT AT RETREAT ON WILLOW CREEK NATURAL AREA

BLANCO RIVER UNIT (INCLUDING BLANCO SHOALS, BLANCO RIVERWALK, BLANCO RIVER VILLAGE)

The Blanco River Unit, including the Blanco Shoals, Blanco Riverwalk and Blanco River Village Natural Areas, make up approximately 160.2 acres along the Blanco River, both west and east of Interstate 35. These natural areas are within the Blanco River watershed. Across these natural areas, there is a maximum elevation change of 50 feet. Underlying geology includes Quaternary deposits of gravel, silt, sand and clay.

The primary water feature throughout these natural areas is the Blanco River. The Blanco Shoals Natural Area contains a large pond near the southern boundary. All three natural areas in the Blanco River Unit are entirely within the FEMA 100-year floodplain. Soils include Seawillow, Orif, and Lewisville series soils. These soils appear around floodplains and

associated water features. Uses include rangeland and cropland. Native grasses commonly consist of hooded windmillgrass, fall witchgrass, Hall's panicum, threeawn grass, grassbur, sideoats grama, Texastridens, and bristlegrass. Woody plants include pecan, sycamore, cypress, live oak, Texas persimmon, Texas colubrina, catclaw, mesquite, whitebrush, and agarita.

Present day vegetation is primarily floodplain hardwood forest, riparian hardwood forest, and deciduous woodland. Invasive species management for chinaberry (*Melia azedarach*) has occurred within the Blanco Shoals Natural Area through herbicide application and manual removal. Invasive species management for castor bean, arundo and bastard cabbage has not occurred.

Management Objectives

- Data collection and record keeping
- Species surveys (following the Habitat Conservation Plan)
- Invasive species surveys
- Erosion problems
- Karst feature surveys
- Riparian zone protection
- Native habitat restoration
- Increase native species diversification and abundance
- Natural resource interpretation and education



NATURAL TRAIL IN BLANCO SHOALS NATURAL AREA



BLANCO RIVER AT BLANCO SHOALS NATURAL AREA

COTTONWOOD CREEK

The Cottonwood Creek Natural Area is approximately 52.9 acres, located in southeast San Marcos. Cottonwood Creek is located within the Cottonwood Creek watershed. There is approximately 40 feet of elevation across the natural area. Underlying geology includes Quaternary deposits of gravel, silt, sand and clay. Cottonwood Creek runs through the length of the natural area, with five ponds from the east to west boundaries.

The FEMA 100-year floodplain is located on the eastern side of the natural area. Soils within

Cottonwood Creek are indicative of the Blackland Prairies ecoregion. These soils include Heiden, Tinn and Houston Black series soils. These soils are on flood plains of dissected plains that drain the Blackland Prairies. Most areas are in pasture or cultivated to crops such as cotton, corn, sorghums, or small grains. Native vegetation is elm, hackberry, oak, and ash, with an understory of grasses such as species of paspalums and panicums.

Present day vegetation includes floodplain herbaceous vegetation, riparian herbaceous vegetation, and mesquite shrubland. There are no known invasive species in Cottonwood Creek.

Management Objectives

- Data collection and record keeping
- Species surveys (following the Habitat Conservation Plan)
- Invasive species surveys
- Erosion problems
- Karst feature surveys
- Riparian zone protection
- Native habitat restoration
- Increase native species diversification and abundance
- Natural resource interpretation and education



SIDEWALK AT COTTONWOOD CREEK NATURAL AREA



OPEN SPACE AT COTTONWOOD CREEK NATURAL AREA

Table 3.3, Natural Area Management Recommendations, below, summarizes the recommended management strategies for each of the San Marcos Natural Areas, described in the previous pages.

TABLE 3.3, NATURAL AREA MANAGEMENT RECOMMENDATIONS

	Data Collection and Record Keeping	Protected Species Habitat Protection	Invasive Species Control	Riparian Zone Protection	Fire Hazard Mitigation
Spring Lake Natural Area	✓	✓	✓	✓	✓
Sessom Creek	✓		✓	✓	✓
Schulle Canyon	✓		✓		✓
Western Loop	✓	✓	✓		✓
Lower Purgatory Creek	✓	✓	✓		✓
Upper Purgatory Creek	✓	✓	✓		✓
Retreat on Willow Creek	✓		✓		
Blanco River Unit	✓		✓	✓	
Cottonwood Creek	✓			✓	

This page intentionally left blank.

Standards &
Management
Recommendations

4

INTRODUCTION

As described in the previous chapters, the natural areas have irreplaceable value in protecting the quality and quantity of water in the Edwards Aquifer and in the watershed of the pristine San Marcos River, as an open space greenbelt around the City, as a recreational amenity, and as habitat for native flora and fauna interwoven with an urban environment.

ADAPTIVE MANAGEMENT APPROACH

It is important to remember that the natural areas are dynamic landscapes. They are ever changing and may respond differently at different times to the same treatment. In addition, land management practices include processes that often take multiple steps over time where conditions may change mid-course. For that reason, all information in this plan should be viewed through an adaptive management lens.

Adaptive management is an iterative process which allows land managers to learn about sites over time, as circumstances change, and adjust methods accordingly. The management objectives herein incorporate and build upon the established best practices of the City, San Marcos Greenbelt Alliance, state agencies, and other entities.

As these guidelines are implemented in different areas, years, and circumstances, outcomes should be monitored and evaluated, and practices adjusted to make the most efficient use of resources and to increase their effectiveness in achieving the desired outcomes.

It is important to note that the use of adaptive management techniques will become even more important as the changing climate and its impacts (e.g., hotter, drier weather, prolonged droughts, increased intensity of storms, etc.) change the natural ecosystems of the San Marcos natural areas over time.

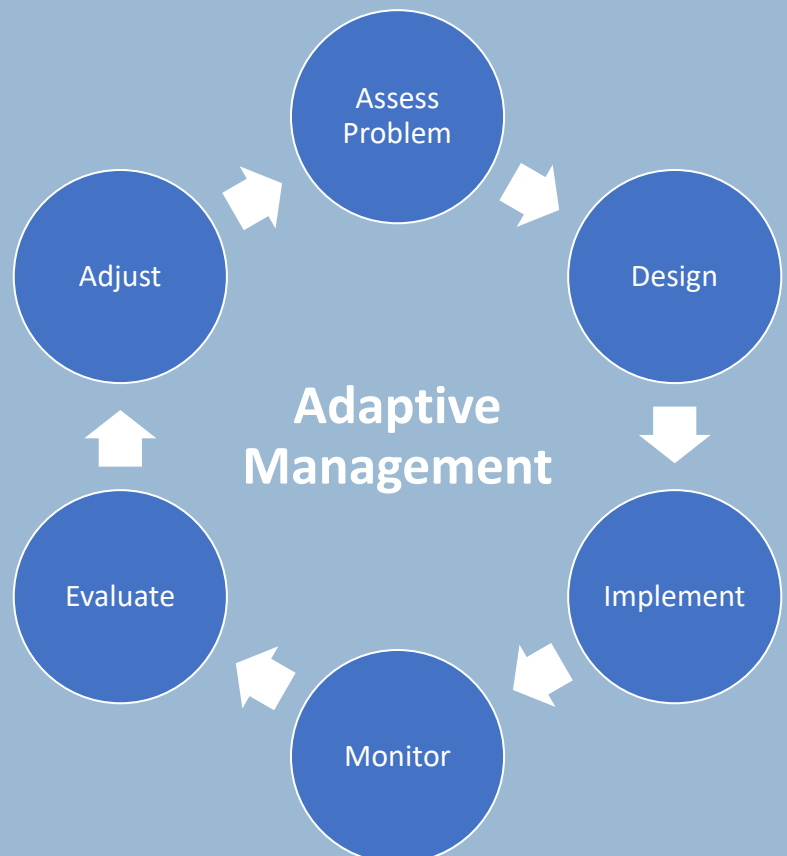
The foundation for developing the management objectives in this plan is the vision statement identified at the end of Chapter 2, and the following three overarching goals:

- Natural Resource Preservation;
- Natural Resource Management; and
- Use, Safety, and Connectivity.

WHAT IS ADAPTIVE MANAGEMENT?

Adaptive management can be broken into six general steps:

1. Assess the existing conditions; identify known problems; determine management goals
2. Design a land management plan that incorporates these goals
3. Implement the land management plan
4. Monitor the impact(s) of the land management plan
5. Evaluate the results of the monitoring process
6. Modify the plan as needed to respond to changing conditions, as identified through the monitoring and evaluation process



MANAGEMENT GOALS AND OBJECTIVES

To achieve these goals, a series of objectives has been developed to support each goal. These objectives include:

GOAL 1: NATURAL RESOURCE PRESERVATION

Objective 1.1 Habitat Preservation

- 1.1.1 Sensitive Habitat Preservation
- 1.1.2 Riparian Zone Protection
- 1.1.3 Climate Change Considerations

Objective 1.2 Edwards Aquifer Protection

- 1.2.1 TCEQ Edwards Aquifer Guidance

GOAL 2: NATURAL RESOURCE MANAGEMENT

Objective 2.1 Habitat Restoration and Stabilization

- 2.1.1 Revegetation
- 2.1.2 Erosion Control

Objective 2.2 Invasive Species Control

- 2.2.1 Invasive Species Management
- 2.2.2 Invasive Species Monitoring
- 2.2.3 Effective Treatment Methods for Management of Invasive Species

Objective 2.3 Fire Hazard Planning Guidance

- 2.3.1 Wildfire Hazard Assessment and Site Mapping
- 2.3.2 Prevention and Mitigation Measures

Objective 2.4 Fire Management

- 2.4.1 Fire Management Plans
- 2.4.2 Fire Breaks and Fuel Management
- 2.4.3 Prescribed Burn

Objective 2.5 General Land Management Best Practices

GOAL 3: USE, SAFETY, AND CONNECTIVITY

Objective 3.1 Safe and Accessible Trail Systems

- 3.1.1 Trail Counting
- 3.1.2 Basic Trail Design, Construction, and Maintenance Standards
- 3.1.3 Trail Materials
- 3.1.4 Trail Maintenance

Objective 3.2 User Safety and Education

- 3.2.1 Enforcement of Rules
- 3.2.2 Emergency Phones
- 3.2.3 Lighting
- 3.2.4 Emergency Access
- 3.2.5 Emergency Location Awareness
- 3.2.6 Trailhead Components and Signage
- 3.2.7 Wayfinding Signage

Objective 3.3 Trail Connectivity and Expansion

- 3.3.1 Complete the Loop and Check System
- 3.3.2 Connect to the Larger Region via the Great Springs Trail



WOODED AREA IN FUTURE NATURAL AREA

GOAL 1: NATURAL RESOURCE PRESERVATION

The establishment and implementation of natural resource preservation land management objectives are essential steps towards ensuring the long-term sustainability and conservation of the ecosystems in our precious natural areas. With the growing recognition of the fragile state of our ecosystems, these objectives form a foundation for responsible stewardship, protection and conservation of our natural resources for current and future generations.

The following management objectives address natural resource preservation.

- 1.1 Habitat Preservation
- 1.2 Edwards Aquifer Protection

OBJECTIVE 1.1 HABITAT PRESERVATION

Habitat preservation is an essential component of natural resource preservation efforts, recognizing the intrinsic value and interdependence of ecosystems and the species they support. By restoring native habitats that have been damaged or degraded, and by safeguarding these habitats from degradation and destruction, habitat preservation protects biodiversity, maintains ecological balance, and secures a sustainable future for both ecosystems and people.

The term “habitat” can often be understood in a narrow way, i.e., habitat consists of the plants, mammals, birds and reptiles we can see. In this plan, “habitat” has a more scientific meaning; it extends to things such as soil microbial biomass, fungi, and organic matter, all of which comprise and contribute to the health of the habitat. Importantly, the biodiversity this plan seeks to enhance extends to all aspects of the native habitats in the natural area.

OBJECTIVE 1.1.1 SENSITIVE HABITAT PRESERVATION

As set out in the introduction to the natural areas, the primary purposes of the San Marcos natural areas are natural resource preservation, protection of water quality and quantity in the Edwards Aquifer and the San Marcos River, and flood mitigation in the watersheds of the San Marcos and Blanco rivers. A secondary purpose for the natural areas is for passive recreational opportunities to promote human physical and mental health and to foster awareness of the importance of proper land conservation.

The natural areas vary in their environmental sensitivity. As identified on **Figure 4.1, Sensitive Lands by Natural Area**, orange and red are used to highlight the most environmentally sensitive areas in the natural areas. It is an important priority to ensure

that these sensitive areas be preserved and protected over time.

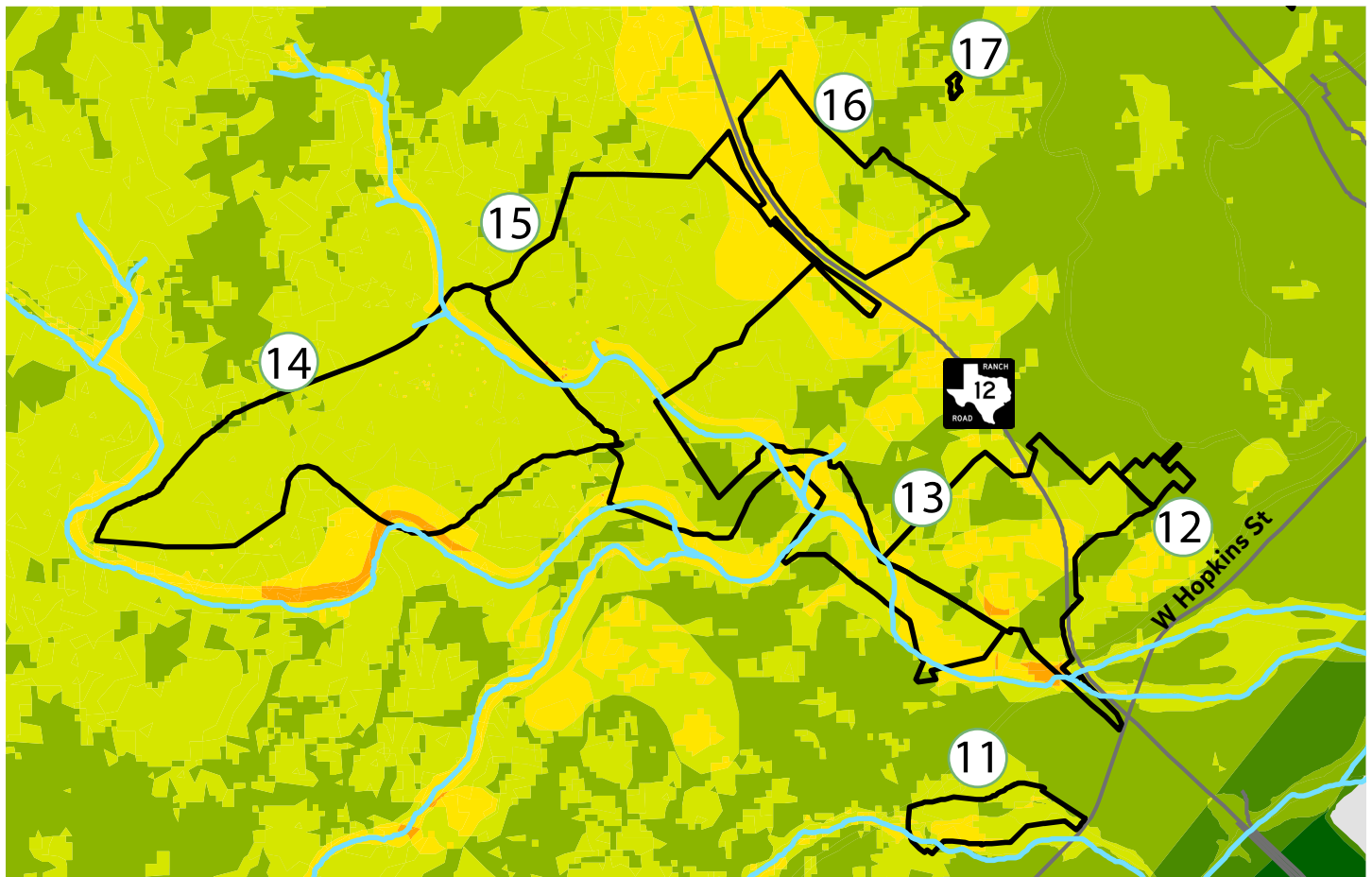
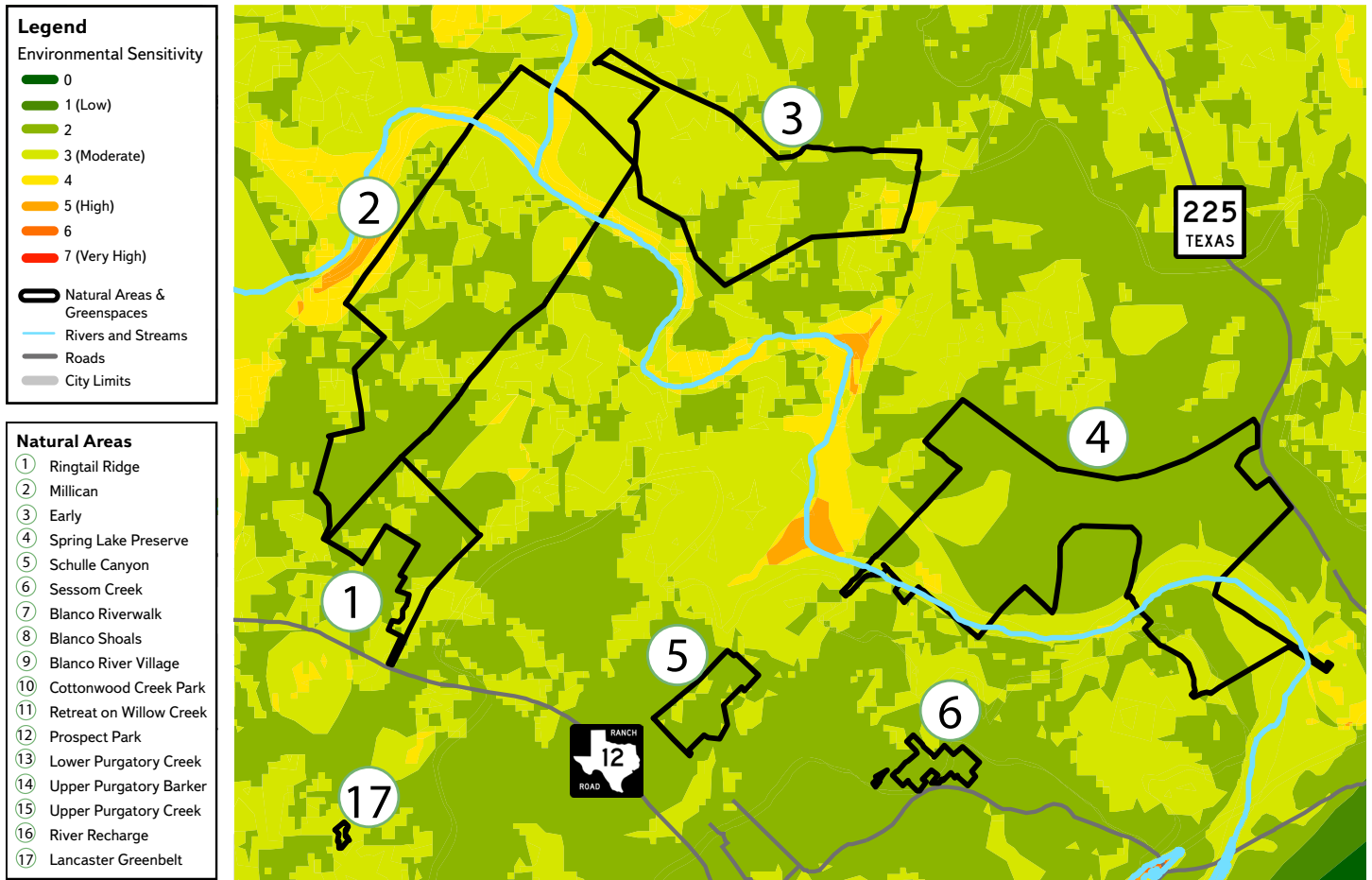
As identified on **Map 3.4, Aquatic Resources**, in **Chapter 3**, most of the natural areas northwest of Interstate 35 are located in one of the Edwards Aquifer protection zones (the recharge zone, contributing zone, and transition zone). Much of the guidance contained in the objectives of this land management plan will focus on preserving, enhancing, and maintaining lands located in the Edwards Aquifer protection zones.

The natural areas to the southeast of Interstate 35, are not in any of the Edwards Aquifer protection zones. However, these natural areas are no less important, since they reside in an area known as the Texas Blackland Prairie—one of the most endangered ecosystems in the U.S. According to the Texas Parks and Wildlife Department (TPWD), less than one percent of the original Blackland Prairie remains. Thinking towards the future, the natural areas to the southeast of Interstate 35 provide a unique opportunity to restore Blackland Prairie habitat. Plants such as little bluestem, big bluestem, indian grass, switch grass, and eastern gama grass can be planted to shade out Bermuda grass in select formal areas with a mix of Texas wildflowers for seasonal interest. The management of these particular areas will need to be a no mow area except for an annual clean up in winter. These areas should not impede recreation but help guide and enhance the user experience.

By continuing to preserve the natural areas and using habitat restoration practices to create more resilient native plant and animal communities, greater populations and biodiversity will occur in the natural areas.

In open areas, tall grass and wildflower plantings would provide cover and forage for resident,

FIGURE 4.1, SENSITIVE LANDS BY NATURAL AREAS



seasonal, and migratory birds. They would also provide habitat and food needed by native animals, including bees, butterflies, and other insects, amphibians, reptiles, and mammals. For example, some native bees nest in the ground, protected by the structure of native bunch grasses, and a small bed of native flowers in an area of full sun can attract dozens of butterfly species.

OBJECTIVE 1.1.2 RIPARIAN ZONE PROTECTION

Riparian zones are the transition space between creeks and rivers and the surrounding uplands. Healthy riparian zones contain a mix of trees, shrubs and understory that fully vegetate the area from the waterway edge to the upland vegetational community.

A robustly vegetated riparian zone benefits the landscape by slowing floodwater, reducing erosion, filtering and removing pollutants, providing habitat for aquatic and terrestrial organisms and lowering water temperature by providing shade to the waterway, all of which increases ecological resilience.

Map 4.1, Sensitive Land Areas, highlights the riparian zones located within the natural areas which need to be protected. Proper protection includes several components including providing proper

vegetative establishment, vegetative security, and debris management.

Proper Vegetative Establishment

Proper establishment of vegetation in riparian zones is essential, and there are different regiments for establishment depending on the type of ecosystem in which the natural area is located. A survey of existing successful native vegetation in a riparian area can be useful in species selection. A great resource on proper riparian zone establishment is the Austin Watershed Protection Department publication, **Riparian Template–Streamside Planting Guide (see Appendix)**. This guide includes a list of appropriate vegetative species for plantings in various riparian zones (see below), based upon whether the zone is located within the Edwards Plateau or Blackland Prairie ecosystem. It recommends that a three-tiered establishment framework be used consisting of groundcover, understory, and upper canopy plantings. It also recommends planting at increased densities so as to crowd out invasives.

Vegetative Security

Once proper establishment occurs, additional considerations are necessary to ensure that the riparian zone is allowed to reach its full potential. In this regard, a no-mow setback or grow zone



Mature Riparian Structure: Unique hydrologic conditions make different zones of the streamside suitable for distinct plant types. The soil in Zone 1 is always wet and frequently underwater. Zone 2 is underwater during most storm events but dries out afterwards. Zone 3 is a transitional area receiving its moisture from rainfall and large storm events.

should be established along creek banks to ensure that these areas remain healthy and effective for achieving their intended ecosystem benefits. In addition, periodic vegetation management must be conducted to remove or treat invasive and non-desirable vegetation and to seed native wildflowers and plants.

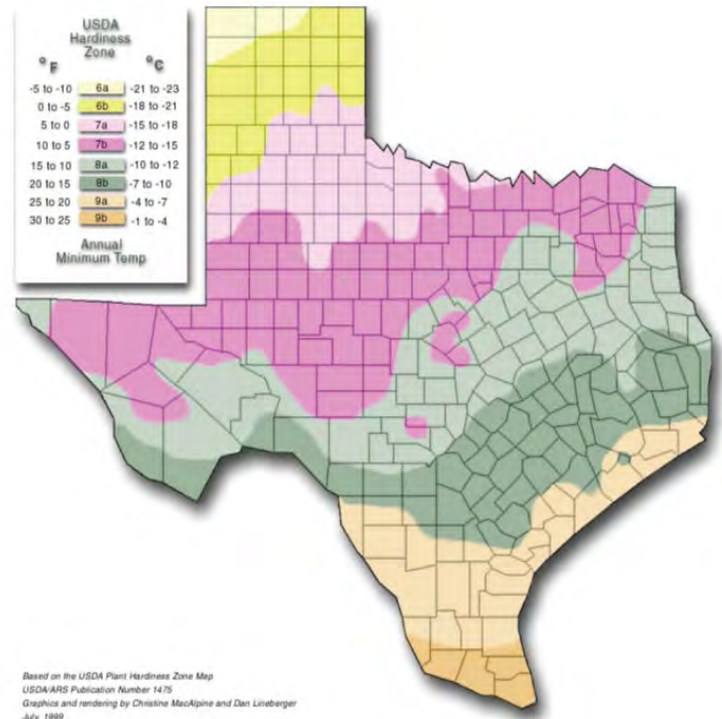
Debris Management

Additional attention should be given to ensuring that both live and dead plant materials are located in the riparian areas. Dead wood and plant material provides a substrate for fungi and improves soil health by recycling nutrients. Unless the dead wood is creating a hazard, it is recommended that it be left in place. Dead wood that is creating an obstruction to human movement can be relocated to the riparian zone. Woody debris in streams creates fish and microorganism habitat.

OBJECTIVE 1.1.3 CLIMATE CHANGE CONSIDERATIONS

Climate change is expected to have a profound impact on the migration patterns of plant and animal species which will affect the natural areas. As temperatures rise and weather patterns shift, many species will face challenges in their traditional habitats, forcing them to seek more suitable conditions.

In response to warming temperatures, plant species may gradually migrate toward higher latitudes or elevations to find cooler environments, potentially leading to shifts in vegetation zones. Similarly, animal species may alter their locations, migration routes

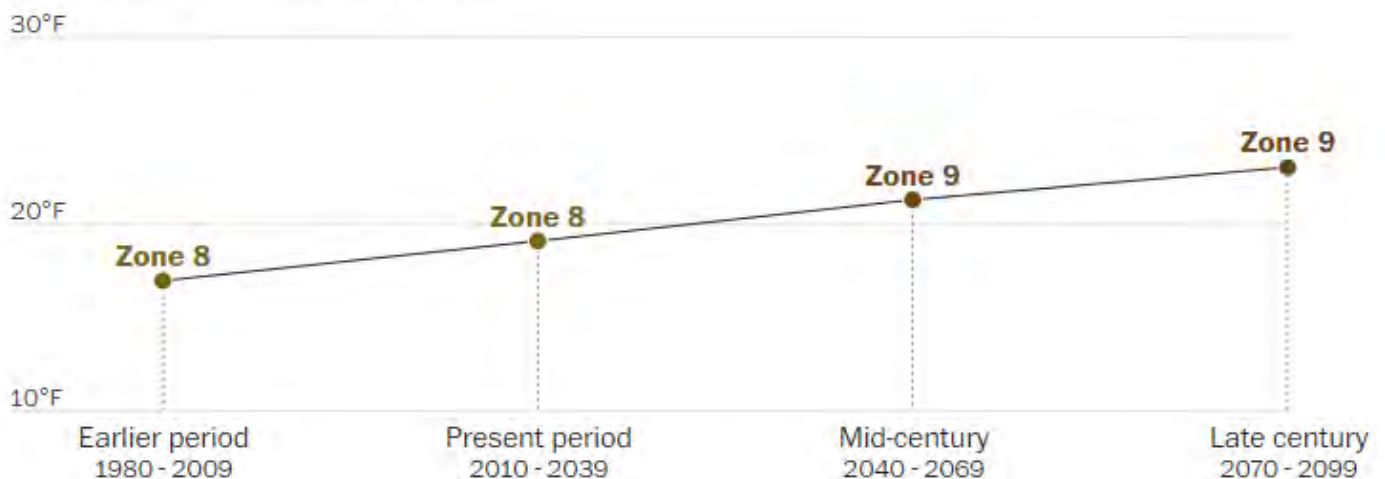


Source: <https://www.ufseeds.com/texas-vegetable-planting-calendar.html>

or timing to follow shifting patterns of temperature, precipitation, and availability of resources.

As these shifts occur, they will disrupt delicate ecological relationships and some species may be unable to adapt or find suitable alternative habitats. Furthermore, fragmented landscapes and human infrastructure can impede species' movements, limiting their ability to respond effectively to changing climatic conditions. These impediments have far-reaching implications for biodiversity, ecosystem

Average annual minimum temperature



Source: Washington Post: <https://www.washingtonpost.com/climate-environment/interactive/2023/tree-species-climate-change-north-shift/>

functioning, and the overall stability of ecosystems, highlighting the urgent need for proactive conservation and management strategies to support species adaptation and ensure the preservation of ecological integrity in the face of climate change.

For the San Marcos area, the climate researchers predict that the city and its surrounding areas will gradually shift between United States Department of Agriculture (USDA) hardiness zones—from Zone 8 to Zone 9—near mid-century.

Why is this important? Considering changes in USDA hardiness zones is essential for effective land management activities because these zones provide valuable information about the climatic conditions that influence the success and survival of plants. As climate change alters temperature and weather patterns, understanding the shifting hardiness zones helps inform decisions on suitable plant species selection, timing of planting or harvesting, and overall ecosystem resilience, ensuring that land management practices align with the changing climate to maintain healthy and productive ecosystems.

The effects of climate change on the ecosystems and land management activities in the San Marcos natural areas should be monitored and analyzed, and the adaptive management process should be used to make adjustments to management activities.

OBJECTIVE 1.2 EDWARDS AQUIFER PROTECTION

As set out in **Map 3.4, Aquatic Resources**, in **Chapter 3**, most of the San Marcos natural areas are located within Edwards Aquifer protection zones, with most of these areas being located in the recharge zone.

The recharge zone of the Edwards Aquifer is a highly faulted and fractured area where Edwards Limestones outcrop at the land surface, allowing large quantities of surface water to flow into the aquifer. The aquifer is the source of the San Marcos Springs—the second largest natural cluster of springs in Texas.

Protection of the Edwards Aquifer occurs through a variety of partners and regulatory agencies. The Edwards Aquifer Authority manages the Balcones Fault Zone segment of the Edwards Aquifer, extending from San Marcos south and west to Uvalde County, by regulating groundwater wells and pumping. Conservation groups such as the San Marcos River Foundation, The Nature Conservancy, and the Great Springs Project, and governmental entities such as the City of San Marcos, the City of San Antonio, and the Edwards Aquifer Authority have helped preserve thousands of acres of sensitive natural lands in the name of aquifer protection.

One of the primary regulatory agencies is the Texas Commission on Environmental Quality (TCEQ), as discussed in Objective 1.2.1 below. The City of San



FAULTED AND FRACTURED LIMESTONE CAVES AND OUTCROPS ALLOW LARGE QUANTITIES OF WATER TO FLOW INTO THE AQUIFER

Marcos has rules restricting land development in the Edwards Aquifer Recharge Zone, Contributing Zone, and Transition Zone that supplement the TCEQ regulations.

OBJECTIVE 1.2.1 TCEQ EDWARDS AQUIFER GUIDANCE

TCEQ, the state’s environmental agency, administers the Edwards Aquifer Protection Program to regulate activities that have the potential to pollute the Edwards Aquifer. An overview of TCEQ rules applied over the Edwards Aquifer can be found in the TCEQ document provided in the **Appendix**, titled **Rules Protecting the Edwards Aquifer Recharge, Contributing, and Transition Zones**.

Regulated activities, as defined in the rules, that occur over the recharge, transition, or contributing zones of the Edwards Aquifer require review and approval of an Edwards Aquifer Protection Plan (EAPP) by TCEQ in order to ensure steps are taken to maintain water quality in areas that impact the Edwards Aquifer. In certain circumstances, a modification request, exception, or extension to an EAPP may be granted by the executive director of the TCEQ. In general, exceptions from the EAPP requirement can be considered for activities such as:

- an activity that does not involve construction but does include soil disturbance and stabilization.
- an activity on a developed site that results in a negligible increase in impervious cover.

Projects in the natural areas that are in the protected zones, and which are not exceptions, require the development of an EAPP, reviewed and approved by TCEQ. Depending on the type and location of the regulated activity, and EAPP may include a water pollution abatement plan or a contributing zone plan.

The Edwards Aquifer Protection Program staff conducts an administrative review and a technical review of all applications for EAPP approval. The turnaround time for administrative review, to determine the completeness of applications, can be up to 30 days. The turnaround time for technical review of an administratively complete EAPP application is 90 days.

The San Marcos natural areas which are subject to TCEQ EAPP rules are included in **Table 4.1, Natural Area Regulation Applicability**.

**TABLE 4.1
NATURAL AREA REGULATION APPLICABILITY**

Natural Area	TCEQ Restrictions	Dedicated Parkland
Upper Purgatory Creek	Yes	Yes
Lower Purgatory Creek	Yes	Yes
Ringtail Ridge	Yes	Yes
Prospect Park	Yes	Yes
River Recharge (Buie)	Yes	Yes
Retreat at Willow Creek	Yes	Yes
Blanco River Village	No	Yes
Blanco River Walk	No	Yes
Blanco Shoals	No	Yes
Cottonwood Creek	No	Yes
Cottonwood Crossing	No	Yes
Spring Lake	Yes	Yes
Early Tract ¹	Yes	Community Forest
Millican Tract ²	Yes	Water Conservation Land
Schulle Canyon	Yes	Yes
Sessom Creek	Yes	Yes
Lancaster Greenbelt	Yes	Yes
Notes:		
¹ Community Forest - education and bike/pedestrian uses.		
² Trail easement only due to water quality use status. Bike/pedestrian use only.		

GOAL 2: NATURAL RESOURCE MANAGEMENT

The establishment and implementation of natural resource management objectives within the San Marcos natural areas is essential to accomplishing the City's goal of appropriate management of the natural resources in the natural areas.

The following management objectives address natural resource management in the natural areas:

- Objective 2.1 Habitat Restoration and Stabilization
- Objective 2.2 Invasive Species Control
- Objective 2.3 Fire Hazard Planning Guidance
- Objective 2.4 Fire Management
- Objective 2.5 General Land Management Best Practices

In the course of establishing and implementing natural resource management activities in the natural areas, it is important to note that the City may be subject to restrictions, covenants and obligations regarding specific tracts of land in the natural areas. These may be included in the City's title to a tract of land, or in a conservation easement or similar document that applies to a tract of land, or in documents tied to sources of funding for acquisition of a tract of land. The City's land managers should be familiar with these restrictions, covenants and obligations to ensure that they are complied with in connection with management activities under this plan.

OBJECTIVE 2.1 HABITAT RESTORATION AND STABILIZATION

Native habitats change over time, even without humans playing a part in the changes. Plants and animals adapt and evolve alongside one another. Soil erosion occurs, along with the deposit of sediments. Karst formations gradually weather, and caves, sinkholes, flow conduits, and springs form. In the Edwards Plateau region, the suppression of fires since the 1850s has resulted in a rapid transition of the native habitat from a savanna grassland dominated by herbaceous plants, with trees along riparian area, to one in which woody plants and tree cover now dominate. In addition, ranching activities at times have resulted in degradation of native habitats.

Revegetation and stabilization are key strategies for restoring and enhancing degraded or disturbed habitats. These practices help to mitigate soil erosion, improve water quality and quantity, and promote biological diversity and resilience.

Revegetation involves the intentional planting of native vegetation. Stabilization measures include the establishment of erosion control measures and the use of erosion-resistant plant species.

By prioritizing habitat restoration through revegetation and stabilization as an integral component of the City's management objectives for the natural areas, the productivity, ecological value, and long-term sustainability of the natural areas can be enhanced.

The City of Austin Water Quality Protection Lands, managed by the Wildlands Conservation Division of the Austin Water Utility, is an example of an ongoing program of native habitat restoration through revegetation and stabilization. The 2010 report, "Recommended Land Management for the Water Quality Protection Lands" (WQPL Plan) prepared by the Lady Bird Johnson Wildflower Center, is a comprehensive resource on this topic.

OBJECTIVE 2.1.1 REVEGETATION

Revegetation is an important strategy to rehabilitate habitat areas that have been degraded by development, improper management, fire suppression, or other causes. Restoring native vegetation within the San Marcos natural areas can require many different types and scales of revegetation. It is widely known that the best management technique for optimizing water quality and quantity is to move towards the grassland or savanna conditions that were historically prevalent in the Central Texas region. Numerous portions of the natural areas are suitable for this type of restoration, although large, stable oak/juniper woodlands would need long-term management to prevent them from expanding and allow grassland restoration. The City may wish to consider as a management objective an ongoing habitat restoration program that gradually restores grassland and savanna habitat. To focus efforts for revegetation projects, the following four questions should be asked.

1. **What are the project goals?** The goals of the revegetation project may include water quality and quantity enhancement, eradication of invasive plants, erosion control, and/or wildlife habitat establishment. Determine the project goals and plan revegetation accordingly.
2. **What is the project size and location?** It is easier and less expensive to accomplish successful revegetation on smaller sites than on larger ones. Project location will determine accessibility, proximity to adjacent landowners, and other constraints.
3. **What are the project issues?** While planning the project, determine the issues likely to be encountered. For example, is the project associated with other activities such as trail construction, erosion stabilization, or prescribed burn? Are there any permit requirements that apply? Are there procurement or contracting procedures that will apply?
4. **What is the best time for the project?** Determine the best time to implement the revegetation project. Consider that it is often best to seed and plant in the fall.

When undertaking revegetation in natural areas, several best practices should be followed to ensure successful restoration and minimize potential negative impacts. These practices include:

- **Native Species Selection.** Use locally adapted and native plant species that are well-suited to the specific site conditions and ecological requirements of the natural area. These species have co-evolved with the local environment and are more likely to establish and thrive.

Rehabilitation, Restoration, and Reclamation

Although habitat restoration efforts have common elements, each area is unique. Work must be guided by site-specific considerations and analysis. However, some generalizations can be made. When soil is disturbed, and especially if it is bare, it must be revegetated with appropriate species to prevent soil loss. The WQPL Plan is an excellent source of information on all aspects of habitat restoration and revegetation in an area that is similar to the San Marcos natural areas. Below is a discussion of some of the factors to consider in a restoration project, followed by a generalized protocol for rapid revegetation of an upland site.

The goal of habitat restoration is to restore ecosystem processes, not simply to replace components. Ecosystem processes allow native habitats to repair themselves and to remain relatively stable.

In practice, the assessment and repair of ecosystem processes begin with the soil. In the course of habitat restoration activities, the soil may be disturbed and left bare and in need of protection against erosion. In some cases, compaction reduction (avoiding work in wet areas, restricting vehicle, equipment, and pedestrian use) and soil additions and amendments may be needed to restore soil. In all cases, existing soil should be protected. Revegetation with appropriate native species provides ongoing protection, but in some cases temporary soil protection measures such as mulch may be needed before a site can be revegetated.



VEGETATED AREA WITHIN NATURAL AREA

Generalized Revegetation Protocol

- Address soil disturbance. Compacted soils may need to be loosened as appropriate prior to seeding.
 - Bare soil areas should be planted, seeded or otherwise stabilized within 15 calendar days of disturbance. Use of other erosion control methods may be necessary on moderate to steep slopes, and areas with more erosive soils.
 - Appropriate native plant material should be added as seed, live plantings, or a combination. Plants vary as to climatic adaptability, soil chemistry, and plant growth characteristics. The WQPL Plan is an authoritative source on seed and plant selection. USDA Soil Service technical guides at the statewide level are also sources of information for seeding mixtures and planting prescriptions. The U.S. Forest Service, Texas Forest Service Service, and county extension agents can also provide helpful suggestions. In addition to selecting a seeding mixture, the seeding rate should be determined so that adequate soil protection can be achieved without overseeding.
- In riparian areas, special consideration should be given to species' contributions to bank stability and water quality. Many species found in central and southwest Texas have been given stability ratings based on their contribution to bank stability, ranging from 1 (bare ground) to 10 (anchored rock). Ideally, riparian areas will be dominated by plants with stability ratings between 6 and 9. Stability ratings of 7 or higher are considered to be the minimum for acceptable bank stability. However, combinations of species, particularly woody species in association with grasses or sedges, can provide higher stabilities than reflected in individual species ratings. In addition to stability ratings, US Fish and Wildlife Service wetland indicator status should be considered. Riparian areas should contain a mix of obligate wetland (always occurs in wet areas), facultative wetland (frequently occur in wet areas) and facultative species (equally likely to occur in wet and non-wet areas), dependent on water availability. Perennial waterways can support a larger complement of obligate and facultative wetland species and ephemeral waterways will require a higher proportion of facultative species. Regardless of the mix, it is important that all riparian areas contain some species from the facultative groups to provide stability as water availability and flow levels fluctuate.



HABITAT RESTORATION EFFORT FOR A NATIVE PRAIRIE IN SCHULLE CANYON NATURAL AREA

- On steep slopes, consider incorporating native woody plants planted in rows, cordons or wattles, and consider other erosion control methods as well.
- Seed during optimum periods for establishment, preferably just prior to spring or fall rains. Most forbs must be sown in the fall; grasses can be sown in either the spring or fall. Supplemental irrigation, if feasible, during the establishment phase will increase germination and establishment. During non-growing seasons, apply appropriate temporary erosion control methods.
- Mulch as needed to hold seed, retard rainfall impact, and preserve soil moisture.
- Amend soil according to site specific conditions and the needs of the plants that will be used.
- Protect planted and seeded areas from grazing and vehicle damage until plants are well established.
- Inspect all planted and seeded areas for failures and make necessary adjustments.

- **Site Preparation.** Prepare the site appropriately by removing invasive species, proactively controlling erosion, and improving soil conditions if necessary. Consider employing methods such as prescribed burns or manual removal to create favorable conditions for the establishment of native vegetation.
- **Seed Collection and Propagation.** Collect or purchase seeds or plant material from nearby native populations within the same ecological region. Use ethical and sustainable collection practices and consider partnering with local seed banks or nurseries for propagation and sourcing of native plant materials.

Be aware that depending on the level of soil disturbance, a TCEQ EAPP may be required.

OBJECTIVE 2.1.2 EROSION CONTROL

Erosion control practices are an important maintenance component of natural area management and may also be an important aspect of post-fire rehabilitation in natural areas. Natural areas may include sites with steep, erosion-prone slopes. Erosion is typically caused by improper ranching, development or construction practices (historic and present-day) and improper recreational use practices. Wind and rain and natural disturbances such as flooding and wildfire can also lead to soil erosion problems.



EXAMPLES OF TRAIL EROSION IN PUBLIC USE AREAS AND WHERE “USER CREATED” TRAILS LACK DESIGN CONSIDERATIONS WHICH SHED WATER

All natural area construction activities that involve significant soil disturbance should implement erosion control practices. Recreation-related erosion problems can occur with trails that are poorly designed or maintained, and with use of unauthorized trails.

Proper use of erosion control practices can help with the following:

- Conserve soil moisture
- Moderate soil temperature
- Prevent erosion
- Improve water filtration
- Prevent soil compaction
- Rebuild organics in soil
- Improve nutrient retention

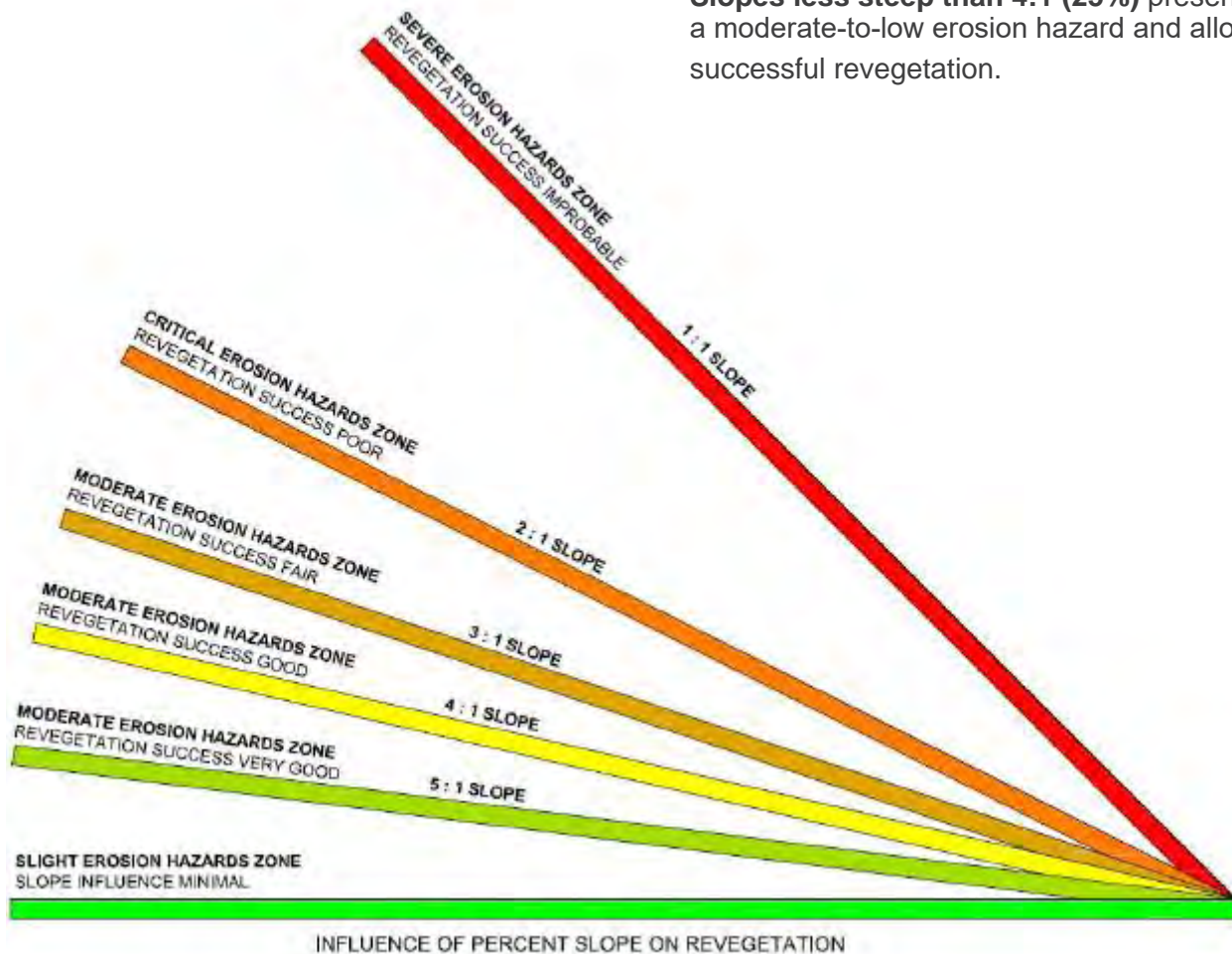
Identifying Erosion Problem Areas

Erosion problems should be identified during annual site inspections. Examples of soil erosion indicators include bare rock or soil, rills, and gullies.

The Influence of Slope on Erosion

The limiting criteria for erosion control in site design is slope steepness. Steeper slopes are prone to greater soil erosion and reduced vegetative stabilization.

- **Slopes 2:1 (50%) and greater** are very difficult to revegetate and present severe soil erosion problems. Disturbance of these steep slopes should be avoided, and project designs should not include 2:1 slopes.
- **Slopes 3:1 (33.5%)** present a moderate-to-high erosion hazard and generally allow fairly successful revegetation, although these slopes should also be avoided. If it is necessary to build on these slopes, additional erosion-control measures need to be included in design and construction to reduce soil erosion problems (e.g., berms, swales, water bars, mulch, silt fence).
- **Slopes 4:1 (25%)** present a moderate erosion hazard but allow successful revegetation.
- **Slopes less steep than 4:1 (25%)** present a moderate-to-low erosion hazard and allow successful revegetation.



INFLUENCE OF PERCENT SLOPE ON REVEGETATION

Source: Salt Lake County Natural Areas Land Management Plan Standards and Operations

Erosion Control Practices

A variety of erosion control practices are used to reduce erosion problems. These practices include the following:

- site grading and vegetative stabilization
- erosion control materials
- bank stabilization
- silt fences
- dikes, berms, and swales

Each of these erosion control practices is described in detail on the following pages.

Site Grading and Vegetative Stabilization

Site grading, conducted during project construction, is the movement of the landscape and soil to form natural slope contours. Vegetative stabilization is the process of establishing vegetation on a site to prevent soil erosion. One of the most effective means of erosion control is appropriate site grading that reduces soil erosion and enhances vegetation establishment.

Erosion Control Materials

All construction and revegetation areas should be covered with erosion control materials immediately after construction, planting, or seeding to reduce soil erosion and provide favorable conditions for establishment of vegetation. Many types of erosion control materials can be used which are appropriate for natural areas. The selected erosion control material should be chosen based upon criteria such as project size, slope steepness, material availability, and project budget.

- **Natural Fiber Products.** Natural fiber erosion control products, such as jute or coir mats, are biodegradable and provide temporary stabilization for slopes and channels. They help reduce soil erosion by promoting the establishment of vegetation while gradually decomposing over time.
- **Mulch.** Organic mulch, such as straw or wood chips, can be applied to bare soil areas to protect against erosion caused by raindrop impact and runoff. Mulch helps retain moisture, stabilize soil temperatures, and prevent the formation of surface crusts.
- **Erosion Control Blankets or Mats.** Erosion control blankets made from biodegradable materials, such as straw or coconut fibers, are used to provide immediate stabilization to slopes

and disturbed areas. These blankets aid in soil moisture retention, prevent erosion, and facilitate seed germination.

- **Geotextiles.** Geotextiles are synthetic materials designed to provide erosion control and stabilization. They can be used in areas with high flow velocities or where permanent stabilization is required. Biodegradable geotextiles are preferable for natural areas to minimize long-term environmental impacts.
- **Live Fascines.** Live fascines are bundles of live cuttings, typically from willow or other native woody species, that are strategically placed along slopes or streambanks. They help stabilize the soil, provide erosion control, and promote vegetation growth through their ability to root and grow.
- **Grid Pavers.** Permeable grid pavers like Truegrid provide erosion control in areas with low to moderate flow velocity. They are useful along trails and driveway and parking areas.
- **Rock and Stone.** In certain situations, strategically placed rocks or stones can be used as erosion control measures. They help dissipate water energy and prevent soil erosion in areas susceptible to high flow velocities, such as streambanks or drainage channels.
- **Additional Materials** are identified in the TCEQ Complying with Edwards Aquifer Rules—Technical Guidance on Best Practices, revised July 2005 with later updated errata and addendum sheets.

It is important to consider the specific characteristics of the site, including soil type, slope gradient, and hydrological conditions, when selecting erosion control materials. Prioritizing the use of natural and biodegradable materials minimizes long-term environmental impacts and ensures compatibility with the ecological processes of the area.

Bank Stabilization

Bank stabilization may be necessary to control erosion and stabilize slopes on steep hillsides and streambanks. Traditional methods include riprap, gabion structures, and retaining walls. An alternative approach is bioengineering, in which live plants are combined with either organic or inorganic materials to create erosion controls. When selecting from the available methods, preference should be given to methods that involve the use of existing materials on-site and natural materials.

Bioengineering advantages include long-term cost effectiveness, greater aesthetic appeal, and increased wildlife habitat. Some disadvantages include high initial labor costs and training, unfamiliarity with design practices and techniques, and limitations of available vegetative material and seasonal installation. A brief explanation of various bank stabilization practices follows.

- **Riprap.** Riprap is a layer of large stones and boulders placed over an eroding bank to protect the bank from the force of moving water. Riprap structures need to be designed by a professional civil engineer.
- **Gabions.** Gabions are wire mesh cages filled with stones and placed as building blocks at eroding banks. They protect the bank from the force of moving water. Gabion structures need to be designed by a professional civil engineer.
- **Wattles.** Wattles are used to control surface erosion by breaking long slopes into shorter slopes. They are made of bound bundles of brush stems. The bundles are placed in shallow trenches, staked to the soil surface perpendicular to the slope, and backfilled until only the top of the bundle is exposed. This technique can be used for hillslope restoration, road embankments, wide gullies, and slump areas.
- **Live Stakes.** These are poles and sprigs collected from riparian willows and cottonwoods and planted in saturated streambank soils. This method provides streambank erosion control.
- **Brush Layering.** This method is used to restore slopes and streambanks by constructing a fill slope with live branches and soils, thereby creating a series of reinforced benches. Large quantities of dormant willow branches can be used, and the area is backfilled with saturated soil.
- **Prevegetated Mats.** Commercially grown prevegetated mats are available for streambank revegetation. They typically come in 4-foot by 8-foot sections. They are placed upon saturated soils, typically at the end of spring runoff. The mats quickly root into the soil and provide effective erosion control. The cost for this product is high.
- **Vegetated Riprap.** Soil and live stems of willows and cottonwoods are placed in pockets in the riprap structures. The plants must be placed deep enough to penetrate soil underneath the riprap and into the bank.



RIPRAP EXAMPLE



LIVE STAKES EXAMPLE

- **Vegetated Gabions.** Willow and cottonwoods are placed into and between gabions to provide streambank erosion control that combines structures and vegetation. The vegetation must penetrate soil underneath the gabion structure.
- **Logs.** Logs from invasive species removal, wildfire hazard mitigation, and trail construction can be laid along slopes to reduce erosion. The crowns of trees can be mulched and spread on the logs after they are laid. This technique has been used effectively in Sessom Creek Natural Area and Schulle Canyon Natural Area. Where mulching is not possible or economic, the crowns can be reduced by lopping and inserted between the logs. In addition, composting can be encouraged by inoculating the logs with fungi. The City of Austin Balcones Canyonlands Preserve has studied this technique and found that selective introduction of wood-destroying fungi can be used to accelerate decomposition of the debris.

Silt Fences

Silt fencing is a temporary erosion control device that traps sediment during and after project construction. It is constructed of a geotextile fabric and vertical posts. Placed at the base of fill slopes and at down-slope edges of construction sites, silt fences trap eroding soil, keeping it on site and thus protecting water resources. It is designed to be used in areas of sheet flow and very shallow flow, not in large drainage ways. Silt fencing should not be used in root areas of the trees that are to be preserved.

- Install silt fencing properly to successfully control erosion.
- Place silt fencing in the appropriate area to effectively trap sediment.



GABIONS EXAMPLE

- Install silt fencing and vertical posts to withstand pressure from flowing water and sediment buildup.
- Purchase and install the fabric in a continuous roll to minimize gaps.
- Place silt fence at the bottom of drainage area, perpendicular to the slope.
- Place silt fencing fabric into an 8-inch trench and backfill the trench.
- Place vertical posts a maximum of 10 feet apart. Place posts closer together in expected areas of high stress and sediment accumulation.
- Monitor the performance of silt fencing and make adjustments as needed to ensure effectiveness.

Dikes, Berms, and Swales

Dikes and berms are ridges of soil or other material used to direct or contain flows on construction sites. Swales are often used in combination with dikes to divert water off of slopes and into sediment traps or away from highly erodible soils. These components can be either temporary or long-term erosion control devices.

- A strawbale dike is a temporary erosion control that can be removed when an area has been successfully revegetated.
- Berms are typically a long-term erosion control that are designed into a site grading plan.
- Swales can be lined with rock or vegetation to low water flow and reduce erosion. Swales are typically a long-term erosion control designed into a site plan. Swale sizes vary depending upon the size of the drainage area and expected runoff rates.

OBJECTIVE 2.2 INVASIVE SPECIES CONTROL

Invasive species control plays a vital role in natural resource management as it is essential for maintaining the health and integrity of the ecosystems in the natural areas. Invasive species can outcompete native plants, disrupt ecological processes, and degrade habitat quality, leading to the loss of biodiversity and reduced ecosystem resilience.

Implementing effective control measures can prevent the introduction, establishment, and spread of invasive species, and can remove existing invasive species and restore native species in their place.

What are Invasive Species?

The National Invasive Species Council defines **Invasive Species** as:

“SPECIES THAT ARE NONNATIVE (OR ALIEN) TO THE ECOSYSTEM UNDER CONSIDERATION AND WHOSE INTRODUCTION CAUSES OR IS LIKELY TO CAUSE ECONOMIC OR ENVIRONMENTAL HARM OR HARM TO HUMAN HEALTH.”

A “nonnative,” or “alien,” species is one that has been introduced into an ecosystem in which it did not previously occur. Introductions occur along a variety of pathways, or vectors, such as through commercial trade of a species or by accidental means. Invasive species can be plants, animals and other organisms (e.g., fungi, insects, etc.).

An invasive species can reproduce and spread rapidly, and can outcompete native species. Invasive species can decrease biodiversity by displacing native plants and animals. The focus, however, of this Objective 2.2 is plant invasive species.

The definition of invasive species used here has two components:

1. Nonnative status; and
2. The causing of economic or environmental harm, harm to human health, or the ability or potential to cause such harm.

Examples of invasive species found in the San Marcos area are shown on the next page. It is important to note that not all nonnative species are considered invasive because many do not, or are not likely to, cause economic or environmental harm or harm to human health. While native species are

preferred and should be prioritized for the natural areas, non-native species are not necessarily bad for the ecosystem, so long as they do not have a measurable negative impact. Some can even be beneficial to the environment, such as Mexican butterfly weed which provides food and habitat for monarchs. In instances where nonnative species do not have a measurable negative impact, the fiscal and physical resources needed to remove the species may not be reasonable.

Conversely, in some situations native species can cause economic or environmental harm or harm to human health. Examples include the economic impact of mesquite (*Prosopis glandulosa* var. *glandulosa*) spreading through a Texas rangeland, Ashe juniper (*Juniperus ashei*) altering the hydrology of the Hill Country, or a painful rash caused by poison ivy (*Toxicodendron radicans*). While all these species can cause problems, and do require management, they are not considered invasive because they are native to the area.

Though the focus of this Objective 2.2 is plant invasive species, invasive animal species can present a problem and the Parks Department should be equipped to respond to invasive fauna.

Why are Invasive Species a Problem?

Invasive species can cause both ecological and economic harm to native ecosystems, including:

- **Soil Health.** Invasive plants can cause detrimental impacts on soil chemistry and structure, soil nutrient pools, and nutrient cycling, and they can introduce pathogens.
- **Tree Cover.** Invasive tree and shrub species can cause significant problems to communities by dominating forest canopies, and interfering with successional patterns.

More specifically, in conditions where invasive trees dominate canopy cover, the native woodland community can be adversely affected. For example, Texas red oak (*Quercus buckleyi*) becomes light-limited when ambient light transmission is less than 40%. The endangered Golden-Cheeked Warbler (*Dendroica chrysoparia*) requires diverse juniper-oak woodland. Below 40% light transmission, red oak regeneration declines and, over time, golden-cheeked warbler habitat is degraded.

- **Displacement of natives.** Invasive plants of all types displace native species.

COMMON INVASIVE PLANTS IN CENTRAL TEXAS



CHINESE TALLOW



CHINESE PRIVET



CAT CLAW VINE



JAPANESE HONEYSUCKLE



HEAVENLY BAMBOO



PURPLE LANTANA



CHINABERRY TREE



YELLOW STAR THISTLE



GOLDEN BAMBOO



KING RANCH (KR) BLUESTEM



TREE-OF-HEAVEN



ELEPHANT EARS



GIANT REED



GLOSSY (JAPANESE) PRIVET



HYDRILLA

- **Hydrology and Water Yield.** Vegetation types differ in rates of evapotranspiration, rainfall interception, surface flow, and ability to access water. Invasive plant species can alter hydrological regimes and lower water tables.

How Do Invasive Plants Get Here?

When an invasive species is transported to a new ecosystem, it is considered “introduced.” Invasive species are introduced through a variety of different mechanisms (e.g., introduced as garden ornamentals, range forage plants for livestock, plants used for erosion control or as biocontrol agents, exotic pests which escape to the wild, etc.).

Once introduced, invasive species can be transported to and through natural areas through various mechanisms, including natural dispersal by wind, water currents, animal movement, or through human activities such as attachment to clothing, gear, or vehicles, or agricultural, ranching, or gardening or landscaping activities.

OBJECTIVE 2.2.1 INVASIVE SPECIES MANAGEMENT

Managing invasive species is a process with multiple steps. After an initial treatment is made, a second treatment may be needed. Determination of treatment practices and application methods should take into consideration the situation, location, and surrounding vegetation, with adjustments made as needed to accommodate special circumstances.

Preventing Introduction

Often the most cost-effective approach to managing invasive species is to keep them from being introduced in the first place.

Preventing the introduction of invasive species into the natural areas will require proactive management measures such as:

- Raising public awareness of the problems caused by the introduction of invasive species.
- Strict protocols for cleaning and inspecting vehicles, gear, and plants at entry points.
- Cooperation with adjacent landowners and nearby farmers, ranchers, nurseries, and landscape workers to prevent introductions.
- Educating local nurseries and landscaping firms about invasive species and encouraging them to stock and use native rather than invasive species.
- Soil disturbance should be limited.
- Recently exposed or disturbed areas should be quickly revegetated with native species.
- When feasible, seeds used in restoration projects should be collected near the area to be restored and should be free of seeds of undesirable species.
- Managers should be careful of introducing invasive plant seeds in purchased soils and other materials for projects such as trail maintenance, erosion control or landscaping. Equipment should be



One invasive species that can be carried on shoes by humans in the Texas Hill Country is the Cheatgrass.

Cheatgrass is an invasive species that has been spreading across the western United States for over a century. It is a grass that grows in dense mats and can quickly take over an area, crowding out native plants and reducing biodiversity.

Cheatgrass is often spread by humans on their shoes or clothing, making it difficult to control its spread

cleaned before bringing into a natural area to prevent bringing in seeds of problem species.

- Managers should monitor areas during and after work has been done to ensure that problem seeds were not introduced. Follow-up monitoring may need to continue for several years.
- Managers should give control efforts along roads and utility corridors high priority, as they can provide a conduit for introduction of invasive seeds as well as a favorable growing environment for invasive species.
- When new construction or invasive removal is performed, soil disturbance should be minimized and disturbed areas should be revegetated with native species, monitored for invasives recurrence, and invasives treated as necessary, following an integrated pest management process. Stockpiled soil should be protected from invasive seed. A simple way to accomplish this is by covering the pile with mulch.
- Departments should develop and periodically update a “watchlist” of species to be on alert for. Land management staff should be trained to recognize highly invasive plants such as buffelgrass and ligustrum.
- Managers should monitor for the introduction and spread of invasive species.
- Monitor burn pile areas for new seedlings.
- Managers should develop methods to avoid spreading nonnative plants to other areas especially when conducting active removal of invasive species and when conducting work along utility corridors. Special attention and procedures should be applied to cleaning boots, hand tools, construction and maintenance machinery.
- Managers should use care when using so-called “native” seed mixes which may contain nonnative and invasive species. Managers should always verify the species composition of seed mixes before purchasing.

Project Planning

When invasive species have been introduced or have become established, control methods will be needed. The first step to using invasive species control methods is to have a plan in place. The plan should be based on the principles, practices, and methods described in this Objective 2.2.1. In preparing plans, land managers should bear in mind that eradication and rehabilitation programs for some invasive species may require several years of treatments, followed by several years of monitoring.

Early Detection and Rapid Response

Early Detection and Rapid Response (EDRR) is a coordinated set of actions to find and eradicate invasive species in a specific location at an initial stage, before they can spread and cause harm. Once a species becomes widely established, control efforts can become costly and eradication may not be likely. Therefore EDRR efforts increase the likelihood that invasive species will be halted and eradicated. EDRR includes monitoring habitats to discover new species soon after introduction, reporting sightings of previously unknown species in an area, and working quickly to keep the species from becoming established and spreading. EDRR success depends on active monitoring and reporting, prompt confirmation by knowledgeable personnel, and quick formulation and execution of a treatment plan.

The establishment of an EDRR team could be undertaken by city staff and volunteer members of the SMGA.

Validation

Several resources in the Central Texas area are available to assist city staff and volunteers with plant identification:

1. The University of Texas Plant Resource Center
2. Texas Parks and Wildlife Department State Botanist
3. The Nature Conservancy of Texas Botanists
4. The Lady Bird Johnson Wildflower Center

Restoration and Rehabilitation

In some cases, once invasive species are removed, native communities can recover without further intervention, provided best management practices prevent re-invasion. However, in cases of severe invasive species degradation, active restoration is required.

Although restoration efforts have common elements, each area is unique. Work must be guided by site-specific considerations and analysis. However, some generalizations can be made. When soil is disturbed, and especially if it is left bare, it must be revegetated with appropriate species to prevent soil loss and reinvasion.

The goal of restoration is to restore ecosystem process, not simply to replace components. Ecosystem processes allow natural systems to repair themselves and to remain relatively stable. In practice, the assessment and repair of natural

processes begins with the soil. In the process of treating and removing invasive species, the soil may be disturbed and left bare. In some cases, compaction reduction activities and organic soil amendments may be needed to restore soil health.

Soil disturbance should be addressed, and the area should be revegetated with appropriate native species as soon as possible. When immediate revegetation is not possible, temporary soil protection measures such as mulch may be needed. However, it should be noted that mulch can suppress seed germination, which can complicate later revegetation efforts.

Standardization of Operating Procedures

In order to streamline detection, treatment, and monitoring activities, it is recommended that a set of minimum standards for control, monitoring, and training be established. Standard operating procedures are recommended for the following:

- **Herbicide/Pesticide Use.** Particular care must be taken regarding herbicide and pesticide use, especially in sensitive areas. Applications should comply with state and federal requirements at a minimum. The **Pesticide Applicator Record** form found in the **Appendix** should be used for each application.

Prioritization of Projects

Invasive species management projects should be prioritized based on the following factors:

- The site's restoration potential, i.e., the current ecological state of the site and the level of difficulty in reaching desired restoration goals.
- The site's ecological, social, educational, and community value.
- The potential for reinvasion, which is influenced by such factors as degree of fragmentation, proximity to invasive seed sources, and use policy.
- The threat to rare, threatened, or endangered plant and animal species or to sensitive areas.
- Resource availability and the potential for follow-up monitoring and treatment.
- Whether the project has potential for collaboration and resource sharing with other city departments and with community groups.
- The availability of needed funding resources, including from outside sources.
- The particular invasive species present.
- The degree of invasion.
- The severity of negative impacts of the particular invasive species.
- Whether there are reasons to delay treatment on particular individuals because of community attachment to them.



In partnership with the San Marcos Greenbelt Alliance, Hays County Master Naturalists, and Hays County Master Gardeners, the City of San Marcos leads monthly volunteer workdays in the natural areas focusing on invasive species removal.

Invasive species control efforts began in 2016 in the Sessom Creek Natural Area. Subsequent efforts have added invasive species control work days at Schulle Canyon Natural Area and Prospect Park.

- Whether complete removal would significantly damage the soil or leave large areas bare, necessitating intensive restoration efforts.

OBJECTIVE 2.2.2 INVASIVE SPECIES MONITORING

Monitoring is an important step in judging the effectiveness of invasive species management. Monitoring can occur in many different ways, though generally it is recommended through geographic, photographic, and narrative descriptions that include annual photo points, early detection evaluation, and land management record keeping and evaluation.

Photo Points

Photo points are a fairly quick and easy way to perform qualitative monitoring and can be accomplished by volunteers. A specific area should be chosen, located through GPS, and recorded so that pictures of the same exact area can be repeated.

It is recommended that photos be taken once a year at each of these points. Comparing the photos over time will provide a sense of how areas are changing—whether they are being actively managed or through unmanaged changes—and give guidance as to what choices to make in the future. These photos along with the general acreage tabulations of treated areas and reoccurrence of issues will be a means by which the success of management tasks can be determined and suggest actions for future activities.

Early Detection Monitoring

Early detection monitoring is not designed to assess whether or not the management guidelines are having their desired effect, but rather to detect new threats at an early stage of development so that they can be addressed quickly. It is not tied to a specific photo point or vegetation plot, but requires a staff member, professional, or volunteer to periodically walk the entire grounds and observe: new invasive threats, expanding invasive plant issues, areas being over used and denuded, new informal trails, and/or new erosion issues. Once new threats are identified, staff or volunteers can quickly take action and prevent a small problem from becoming a larger one that takes more time and resources to control in the future.

To be effective, early detection monitoring requires a staff member, professional, or volunteer who is:

- Adept at identifying invasive plants, even obscure ones;
- Very familiar with the areas so that they can accurately determine if change is occurring; and
- Willing to walk the grounds a minimum once a year looking for new threats.



In partnership with the Habitat Conservation Plan Conservation (HCP) crew, SMGA volunteers have been working hard to reduce invasive species in Sesson Creek Natural Area.

Efforts to reduce invasive plants (e.g., glossy privet, chinaberry and bamboo) include cutting, girdling and herbicide application throughout the natural area.

Source: San Marcos Greenbelt Alliance

OBJECTIVE 2.2.3 EFFECTIVE TREATMENT METHODS FOR MANAGEMENT OF INVASIVE SPECIES

The following treatment methods can be used for management of invasive species:

- Manual Methods
- Mechanical Methods
- Chemical Methods
- Cultural Methods
- Strategic Control Method: Combination of Control Methods
- Rehabilitation, Restoration, and Reclamation

The following section overviews each of these treatment methods. A successful invasive species management program depends on integrated management that considers all methods relative to the site and usually involves a combination of treatment methods. The preferred methods will be those that are the most resource efficient and have the least impact on non-target species and the environment.

Manual Methods

Manual methods include hand pulling as well as use of a wide array of tools for cutting, chopping, wrenching and girdling invasive plants. Manual methods are generally used on woody invasive plants



SMGA RESTORATION PROJECT AT PROSPECT PARK USING SOLARIZATION TO KILL INVASIVES

when they are small. Eradication is only possible when the root crown or roots that can resprout are completely extracted and seedlings are pulled or eliminated following seed germination. Because it is difficult and even impossible to extract all of the shallow roots, stolons, and rhizomes of many mature invasives, resprouting will usually occur. When this occurs, chemical treatment is usually required.

Mechanical Methods

Mechanical methods usually involve top removal or uprooting of individual plants. This method may be accomplished using hand tools, chain saws or heavy equipment. These methods can complement and increase the efficiency of herbicide treatments, followed by revegetation with desirable plants. Some equipment, with appropriate attachments, can prepare the site for seeding and tree planting. Most important is using the appropriate size equipment to meet job requirements and minimize damage to soils and streams. Timely follow-up with other control methods is essential because disturbance of the soil creates favorable conditions for regrowth from seeds and root fragments. Mechanical removal with heavy equipment may be appropriate in some natural areas. However, care should be taken and the use of heavy equipment should be limited or eliminated, in particularly sensitive areas (e.g. near streams or karst features).

Mechanical treatments will be applied in a manner that minimizes ground disturbance. Methods will be limited to those that allow selection of individual plants. These include use of hand tools, chain saws, and tractor or skid steer mounted devices such as tree shears and others. Less discriminating treatments such as chaining and root plowing will be avoided. Exceptions may be considered on a case-by-case basis.

- **Skid-Steer Loaders.** Tracks attached to the tires of the loader help traction and access to difficult terrain. Skid loaders are easily transported, highly maneuverable, and capable of lift and tilt, which gives this machine, if equipped with appropriate attachments, potential for other invasive plant removal tasks in dense infestations. However, track driven equipment can cause a high level of soil disturbance and should be used with care, and where possible, managers should opt for wheeled equipment.
- **Mulchers.** Mulchers are increasingly preferred for reducing both standing invasive and native woody plants in dense infestations. Mulching machines are best for nonselective situations where the cost of selective control is prohibitive. Mulching machines are land-clearing tools that

can cut through dense stands of nonnative plants, reducing them to small pieces of woody debris. After a mulched area has dried and regrowth occurs, prescribed burning can be used to reduce the surface mass, while herbicides can be more efficiently applied to the resprouts.

- **Bulldozers.** Bulldozers (or tracked tractors) are made in a range of sizes and have found use in large-scale invasive plant reclamation projects tackling extensive woody infestation, although smaller tractors and implements are used. The amount of soil disturbance and compaction is considerable with bulldozers, varying by equipment size, soil moisture, number of passes, stand density, and tree/shrub size. The substantial soil damage caused by bulldozers should be an important consideration when weighing the benefits of using such equipment against the drawbacks.

Chemical Methods

When other techniques are not sufficient, herbicide can offer an alternative. Effective herbicide applications can kill roots without exposing soil, though herbicide toxicity to non-target species and persistence, activity and mobility in soil or water must be considered. Exposed soil is susceptible to reinvasion and erosion.



Source: San Marcos Greenbelt Alliance

CITY STAFF MEMBER USING MECHANICAL TREATMENT REMOVAL OF CHINABERRY IN SCHULLE CREEK NATURAL AREA

For successful herbicide treatments:

- Select the least toxic herbicide that is effective for the target species and appropriate for the landscape. Also consider soil mobility, activity in soil and half-life.
- Follow application and mixing requirements prescribed on the label and use the most directed application method that will be effective.
- Choose the optimum time for applications. Factors to consider include the condition and stage of growth of target species, and weather considerations (probability of rain following application, wind speed during application). Many herbicides are effective only when plants are actively growing, so periods of drought, cold or heat may render pesticides ineffective. Uptake of foliar application may be hindered when leaf stomata are closed due to high temperatures.
- Be patient. Allow herbicides to work for several months to a year before resorting to other treatment options or re-treating.

Selecting an Effective Herbicide

If a herbicide is not prohibited for use on a specific site, then the broad category of non-crop areas even allows use in “non-used” lands and parks in urban and suburban environments. Some prescriptions for these other land types will also be given along with aquatic sites. Carefully read and study the herbicide label for information on specified areas of use, crops and prohibitions. It is not necessary for the target invasive plant to be listed on the label for permitted use if the label allows use for general weed control or control of broad categories, such as “annual weeds,” “perennial weeds,” or “woody species.” These more general uses are often discussed on the label under the heading of “non-crop areas,” “natural areas,” or “habitat management.”

Additional sources of information on both effectiveness and toxicity include Safety Data Sheets (SDS) that can be obtained from manufacturers and herbicide fact sheets. Fact sheets, if used, should come from reputable sources.

Adjuvants and Additives to Herbicide Spray Solutions

Adjuvants are any product added to a spray solution to improve herbicide performance and effectiveness, including delivery, retention on foliage, and foliar or bark penetration. Adjuvants may be included as part of the commercial herbicide product or sold separately as an additive you must mix with the herbicide before application.

Choose an adjuvant, according to label recommendations, that is appropriate for your particular application method and field conditions. Obtaining information about adjuvants and their effects can be difficult. SDS sheets are often the best source of information. Be aware that adjuvants may have more serious or long lasting environmental effects than the active ingredient of the herbicide, especially on aquatic organisms.

Another common additive used by professionals is a marking dye, which makes it easier to determine which areas have been sprayed and which still need treatment. Dyes marketed for this purpose will fade after a period of sunlight exposure.

Water Quality Protection

Water quality is an important environmental issue in relation to pesticide use. The strategies for reducing or preventing water contamination by these products are largely based on common sense. When applying pesticides, the applicator should read the product labels and use the lowest effective rate listed on the label for any one application. Calibrate equipment to deliver herbicides according to label recommendations and keep records of the amount of product applied. An applicator should NEVER double the rate for better results and NEVER deviate from strict label application rates.

The key to minimizing impact is reducing the levels of possible pollutants that enter the system. Factors determining the potential for ground water and surface water contamination include tendency for the pesticide to attach to soil particles or organic matter, solubility in water, rate of degradation, and volatility.

Soil is a common pathway to groundwater and soil characteristics, along with the chemical's inherent



**CHEMICAL TREATMENT NEAR WATER BODIES
REQUIRES STRICT COMPLIANCE TO RULES AND BMPS**

mobility, determine the rate at which chemicals move through the soil. Soils with high clay or organic matter content are more likely to bind herbicide molecules, tying up the material while it is decomposed by microorganisms or other degradation processes. To minimize contamination due to runoff, do not apply products within 48 hours of expected heavy rainfall.

Pesticide drift can be controlled by spraying only on calm days, using lower pressure, larger droplet size and drift control additives in the spray solution to reduce spray drift. These precautions should be taken to reduce spray drift on all occasions. More detail on managing spray drift is given in the following section of this plan. The use of broadcast spray methods should be minimized in favor of more directed application methods.

One potential source of water contamination is the disposal of unused herbicide, product containers, and rinse water. Prepare only the amount recommended for the area to be treated to prevent having unused herbicide at the end of an application. Rinse all empty containers, regardless of their type, three times before disposal. Do not dispose of container rinse water where it may flow into a waterway.

Instead, dispose of rinse water by application on the treated area. Dispose of the product containers according to label directions.

Selective Herbicide Applications

The best approach is usually selective applications to target plants while avoiding or minimizing application to desirable plants. The following selective methods are described in greater detail.

- Foliar sprays and wipes
- Basal sprays and wipes
- Stem injection
- Cut-treat / Cut-stump
- Soil spots

Directed Foliar Sprays and Wipes

Directed foliar sprays are herbicide-water-adjuvant solutions aimed at target plant foliage to wet all leaves, applied by either low- or high-volume sprayers. Herbicide application by directed foliar spray is one of the most cost-effective methods for treating many types of herbaceous and woody invasive plant species.

With this method, herbicide mixtures are applied to the foliage and especially the growing tips of woody plants, or to completely cover all leaves. Foliar sprays

can be applied whenever leaves are present but, for woody plant control, are usually most effective from midsummer to late fall. Winter and spring applications are also effective in controlling some species and are often required to prevent seed formation.

Selective treatment is possible because the applicator can direct the spray towards target plants and away from desirable plants. The addition of a spray shield to the end of the wand confines spray to the target. Another safeguard is to only use foliar-active herbicides because directed sprays of soil-active herbicides can damage or kill surrounding plants when their roots are within the treatment zone. Never use herbicides with soil activity to treat invasive plants under desirable trees or shrubs that are susceptible to the herbicide. If non-target foliage is accidentally sprayed, clip off the foliage to prevent uptake.

Low-volume foliar sprays using spray tips and spraying pressures of 20 to 30 pounds per square inch can ensure productivity and limit drift. Wind must be minimal (less than 10 miles per hour) and used by the applicator to facilitate upper crown coverage. Low wind can be dangerous because it is variable and unpredictable, wind speeds of 5-10 mph is optimal.

Directed foliar sprays can be applied in higher volumes by using spray wands attached by hoses to vehicle-mounted spraying systems that have much larger herbicide tank capacities. The high-volume directed foliar spray is the most efficient approach to large infestations of multiple invasive species where there are few non-target plants.

Handheld weed wicks and rollers apply ultra-low volumes by wiping the herbicide mix onto the target leaf surfaces or bark; the herbicide mixture is contained in the handle. Most wick systems have limited use and durability in forest and field situations, but are useful when the applicator needs to avoid applying herbicide to rare or protected plants. Vehicle mounted wipe bars can be used to selectively target large areas of taller target species (e.g., Johnsongrass) with minimal impacts to shorter desirable species.

Basal Sprays and Wipes

Basal sprays are herbicide-oil-penetrant mixtures sprayed on the lower portion of woody stems. The sprays are usually applied with a backpack sprayer or wick applicator. Avoid spray contact with desirable trees or heavy use within their root zone. The herbicide must be an oil-soluble formulation and mixed with a special basal oil product, penetrating oil,

diesel fuel, fuel oil, mineral oil, vegetable oil with a penetrant, or blends of these ingredients.

The most effective time period in most of the South United States for a basal spray and streamline is June through September, while winter treatments are easier when leaves do not block access and spray. After treating with a basal spray, wait at least two years before disturbing aboveground plant material, because herbicide activity within plant roots can continue for an extended period.

Stem Injection

Stem injection (including hack-and-squirt) involves the use of mechanical herbicide injectors or the application of herbicide concentrate or herbicide-water mixtures into downward incision cuts spaced around woody stems and often made by a hatchet or machete. Tree injection is a selective method of controlling larger trees, shrubs and vines with minimum damage to surrounding plants. Injection treatments are sometimes not as effective in controlling multiple-stemmed species compared to the faster basal bark treatments, but may be easier in remote or rough terrain where a backpack sprayer might be impractical or cumbersome. Incisions should be spaced around the stem, deep enough to penetrate the bark and inner cambium, slightly into the wood. Do not make multiple cuts directly above or below each other because this will inhibit movement of the herbicide within the stem. A complete girdle or frill of the stem is not needed or desirable.

Cut-Treat or Cut-Stump

Cut-treat involves applying herbicide concentrates, herbicide-water or herbicide-penetrant mixtures to the outer circumference of freshly cut stumps or the entire top surface of cut stems. Applications are made with a spray bottle, squeeze bottle, backpack sprayer, wick or paint brush. Freshly cut stems and stumps can be treated with herbicide mixtures to prevent resprouting and to kill roots.

It is critical that the cut is made as low as possible to the ground, and that the stem is treated immediately after the cut is made. To minimize deactivation of the herbicide in the cut-treat method, remove sawdust from stumps before treatment. For stumps over three inches in diameter, completely wet the outer edge with the herbicide or herbicide mixture. Make certain that the solution thoroughly covers the wood next to the bark of the stump. Completely wet the tops of smaller stumps and all cut stems in a clump. Note that some herbicide labels advise treating the outer portion of the stump down to the ground.

Broadcast Herbicide Applications

Broadcast application of pesticides should be avoided. However, in rare cases in which broadcast application is deemed appropriate, chemicals should be selected that have low-non target toxicity, low potential for movement, and a short half life in the environment. The Texas Agricultural Extension has developed a list of recommended chemicals for broadcast application with these characteristics.

Cultural Methods

Cultural methods can include prescribed burning, mulching, and solarization. Some cultural practices may have undesirable impacts to soils, animal habitat and native species, so care in planning and implementation must be exercised.

Strategic Control Method: Combination of Control Methods

The most appropriate, effective, and safest control of an invasive species may be a strategic combination of two or more control methods. As an example, experience has taught City staff and SMGA that herbicide treatment of *Ligustrum* is not necessary. While felling *Ligustrum* trees and immediately treating the stumps with herbicide certainly kills the trees, it has been found that simply leaving the stump is sufficient. Native white-tailed deer, common throughout the natural areas of western San Marcos, will browse the fresh sprouts from *Ligustrum* stumps, and eventually the *Ligustrum*s die.

Control Methods of Invasive Animal Species

Wild hogs, also known as feral pigs, are a significant issue in Texas and many other parts of the United States. Wild hogs have become a major concern due to their highly adaptable and prolific breeding capabilities. They are opportunistic feeders and are known for their destructive feeding behaviors, as they root and dig for food using their strong snouts. This behavior damages sensitive ecosystems and wild hogs are known to outcompete native wildlife for resources, damage native plant species, and potentially spread diseases to both wildlife and livestock. This rooting behavior also has the potential to alter normal soil chemistry and alter vegetative communities, allowing for the establishment and spread of invasive plant species. Park departments in Texas and other affected states have implemented a range of strategies to manage wild hog populations and mitigate their negative impacts.

Some common approaches include:

- **Trapping and Relocating.** Some park departments may use trapping as a method to capture wild hogs, followed by relocation to areas with lower ecological sensitivity or where hunting pressure can help control their numbers.
- **Hunting and Trapping.** Many park departments allow controlled hunting and trapping of wild hogs to help reduce their numbers. This can be done through organized hunting programs, permits, or contracts with professional trappers.
- **Fencing.** Installing fences can help protect sensitive areas, such as native habitats and agricultural lands, from wild hog intrusion. However, these animals are known for their ability to dig under or break through fences, so effective design is important.
- **Public Education.** Park departments often engage in public education efforts to raise awareness about the negative impacts of wild hogs and to encourage responsible practices, such as not feeding them, reporting sightings, and following proper hunting and trapping regulations.
- **Research and Monitoring.** Continuous research and monitoring of wild hog populations and their impacts help park departments make informed management decisions. This includes studying population dynamics, behavior, and potential disease transmission.

It is important to note that managing wild hog populations is an ongoing challenge due to their reproductive capabilities and adaptability. Effective management typically involves a combination of strategies tailored to the specific needs of the area and the goals of the park department.

Source: Kinsey, J. (2020). *Ecology and Management of Wild Pigs*. Texas Parks and Wildlife Department. tpwd.texas.gov/publications/pwdpubs/media/pwd_bk_w7000_1943.pdf



Source: San Marcos Greenbelt Alliance

**SMGA TRAINING ON INVASIVES CONTROL
BY MINNETTE MARR, LADY BIRD JOHNSON
WILDFLOWER CENTER BOTANIST**

OBJECTIVE 2.3 FIRE HAZARD PLANNING GUIDANCE

This objective overviews the importance of assessing and mapping wildfire hazard risks in advance, and implementing fire prevention and mitigation measures to reduce the risk of wildfires before they occur. Fire hazard management is an important component of managing and maintaining the natural areas. It can also be one of the most dangerous management activities undertaken.

The natural areas are woven into the community fabric and are a part of what is called the “wildland-urban interface,” where urban residential and commercial infrastructure is adjacent to and/or intermixed with the natural areas. Wildfires are part of a natural process that helps to maintain healthy ecosystems, but a historic emphasis on fire suppression since the initial settlement of San Marcos and Central Texas area has transformed the ecosystems there and increased the risk of wildfires. Today, the risk of a wildfire in a natural area is a significant concern to residents in the wildland-urban interface in and near the natural areas. Natural area management strategies that include management and maintenance of vegetation, in addition to public education and involvement, will mitigate some of the area’s wildfire hazards.

It is important to understand that undertaking wildfire risk assessment and mapping, and implementing fire prevention and mitigation measures within the San Marcos natural areas are parts of a toolbox of solutions needed to reduce risk in the wildland urban interface. Moving forward, the City should consider the following list of most important programs and regulations communities can use to reduce risk in the wildland-urban interface:

- **Community Wildfire Protection Plans (CWPPs).** CWPPs are essential programs that communities can adopt to assess wildfire risks, develop mitigation strategies, and establish emergency response plans. These plans guide coordinated efforts and prioritize actions to reduce wildfire risk within the community. This is an important tool needed for each natural area.
- **Zoning and Land Use Regulations.** Implementing zoning and land use regulations specific to the wildland-urban interface is essential for reducing risk. These regulations can include setbacks, buffer zones, and restrictions on certain types of development in high-risk areas to ensure appropriate land use planning that considers wildfire hazards. These regulations should be located in the City’s zoning, subdivision, and

other development-related codes, and should mandate minimum fire protection standards for construction of all new residential and nonresidential development.

- **Building Codes and Standards.** Enforcing and updating building and fire codes and standards that address wildfire resilience is vital. The City should adopt and enforce codes that require fire-resistant construction materials, ember-resistant vents, and other measures to enhance the ability of structures to withstand wildfires.
- **Vegetation Management Program.** Establishing a vegetation management program is essential for reducing fuel loads and mitigating wildfire risks. This program will involve strategies such as prescribed burning, selective thinning, and clearing of hazardous vegetation to create defensible spaces and minimize the potential for fire spread. This should be undertaken in natural areas which abut adjacent development.
- **Firewise Communities/Ready, Set, Go Programs.** Participating in Firewise Communities or similar programs promotes community-wide preparedness and encourages residents to take proactive steps to reduce wildfire risk. These programs provide educational resources, training, and guidelines for creating defensible spaces, developing evacuation plans, and improving overall community readiness.

By implementing these programs and regulations, the City can effectively reduce the risk of wildfires in the wildland-urban interface. Each program or regulation plays a significant role in promoting community resilience, enhancing land use planning, and ensuring that structures and residents are better prepared to face the challenges posed by wildfires.



IMPROVING WILDFIRE MANAGEMENT STRATEGIES IN THE WILDLAND URBAN INTERFACE WILL REDUCE RISK TO ABUTTING DEVELOPMENTS

OBJECTIVE 2.3.1 WILDFIRE HAZARD ASSESSMENT & SITE MAPPING

To begin the process of wildfire management, it is necessary to conduct a wildfire hazard assessment for each natural area. This will assess each natural area for wildfire potential along with risks to adjacent properties. The **City of San Marcos Natural Areas Fire Hazard Assessment Form** provided in the **Appendix** can be used to guide the user through the fire hazard assessment process. The following six items are necessary for conducting the assessment and are included in the example Fire Hazard Assessment Form.

- 1. Coordinate with local fire authorities.** This wildfire hazard assessment should be coordinated with personnel in the local fire authorities, including the City Fire Department and Fire Marshal, and the county fire marshals for the counties in which the natural areas are located. This will provide the natural area managers with professional assistance and guidance from wildfire professionals. Coordination will also foster communication between all agencies involved.
- 2. Identify and evaluate fire-prone vegetation and slope.** Three basic elements required for a fire to occur include (1) a heat source, (2) oxygen, and (3) fuel. Vegetation in the City natural areas (both live and dead) provides fuel for a wildfire and hot, dry climate conditions can create a fuel that is ready to burn. Historic fire suppression has allowed fuels to build up in specific vegetation cover types and has created an increased fuel load.

The following fire prone vegetation factors are shown on the **Natural Areas Fire Hazard Assessment** form, included in the **Appendix**:

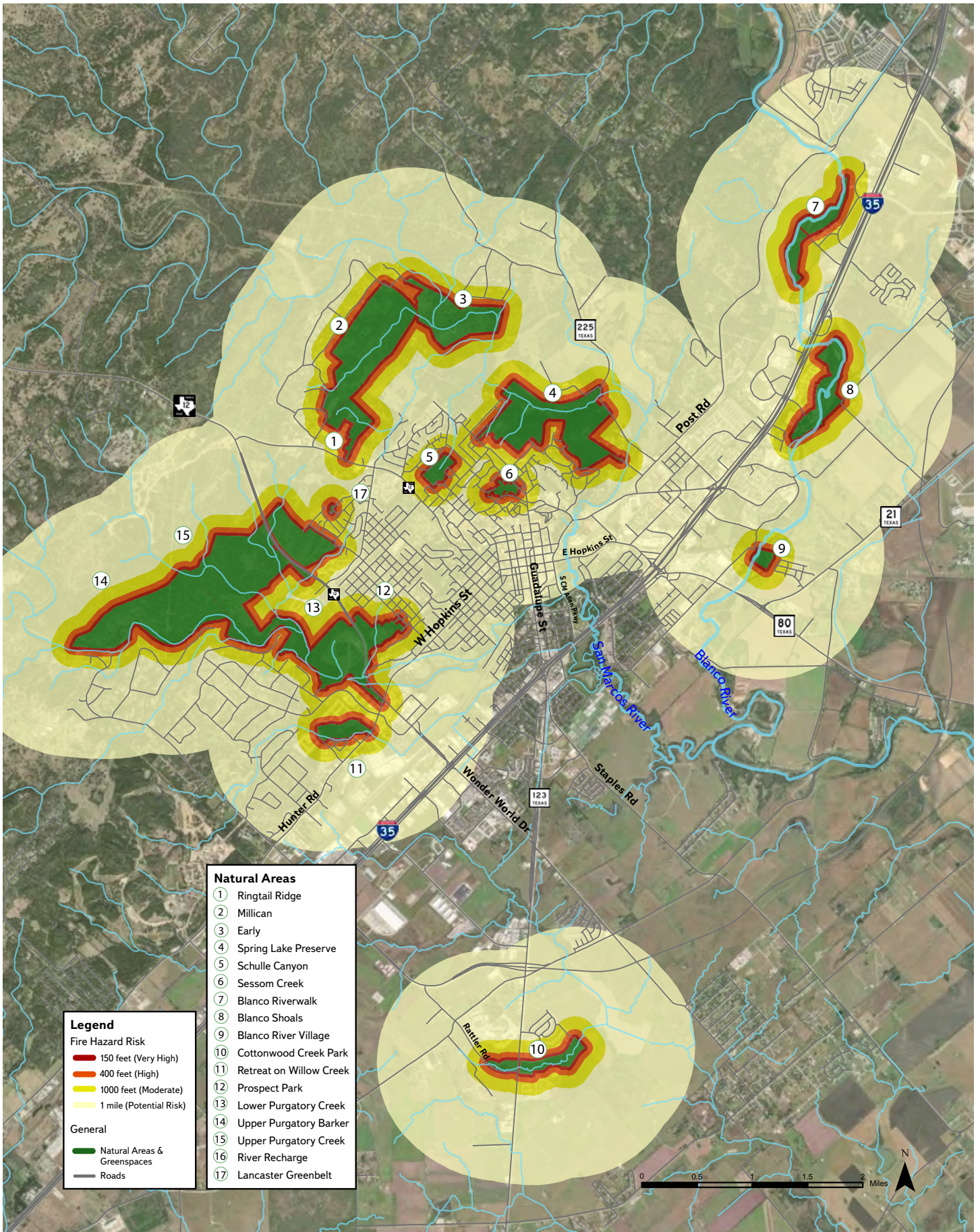
- **Forest Vegetation Density.** Moderate to heavy density forest vegetation poses a greater wildfire risk. A high hazard crown fire is more likely to occur in a dense forest.
- **Surface Vegetation.** Surface vegetation includes grasses, shrubs, and dead and down woody material which adds to wildfire risks.
- **Ladder Fuels.** Ladder fuels are shrubs, immature trees, and branches that extend near the ground surface that give surface fires a pathway to the upper canopies of trees.
- **Slope.** Slope has a direct effect on fire behavior. The steeper the slope, the faster a fire will spread uphill.

- **Position on Slope.** The position of fire prone vegetation on a slope is an important factor in fire behavior. Long slopes of fire prone vegetation with adjacent uphill properties represent the highest risk.
 - **Types of Vegetation.** Some vegetation types are more susceptible to igniting and burning. Fire suppression may be difficult in woodland areas.
- 3. Identify fuel breaks.** Fuel breaks are natural or constructed landscape features that may help to contain a wildfire. These include roads, trails, rivers, streams, rock outcrops, and fuel breaks created by removing vegetation.
 - 4. Locate adjacent residential/commercial structures and private property.** The City may determine the distances adjacent to a natural area border that will be identified as within the wildland-urban interface and therefore at risk of wildfire. Buildings within these areas should be identified as “high wildfire risk” properties. The City should notify these property owners of the potential for wildfire and the City should provide assistance in identifying and implementing landscape mitigation strategies.
 - 5. Identify emergency access locations.** In the event of a wildfire occurring in a natural area, emergency access to the wildfire area and adjacent properties is essential. Identify all natural area access locations. Survey the adjacent residential areas for additional access/egress areas.
 - 6. Identify water sources.** A water source for firefighting should be accessible within or near all natural areas. The source may be a fire hydrant, stream, pond, or water tank.

Site Mapping

Subsequent to assessing the fire hazard for each natural area, both aerial and on-site mapping should be done to document the identified site features. An example is included in **Map 4.1, Example Fire Hazard Mapping**, on the next page. A similar map should be created identifying all the structures and properties located in or adjacent to high fire hazard risk zones in the natural areas.

MAP 4.1, FIRE HAZARD MAPPING



OBJECTIVE 2.3.2 PREVENTION AND MITIGATION STRATEGIES

Upon completion of the wildfire hazard assessment and mapping, prevention and mitigation measures can be planned and implemented. These measures are programs and/or practices put into place to reduce wildfire hazards and risks to adjacent properties. These prevention and mitigation measures are described below.

- **Fuels Modification.** For high wildfire risk areas, planning and conducting fuels modification projects, consisting of thinning trees and shrubs, removing fuels, and maintaining defensible spaces around structures should be considered. A professional fire specialist should be contacted to help in planning and conducting any fuels modification project within natural areas.
- **Fire Response and Evacuation Guidelines.** Fire suppression activities and the evacuation of residents and building occupants will be most effective if a fire response and evacuation plan for each natural area is developed. Communicating and coordinating this information to the appropriate agencies will assist fire fighters in their efforts. Residents and building occupants in areas adjacent to natural areas should be educated in evacuation routes and what to do if a wildfire does occur.
- **Property Owner and Resident Education.** Natural area land managers can partner with fire department personnel and with adjacent property owners and residents to develop an education plan. Property owners and residents should be educated in the concept of “defensible space,” which is the modification of vegetation on a property to reduce the chance that a wildfire will spread onto adjacent property. See the **Appendix** for the firewise guide on home preparation, titled **How to Prepare Your Home for Wildfire**.
- **Access Management.** Access management is an important component of fire prevention and mitigation. Access controls include closing natural area parks and trails with gates or signage to limit the number of people entering a specific area and reduce the potential for unwanted activities. Enabling access for fire fighting activities will help ensure prompt response. Other important access considerations include regular inspections to ensure that all gates are in good working condition, standardization of locks on gates, and availability of keys or codes to locks for all involved agencies where applicable.



CONTROLLED ACCESS IN NATURAL AREAS CAN BE USED AS A TOOL IN WILDFIRE MANAGEMENT ACTIVITIES

OBJECTIVE 2.4 FIRE MANAGEMENT

Once Wildfire Hazard Assessment & Site Mapping is complete, it is important to move directly to fire management implementation actions in the natural areas. Some of the top priorities for fire management in natural areas include:

- **Fire Management Plans.** Developing and implementing comprehensive fire management plans is essential for effective fire management in natural areas. These plans outline strategies for fire prevention, preparedness, suppression, and post-fire recovery. They consider factors such as fire behavior, ecological impacts, community safety, and resource allocation.
- **Firebreaks and Fuel Management.** Firebreaks and fuel management practices are both essential tools for fire management. Firebreaks are strategically placed cleared areas that can slow or halt the spread of wildfires, providing safer conditions for firefighting operations. Fuel management involves reducing fuel loads through techniques such as selective thinning, clearing of hazardous vegetation, and maintaining defensible spaces around structures.
- **Prescribed Burns.** Prescribed burning, also known as controlled burning, is a valuable tool for managing fire in natural areas. It involves carefully planned and controlled fires under specific weather conditions to reduce fuel loads, maintain ecosystem health, and minimize the risk of uncontrolled wildfires. Prescribed burns can mimic natural fire regimes and promote the regeneration of fire-adapted ecosystems.
- **Early Detection and Monitoring Systems.** Deploying early detection and monitoring systems significantly enhances fire management capabilities. These systems include remote sensing technologies, weather monitoring stations, and fire behavior prediction models. They help detect fires early, track fire behavior, and provide vital information for making informed decisions about fire response and resource allocation.
- **Collaborative Partnerships.** Establishing collaborative partnerships among area communities, fire agencies, land managers, and stakeholders is essential for effective fire management. Cooperation allows for resource sharing, coordinated planning, and a collective approach to fire prevention, preparedness, and response. Collaborative partnerships enhance communication, foster knowledge exchange, and facilitate joint efforts in managing fire in the natural areas.

By utilizing these tools, the City can enhance its ability to manage fire in the natural areas more effectively. It is important to adapt these tools to local conditions, engage in ongoing monitoring and evaluation, and foster a culture of proactive fire management that balances ecological health, community safety, and resource protection.

Natural areas with a higher risk of wildfire as identified on **Map 4.2, Wildfire Intensity Risk**, on the next page. Measures of Wildfire Intensity indicate areas where significant fuel hazards are present and the potential for dangerous fire behavior exists.

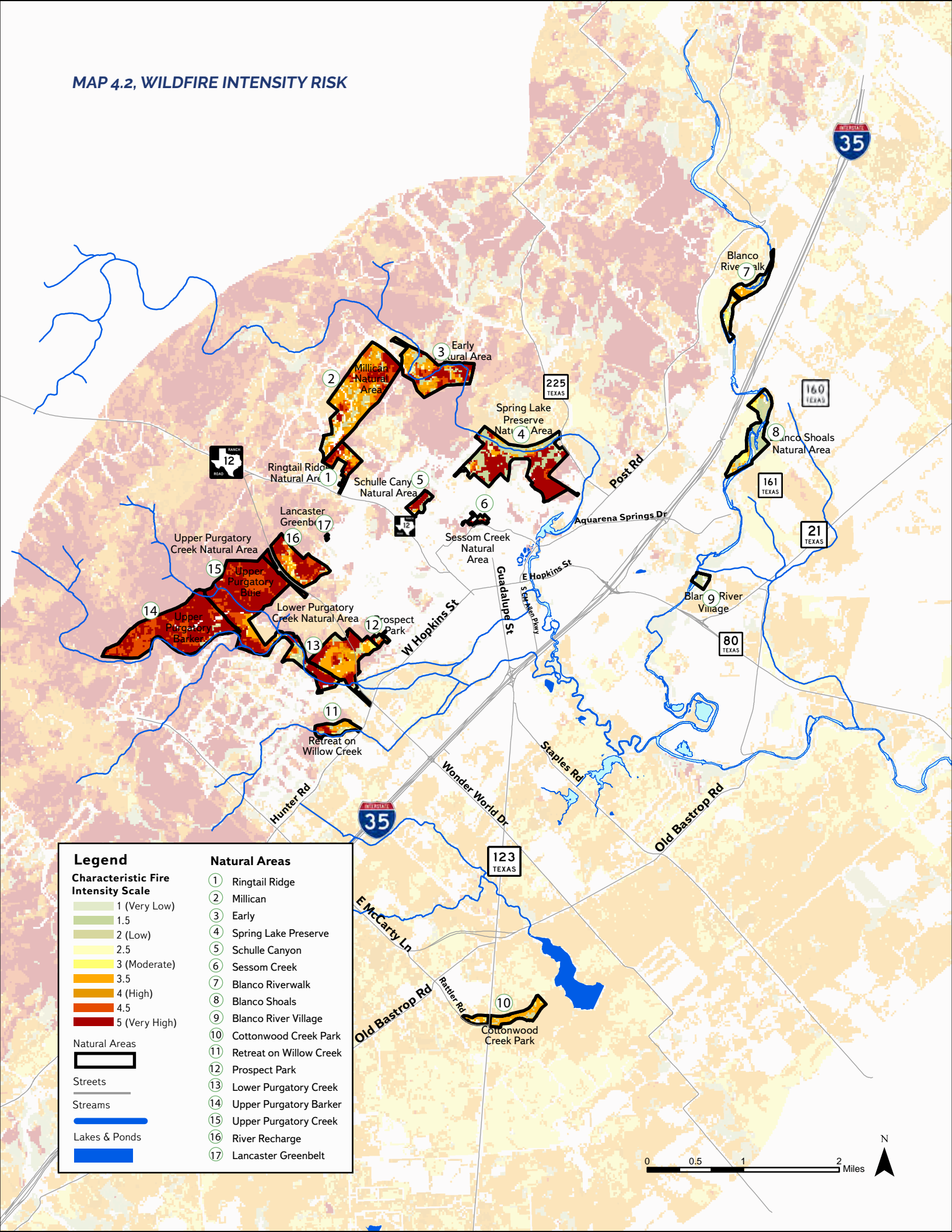
Areas with higher wildfire intensity risk should receive greater priority when implementing the fire management techniques described herein. The majority of Upper Purgatory Natural Area and portions of Spring Lake, Lower Purgatory, Ringtail Ridge, Milican, Early, and Schulle Canyon natural areas pose a greater risk of very intense wildfires.

More information about Wildfire Intensity Risk can be found in **Chapter 3**. These identified areas should be prioritized for wildfire hazard mitigation strategies. The Parks Department should work with the Fire Department and relevant state agencies to determine the best preventative course of action.



REDUCING FUEL LOADS IN AREAS OF THE NATURAL AREAS THAT ABUT RESIDENTIAL DEVELOPMENT CAN REDUCE RISK WHEN A WILDLAND FIRE BREAKS OUT

MAP 4.2, WILDFIRE INTENSITY RISK



Legend

Characteristic Fire Intensity Scale

- 1 (Very Low)
- 1.5
- 2 (Low)
- 2.5
- 3 (Moderate)
- 3.5
- 4 (High)
- 4.5
- 5 (Very High)

Natural Areas

- Natural Areas
- Streets
- Streams
- Lakes & Ponds

Natural Areas

- 1 Ringtail Ridge
- 2 Millican
- 3 Early
- 4 Spring Lake Preserve
- 5 Schulle Canyon
- 6 Sessom Creek
- 7 Blanco Riverwalk
- 8 Blanco Shoals
- 9 Blanco River Village
- 10 Cottonwood Creek Park
- 11 Retreat on Willow Creek
- 12 Prospect Park
- 13 Lower Purgatory Creek
- 14 Upper Purgatory Barker
- 15 Upper Purgatory Creek
- 16 River Recharge
- 17 Lancaster Greenbelt



OBJECTIVE 2.4.1 FIRE MANAGEMENT PLANS

A Fire Management Plan is a comprehensive document that outlines strategies, protocols, and procedures for managing wildfires and prescribed burns within a specific area. It encompasses all aspects of fire management, including prevention, preparedness, suppression, and post-fire recovery.

The plan considers factors such as fire behavior, ecological objectives, community safety, and resource allocation. It provides a framework for coordinated action among stakeholders, including fire agencies, land managers, and local communities. A fire management plan is crucial as it helps mitigate the risks associated with wildfires, protect lives and property, conserve natural resources, and maintain the ecological health and resilience of the landscape. It ensures that fire management efforts are well-coordinated, based on sound scientific principles, and aligned with the specific needs and values of the area being managed.

The City of San Marcos Fire Department has already begun assessing the natural areas to ensure appropriate and effective emergency response. In particular, they have begun mapping the Upper and Lower Purgatory Natural Areas to identify emergency access routes for rescue scenarios. The map identifies all possible entry points and which trails are accessible only by foot and which can accommodate rescue equipment or vehicles.

The City of San Marcos Fire Department and Parks and Recreation Department should coordinate to identify ideal emergency access routes for each natural area, with priority given to higher risk areas, such as those identified in the **Fire Hazard Planning Guidance** section of this chapter. Routes should ideally be wide enough to allow access for a fire truck. Utilizing existing easements, roads, and other rights-of-way, such as utility easements, can serve as an efficient method for identifying emergency access routes.

Emergency access routes are not generally for use by the public, and as such, these trail corridors should have limited access. A gate with code access is recommended on these routes, as code access will readily allow trail access by any authorized personnel with the code in the event of an emergency, as opposed to the use of a gate key.

The Fire Department should create similar maps for all of the natural areas, starting with the ones most at risk for wildfire. These maps should be followed by the preparation of full Fire Management Plans (called Emergency Preparedness and Management Plans in the San Marcos Parks, Recreation, and Open Space Master Plan) for each natural area.



EXAMPLE FIRE ACCESS MAP FOR PURGATORY NATURAL AREAS

OBJECTIVE 2.4.2 FIREBREAKS AND FUEL MANAGEMENT

Firebreaks are crucial tools to employ during wildfire emergencies to help control the spread of fire and protect lives and property. Firebreaks serve as an obstacle to the spread of fire and slow or stop the progress of a fire. They are typically used strategically in specific circumstances to create a barrier that interrupts the path of advancing flames.

Firebreaks are especially effective when implemented in advance of the fire's arrival, allowing firefighters to work safely and strategically to halt the fire's progression. They can be strategically placed to safeguard critical infrastructure, key access routes, or areas with high-value assets. Firebreaks are most commonly utilized in situations where other firefighting tactics, such as aerial water drops or direct suppression, may be challenging or ineffective due to terrain, vegetation density, or fire behavior.

By establishing firebreaks in strategic locations and maintaining them appropriately, fire management teams can gain valuable time to implement suppression strategies and protect communities and natural resources from the devastating impacts of wildfires.

Firebreaks may exist naturally as a gap in a forest or a body of water, or may be manmade breaks in the vegetation such as roads. Firebreaks also provide access for personnel and equipment. Firebreaks should be bare ground or mineral soil constructed in a manner which prevents erosion issues. These breaks are usually a combination of bare ground,



BODIES OF WATER SERVE AS NATURAL BARRIERS TO WILDFIRES

mowed strips, and backfired or blackened strips. If the firebreak is insufficient, an escaped fire may occur.

Firebreak Widths

According to the Texas Prescribed Burn Handbook, issued by the Texas A&M Agrilife Extension Office, the width of a firebreak on the downwind side of the burn area should be 10 times the height of the flammable vegetation within the burn area. Some recommended widths of blackened areas are:

- Grass fuels only: 100 feet
- Grass fuels with cedar: 300 feet
- Grass fuels with sand shinnery oak: 200 feet
- Grass fuels with sand sage brush: 200 feet
- Forest understory of leaf litter fuels: 50 feet
- Forest understory of leaf litter fuels with cedar: 300 feet

The size of the firebreak will be determined during the actual incident by the wildland firefighters and other emergency responders based on the conditions of the wildfire they are needed to stop.

Firebreak Types

There are various types of firebreak lines, including:

- **Mowed Lines / Wet Lines.** Require more personnel, equipment, water, and takes longer to implement. These types of breaks are risky without a high level of prescribed burn experience.
- **Cattle Trails.** Use mowing to reduce fuel loads next to cattle trails
- **Roads.** Roads of any type, including paved, county, two track or feed roads
- **Dozed Lines.** Paths scraped to mineral soil to remove fuels
- **Disked Lines.** Should be mowed and then the area is to be disked twice to ensure there is no continuous fuel in the line
- **Leaf Blower or Raked Lines.** Works well for short distances in forested areas where fuel levels are low
- **Natural Barriers.** Creeks, rivers, lakes, cultivated fields, forest edges can be used to minimize cost, effort and erosion potential

Fuel Management

Fuel management in natural areas involves implementing various techniques to reduce the amount and continuity of flammable vegetation, thereby mitigating the risk of wildfires and promoting ecosystem health.

One common fuel management technique is selective thinning, which involves selectively removing smaller trees, shrubs, and understory vegetation to create wider spacing between vegetation and reduce fuel loads.

Each fuel management method should be carefully planned and executed, taking into account ecological objectives, fire behavior modeling, and the desired balance between fire risk reduction and maintaining the natural integrity of the area. By implementing these fuel management strategies, natural areas can be better prepared to withstand wildfire events and support the long-term health and resilience of the ecosystem.

In natural areas abutting residential development, several types of mechanical fuel management techniques can, and should, be employed to reduce wildfire risk and enhance safety. One effective approach is the selective thinning, or fuel reduction zones, of vegetation in areas abutting residential development.

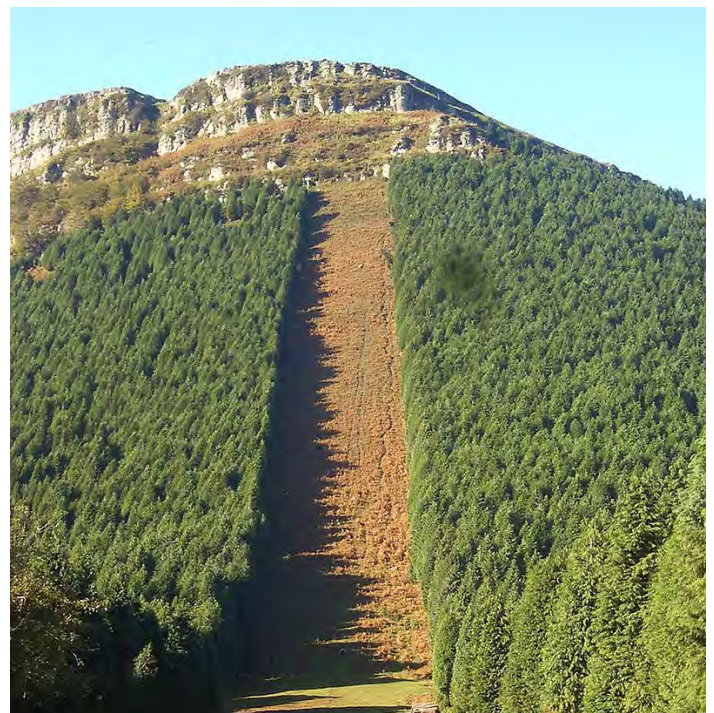


ROAD FORMING A FIRE BREAK

This involves the removal of vegetation and the establishment of clearings or low fuel-density areas adjacent to residential areas. This can be achieved through techniques such as mowing, mechanical clearing, or mulching, which reduce the amount of flammable vegetation near homes.

This should be combined with subdivision regulations which require the creation of defensible space (i.e., the clearing vegetation around structures and maintaining a buffer zone to reduce the likelihood of ignition from nearby wildfires) by property owners which abut the San Marcos Natural Areas. The creation of defensible space includes the removal of dead vegetation, trimming tree branches, and ensuring adequate spacing between plants.

By implementing these mechanical fuel management practices, the risk of fire spread from natural areas to residential developments can be minimized, providing a safer environment for residents and enhancing overall wildfire preparedness.



EMERGENCY ACCESS OR UTILITY ROUTES CAN BE FIRE BREAKS

OBJECTIVE 2.4.3 PRESCRIBED BURNS

Prescribed burns are an important fire management strategy in natural areas within the wildland-urban interface for several reasons.

Firstly, prescribed burns help reduce hazardous fuel loads by removing accumulated dead vegetation and reducing the density of flammable vegetation. This proactive approach decreases the likelihood and intensity of future wildfires, mitigating the risk to both natural areas and nearby urban developments.

Additionally, prescribed burns promote ecosystem health and resilience by mimicking natural fire regimes, which many plant and animal species depend on for their life cycles and habitat maintenance. By reintroducing controlled fire, prescribed burns can help maintain biodiversity, restore native vegetation, and reduce the dominance of invasive species.

Furthermore, prescribed burns can create defensible space by strategically reducing fuel continuity between natural areas and residential communities. This provides a buffer zone and enhances the ability of firefighters to protect lives and property during wildfire events.

The Dangers of Prescribed Burns

Prescribed burns, while an important fire management tool, can pose potential dangers when conducted in the wildland-urban interface. The proximity of residential areas and infrastructure increases the complexity and risks associated with prescribed burns.

The presence of structures and human populations requires careful planning, coordination, and monitoring to minimize the risk of unintended fire spread and smoke impacts. Wind patterns, fuel conditions, and weather variables need to be carefully evaluated to ensure that the prescribed burn remains under control and does not pose a threat to nearby communities.

Adequate communication with residents, emergency services, and air quality management agencies is essential to address safety concerns and minimize disruptions. Effective risk assessment, strategic burn planning, and comprehensive safety protocols are crucial to mitigate the potential hazards and ensure the safe implementation of prescribed burns in the wildland-urban interface.

Planning Prescribed Burns

In order to safely meet the specific objectives of a burn, prescribed burns require careful planning including the detailed analysis of fuels, weather, and topography, and the development of a prescribed burn plan that dictates a specific range of weather and fuel conditions and the appropriate steps to meet these objectives. Additional information regarding outdoor burning in Texas can be found in the **Outdoor Burning in Texas** resource provided in the **Appendix**.

Prescribed Burn Agencies

A variety of state agencies provide resources and/or oversight of prescribed burns for wildlife and range management in Texas. These include, but are not limited to:

- U.S. Dept. of Agriculture (USDA) Natural Resources Conservation Service (NRCS)
- Texas Parks and Wildlife Department (TPWD)
- Texas A&M Agrilife Extension
- Texas A&M Forest Service
- Texas Commission on Environmental Quality (TCEQ)

The Texas A&M Forest Service, TPWD Wildland Fire Management team, and the USDA NRCS provide education and training to private landowners for the implementation of prescribed burning. A number of prescribed burn associations are also present throughout Texas to assist with the application and safety of prescribed burns.

Prescribed burns, when conducted, should be carefully and thoroughly planned events performed by a trained crew. Prior to burning, a detailed burn plan must be completed.

Prescribed Burn Plans

A prescribed burn plan is a comprehensive document that outlines the specific objectives, strategies, and procedures for conducting a controlled burn in a designated area. It includes considerations such as weather conditions, fuel moisture levels, smoke management, and safety protocols to ensure the safe and effective implementation of the prescribed burn while achieving desired ecological outcomes.

In general a prescribed burn plan includes:

- Objectives of the prescribed burn
- Outline of safety measures in place (contingency plan and smoke management plan)

- Applicable contacts
- Weather conditions, Site conditions, and Area Description

A prescribed burn template can be found at the TPWD website and in the **Appendix**.

Prescribed Burn Notification

It is important to notify responsible agencies before conducting a prescribed burn to ensure proper coordination, communication, and oversight of the burn operation. By informing the relevant authorities, such as fire agencies and land management agencies, they can provide valuable input, review the burn plan, and offer support in terms of resources, personnel, and potential mitigation measures, enhancing safety and effectiveness of the prescribed burn. For the San Marcos Natural Areas, the following notifications, at minimum, are required:

- City staff (if being undertaken by others)
- County sheriff
- County fire marshal
- Fire department
- Texas Forest Service
- TCEQ (regional office)
- Neighboring landowners (recommended)

A prescribed burn permit may need to be obtained through the Hays County Fire Marshal's Office prior to conducting any burns.

OBJECTIVE 2.4.4 EMERGENCY WARNING SYSTEMS

Outdoor warning sirens can alert residents about wildfires and can be a crucial safety measure to protect lives. Additional outdoor warning sirens could be strategically located in the natural areas, or existing inclement weather warning systems can be updated to warn of wildfires. The speed at which wildfires can spread leaves little time for residents to react, making timely alerts vital. Outdoor warning sirens serve as a universal signal that can quickly capture attention and convey the urgency of the situation. Moreover, they transcend language and technology barriers, ensuring that all members of the community, including those with limited access to electronic devices, receive immediate and clear warnings. By incorporating these sirens into their emergency response strategies, the City can enhance its disaster preparedness and response capabilities, ultimately safeguarding lives and property from the devastating impact of wildfires.

Steps to Complete a Prescribed Burn

1. Complete a prescribed burn plan.
2. Provide notification before burning to the appropriate agencies.
3. Install firebreaks where natural or manmade firebreaks do not already exist. The entire perimeter of the designated burn area should be inspected prior to ignition to ensure fire cannot get across the installed firebreaks.
4. Prescribed burns are only to be carried out following certain conditions, which include:
 - a. Humidity: between 25 to 40 percent
 - b. Wind Speed: between 10 to 15 miles per hour
 - c. Minimum 1 hour after sunrise and not after 1 hour prior to sunset
 - d. Always burn into the wind first 50 yards into the woods or pasture then set fire with the wind
5. Conduct a Go/No-Go Checklist for the day of the prescribed burn to ensure the burn precautions and treatment steps were implemented according to the prescribed burn plan. Example checklists and additional information can be found through the Texas A&M Forest Service.
6. Burn areas are to be carefully monitored by prescribed burn managers and local fire department personnel until the fire is out.
7. Upon completion of the burn, all notified parties should be informed the burn is complete.
8. Complete a survey about the prescribed burn through the Texas Prescribed Burn Reporting System to contribute to safe and effective future prescribed burn efforts.

OBJECTIVE 2.5 GENERAL LAND MANAGEMENT BEST PRACTICES

There are several best practices which apply to land management activities. Standardized procedures and record keeping can help enhance continuity of knowledge and efficiency in land management activities by minimizing inconsistencies or duplicative efforts.

Standardization of Operating Procedures

In order to streamline detection, treatment, and monitoring activities, it is recommended that a set of minimum standards for control, monitoring, and training be established. Standard operating procedures are recommended for the following:

- **Standardized Record Keeping.** Standardized record keeping should be utilized to facilitate interdepartmental communication, early detection, rapid response, and long term monitoring.
- **Volunteers.** Volunteers are an essential asset to successful invasive species management. Effective use of volunteers requires that their efforts be coordinated with city staff and that volunteers receive proper training. A consistent policy should be developed to ensure appropriate city and volunteer coordination and training to guide volunteer efforts.
- **Fuel reduction.** As discussed in greater detail in Objective 2.3.2, standardized procedures for the regular maintenance, thinning, and removal of vegetative fuel can help mitigate wildfire risks.
- **Trail construction and maintenance.** Discussed in greater detail in Objective 3.1.2, standards for trail construction and maintenance can help ensure trails are safe, sustainable, and enjoyable.

Land Management Record Keeping

The San Marcos PARD and its partners have been actively managing and improving the natural areas through trail development, invasive species control, and other methods. However, piecing together a narrative of their efforts currently relies heavily on the institutional memory of key individuals. A simple, standard stewardship action form, such as the **Habitat Monitoring Form, Pollinator Habitat Monitoring Form, and Pollinator Habitat Evaluation Form** found in the **Appendix**, should be utilized in the future to help future caretakers understand the actions that have been taken, and provide an avenue by which management successes and failures can be better understood.

It is recommended the park staff keep a form and require all volunteer groups to complete said form. The form should be filled out at the time of a land management activity that includes area treated, location of area, size of area how it was treated, resources used (including labor), along with photo documentation. These areas should then be documented as areas to be regularly evaluated with the use of existing photo points.

The Austin Watershed Department also uses pre-made handouts to guide volunteer efforts regarding invasive species control and restoration. An example guide, titled **Guide to Self-Led Johnsongrass, Bamboo & Giant Cane Management Workday** is provided in the **Appendix**. More example forms can be found on the City of Austin Watershed Protection Department's website under Creekside Restoration FAQs. (<https://www.austintexas.gov/content/1361/faq/14739>)



ACCUMULATED BRUSH



TRAIL SIGNAGE AND WAYFINDING



TRAIL IN SCHULLE CANYON NATURAL AREA

GOAL 3: USE, SAFETY, AND CONNECTIVITY

The establishment and implementation of use, safety, and connectivity land management objectives provide essential guidance for management of the San Marcos natural areas, working within the opportunities and constraints set out by the natural resource preservation and natural resource management goals and objectives.

The following management objectives address use, safety, and connectivity.

- Objective 3.1 Safe and Accessible Trail Systems
- Objective 3.2 User Safety and Education
- Objective 3.3 Trail Connectivity and Expansion

Public use, safety, and trail connectivity are important aspects of land management in natural areas, as they enable residents and visitors to engage with and benefit from these valuable resources. Establishing and implementing land management objectives that properly balance public access and trail connectivity with preserving the ecological integrity of the natural areas is of paramount importance. Achieving this balance requires careful planning and collaboration with stakeholders, and the development of strategies that promote responsible recreation and ensure the long-term sustainability of these cherished landscapes. By effectively managing public use, safety, and trail connectivity, the City can foster a harmonious relationship between people and nature, providing opportunities for enjoyment, education, and appreciation while safeguarding the ecological health and resilience of the natural areas.

The most important public use, safety, and trail connectivity land management objectives for the natural areas include:

- **Safe and Accessible Trail Systems.** Developing and maintaining a network of safe and accessible trails that provide opportunities for public recreation while minimizing risks. This objective includes ensuring proper trail design and maintenance, address potential hazards, and providing clear directions and information to trail users.

- **Visitor Safety and Education.** Implementing measures to promote visitor safety, including the provision of safety information, trail regulations, and guidelines for responsible behavior. This objective also involves educating visitors about potential risks, emergency procedures, and the importance of practicing Leave No Trace principles to minimize impacts on the natural environment. Visitor safety can sometimes involve closing trails, either to allow for repairs or hazard removal, or because factors such as wet weather can create unsafe conditions or cause damage to trails.
- **Trail Connectivity and Expansion.** Enhancing trail connectivity within and between the natural areas and other bicycle/pedestrian components of the city transportation system, including sidewalks, green alleys and urban trails, to create a comprehensive system that allows for seamless movement and exploration. This objective involves identifying key trail corridors, establishing new connections, and collaborating with neighboring communities, landowners, and agencies to expand trail networks and promote connectivity.

By focusing on these public use, safety, and trail connectivity land management objectives, the natural areas can provide enjoyable and accessible experiences for visitors while ensuring their safety, protecting the environment, and fostering a sense of connection to the natural world.



TRAIL SIGNAGE, WAYFINDING, AND AMENITIES

OBJECTIVE 3.1 SAFE AND ACCESSIBLE TRAIL SYSTEMS

Establishing and implementing land management objectives for safe and accessible trail systems in natural areas is essential for ensuring enjoyable outdoor experiences while prioritizing visitor safety and environmental protection.

These objectives aim to create well-designed trails that offer access to the natural beauty of the natural areas while minimizing risks, providing clear wayfinding, and incorporating universal design principles to accommodate diverse user groups. By setting clear goals, engaging stakeholders, and implementing effective strategies, land managers can develop trail systems that promote inclusivity, enhance visitor experiences, and preserve the ecological integrity of the surrounding environment.

OBJECTIVE 3.1.1 TRAIL COUNTING

Trail counting is a process used to determine the number and other characteristics of trail users. The process can be manual, such as sign-in or registration by users or by persons staffing trailheads, or the process can involve the use of automated counters. Both manual and automated counter processes have been used in the past in some of the San Marcos natural areas. This objective focuses on the use of automated counters.

Trail counting can serve several useful purposes. First, it can provide valuable data and insights into visitor usage patterns. By understanding peak usage times, trail popularity, and visitor demographics, land managers can optimize trail experiences, address overcrowding concerns, and allocate resources effectively.

Second, trail counting can help monitor and assess the impact of visitation on the natural environment. This will allow land managers to implement measures to mitigate negative impacts, and strike a balance between providing public access and preserving the ecological integrity of the natural areas.

Third, trail user data can help demonstrate the benefits of trails in a quantitative way, which can assist in securing funding for trail improvements. A number of agencies include trail user data in the factors influencing funding decisions.

Some of the best practices for establishing and implementing a Trail Counter Program in the San Marcos natural areas include:

- **Clearly Define Purpose.** Determine the specific purpose of the trail counter program. Identify what information needs to be collected, such as trail usage patterns, visitor demographics, or peak usage times, and determine how the information will be used. This will help guide the implementation process and ensure the program meets its intended purpose.
- **Select Appropriate Technology.** Choose trail counter technology that aligns with the purpose and setting of the program. Consider factors such as accuracy, reliability, ease of installation and maintenance, compatibility with the trail environment, and data collection capabilities. Consider any applicable standards, such as those of the Texas Department of Transportation (TxDOT), that apply to the technology. The chosen technology should be able to provide accurate and meaningful data for analysis and decision-making.

Other City departments may have a need for use of pedestrian counters for other purposes, such as quantifying pedestrian activity along sidewalks and other transportation corridors. As such, consider use of trail counter technology that may also be used by the other departments.

- **Strategic Placement.** Carefully select the locations for installing trail counters. Place them at key trailheads, trail intersections, or other relevant points to capture representative data. Consider factors such as trail popularity, visitor flow, and diversity of trail experiences. Install counters in a way that minimizes interference with the natural environment and visitor experience. Trail counters can also be used to help enforce trail closures (e.g., user-created informal trails or seasonal trail closure for protected species).
- **Proper Installation and Maintenance.** Ensure the trail counters are correctly installed and regularly maintained. Follow manufacturer guidelines for installation and calibration to ensure accurate data collection. Regularly inspect and maintain the counters to ensure they are functioning properly and to address any technical issues promptly.
- **Data Management, Analysis, and Use.** Establish a system for managing and analyzing the trail counter data. This may involve using software or online platforms specifically designed for data analysis. Develop protocols for data collection, storage, and analysis to ensure consistency and reliability. Use the collected data to inform trail management decisions, such as trail maintenance, resource allocation, or visitor education initiatives. Data points should be integrated into a GIS-based platform so information can be assessed both quantifiably and spatially over time.

- **Stakeholder Engagement.** Engage stakeholders, including neighborhoods and user groups, in the trail counter program. Communicate the objectives and benefits of the program, and seek input and feedback from stakeholders. Encourage collaboration and involve stakeholders in the interpretation and utilization of the collected data. Implementing and maintaining a robust trail counter program is an ideal opportunity for user groups (e.g., SMGA) to get involved.
- **Privacy and Data Protection.** Establish protocols to protect visitor privacy and ensure data security. Adhere to relevant privacy laws and regulations when collecting and storing visitor data. Consider anonymizing data and using aggregate data reporting to protect individual privacy.
- **Use of Data.** Use the collected data to inform trail management decisions, such as trail maintenance, resource allocation, or visitor education initiatives. Data points should be integrated into a GIS-based platform so information can be assessed both quantifiably and spatially over time. Use data to prepare periodic reports of visitor usage of the natural areas and opportunities for changing management objectives in the future.
- **Communication and Outreach.** Effectively communicate the purpose and results of the trail counter program to trail users and the wider community. Provide information on the program’s objectives, how the data will be used, and any resulting trail management actions. Use various communication channels, such as signage, websites, or social media, to share updates and encourage visitor participation.

By following these best practices, a trail counter program can effectively collect valuable data on trail usage in natural areas, enabling informed decision-making and promoting sustainable trail management practices.



TRAIL CLOSURE DURING GOLDEN-CHEEKED WARBLER SEASON

TRAIL COUNTING IN ACTION

Between May and June, four trail counters were installed at various locations in the Purgatory Natural Area and Spring Lake Natural Area in order to collect data on trail usage in these areas. Trail use data is summarized below in **Table 4.2, Trail Counter Data**. Because this data was collected in early summer months, the City should consider performing similar data collection during spring and fall seasons when trail use is generally at its peak. The City should also consider collecting trail use data for the other natural areas.

TABLE 4.2, TRAIL COUNTER DATA

	Upper Purgatory Creek Natural Area	Spring Lake Natural Area
Total Use Count	4657	1643
Average Daily Use Count	115	15

TRAIL CLOSURE DATA

Between March 1st and May 31st each year certain trails within Upper Purgatory Creek and Spring Lake Natural Areas are closed to protect Golden-Cheeked Warblers, an endangered bird species, during their breeding season. In 2022, a trail counter was placed on Paraiso Trail in Upper Purgatory Natural Area from May 14th to June 23rd to measure the effectiveness in closing the trail. As seen in **Table 4.3, Golden-Cheeked Warbler Trail Counter Data**, closing the trails and posting signs informing trail users why the trail is closed greatly reduced the average daily count during this period.

TABLE 4.3, GOLDEN-CHEEKED WARBLER TRAIL COUNTER DATA

	Upper Purgatory Creek Golden-Cheeked Warbler Trail
Average Daily Use Count on Closed GCW Trail	1
Average Daily Use Count on Open GCW Trail	11

OBJECTIVE 3.1.2 BASIC TRAIL DESIGN, CONSTRUCTION AND MAINTENANCE STANDARDS

Adhering to trail design and maintenance standards is of paramount importance when it comes to developing and managing trails in the natural areas. The standards set out in this Objective are guidelines and best practices that help ensure trails are safe, sustainable, and enjoyable for visitors while minimizing the impact on the environment—a paramount priority for San Marcos. By following these standards, land managers can strike a balance between providing access to natural areas and preserving their ecological integrity.

Importance of Adherence to Trail Standards:

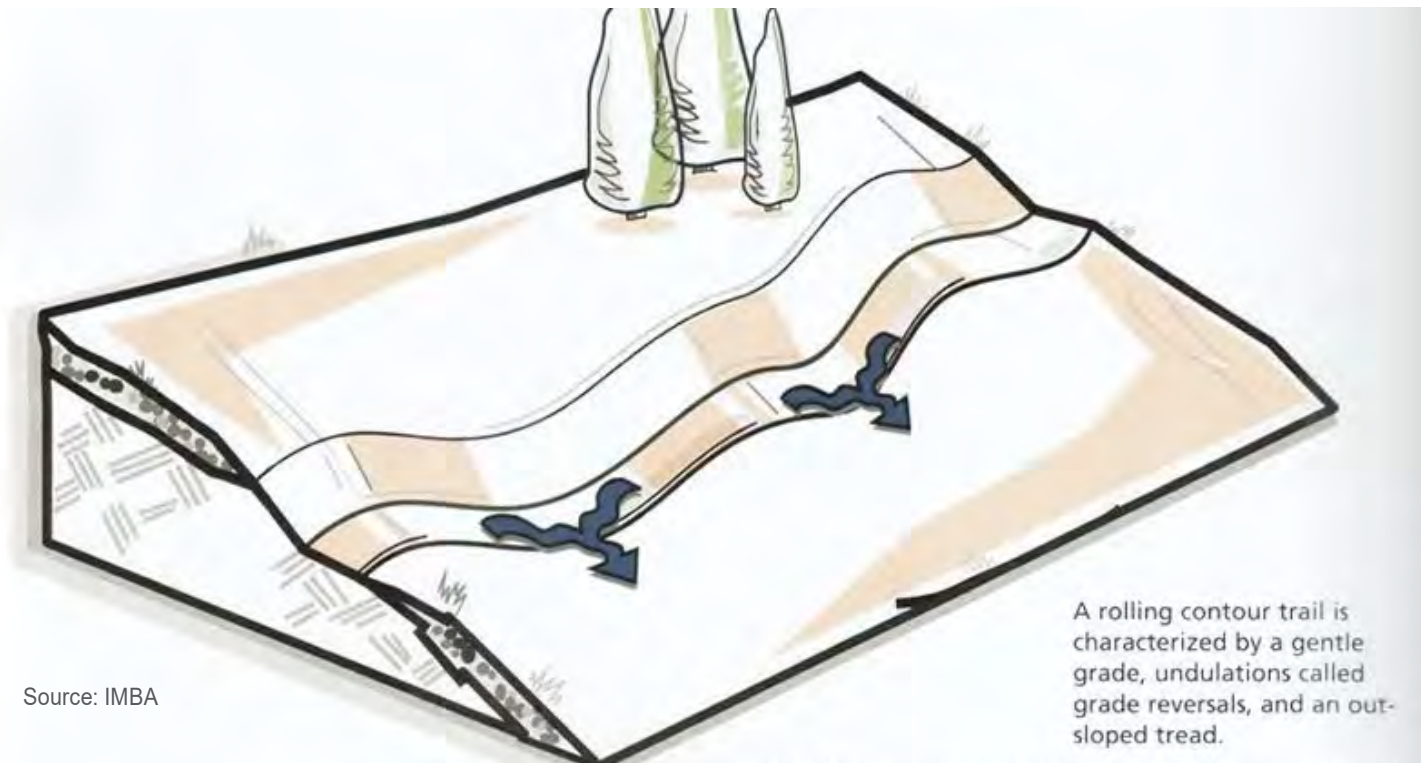
Adhering to trail standards in natural areas is important for several reasons. First, it helps to ensure the safety of trail users. Second, it will improve accessibility for diverse user groups. Third, it will enhance the overall trail experience. Fourth, it will help protect the natural environment by minimizing erosion, preserving sensitive habitats, and preventing damage to vegetation and wildlife.

Basic Trail Standards:

Basic trail design, construction and maintenance standards for the natural areas include the following:

- **Width.** Trail width should accommodate the expected user capacity and desired trail experience, and will vary with the trail type. Generally, trail width in the natural areas should be as narrow as possible for each trail type.
- **Slope and Grade.** Gentle slopes and manageable grades should be used to enhance user safety and accessibility. Generally, grades should not exceed 5% for accessible trails and 10% for other trails. Trails in steeper terrain should include switchbacks or steps for ease of ascent and descent.
- **Tread Surface.** Utilize native materials on the site to the greatest extent possible. When adding materials, utilize natural materials, such as soil, gravel, or crushed stone. Compact the surface to minimize erosion. Avoid adding materials that may cause erosion or damage to the surrounding environment. In higher trafficked areas such as trailheads or on shared use trails, a more durable surface may be warranted, but used sparingly.

FIGURE 4.2, ROLLING CONTOUR TRAIL DESIGN



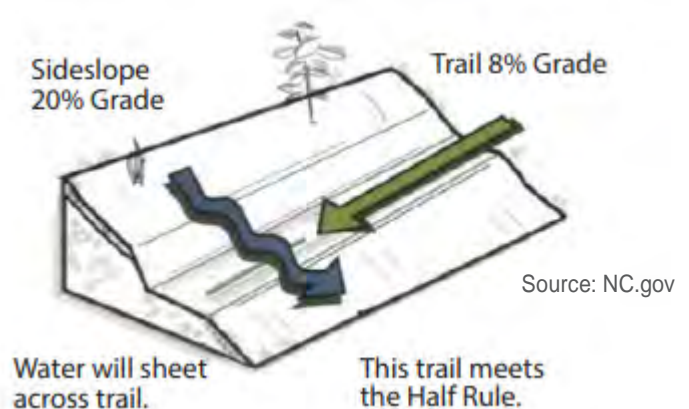
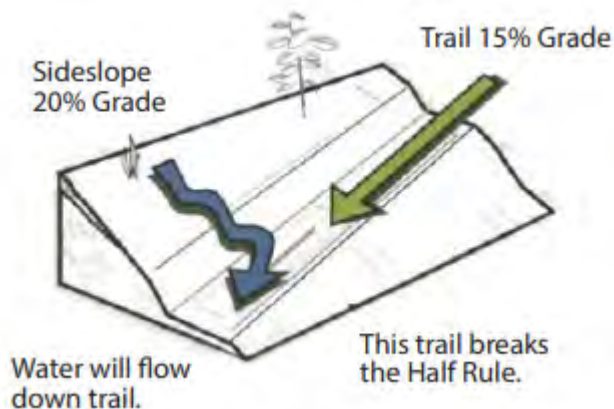
Source: IMBA

ANY NATURAL SURFACE TRAIL SHOULD BE DESIGNED WITH OUTSLOPE AND GENTLE ROLLING TERRAIN TO SHED WATER

- **Erosion Control.** Route trails perpendicular to the slope and with rolling contours and grade reversals as much as possible. Construct and maintain trails so that tread is outsloped to direct drainage off the trail instead of along the trail. The “half rule” should be followed when constructing trail along a side-sloping area: a trail’s grade should not exceed half that of the side slope. Incorporate properly designed and constructed water bars and rock armoring to prevent trail erosion. When paving or adding materials to the tread surface, ensure that the paving or materials maintain natural drainage patterns. When necessary, excavate existing materials so that added materials do not alter existing drainage.
- **Clearance and Overhead Obstacles.** Ensure adequate clearance height for trail users, including cyclists, to pass under overhead obstacles like tree branches. Trim or remove vegetation that may impede trail access or pose a safety risk. Clearance height should be tailored to meet the character and experience intended for the trail. For example, a single-track trail used primarily for hiking can have less clearance to maximize the feeling of being immersed in nature. A shared-use trail should have greater clearance to meet the needs of a busier trail segment.
- **Signage and Wayfinding.** Install clear and visible signage at trailheads, intersections, and other points to guide users and prevent confusion. Include trail maps, trail difficulty ratings, and safety information. Use interpretive signs to point out natural features and educate trail users. Use consistent signage standards for ease of understanding.
- **Crossings and Structures.** Design safe and sturdy crossings for streams, wetlands, and other natural features. Install bridges, boardwalks, or stepping stones where necessary to protect sensitive habitats and allow for user passage.
- **Amenities and Facilities.** Provide appropriate amenities along trails, such as rest areas, benches, picnic tables, and trash receptacles. Consider the need for accessible parking, restrooms, and potable water sources based on trail length and anticipated user demands.
- **Accessibility.** Incorporate appropriate design principles to ensure trails are accessible to individuals with disabilities to the extent possible. Consider features like gentle slopes, wider tread, handrails, and resting areas.
- **Natural Resource Protection.** Design, construct, and maintain trails to minimize impact on sensitive natural resources. Route trails to avoid sensitive habitats, cultural sites, and wildlife corridors. Use best practices for vegetation restoration and erosion control to protect the surrounding environment.
- **Maintenance and Monitoring.** Perform regular trail maintenance, including vegetation management, erosion control, and infrastructure repairs. Establish monitoring protocols to assess trail conditions, user feedback, and potential environmental impacts.

Over the course of the following pages, guidance is provided regarding the following:

- Trail design guidance basics, including recommendations on trail loops and stacking; trail width, surface, accessibility, clearance, mode split, intersections, design speed and connectivity
- Trail design features and guidance sources
- Trail typologies appropriate for natural areas, including single track trails, double track trails, shared-use trails, riparian corridor trails, vehicle trails/service roads, and utility easement trails



Source: NC.gov

TRAILS CONSTRUCTED ALONG A SIDE-SLOPING AREA SHOULD ADHERE TO THE “HALF-RULE” TO MINIMIZE EROSION

FIGURE 4.3 TRAIL LOOPS & STACKING

Creating loop trails and implementing trail stacking in the natural areas offer several benefits for both visitors and the environment.

Loop trails, which start and end at the same location, provide a sense of completion and allow hikers to experience a variety of scenery and habitats during their journey. They enhance visitor satisfaction by eliminating the need to backtrack, and can offer opportunities for different loops of varying lengths and difficulty levels.

Trail stacking, on the other hand, involves multiple trails overlapping or intersecting at strategic points, allowing for more diverse experiences and route options. This approach can maximize the efficient use of trail networks, optimizing space and resources

while reducing the impact on the environment. Both loop trails and trail stacking provide opportunities for exploration, reduce trail congestion, and enhance safety. They can also support trail sustainability by distributing visitor use more evenly and reducing the ecological disturbance associated with linear trails. However, the use of loop trails and trail stacking strategies should be considered cautiously in light of other management objectives such as natural resource preservation and native habitat restoration. In planning trails in a natural area, there is a point at which the number and extent of trails can overwhelm ecological protections and lead to habitat degradation. Keep in mind that protection of natural resources is the primary purpose of the natural areas; recreational use is secondary.

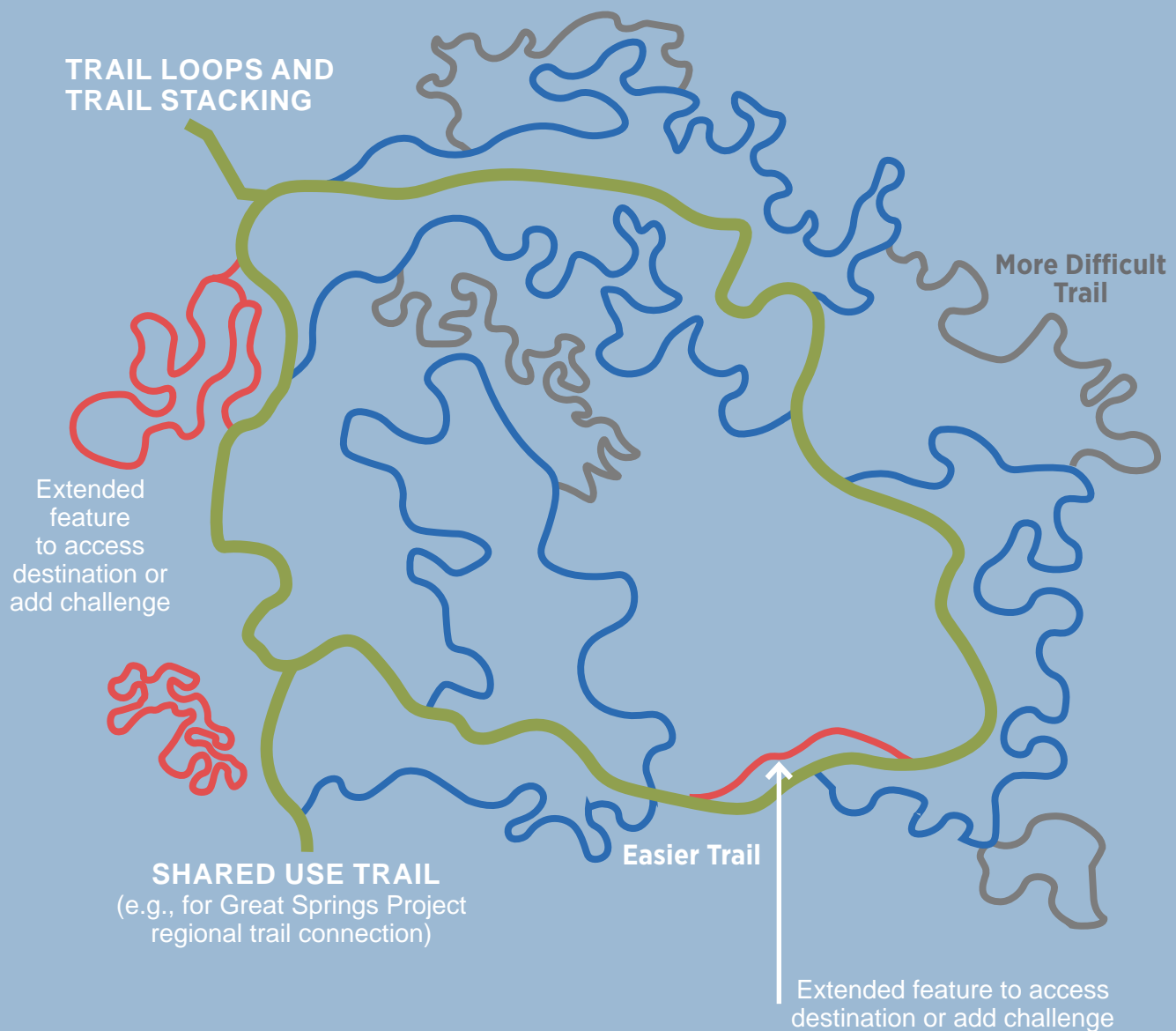


FIGURE 4.4, MISCELLANEOUS TRAIL DESIGN GUIDANCE

TRAIL WIDTH

Although national guidance suggests a standard (two-way) shared-use trail width of 10 feet, greater widths can better accommodate bicycle and pedestrian traffic for popular trail segments. The FHWA’s Shared-use Path Level of Service Calculator (SUPLOS) may be used during design to determine if trail widths of greater than 10 feet are needed. Narrower trail widths may be necessary at times for lesser used pedestrian-only connector segments.

TRAIL SURFACE

For maximum accessibility, many shared-use trails employ a hard surface such as asphalt or concrete. However, in the natural areas, the predominant surface should be materials such as crushed stone for heavy trafficked areas (e.g., near trailheads) and just natural surface for other trails.

TRAIL CLEARANCE

Well-designed and maintained shared-use trails should be kept clear of obstructions. Horizontal clearance – the distance from the trail edge to the nearest adjacent encroachment – will vary from a minimum of 2 feet or more depending on whether accessory amenities such as signage or seating are present. Vertical clearance should be a minimum of 10 feet.

ACCESSIBILITY

National guidelines establish clear requirements on maximum cross-slopes, running grades, compliant curb ramps and more to ensure trail accessibility to a wide cross-section of users. The US Access Board’s Public Rights-of-Way Accessibility Guidelines (PROWAG) should be consulted to ensure compliance with the Americans with Disabilities Act (ADA). In the natural areas, this will primarily affect more heavily trafficked areas.

MODE SPLIT

In some heavily trafficked areas, where high volumes of users are expected, consideration should be given to splitting users onto two parallel facilities. An example of this is where a prominent citywide greenway trail (e.g., the main corridor alignment of the Great Springs Trail) traverses a natural area.

INTERSECTIONS

There may be areas where the natural area trail system crosses vehicular roadways at controlled and uncontrolled intersections. In these instances, pavement markings, signage, signalization and traffic calming features may be used, based on trail user and traffic volumes, street widths, mid-block versus intersecting street locations, and the location of the trail crossing.

DESIGN SPEED

There is no common design speed recommended for shared-use trails. Design speed will vary depending on the type of users (and mode split) anticipated, terrain and preferred surface. Design speed should consider the fastest possible user which the trail may accommodate (i.e. walkers, hikers, recreational bicyclists, mountain bikers) and how the user’s speed may be moderated in a way that respects the comfort and safety of slower trail users.

CONNECTIVITY

Trail safety, comfort and utilization will depend on the frequency of access points to and from adjacent properties. The City’s development codes should require unobstructed pathways between adjacent development and all nature area trail corridors where feasible and should define an expected frequency of access points from adjacent development to trail corridors.

FIGURE 4.5, SPECIALIZED TRAIL DESIGN FEATURES & SOURCES

The specific focus of many types of recreational trails means that they should incorporate specialized design features to serve the unique needs of focused user groups.

HIKING TRAILS

Hiking trails provide able-bodied hikers and walkers with the opportunity to enjoy an “up-close” experience with the surrounding natural environment and are often located in areas with challenging topography that may be inaccessible to some users. Hiking trail design is meant to promote passive enjoyment of nature and low-impact design is meant to limit disturbances to the area.

Essential United States Forest Service resources on hiking trail design include the following:

- Standard Trail Plans and Specifications (2014)
- TRACS, Trail Assessment and Condition Surveys (2011)
- Forest Service Trail Accessibility Guidelines (2013)



HIKING TRAILS

BICYCLES / MOUNTAIN BIKING TRAILS

Specialized mountain biking trails (including cross-country, flow, and downhill sub-types) can be designed to utilize natural terrain to provide users with riding challenges extending across a range of difficulty. Mountain biking trails can include design features that combine speed, jumps and drops.

Key mountain biking trail features include trailheads with parking, wayfinding and bike maintenance features, hub markers for orientation and trail signage that provides a description of the features of each trail segment and trail safety/etiquette. The International Mountain Biking Association (IMBA) produces authoritative resources on mountain bike trail design:

- Guidelines for a Quality Trail Experience (2018, with the U.S. Dept. of Interior, Bureau of Land Management)
- Trail Solutions, IMBA's Guide to Building Sweet Singletrack (2004)

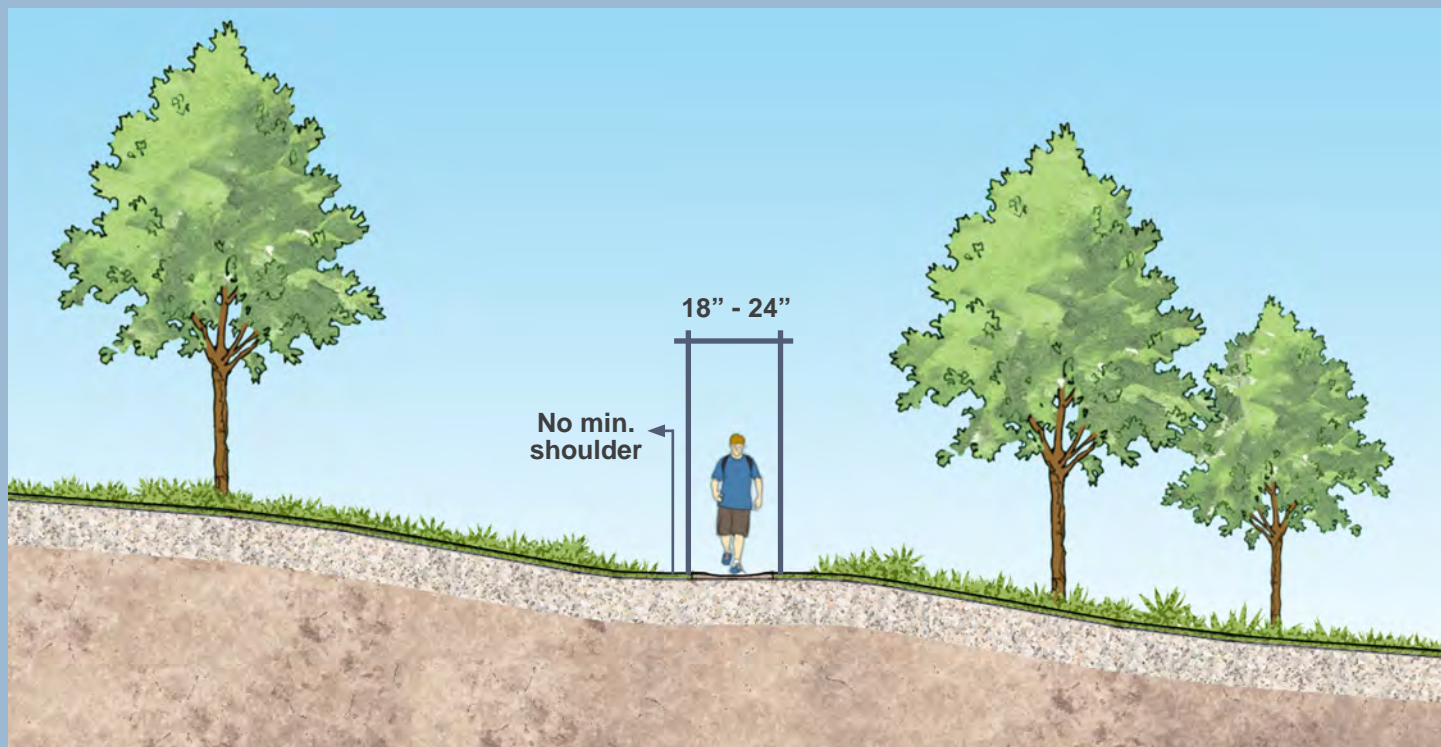
At the present time, there are no trails in the natural areas that are restricted solely to either bicycle or pedestrian use. In the future, the City may wish to consider using such restrictions in the interest of safety and to prevent trail user conflicts, after appropriate stakeholder input and consideration of alternatives.

Electric bicycles (e-bikes) are becoming increasingly popular in San Marcos, and increased use is occurring on trails in the natural areas. E-bikes fall into three classes based on speed limitations and whether the motor can be engaged without peddling by the rider. In the future, the City may wish to restrict e-bike use on specific trail segments to certain classes, or prohibit e-bike use on specific trail segments.



MOUNTAIN BIKING TRAIL

FIGURE 4.6, SINGLE TRACK TRAIL CROSS-SECTION



TPOLOGY DESCRIPTION

Single track trails have a tread width of approximately 18-24 inches which allows for use in a single-file manner. These trails are characterized by use of existing materials or other natural materials for tread surface. Single track trails should comply with all applicable basic trail standards.

TYPICAL USERS

Hikers, walkers/runners, mountain bikers

SUITABLE LOCATIONS

Single track trails are most appropriate in environmentally sensitive areas where little disturbance to the natural area is desired. Because these trails utilize natural surface materials and minimize changes to the natural terrain, erosion and increased runoff are minimal and readily mitigated as long as the basic trail standards regarding erosion control are followed. In terms of trail stacking, single track trails should be used to connect users to the most intimate experience of being in a natural area.

REPRESENTATIVE EXAMPLES



Ringtail Ridge Natural Area
San Marcos, TX

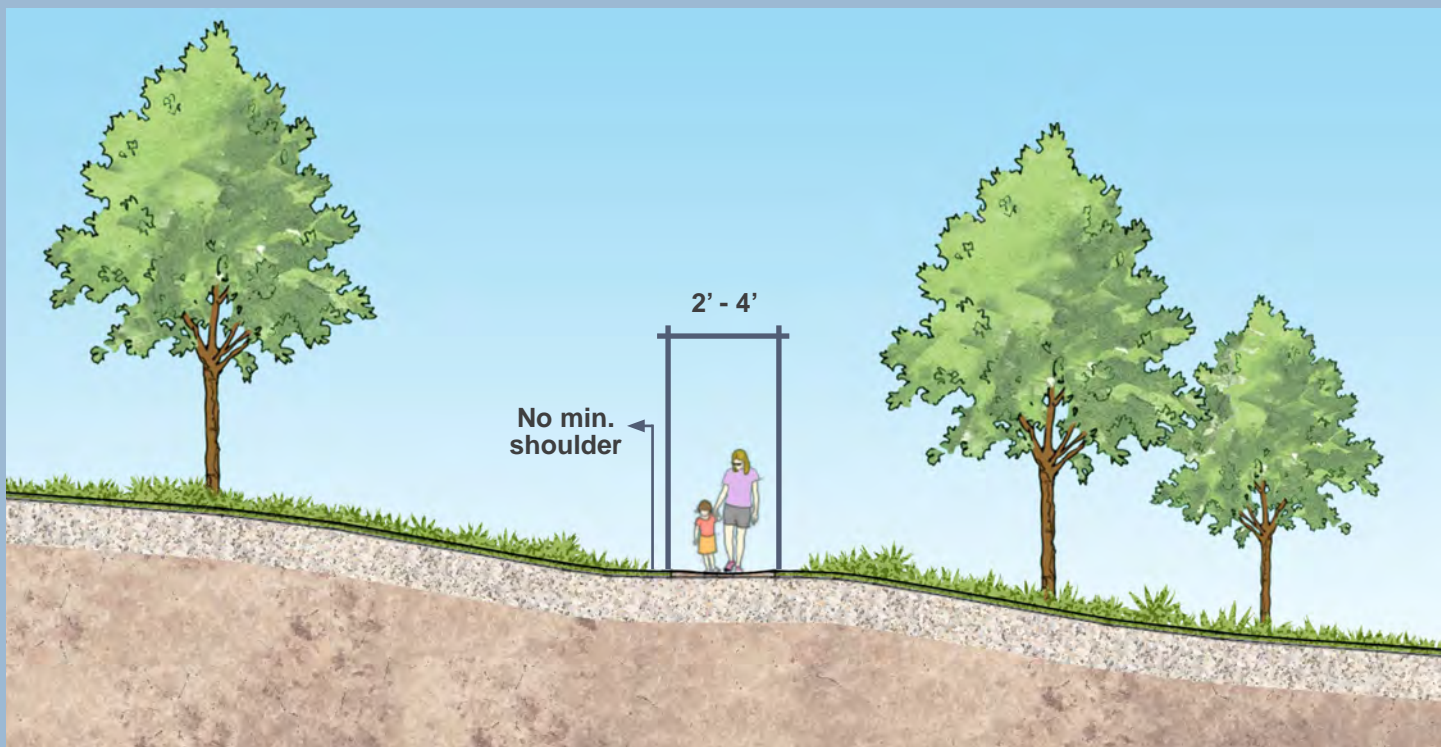


Tejas Park Trail
Liberty Hill, TX



Cypress Creek Hike & Bike Trail
Houston, TX

FIGURE 4.7, DOUBLE TRACK TRAIL CROSS-SECTION



TYOLOGY DESCRIPTION

Double track trails are utilized in the same manner as single-track trails with the exception of a primary tread width of 4 feet, which allows passage of two users side-by-side or for a 4-wheel All-Terrain Vehicle (ATV) or utility vehicle. Most natural surface trails fall within the double track trail category.

Vehicle access on unpaved double track trails should be restricted to fire crews, maintenance crews, or other first responder groups, generally in the event of an emergency. Natural surface double track trails should comply with all applicable basic trail standards.

TYPICAL USERS

Hikers, walkers/runners, mountain bikers

SUITABLE LOCATIONS

Double track trails are appropriate in environmentally sensitive areas where little disturbance to the natural area is desired. Because these trails utilize natural surface materials and minimize changes to the natural terrain, erosion and increased runoff are minimal and readily mitigated as long as the basic trail standards regarding erosion control are followed. In terms of trail stacking, double track trails should be used for loop trails and as a connection between multi-use and single track trails.

REPRESENTATIVE EXAMPLES



Round Rock Lake Creek Trail
Round Rock, TX

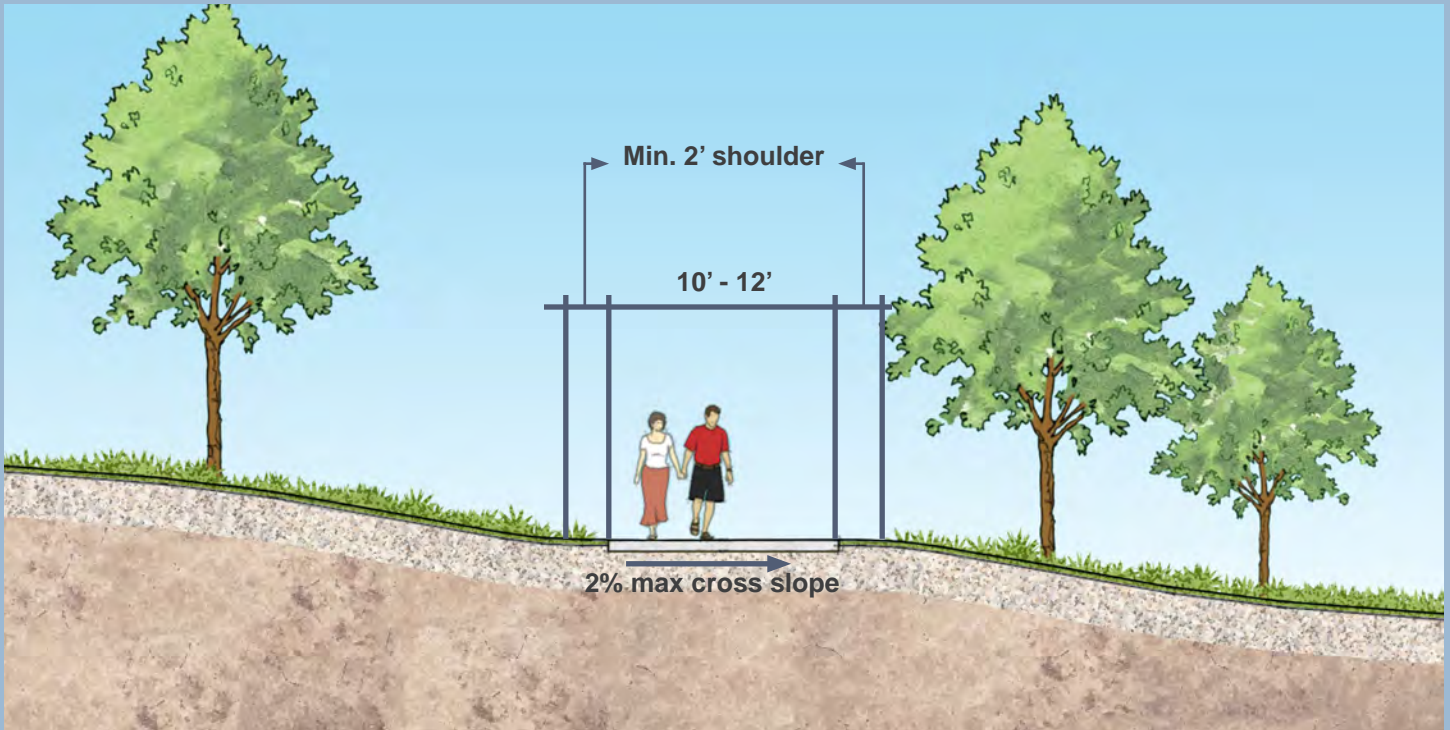


Purgatory Creek Natural Area
San Marcos, TX



Brushy Creek Trail
Round Rock, TX

FIGURE 4.8, SHARED-USE TRAIL CROSS-SECTION



TYOLOGY DESCRIPTION

Shared-use trails have a tread width of 8 to 12 feet, depending on location and intended use. These trails would typically be natural surface in the natural areas, but in higher trafficked areas, they could be paved with concrete, asphalt, or other materials to allow for a wider range of user types and to be ADA compliant.

TYPICAL USERS

Hikers, walkers/runners, cyclists, stroller pushers

SUITABLE LOCATIONS

Shared-use trails should generally be located in less environmentally sensitive areas. Multi-use trails could be constructed with natural surface materials in environmentally sensitive areas. In terms of trail stacking, these trails would be most applicable in less environmentally sensitive areas and should form spine trails which connect the natural areas to each other, to the City's broader transportation system, and to regional trails like the Great Springs Trail.

REPRESENTATIVE EXAMPLES



Upper Purgatory Natural Area
San Marcos, TX

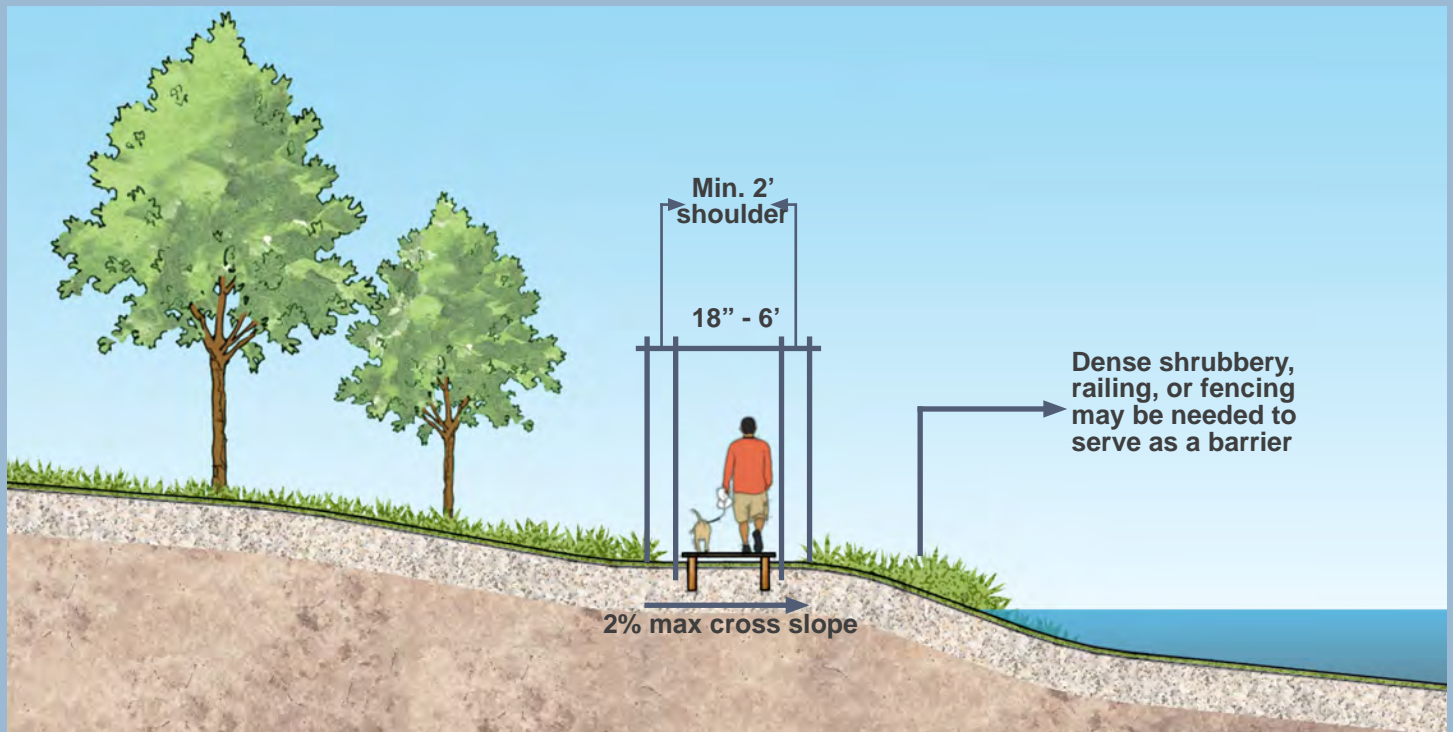


Schulle Canyon Natural Areas
San Marcos, TX



Katy Trail
Dallas, TX

FIGURE 4.9, RIPARIAN CORRIDOR TRAIL CROSS-SECTION



TYOLOGY DESCRIPTION

Riparian corridor trails will have a tread width of 18 inches to 6 feet, depending on context and intended use. These trails should be constructed with soft surface materials either earth, wood chip, or boardwalk in some instances. These trails are intended as a low-impact solution.

TYPICAL USERS

Hikers, walkers/runners, cyclists, stroller pushers

SUITABLE LOCATIONS

These trails may be located in areas with limited development, along creeks, rivers, or wetlands, in floodways, floodplains, and other areas that are subject to flooding, and in environmentally sensitive areas. Width and surface materials will depend on context and environmental use restrictions.

REPRESENTATIVE EXAMPLES



Lady Bird Lake Trail
Austin, TX

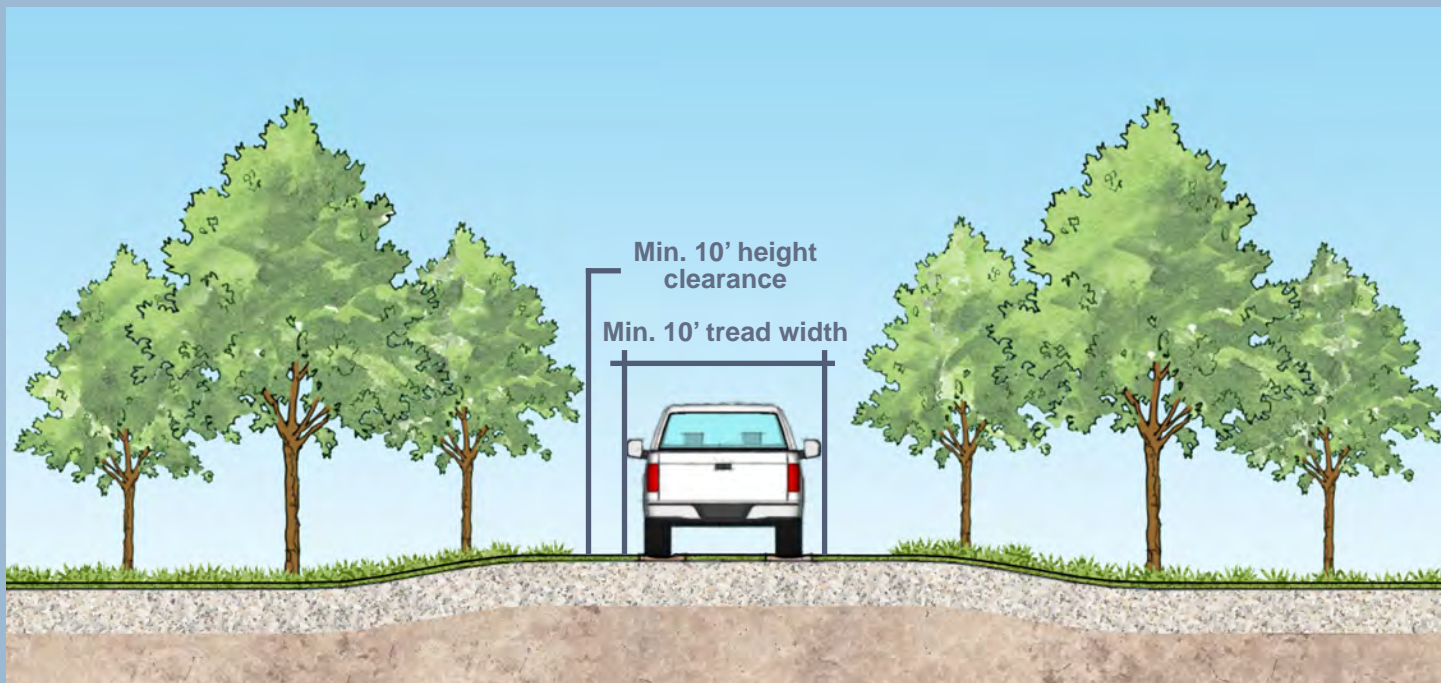


Ringtail Ridge Natural Area
San Marcos, TX



Walnut Creek Trail
Austin, TX

FIGURE 4.10, VEHICLE TRAIL / SERVICE LANES CROSS-SECTION



TPOLOGY DESCRIPTION

Vehicle trails or service lanes are intended for utilization by emergency responders and maintenance crews. Vehicle tracks segments may overlap with portions of single or double-track trails. The corridor should be a clear opening of minimum 10 feet width and height with a 10-foot tread. The tread may be constructed of crushed stone, gravel, or a thick, non-woody ground cover. Service lanes should contain steel (or similar material) pin markers on the driver's side positioned as needed, typically at locations where the lanes change directions, enter tree cover, or at a frequency that allows drivers a line of sight to the next marker in open areas. Clearances should be maintained at least annually.

TYPICAL USERS

Off-highway vehicles (OHVs) and light-duty trucks used for maintenance personnel or emergency responders

SUITABLE LOCATIONS

Emergency services such as the City Fire Department should be consulted for trail locations for brush or fire truck access. The Parks and Recreation Department will determine needs for additional vehicle trails or service lanes for maintenance requirements.

REPRESENTATIVE EXAMPLES



Blanco Shoals Natural Area
San Marcos, TX

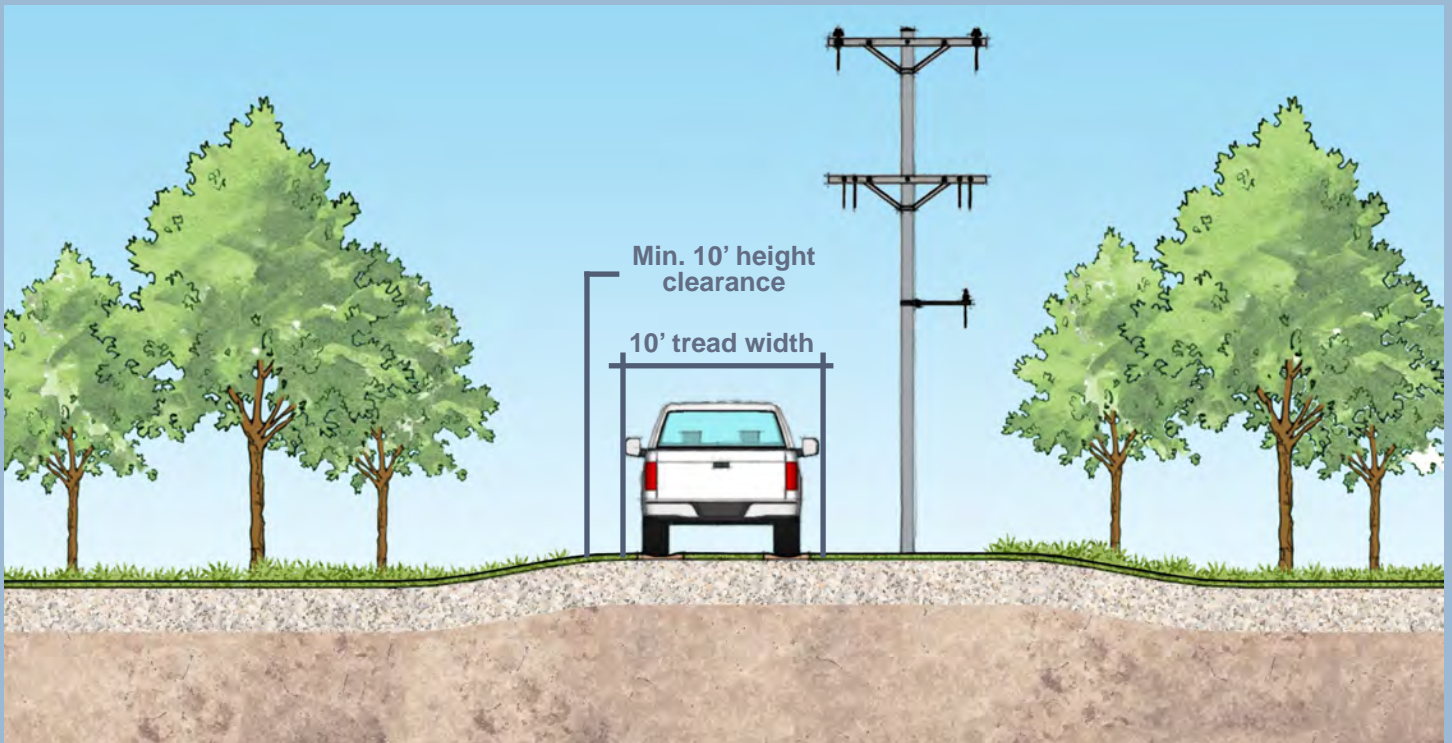


Purgatory Creek Natural Area
San Marcos, TX



Utility Service Access
San Marcos, TX

FIGURE 4.11, ROW TRAIL CROSS-SECTION



TPOLOGY DESCRIPTION

Utility easement trails, otherwise known as right-of-way trails, often follow along power lines, underground utility lines, or even railroad lines. Utility easement trails can vary in width depending on right-of-way available but will generally follow vehicle trails or service lane standards.

While not the most ideal natural area trail typology, these protected corridors can provide key connections to enhance overall connectivity

When possible, the trail surfaces should consist of natural materials in the natural areas.

REPRESENTATIVE EXAMPLES

TYPICAL USERS

Multiple users, including utility and service vehicles

SUITABLE LOCATIONS

The location of these easements will be pre-determined by the utility company, but the specific context may influence the type of trail provided. For example, some easement trails may exist in environmentally sensitive areas or near bodies of water and should follow single-track trail standards. In other scenarios, power line easements may be along wide, flat easements and allow for a multi-use trail or vehicle trail. Some easements may not have public access for trail users. New utility corridor easements should include the dedication of public access easements.



Preston Ridge Trail
Dallas, TX



Northaven Trail
Dallas, TX



Southwest Houston Trail
Houston, TX

OBJECTIVE 3.1.3 TRAIL MATERIALS

When selecting trail materials for natural areas, it is important to consider factors such as sustainability, durability, and compatibility with the surrounding environment. Here is a list of appropriate trail materials commonly used in natural areas:

- **Compacted Soil**
- **Gravel**
- **Decomposed Granite**
- **Wood**
- **Recycled Plastic**
- **Concrete or Asphalt**
- **Natural Stone**

A table explaining the pros and cons of each of these materials is on the following page.



Eco-Friendly Trail Design and Materials

These materials and approaches can be considered to incorporate values of sustainability as trails are designed and built.

- **Aggregate Binding.** Natural surface trails can use a binding application that allows for water permeability while maintaining the durability and accessibility of a paved trail.
- **Native Planting and Contour Filters.** Grading and landscaping should utilize native plantings and techniques that encourage surface water filtration and provide benefits such as drought mitigation, flood mitigation, groundwater enhancement, and habitat regeneration.
- **Carbon Sequestering Concrete.** When concrete is needed, carbon sequestering processes can be applied to improve the overall sustainability of the project, without compromising characteristics of the material.

It is important to select trail materials that are ecologically compatible, minimize erosion, and promote sustainability. When choosing materials, consider the local climate, the expected trail usage, and the potential impact on the natural environment. Regular maintenance and monitoring should also be conducted to ensure the trail materials remain in good condition and any necessary repairs or modifications are addressed.



NATURAL SURFACE TRAIL MATERIALS SHOULD BE THE PRIMARY TRAIL MATERIAL USED

FIGURE 4.12, TRAIL MATERIALS

Example	Material	Pros	Cons
	<p>Compacted Soil</p>	<p>Compacted soil is a cost-effective option that blends well with the natural surroundings. It requires minimal maintenance and provides a natural appearance. It can also be reinforced with stabilizers to enhance durability.</p>	<p>Compacted soil may become muddy during wet conditions and can erode over time, requiring periodic maintenance. It may also be less suitable for heavily trafficked areas.</p>
	<p>Crushed Stone/Gravel</p>	<p>Crushed stone or gravel provides a firm and stable surface that allows for proper drainage. It is more durable than soil, capable of withstanding heavy foot traffic, and can be easily replenished. It is also visually appealing and compatible with various natural settings.</p>	<p>Gravel trails may require periodic regrading and maintenance to address unevenness or erosion. Loose gravel may pose challenges for some users, particularly those with mobility issues or those using bicycles or other wheeled devices.</p>
	<p>Wood</p>	<p>Wood is commonly used for elevated boardwalks, bridges, and steps in wetland areas or to cross streams. It provides a natural and rustic appearance, blends with the surroundings, and is suitable for sensitive habitats.</p>	<p>Wood requires regular maintenance, including sealing and treating to prevent decay and maintain structural integrity. It can be prone to splintering, rotting, and becoming slippery when wet.</p>
	<p>Recycled Plastic</p>	<p>Recycled plastic can have a long lifespan, making it a durable option for trail surfaces, particularly in riparian areas. Some recycled plastics are designed to be permeable.</p>	<p>Recycled plastic can have a more expensive up front cost compared to traditional materials. It can also have a manufactured appearance that may not naturally blend as well in natural areas.</p>
	<p>Concrete or Asphalt</p>	<p>Concrete or asphalt is highly durable and can withstand heavy use and weathering over time. They are typically low maintenance and may be appropriate in areas where traditional materials could seasonally wash out.</p>	<p>Concrete or asphalt has a more engineered appearance, which can be less visually appealing in natural areas. In the Edwards Aquifer Recharge Zone, use of concrete or asphalt materials may make approval more difficult.</p>
	<p>Natural Stone</p>	<p>Natural stone, such as flagstone or cobblestone, offers a visually appealing and durable trail surface. It can blend well with natural environments, provides stability, and withstands heavy use.</p>	<p>Natural stone trails can be expensive to install and require skilled labor. They may have uneven surfaces, making them less suitable for users with mobility limitations. Maintenance may be required to address shifting or settling of stones.</p>

OBJECTIVE 3.1.4 TRAIL MAINTENANCE

Proper maintenance of any trail is one of the most important aspects to ensure user safety and enjoyment. Trails are generally designed to minimize the impact on the environment, and proper ongoing maintenance is important in avoiding negative impacts.

Trails can deteriorate or be damaged due to water run-off, erosion, or normal wear and tear. Natural surface trails will undergo more erosion than paved trails. Proper trail design and construction will increase durability and lessen maintenance needs. Addressing maintenance issues promptly will avoid the need for more extensive and costly repairs.

Well defined maintenance standards, regular observation (especially after weekends or rain events), and continued up-keep and investment are all best practices for trails in the natural areas. The **City of San Marcos Trail Monitoring Form** found in the **Appendix** will help maintenance personnel identify maintenance needs and proactively schedule maintenance activities, including volunteer efforts with the San Marcos Greenbelt Alliance and other area partners.

Prevention of User-Created Trails

It is important to put policies and procedures in place to prevent user-created trails and paths. These trails have not been assessed for safety and environmental impacts. Prevention of user-created / renegade trails is best achieved through constant observation and

maintenance. Physical barriers and replanting of vegetation may be needed to prevent continued access. In addition, adding trail signage and ensuring clearly marked routes can help users identify which trails are safe and able to be used.



TEMPORARY TRAIL CLOSURE IN LOWER PURGATORY CREEK NATURAL AREA

Ensuring that trails for all technical abilities are offered helps in preventing user-created trails, as the persistence of user-created trails usually means one of three things:

1. The users feel that the existing trails are too easy
2. Additional trails may be needed
3. Rerouting of trails may be needed

Maintenance Standards Overview

When establishing maintenance standards for trails in natural areas, it's important to prioritize the preservation of the environment and ensure visitor safety. Here are some key considerations to include in the standards:

- **Regular Inspections.** Trails should be regularly inspected for any signs of erosion, vegetation encroachment, or damage caused by weather or usage. Inspections can help identify maintenance needs and ensure timely repairs. **Figure 4.13, Suggested Annual Trail Maintenance Schedule** provides a suggested annual schedule of maintenance activities.
- **Erosion Control.** When erosion-related maintenance is needed, determine and address the causes in a way that will improve durability.
- **Trail Clearing/Vegetative Management.** Remove fallen trees, branches, and other debris from the trail to ensure it remains accessible and safe for users. This includes maintaining proper clearance for overhead branches or vegetation.
- **Surface Maintenance.** Repair trail surface damage to restore the trail's function. Consider using environmentally friendly materials for repairs.
- **Trail Closures.** Trail closures are needed at times for seasonal protection of protected species habitat areas. Closures are also needed on occasion because of hazards such as fallen trees or for repairs or maintenance. Closures of natural surface trails are needed when conditions are wet, making them difficult to safely use and prone to rutting and other damage from pedestrians and cyclists. The Parks Department staff should have protocols on trail closures that include informing the public and enforcement of closures.
- **Educate Users.** Promote ecological sustainability by following best practices for trail use and stewardship. Use interpretive signage which educates users and asks them to be partners in ensuring quality stewardship of the San Marcos natural areas.

OBJECTIVE 3.2 USER SAFETY AND EDUCATION

Trails in natural areas provide a gateway for people to immerse themselves in the beauty and tranquility of nature. However, the natural areas harbor potential hazards, ranging from rugged terrain and wildlife encounters to rapidly changing weather conditions. Robust safety and education standards are necessary to avoid injuries and ensure enjoyable visitor experiences.

By implementing safety protocols and educating trail users about these inherent risks, the City can empower visitors to make informed decisions about trail use, mitigate dangers, and responsibly enjoy their outdoor experiences. Education also plays a vital role in fostering understanding of the ecological importance of the natural areas, promoting conservation practices, and nurturing a sense of respect and stewardship among trail users.

OBJECTIVE 3.2.1 ENFORCEMENT OF RULES

An important component of user safety in the natural areas is the enforcement of rules, which range from those applicable only in the natural areas to city ordinances on parkland use to state criminal statutes. Common rule violations in the natural areas include littering, failure to remove pet waste, curfew violations, and unleashed dogs. More serious violations include construction of unauthorized structures and fire pits, and vandalism along trails and in parking areas.

City personnel responsible for enforcement of rules in the natural area include the City Marshal, Deputy City Marshals, and Park Rangers. These personnel are usually qualified to perform emergency medical services in addition to their enforcement functions.

Rules enforcement in the natural areas poses challenges to enforcement personnel due to the remoteness of trail locations, access issues, and difficulties in reporting the location of violations. Another significant challenge has been the ongoing acquisition of additional natural areas and expansion of the City's natural areas system.

Some of these challenges are addressed in other management objectives, such as Objective 3.2.3 Emergency Access and Objective 3.2.4 Emergency Location Awareness. Others will require a commitment of resources by the City.

Prominent use of signage to inform trail users of the rules applicable to use of the natural areas can help minimize violations.

The City may wish to consider developing a program to train and use volunteers to inform trail users about rules and to monitor for rule violations on trails.

OBJECTIVE 3.2.2 EMERGENCY PHONES

Emergency phones provide a means of contacting emergency personnel while using trail facilities and for convenience of trail users. Guidelines and considerations for installing emergency phones along trails include:

- Locate emergency phones at all trail heads, major intersections, areas of potential conflict along the trail.
- Locate at strategic sites along the trail.
- When installing the emergency phones, provide reference information on the location, such as mile markers so that a caller can be located via georeferenced address.
- Emergency phones have options for cellular and arrangements may be possible with local cell phone providers for reduced service fees.
- Emergency phones also have options for power. If phones are located in a remote area, it may be feasible to use solar power to avoid electric wiring installation and service costs.

OBJECTIVE 3.2.3 LIGHTING

Lighting within the natural areas should be kept to a minimum so as not to disturb wildlife. However, installation of pedestrian-scale lighting should be considered at the following locations along trails:

- Inside tunnels or at overpasses
- Major trailheads or public gathering spaces (such as parking lots)
- Bridge entrances and exits
- At street crossings

Any light fixtures used within the natural areas should be chosen to reduce the loss of light and comply with city dark skies regulations. Solar-powered lighting should be considered if appropriate for the setting.



TRAIL MARKER IN RINGTAIL RIDGE NATURAL AREA

OBJECTIVE 3.2.4 EMERGENCY ACCESS

Emergency access routes to and within the natural areas are essential for fire, medical, and law enforcement personnel responding to emergencies. Emergency access routes can also serve a dual purpose as fire breaks to help slow the spread of wildfires.

The City of San Marcos Fire Department has created a map for the Upper and Lower Purgatory Creek Natural Areas which identifies emergency access routes for rescue scenarios. The map identifies all possible entry points and which trails are accessible only by foot and which can accommodate emergency vehicles.

The City of San Marcos Fire Department and Parks and Recreation Department should coordinate to identify and map emergency access routes for each natural area, with priority given to higher risk areas,

such as those identified in the Fire Hazard Planning Guidance section of this chapter. Routes should ideally be wide enough to allow access for a fire truck. Utilizing existing easements, roads, and other rights-of-way, such as utility easements, can serve as an efficient method for identifying emergency access routes.

Emergency access routes are not generally for use by the public, and as such, these corridors should have limited access. A gate with code access is recommended on these routes.



GATE ACCESS IN LOWER SPRING LAKE NATURAL AREA

OBJECTIVE 3.2.5 EMERGENCY LOCATION AWARENESS

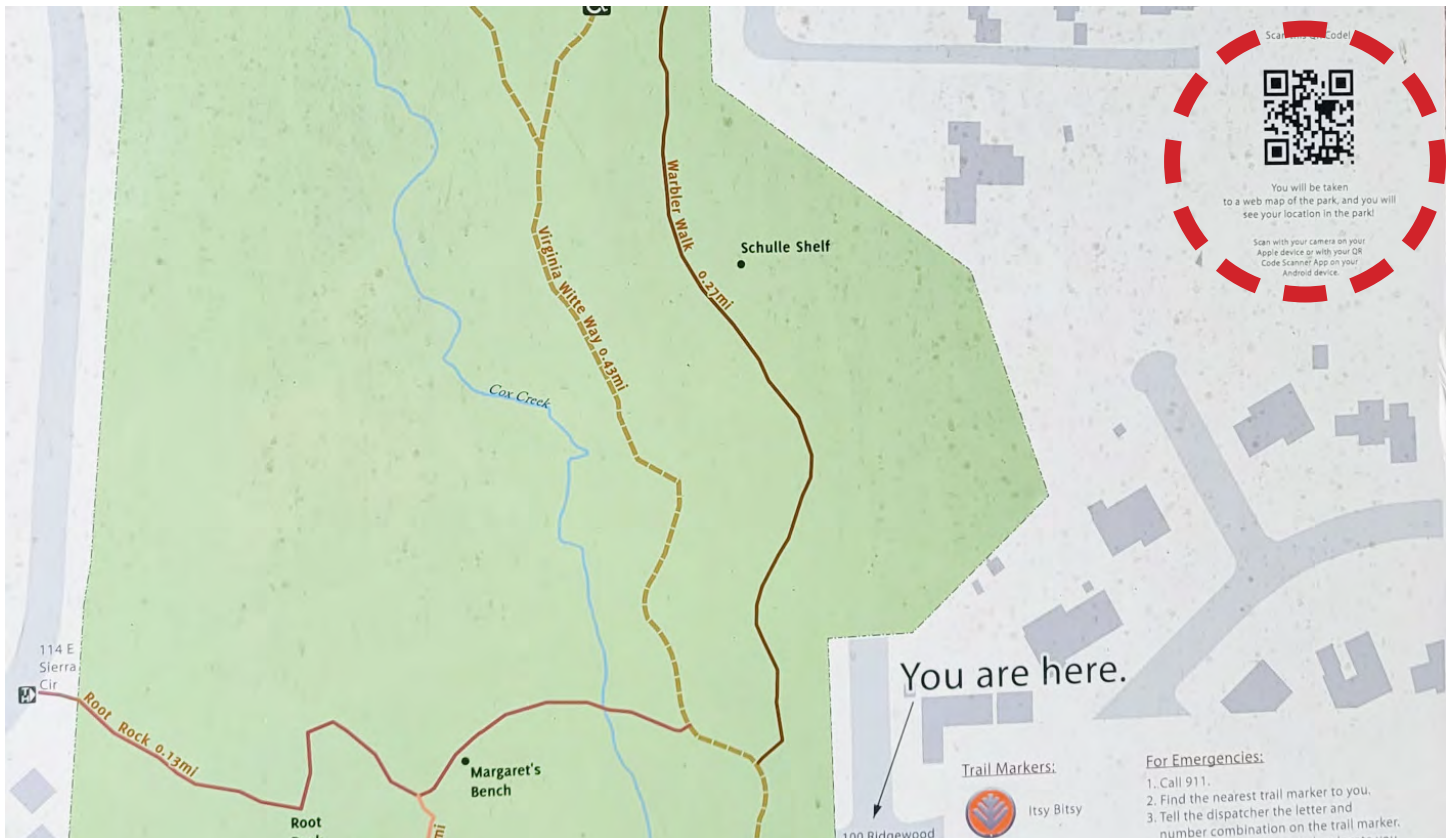
As part of a very proactive emergency response partnership program, the City of San Marcos has installed trail markers in several of the natural areas.

These markers are color coded and marked with a unique identifier which provides emergency responders with the exact coordinates of a caller. When combined with an emergency access plan, the markers provide emergency responders with the ability to determine the best available route to help with the emergency.

The Parks Department and the Fire Department should work to improve location markers and public awareness of this program, including improved program signage at trail heads and informational reminders at key points throughout the trail system. Public awareness could also be fostered by on-site visits by the city staff as part of an awareness campaign.



TRAIL MARKER IN RINGTAIL RIDGE NATURAL AREA



BESIDES AN UNMARKED QR CODE, THE TRAILHEAD MAP DOESN'T PROVIDE ANY INDICATION ABOUT THE TRAIL MARKER SYSTEM AND NOTIFICATION TO EMERGENCY RESPONDERS

OBJECTIVE 3.2.6 TRAILHEAD COMPONENTS AND SIGNAGE

Trailheads are often the first impression visitors have of the city's trail system and should reflect the quality of the natural areas and recreational opportunities.

Clear, informative, and well-designed signage at trailheads enhances the overall visitor experience by providing essential information about trail routes, distances, difficulty levels, trail regulations and safety considerations. Signage not only aids in wayfinding and prevents visitors from getting lost but also enhances their safety by alerting them to potential hazards, such as steep slopes or wildlife habitats.

Additionally, informative trailhead signage can educate visitors about the ecological significance of the natural areas, encouraging responsible behavior and promoting environmental stewardship. Quality trailhead signage can effectively communicate vital information, enrich visitor experiences, and foster a sense of connection and appreciation for trail users.

Trailhead Components

Trailheads function as entry and exit points for the trail network. Common elements at trailheads include

parking, seating, kiosk/trail maps, bike racks, drinking fountains, and waste receptacles. The components of each trailhead, however, are dependent on the number of anticipated users, the type of trail, the physical setting, and the availability of vehicle access and utilities.

Recommended trailhead signage and components are as follows:

- A map depicting the natural area and all trails within the area
- Signage depicting:
 - » Rules of the trail
 - » Safety information
- Additional amenities may include:
 - » Benches and picnic tables
 - » Restroom facilities
 - » Bicycle racks and repair stands
 - » Water fountains
 - » Waste receptacles



QUALITY TRAILHEAD SIGNAGE FEATURES CAN SIGNIFY THAT THIS IS AN IMPORTANT COMMUNITY PLACE

A typical trail system map should include the following:

- Water elements
- Trail alignments, including difficulty rankings and direction of travel (see below)
- Any potentially challenging elements or locations
- Parking, emergency facilities, entry / exit points, and connections to other elements of the bicycle and pedestrian transportation system
- Other destinations or amenities connected to the trail

A typical 'Rules of the Trail / Responsibility Code' signage should include:

- Descriptions, or photographs, of each type of difficulty level
- Statement declaring the use and intended user groups on each trail

- Space to post statements about hazards, closures, or temporary changes due to weather conditions
- List of rules
- Any additional safety information

Trailhead signage design should be consistent with the wayfinding signage design standards in Objective 3.2.6.

OBJECTIVE 3.2.7 WAYFINDING SIGNAGE

A consistent and coordinated wayfinding and signage system can improve the coherency of the City's trail network and improve the user experience by providing a greater sense of security and comfort. Wayfinding signs should be placed at key locations, including trailheads and trail intersections. Signage which indicates trail length and difficulty can increase the comfort and accessibility along a trail by familiarizing users with the trail conditions.



PURGATORY NATURAL AREA

The SMGA is a local non-profit whose mission is to create and conserve an interconnected system of parks and natural areas for our community and future generations. <http://www.smgreenbelt.org>

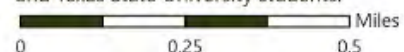
Park Rules

- Take only photos, leave only footprints.
- Park open dawn to dusk.
- Keep dogs on a leash and remove their waste.
- Campfires, glass containers, motor vehicles, weapons, horses, and camping are not permitted.
- Stay on established trails on public property. Bicycles yield to hikers and refrain from hiking/ biking on muddy trails.

- Virgil's, Styx, and a small section of Dante are ADA accessible.
- Report problems to San Marcos Parks and Rec at (512) 393-8400.
- For emergencies, call 911.
- Map created April 2022 as a collaboration between the SMGA and Texas State University students.

Difficulty Rating

- Easy
- Moderate
- Difficult



SAN MARCOS GREENBELT ALLIANCE (SMGA) TRAIL DIFFICULTY RATING PROJECT

Much of the existing wayfinding signage along natural area trails has been installed and maintained by SMGA. The City and SMGA should analyze the existing trail signage for commonalities, strengths and aspects that can be improved. Moving forward, the City, in partnership with SMGA, should develop a consistent package of trail wayfinding design standards to create a cohesive, quality brand for the City’s trail system. At a minimum, the design standards should consider:

- **Clarity and Legibility.** Ensure that the signage is clear and easily readable, even from a distance or under varying lighting conditions. Use legible fonts, appropriate font sizes, and high contrast between text and background to enhance visibility.
- **Consistency.** Maintain a consistent design and visual language throughout the trail system to create a cohesive and intuitive wayfinding experience. Consistent colors, symbols, and placement of signage elements help visitors navigate with ease.
- **Distinctiveness.** Design signage that stands out within the natural environment while complementing its surroundings. Use natural and earthy color palettes, incorporate elements inspired by local flora and fauna, and choose materials that blend harmoniously with the landscape.

- **Content.** Provide clear directional information to guide trail users, include estimated distances and time required to reach key destinations or landmarks on the trail, and display safety reminders and relevant regulations to ensure visitor well-being and protect the natural areas.
- **Accessibility.** Design signage that is inclusive and accessible to individuals with disabilities. Incorporate features such as tactile elements, Braille translations, and appropriate color contrast to facilitate universal access.
- **Interpretive Information.** Provide interpretive information on panels or supplementary signage that includes educational content about the natural environment (e.g., the Edwards Aquifer), history, geology, or cultural significance of an area. This enhances the visitor experience and fosters a deeper appreciation for the natural areas.
- **Durability and Sustainability.** Select durable materials that can withstand weather conditions, vandalism, and regular maintenance. Consider sustainable signage options (e.g., recycled materials), to minimize the environmental impact.



EXAMPLE SIGN PALETTE

OBJECTIVE 3.3 TRAIL CONNECTIVITY AND EXPANSION

Connecting the San Marcos natural areas trail system to other elements of the City's bicycle and pedestrian transportation system (sidewalks, bike lanes, urban trails, green alleys), and to other trails in the larger Central Texas region holds immense importance as it helps create a web of ecological, recreational, educational, and transportation opportunities that extend beyond the city's boundaries.

By establishing seamless connectivity within the City and the region, the trail system in the natural areas will become an integral part of the larger regional network, allowing residents and visitors to experience a more diverse range of natural landscapes and habitats and greater opportunities for bicycle and pedestrian transit. Regional connectivity fosters a sense of unity and shared responsibility between the City and neighboring communities, promoting collaborative conservation efforts (e.g., protection of the Edwards Aquifer Recharge Zone) and a collective understanding of the region's ecological interdependencies.

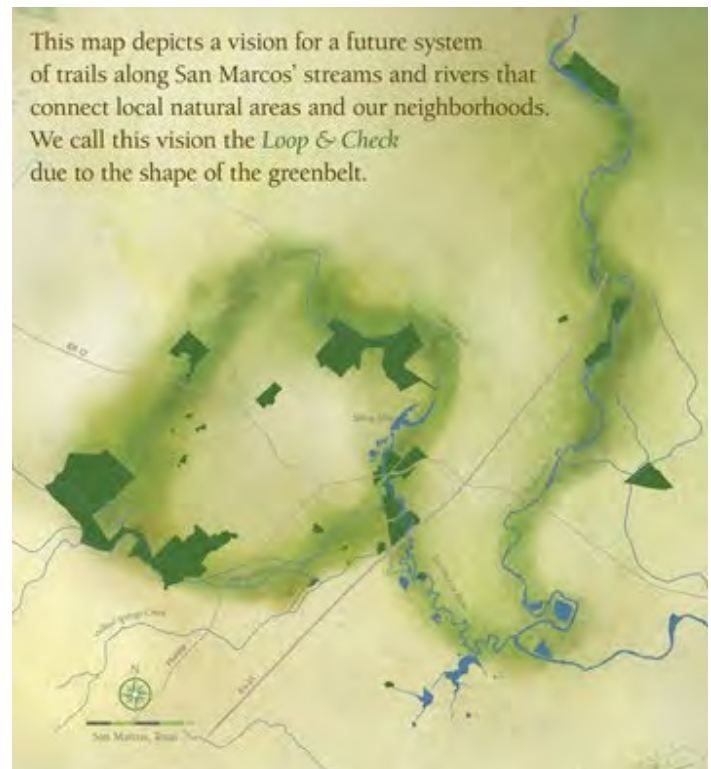
Furthermore, linking the natural areas trail system to other elements of the City's bicycle and pedestrian transportation system, and to other trails in the larger region will attract a broader audience and generate economic benefits through expanded ecotourism and outdoor recreational activities. By nurturing these connections, the San Marcos natural areas trail system can thrive as a treasured resource, inspiring a deeper appreciation for nature, and fostering a sustainable relationship between people and their environment. While the current focus for regional trail connectivity is the Great Springs Trail (see Objective 3.1.2 below), the City should consider other regional trails to connect San Marcos with other neighboring communities to the east, such as Martindale and Lockhart, and to the west, such as Wimberley.

OBJECTIVE 3.3.1 COMPLETE THE LOOP & CHECK SYSTEM

Acquiring land around the city to complete the vision for the Loop & Check greenbelt system (developed by the San Marcos Greenbelt Alliance) in San Marcos requires a strategic approach that involves continued collaboration, planning, and resource allocation. It not only involves land acquisition, but a plan of action for long-term land management, staffing, and maintenance.

Several natural areas found in the western portion of San Marcos currently have existing trail systems. Future trail development should aim to complete the loop and check system of natural area trails around the city. Using grant funding, donations and other funding sources, and land trusts, land exchanges, easements, and other collaborative partnerships, the City should prioritize completing these trails even if the full acquisition of individual parcels is not possible.

Potential trail corridors should be considered along floodplains to connect to the Riverfront Parks system, as well as to protect natural riparian corridors. As a loop of trails is developed around the City, efforts should also be taken to connect to Sessom Creek and Schulle Canyon, located in the interior of the proposed loop, via a network of sidewalks and bike lanes.



SMGA'S VISION FOR THE LOOP & CHECK GREENBELT

Map 4.2, Citywide Trails System, on the next page, demonstrates a broad suggested alignment of trail corridors for connecting the natural areas and other elements of the City’s bicycle and pedestrian transportation system. Further study would be needed to determine feasible alignments. The City should consider development of a Greenways Master Plan for the City with assessments to determine, in detail, the most suitable locations for trail connections between the natural areas and with other elements of the City’s bicycle and pedestrian transportation system.

Natural areas found in the eastern portion of San Marcos currently have less developed trail systems, especially Cottonwood Creek Natural Area. Because there is not currently a planned trail corridor alignment for this area, development of bicycle and pedestrian connections to Cottonwood Creek should be considered as part of the City’s comprehensive planning process and as development in the City’s eastern portion occurs.

Efforts to extend trail connectivity should continue to leverage the existing momentum and support generated by several organizations within the area including the San Marcos Greenbelt Alliance and Great Springs Project. These organizations are able to provide support and capacity in fostering public awareness of trails, identifying feasible trail corridors, and constructing and maintaining trails.

OBJECTIVE 3.3.2 CONNECT TO THE LARGER REGION VIA THE GREAT SPRINGS TRAIL

Moving forward, the City of San Marcos should continue to prioritize collaboration with the Great Springs Project to complete the vision for the Great Springs Trail connecting the four great springs in Central Texas. Building the Great Springs Project trail through the city and connecting it to the City’s natural areas and riverfront parks system, will bring numerous benefits to San Marcos citizens and the larger region.

The Great Springs Trail, extending from the Alamo in San Antonio to the state capitol in Austin, presents a unique opportunity to showcase the city’s natural treasures and reinforce its long-standing commitment to environmental stewardship. By prioritizing the development of this trail, San Marcos can attract visitors who are eager to experience the unparalleled beauty and ecological significance of the San Marcos Springs and the City’s natural areas. The Great Springs Trail can generate economic benefits by boosting tourism, attracting outdoor enthusiasts, and supporting local businesses. The Great Springs Trail will also offer expanded opportunities for cyclists and pedestrians to travel regionally without using motor vehicles.

Being a partner in the implementation of this trail will achieve multiple benefits for the City, including the conservation of additional land in the Edwards Aquifer Recharge Zone and greater recreational access for all citizens.



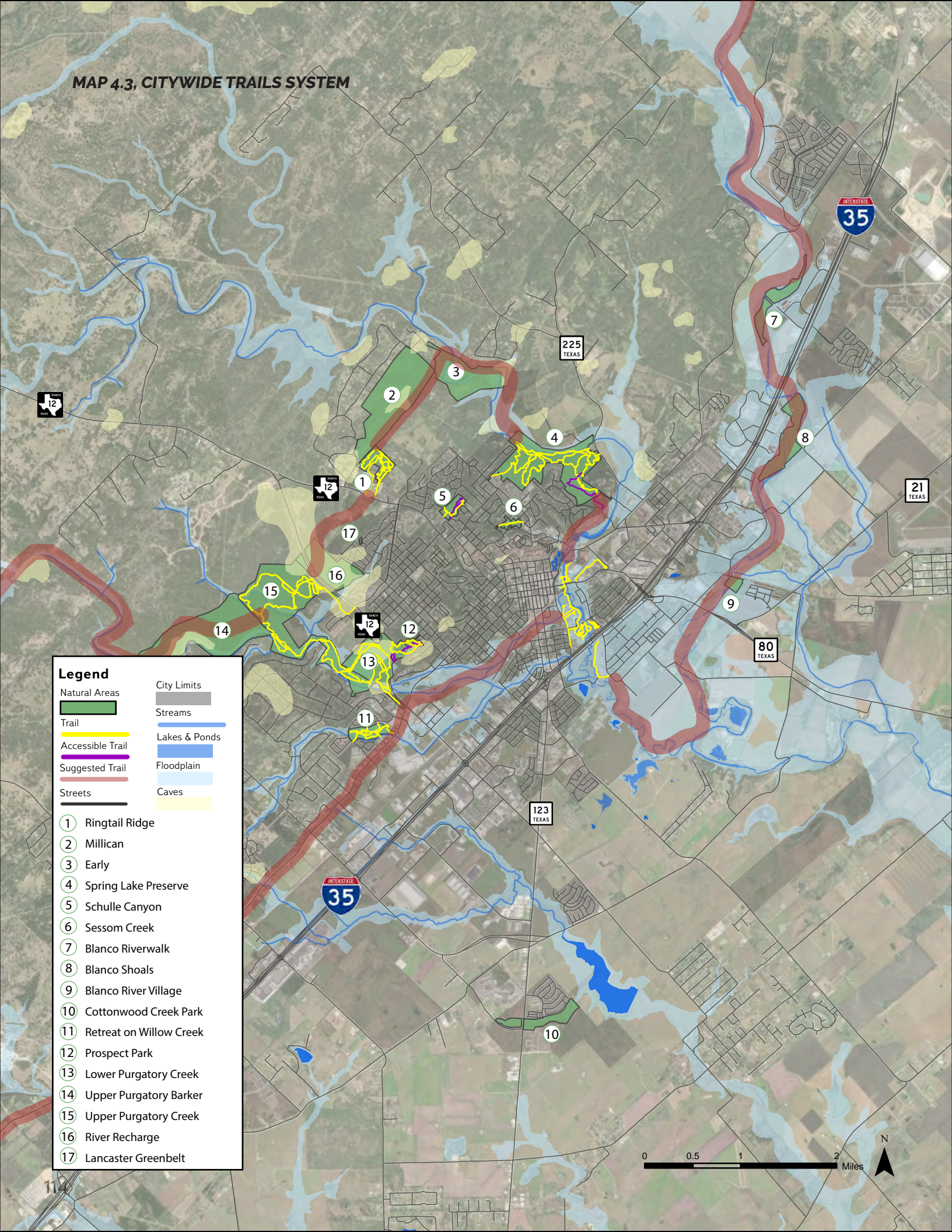
THE GREAT SPRINGS PROJECT

MAP 4.3, CITYWIDE TRAILS SYSTEM

Legend

Natural Areas	City Limits
Trail	Streams
Accessible Trail	Lakes & Ponds
Suggested Trail	Floodplain
Streets	Caves

1 Ringtail Ridge
2 Millican
3 Early
4 Spring Lake Preserve
5 Schulle Canyon
6 Sessom Creek
7 Blanco Riverwalk
8 Blanco Shoals
9 Blanco River Village
10 Cottonwood Creek Park
11 Retreat on Willow Creek
12 Prospect Park
13 Lower Purgatory Creek
14 Upper Purgatory Barker
15 Upper Purgatory Creek
16 River Recharge
17 Lancaster Greenbelt



Implementation

5

IMPLEMENTATION

INTRODUCTION

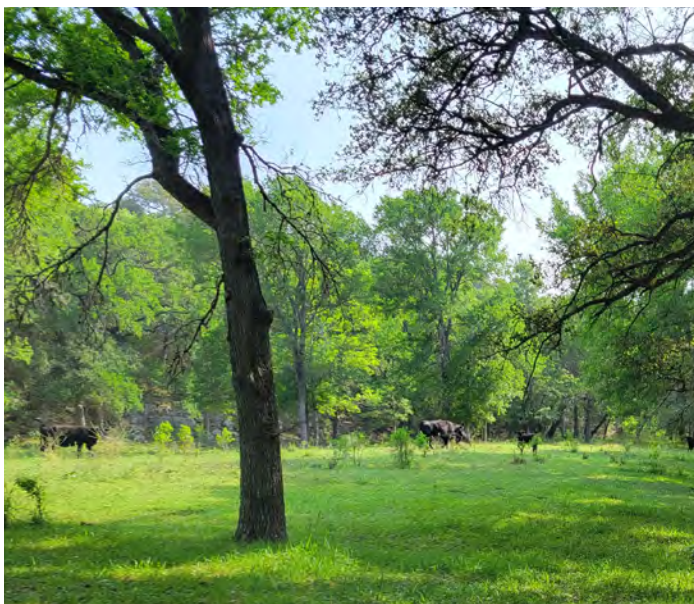
It is through action, decision making, coordination, and monitoring that plans come to fruition. Though this land management plan functions as a guide for city staff, there are a few key next steps that should be undertaken or considered.

The San Marcos Natural Areas Land Management Plan is a guiding resource of management objectives, best practices and action steps to preserve and enhance the environmental sustainability of the natural areas. This plan is more of a toolbox which summarizes recommended next steps for management of the natural areas. This is not a comprehensive list but rather a prioritized list of steps that can be taken to properly manage the natural areas.

NEXT STEPS CATEGORIES

Next steps listed in the Implementation and Prioritization Table on the next page are classified under the following broad categories:

- **Action.** These initiatives may include undertaking a new project, expanding upon existing programs, or conducting a study.
- **Policy.** Official procedures or policies used to make decisions.
- **Partnership.** These initiatives will include two or more entities working close together to serve as champions of the plan.



SHADED OPEN SPACE IN A FUTURE NATURAL AREA

The steps listed within the implementation tables in this section are allocated among three levels of prioritization and reflect the action's suggested priority as determined from best practice standards. Many of the recommended management strategies timeframes will depend upon further study or field surveys.

The assigned time frame identifies when recommendations should be initiated based on existing knowledge:

- **(0-2).** Next steps should be initiated within the next one to two years although completion may extend across a larger time frame. These are the top priorities for implementation.
- **(3-5).** Next steps which may be initiated within the next three to five years.
- **(Ongoing).** Next steps may also be ongoing where they represent a policy or practice that should begin immediately and occur on an annual or scheduled basis.

FUNDING

Many of the next steps to implement this plan will require funding resources. As discussed in the introduction to this plan, funding for improvements to and maintenance and management of the natural areas has primarily involved funds from the City General Fund appropriated to the Parks and Recreation Department.

The City's 2019 Parks, Recreation and Open Space Master Plan includes a recommendation to "Identify additional resources to better respond to reoccurring maintenance and enforcement issues in the greenspace park properties". To assist in carrying out the next steps for implementing this plan, the City may wish to consider funding sources other than the General Fund.

The City may also wish to consider implementing user fees or a voluntary donation system at trailheads in the natural areas to increase General Fund revenues available for management of the natural areas.

Appendix B of the Parks, Recreation and Open Space Master Plan identifies a variety of federal, state and private funding sources that the City can consider to accomplish the next steps for implementing this plan.

TABLE 5.1, IMPLEMENTATION AND PRIORITIZATION

NEXT STEPS	ACTION TYPE	TIMEFRAME (YEARS)			INVOLVED DEPARTMENTS (AND PARTNERING ENTITIES)
		0-2	3-5	ON-GOING	
Natural Resource Management					
Conduct wildfire hazard assessments for each natural area. Prioritize Upper Purgatory Creek, Lower Purgatory Creek, Spring Lake, the Western Loop Unit, and Schulle Canyon due to Wildfire Risk Index.	Action		0-2		PARD and FD
Create Community Wildfire Protection Plans for each Natural Area. Prioritize Upper Purgatory, Lower Purgatory, Spring Lake, the Western Loop Unit, and Schulle Canyon due to Wildfire Risk Index.	Action/ Partnership		0-2		PARD, FD, and owners and occupants of adjacent properties
Establish standard operating procedures for management activities. Provide for compliance with TCEQ EAPP regulations where applicable. Include a process for record keeping of natural area land management activities. Require all staff and volunteers to complete the required forms for record keeping. Train volunteers and staff on procedures.	Policy/Action		0-2/ Ongoing		PARD and Volunteers
Identify and create an initial inventory of areas in need of revegetation/stabilization measures; for each area, create a revegetation/stabilization plan; prioritize the plans and implement revegetation/stabilization projects.	Action		0-2		PARD, SW, and Volunteers
Identify and create an initial inventory of trails or areas in need of erosion control measures; for each area, create an erosion control plan; prioritize the plans and implement erosion control projects.	Action		0-2		PARD, SW, and Volunteers
Conduct comprehensive invasive species surveys for all natural areas. For each area where invasive species are present, create a plan for invasive species management.	Action		0-2		PARD and Volunteers
Prioritize the plans and implement invasive species control projects. For suitable projects, use EDRR methodology.	Action		0-2		PARD and Volunteers

PARD: Parks and Recreation Department; FD: Fire Department; PD: Police Department; CoSM: City of San Marcos; Volunteers: Volunteer groups such as SMGA; PADS: Planning and Development Services Department; SMU: San Marcos Utilities; SW: Stormwater Division

ACTION	ACTION TYPE	TIMEFRAME (YEARS)			INVOLVED DEPARTMENTS (AND PARTNERING ENTITIES)
		0-2	3-5	ON-GO-ING	
Natural Resource Management (cont.)					
Restore Blackland Prairie habitat. Plants such as little bluestem, big bluestem, indian grass, switch grass, and eastern gama grass can be planted to shade out nonnative grasses in select areas with a mix of Texas wildflowers for seasonal interest. These areas will need to be no mow areas except for an annual clean up in winter.	Action	0-2			PARD and Volunteers
Create more resilient native plant communities with an emphasis on plants that are beneficial to wildlife for food or habitat, greater amounts and diversity of wildlife.	Action	0-2			PARD and Volunteers
Replace locks to all entrance gates/maintenance roads with combo locks that are universally the same.	Action	3-5			CoSM, PARD, and FD
Examine current zoning, land use regulations, and building codes for opportunities to reduce wildfire risk within the wildland-urban interface. These regulations can include setbacks, buffer zones, and other restrictions on development in high-risk areas. Draft and consider adopting modifications to regulations and codes.	Policy/ Partnership	3-5			PARD and PADS
Modify existing access routes and construct additional access routes to provide increased access for maintenance and emergency personnel.	Action	3-5			PARD, FD, PD, and SMU
Reduce the fuel load near the wild land urban interface. This should include removal of dead material on the ground and dead standing timber and Ashe juniper thinning and removal (dead and living).	Action	3-5			PARD and FD and adjacent property owners and occupants
Encourage/prioritize maintenance of electrical easements/right-of-ways for all agencies operating electric utility lines within natural areas to reduce the risk of a fire due to sparking lines or downed lines.	Policy	Ongoing			PARD, FD, Utility Companies

PARD: Parks and Recreation Department; FD: Fire Department; PD: Police Department; CoSM: City of San Marcos; Volunteers: Volunteer groups such as SMGA; PADS: Planning and Development Services Department; SMU: San Marcos Utilities; SW: Stormwater Division

ACTION	ACTION TYPE	TIMEFRAME (YEARS)			INVOLVED DEPARTMENTS (AND PARTNERING ENTITIES)
		0-2	3-5	ON-GOING	
Natural Resource Management(cont.)					
Create a monitoring plan for areas which have undergone revegetation /stabilization, erosion control or invasive species management. Plan for and carry out follow-up actions as needed.	Action		Ongoing		PARD, SW, and Volunteers
Establish a Fire Wise Communities Program. Coordinate public education presentations by Texas Forest Service, Fire Department to help reduce fire hazard on private property near the natural areas.	Policy/ Partnership		Ongoing		PARD and FD
Conduct an annual survey in each natural area for revegetation/stabilization, erosion control and invasive species control measures. Plan for and carry out response actions as needed.	Action		Ongoing		PARD, SW, and Volunteers
Train volunteers or staff members in invasive species identification.	Policy		Ongoing		PARD and Volunteers
Stabilize riparian corridors by providing proper vegetation establishment, vegetative security, and debris management – PARD and Stormwater Management Department https://sanmarcostx.gov/298/Stormwater-Management	Action		Ongoing		PARD, SW, Edwards Aquifer Authority
Monitor ecosystems for effects of climate change, and use adaptive management to respond as needed.	Action		Ongoing		PARD and Volunteers
Use, Safety, and Connectivity					
Update trailhead and wayfinding signage to be consistent across all natural areas to provide accurate information and wayfinding.	Action		0-2		PARD
Implement a maintenance schedule such as the one suggested in Figure 4.13, for regular trail maintenance	Policy		0-2		PARD
Develop necessary overlays for dispatch to better cross-reference location data for 911 callers within the natural areas.	Action		0-2		PARD, EMS, FD, and PD

PARD: Parks and Recreation Department; FD: Fire Department; PD: Police Department; CoSM: City of San Marcos; Volunteers: Volunteer groups such as SMGA; PADS: Planning and Development Services Department; SMU: San Marcos Utilities; SW: Stormwater Division

ACTION	ACTION TYPE	TIMEFRAME (YEARS)			INVOLVED DEPARTMENTS (AND PARTNERING ENTITIES)
		0-2	3-5	ON-GO-ING	
Use, Safety, and Connectivity (cont.)					
Collect additional trail counter data to determine trail and natural area popularity as well as hours of use.	Action		3-5		PARD
Consider creating a Citywide Greenways Master Plan to coordinate trail development and prioritize citywide connectivity. Greenways Master Planning efforts could also include emergency access routes.	Action		3-5		PARD, FD and CoSM
Consider installation of emergency phones at key locations in natural areas.	Action		3-5		PARD, FD, PD, and CoSM

PARD: Parks and Recreation Department; FD: Fire Department; PD: Police Department; CoSM: City of San Marcos; Volunteers: Volunteer groups such as SMGA; PADS: Planning and Development Services Department; SMU: San Marcos Utilities; SW: Stormwater Division

This page intentionally left blank.

Appendix

RIPARIAN TEMPLATE

STREAMSIDE PLANTING GUIDE

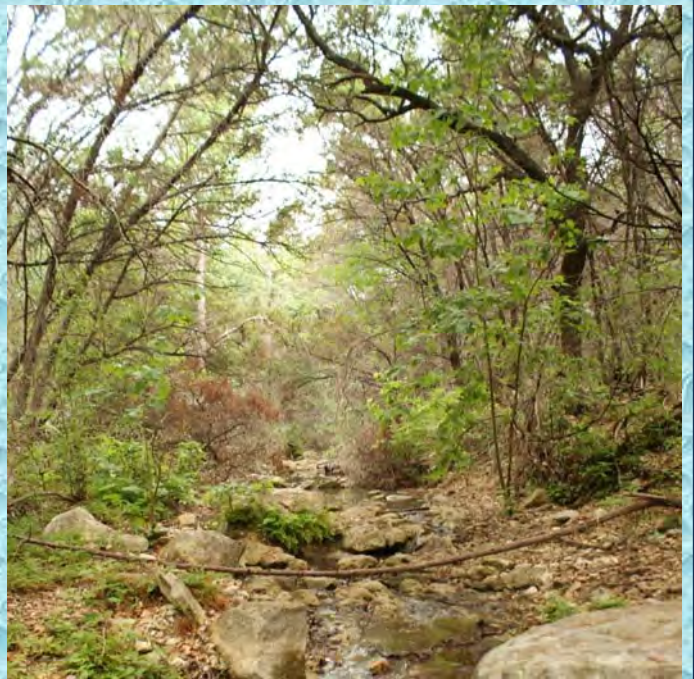
The land alongside a stream, the riparian zone, plays a critical role in maintaining the integrity of the stream. Mature plants in the riparian zone help maintain water quality in the stream.

They also function structurally to prevent erosion and flooding downstream.

This template provides guidance for landowners and developers interested in improving the integrity of the riparian corridor of their waterways. Recommendations for native grasses, forbs, shrubs and trees are provided for large and small drainage areas in both Edwards Plateau and Blackland Prairie riparian zones.

Although native plants are adapted to the extreme conditions of our local weather patterns, it is important to have an irrigation system in place for the first two years to help establish new plants. Placing 3"-4" of mulch around the plants will keep soil moist and reduce weeds.

All of the plants listed here are found in the riparian areas of Austin's streams. When replanting a degraded riparian zone it is wise to increase plant density of the woody plants as well as the grasses and wildflowers. Maintaining a diverse vegetative community, comprised of plants in all tiers and zones will help combat aggressive and non-native plants.





Zone 3 Zone 2 Zone 1 Creek

Mature Riparian Structure: Unique hydrologic conditions make different zones of the streamside suitable for distinct plant types. The soil in Zone 1 is always wet and frequently underwater. Zone 2 is underwater during most storm events but dries out afterwards. Zone 3 is a transitional area receiving its moisture from rainfall and large storm events.



Groundcover

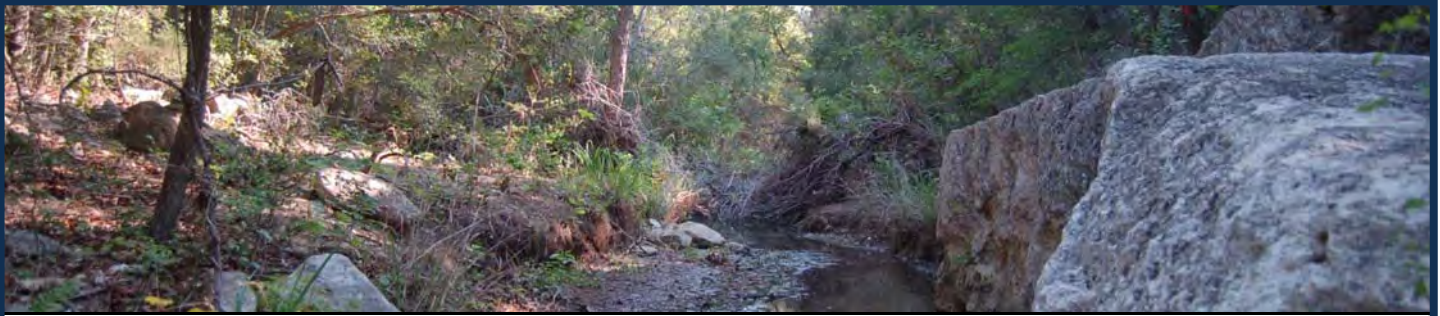
Understory

Upper Canopy

Tiered Vegetation Scenarios: Wildflowers, grasses and other groundcover plants grow densely without canopy cover from trees and shrubs. In the presence of understory trees and shrubs, groundcover often thins out. When all three tiers of vegetation exist, grasses and forbs cover a very small percentage of area. It is recommended that trees, shrubs and groundcover be planted at increased densities to better facilitate success of the desired plant communities.

Additional Resources:

- CoA Riparian Website <http://www.cityofaustin.org/watershed/creekside.htm>
- Lady Bird Johnson Wildflower Center <http://www.wildflower.org/plants/>
- Texas Riparian Association <http://www.texasriparian.org/>
- CoA Tree Encyclopedia http://www.ci.austin.tx.us/trees/en_spec.htm
- National Plant Society of Texas <http://npsot.org/wp/austin/>
- Improving Urban Streams <http://www.msdlouky.org/insidemsd/wqstreams.htm>
- Tree Folks <http://treefolks.org/>



Edwards Plateau Small Drainage (<1800 acres)

	Growth	Common names	Scientific Name	Zones
Groundcover	Forb	Brown-eyed Susan	<i>Rudbeckia triloba</i>	2,3
	Forb	Cedar sage	<i>Salvia roemeriana</i>	2,3
	Forb	Frost weed	<i>Verbesina virginica</i>	1,2,3
	Forb	Plateau goldeneye	<i>Viguiera dentata</i>	2,3
	Grass	Arapaho muhly	<i>Muhlenbergia utilis</i>	1,2
	Grass	Cedar sedge	<i>Carex planostachys</i>	2,3
	Grass	Inland sea oats	<i>Hasmanthium latifolium</i>	1,2,3
	Grass	Lindheimer muhly	<i>Muhlenbergia lindheimeri</i>	2,3
	Grass	Little bluestem	<i>Schizachyrium scoparium</i>	2,3
	Grass	Scribner's panic grass	<i>Dichantherium oligosanthes var. scribnerianum</i>	1,2,3
	Grass	Seep muhly	<i>Muhlenbergia reverchonii</i>	1,2
Grass	Switchgrass	<i>Panicum virgatum</i>	1,2	
Understory	Shrub	Agarita	<i>Mahonia trifoliolata</i>	3
	Shrub	Button bush	<i>Cephalanthus occidentalis</i>	1,2
	Shrub	Elbow bush	<i>Forestiera pubescens</i>	3
	Shrub	Silk tassel	<i>Garrya lindheimeri</i>	2,3
	Shrub	Turks Cap	<i>Malvaviscus drummondii</i>	2,3
	Tree/Shrub	Ashe juniper	<i>Juniperus ashei</i>	2,3
	Tree/Shrub	Escarpment black cherry	<i>Prunus serotina var. eximia</i>	2,3
	Tree/Shrub	Gum bumelia (Chittamwood)	<i>Bumelia lanuginosa</i>	2,3
	Tree/Shrub	Possum-haw (Deciduous holly)	<i>Ilex decidua</i>	1,2,3
	Tree/Shrub	Red Buckeye	<i>Aesculus pavia</i>	2
	Tree/Shrub	Texas persimmon	<i>Diospyros texana</i>	2,3
	Tree/Shrub	Yaupon	<i>Ilex vomitoria</i>	2,3
	Vine	Mustang grape	<i>Vitis mustangensis</i>	2,3
	Vine	Peppervine	<i>Ampelopsis arborea</i>	1,2,3
	Vine	Rattan Vine	<i>Berchemia scandens</i>	2
Vine	Sweet mountain grape	<i>Vitis monticola</i>	2,3	
Vine	Virginia creeper	<i>Parthenocissus quinquefolia</i>	1,2	
Overstory	Tree	Box elder	<i>Acer negundo</i>	1,2
	Tree	Cedar elm	<i>Ulmus crassifolia</i>	2,3
	Tree	Hackberry	<i>Celtis sp.</i>	2,3
	Tree	Texas ash	<i>Fraxinus texensis</i>	1,2,3
	Tree	Texas red oak	<i>Quercus buckleyi</i>	1,2,3

Notes:

These streams tend to have a rocky/bedrock substrate. The flow is intermittent, commonly occurring for only a short while after rain. A more comprehensive plant list can be found on the City of Austin's Riparian website.

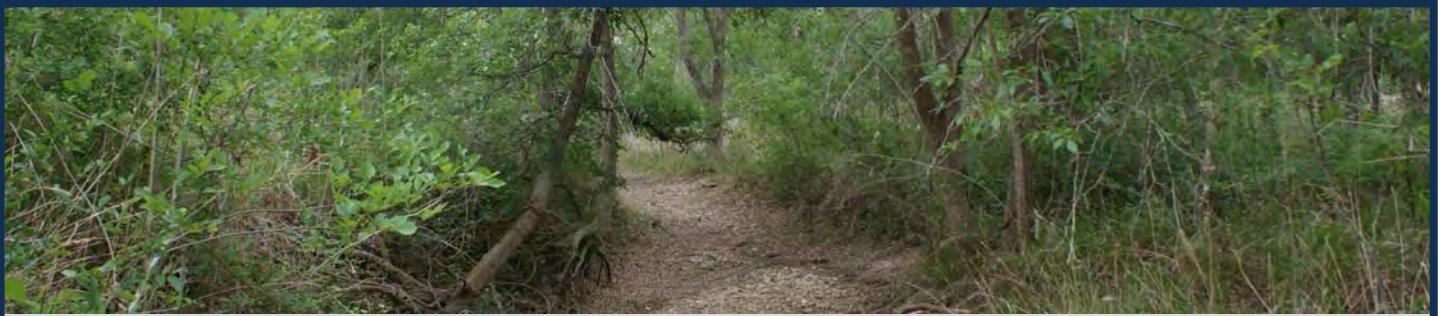


Edwards Plateau Large Drainage (>1800 acres)

	Growth	Common names	Scientific Name	Zones
Groundcover	Forb	Frost weed	<i>Verbesina virginica</i>	3
	Forb	Maximillian sunflower	<i>Helianthus maximiliani</i>	2,3
	Forb	Rain lily	<i>Cooperia drummondii</i>	1,2
	Forb	Straggler daisy	<i>Calyptocarpus vialis</i>	1,2,3
	Grass	Curly mesquite	<i>Hilaria belangeri</i>	3
	Grass	Eastern gamagrass	<i>Tripsacum dactyloides</i>	2,3
	Grass	Inland saltgrass	<i>Distichlis spicata car. Stricta</i>	1,2,3
	Grass	Inland sea oats	<i>Chasmanthium latifolium</i>	1,2,3
	Grass	Lindheimer muhly	<i>Muhlenbergia lindheimeri</i>	2,3
	Grass	Little bluestem	<i>Schizachyrium scoparium</i>	2,3
	Grass	Sideoats grama	<i>Bouteloua curtipendula</i>	1,2,3
	Grass	Switchgrass	<i>Panicum virgatum</i>	1,2
	Grass	Virginia wildrye	<i>Elymus virginicus</i>	1,2,3
Understory	Shrub	Cat's-claw mimosa	<i>Mimosa biuncifera</i>	3
	Tree/Shrub	Ashe juniper	<i>Juniperus ashei</i>	3
	Tree/Shrub	Texas persimmon	<i>Diospyros texana</i>	3
	Tree/Shrub	Yaupon	<i>Ilex vomitoria</i>	1,2,3
	Vine	Dewberry	<i>Rubus sp.</i>	1,2,3
	Vine	Mustang grape	<i>Vitis mustangensis</i>	2,3
	Vine	Peppervine	<i>Ampelopsis arborea</i>	1,2,3
	Vine	Rattan vine	<i>Berchemia scandens</i>	1
Overstory	Tree	American elm	<i>Ulmus americana</i>	2,3
	Tree	Boxelder maple	<i>Acer negundo</i>	1,2,3
	Tree	Cedar elm	<i>Ulmus crassifolia</i>	2,3
	Tree	Hackberry	<i>Celtis sp.</i>	1,2,3
	Tree	Roughleaf dogwood	<i>Cornus drummondii</i>	1,2,3
	Tree	Texas ash	<i>Fraxinus texensis</i>	2,3
	Tree	Texas red oak	<i>Quercus buckleyi</i>	3

Notes:

These streams tend to have a rocky/bedrock substrate. Large pools remain as aquatic habitat throughout the year. A more comprehensive plant list can be found on the City of Austin's Riparian website.

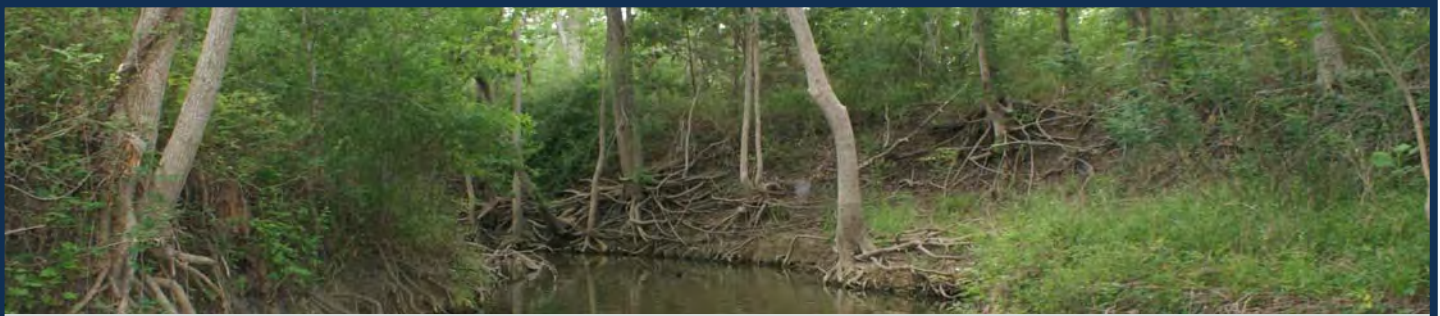


Blackland Prairies Small Drainage (<1800 acres)

	Growth	Common names	Scientific Name	Zones
Groundcover	Forb	Brown-eyed Susan	<i>Rudbeckia triloba</i>	1,2,3
	Forb	Gayfeather	<i>Liatris mucronata</i>	2,3
	Forb	Illinois bundleflower	<i>Desmanthus illinoensis</i>	2
	Forb	Maximillian sunflower	<i>Helianthus maximiliani</i>	1,2
	Forb	Texas aster	<i>Aster texanus</i>	2,3
	Grass	Big bluestem	<i>Andropogon gerardii</i>	3
	Grass	Blue grama	<i>Bouteloua gracilis</i>	3
	Grass	Estern Gamagrass	<i>Tripsacum dactyloides</i>	1,2
	Grass	Ryegrass	<i>Lolium perenne</i>	1,2,3
	Grass	Sideoats grama	<i>Bouteloua curtipendula</i>	1,2
	Grass	Switchgrass	<i>Panicum virgatum</i>	2,3
	Grass	Virginia wildrye	<i>Elymus virginicus</i>	1,2,3
	Grass	Yellow indiagrass	<i>Solrgum nutans</i>	3
Understory	Shrub	Cat's-claw mimosa	<i>Mimosa biuncifera</i>	3
	Shrub	Coralberry	<i>Symphoricarpos orbiculatus</i>	1,2,3
	Shrub	Elbowbush	<i>Forestiera pubescens</i>	1,2,3
	Shrub	Turk's Cap	<i>Malvaviscus drummondii</i>	3
	Tree/Shrub	Western soapberry	<i>Sapindus saponaria var. drummondii</i>	2,3
	Vine	Ivy treebine, Cow-itch	<i>Cissus incisa</i>	1,2,3
	Vine	Purple Bindweed	<i>Iponea trilocarpe</i>	2,3
Vine	Virginia creeper	<i>Parthenocissus quinquefolia</i>	1,2,3	
Overstory	Tree	Cedar elm	<i>Ulmus crassifolia</i>	1,2,3
	Tree	Green ash	<i>Fraxinus pennsylvanica</i>	1,2,3
	Tree	Hackberry	<i>Celtis spp.</i>	1,2,3
	Tree	Live oak	<i>Quercus fusiformis</i>	1,2,3

Notes:

These streams tend to have a silty or muddy substrate. The flow is intermittent to perennial, with small pools lasting through most of the year. A more comprehensive plant list can be found on the City of Austin's Riparian website.



Blackland Prairies Large Drainage (>1800 acres)

	Growth	Common names	Scientific Name	Zones
Groundcover	Forb	Frog fruit	<i>Phyla incisa</i>	2
	Forb	Frostweed	<i>Verbesina virginica</i>	2
	Forb	Late goldenrod	<i>Solidago altissima</i>	2
	Forb	Smartweed	<i>Polygonum sp.</i>	1,2
	Forb	Southern Dewberry	<i>Rubus trivialis</i>	2,3
	Forb	Swamp smartweed	<i>Polygonum hydropiperoides</i>	1
	Forb	Yerba de tago (False daisy)	<i>Eclipta alba</i>	1
	Grass	Bead grass	<i>Paspalum sp.</i>	1,2,3
	Grass	Big muhly	<i>Muhlenbergia lindheimeri</i>	2,3
	Grass	Devil's shoestring	<i>Nolina lindheimeriana</i>	3
	Grass	Dichanthelium	<i>Dichanthelium sp.</i>	1,2,3
	Grass	Emory's sedge	<i>Carex emoryi</i>	1,2
	Grass	Flatsedge	<i>Cyperus sp.</i>	2,3
	Grass	Inland sea oats	<i>Chasmanthium latifolium</i>	1,2,3
	Grass	Virginia wildrye	<i>Elymus virginicus</i>	1,2,3
Grass	Walter's millet	<i>Echinochloa walteri</i>	1,2,3	
Understory	Shrub	American beautyberry	<i>Callicarpa americana</i>	2
	Shrub	Coralberry	<i>Symphoricarpos orbiculatus</i>	1,2,3
	Shrub	Deciduous holly	<i>Ilex decidua</i>	1,2,3
	Shrub	Elbowbush	<i>Forestiera pubescens</i>	1,2,3
	Shrub	Pigeon Berry	<i>Rivina humilis</i>	2,3
	Shrub	Turk's Cap	<i>Malvaviscus drummondii</i>	2,3
	Tree/Shrub	Roughleaf dogwood	<i>Cornus drummondii</i>	2,3
	Tree/Shrub	Western soapberry	<i>Sapindus saponaria var. Drummondii</i>	1,2,3
	Vine	Virginia creeper	<i>Parthenocissus quinquefolia</i>	2,3
Overstory	Tree	Black Walnut	<i>Juglans nigra</i>	3
	Tree	Bois d' Arc	<i>Maclura pomifera</i>	3
	Tree	Bur Oak	<i>Quercus macrocarpa</i>	3
	Tree	Cedar elm	<i>Ulmus crassifolia</i>	1,2,3
	Tree	Cottonwood	<i>Populus deltoides</i>	1,2,3
	Tree	Eastern red cedar	<i>Juniperus virginiana</i>	3
	Tree	Hackberry	<i>Celtis spp.</i>	1,2,3
	Tree	Little Walnut	<i>Juglans microcarpa</i>	3
	Tree	Live Oak	<i>Quercus fusiformis</i>	3
	Tree	Pecan	<i>Carya illinoensis</i>	3
	Tree	Post Oak	<i>Quercus stellata</i>	3
	Tree	Sycamore	<i>Platanus occidentalis</i>	1,2

Notes:

These streams tend to have a combination of muddy and rocky substrates. Large pools remain as aquatic habitat throughout the year. A more comprehensive plant list can be found on the City of Austin's Riparian website.



Rules Protecting the Edwards Aquifer Recharge, Contributing, and Transition Zones

A large number of people in Texas, including San Antonio's growing population, depend on the Edwards Aquifer for drinking water. The aquifer is an underground water-bearing formation that lies beneath a belt of counties along I-35 and US 90 in Central Texas.

Eight of these counties—Williamson, Travis, Hays, Comal, Bexar, Medina, Uvalde, and Kinney—fall under the Edwards Aquifer rules of the Texas Commission on Environmental Quality (TCEQ). These rules were established to ensure that contaminated runoff does not harm the quality of water in the Edwards Aquifer.

What this pamphlet covers (and what it doesn't).

This pamphlet will help you find out (1) whether the Edwards Aquifer rules apply to you, (2) the type of protective practices you may have to adopt, and (3) where to get more information.

This regulatory guidance pamphlet provides general information about the Edwards Aquifer rules, and is not intended to be a substitute for the official Edwards Aquifer rules or any other final TCEQ rules. To see the official Edwards Aquifer rules, please refer to Title 30 of the Texas Administrative Code (TAC), Chapter 213. These rules are available on our Web site, at www.tceq.state.tx.us/goto/rules.

What are the “Recharge, Contributing, and Transition, Zones”?

As was mentioned above, aquifers are underground water-bearing formations. In protecting water quality in aquifers, the focus is placed primarily on activities in their recharge, contributing, and transition zones.

The *recharge zone* of an aquifer is the area where geologic layers of the aquifer are exposed at the surface, and water infiltrates into the aquifer through cracks, fissures, caves, and other openings

throughout these layers. In this zone, contaminants in surface water can readily enter the aquifer.

The *contributing zone* of an aquifer includes all watersheds that feed runoff into rivers and streams that flow over the recharge zone.

In the *transition zone*, geologic features such as faults and fractures present possible avenues for contaminants in surface water to reach the aquifer.

The recharge, contributing, and transition, zones are shown on official maps.

How do I tell which zone I am in?

There are several ways to find out what zone of the aquifer you're in.

You can look it up in our Edwards Aquifer map viewer, which is located on the TCEQ Web site, at www.tceq.state.tx.us/goto/eapp/mapviewer. (These maps are not official, but the Web page has links to sources for the official maps.)

In addition, you can also contact your regional TCEQ office, and staff there will be able to help. They also have hard copies of the aquifer maps available for viewing. Contact information for these offices is provided at the end of this pamphlet.

Who is NOT affected?

If you are conducting the following activities, you are not affected by the Edwards Aquifer rules (but you still may have to follow other TCEQ rules that are in effect statewide):

- Clearing vegetation without disturbing the soil,
- Farming, ranching, and other agricultural activities except concentrated animal feeding operations that are regulated under 30 TAC, Chapter 321.
- Maintenance of existing facilities (no added site disturbance).
- Resurfacing paved roads, parking lots, sidewalks, or other impervious surfaces.
- Exploring for, developing, or producing oil, gas, or geothermal resources.

- Building single-family homes on lots over five acres, with no more than one single-family residence per lot.
- Building fences or engaging in other similar activities where there is little or no potential for (1) contaminating groundwater or (2) changing topographic, geologic, or sensitive features.

Who IS affected?

If (1) you are carrying out construction-related or post-construction activity on the recharge or transition zones and (2) your activity has a potential for polluting the aquifer and surface streams that recharge it, then you are affected by the Edwards Aquifer rules. Some examples of activities covered by these rules are:

- Constructing buildings, utility stations, utility lines, roads, highways, or railroads.
- Filling, clearing, excavating, or carrying out any other activity that alters or disturbs topographic, geologic, or recharge characteristics of a site.
- Conducting other activities that may pose a potential for contaminating the Edwards Aquifer or surface streams that recharge it.

On the *recharge and transition zones*, you are affected by the Edwards Aquifer rules if you install underground or aboveground storage tanks (USTs or ASTs) or piping, and the installation is designed to store either hazardous substances or fuels, lubricating oils, mineral spirits, or other petroleum-based liquids.

On the *contributing zone*, you are affected by the Edwards Aquifer rules if (1) you disturb more than five acres or (2) you are conducting activities as part of a large plan of development that may disturb five or more acres.

I AM affected, so what do I have to do?

This section describes the steps you have to take, depending on what you plan to do on your land, —to protect water quality during and after construction. The first order of business is to determine whether you must prepare and submit an Edwards Aquifer Protection Plan (EAPP).

Protect water quality during construction— when an EAPP is NOT required.

In all cases, before any work begins, *you must install erosion and sediment (E&S) controls* that meet the requirements of the Edwards Aquifer rules, and you must maintain these controls throughout the construction process.

In certain cases, however, you do not have to file an EAPP. The activities exempted from an EAPP (but still requiring E&S controls) are:

- Installing natural gas, telephone, electric, water, or other utility lines that do not carry pollutants.
- Installing one or more permanent AST facilities with a cumulative volume of 500 gallons or less.
- Installing equipment used to transmit electricity that uses oil circuit breakers (construction of supporting structures, however is not exempt).
- Constructing a single-family residence or any associated residential structure when the construction is for the individual landowner on his or her own property, as long as the construction does not cause the site's impervious cover to exceed 20 percent.

You must wait until vegetation is established and the exposed soil in the construction area is stabilized before removing the E&S controls for the activities listed above.

Protect water quality during construction— when an EAPP IS required.

If you are involved in activities other than those listed above, you must submit an EAPP. Consult with your TCEQ regional office on how to prepare and submit one. The plan must show how contaminants will be removed from runoff—both during construction and after your construction is complete—by implementing and maintaining permanent best management practices (BMPs) designed by a Texas Licensed Professional Engineer. One of the main concerns for water quality is silt and sediment carried from the site and into the aquifer by storm water runoff.

You must get your EAPP approved before you start any activity that could cause runoff contamination, such as:

- Disturbing the soil—for example, by clearing, bulldozing, or excavating.

- Beginning to construct roads, highways, or buildings.
- Installing AST facilities over the recharge and transition zones that have a cumulative volume of 500 gallons or more stored in tanks, and any UST facilities that are to be used for storing hazardous substances or liquid petroleum fuels (UST facilities are the only regulated activity in the transition zone).

Of course, before any work begins, you must also install E&S controls that meet the requirements of the Edwards Aquifer rules, and you must maintain these controls throughout the construction process.

Getting your plan reviewed and approved.

Submit your plan to the TCEQ regional office that serves the county in which your development is located. The eight counties that fall under the Edwards Aquifer rules are served by either the San Antonio office or the Austin office (see contact information at the end of this pamphlet).

Applications for activities in the recharge, contributing, and transition zones will receive a two-stage review. In the first stage, called administrative review, we determine whether your application is complete. If your application is submitted in person during a scheduled meeting with staff, we will complete this review as part of our meeting.

The second stage of the review focuses on technical aspects of your application. In the technical review, we determine whether your plan will adequately protect surface water and the aquifer as you carry out the intended activity.

No site disturbance may begin until both of these review periods are completed and an approval letter has been issued.

We may inspect your site periodically to ensure that you are complying with (1) the temporary provisions of your approved plan during construction and (2) the plan's permanent provisions after construction.

Where can I find more answers?

Two TCEQ publications offer thorough information on the Edwards Aquifer rules: *Complying with the Edwards Aquifer Rules: Technical Guidance on Best Management Practices* (RG-348) and *Optional Enhanced Measures for the Protection of Water Quality in the Edwards Aquifer: An Appendix to RG-348* (RG-348a).

You can find forms, checklists, publications and other information regarding our Edwards Aquifer Protection Program on our Web site, at <www.tceq.state.tx.us/goto/eapp>.

You can also contact Edwards Aquifer Protection Program staff at the TCEQ regional office that serves your county:

Williamson, Travis, or Hays County

Austin Regional Office, TCEQ
2800 S IH-35, Ste. 100
Austin, TX 78704-5700
Phone: 512-339-2929 • Fax: 512-339-3795

Comal, Bexar, Medina, Uvalde, or Kinney County

San Antonio Regional Office, TCEQ
14250 Judson Rd.
San Antonio, TX 78233-4480
Phone: 210-490-3096 • Fax: 210-545-4329

**Texas Department of Agriculture
Pesticide Applicator Record**



COMMISSIONER SID MILLER

Business/Applicator Name _____ Address _____

Application Date	Time Started	Name of the person for whom the application was made	Location of Land Treated		Site Treated	Wind Direction	Wind Velocity	Air Temp
Product Trade Name		EPA Registration Number	Target Pest	Rate of Product Per Unit	Method or Type of Equipment Used To Make Application	FAA "N" Number for Aerial Application Equipment:		
Is Application Applied in Regulated County: <input type="checkbox"/> Yes <input type="checkbox"/> No					Regulated Herbicide Permit Number:			
Licensed Applicator's Name and License Number			Non-licensed Applicator's Name Working Under Licensee		Total Acres or Volume of Area Treated	Total Volume of Spray Mix, Dust, Granules or Other Materials Applied Per Unit		
Documentation used to verify training of non-licensed applicator (Mark Applicable Box) <input type="checkbox"/> Direct Supervisor Affidavit <input type="checkbox"/> WPS Handler Card <input type="checkbox"/> Signed & Dated Label								

Application Date	Time Started	Name of the person for whom the application was made	Location of Land Treated		Site Treated	Wind Direction	Wind Velocity	Air Temp
Product Trade Name		EPA Registration Number	Target Pest	Rate of Product Per Unit	Method or Type of Equipment Used To Make Application	FAA "N" Number for Aerial Application Equipment:		
Is Application Applied in Regulated County: <input type="checkbox"/> Yes <input type="checkbox"/> No					Regulated Herbicide Permit Number:			
Licensed Applicator's Name and License Number			Non-licensed Applicator's Name Working Under Licensee		Total Acres or Volume of Area Treated	Total Volume of Spray Mix, Dust, Granules or Other Materials Applied Per Unit		
Documentation used to verify training of non-licensed applicator (Mark Applicable Box) <input type="checkbox"/> Direct Supervisor Affidavit <input type="checkbox"/> WPS Handler Card <input type="checkbox"/> Signed & Dated Label								

HABITAT MONITORING FORM

Keeping track of management techniques helps assess effectiveness of timing and method, allowing for improved implementation in future years.

STEP 1 - Photocopy or print copies of this form in advance

STEP 2 - Site Name: _____

STEP 3 - Management Practices Record

Record all management techniques used. Be sure to include the timing of when the action was taken so if it is not effective, management can be adjusted in the future. In addition, record what the intended goal for the management (for example, "to reduce or eradicate King Ranch Bluestem from the meadow").

Note: Before implementing techniques the following year, be sure to evaluate whether the technique utilized met the intended goal. If not, adapt the existing technique (e.g., different timing and/or frequency) or trial a new one.

BEFORE Implementation			
Management Techniques Log			
1.	Year:		Month(s):
	Technique Used:		
	Intended Goal:		
	Completed by:		

AFTER Implementation			
Efficacy Assessment			
1.	Evaluation Date(s):		Technique Successful? Y / N
	Notes:		
	Suggested Changes/ Next Steps:		
	Completed by:		

BEFORE Implementation			
Management Techniques Log			
2.	Year:		Month(s):
	Technique Used:		
	Intended Goal:		
	Completed by:		

AFTER Implementation			
Efficacy Assessment			
2.	Evaluation Date(s):		Technique Successful? Y / N
	Notes:		
	Suggested Changes/ Next Steps:		
	Completed by:		

BEFORE Implementation				
Management Techniques Log				
3.	Year:		Month(s):	
	Technique Used:			
	Intended Goal:			
Completed by:				

AFTER Implementation				
Efficacy Assessment				
3.	Evaluation Date(s):		Technique Successful?	Y / N
	Notes:			
	Suggested Changes/ Next Steps:			
Completed by:				

BEFORE Implementation				
Management Techniques Log				
4.	Year:		Month(s):	
	Technique Used:			
	Intended Goal:			
Completed by:				

AFTER Implementation				
Efficacy Assessment				
4.	Evaluation Date(s):		Technique Successful?	Y / N
	Notes:			
	Suggested Changes/ Next Steps:			
Completed by:				

BEFORE Implementation				
Management Techniques Log				
5.	Year:		Month(s):	
	Technique Used:			
	Intended Goal:			
Completed by:				

AFTER Implementation				
Efficacy Assessment				
5.	Evaluation Date(s):		Technique Successful?	Y / N
	Notes:			
	Suggested Changes/ Next Steps:			
Completed by:				

City of San Marcos Natural Areas Trail Monitoring Form

Site Name		
Site Location		
Site Purpose		
Inspector Name		Date:
Aerial Photo Used	Yes / No	

ISSUES	Description (location, scale, severity)	Action Taken / Recommendation
User Created Trails		
BMX Tracks		
ATV Trespass		
Vehicular Access		
Fire Rings		
Homeless Use		
Fire Hazards		
Garbage		

EROSION
Location
Type / Description
Scale / Size
Photograph Numbers
Recommendations

City of San Marcos Natural Areas Volunteer Interest Form

Please return to: San Marcos Parks & Recreation
401 E. Hopkins, San Marcos, TX 78666 or parksinfo@sanmarcostx.gov

Name: _____

Organization (if any): _____

Address: _____

Home Phone: _____ Cell: _____

Email address: _____

1. Why are you interested in participating in the City of San Marcos Natural Areas?

2. Have you volunteered for similar projects? If so, for what organization and please give a brief summary of your volunteer duties.

3. Do you have any disabilities, limitations on physical work, etc. that we should be aware of?

4. Do you have any special skills, interests, or work experience? Examples: biologist, geographer, master naturalist/gardener

5. Are you able to work outside in direct sun or varied temperatures throughout the year?

6. Are you willing to hike 2-3 miles to survey undisturbed natural areas? (not a requirement)

7. Are you willing to travel to survey undisturbed natural areas? (not a requirement)

8. Have you led groups or do you feel comfortable training others?

9. How many hours per month would you be able to commit to the project?

10. Are you available weekdays? (Please circle Yes or No) Y/N Weekends? Y/N

11. Are you familiar or have experience with:
 - Plant Identification?
 - GPS Units?
 - Digital Camera
 - Map Reading?
 - Compass Use?

POLLINATOR HABITAT MONITORING FORM



STEP 1—Monitoring Record

1. Photocopy or print a copy of this form in advance (www.xerces.org/habitat-assessment-guides);
2. Record all of the species initially seeded into the site on your Pollinator Habitat Installation Plan BEFORE first monitoring (i.e., during or immediately after planting); **AND**
3. Bring a copy of your Pollinator Habitat Installation Plan to refer to during each monitoring.

STEP 2—Site Details

SITE NAME: _____

CURRENT DATE: _____

SEASON: Early (Spring) Middle (Summer) Late (Late summer/fall) Dormant (Winter)

DATE OF LAST MONITORING: _____

STEP 3—Survey Desirable Species

We recommend monitoring once a month during the dormant season and every two weeks once the meadow starts blooming in spring. On sites with low maintenance needs—typically perennial plantings on established sites—we recommend monitoring at least 2x a year (in spring and late summer). For more information on suggested regional monitoring schedules, see Table 2.1.

Desirable Species: Native Wildflowers & Grasses

SPECIES & NOTES <small>(COMMON OR SCIENTIFIC NAME)</small>		ABUNDANCE* <small>(CIRCLE ONE)</small>	BLOOMING?† <small>(CIRCLE ONE)</small>	SCORE‡ <small>0 OR 1</small>
3.1: NATIVE WILDFLOWERS		A/C/R/N	☼ / ☻	
		A/C/R/N	☼ / ☻	
		A/C/R/N	☼ / ☻	
		A/C/R/N	☼ / ☻	
		A/C/R/N	☼ / ☻	
		A/C/R/N	☼ / ☻	
		A/C/R/N	☼ / ☻	
		A/C/R/N	☼ / ☻	
		A/C/R/N	☼ / ☻	
		A/C/R/N	☼ / ☻	
		A/C/R/N	☼ / ☻	
		A/C/R/N	☼ / ☻	
3.2: NATIVE GRASSES		A/C/R/N	☼ / ☻	
		A/C/R/N	☼ / ☻	
		A/C/R/N	☼ / ☻	
		A/C/R/N	☼ / ☻	

TOTAL Bloom Score

KEY	ABUNDANCE*				BLOOMING?†		SCORE‡								
	A	Abundant	C	Common	R	Rare	N	Not present	☼	Blooming	☻	Vegetative	1	☼ + A or C or R	0

STEP 4—Survey Unwanted Species

Unwanted Species: Native Forbs & Grasses				
SPECIES & NOTES (COMMON OR SCIENTIFIC NAME)		ABUNDANCE* (CIRCLE ONE)	BLOOMING?† (CIRCLE ONE)	⚠️
4.2: TREES/SHRUBS		A/C/R/N	🌸 / 🌿	
		A/C/R/N	🌸 / 🌿	
		A/C/R/N	🌸 / 🌿	
		A/C/R/N	🌸 / 🌿	
4.1: WEEDY FORBS		A/C/R/N	🌸 / 🌿	
		A/C/R/N	🌸 / 🌿	
		A/C/R/N	🌸 / 🌿	
		A/C/R/N	🌸 / 🌿	
4.3: WEEDY GRASSES		A/C/R/N	🌸 / 🌿	
		A/C/R/N	🌸 / 🌿	
		A/C/R/N	🌸 / 🌿	
		A/C/R/N	🌸 / 🌿	

KEY	ABUNDANCE*				BLOOMING?†		⚠️ (Highly Problematic)
	A	C	R	N	🌸	🌿	✗
	Abundant	Common	Rare	Not present	Blooming	Vegetative	Mark if species is highly problematic

Notes:

- * **Abundance:** Is the species Abundant (present in high numbers), Common (present and fairly abundant), Rare (present but in low numbers), or Not present?
- † **Blooming:** Is the species CURRENTLY Blooming (🌸) or Vegetative (🌿)?
- + **Score:** The Bloom Score of a DESIRABLE species is calculated based on its abundance and whether it is blooming:
 - 0 = Any species that is 🌿 (CURRENTLY vegetative) or Not present
 - 1 = Any species that is 🌸 (CURRENTLY blooming) AND Abundant, Common, or Rare
- ⚠️ **Highly Problematic Weed:** The presence or status of an UNWANTED species that requires immediate management action.

STEP 5—Calculate Species Diversity & Abundance

Tracking the levels of the desirable and unwanted species on a site over time will help to decide when management is necessary.

Desirable Species Total					
STEP	A	C	R	TOTAL	
1				Tally present species by abundance (Calculate total number of species)	
2				Count the number of species that are currently not present (Compare with Pollinator Habitat Installation Plan)	
3				Calculate TOTAL Bloom Score (Step 3) (If the TOTAL Bloom Score is ≤2, record this date as a Gap in Bloom on the Pollinator Habitat Evaluation Form) 🖨️	

Unwanted Species Total					
STEP	A	C	R	TOTAL	
1				Tally present species by abundance (Calculate total number of species)	
2				Count the number of species that are currently not present (Compare with previous Monitoring Forms)	
3				Calculate TOTAL Highly Problematic Weeds (Highly Problematic species require immediate action—track actions taken on the Pollinator Habitat Management Log) 🖨️	

STEP 6—Repeat Monitoring

Regular monitoring is important during the establishment phase (years 1 – 5). Consistent data, collected every 2–4 weeks from spring through fall during the key establishment years (which varies regionally; see regional variation Table 2.1), provides the best foundation for formulating management decisions. After the establishment time period, monitoring intervals can be increased. We do recommend periodic intensive monitoring every third year to ensure the habitat maintains desired conditions. Monitoring in years following severe or unusual weather can also help detect novel conditions that respond to the changing environment.

Example

POLLINATOR HABITAT MONITORING FORM



STEP 1—Monitoring Record

1. Photocopy or print a copy of this form in advance (www.xerces.org/habitat-assessment-guides);
2. Record all of the species initially seeded into the site on your Pollinator Habitat Installation Plan BEFORE first monitoring (i.e., during or immediately after planting); AND
3. Bring a copy of your Pollinator Habitat Installation Plan to refer to during each monitoring.

STEP 2—Site Details

SITE NAME: Oregon Meadow

SEASON: Early (Spring) Middle (Summer) Late (Late summer/fall) Dormant (Winter)

CURRENT DATE: June 20, 2016

DATE OF LAST MONITORING: May 28, 2016

STEP 3—Survey Desirable Species

We recommend monitoring once a month during the dormant season and every two weeks once the meadow starts blooming in spring. On sites with low maintenance needs—typically perennial plantings on established sites—we recommend monitoring at least 2x a year (in spring and late summer). For more information on suggested regional monitoring schedules, see Table 2.1.

Desirable Species: Native Forbs & Grasses

SPECIES & NOTES (COMMON OR SCIENTIFIC NAME)		ABUNDANCE* (CIRCLE ONE)	BLOOMING?† (CIRCLE ONE)	SCORE‡ 0 OR 1
3.1: NATIVE FORBS	1. California poppy (<i>Eschscholzia californica</i>)	A / (C) / R / N	(*) / (V)	1
	2. Globe gilia (<i>Gilia capitata</i>)	A / C / R / (N)	* / (V)	0
	3. Clarkia (<i>Clarkia</i> spp.)	(A) / C / R / N	(*) / (V)	1
	4. western yarrow (<i>Achillea millefolium</i>)	(A) / C / R / N	(*) / (V)	1
	5. Bigleaf lupine (<i>Lupinus polyphyllus</i>)	A / C / (R) / N	(*) / (V)	1
	6. Oregon sunshine (<i>Eriophyllum lanatum</i>)	A / C / (R) / N	(*) / (V)	1
	7. Douglas aster (<i>Symphotrichum subspicatum</i>)	A / C / (R) / N	* / (V)	0
	8. western goldentop (<i>Euthamia occidentalis</i>)	(A) / C / R / N	* / (V)	0
	A / C / R / N	* / (V)		
	A / C / R / N	* / (V)		
	A / C / R / N	* / (V)		
	A / C / R / N	* / (V)		
3.2: NATIVE GRASSES	1. Roemer's fescue (<i>Festuca roemerii</i>)	A / C / (R) / N	* / (V)	0
		A / C / R / N	* / (V)	
		A / C / R / N	* / (V)	
		A / C / R / N	* / (V)	

TOTAL Bloom Score 5

KEY	ABUNDANCE*				BLOOMING?†		SCORE‡								
	A	Abundant	C	Common	R	Rare	N	Not present	*	Blooming	(V)	Vegetative	1	* + A or C or R	0

STEP 4—Survey Unwanted Species

Unwanted Species: Native Forbs & Grasses						
SPECIES & NOTES (COMMON OR SCIENTIFIC NAME)		ABUNDANCE* (CIRCLE ONE)	BLOOMING?† (CIRCLE ONE)	▲		
4.2: TREES/SHRUBS	1. Himalayan blackberry (<i>Rubus armeniacus</i>)	A / C / R / N	* /	X		
		A / C / R / N	* /			
		A / C / R / N	* /			
		A / C / R / N	* /			
4.1: WEEDY FORBS	1. Bindweed (<i>Convolvulus arvensis</i>)	A / C / R / N	* /	X		
	2. English plantain (<i>Plantago lanceolata</i>)	A / C / R / N	* /			
		A / C / R / N	* /			
		A / C / R / N	* /			
4.3: WEEDY GRASSES	1. Giant foxtail (<i>Setaria faberi</i>)	A / C / R / N	* /			
	2. wild oat (<i>Avena fatua</i>)	A / C / R / N	* /	X		
		A / C / R / N	* /			
		A / C / R / N	* /			
KEY	ABUNDANCE*		BLOOMING?†		▲ (Highly Problematic)	
	A Abundant	C Common	R Rare	N Not present	* Blooming	Vegetative

Notes:

- * **Abundance:** Is the species Abundant (present in high numbers), Common (present and fairly abundant), Rare (present but in low numbers), or Not present?
- † **Blooming:** Is the species CURRENTLY Blooming (*****) or Vegetative ()?
- ‡ **Score:** The Bloom Score of a DESIRABLE species is calculated based on its abundance and whether it is blooming:
 0 = Any species that is (CURRENTLY vegetative) or Not present
 1 = Any species that is ***** (CURRENTLY blooming) AND Abundant, Common, or Rare
- ▲ **Highly Problematic Weed:** The presence or status of an UNWANTED species that requires immediate management action.

STEP 5—Calculate Species Diversity & Abundance

Tracking the levels of the desirable and unwanted species on a site over time will help to decide when management is necessary.

Desirable Species Total					Unwanted Species Total						
STEP	A	C	R	TOTAL	STEP	A	C	R	TOTAL		
1	Tally present species by abundance (Calculate total number of species)	3	1	5	9	1	Tally present species by abundance (Calculate total number of species)	0	2	3	5
2	Count the number of species that are currently not present (Compare with Pollinator Habitat Installation Plan)				1	2	Count the number of species that are currently not present (Compare with previous Monitoring Forms)				1
3	Calculate TOTAL Bloom Score (Step 3) (If the TOTAL Bloom Score is ≤2, record this date as a Gap in Bloom on the Pollinator Habitat Evaluation Form)				5	3	Calculate TOTAL Highly Problematic Weeds (Highly Problematic species require immediate action—track actions taken on the Pollinator Habitat Management Log)				3

STEP 6—Repeat Monitoring

Regular monitoring is important during the establishment phase (years 1 – 5). Consistent data, collected every 2–4 weeks from spring through fall during the key establishment years (which varies regionally; see regional variation Table 2.1), provides the best foundation for formulating management decisions. After the establishment time period, monitoring intervals can be increased. We do recommend periodic intensive monitoring every third year to ensure the habitat maintains desired conditions. Monitoring in years following severe or unusual weather can also help detect novel conditions that respond to the changing environment.

POLLINATOR HABITAT EVALUATION FORM



**XERCES
SOCIETY**
for Invertebrate Conservation

Evaluating habitat annually can help identify conditions and facilitate selection of management activities. **BEFORE YOU BEGIN:**

STEP 1—Monitoring Record

1. **Photocopy or print a copy** of this form in advance (www.xerces.org/habitat-assessment-guides); **AND**
2. **Record all of the species** initially seeded into the site on your Pollinator Habitat Installation Plan **BEFORE** first monitoring (i.e., during or immediately after planting).
3. Gather all Monitoring Forms from previous year.

STEP 2—Site Details

SITE NAME: _____

STEP 3—Desirable Species Persistence

Recording all the species initially seeded into the site and their abundance over time can help determine whether they are persisting, or are in danger of either disappearing or taking over the meadow. Use this information to determine when a management action, such as interseeding (seeding into existing stands of vegetation), is necessary.

NATIVE FORBS

Use the Pollinator Habitat Monitoring Forms to determine whether each native forb species is present year after year and estimate average abundance (use the record from the middle of the species' bloom period) in order to indicate if a species has low or high abundance and requires action:

1. **Low Abundance Species Management**—Highlight species that are expected to be Abundant or Common, but were found to be Rare or Not Present at least two years in a row or Rare species that were Not present for multiple years. Only wildflower species not present for more than three consecutive years should be considered to have disappeared (some may lie dormant for a brief period, then suddenly return). **NOTE:** in exceptionally diverse plantings (common in some regions like the Midwest), many species will be Rare for the lifetime of planting; **OR** some annual species that are early successional are expected to disappear over time and do not need to be re-seeded if other high value perennial species are present and abundant;
2. **High Abundance Management**—Mark species that are Abundant for multiple years in a row. If the abundance of a native species increases consistently over time and maintains high numbers, it may limit the presence of other species. Consider management actions to reduce its population (e.g., disking, hand-weeding, or spot-spraying herbicide);
3. **Bloom Time**—Note the average bloom time of each species in your planting;

#	SPECIES (COMMON OR SCIENTIFIC NAME)	BLOOM TIME	YEAR 1:	YEAR 2:	YEAR 3:	YEAR 4:	YEAR 5:
		Early Mid Late <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>					
		Early Mid Late <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>					
		Early Mid Late <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>					
		Early Mid Late <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>					
		Early Mid Late <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>					
		Early Mid Late <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>					
		Early Mid Late <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>					
		Early Mid Late <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>					
		Early Mid Late <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>					
		Early Mid Late <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>					

GAPS IN BLOOM	YEAR 1:	YEAR 2:	YEAR 3:	YEAR 4:	YEAR 5:
1. Record sampling dates with a TOTAL Bloom Score of ≤ 2 in the appropriate column by year (this information can be found in Step 5 of the Pollinator Habitat Monitoring Forms).					
2. Compare these dates with the average predicted Bloom Times to identify gaps in bloom greater than two weeks—potentially caused by low abundance or a lack of species diversity during certain times of year—that should trigger management actions.					

STEP 3—Desirable Species Persistence *continued*

NATIVE GRASSES						
<p>Native Grass Management—using the Pollinator Habitat Monitoring Forms, determine whether each native grass species is present year after year, then estimate average abundance throughout the year in order to determine if a species requires management, and circle any species that have reached a threshold amount. Track these species to ensure that their populations remain under the levels you deem acceptable.</p>						
#	SPECIES (COMMON OR SCIENTIFIC NAME)	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5

STEP 4—Unwanted Species Persistence

Keeping track of the levels of weedy species present will help to decide when management is necessary. We recommend setting a threshold level that weed populations should not exceed. When weeds get to those levels, it should trigger a management action.

Weeds, Non-natives, Invasive Species, etc.						
<p>Weed Management—using the Pollinator Habitat Monitoring Forms, determine which weedy species are present year after year and which species are Highly Problematic in order to determine if a species requires management. Circle any species that have reached a threshold amount or require immediate action. Track these species to ensure that their populations remain under the levels you deem acceptable. Many weed species are easy to control when their populations are low, but can quickly take over a site, necessitating re-starting when their numbers get too high.</p>						

TREES/SHRUBS						
#	SPECIES (COMMON OR SCIENTIFIC NAME)	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5

FORBS						
#	SPECIES (COMMON OR SCIENTIFIC NAME)	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5

GRASSES						
#	SPECIES (COMMON OR SCIENTIFIC NAME)	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5

Supplemental POLLINATOR HABITAT EVALUATION FORM

STEP 1—Photocopy or print copies of this form in advance (www.xerces.org/habitat-assessment-guides)

STEP 2—Continue Pollinator Habitat Evaluation Form

Attach this and all additional *Supplemental* Pollinator Habitat Evaluation Form sheets to the original Pollinator Habitat Evaluation Form.

STEP 3—Desirable Species Persistence *continued*

Recording all the species initially seeded into the site and their abundance over time can help determine whether they are persisting, or are in danger of either disappearing or taking over the meadow. Use this information to determine when a management action, such as interseeding (seeding into existing stands of vegetation), is necessary.

NATIVE FORBS

Use the Pollinator Habitat Monitoring Forms to determine whether each native forb species is present year after year and estimate average abundance (use the record from the middle of the species' bloom period) in order to indicate if a species has low or high abundance and requires action:

- Low Abundance Species Management**—Highlight species that are expected to be Abundant or Common, but were found to be Rare or Not Present at least two years in a row or Rare species that were Not present for multiple years. Only wildflower species not present for more than three consecutive years should be considered to have disappeared (some may lie dormant for a brief period, then suddenly return). **NOTE:** in exceptionally diverse plantings (common in some regions like the Midwest), many species will be Rare for the lifetime of planting; **OR** some annual species that are early successional are expected to disappear over time and do not need to be re-seeded if other high value perennial species are present and abundant;
- High Abundance Management**—Mark species that are Abundant for multiple years in a row. If the abundance of a native species increases consistently over time and maintains high numbers, it may limit the presence of other species. Consider management actions to reduce its population (e.g., disking, hand-weeding, or spot-spraying herbicide);
- Bloom Time**—Note the average bloom time of each species in your planting;

#	SPECIES (COMMON OR SCIENTIFIC NAME)	BLOOM TIME	YEAR 1:	YEAR 2:	YEAR 3:	YEAR 4:	YEAR 5:
		Early <input type="checkbox"/> Mid <input type="checkbox"/> Late <input type="checkbox"/>					
		Early <input type="checkbox"/> Mid <input type="checkbox"/> Late <input type="checkbox"/>					
		Early <input type="checkbox"/> Mid <input type="checkbox"/> Late <input type="checkbox"/>					
		Early <input type="checkbox"/> Mid <input type="checkbox"/> Late <input type="checkbox"/>					
		Early <input type="checkbox"/> Mid <input type="checkbox"/> Late <input type="checkbox"/>					
		Early <input type="checkbox"/> Mid <input type="checkbox"/> Late <input type="checkbox"/>					
		Early <input type="checkbox"/> Mid <input type="checkbox"/> Late <input type="checkbox"/>					
		Early <input type="checkbox"/> Mid <input type="checkbox"/> Late <input type="checkbox"/>					
		Early <input type="checkbox"/> Mid <input type="checkbox"/> Late <input type="checkbox"/>					
		Early <input type="checkbox"/> Mid <input type="checkbox"/> Late <input type="checkbox"/>					
		Early <input type="checkbox"/> Mid <input type="checkbox"/> Late <input type="checkbox"/>					
		Early <input type="checkbox"/> Mid <input type="checkbox"/> Late <input type="checkbox"/>					
		Early <input type="checkbox"/> Mid <input type="checkbox"/> Late <input type="checkbox"/>					

GAPS IN BLOOM	YEAR 1:	YEAR 2:	YEAR 3:	YEAR 4:	YEAR 5:
1. Record sampling dates with a TOTAL Bloom Score of ≤ 2 in the appropriate column by year (this information can be found in Step 5 of the Pollinator Habitat Monitoring Forms).					
2. Compare these dates with the average predicted Bloom Times to identify gaps in bloom greater than two weeks—potentially caused by low abundance or a lack of species diversity during certain times of year—that should trigger management actions.					

Example

POLLINATOR HABITAT EVALUATION FORM



Evaluating habitat annually can help identify conditions and facilitate selection of management activities. **BEFORE YOU BEGIN:**

STEP 1—Monitoring Record

1. Photocopy or print a copy of this form in advance (www.xerces.org/habitat-assessment-guides); AND
2. Record all of the species initially seeded into the site on your Pollinator Habitat Installation Plan **BEFORE** first monitoring (i.e., during or immediately after planting).
3. Gather all Monitoring Forms from previous year.

STEP 2—Site Details

SITE NAME: Oregon Meadow

STEP 3—Desirable Species Persistence

Recording all the species initially seeded into the site and their abundance over time can help determine whether they are persisting, or are in danger of either disappearing or taking over the meadow. Use this information to determine when a management action, such as interseeding (seeding into existing stands of vegetation), is necessary.

NATIVE FORBS

Use the Pollinator Habitat Monitoring Forms to determine whether each native forb species is present year after year and estimate average abundance (use the record from the middle of the species' bloom period) in order to indicate if a species has low or high abundance and requires action:

1. **Low Abundance Species Management**—Highlight species that are expected to be Abundant or Common, but were found to be Rare or Not Present at least two years in a row or Rare species that were Not present for multiple years. Only wildflower species not present for more than three consecutive years should be considered to have disappeared (some may lie dormant for a brief period, then suddenly return). **NOTE:** in exceptionally diverse plantings (common in some regions like the Midwest), many species will be Rare for the lifetime of planting; **OR** some annual species that are early successional are expected to disappear over time and do not need to be re-seeded if other high value perennial species are present and abundant;
2. **High Abundance Management**—Mark species that are Abundant for multiple years in a row. If the abundance of a native species increases consistently over time and maintains high numbers, it may limit the presence of other species. Consider management actions to reduce its population (e.g., disking, hand-weeding, or spot-spraying herbicide);
3. **Bloom Time**—Note the average bloom time of each species in your planting;

#	SPECIES (COMMON OR SCIENTIFIC NAME)	BLOOM TIME	YEAR 1: 2013	YEAR 2: 2014	YEAR 3: 2015	YEAR 4: 2016	YEAR 5:
1.	California poppy (<i>Eschscholzia californica</i>)	Early <input checked="" type="checkbox"/> Mid <input checked="" type="checkbox"/> Late <input checked="" type="checkbox"/>	*A	C	C	C	
2.	Globe gilia (<i>Gilia capitata</i>)	Early <input checked="" type="checkbox"/> Mid <input type="checkbox"/> Late <input type="checkbox"/>	C	N	R	N	
3.	Clarkia (<i>Clarkia</i> spp.)	Early <input type="checkbox"/> Mid <input checked="" type="checkbox"/> Late <input type="checkbox"/>	A	C	C	A	
4.	western yarrow (<i>Achillea millefolium</i>)	Early <input type="checkbox"/> Mid <input checked="" type="checkbox"/> Late <input checked="" type="checkbox"/>	C	C	C	C	
5.	Bigleaf lupine (<i>Lupinus polyphyllus</i>)	Early <input type="checkbox"/> Mid <input checked="" type="checkbox"/> Late <input type="checkbox"/>	C	C	R	R	
6.	Oregon sunshine (<i>Eriophyllum lanatum</i>)	Early <input type="checkbox"/> Mid <input checked="" type="checkbox"/> Late <input type="checkbox"/>	C	C	C	C	
7.	Douglas aster (<i>Symphotrichum subspicatum</i>)	Early <input type="checkbox"/> Mid <input type="checkbox"/> Late <input checked="" type="checkbox"/>	C	C	C	R	
8.	western goldentop (<i>Euthamia occidentalis</i>)	Early <input type="checkbox"/> Mid <input type="checkbox"/> Late <input checked="" type="checkbox"/>	*A	*A	*A	A-C	
		Early <input type="checkbox"/> Mid <input type="checkbox"/> Late <input type="checkbox"/>					
		Early <input type="checkbox"/> Mid <input type="checkbox"/> Late <input type="checkbox"/>					

GAPS IN BLOOM	YEAR 1:	YEAR 2:	YEAR 3:	YEAR 4:	YEAR 5:
1. Record sampling dates with a TOTAL Bloom Score of ≤ 2 in the appropriate column by year (this information can be found in Step 5 of the Pollinator Habitat Monitoring Forms).			3/20/15	3/28/16	
2. Compare these dates with the average predicted Bloom Times to identify gaps in bloom greater than two weeks—potentially caused by low abundance or a lack of species diversity during certain times of year—that should trigger management actions.				5/28/16	

Example

STEP 3—Desirable Species Persistence *continued*

NATIVE GRASSES						
Native Grass Management—using the Pollinator Habitat Monitoring Forms, determine whether each native grass species is present year after year, then estimate average abundance throughout the year in order to determine if a species requires management, and circle any species that have reached a threshold amount. Track these species to ensure that their populations remain under the levels you deem acceptable.						
#	SPECIES (COMMON OR SCIENTIFIC NAME)	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
1	Roemer's fescue (<i>Festuca roemerii</i>)	R	C	C	R	

STEP 4—Unwanted Species Persistence

Keeping track of the levels of weedy species present will help to decide when management is necessary. We recommend setting a threshold level that weed populations should not exceed. When weeds get to those levels, it should trigger a management action.

Weeds, Non-natives, Invasive Species, etc.

Weed Management—using the Pollinator Habitat Monitoring Forms, determine which weedy species are present year after year and which species are Highly Problematic in order to determine if a species requires management. **Circle** any species that have reached a threshold amount or require immediate action. Track these species to ensure that their populations remain under the levels you deem acceptable. Many weed species are easy to control when their populations are low, but can quickly take over a site, necessitating re-starting when their numbers get too high.

TREES/SHRUBS						
#	SPECIES (COMMON OR SCIENTIFIC NAME)	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
1	Himalayan blackberry (<i>Rubus armeniacus</i>)	R	R	N	R	

FORBS						
#	SPECIES (COMMON OR SCIENTIFIC NAME)	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
1	Bindweed (<i>Convolvulus arvensis</i>)	R	R	C	(A)	
2	English plaintain (<i>Plantago lanceolata</i>)	N	R	N	N	
3	Dock/sorrel (<i>Rumex spp.</i>)	R	R	R	N	

GRASSES						
#	SPECIES (COMMON OR SCIENTIFIC NAME)	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
1	Giant foxtail (<i>Setaria faberi</i>)	R	(C)	(C)	R	
2	wild oat (<i>Avena fatua</i>)	R	(C)	(C)	R	

This page intentionally left blank.

POLLINATOR HABITAT MANAGEMENT LOG



**XERCES
SOCIETY**
for Invertebrate Conservation

Keeping track of management techniques helps assess effectiveness of timing and method, allowing for improved implementation in future years.

STEP 1—Photocopy or print copies of this form in advance (www.xerces.org/habitat-assessment-guides)

STEP 2—Site Name: _____

STEP 3—Management Practices Record

Record all management techniques used. Be sure to include the timing of when the action was taken so if it is not effective, management can be adjusted in the future. In addition, record what the intended goal for the management (for example, “to reduce or eradicate Harding grass from the meadow”).

NOTE: Before implementing techniques the following year, be sure to evaluate whether the technique utilized met the intended goal. If not, adapt the existing technique (e.g., different timing and/or frequency) or trial a new one.

BEFORE IMPLEMENTATION				AFTER IMPLEMENTATION				
#	MANAGEMENT TECHNIQUES LOG			EFFICACY ASSESSMENT				
1.	YEAR:		MONTH(S):		EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			
2.	YEAR:		MONTH(S):		EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			
3.	YEAR:		MONTH(S):		EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			
4.	YEAR:		MONTH(S):		EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			

STEP 3—Management Practices Record *continued*

Continue to record all management techniques used, including: 1), timing of when the action was taken (so if it is not effective, management can be adjusted in the future); 2), the intended goal for the management (for example, “to reduce or eradicate Harding grass from the meadow”); **AND 3), before implementing techniques the following year, be sure to evaluate whether the technique utilized met the intended goal**—if not, adapt the existing technique (e.g., different timing and/or frequency) or trial a new one. If you run out of space, print *Supplemental Management Practices Record* sheets online at: www.xerces.org/habitat-assessment-guides.

BEFORE IMPLEMENTATION				AFTER IMPLEMENTATION				
#	MANAGEMENT TECHNIQUES LOG			EFFICACY ASSESSMENT				
5.	YEAR:		MONTH(S):	EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N	
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			
6.	YEAR:		MONTH(S):	EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N	
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			
7.	YEAR:		MONTH(S):	EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N	
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			
8.	YEAR:		MONTH(S):	EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N	
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			
9.	YEAR:		MONTH(S):	EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N	
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			

Supplemental POLLINATOR HABITAT MANAGEMENT LOG

Keeping track of management techniques helps assess effectiveness of timing and method, allowing for improved implementation in future years.

STEP 1—Photocopy or print copies of this form in advance (www.xerces.org/habitat-assessment-guides)

STEP 2—Continue Management Log

Attach this and all additional *Supplemental* Management Practices Log sheets to the original Pollinator Habitat Management Log.

STEP 3—Management Practices Record

Continue to record all management techniques used, including: 1), timing of when the action was taken (so if it is not effective, management can be adjusted in the future); 2), the intended goal for the management (for example, “to reduce or eradicate Harding grass from the meadow”); **AND** 3), **before implementing techniques the following year, be sure to evaluate whether the technique utilized met the intended goal**—if not, adapt the existing technique (e.g., different timing and/or frequency) or trial a new one. If you run out of space, print additional *Supplemental* Management Practices Record sheets online at: www.xerces.org/habitat-assessment-guides.

BEFORE IMPLEMENTATION				AFTER IMPLEMENTATION				
#	MANAGEMENT TECHNIQUES LOG			EFFICACY ASSESSMENT				
→	YEAR:		MONTH(S):	EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N	
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			
→	YEAR:		MONTH(S):	EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N	
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			
→	YEAR:		MONTH(S):	EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N	
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			
→	YEAR:		MONTH(S):	EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N	
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			

Example

POLLINATOR HABITAT MANAGEMENT LOG



Keeping track of management techniques helps assess effectiveness of timing and method, allowing for improved implementation in future years.

STEP 1—Photocopy or print copies of this form in advance (www.xerces.org/habitat-assessment-guides)

STEP 2—Site Name: Oregon Meadow

STEP 3—Management Practices Record

Record all management techniques used. Be sure to include the timing of when the action was taken so if it is not effective, management can be adjusted in the future. In addition, record what the intended goal for the management (for example, “to reduce or eradicate Harding grass from the meadow”).

NOTE: Before implementing techniques the following year, be sure to evaluate whether the technique utilized met the intended goal. If not, adapt the existing technique (e.g., different timing and/or frequency) or trial a new one.

BEFORE IMPLEMENTATION				AFTER IMPLEMENTATION				
#	MANAGEMENT TECHNIQUES LOG			EFFICACY ASSESSMENT				
1.	YEAR:	2015	MONTH(S):	Jun + Nov	EVALUATION DATE(S):	02/15/16	TECHNIQUE SUCCESSFUL?	Y / (N)
	TECHNIQUE USED:	Sprayed grass-selective herbicide			NOTES	Abundance of non-native grasses increased		
	INTENDED GOAL:	Decrease non-native grass cover, specifically harding grass + wild oat			SUGGESTED CHANGES/NEXT STEPS:	Spot-spray more frequently, starting in early spring to target during active growth		
2.	YEAR:	2016	MONTH(S):	Mar, Jun, Aug + Nov	EVALUATION DATE(S):	11/25/16	TECHNIQUE SUCCESSFUL?	(Y) / N
	TECHNIQUE USED:	Repeatedly spot-spray grass-selective herbicide, starting in early spring			NOTES	Reduced non-native cover so both target species were Rare		
	INTENDED GOAL:	Decrease non-native grass cover, specifically harding grass + wild oat			SUGGESTED CHANGES/NEXT STEPS:	None		
3.	YEAR:	2016	MONTH(S):	Oct + Nov	EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N
	TECHNIQUE USED:	Interseeded site in fall with globe gilia + bigleaf lupine			NOTES			
	INTENDED GOAL:	Increase abundance of declining spring/early summer wildflower species			SUGGESTED CHANGES/NEXT STEPS:			
4.	YEAR:		MONTH(S):		EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/NEXT STEPS:			

Guide to Self-Led Johnsongrass, Bamboo & Giant Cane Management Workday

Your responsibilities

- Have an approved restoration plan
- Submit [form](#) to parksvolunteer@austintexas.gov 30 days prior to event
- Establish, in agreement with Park Manager, location for the removed plant material
- Estimate volunteer needs (2 units minimum suggested in 2-hour shifts; 1 unit = 2 hours with 15 volunteers)
- Recruit volunteers. Keep Austin Beautiful and Austin Parks Foundation can provide support with this process.
- Coordinate information/training tasks
- Give safety orientation
- Provide work gloves, hand pruners, bags. Keep Austin Beautiful and Austin Parks Foundation can provide support with this process.
- Cleanup and organize removed plant material

Volunteer profile, age range: Activity appropriate for 10+ years old for johnsongrass and 15+ years old for giant cane and bamboo (volunteers under 18 years require adult supervision).

Volunteers must have received training on identifying johnsongrass, giant cane, and/or bamboo (training on site is OK).

Volunteers must demonstrate having ability to safely handle/use hand pruners (training on site is OK)

Clothes and safety: Closed-toe shoes, adequate drinking water, sun protection, poison ivy protection

Tools/Supplies: poison ivy block, poison ivy wash, gloves, pruners, loppers, lawn bags, invasive plant ID guides

Background

Johnsongrass (*Sorghum halepense*), golden bamboo (*Phyllostachys aurea*), and giant cane (*Arundo donax*) are invasive grasses that crowd out native plants, particularly in riparian areas. Ecological restoration is a long-term process. Control of exotic invasive species is only a part of this process and must be done gradually, particularly in areas with high densities on exotic invasive plants. Areas where invasive species are managed need to be seeded with native grasses and wildflowers. Tree seedling planting and/or seed bank enrichment are crucial to restore the native plant community, especially in areas with very little growth of native vegetation.

Johnsongrass is easily identified by its wide leaf blade with white stripe down the center. It is hard to control in open grasslands due to its long term seed viability and extensive root system. However, because it is a



Johnson grass

species that does not tolerate shade, once trees and shrubs outgrow it, it will not be a dominant species in

areas with full canopy. Constant removal of johnsongrass helps reduce its competitive ability against native tree saplings while they are growing. Removal requires manually pulling as much of the root system as possible with continued follow-up. Seed heads need to be removed to decrease further spread. Mid-spring is the best time to start removing johnsongrass, before it produces seeds. Continue removing monthly during the growing season. This will force the plants to exhaust their reserves every time it tries to grow. The above-ground portion of the plants often dies back in winter due to freezes, making locating/identifying plants difficult at this time of year.

Golden bamboo has fan-like cluster leaves and jointed stems. **Giant cane**, “Arundo”, is identified by alternate pointed leaves with bases that envelope the stem. Both species have extensive underground root structures



Bamboo



Giant Cane

that sprout when the aboveground parts are removed. Large areas infested with bamboo and giant cane are difficult to control. Small patches (100 sq ft or less) of bamboo and giant cane can be successfully managed with repeated manual removals, especially if roots systems are removed (only on gentle slopes and flat areas). If your site has an area larger than 100 square ft, a coordinated effort that includes very specific and targeted chemical treatment will likely be needed. Contact John Clement at john.clement@austintexas.gov for information on the requirements.

Day of event, removing johnsongrass, giant cane and/or bamboo

Note: Positively identify invasive plants before removing. Refer to www.austintexas.gov/invasive

Johnsongrass

- Hand dig the plants, including as much of the roots as possible in areas with gentle slopes (less than 3:1).
- If seeds have **NOT** formed, removed plants can be laid on the ground as mulch. If seeds **are already formed**, even if green, bag seed heads to minimize reseeding.

Giant Cane and Bamboo

- Hand dig small plants in areas with gentle slope (less than 3:1) and cut large plants to the base of the plant. Plants must be cut as close to the ground as possible, with a horizontal cut. Diagonal cuts create a hazard for park users.
- Cutting these plants once will have little impact on the infestation, so plan for monthly follow up workdays (or every other week if possible) to remove regrowth.



- Giant cane cuttings cannot be left on site; they can readily grow roots and re-establish. All cuttings need to be piled up in an orderly fashion, ready for pick-up. Piles must be not taller than 3' and must be placed at least 5' apart from each other. This location **must be agreed upon** through communication with PARD manager **prior to the event day**.

Workday follow up should include replanting and/or seeding (refer to Self-led Guide to Seeding).

Provided by Parks and Recreation Department

Retrieval of bamboo and/or giant cane cuttings and/or bags with johnsongrass. Location for staging plant material **MUST** be agreed upon with Park manager **PRIOR** to event day.

Provided by Watershed Protection Department

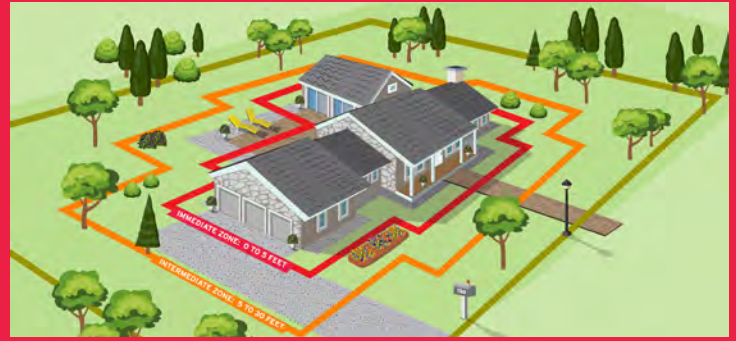
Support and guidance through development of a restoration plan. Assist with initial site visit to help determine area extent, scope, and potential follow-ups of the project.

City of San Marcos Natural Areas Fire Hazard Assessment

Site Name				
Site Location				
Site Purpose				
Inspector Name				Date:
Aerial Photo Used		Yes / no		
Coordination with City of San Marcos Fire Dept.				
Hazard Factor	Characteristics and Point Ratings			Score
Forest Vegetation Density Score	Non-Forested	Light Density	Moderate/Heavy Density	
	0	15	25	
Surface Vegetation Score	Lawn or non combustible material	Native and introduced grasses or shrubs	Dead and down woody material	
	0	5	Scatter = 5 Abundant = 15	
Ladder Fuels Score	Absent	Scattered	Continuous	
	0	5	10	
Slope Score	0 – 10%	10 – 25%	>25%	
	0	5	10	
Position on Slope Score	Valley bottom or lower slope	Mid-slope	Upper-slope	
	0	3	5	
Total Score				
Area Hazard Level				
Hazard Level Low<21 points Moderate 21-29 points High 30-35 points Extreme >35 points				
Fuel Break Locations (roads, rivers, rock outcrops, unvegetated areas, mark on aerial photos)				
Adjacent Properties at Risk (list addresses and mark on aerial photo)				
Identify Emergency Access Locations (list and mark on aerial photo)				
Outline potential mitigation strategies and other comments				

HOW TO PREPARE YOUR HOME FOR WILDFIRES

WILDFIRE RISK REDUCTION STEPS THAT CAN MAKE YOUR HOME SAFER DURING A WILDFIRE



■ VEGETATION MANAGEMENT

1. HOME IGNITION ZONES

To increase your home's chance of surviving a wildfire, choose fire-resistant building materials and limit the amount of flammable vegetation in the three home ignition zones. The zones include the **Immediate Zone**: (0 to 5 feet around the house), the **Intermediate Zone** (5 to 30 feet), and the **Extended Zone** (30 to 100 feet).

2. LANDSCAPING AND MAINTENANCE

To reduce ember ignitions and fire spread, trim branches that overhang the home, porch, and deck and prune branches of large trees up to 6 to 10 feet (depending on their height) from the ground. Remove plants containing resins, oils, and waxes. Use crushed stone or gravel instead of flammable mulches in the **Immediate Zone** (0 to 5 feet around the house). Keep your landscape in good condition.

■ FIRE RESISTIVE CONSTRUCTION

3. ROOFING AND VENTS

Class A fire-rated roofing products, such as composite shingles, metal, concrete, and clay tiles, offer the best protection. Inspect shingles or roof tiles and replace or repair those that are loose or missing to prevent ember penetration. Box in eaves, but provide ventilation to prevent condensation and mildew. Roof and attic vents should be screened to prevent ember entry.

4. DECKS AND PORCHES

Never store flammable materials underneath decks or porches. Remove dead vegetation and debris from under decks and porches and between deck board joints.

5. SIDING AND WINDOWS

Embers can collect in small nooks and crannies and ignite combustible materials; radiant heat from flames can crack windows. Use fire-resistant siding such as brick, fiber-cement, plaster, or stucco, and use dual-pane tempered glass windows.

■ BE PREPARED

6. EMERGENCY RESPONDER ACCESS

Ensure your home and neighborhood have legible and clearly marked street names and numbers. Driveways should be at least 12 feet wide with a vertical clearance of 15 feet for emergency vehicle access.

- Develop, discuss, and practice an emergency action plan with everyone in your home. Include details for handling pets, large animals, and livestock.
- Know two ways out of your neighborhood and have a predesignated meeting place.
- Always evacuate if you feel it's unsafe to stay—don't wait to receive an emergency notification if you feel threatened from the fire.
- Conduct an annual insurance policy checkup to adjust for local building costs, codes, and new renovations.
- Create or update a home inventory to help settle claims faster.



**TALK TO YOUR LOCAL FORESTRY AGENCY
OR FIRE DEPARTMENT TO LEARN MORE
ABOUT THE SPECIFIC WILDFIRE RISK
WHERE YOU LIVE.**



FIREWISE USA®
RESIDENTS REDUCING WILDFIRE RISKS

VISIT [FIREWISE.ORG](https://www.firewise.org) FOR MORE DETAILS

Firewise® is a program of the National Fire Protection Association. This publication was produced in cooperation with the USDA Forest Service, US Department of the Interior, and the National Association of State Foresters. NFPA is an equal opportunity provider. Firewise® and Firewise USA® are registered trademarks of the National Fire Protection Association, Quincy, MA 02169.

Order a Reducing Wildfire Risks in the Home Ignition Zone checklist/poster at [Firewise.org](https://www.firewise.org)



Outdoor Burning in Texas

Field Operations

Texas Commission on Environmental Quality



Texas Commission on Environmental Quality

Bryan W. Shaw, Ph.D., P.E., *Chairman*

Toby Baker, *Commissioner*

Zak Covar, *Commissioner*

Richard A. Hyde, P.E., *Executive Director*

We authorize you to use or reproduce any original material contained in this publication—that is, any material we did not obtain from other sources. Please acknowledge the TCEQ as your source.

Copies of this publication are available for public use through the Texas State Library, other state depository libraries, and the TCEQ Library, in compliance with state depository law. For more information on TCEQ publications call 512-239-0028 or visit our website at:

tceq.texas.gov/publications

Published and distributed
by the
Texas Commission on Environmental Quality
P.O. Box 13087
Austin TX 78711-3087

How is our customer service?
tceq.texas.gov/customersurvey

Outdoor Burning in Texas

Field Operations

Texas
Commission on
Environmental
Quality



Contents

Introduction 5

Limitations of This Guide 5

The Outdoor Burning Rule Explained 5

Summary of the Rule 5

Exceptions to the Prohibition 6

Firefighter Training 6

Fires for Recreation, Ceremonies, Cooking, or Warmth 7

Fires for Disposal or Land Clearing 7

Prescribed Burns 10

Pipeline Breaks and Oil Spills 10

Other Situations 11

General Requirements for Burning 11

Practical Alternatives to Burning 12

Related TCEQ Publications 12

Appendix A: Outdoor Burning— When Should You Notify the TCEQ? 13

Appendix B: TCEQ Areas and Regional Offices 14

Appendix C: Outdoor Burning Rule 16

Appendix D: Background 20

Appendix E: Arson Resources and Contact Information 22

 printed on recycled paper using vegetable-based ink.





Introduction

This guide helps interpret the revised Outdoor Burning Rule, Title 30, Texas Administrative Code, Sections 111.201–221,¹ for the general public, the regulated community, and responsible state and local officials.

This document covers all aspects of the outdoor burning rule, including:

- exceptions that allow outdoor burning
- general requirements for allowing outdoor burning
- notification requirements for allowable outdoor burning

At the end of various sections, common questions relating to the material in the section are answered.

State and local officials may find Appendixes C and D to be particularly useful. They contain a copy of the rule itself and background information for each of its sections.

This guide is not a substitute for the actual rule. A current copy of the rule can be obtained from the TCEQ by calling 512-239-0028, or online at <www.tceq.texas.gov/rules>.

Limitations of This Guide

This document does not include requirements of other government agencies. Local ordinances and governmental entities may restrict when, where, how, and if individuals and organizations can conduct outdoor burning.

Some municipalities have enacted local ordinances that prohibit or restrict outdoor fires within their corporate limits. Residents should always check with municipal officials about possible limitations on outdoor burning so they do not unintentionally violate an existing ordinance.

During extreme fire danger, governmental units may ban outdoor burning to help prevent possibly disastrous wildfires. A county judge and county commissioners' court may issue a ban on outdoor burning that is applicable to unincorporated portions of the county.

In addition, Texas criminal statutes specify penalties that pertain to escaped control fires and wildland fires that were deliberately set. Persons responsible for escaped control or arson wildfires may also be faced with civil suits for damages caused by these fires.

¹ In this document, "30 TAC 111" is short for "Title 30, Texas Administrative Code, Chapter 111."

Numerous authorities, including the National Weather Service and the Texas A&M Forest Service, may issue advisories, watches, or warnings when weather and fuel conditions increase the risk of escaped fires or the severity of wildfires. Public cooperation during the dangerous wildfire conditions is essential to prevent needless wildfires and the losses they may cause.

The Outdoor Burning Rule Explained

The current version of the Outdoor Burning Rule is the result of a concerted effort to produce a streamlined, unambiguous rule that can be applied consistently and fairly throughout Texas. Its purpose is to protect the environment, promote public health and safety, and avoid nuisance conditions through the sensible regulation of outdoor burning.

Summary of the Rule

The Outdoor Burning Rule first prohibits outdoor burning anywhere in Texas, and then allows exceptions for specific situations in which burning is necessary or does not pose a threat to the environment. The rule also prescribes conditions that must be met to protect the environment and avoid other adverse impacts when burning is allowed. If burning seems necessary, but the situation does not fit an exception stated in the rule, then it is possible to request a special authorization to conduct burning from the TCEQ.

How do I obtain a burning permit from the TCEQ?

The TCEQ does not issue burning permits. Outdoor burning in general is prohibited in Texas, although the Outdoor Burning Rule (Appendix C) does allow certain exceptions. If your situation fits all requirements for one of the exceptions described in the rule, you may conduct outdoor burning, as long as you comply with all the conditions. Depending on the circumstances, you may also need authorization from the appropriate regional office before you burn. Remember to check local ordinances or other regulations about burning.

It looks like I can get the TCEQ's authorization to burn, but my neighbors may complain. Do I have to worry about what they think?

Yes. In addition to common courtesy, the Outdoor Burning Rule requires that certain kinds of burning be conducted downwind of, or at least 300 feet from, any structure containing sensitive receptors (for example, a residence, business, barn, or greenhouse; see box, page 8) located on adjacent properties unless written approval is obtained beforehand from the owner or occupant—the one who will suffer adverse effects—of the adjacent or downwind property. Also, the burning must not cause a nuisance or traffic hazard.

The rule authorizes (or the TCEQ has authorized) my outdoor burning. Before I actually set the fire, do I have to notify the TCEQ?

It depends. For certain types of burning, the rule requires you to notify the appropriate TCEQ regional office. For others, you are not required to notify the TCEQ. But, before you strike that match, remember that you may have to contact other agencies—or even your neighbors—as well as the TCEQ. See Appendix A for the notification requirements for the various kinds of burning covered under the rule. Up-to-date information regarding weather conditions can be obtained online through a number of websites. This information should be referenced before conducting outdoor burning in order to determine which way (and how fast) the wind is blowing, whether winds are expected to shift, whether your area is under a temperature inversion, and whether high ozone levels are forecast. Ozone level information is available on TCEQ's Texas Air Quality Forecast page: <www.tceq.texas.gov/goto/airtoday>.

How do I report someone who is illegally burning outdoors?

Report the burning to the local air pollution-control office, or the nearest TCEQ regional office. The TCEQ's Environmental Complaint Hotline is 888-777-3186. Complaints can also be submitted by e-mail at <complaint@tceq.texas.gov> or using the online form available at <www.tceq.texas.gov/complaints>.

Exceptions to the Prohibition

The standard exceptions, explained below, cover the most common situations in which burning is an acceptable practice. In most of these instances, the burning must follow the

general requirements outlined later in this document. It may be necessary to notify the TCEQ, local governmental agencies, and neighbors before conducting burning under one of these exceptions. See Appendix A for details on notification requirements in specific situations. There may be local ordinances or county burn bans that regulate burning; if so, the requirements and restrictions of those ordinances must also be met.

Firefighter Training

Organizations that train firefighters may obtain authorization to conduct outdoor burning for such training, including training in the operation of fire extinguishers. To obtain an authorization, the organization responsible for the training must send a written request to the local air pollution-control agency under contract with the TCEQ, or, if there is no such agency, the appropriate TCEQ regional office. For a list of regional offices, see Appendix B.

If training occurs regularly at a dedicated facility, it may be possible to inform the regional office of all such training events with one annual written notification. If a dedicated training facility conducts training regularly but less often than once a week, a telephone or fax notification will be necessary 24 hours in advance of each event.

Burning conducted to train firefighters does not have to conform to the general requirements for other forms of allowable outdoor burning, but it must not cause a nuisance or traffic hazard. The TCEQ may revoke its authorization if it is used in an attempt to avoid complying with other portions of the Outdoor Burning Rule.

We want to conduct fire training for our volunteer fire department. Can we burn this abandoned house?

The training of firefighters may be authorized as an exception to the prohibition on outdoor burning. Submit a written request on behalf of the VFD to the local air pollution-control agency, or, if there is no local agency, the TCEQ office for your region. The TCEQ may authorize such training orally or in writing; if it denies the request, your VFD will receive a notice of denial within 10 working days after the postmark date or the date of personal delivery of the request to the regional office. To ensure that the fire will not form or disperse toxic substances, the local air pollution-control agency or the reviewing TCEQ regional office may require that the building be stripped of many common construction materials—including electrical wiring, lead flashing, carpet, asbestos, and many others—before the fire is ignited.

Note that the burning of abandoned buildings by a fire department is not automatically considered fire training. There must be a specific benefit to the fire department. Simply preventing the spread of fire from an abandoned building to neighboring property is not considered training. Such burns constitute an attempt to circumvent the Outdoor Burning Rule and are prohibited.

Fires for Recreation, Ceremonies, Cooking, or Warmth

Outdoor burning is allowed when used solely for recreational or ceremonial purposes, in the noncommercial preparation of food, or exclusively as a means of generating warmth in cold weather. In other words, campfires, bonfires, and cooking fires are allowed. Fires built under this exception may not contain electrical insulation, treated lumber (including paint, stain, varnish, clear coat, or any other kind of treatment), plastics, construction or demolition materials not made of wood, heavy oils, asphaltic materials, potentially explosive materials, chemical wastes, or items containing natural or synthetic rubber. The other general requirements on allowable outdoor burning do not apply to fires covered by this exception, but the burning must not cause a nuisance or traffic hazard.

May I cook food on my charcoal grill in my backyard?

Yes. Fires used in the noncommercial preparation of food are allowed.

May I build a fire in my fireplace?

Yes. Indoor fires are not regulated by the Outdoor Burning Rule. Domestic-use fireplaces are authorized under the TCEQ’s de minimis rules in 30 TAC 116.119.

Are campfires allowed inside the city limits?

Fires used solely for recreation or ceremony are allowed by state law; however, local ordinance may prohibit this kind of burning. Make sure no oils, asphalt, synthetic rubber, or other materials that produce heavy smoke are in the fire: they could release toxic gases or cause a nuisance or traffic hazard.

Fires for Disposal or Land Clearing

A broad exception for fires to dispose of waste or clear land covers seven more specific categories, described below. Residents of Montgomery County are subject to special restrictions (see below); these restrictions could be extended

to other areas of the state should growth in neighboring counties render them subject to the provisions of Texas Local Government Code 352.082.

1. Domestic waste. Domestic waste—in other words, household trash or rubbish—may be burned when the local governmental organization with jurisdiction over such matters does not collect trash and does not authorize a business or other service to do so. To qualify for this exception, the waste must come from a property that is designed to be a private residence and used exclusively as a private residence for no more than three families. The waste must also be burned on the property where it was produced. According to TCEQ rules [30 TAC 101.1(26)], domestic wastes include wastes that normally result from the function of life within a residence—for example, kitchen garbage, untreated lumber, cardboard boxes, packaging, clothing, grass, leaves, and branch trimmings. Such items as tires, construction debris, furniture, carpet, electrical wire, and appliances are not considered to be domestic waste and cannot be burned. Other conditions of the general requirements for outdoor burning do not apply to the burning of domestic waste, but the outdoor burn must not cause a nuisance or traffic hazard.

2. Diseased animal carcasses. These may be burned when burning is the most effective means of controlling the spread of disease. The general requirements for outdoor burning do not apply to this exception, but burning under this exception must not cause a nuisance or traffic hazard.

3. Burning of animal remains by a veterinarian. A veterinarian may burn animal remains and medical waste—not including sharps (e.g., needles)—associated with animals in his or her care on his or her property if the property is located outside the corporate boundaries of a municipality (or within such boundaries if annexed on or after September 1, 2003). This section prevails over any other law that authorizes a governmental authority to abate a public nuisance. (Texas Occupations Code 801.361.)

4. On-site burning of waste plant growth. Trees, brush, grass, leaves, branch trimmings, or other plant growth may be burned on the property on which the material grew in most attainment counties, as described below. In all cases, the plant growth must be burned by the property owner or any other person authorized by the owner.

- *All designated nonattainment counties and some attainment counties.* Burning of waste plant growth is allowed only if the material was generated as a result of right-of-way maintenance, land clearing, or maintenance along water canals, and no practical alternative to burning exists. “Practical alternative” is defined as ‘an economically, technologically, ecologically, and logistically viable

option.’ See Appendix D. Burning carried out under this exception must conform to all the general requirements for outdoor burning.

- *Most attainment counties.* Burning of waste plant growth is allowed regardless of the activity that generated the material. Practical alternatives need not be considered. Burning carried out under this exception must conform to some of the general requirements for outdoor burning, specifically the requirements in 30 TAC 111.219(3, 4, 6, 7) (see Appendix C). Such burning is also subject to local ordinances that prohibit burning within the corporate limits of a city or town. Some attainment counties are treated as nonattainment counties for the purposes of this exception. Specifically, any attainment county that contains any part of a municipality that extends into a bordering nonattainment county is treated as a nonattainment county for the purposes of this exception.

To determine if your county is an attainment or a nonattainment county for the purposes of this exception, call your regional TCEQ office. TCEQ regional-office phone numbers appear in Appendix B.

5. Designated burn sites. This exception allows rural homeowners to transport their yard waste to a designated site for consolidated burning, rather than having numerous smaller fires in the yards of rural neighborhoods. All burning at a designated site must be directly supervised by a fire-department employee. Designated burn sites must be located outside the corporate limits of a municipality and within a county that has a population of less than 50,000. The site must be designated by its owner; designation does not require registration with the agency. A site is designated by:

- posting all entrances to the site with a placard measuring at least 2 feet wide by 4 feet high bearing specific information as stated in 30 TAC 111.209(5)(A) (see Appendix C)—each placard must be clearly visible and legible at all times; and
- specifying residential properties for which the site has been designated, and maintaining a record of those specific residential properties. The record must contain a description of a platted subdivision, a list of all specific residential addresses, or both. This record must be made available within 48 hours of any request by any authority having jurisdiction.

Furthermore, the owner of the site is required to ensure that all activities at the site comply with this exception. The owner must:

- ensure that all waste burned at the site consists of trees, brush, grass, leaves, branch trimmings, or other plant

growth, and was generated at one of the specific residential properties for which the site is designated; and

- ensure that all burning at the site is directly supervised by a paid, on-duty fire department employee who is part of the fire protection personnel and is acting in the scope of his or her employment. The fire-department employee must notify the appropriate TCEQ regional office by phone or fax 24 hours in advance of each burn. The TCEQ will supply the employee with information on practical alternatives to burning.

6. Crop residues. When there is no practical alternative, crop residues may be burned as part of agricultural management. Burning carried out under this exception must conform to the general requirements for outdoor burning, and structures containing “sensitive receptors” (see box) must not be negatively affected by the burn. This exception does not apply to crop-residue burning covered by an administrative order.

“Sensitive receptors” include humans and livestock, as well as “sensitive live vegetation” such as nursery plants, mushrooms under cultivation, and plants raised for pharmaceutical production or used in lab experiments. For a complete definition, see 30 TAC 111.203(7) (see Appendix C).

7. Brush, trees, etc., off-site. A county or municipal government may request site and burn authorization in writing from the appropriate TCEQ regional office to burn accumulations of brush, trees, and other plant growth that cause a condition detrimental to public health and safety. The burn must occur at a site owned by the local government and will be authorized only if the TCEQ determines that there is no practical alternative. The frequency of such burns may not exceed once every two months, and they cannot be used in place of other sound brush-management practices. Burning conducted under this exception must conform to the general requirements for allowable outdoor burning. The burning may not occur at a municipal landfill without advance permission from the TCEQ.

Special restrictions in Montgomery County. Regardless of the seven exceptions given above, in unincorporated areas of Montgomery County it is a criminal offense, as well as a violation of agency rules, to burn household refuse on a lot smaller than five acres or located in a “neighborhood.” The terms “neighborhood” and “refuse” are defined in 30 TAC 111.203 (see Appendix C). Under Texas Local Government Code 352.082, this restriction could in the future also apply to certain planned communities if a county adjacent to the

one where such a community is located grows to 3.3 million or more in population.

I live in a small rural town where most people have their trash picked up by a commercial trash-collection service. I can't afford to pay that money each month. May I burn my trash in a 55-gallon drum in my backyard?

If there is no governmentally provided or authorized trash-collection service available to you, you may burn domestic waste on the property where it is produced, as long as outdoor burning is not prohibited by local rule or ordinance and does not create a nuisance or a traffic hazard.

May I burn my old oil filters in a metal barrel on my property?

No. Take oil filters to an authorized recycling site, along with your used oil. You may call 800-CLEAN-UP for more information on recycling.

I want to burn boxes from my business. The TCEQ rules say that I may burn waste from my residence, but what about waste from my business?

According to the Outdoor Burning Rule, you can't burn business waste. The exception that allows the burning of domestic waste applies only if the property is used exclusively as a private residence and the local governmental authority does not provide or authorize the collection of waste at the premises where the waste is generated. There is no such exception for businesses. You should look into the possibility of recycling your boxes and other business or commercial wastes such as pallets, cardboard, barrels, etc. or find ways that you or others could reuse them.

We have a hard time disposing of scrap tires. Will the TCEQ let us burn them?

No. The rule provides no exception for the disposal of tires through outdoor burning—or any other items that contain natural or synthetic rubber—because of the air pollution that would result. The TCEQ's Scrap Tire Program (512-239-2515, <www.tceq.texas.gov/tires>) can give you more information regarding proper methods for tire disposal.

What may be burned at municipal landfills?

Routine burning is not allowed at municipal landfills.

I am a licensed veterinarian. Do I need authorization to burn animals that died while in my care?

Not if you are located outside the corporate boundaries of a municipality (or within those boundaries if annexed on or after September 1, 2003) and you burn the animal remains on property owned by you. You can also burn medical waste associated with the animal, with the exception of sharps (e.g., needles). For details, see section 801.361 of the Texas Occupations Code.

May I burn trees that I have cut down in my backyard?

There are a couple of exceptions to the prohibition on outdoor burning that may allow you to burn trees.

First, grass, leaves, and branch trimmings from residences are all considered "domestic waste." If your local government does not collect domestic waste and does not authorize a private collector to do so, you may burn material of this type. If such waste collection is available, then it cannot be burned under the domestic-waste exception.

Regardless of whether domestic-waste pickup is available, a separate exception may apply depending on your location. If you are in a county that does not contain any part of a city that extends into a nonattainment county, you may burn plant waste (not all domestic waste) on the property on which it was generated. For information regarding nonattainment counties visit <www.tceq.texas.gov/airquality/sip>.

However, under both of these exceptions, the burning must not create a nuisance or traffic hazard, and you must comply with all applicable local rules or ordinances.

I have some uncleared property inside the city limits that I would like to develop. Hauling the trees and brush off would not be practical because it is too expensive. May I dispose of the trees and brush by burning?

It depends on the attainment status of the county in which you wish to burn. In designated nonattainment counties, and attainment counties that border nonattainment counties and contain any part of a city that extends into the nonattainment county, this type of burning does not meet the exception unless the municipal government has enacted ordinances that permit burning consistent with state law. You must consider alternatives such as chipping or trench burning. If there is no practical alternative, and the city has not enacted ordinances that permit burning, you may request

written permission from the TCEQ for authorization to burn, and you cannot commence with the burning until you receive such authorization. Such requests are evaluated on a case-by-case basis. Contact the appropriate TCEQ regional office for guidance.

In all other counties this burning meets the agency exception unless the municipal government has enacted ordinances that prohibit burning.

For information regarding nonattainment counties visit <www.tceq.texas.gov/airquality/sip>.

I am in the business of trimming people's trees and shrubs in town. I realize that the tree limbs and trimmings can't be burned in town, but I own some land outside of town. May I take it out there and burn it?

No. The Outdoor Burning Rule allows the burning of land clearing materials only at the site of the land clearing.

Why are sugar growers allowed to burn their cane fields?

At the request of Rio Grande Valley Sugar Growers, Inc., the TCEQ conducted extended air-monitoring studies of the Texas sugarcane-growing area. The agency determined that no practical alternative to burning exists for this industry. The TCEQ then adopted an agreed order with the Rio Grande Valley Sugar Growers, Inc., that outlines conditions under which the sugarcane industry can conduct burning.

The burning of corn stubble produces a great amount of smoke. Is this type of burning authorized?

Yes. Burning for crop management is allowed if there is no practical alternative, if it is conducted under appropriate weather conditions and at appropriate times, and if it does not cause a nuisance or traffic hazard.

There are tree limbs in an area of our community that pose a public safety risk. What are our options for solving this problem?

Brush, trees, and other forms of plant growth that present a detriment to public health and safety may be burned by a county or municipal government at a site it owns upon receiving site and burn authorization from the TCEQ. Such burning can only be authorized when there is no practical alternative, and it may be done no more than once every two months. The local government has the burden of proving

that there is no practical alternative and that the growth poses a detriment to public health or safety. Burning to augment normal brush disposal cannot be a continual or a standard operating procedure and cannot be conducted at municipal landfills unless authorized in writing by the TCEQ.

Is hay that has been used as bedding for animals considered crop residue?

No. Hay used for this purpose will need to be properly disposed of by a method other than burning. Check with your local county officials or agricultural organizations. They may need this material for erosion control or other purposes.

Prescribed Burns

This exception covers the use of fire to manage forests, rangeland, wildland and wildlife, coastal salt marsh in 14 counties, and for wildfire-hazard mitigation. All of these forms of burning are subject to the general requirements for allowable outdoor burning. Coastal salt-marsh burning also entails more specific notification requirements, which are stated in 30 TAC 111.211(2)(A) and (B).

Who can I contact for technical information relating to prescribed burning?

A good source is the Prescribed Burning Board of the Texas Department of Agriculture, which sets standards for prescribed burning; develops a comprehensive training curriculum for prescribed-burn managers and sets standards for their certification, recertification and training; establishes minimum education and professional requirements for instructors for the approved curriculum; and sets minimum insurance requirements for prescribed-burn managers.

For safety reasons, a prescribed-burn plan may call for burning at night. Such a plan requires special authorization and must consider the effects of a temperature inversion on smoke dispersal in order to protect public health.

Pipeline Breaks and Oil Spills

An oil (or other hydrocarbon) spill or pipeline break may trigger a requirement to notify the appropriate TCEQ regional office. Once notified of the spill, the regional office staff will decide whether burning is necessary to protect the public welfare. If the TCEQ gives the company or person responsible for the spill permission to burn, the TCEQ may also require that company or person to take samples and monitor the site to determine and evaluate environmental impacts.

Other Situations

If a situation may require outdoor burning but is not covered by the previously described exceptions, you may request permission to burn from the TCEQ regional office. Its staff, acting on behalf of the executive director, will consider whether there is a practical alternative, whether the burning will cause or contribute to a nuisance or traffic hazard, and whether the practice will violate any federal or state primary or secondary standard for ambient air quality. Such an authorization may require you to follow certain procedures to control or abate emissions. The authorization may be revoked at any time if the TCEQ determines that the outdoor burning is creating a nuisance, violating any provision of an applicable permit, causing a violation of any air quality standard, or not conforming to the conditions specified in the authorization.

A bad storm knocked a lot of trees down in our community. May we burn the debris? May we haul it to the landfill and burn it?

Regardless of whether the brush is to be burned on-site or at the landfill, this type of burning is not specifically authorized in the exceptions to the prohibition on outdoor burning. However, the TCEQ may authorize the disposal of storm debris if there are no practical alternatives. Such requests are evaluated on a case-by-case basis. Contact the appropriate TCEQ regional office for guidance.

Why are housing subdivisions allowed to dig pits and burn their land-clearing materials within city limits?

They are using a process called air-curtain incineration (trench burning), which is authorized under a permit by rule or standard permit. Companies that specialize in that business must obtain prior TCEQ approval, obtain a federal operating permit, and follow specific written operating procedures.

General Requirements for Outdoor Burning

- If a proposed outdoor burn meets the conditions for an exception to the general prohibition of outdoor burning, additional requirements designed to protect public health, safety, and the environment may apply. They are designed to reduce the likelihood that the burning will create a nuisance, cause a hazard, or harm the environment. The specific requirements applicable to each type of allowable outdoor burn are identified in the exceptions (see Appendix C). The party responsible for the burn remains liable for damages, injuries, or other consequences that may result from burning, even when it is carried out in compliance with these regulations.
- Notify the Texas A&M Forest Service before carrying out any prescribed or controlled burns that are intended for forest management.
- Burn only outside the corporate limits of a city or town, unless the incorporated city or town has an ordinance, consistent with the Texas Clean Air Act, Subchapter E, that permits burning.
- Commence or continue burning only when the wind direction and other weather conditions are such that the smoke and other pollutants will not present a hazard to any public road, landing strip, or navigable water (e.g., lake, river, stream, or bay) or have an adverse effect on any off-site structure containing “sensitive receptors” (e.g., a residence, business, farm building, or greenhouse; see box, page 8). Up to date information regarding weather conditions can be obtained online through a number of websites. This information should be referenced before conducting outdoor burning in order to determine the direction and speed of the wind, whether winds are expected to shift, whether your area is under a temperature inversion, and whether high ozone levels are forecast. Ozone level information is available on the TCEQ’s Texas Air Quality Forecast page: <www.tceq.texas.gov/goto/airtoday>.
- Post someone to flag traffic if at any time the burning causes or may tend to cause smoke to blow onto or across a road or highway.
- Keep fires downwind of, or at least 300 feet away from, any neighboring structure that contains sensitive receptors. This requirement may be waived only with the prior written approval of whoever owns or rents the adjacent property and either resides or conducts business there.
- Begin burning no earlier than one hour after sunrise. Cease burning the same day no later than one hour before sunset, and make sure that a responsible party is present while the burn is active and the fire is progressing. At the end of the burn, extinguish isolated residual fires or smoldering objects if the smoke they produce can be a nuisance or a traffic hazard. Do not start burning unless weather conditions are such that the smoke will dissipate (winds of at least 6 miles per hour; no temperature inversions) while still allowing the fire to be contained and controlled (winds no faster than 23 miles per hour).

- Do not burn any electrical insulation, treated lumber, plastics, non-wooden construction or demolition materials, heavy oils, asphaltic materials, potentially explosive materials, chemical wastes, or items that contain natural or synthetic rubber.

My situation doesn't fit any of the exceptions given in the rule, but I still think that burning is the only practical alternative. What can I do?

Submit a written request to the TCEQ regional office that serves the county where you wish to conduct outdoor burning. Acting on behalf of the executive director, regional personnel will review your request and determine whether a practical alternative is available. If they agree that none can be found, they will issue you a written authorization to burn that outlines specific conditions you must follow to control the emissions.

We are burning in compliance with TCEQ regulations, but the local fire marshal objects. Is our compliance with state rules not enough?

Your compliance with TCEQ regulations does not mean that other, stricter laws, regulations, or ordinances cannot be enforced by cities, counties, or other jurisdictions. You must comply with all such regulations (e.g., county burn bans) as well as the TCEQ rules.

Practical Alternatives to Burning

The Outdoor Burning Rule defines a practical alternative as “an economically, technologically, ecologically, and logistically viable option.” The following methods can sometimes serve as practical alternatives to burning as a means to dispose of waste. With creative thinking and the help of the local TCEQ regional office, you may be able to develop ways to dispose of your waste other than burning it.

Recycling. Manually or mechanically separate salvageable metals from other material and sell them at a salvage yard.

Composting. Wastes from landscape maintenance can often be composted on-site easily and cleanly. Similar wastes—even paper, in some instances—can be composted under the right conditions.

Mechanical chipping or mulching. The mulch that is produced could be put to use for soil enrichment and moisture retention, or used to create compost. In some cases, the mulch could become a marketable product, be put to use where it is produced, or be given to individuals or nurseries. If the material cannot be used as a landscape mulch, chipping can still be useful to reduce the volume of waste that must be disposed of by some other means.

Logging. Timber sometimes can be converted to a marketable product—lumber, pulp, or firewood—as one way to reduce the costs of disposal. The remaining small limbs and brush are then much easier to dispose of through one of the other alternatives.

Landfills. Some landfills have recycling centers, with chippers for wood waste and collection bins for paper, plastic, and glass. Type IV landfills accept brush. Contact your local landfills for details.

Air-curtain incineration (trench burning). Many land-clearing contractors have portable devices, known as *trench burners* or *air-curtain incinerators*, that can be used to dispose of brush or untreated lumber with minimal emissions. These devices must be authorized by the TCEQ prior to their construction at a burn site and the contractor must have obtained a federal operating permit. Many contractors and distributors lease out these devices.

Related TCEQ Publications

The TCEQ has a variety of publications available on issues related to outdoor burning. Several of them explain, in detail, specific alternatives to outdoor burning, for example:

- RG-325: *Used Oil Recycling Handbook: Guidance for Used Oil Handlers*
- GI-036: *Mulching and Composting*
- RG-419: *Disposal of Domestic or Exotic Livestock Carcasses*

To order single copies of these or other TCEQ publications, call TCEQ Publications Distribution at 512-239-0028 or write:

TCEQ Publications, MC 118
P.O. Box 13087
Austin, TX 78711-3087

Appendix A: Outdoor Burning—When Should You Notify the TCEQ?

Purpose of Burning	Notify the TCEQ	Who Else to Notify	Rule Section
Fire Training			
Statewide	In writing, 10 working days prior	1	111.205(a)
Dedicated facility, used at least once per week	Every year	1	111.205(b)
Dedicated facility, used less frequently	In writing every year, and by phone or fax 24 hours before event	1	111.205(c)
Disposal			
Domestic waste	Not required	2	111.209(1)
Diseased animal carcasses	Not required	2	111.209(2)
Animal remains and associated medical waste	Not required	2	111.209(3)
Plant growth on-site	Not required	2, 4	111.209(4)
Plant growth at designated burn site	Verbally or in writing, by fire department employee; must be 24 hours before event	2, 4	111.209(5)
Crop residue	Verbally or in writing, when possible	2, 4	111.209(6)
Brush, off-site, by county or city	In writing; also notify verbally when possible	2, 4	111.209(7)
Prescribed burns			
Other than coastal salt marsh	Verbally or in writing, when possible	2, 3, 4	111.211(1)
Coastal salt marsh	15 working days prior, in writing; verbal notification also required	4	111.211(2)(A)
Other			
Oil spills	Spill notification and prior approval, in writing; verbal notification also required	2	111.213
Ceremonial fires	Not required	2	111.207

Note: This table shows notification requirements only. See also the general requirements for allowable burning given later in this document. In instances where a general requirement does not apply, it may be included as part of a required TCEQ authorization.

1. If there is a local air pollution–control agency, notify that agency.
2. Check local ordinances, and notify any other government having jurisdiction over the area—for example, the county fire marshal, local fire department, or local law-enforcement officials.
3. Notify the Texas Forest Service before conducting prescribed burns for forest management.
4. Before conducting the burn, determine whether any structures containing sensitive receptors (for example, residences, greenhouses, stables, etc.) are within 300 feet of, and in the general direction downwind from, the site of the burn. If so, obtain written permission from the occupants or operators of those structures before you begin the burn.

Appendix B: TCEQ Areas and Regional Offices

TCEQ AREA OFFICES

BORDER AND PERMIAN BASIN

Region 6, El Paso • Region 7, Midland
Region 15, Harlingen • Region 16, Laredo
1804 W. Jefferson Ave. • Harlingen, TX 78550-5247
956-425-6010 • FAX: 956-412-5059

CENTRAL TEXAS

Region 9, Waco • Region 11, Austin
Region 13, San Antonio
P.O. Box 13087 • Austin, TX 78711-3087
12100 Park 35 Circle • Austin, TX 78753
512-239-6731 • FAX: 512-239-4390

COASTAL AND EAST TEXAS

Region 5, Tyler • Region 10, Beaumont
Region 12, Houston • Region 14, Corpus Christi
P.O. Box 13087 • Austin, TX 78711-3087
12100 Park 35 Circle • Austin, TX 78753
512-239-3607 • FAX: 512-239-4390

NORTH CENTRAL AND WEST TEXAS

Region 1, Amarillo • Region 2, Lubbock • Region 3, Abilene
Region 4, Dallas/Fort Worth • Region 8, San Angelo
5012 50th St., Ste. 100 • Lubbock, TX 79414-3426
806-796-7092 • FAX: 806-796-7107

TCEQ REGIONAL AND WATERMASTER OFFICES

1 – AMARILLO

3918 Canyon Dr.
Amarillo, TX 79109-4933
806-353-9251 • FAX: 806-358-9545

2 – LUBBOCK

5012 50th St., Ste. 100
Lubbock, TX 79414-3426
806-796-7092 • FAX: 806-796-7107

3 – ABILENE

1977 Industrial Blvd.
Abilene, TX 79602-7833
325-698-9674 • FAX: 325-692-5869

4 – DALLAS/FORT WORTH

2309 Gravel Dr.
Fort Worth, TX 76118-6951
817-588-5800 • FAX: 817-588-5700

Stephenville Office

(Concentrated Animal Feeding Operations)
580 W. Lingleville Rd., Ste. D
Stephenville, TX 76401-2209
254-965-9200 or 800-687-7078

5 – TYLER

2916 Teague Dr.
Tyler, TX 75701-3734
903-535-5100 • FAX: 903-595-1562

6 – EL PASO

401 E. Franklin Ave., Ste. 560
El Paso, TX 79901-1212
915-834-4949 • FAX: 915-834-4940

7 – MIDLAND

9900 W. IH-20, Ste. 100
Midland, TX 79706
432-570-1359 • FAX: 432-561-5512

8 – SAN ANGELO

622 S. Oakes, Ste. K
San Angelo, TX 76903-7035
325-655-9479 • FAX: 325-658-5431

9 – WACO

6801 Sanger Ave., Ste. 2500
Waco, TX 76710-7826
254-751-0335 • FAX: 254-772-9241

10 – BEAUMONT

3870 Eastex Fwy.
Beaumont, TX 77703-1830
409-898-3838 • FAX: 409-892-2119

11 – AUSTIN

P.O. Box 13087 • Austin, TX 78711-3087
12100 Park 35 Circle • Austin, TX 78753
512-339-2929 • FAX: 512-339-3795

12 – HOUSTON

5425 Polk St., Ste. H
Houston, TX 77023-1452
713-767-3500 • FAX: 713-767-3520

13 – SAN ANTONIO

14250 Judson Rd.
San Antonio, TX 78233-4480
210-490-3096 • FAX: 210-545-4329

14 – CORPUS CHRISTI

NRC Bldg., Ste. 1200,
6300 Ocean Dr., Unit 5839
Corpus Christi, TX 78412-5839
361-825-3100 • FAX: 361-825-3101

15 – HARLINGEN

1804 W. Jefferson Ave.
Harlingen, TX 78550-5247
956-425-6010 • FAX: 956-412-5059

16 – LAREDO

707 E. Calton Rd., Ste. 304
Laredo, TX 78041-3887
956-791-6611 • FAX: 956-791-6716

TEXAS WATERMASTERS

Brazos Watermaster

6801 Sanger Ave., Ste. 2500
Waco, TX 76710-7826
254-751-0335 • FAX: 254-772-9241

Concho Watermaster

622 S. Oakes, Ste. K
San Angelo, TX 76903-7035
325-481-8069 or 866-314-4894
FAX: 325-658-5431

Rio Grande Watermaster

Eagle Pass Office
P.O. Box 1185
Eagle Pass, TX 78853-1185
1152 Ferry St., Ste. E & F
Eagle Pass, TX 78852-4367
830-773-5059 • 800-609-1219
FAX: 830-773-4103

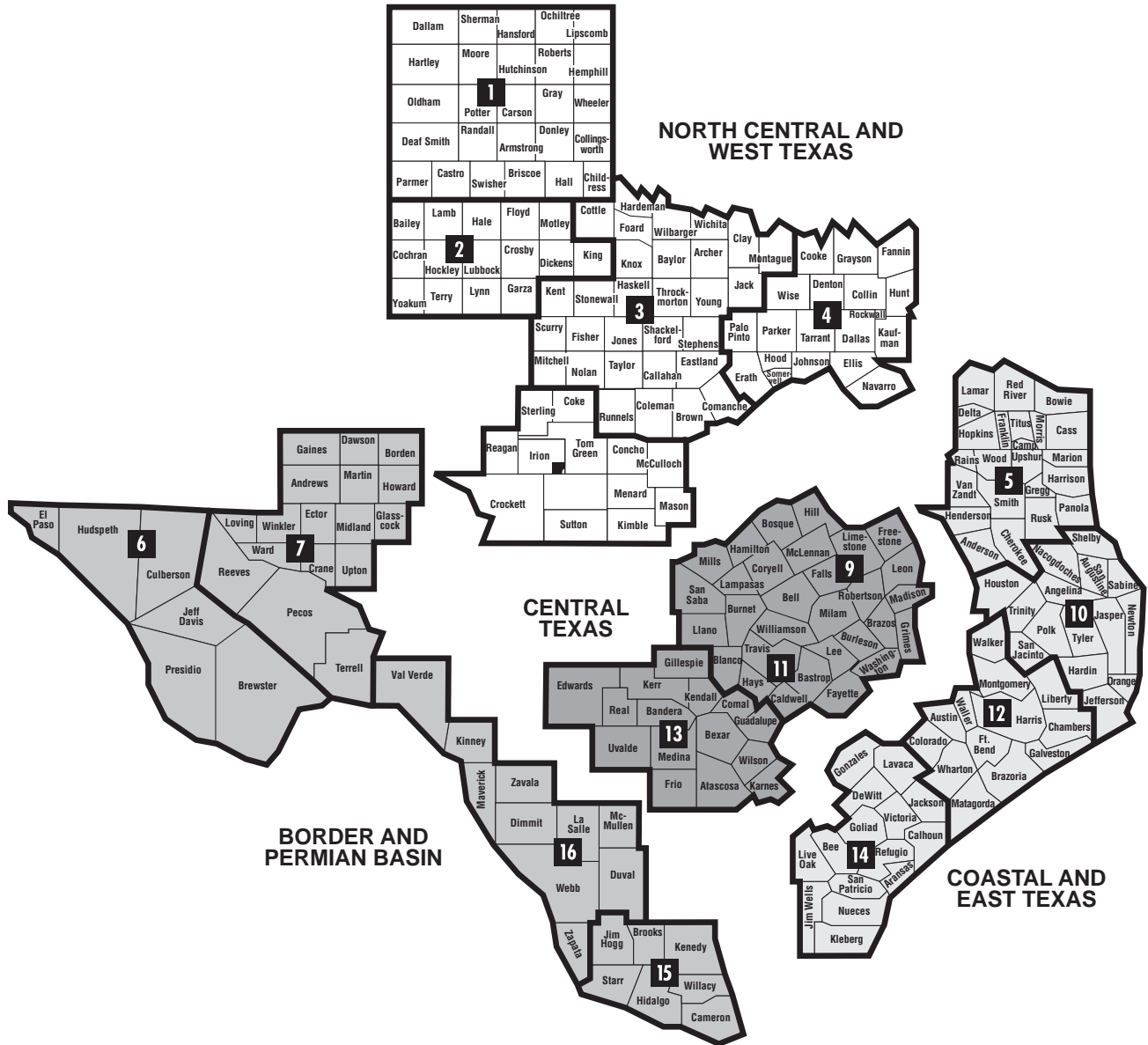
Harlingen Office

1804 W. Jefferson Ave.
Harlingen, TX 78550-5247
956-430-6056 or 800-609-1219
FAX: 956-430-6052

South Texas Watermaster

14250 Judson Rd.
San Antonio, TX 78233-4480
210-490-3096 or 800-733-2733
FAX: 210-545-4329

TCEQ Areas and Regional Offices (continued)



TCEQ REGIONS

- | | | | |
|----------------------------|---------------------|--------------------|--------------------------|
| 1 AMARILLO | 5 TYLER | 9 WACO | 13 SAN ANTONIO |
| 2 LUBBOCK | 6 EL PASO | 10 BEAUMONT | 14 CORPUS CHRISTI |
| 3 ABILENE | 7 MIDLAND | 11 AUSTIN | 15 HARLINGEN |
| 4 DALLAS/FORT WORTH | 8 SAN ANGELO | 12 HOUSTON | 16 LAREDO |

Appendix C: Outdoor Burning Rule

The Outdoor Burning Rule is reproduced below from 30 TAC 111.201–221. A current copy of the rule can be obtained from the TCEQ by calling 512-239-0028, or at <www.tceq.texas.gov/rules>.

§111.201. General Prohibition.

No person may cause, suffer, allow, or permit any outdoor burning within the State of Texas, except as provided by this subchapter or by orders or permits of the commission. Outdoor disposal or deposition of any material capable of igniting spontaneously, with the exception of the storage of solid fossil fuels, shall not be allowed without written permission of the executive director. The term “executive director,” as defined in Chapter 3 of this title (relating to Definitions), includes authorized staff representatives.

§111.203. Definitions.

Unless specifically defined in the Texas Clean Air Act (TCAA) or in the rules of the Texas Commission on Environmental Quality (commission), the terms used by the commission have the meanings commonly ascribed to them in the field of air pollution control. In addition to the terms that are defined by the TCAA, the following terms, when used in this chapter, have the following meanings, unless the context clearly indicates otherwise.

- (1) **Extinguished**—The absence of any visible flames, glowing coals, or smoke.
- (2) **Landclearing operation**—The uprooting, cutting, or clearing of vegetation in connection with conversion for the construction of buildings, rights-of-way, residential, commercial, or industrial development, or the clearing of vegetation to enhance property value, access, or production. It does not include the maintenance burning of on-site property wastes such as fallen limbs, branches, or leaves, or other wastes from routine property clean-up activities, nor does it include burning following clearing for ecological restoration.
- (3) **Neighborhood**—A platted subdivision or property contiguous to and within 300 feet of a platted subdivision.
- (4) **Practical alternative**—An economically, technologically, ecologically, and logistically viable option.
- (5) **Prescribed burn**—The controlled application of fire to naturally occurring vegetative fuels under specified environmental conditions and confined to a predetermined area, following appropriate planning and precautionary measures.
- (6) **Refuse**—Garbage, rubbish, paper, and other decayable and nondecayable waste, including vegetable matter and animal and fish carcasses.
- (7) **Structure containing sensitive receptor(s)**—A man-made structure utilized for human residence or business, the containment of livestock, or the housing of sensitive live vegetation. The term “man-made structure” does not include such things as range fences, roads, bridges, hunting blinds, or facilities used solely for the storage of hay or other livestock feeds. The term “sensitive live vegetation” is defined as vegetation that has potential to be damaged by smoke and heat, examples of which include, but are not limited to, nursery production, mushroom cultivation, pharmaceutical plant production, or laboratory experiments involving plants.
- (8) **Sunrise/Sunset**—Official sunrise/sunset as set forth in the United States Naval Observatory tables available from National Weather Service offices.
- (9) **Wildland**—Uncultivated land other than fallow, land minimally influenced by human activity, and land maintained for biodiversity, wildlife forage production, protective plant cover, or wildlife habitat.

§111.205. Exception for Fire Training.

- (A) Outdoor burning shall be authorized for training firefighting personnel when requested in writing and when authorized either verbally or in writing by the local air pollution control agency. In the absence of such local entities, the appropriate commission regional office shall be notified. The burning shall be authorized if notice of denial from the local air pollution control agency, or commission regional office is not received within 10 working days after the date of postmark or the date of personal delivery of the request.
- (B) Facilities dedicated solely for firefighting training, at which training routinely will be conducted on a

frequency of at least once per week, shall submit an annual written notification of intent to continue such training to the appropriate commission regional office and any local air pollution control agency.

- (C) Facilities dedicated solely for firefighting training, at which training is conducted less than weekly, shall provide an annual written notification of intent, with a telephone or electronic facsimile notice 24 hours in advance of any scheduled training session. No more than one such notification is required for multiple training sessions scheduled within any one-week period, provided the initial telephone/facsimile notice includes all such sessions. Both the written and telephone notifications shall be submitted to the appropriate commission regional office and any local air pollution control agency.
- (D) Authorization to conduct outdoor burning under this provision may be revoked by the executive director if the authorization is used to circumvent other prohibitions of this subchapter.

§111.207. Exception for Fires Used for Recreation, Ceremony, Cooking, and Warmth.

Outdoor burning shall be authorized for fires used solely for recreational or ceremonial purposes, or in the noncommercial preparation of food, or used exclusively for the purpose of supplying warmth during cold weather. Such burning shall be subject to the requirements of §111.219(7) of this title (relating to General Requirements for Allowable Outdoor Burning).

§111.209. Exception for Disposal Fires.

Except as provided in Local Government Code, §352.082, outdoor burning is authorized for the following:

- (1) domestic waste burning at a property designed for and used exclusively as a private residence, housing not more than three families, when collection of domestic waste is not provided or authorized by the local governmental entity having jurisdiction, and when the waste is generated only from that property. Provision of waste collection refers to collection at the premises where the waste is generated. The term “domestic waste” is defined in §101.1 of this title (relating to Definitions). Wastes normally resulting from the function of life within a residence that can be burned include such things as kitchen garbage, untreated lumber, cardboard boxes, packaging (including plastics and rubber), clothing, grass, leaves, and branch trimmings. Examples of wastes not consid-

ered domestic waste that cannot be burned, include such things as tires, non-wood construction debris, furniture, carpet, electrical wire, and appliances;

- (2) diseased animal carcass burning when burning is the most effective means of controlling the spread of disease;
- (3) veterinarians in accordance with Texas Occupations Code, §801.361, Disposal of Animal Remains;
- (4) on-site burning of trees, brush, grass, leaves, branch trimmings, or other plant growth, by the owner of the property or any other person authorized by the owner, and when the material is generated only from that property:
 - (A) in a county that is part of a designated nonattainment area or that contains any part of a municipality that extends into a designated nonattainment area; if the plant growth was generated as a result of right-of-way maintenance, landclearing operations, and maintenance along water canals when no practical alternative to burning exists. Such burning is subject to the requirements of §111.219 of this title (relating to General Requirements for Allowable Outdoor Burning). Commission notification or approval is not required; or
 - (B) in a county that is not part of a designated nonattainment area and that does not contain any part of a municipality that extends into a designated nonattainment area; this provision includes, but is not limited to, the burning of plant growth generated as a result of right-of-way maintenance, landclearing operations, and maintenance along water canals. Such burning is subject to local ordinances that prohibit burning inside the corporate limits of a city or town and that are consistent with the Texas Clean Air Act, Chapter 382, Subchapter E, Authority of Local Governments, and the requirements of §111.219(3), (4), (6), and (7) of this title. Commission notification or approval is not required.
- (5) at a site designated for consolidated burning of waste generated from specific residential properties. A designated site must be located outside of a municipality and within a county with a population of less than 50,000. The owner of the designated site or the owner’s authorized agent shall:
 - (A) post at all entrances to the site a placard measuring a minimum of 48 inches in width and 24 inches in height and containing, at a minimum, the words “DESIGNATED BURN SITE - No burning of

any material is allowed except for trees, brush, grass, leaves, branch trimmings, or other plant growth generated from specific residential properties for which this site is designated. All burning must be supervised by a fire department employee. For more information call {PHONE NUMBER OF OWNER OR AUTHORIZED AGENT}.” The placard(s) must be clearly visible and legible at all times;

- (B) designate specific residential properties for consolidated burning at the designated site;
 - (C) maintain a record of the designated residential properties. The record must contain the description of a platted subdivision and/or a list of each property address. The description must be made available to commission or local air pollution control agency staff within 48 hours, if requested;
 - (D) ensure that all waste burned at the designated site consists of trees, brush, grass, leaves, branch trimmings, or other plant growth;
 - (E) ensure that all such waste was generated at specific residential properties for which the site is designated; and
 - (F) ensure that all burning at the designated site is directly supervised by an employee of a fire department who is part of the fire protection personnel, as defined by Texas Government Code, §419.021, and is acting in the scope of the person’s employment. The fire department employee shall notify the appropriate commission regional office with a telephone or electronic facsimile notice 24 hours in advance of any scheduled supervised burn. The commission shall provide the employee with information on practical alternatives to burning. Commission approval is not required;
- (6) crop residue burning for agricultural management purposes when no practical alternative exists. Such burning shall be subject to the requirements of §111.219 of this title and structures containing sensitive receptors must not be negatively affected by the burn. When possible, notification of the intent to burn should be made to the appropriate commission regional office prior to the proposed burn. Commission notification or approval is not required. This section is not applicable to crop residue burning covered by an administrative order; and
 - (7) brush, trees, and other plant growth causing a detrimental public health and safety condition burned by a county or municipal government at a site it owns upon

receiving site and burn approval from the executive director. Such a burn can only be authorized when there is no practical alternative, and it may be done no more frequently than once every two months. Such burns cannot be conducted at municipal landfills unless authorized under §111.215 of this title (relating to Executive Director Approval of Otherwise Prohibited Outdoor Burning), and shall be subject to the requirements of §111.219 of this title.

§111.211. Exception for Prescribed Burn.

Outdoor burning shall be authorized for:

- (1) Prescribed burning for forest, range and wildland/wildlife management, and wildfire hazard mitigation purposes, with the exception of coastal salt-marsh management burning. Such burning shall be subject to the requirements of §111.219 of this title (relating to General Requirements for Allowable Outdoor Burning), and structures containing sensitive receptors must not be negatively affected by the burn. When possible, notification of intent to burn should be made to the appropriate commission regional office prior to the proposed burn. Commission notification or approval is not required.
- (2) Coastal salt-marsh management burning conducted in Aransas, Brazoria, Calhoun, Chambers, Galveston, Harris, Jackson, Jefferson, Kleberg, Matagorda, Nueces, Orange, Refugio, and San Patricio Counties. Coastal salt-marsh burning in these counties shall be subject to the following requirements:
 - (A) All land on which burning is to be conducted shall be registered with the appropriate commission regional office using a United States Geological Survey map or equivalent upon which are identified significant points such as roads, canals, lakes, and streams, and the method by which access is made to the site. For large acreage, the map should be divided into manageable blocks with identification for each defined block. The information must be received for review at least 15 working days before the burning takes place.
 - (B) Prior to any burning, notification, either verbal or written, must be made to, and authorization must be received from the appropriate commission regional office. Notification must identify the specific area and/or block to be burned, approximate start and end time, and a responsible party who can be contacted during the burn period.

(C) Such burning shall be subject to the requirements of §111.219 of this title.

§111.213. Exception for Hydrocarbon Burning.

Outdoor burning shall be authorized for hydrocarbon burning from pipeline breaks and oil spills only upon proper notification as set forth in §101.6 of this title (relating to Notification Requirements for Major Upset), and if the executive director has determined that the burning is necessary to protect the public welfare. Sampling and monitoring may be required to determine and evaluate environmental impacts.

§111.215. Executive Director Approval of Otherwise Prohibited Outdoor Burning.

If not otherwise authorized by this chapter, outdoor burning may be authorized by written permission from the executive director if there is no practical alternative and if the burning will not cause or contribute to a nuisance, traffic hazard or to a violation of any federal or state primary or secondary ambient air standard. The executive director may specify procedures or methods to control or abate emissions from outdoor burning authorized pursuant to this rule. Authorization to burn may be revoked by the executive director at any time if the burning causes nuisance conditions, is not conducted in accordance with the specified conditions, violates any provision of an applicable permit, or causes a violation of any air quality standard.

§111.219. General Requirements for Allowable Outdoor Burning.

Outdoor burning which is otherwise authorized shall also be subject to the following requirements when specified in any section of this subchapter.

- (1) Prior to prescribed or controlled burning for forest management purposes, the Texas Forest Service shall be notified.
- (2) Burning must be outside the corporate limits of a city or town except where the incorporated city or town has enacted ordinances which permit burning consistent with the Texas Clean Air Act, Subchapter E, Authority of Local Governments.
- (3) Burning shall be commenced and conducted only when wind direction and other meteorological conditions are such that smoke and other pollutants will not cause adverse effects to any public road, landing strip, navigable water, or off-site structure containing sensitive receptor(s).

- (4) If at any time the burning causes or may tend to cause smoke to blow onto or across a road or highway, it is the responsibility of the person initiating the burn to post flag-persons on affected roads.
- (5) Burning must be conducted downwind of or at least 300 feet (90 meters) from any structure containing sensitive receptors located on adjacent properties unless prior written approval is obtained from the adjacent occupant with possessory control.
- (6) Burning shall be conducted in compliance with the following meteorological and timing considerations:
 - (A) The initiation of burning shall commence no earlier than one hour after sunrise. Burning shall be completed on the same day not later than one hour before sunset, and shall be attended by a responsible party at all times during the active burn phase when the fire is progressing. In cases where residual fires and/or smoldering objects continue to emit smoke after this time, such areas shall be extinguished if the smoke from these areas has the potential to create a nuisance or traffic hazard condition. In no case shall the extent of the burn area be allowed to increase after this time.
 - (B) Burning shall not be commenced when surface wind speed is predicted to be less than six miles per hour (mph) (five knots) or greater than 23 mph (20 knots) during the burn period.
 - (C) Burning shall not be conducted during periods of actual or predicted persistent low level atmospheric temperature inversions.
- (7) Electrical insulation, treated lumber, plastics, non-wood construction/demolition materials, heavy oils, asphaltic materials, potentially explosive materials, chemical wastes, and items containing natural or synthetic rubber must not be burned.

§111.221. Responsibility for Consequences of Outdoor Burning.

The authority to conduct outdoor burning under this regulation does not exempt or excuse any person responsible from the consequences, damages, or injuries resulting from the burning and does not exempt or excuse anyone from complying with all other applicable laws or ordinances, regulations, and orders of governmental entities having jurisdiction, even though the burning is otherwise conducted in compliance with this regulation.

Appendix D: Background

30 TAC 111.201 prohibits outdoor burning in Texas, except as stated in Sections 111.205–15. It also prohibits storing spontaneously combustible materials other than “solid fossil fuel” (i.e., coal) outside. The exception for coal was made to be consistent with the intent expressed in the preamble to the 1989 revisions to the rule.

Land-clearing operation. The last sentence of this definition indicates two different kinds of exclusions. The first, for on-site property waste burns, is covered in Section 111.209(4); the second, for burns for ecological restoration, is covered in Section 111.211(1). In practice, prescribed burns and land-clearing burns may have similarities; occasionally it is necessary in a prescribed burn to bulldoze trees or brush into piles to obtain the appropriate effect. The key difference is the concept of “conversion.” The goal of land clearing is a major change in land use, i.e. the conversion of the land from one use to another; the goal of a prescribed burn is to restore, maintain, or renew the ecosystem.

Practical alternative. This definition contains four criteria, each of which must be considered to determine whether an alternative is practical. The standard of judgment should be that of a reasonable person. For example, an option that is technologically available but neither economically affordable nor logistically possible is not practical. A method other than burning may not be practical if it cannot achieve the desired ecological outcome. An alternative that is technologically, economically, and logistically feasible is not practical if it causes a greater ecological harm than burning.

In Section 111.205(b), the wording “at which training routinely will be conducted” is used to eliminate potential confusion. For example, if training is conducted weekly except during holidays and when meteorological conditions are unfavorable, the facility still would qualify under this section of the rule. Other similar situations may also qualify.

Section 111.209(1) specifies that collection of domestic waste by the local governmental agency or authorized agent must occur on the premises where the waste is generated. The governmental provision of a transfer or convenience station to which residents may bring waste does not constitute collection of domestic waste; therefore, burning may take place in that instance. Any authorization of collection services by a government or other jurisdiction must be specific and well-defined. For a government merely to say it

is OK for anybody to collect garbage commercially within its jurisdiction does not constitute authorized collection for the purposes of this rule.

Section 111.209(6) recognizes an agricultural practice that continues in many parts of the state. The key factor is whether a practical alternative exists. Determining whether there is a practical alternative requires evaluating such things as the type of crop, soil moisture level, soil nutrient benefits, cropping sequence, and cost of alternative disposal methods.

Section 111.209(7) was added to deal with situations in which accumulated vegetation has the potential to do such things as obstruct the flow of water and cause flooding or provide habitat for vermin, but where it is not feasible to burn on-site because doing so would create a nuisance or traffic hazard. Each such burn requires prior approval from the regional office. A site cannot be designated by the municipality or county for continual use, as a standard operating procedure, to augment normal brush disposal. The intent is that the government (or other organization) will not conduct such a burn more frequently than once every two months, no matter how many sites it may have available. For example, it is not permissible for it to conduct a burn at one site and then have another burn at another site a few days later, circumventing the intent of the rule.

Section 111.211 recognizes the use of fire as a necessary management tool for particular situations for which there is no practical alternative. All such burns are subject to the General Requirements for Allowable Outdoor Burning (111.219).

Section 111.213 sets forth a mechanism for remediation to avoid additional environmental degradation in an emergency, such as preventing a petroleum substance from entering a waterway. Once the emergency is under control, it is not permissible to burn the material used to absorb the hydrocarbon or other wastes associated with emergency control. This section should not be used to sanction disposal. Note that the Outdoor Burning Rule refers to Section 101.6 (Notification Requirements for Major Upsets). However, that section has been repealed and replaced by Section 101.201 (Emissions Events Reporting and Record-keeping Requirements).

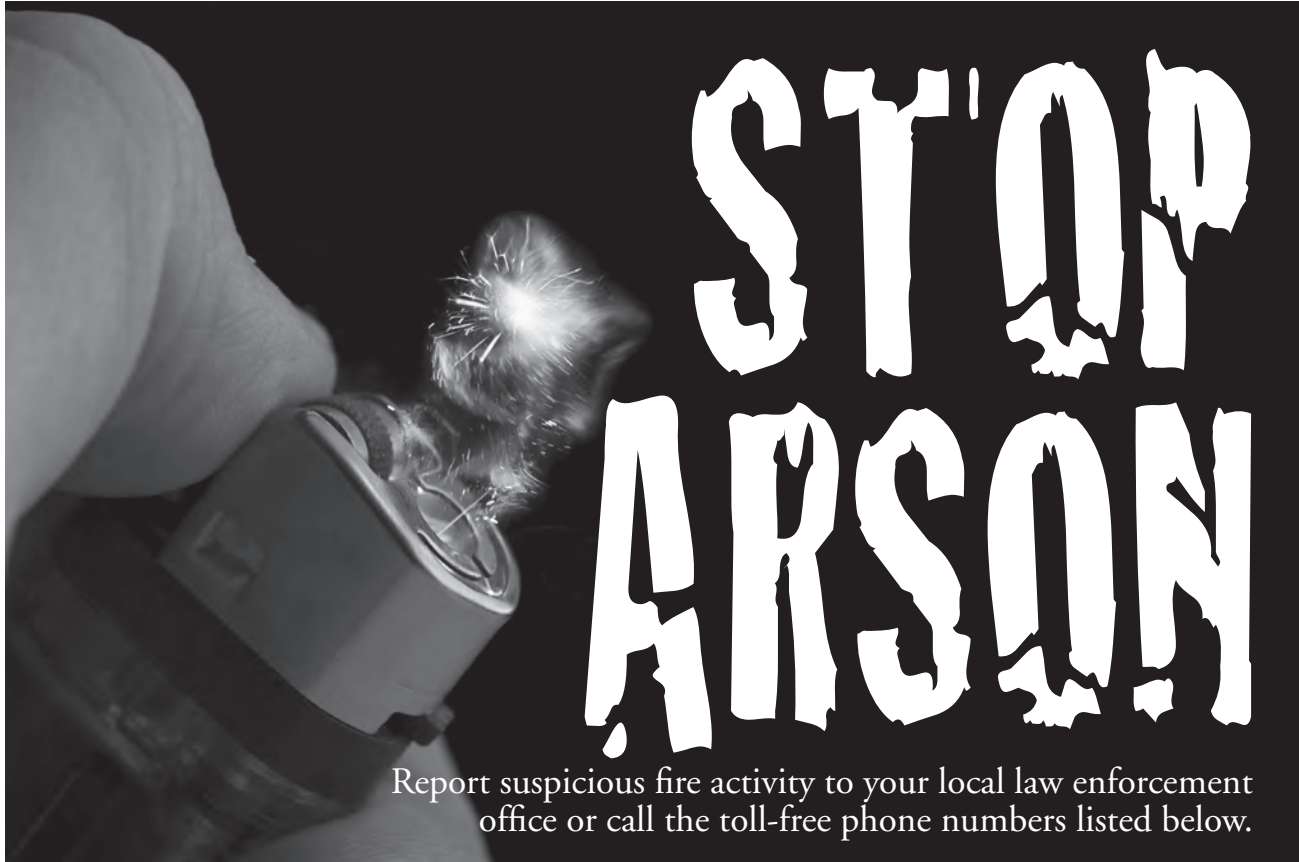
Section 111.219(6)(A) allows flexible burn opportunities with consideration for meteorological conditions conducive to dispersion. The requirement for having a responsible

party in attendance during the active burn phase does not mean someone has to be in attendance once the fire is virtually complete and is not advancing, i.e., once it principally consists of glowing coals with possibly some patchy residual fires. The extent of the burn may not be allowed to increase after one hour before sunset. A fire that has burned down to glowing coals has consumed most of the volatile substances and will not progress as a flame. It is understood that items such as stumps may burn for several days. Residual fires and smoldering objects without the potential to create a nuisance or traffic hazard need not be quenched. For example, if you

wish to burn 100 acres with a road on one side and no sensitive structures in other directions from the burn area, you would be prudent to extinguish residual fires and smoldering objects within a swath along the boundary with the road where the potential for nuisance or traffic hazard exists, but allow the remaining portion of the burn site to subside at a natural rate.

Section 111.219(7) specifically prohibits the burning of insulated wire without prohibiting the burning of piles created by fence demolition that contain wire and untreated wood wastes.

Appendix E: Arson Resources and Contact Information



Texas Toll-Free Arson Hotline
1-877-4FIRE45 (1-877-434-7345)

Texas A&M Forest Service Wildland Arson Hotline
800-364-3470

You may be eligible for a reward up to \$2,000 if your information leads to the arrest and grand jury indictment of the person or persons responsible for arson.



Take Care OF Texas

It's the only one we've got.

Recording Artist and
Take Care of Texas
Spokesperson

KEVIN
FOWLER

“The only thing I love more than playing music is being outdoors in the great state of Texas.”

Texas has clean air, rivers, lakes, and bays, so let's get outdoors and enjoy them.

Visit **TakeCareOfTexas.org** and take a pledge to conserve water and energy, and keep the air clean.

★
KEVIN
FOWLER

For tips on keeping Texas great, visit
TakeCareOfTexas.org



Be in the know & follow us.



A message
from the

TEXAS COMMISSION
ON ENVIRONMENTAL
QUALITY

TAKE CARE OF TEXAS WITH YOUR OWN LICENSE PLATE!

\$22 of the \$30 plate fee goes to support
the Take Care of Texas Program.

Order yours today at TakeCareOfTexas.org/license-plate.



This page intentionally left blank.

TEXAS PARKS AND WILDLIFE

PRESCRIBED FIRE PLAN
For Use on Private Lands

RANCH NAME: _____ Click here to enter text. ____

LANDOWNER: _____ Click here to enter text. ____

BURN UNIT NAME(S): _____ Click here to enter text. ____

PLAN PREPARED BY:

Name (print): _____ Signature: _____ Date: _____

PLAN REVIEWED BY:

Name - RXBB (print): _____ Signature: _____ Date: _____

PLAN REVIEWED BY:

Name - Burn Boss (print): _____ Signature: _____ Date: _____

1. Description of Prescribed Fire Area

A. Physical Description:

County: _____ Lat/Long: _____
911 Address: _____ Topography/Elevation: _____
Size: _____

B. Vegetation/Fuels Description:

Live Fuels - Type, Density, Size: _____
Dead Fuels - Description, Moisture, Time-Lag, Load: _____

C. Description of Unique Features, Natural Resources, Values at Risk:

Inside the Unit:

Structures: _____ Livestock: _____
Utilities: _____ Wildlife: _____
Oil/Gas Facilities: _____ Threatened/Endangered Species: _____
Fences: _____ Other Protected Areas: _____

Outside the Unit:

Structures: _____ Livestock: _____
Utilities: _____ Wildlife: _____
Oil/Gas Facilities: _____ Threatened/Endangered Species: _____
Fences: _____ Other Protected Areas: _____

D. Previous Treatments:

Burn Treatment Date:_Click here to enter text._

Results:_Click here to enter text._

Other Treatments/Dates:_Click here to enter text._

2. Prescribed Burn Justification (goals, objectives, rationale, purpose)

A. Long-term Resource Goals:_Click here to enter text._

B. Prescribed Fire Objectives: Complete a safe fire operation with no injuries or adverse effects to personnel on the fire and the public. Click here to enter text._

3. Prescription

In order to meet the prescribed fire goals and objectives; weather, environmental, and fire behavior conditions must meet specific criteria prior to the start of, and during, fire operations. The below environmental conditions represent the broadest possible conditions that will allow for a successful burn. However, it is important to note that conditions at the edge of each range may compound or mitigate each other. Low humidity and high wind speeds on the same day may pose safety and containment problems, while both are still within the acceptable range. Conversely, a burn could be implemented and meet objectives with higher winds if humidity levels are also high.

Prescription Parameters	Acceptable Range	
	Low	High
Weather Conditions		
Temperature (°F)		
Relative Humidity (%)		
Wind Speed, 20-ft forecast (mph)		
Wind Speed, mid-flame (mph)		
Wind Direction		
Transport Wind Speed (mph)		
Transport Wind Direction		
Mixing Height (ft)		
Environmental Conditions		
1-hr Fuel Moisture (%)		
10-hr Fuel Moisture (%)		
100-hr Fuel Moisture (%)		
Live Fuel Moisture (%)		
Soil Moisture (KBDI)		
Fire Behavior		
Flame Length (ft)		
Rate of Spread (ch/hr, [ft/min])		
Fireline Intensity (BTU/ft/sec)		

4. Scheduling

A. Implementation Schedule:_Click here to enter text._

B. Projected Duration:_Click here to enter text._

C. Constraints:_Click here to enter text._

5. Pre-burn Considerations

A. Fire Breaks (specify width):

Plow or Blade:_Click here to enter text._

Blackline:_Click here to enter text._

Mow:_Click here to enter text._

Natural Features (please describe):_Click here to enter text._

Wet Line:_Click here to enter text._

Other:_Click here to enter text._

B. Special Fire Protection Considerations: (See Section 1.C. Description of Unique Features, Natural Resources, Values at Risk):_Click here to enter text._

C. Method and Frequency for Obtaining Weather and Smoke Management Forecast(s): A fire weather planning forecast will be obtained prior to ignition. On-site weather observations will be taken prior to ignition and during burn operations. If possible, a spot weather forecast will also be obtained from the NWS office.

D. Notifications:

Notifications should be made both prior to ignition of the prescribed burn and upon completion of the burn.

Contact Name		Phone Number
	County Sheriff (Dispatch)	
	County Fire Marshal	
	Fire Department(s)	
	Texas Forest Service	
	TCEQ	
	Other	
Neighboring Landowners		

6. Organization and Equipment

A. Positions:

Crew Size (minimum number required):_Click here to enter text._

The organization chart (Section 14.B) at the end of this template can be used as a guide to identify positions needed. The numbers/organization of the chart may need to be adjusted depending on the size and/or complexity of the burn. One person can hold more than one position on the organization chart. The Burn Boss will complete an organization chart before ignition of the prescribed fire and include the chart with the post-burn documentation.

B. Equipment:

Equipment	Number	Name(s)
Holding/Water Equipment		
Pumper/Engine		
UTV w/ sprayer		
ATV w/sprayer		
ATV or UTV w/o sprayer		
Dozer/Tractor w/ plow		
Backpack Pumps (bladder bags)		
Hand Tools (assortment)		
Ignition Equipment		
Drip Torch		
Drip Torch fuel (gallons)		
Other Equipment		
Radios (portable)		
Smoke On Road/Smoke Ahead Signs		
Belt Weather Kit		
Other:		

7. Communication

A. Radio Frequency/Channel (if applicable):_Click here to enter text._

B. Telephone Numbers (to be filled out prior to burning):

Position	Name	Phone Number

8. Safety

A job hazard analysis has been included in Section 16 to assist with identifying and mitigating safety hazards associated with prescribed burning. Safety hazards unique to a particular burn unit should be identified below as well as the measures that need to be taken to reduce the hazards.

A. Specific Safety Hazards:_Click here to enter text._

B. Mitigation Measures Taken to Reduce the Hazards:_Click here to enter text._

C. Emergency Medical Procedures:

EMTs and anyone trained in CPR, First Aid, or AED operation will be identified at the briefing. The location of first aid/trauma kits, AEDs, and other similar medical equipment will also be identified during the briefing.

If a medical emergency takes place, the Burn Boss should be immediately notified and told the nature of the emergency.

The Burn Boss should:

1. Obtain clear patient assessment and location.
2. Initiate 911, establish on scene care provider.
3. Identify transportation needs.
4. Document all information.

D. Emergency Evacuation Procedures: Injured personnel will be transported, if possible, along the perimeter of the burn unit to. If evacuation by air is necessary, the Burn Boss will coordinate with the emergency responders to determine the best spot for a landing zone.

E. Nearest Medical Emergency Facilities: [_Click here to enter text._](#)

9. Test Fire

A. Planned Location:

A test fire will be initiated on the downwind portion of the burn unit in representative fuels nearest the proposed blacklining anchor point. This will be determined by the Burn Boss based on the on-site weather observations the day of the burn.

B. Test Fire Documentation:

Location of Test Fire:					
Weather Conditions at Test Fire					
Time	Temp (°F)	RH (%)	Wind Speed (mph)	Wind Direction	Cloud Cover (%)
Fire Behavior at Test Fire					
Backing Fire		Flanking Fire		Head Fire	
Flame Length	Rate of Spread	Flame Length	Rate of Spread	Flame Length	Rate of Spread
Smoke Conditions at Test Fire					
Direction		Production		Dispersion	

10. Ignition Plan (techniques, sequences, and patterns)

The Burn Boss will determine the ignition strategy and sequences of fire activities on the day of the burn, based on the observed and forecasted fuel and environmental conditions. The selected firing strategy will be explained at the pre-burn briefing. Ignition will begin as a backfire on the downwind side of the burn unit. The Burn Boss will coordinate all ignition crews to maintain safe procedures.

Special Ignition Procedures: [_Click here to enter text._](#)

11. Holding Plan

A. General Procedures for Holding:

Holding resources will follow ignition along control lines monitoring for: creep in the line, high fire intensity along the control line, engaged snags/aerial fuels, and spot fires outside of control lines. Holding resources should also patrol back along the control lines to the point of ignition (test fire) as often as possible.

B. Critical Holding Points and Actions: [_Click here to enter text._](#)

C. Mop-up Plan

As a general rule, all surface fuels will require complete mop up within 30 feet of the unit perimeter once ignition is complete. Aerial fuels should be mopped to a distance of three times their height to the fireline with a minimum distance of 60 feet.

Combinations of high winds and low relative humidity will increase the distance to which combusting fuels will need to be extinguished

Special Mop-up Requirements:_Click here to enter text._

12. Contingency Plan (plan of action if fire escapes)

Some spotting or creeping across fire breaks may occur as normal activity on the prescribed burn. These small fires outside the control lines can usually be suppressed by the holding resources. However, it is part of the planning process to identify what resources are available in the event that any fire outside of the control lines cannot be suppressed by personnel on the prescribed fire. It is also necessary to establish trigger points in order to determine at what point these contingency resources will be brought to the fire and how they will be requested.

A. Contingency Resources Available:_Click here to enter text._

B. Method for Requesting Additional Resources:_Click here to enter text._

C. Contingency Lines/Fire Breaks Outside the Burn Unit (show on map):_Click here to enter text._

D. Trigger Points (when/at what point will contingency resources be ordered)

IF (fire outside control lines, multiple spot fires, etc.)	THEN (actions to be taken)
Spot fire outside fire break.	Direct attack will be used. Fires outside control lines will be completely extinguished. Ignition will stop while spot fire is being controlled.
Multiple spot fires outside fire breaks	All ignition operations will cease on the burn unit. The Burn Boss will coordinate resources on burn to suppress spot fires.
Fire becomes established outside burn unit.	If direct attack is not successful

13. Smoke Management and Air Quality

All prescribed fire operations will comply with the Texas Commission on Environmental Quality (TCEQ) regulations unless special permissions for TCEQ have been obtained.

A. Smoke-Sensitive Receptors: No Yes

If yes, please explain (approximate distance and direction form burn unit):_Click here to enter text._

B. Potential Impacted Areas: No Yes

If yes, please explain (approximate distance and direction form burn unit):_Click here to enter text._

C. Mitigation Strategies and Techniques to Reduce Smoke Impacts (to smoke sensitive receptors or potential impact areas identified above):_Click here to enter text._

14. Post-burn Activities

A. Required Checklist and Evaluations

The following table should be filled out after every burn and attached to the burn plan. It is also recommended a copy of the fire weather forecast for the day of the burn be attached to the plan as well.

Landowner:	County:
Date of Burn:	Time of Burn:
Burn Boss:	Acres of Burn:
Number of Crew On	Number and Size of Spot Fires:

Forecasted Environmental Variables:	Minimum	Maximum	Forecast Location
Temperature (°F):			
Relative Humidity (%):			
Wind Speed (mph):			
Wind Direction:			

Forecasted Smoke Management Variables

Forecast Location:	Transport Wind Direction:
Transport Winds Speed	Mixing Height (ft):

Observed Environmental Variables:	Minimum	Maximum	Average	Observer
Temperature (°F):				
Relative Humidity (%):				
Wind Speed (mph) and				

Estimated Fuel Conditions	Percent (%)	Method of Calculation
1-hour Fuel Moisture:		
10-hour Fuel Moisture:		
Live Fuel Moisture:		

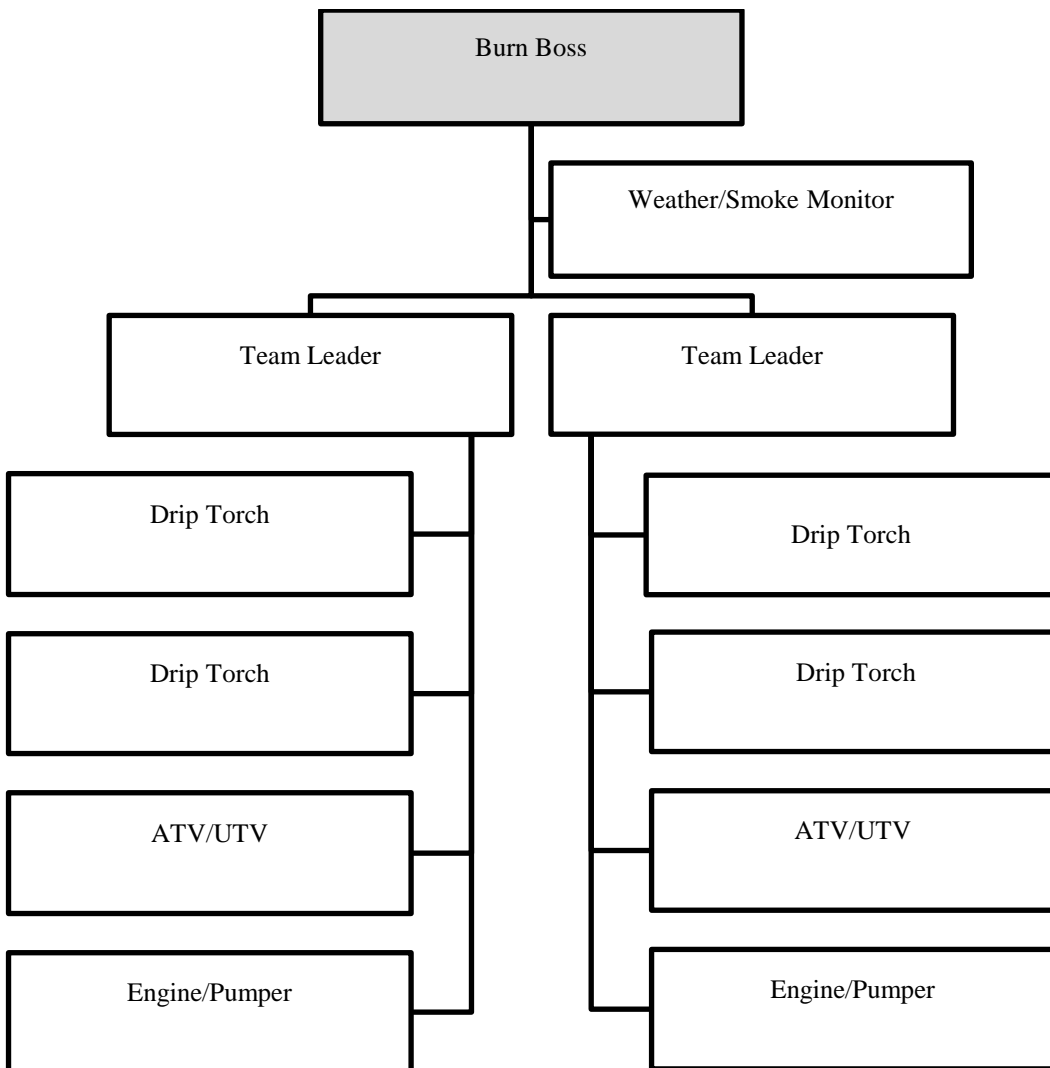
Crew Assignments

Activity	Personnel Assigned (note certified burners)
Ignition Crew:	
Suppression and Mop Up Crew:	
Weather Observer:	
Media / Information:	
Road Flagmen:	
Maintain close observation of the burned area until the fire is completely extinguished:	

Final Evaluation

Identify any equipment failures, injuries, or other problems:
Public complaints, explain:
Were objectives achieved? What should have been done differently?

B. Organization Chart (required positions shaded)



15. Maps

Include items such as: legend, magnetic north, property boundaries, water sources, roads, gates, safety zones, escape routes, fire breaks, areas to be protected, ignition area, smoke sensitive areas, contingency lines, special precautions, etc.

16. Release of Liability

**DISCLAIMER OF LIABILITY, RELEASE AND INDEMNITY AGREEMENT
PRESCRIBED BURNING**

Landowner: _____
 Address: _____
 City, State, Zip _____
 Home: _____ Ranch: _____
 Business: _____ Mobile: _____
 Fax: _____ Email: _____
 Date of Prescribed Burn: _____

In consideration for receiving technical guidance, training, and/or assistance from Texas Parks and Wildlife Department (TPWD) associated with the implementation of a prescribed burn on my property, on property for which I am the manager and/or authorized agent of the landowner, and/or as an individual assisting with a prescribed burn, I personally assume all risks associated with the prescribed burn, whether foreseen or unforeseen, and unconditionally release and hold harmless TPWD, its commissioners, directors, officers, employees, volunteers, agents and representatives, from and against any and all liabilities, costs, expenses, claims, and damages for which TPWD might otherwise become liable by reason of any accidents, or injuries to, or death of any persons, or damage to property, or both, in any manner arising or resulting from, caused by, connected with or related to the prescribed burn, regardless of how, where, or when such injury, death or damage occurs even if caused by the negligence of TPWD.

I have read this release and understand all its terms. I execute the agreement voluntarily with full knowledge of its significance.

SIGNED AND EXECUTED this _____ day of _____, 20 _____

 Landowner Signature

 Manager/Agent/Burn Boss

 Individual Assisting with Prescribed Burn

17. Job Aids

A. Prescribed Fire GO/NO-GO Checklist

<p>A. Has the burn unit experienced unusual drought conditions or does it contain above normal fuel loadings which were not considered in the prescription development? If <u>NO</u> proceed with checklist below, if <u>YES</u> go to item B.</p>	YES	NO
<p>B. Has the prescribed fire plan been reviewed and an amendment and technical review been completed; or has it been determined that no amendment is necessary? If <u>YES</u> to any, proceed with checklist below, if <u>NO</u>, STOP._</p>		

YES	NO	QUESTIONS
		Are ALL pre-burn prescription parameters met?
		Are ALL smoke management specifications met?
		Has ALL required current and projected fire weather forecasts been obtained and are they favorable?
		Are ALL planned operations personnel and equipment on-site, available, and operational?
		Has the availability of ALL contingency resources been checked and are they available?
		Have ALL personnel been briefed on the project objectives, their assignment, safety hazards, escape routes, and safety zones?
		Have all the pre-burn considerations identified in the Prescribed Fire Plan been completed or addressed?
		Have ALL the required notifications been made?
		Are ALL permits and clearances obtained?
		Has the Request for Technical Guidance AND the Release of Liability been reviewed and signed by ALL parties?
		In your opinion, can the burn be carried out according to the Prescribed Fire Plan and will it meet the planned objective?

If all the questions were answered "YES" proceed with a test fire. Document the current conditions, location, and results

Burn Boss

Date

B. Briefing Outline

I. Burn Organization

- A. Organizational Chart/Personnel Assignments
- B. Equipment Assignments
- C. Other Resources

II. Burn Objectives

III. Description of Burn Area

- A. Review Map of Burn (acreage, topographic features, etc.)
- B. Values at Risk (structures, T&E species, etc.)
- C. Problem Areas (fuel loading, smoke mgmt., etc.)
- D. Fuel Type (Both inside and outside the burn unit)
- E. Roads/Access
- F. Water Sources
- G. Control lines/Fire Breaks

IV. Ignition/Holding Plan

- A. Test Burn
- B. Ignition/Holding Equipment
- C. Ignition Strategy

V. Weather/Fire Behavior

- A. General History (previous period, drought, etc.)
- B. Expected Weather
 - 1. Wind Speed and Direction
 - 2. Relative Humidity
 - 3. Temperature
- C. Current Weather (relate to expected weather)
- D. Fuel Moisture
- E. Expected Fire Behavior

VI. Communications

- A. Procedures
- B. Frequencies/Channels (if applicable)
- C. Cell Phones (Burn Boss, etc.)

VII. Contingency Plan

VIII. Safety

- A. Personal Protective Equipment
- B. Lookouts, Escape Routes and Safety Zones
- C. Hazards (Poisonous animals/insects, smoke, visibility, etc.)
- D. EMT's – Medical Plan
- E. Other

C. Job Hazard Analysis (JHA)

ACTIVITY	HAZARDS	ACTION TO ELIMINATE HAZARD
Driving to work site	General operations and public traffic.	Defensive driving techniques.
	Winding, narrow roads.	Drive slow. Be able to stop in ½ the usual distance. Lights on.
	Hauling flammable substances.	Use appropriate containers for hauling driptorch fuel and gas.
	Transporting sharp tools and equipment.	Use guards, cages, boxes, or tool mounts. Tie down all loads.
Flammable Materials	Loading vehicles.	Check load before departing. The driver is responsible.
	Exposure to sparks, embers, and heat.	Use proper containers, move away from hot areas, no smoking.
	Leaking containers or torches	Empty and tag in the field, have repairs made before next use.
	Improper gas/diesel ratios for driptorch fuel.	Use labels on containers, field test small amounts before use.
Driving at or near work site	Backing or turning around in small areas.	Use spotters. Face the hazard while turning around.
	Smoke, poor visibility.	Place a guide on foot ahead of the vehicle. Wait until smoke is less dense. Lights on. Use light bars and/or warning lights. Use radio communication.
	Parking near a prescribed burn.	Use parking brake. Leave keys in ignition. Avoid leaving exposed combustible materials in bed of vehicle. All windows closed.
	ATVs and UTVs	Operated by trained and experienced drivers only. Lights on. Avoid steep slopes. Full PPE
	Public safety and smoke on road	Post signs and/or use road blocks if needed.
Equipment set-up	Operating pumps and saws.	Tuck in shirt tails, remove scarves and jewelry. Proper PPE used at all times.
	Operating high pressure nozzles.	Maintain visual contact with pump operator and other crew members. Use goggles.
Hand ignition	Close proximity to intense heat and erratic fire behavior	Use PPE. Maintain communication. Know escape routes.
	Smoke, sparks, and cinders.	Avoid very dense smoke. Wear PPE, Alter firing patterns. Rotate personnel out of worst areas.
	Poor footing, steep slopes, heavy fuels.	Constant awareness, learn to identify hazard area. Slow down.
	Burning fuel dripping from torches.	Know location of others. Extinguish when not inside burn unit. Be aware of spurting from drip torch.
	Misguided lighter lighting wrong area. Inadvertent firing over/under shot.	Post lookouts. Notify Burn Boss. Holding crews extinguish spot, subsequent to further ignition.
ATV Ignition	Rough terrain, heavy ground fuels, side hills and slopes.	Scout and locate accessible routes, make dry run, experienced operator or supervised trainee. Fire by hand if needed.
	Noise of ATV and fire obscures verbal warnings.	Hand held radios recommended for all ignition personnel.
Holding	Tool Use.	Proper training. Keep tool guards on while traveling, remove only while in use.
	Burned snags or widow-makers.	Avoid entering burned over areas. Post lookout, flag.
	Burns from radiant heat and hot embers.	Nomex clothing, hard hats and gloves required.
	Rolling debris.	Post lookouts, brief crew as to potential hazard areas.
	Erratic fire behavior	To be covered by Burn Boss in pre-burn briefing, escape routes shall be known by everyone.
Mop-up	Snag falling.	Falling and bucking to be done only by trained personnel.
	Smoke inhalation.	Crews will be rotated in and out of dense smoke.
	Fatigue, long hours of work.	The Burn Boss will monitor crew for signs of fatigue. For long mop-up operations, additional crew members may be needed. Work in pairs, have rested drivers available.
	Heat	Drink adequate fluids to maintain hydration.
	Venomous Insects & Reptiles	Stay Alert for snakes, bees, and scorpions.

Texas State Government Privacy Policy

Texas Parks and Wildlife maintains the information collected through this form. With few exceptions, you are entitled to be informed about the information we collect. Under Sections 552.021 and 552.023 of the Texas Government Code, you are also entitled to receive and review the information. Under Section 559.004, you are also entitled to have this information corrected. Contact information:

Texas Parks and Wildlife Department
4200 Smith School Road, Austin, TX 78744
(512) 389-4800 | (800) 792-1112
www.tpwd.state.tx.us

THE SAN MARCOS GREEN ALLEY INITIATIVE

*A Framework + Toolkit for Resilient, Green
Infrastructure in Downtown San Marcos, Texas*



Created for the Community of San Marcos, Texas

Copyright June 2021



Prepared by:

Colorspace Architecture & Urban Design
Tristan Roger, Planning Intern + Sarah Simpson, Architect, Urban Designer, LEED GA

In collaboration with:

Elizabeth Arceneaux, PE, Environmental Engineer

The Meadows Center for Water and the Environment
Aspen Navarro, Program Coordinator, Watershed Services + Allyson Schlandt, Grant Technician II, Watershed Services



With review and additional assistance by:

Jon Dienst, P.E., Civil Engineer II, City of Dubuque, Iowa
Tom Hegemier, P.E., D.WRE, CFM, Senior Project Manager, Doucet & Associates
Melani Howard, Habitat Conservation Plan Manager, City of San Marcos Engineering & Capital Improvements

And endorsed by the following partners:



THE SAN MARCOS GREEN ALLEY INITIATIVE

CONTENTS

<i>Foreword: Green Alleys for a Sustainable Future</i>	1
<i>Executive Summary: Findings of the Green Alley Initiative</i>	2
1 / INTRODUCTION	4
<i>Inspiration</i>	4
<i>A Response to Pressing Issues</i>	4
2 / ALLEYS IN THE CITY	5
<i>Alleys Over Time</i>	5
<i>Alleys as Green Infrastructure</i>	6
<i>Alleys as Activated Public Space</i>	8
<i>Green Alley Precedents: A Nationwide Movement</i>	10
3 / DOWNTOWN ALLEYS TODAY	12
<i>Downtown San Marcos + The San Marcos River</i>	12
<i>Existing Downtown Alleys</i>	14
<i>Downtown Soils + Stormwater Infrastructure</i>	16
<i>Downtown Groundwater</i>	18
<i>Existing Alley Conditions</i>	20
<i>Beneficial Characteristics, Challenges + Opportunities</i>	22
<i>Assessed Alley Conditions + Potentials</i>	24
4 / GREEN ALLEYS OF TOMORROW	26
<i>Conceptualizing a Green Alley Network</i>	26
<i>A Green Alley Catalyst</i>	28
5 / GREEN ALLEY TOOLKIT	33
<i>Green Infrastructure Toolkit</i>	34
<i>Public Space Toolkit</i>	36
<i>Adjacent Properties Toolkit</i>	38
<i>Metrics + Outcomes</i>	40
<i>Anticipated Green Alley Pollutant Removal</i>	41
<i>Potential Funding Sources</i>	42
<i>Industry Contacts + Resources</i>	44
<i>Frequently Asked Questions</i>	46
6 / NEXT STEPS	48
<i>Building a Green Alley Community</i>	48
<i>References</i>	50
<i>Appendices</i>	52

FOREWORD

GREEN ALLEYS FOR A SUSTAINABLE FUTURE

Downtown San Marcos falls within the boundary of the Upper San Marcos River Watershed, a body of water highly valued by both permanent residents, students, and tourists alike. This portion of the San Marcos River (the River) is the most urbanized area in the watershed, where the River and its tributaries run through the city, providing a source of drinking water, recreational opportunities, and habitat for endangered and threatened species. As San Marcos continues to experience growth, implementing resilient green infrastructure strategies - like Green Alleys - becomes important to not only reduce stormwater runoff and pollutants in the River but also to ensure the vitality of San Marcos' urban areas.

In addition to addressing environmental impact, Green Alleys are a mechanism to improve existing infrastructure while bolstering the local economy. Improved alleys act as gathering spaces for a multitude of different events, as already seen in the utilization of Kissing Alley by the City and local businesses. Alley improvements will increase connectivity throughout downtown, increase the space available for hosting community events, and make access to businesses more feasible to foot and bike traffic by providing safe alternative routes to main streets and sidewalks. Rather than highlighting just one alley, building a network will promote downtown as a whole, and provide a platform for businesses to work together to best utilize alleys for economic vitality.

Green Alleys also have the potential to improve the lives of all community members. Involving citizens in their reconstruction from the beginning will provide a sense of ownership and pride over these revamped and environmentally conscious spaces. As they are completed, the hope is to provide aesthetically pleasing multi-use spaces accessible to all citizens and community members, as well as education about the importance of protecting the natural resources around them through the implementation of green infrastructure projects.

A Green Alley Initiative will enhance and improve the environment, economics, and equity for the city and its citizens. Placing an equal value on all three of these elements is vital to the long-term success of reconstruction efforts, and ensures that the goals of Green Alleys and the vibrancy of San Marcos' downtown will be sustained well into the future.

- Aspen Navarro,
Program Coordinator, Watershed Services
The Meadows Center for Water and the Environment

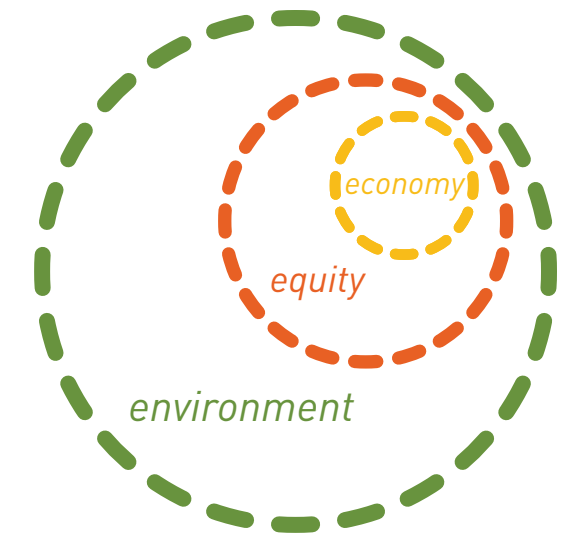


Fig. 1 The Improved Three E's



Fig. 2 Alley Transformations

EXECUTIVE SUMMARY

FINDINGS OF THE GREEN ALLEY INITIATIVE

Often overlooked, alleys are resilient pieces of infrastructure, readily adapting over centuries to meet the needs of the current day. Today, North American cities of all sizes are increasingly converting gray alleys to green infrastructure. Inspired by such alley greening precedents, as well as the local efforts behind Kissing Alley, recent San Marcos city council initiatives prioritizing Downtown Vitality and Stormwater Management, and City of San Marcos downtown alley reconstruction plans, local advocates in San Marcos have come together to support a comprehensive 21st century vision for Green Alleys in San Marcos. Thus, the Green Alley Initiative was formed.

With a pristine river ecosystem just east of downtown, growing demands for more liveable, walkable environments, and increasing climate and social crises, community ideas for alleys have naturally started to surface. Through the investigations of the Green Alley Initiative, downtown alleys in San Marcos have been revealed to be powerful stormwater tools - with the capacity to capture nearly half a million gallons of stormwater and filter over 10,720 pounds of total suspended solids a year if converted to green reconstructions! This potential is further augmented by the social and economic benefits that would result from the quality of improved public space.

With this information in hand, the purpose of the Green Alley Initiative is to inspire greater use of urban alleys and make the case for their use as green infrastructure, social space, and economic stimulus in downtown. More specifically, this document:

- Provides a high-level overview of alleys in today's general urban context alongside best practices for realizing their full capacity to contribute to both practical everyday needs of a city, as well as the pressing environmental and social issues of our time;
- Captures a current snapshot of San Marcos' downtown alley network within an ecological and infrastructural context, while assessing current conditions and potential for enhancement;
- Envisions and illustrates how a performative Green Alley network can increase resilience and deliver ecological, social, and economic services to downtown San Marcos; and,
- Provides a strategic toolkit of green infrastructure practices, public space improvements, and other features that can be flexibly deployed to activate an alley, deliver ecosystem services, and vitalize downtown San Marcos.

SHORT-TERM GOALS

The ideas, case studies, and solutions in this document are presented as an indication of collective community desire and recommendation for more performative public urban space in the city.

In the last century, urban zones have been seen as separate from the natural landscape and are too often dominated by the automobile. But citizens, environmentalists, urbanists, scientists, and planners alike understand that there is a greener, more integrated way forward.

Thus, the short term goals of this document are:

- To implement a first phase, pilot alley project and demonstrate the multitude of ecological benefits, social possibilities, and economic benefits possible in downtown San Marcos, particularly when considered collectively as a network; and,
- To encourage the integration of green infrastructure best practices for both public and private investment throughout San Marcos and the Central Texas region.

LONG-TERM OBJECTIVES + BENEFITS

The long-term objectives and benefits of the Green Alley Initiative include:

- Protection and improvement of water quality in the Upper San Marcos River Watershed and lessened localized flooding;
- Enhanced air quality, mitigation of the urban heat island effect, and increased urban biodiversity in downtown San Marcos;
- Community education and expanded awareness of the social and ecological impacts of the green alley network;
- Increased economic vitality for local businesses by improved service, functionality, and aesthetics of downtown alleys;
- Encouraged walking and biking into and through downtown San Marcos via friendly, safe, and accessible connectivity; and,
- Creation of a human scale network that fosters a sense of discovery and exploration and cultivates unique cultural uses by businesses, visitors, and residents alike.

GREEN ALLEY RECOMMENDATIONS

To accomplish these goals and objectives, the Green Alley Initiative recommends the following for San Marcos' downtown alleys:

- Reassess all current and future City of San Marcos Capital Improvement Plan (CIP) projects that pertain to downtown alleys for inclusion in a new city-led effort for Green Alleys;
- Create a Green Alley framework, which would assess all currently planned and future alley projects systematically across downtown San Marcos for their collective ecological, social, and economic services potential;
- Adopt a toolkit of green infrastructure and public space components, as well as scope requirements, for all alley improvements across downtown, including at a minimum:
 - Use of permeable pavers in alley surface reconstructions to infiltrate and filter stormwater on-site, while enhancing aesthetics and visitor experience in the heart of San Marcos;
 - Naming and providing physical identification of alleys through a public ideas process; and,
 - Incentivized participation of adjacent properties / businesses in green alley improvements, such as depaving, waste enclosures, rainwater harvesting, and more
- Support knowledge building amongst the community and City of San Marcos staff through trainings and collaborative research to ensure widespread familiarity with and acceptance of green infrastructure concepts required for successful deployment
- Work in cooperation with downtown businesses and local organizations / non-profits to help guide and support the Green Alley Initiative as an exemplary urban infrastructure project that benefits the local economy, environment, and community
- Invest in the creation of a Green Stormwater Maintenance Department to develop long-term GSI maintenance protocols
- Actively pursue grants applicable to Green Alleys and GSI to increase their feasibility; and dedicate a revenue stream for their maintenance to ensure both opportunity and long-term success

1 / INTRODUCTION

CREATING A VISION FOR ALLEYS IN SAN MARCOS

INSPIRATION

Several years ago, Main Street San Marcos undertook a placemaking effort to put a downtown alley on the map. One parklet, a wedding, and many concerts later, Kissing Alley was officially dedicated as such in 2017 and has become a celebrated community gathering space.

This wonderful act of creation has since spurred a larger dialogue about alleys generally in San Marcos - where alleys exist, how alleys function, who alleys serve today and in the future, and what could be altered or added to them so that they support not only downtown businesses but also other city-wide needs and systems.

Unlike primary roads running through San Marcos' downtown owned by TXDOT, all alleys are City-owned and maintained, and, with lower levels of traffic, lend themselves to less conventional treatment. Inspired by alley greening precedents, as well as the local efforts behind Kissing Alley, recent San Marcos city council initiatives prioritizing Downtown Vitality and Stormwater Management, and City of San Marcos downtown alley reconstruction plans, local advocates in San Marcos have come together to support a comprehensive 21st century vision for Green Alleys in San Marcos. Thus, the Green Alley Initiative was formed.

A RESPONSE TO PRESSING ISSUES

The recommendations in this document acknowledge the many local, regional, and global issues we face in 2020, as well as the existing efforts to address them, and strives to support and act in response to these forces, including:

- Anthropogenic impacts on local / global environments that have led to today's climate crisis, solutions to which require more compact, connected, and multi-functional urban environments;
- The National Weather Service's 2018 rainfall study [Atlas14](#), which demonstrates considerable rain volume increases and necessitates resilient stormwater infrastructure, particularly for already flood-prone zones including the central Texas towns of "Flash Flood Alley" along the Balcones Escarpment;

- The long-time presence of threatened and endangered species in the Upper San Marcos River ecosystems, requiring pollutant capture and compliance with the [Edwards Aquifer Habitat Conservation Plan \(EAHCP\)](#);
- San Marcos City Council's recent Strategic Initiatives focusing on Stormwater Management and Downtown Vitality, as well as efforts to implement a city-wide sustainability plan; and,
- [Main Street's](#) ongoing efforts to ensure the continued relevance and success of San Marcos' downtown - amidst a time of increasing physical separation, social isolation, and economic instability.

In spite of these many challenges and goals, a disconnect exists between growing needs and implementation. Local street standards can be improved to encourage enhancement of alleys beyond impermeable surfaces. Similarly, while the [San Marcos CIP Plan](#) has taken small encouraging steps to consider more green infrastructure, a systematic commitment to it has not yet been made.

The City has indicated that all downtown alleys are planned for reconstruction within the coming decade (by 2027). Thus, it is the aim of this document to demonstrate both possibilities and community support for a network of multifunctional urban alleys so as to not lose an opportunity for impactful change downtown.

Although the challenges ahead of San Marcos, the Central Texas region, and the planet as a whole are daunting, the Green Alley Initiative understands that community commitment and focused projects are key to social and ecological progress. As demonstrated on the following pages, we believe Green Alleys are one such project in a wider web of positive environmental and social action.



You can't solve a problem at the same level it was created. You have to rise above it to the next level.

- ALBERT EINSTEIN

2 / ALLEYS IN THE CITY

LEVERAGING HISTORIC SUPPORT FOR A RESILIENT DOWNTOWN

ALLEYS OVER TIME

Trash collection. Pedestrian pathway. Utility line route. Outdoor play area. Delivery zone. Informal gathering space. Car parking. Shop storefront. Such is the versatile realm of alleys.

For over two millennia dating back to Greek civilizations, alleys have been a vital component of functional urban places (Wolch et al, 2010). Typically designed as a secondary grid of circulation at the rear of lots, alleys have historically provided service for pedestrians and utilitarian functions and were integral to the urban design of many North American settlements founded in and prior to the 19th century.

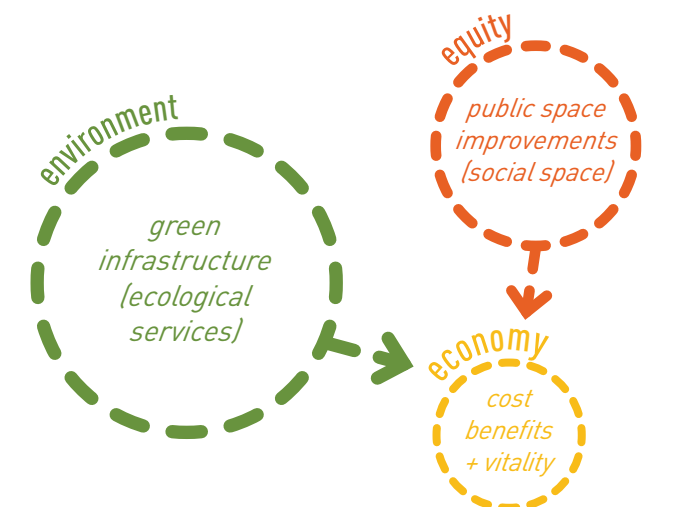
Yet, alleys commonly go unnamed and overlooked as meaningful infrastructure. Synonymous with "city" and the urban condition, alleys fell into disfavor in the 20th century. Described in popular narratives as dark, dangerous spaces in dark, dangerous cities, alleys were effectively banned by federal housing policy by 1930 (Newell et al, 2012). Later, as the civil rights movement of the 1960s was met with white flight and highway building, planning policies shifted away from compact cities where alleys originated. Instead, the nation adopted and heavily subsidized suburban, auto-oriented patterns where private rear lawns pushed vehicles and services to the primary street grid.

Today, many alleys have all but vanished due to 20th century urban renewal projects that cleared large portions of American urban fabric. However, a sea-change is underway to reverse this trajectory and redefine the 21st century role of alleys - this time as green infrastructure and public space, as explored in the following pages.



Fig. 3

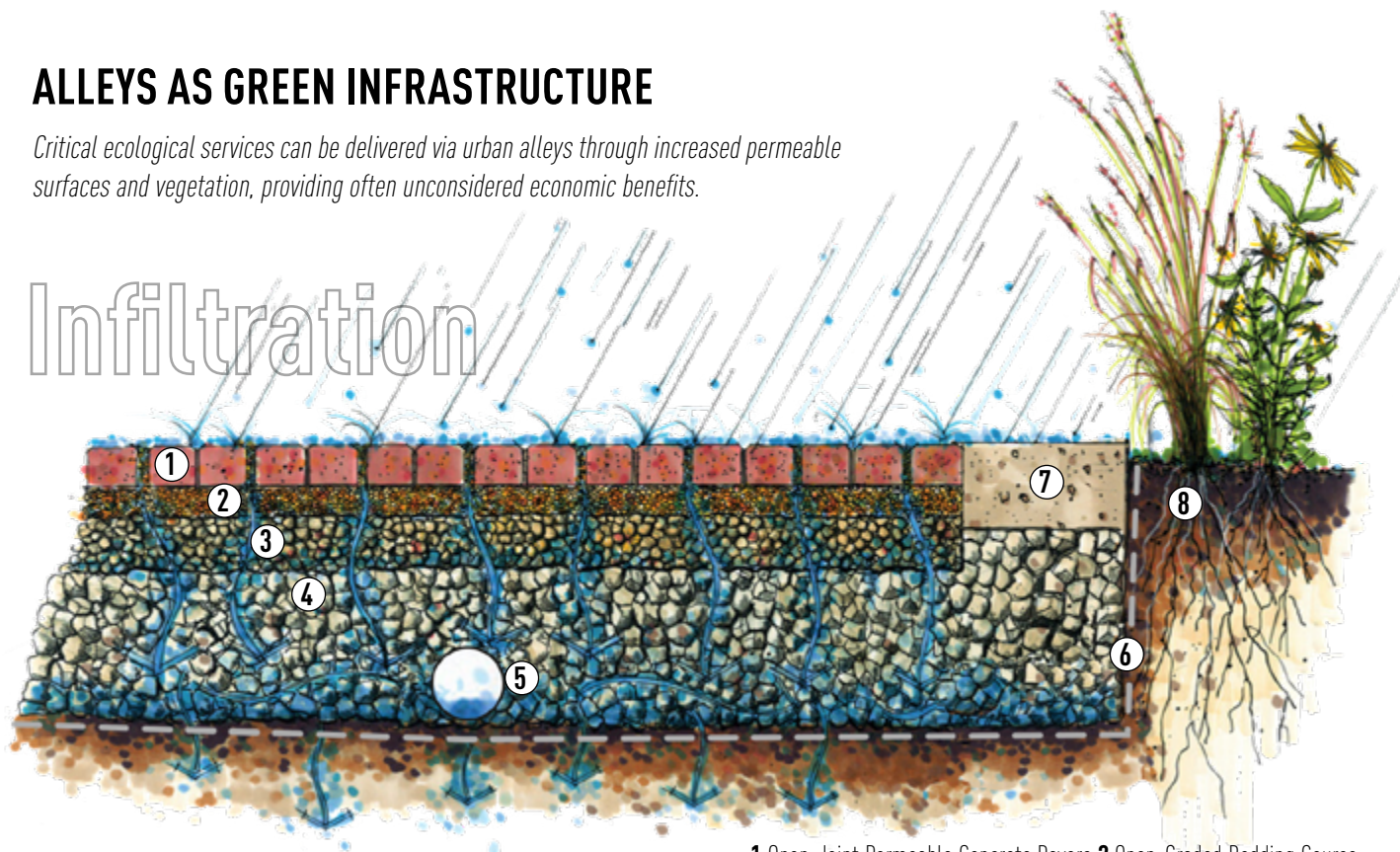
Integral to San Marcos' downtown center as conceived in 1851 is a network of alleys that deliver necessary services to the rear of each lot, as shown on the town plat above from 1881 in green. Many of these original alleys remain intact today and continue to ensure reliable services to downtown businesses and residences. By upgrading alleys with green infrastructure and public space improvements, this historic network can deliver critical benefits relevant to the 21st century, including ecological services, equitable social space, and economic vitality.



ALLEYS AS GREEN INFRASTRUCTURE

Critical ecological services can be delivered via urban alleys through increased permeable surfaces and vegetation, providing often unconsidered economic benefits.

Infiltration



- 1 Open-Joint Permeable Concrete Pavers 2 Open-Graded Bedding Course
3 Open-Graded Base Reservoir 4 Open-Graded Subbase Reservoir
5 Underdrain (as required) 6 Geotextile Fabric, Waterproof Liner (as required)
7 Concrete Collar 8 Permeable Biofilter / Planter / Rain Garden

IMPROVED STORMWATER QUALITY + REDUCED LOCALIZED FLOODING

Permeable surfaces and Green Stormwater Infrastructure (GSI) practices, such as the use of permeable pavers and rain gardens, are increasingly replacing traditional gray hardscapes in urban settings, helping to create a distributed network of stormwater filtration in urban spaces. Permeable hard surfaces work particularly well in alleys due to their ability to capture and clean stormwater, lessen flooding, and slow runoff while also supporting vehicular loading.

The typical cross section of permeable interlocking concrete pavers, above demonstrates how this durable surface, with a strength of over 8,000 pounds per square inch, allows stormwater to infiltrate.

- The joints between interlocking pavers allow a high infiltration rate of up to 500 to 800 inches per hour. Compared to sand at 30 to 200 inches per hour, these paver systems are extremely permeable yet function as an effective replacement to impervious cover such as asphalt and concrete.
- Water that passes between the pavers into the open graded base (gravel and stone having a porosity of 30 to 40%) is slowed down, filtered, and cooled much like in an underground aquifer.

- Water stored in the open void spaces slowly infiltrates into the underlying soils. Even in tight clay soils with an infiltration rate of 0.5 inches per hour, a 12 inch stored layer of water can infiltrate over a 24 to 48 hour time.
- Permeable pavers for green alleys can be designed to detain a 25-year 24-hour storm and achieve an 89% -93% reduction in suspended solids and over 40% reduction in the total nutrients, including phosphorus and nitrogen (RG-348, City of San Marcos Technical Stormwater Manual and WERF SELECT model, 2013).

GSI practices' ability to infiltrate, treat, and detain runoff is an advantage over conventional gray infrastructure systems that simply direct runoff directly toward waterways without treatment. The impact of high velocity and high pollutant load runoff is detrimental to stream ecosystems and has long term environmental and economic effects. By reducing impervious cover in urban right-of-ways, we can reverse these effects and create more livable spaces.

- \$ cost benefits + economic vitality:**
- avoided costs for upgraded storm pipe, improved aesthetics that stimulate downtown visits

“ Underlying these techniques is a change in philosophy for handling stormwater. Previous methods were often based on getting water off of the land as quickly as possible...By contrast, LID uses various solutions often spread across the site to capture as much water as possible.

- CHRISTINE MIDDLETON, THE WIMBERLEY VIEW



AIR QUALITY + URBAN HEAT ISLAND MITIGATION

The urban heat island effect and poor air pollution are common issues that plague urban environments due to large amounts of hot, hard surfaces and car exhaust. Finding opportunities to introduce cooler surfaces, however, can help create cooler spaces with improved air quality.

Introducing more native trees and groundcover can help clean the air, reduce CO₂, and provide shade. Use of permeable hard surfaces with high albedo in alleys also reduces ambient temperatures through solar reflectance and evapotranspiration. Up to two times cooler than asphalt, high albedo pavement also helps to reduce the temperature of runoff to the river, which reduces negative impacts to aquatic life in receiving waters (EPA, 2014).

- reduced energy costs, cleaner air, increased human health + pedestrian activity, stimulated business

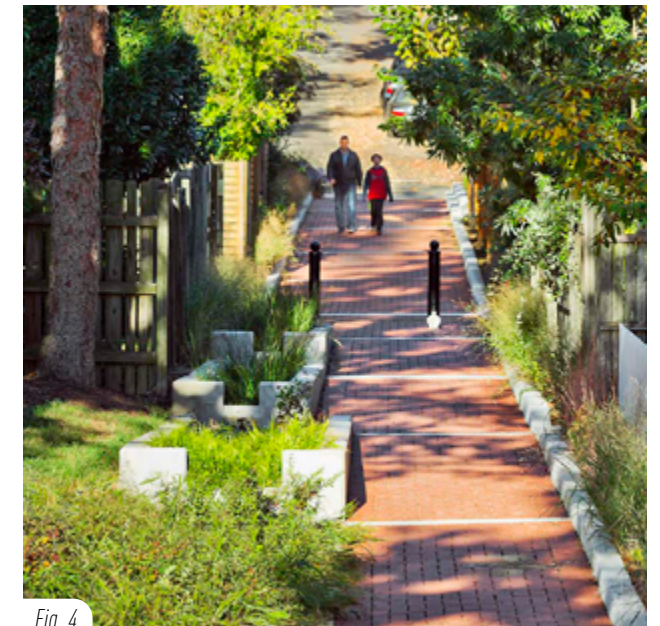


Fig. 4

INCREASED URBAN BIODIVERSITY + QUALITY OF LIFE

Cities have too commonly been viewed and constructed as gray, sacrificial zones where natural ecologies and systems are suppressed or broken. However, efforts like the Biophilic City (Beatley, 2010) project are working to repair this rift by bolstering and celebrating the unique qualities and strengths of urban ecosystems while improving quality of life for all human and non-human residents.

The innate flexibility and lower traffic levels of alleys can help cultivate biophilic space and increase urban biodiversity by providing spatial networks for native groundcover, shrubs, and trees. This increased vegetation helps absorb stormwater runoff, build wildlife habitat for pollinators and avian populations, and contribute to overall ecosystem health.

Support for local wildlife can be further cultivated with the strategic insertion and maintenance of nesting boxes. Species well-suited for green alley habitat include hummingbirds, House Finches, Western Kingbirds, and other species common to urbanized areas.

- avoided costs for upgraded storm pipe, improved aesthetics, increased human health + pedestrian activity, stimulated business

ALLEYS AS EQUITABLE PUBLIC SPACE

Important social services can be cultivated by creating a functional, supportive, and educational urban alley network that also helps boost downtown business.



Fig. 5

IMPROVED SERVICE SUPPORT + ALLEY FUNCTION

Central to their design, alleys provide a valuable service network for utilities, deliveries, waste services, and general back-of-house access. This service functionality should remain a priority for all alleys, particularly those with intended vehicular access, and opportunities to improve service for property and business owners should be prioritized.

Areas of common use can often be streamlined and the pedestrian experience improved through the use of trash enclosures or combined trash facilities. Overhead utility lines can be buried for electric line protection and enhanced aesthetics. In instances where right-of-way is limited, traffic can be simplified by moving to one-way travel. Water drainage can also be improved through the use of permeable surfaces, as previously described, to ensure year-round functionality.

cost benefits + economic vitality:

- streamlined + consistent business function, improved aesthetics



Fig. 6

HUMAN SCALE DISCOVERY + CULTURAL USE

Humans are naturally drawn to enclosed spaces that reflect and compliment our scale. Thus, it is no surprise that the more personal scale of alleyways tend to attract and leave a memorable impression on many. At typical widths of 16' - 20', current downtown alleys provide a more intimate way to explore cities for residents and visitors alike when made safe, interesting, and welcoming.

Encouraging business and residential uses to provide access off of alleys can help provide more regular surveillance. Beyond pure utility, alleys can also provide vibrant, informal public space for the many cultural activities of a city's inhabitants. Efforts to bring arts programming, impromptu gatherings, and organized events into alley space have been heralded world wide and should be embraced where initiated. Community art programs also create reasons for exploration and contribute to a hidden yet discoverable, or off-the-beaten-path, experience for a city's inhabitants.

- improved business access + visibility

“ While alleys vary in width, material, use, and even go by different names in other countries, one thing is certain: alleys not only provide important space for services but also invaluable public space.

- SEATTLE INTEGRATED ALLEY HANDBOOK, FIALKO, HAMPTON, + GEHL PARTNERS



Fig. 7

WALKABLE, BIKEABLE ACCESS + CONNECTIVITY

Nothing deters pedestrians or cyclists from hitting the streets like hostile vehicular traffic, a lack of sidewalk continuity, or little shade and few places to sit and rest in hot climates. Primary street grids often take on these characteristics - but, conversely, alleys can serve as a safer, quieter, and cooler network for walking and cycling.

By ensuring that an alley network is accessible, connected, and advertised as such through the strategic placement of benches and bike racks, healthy, low-carbon active transportation can be boosted considerably via a functioning secondary alley grid.

Safety must always remain a priority and special consideration should be given to the intersections of alleys and primary streets to minimize conflict between varying environments and speeds.

- improved downtown access, increased pedestrian + bike activity which produces higher rates of business patronage

EDUCATION + COMMUNITY AWARENESS

Through informative wayfinding and interpretive signs, the many benefits and services rendered by alleys described herein should be communicated to help educate residents and visitors. Awareness of alleyway histories and the environmental connectivity of urban areas to waterways can be increased with illustrated signage and maps. Educational tours that integrate informative talks with walking or cycling activities can impart positive memories and leave a lasting impact on participants.

- increased destination presence of downtown San Marcos

GREEN ALLEY PRECEDENTS: A NATION-WIDE MOVEMENT

As previously explored, Green Alleys can help deliver needed urban infrastructure. Many US cities have initiated different types of alley programs over the last decade in an attempt to reinvigorate these forgotten spaces, and Green Alleys in particular are gaining momentum not only in large cities but also in small and mid-sized towns like San Marcos due to the lived benefits. The following case studies of best practice alley programs provide a high-level overview of successes and inspiration for an improved future for San Marcos' downtown and the River.

“ Green alleys use pervious pavements and effective drainage to create an inviting public space for people to walk, play, and interact.

- NATIONAL ASSOCIATION OF CITY TRANSPORTATION OFFICIALS (NACTO)



Fig. 8



Fig. 9

DUBUQUE, IOWA

POPULATION (2019): 58,000

[2012 - Present Bee Branch Watershed Flood Mitigation Project - 240 planned alleys](#)

Investment Costs: \$200,000,000 in 12 Phases

As a Mississippi River town prone to flash floods, the City of Dubuque, Iowa initiated the ambitious Bee Branch Watershed Flood Mitigation Project in the early 2000s after experiencing devastating and reoccurring flooding disasters. The flood mitigation project takes a multi-faceted approach but focuses heavily on the reduction of impervious surfaces through the installation of permeable pavers on 240 alleys across the watershed. Abutting property owners are assessed a portion of the cost (typically 15%) based on frontage. With 80 green alleys completed to date, city engineers have already seen success from their efforts to curb the flow of pollutant-laden runoff into the river, and the treatment plant observed a reduction of 60% in total suspended solids (TSS). The program was named Public Works Project Of The Year in 2015 by the Iowa Chapter of the APWA.

ROSWELL, GEORGIA

POPULATION (2019): 78,000

[2015 East-West Alley Master Plan - Seven alleys](#)

Investment Costs: \$1,700,000

Roswell, Georgia launched the East-West Alley Master Plan in 2015 after gathering public input during a full-day design charrette with city staff, business owners, heritage professionals, and other stakeholders. The plan focused on the ecological and economical activation of seven alleys located in the downtown commercial area with enhanced pedestrian access, permeable pavers, enlarged landscaped areas, widened sidewalks, string lighting, flexible social space, and outdoor dining. Owners and local businesses received this project as an amazing addition to the character of the historic district as well as a much needed improvement in local stormwater management.

GREAT ALLEY TRENDS

- **Identification:** Naming alleys is essential to giving them identity and starting the activation process.
- **Community Art Programs:** Mural and arts programs are a good way to show an alley is safe, cared for, and occupied.
- **Open Facades:** Doors and windows opening onto alleys are welcoming and increase the rates of pedestrian traffic.
- **Permeable Surfaces:** Alleys present opportunities to insert permeable surfaces that can help capture and clean stormwater.
- **Urban Landscapes:** Native vegetation in alleys can contribute to a city's biodiversity and larger environmental strategies.
- **Placemaking + Exploration:** With thoughtful design, alleys can encourage locals and tourists to explore urban centers.



Fig. 10

LONGMONT, COLORADO

POPULATION (2019): 94,000

[2010 - 2017 Alleyscape Development Project - Three alleys](#)

Investment Costs: Unknown with \$200,000 Private Improvement
25% Matching Grants allocated in two Phases

The City of Longmont, Colorado's Alleyscape Development Project resulted from a collaborative effort between the city's Public Works and Natural Resources department and the Longmont Downtown Development Authority (LDDA). After reoccurring floods caused extensive infrastructural damage, efforts to reduce impervious cover downtown called for the installation of permeable paving systems on alleyways with underground piping to adjacent street storm drain systems. Public space enhancements were also made in parallel, including the completion of underground utilities, consolidated trash, lighting, public art, and facade improvements. During reconstruction, businesses were incentivized to make additional private improvements with 25% matching alley LDDA grants of up to \$10,000 each. The alleys are now more functional, inviting to the public, and able to fully contain up to 10-year storm events.



Fig. 11

SOUTH PARK, CALIFORNIA

POPULATION (2008): 32,850

[2015 Avalon Project - Six planned alleys](#)

Investment Costs: \$400,000

Located in the heart of South Los Angeles, the neighborhood of South Park led a collaborative effort for a green alley pilot project. In partnership with the City of Los Angeles and the Trust for Public Land, the Avalon Project was regarded as a framework for the systematic revitalization of alleys located throughout South Los Angeles. The plan had many goals and aimed at improving community health and fitness, safety, and water quality, as well as providing neighborhood connections and reducing urban heat island effects. Plants, bioswales, permeable pavers, street lights, and signage were used and installed over a one year construction period. The program relied heavily on public input, and the population is now requesting its expansion to other neighborhoods in the city.

3 / DOWNTOWN ALLEYS TODAY

BIOREGIONAL CONTEXT, INVENTORY, & EXISTING CONDITIONS

DOWNTOWN SAN MARCOS + THE SAN MARCOS RIVER

Situated at the edge of the Edwards Plateau / Balcones Escarpment and primarily within the Blackland Prairies ecoregion, downtown San Marcos is a well-known gateway to the Texas Hill Country. One of the oldest inhabited sites in the Americas, it has been home to Clovis Indians 12,000+ years ago and, more recently, Texas settlers from the 1840s to today, all of whom have been drawn to the flowing waters of the River - a pristine habitat for many unique and endangered species found no where else on earth.

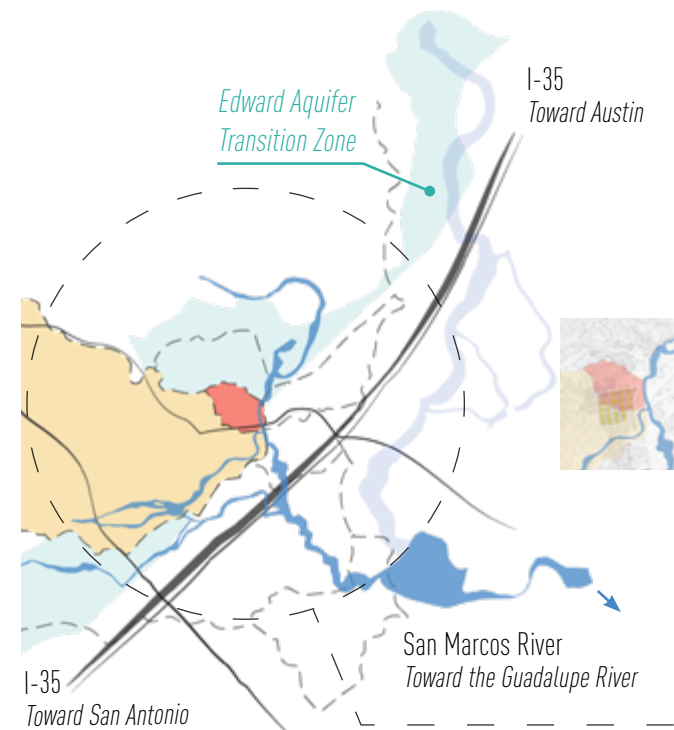


FIG. 12 UPPER SAN MARCOS RIVER WATERSHEDS

- NOT TO SCALE
- Downtown Watershed
- Purgatory Creek Watershed

Downtown San Marcos contributes both directly and indirectly to the Upper San Marcos River Watershed. The Downtown Watershed collects runoff from the northeast portion of downtown, as well as a sizable portion of Texas State University's main campus, and flows directly into the San Marcos River. The Purgatory Creek Watershed, a sub-watershed of the Upper San Marcos River Watershed, collects runoff from the remaining southwest portion of downtown and flows into Purgatory Creek before flowing to the San Marcos River (The Meadows Center for Water and the Environment, 2014).

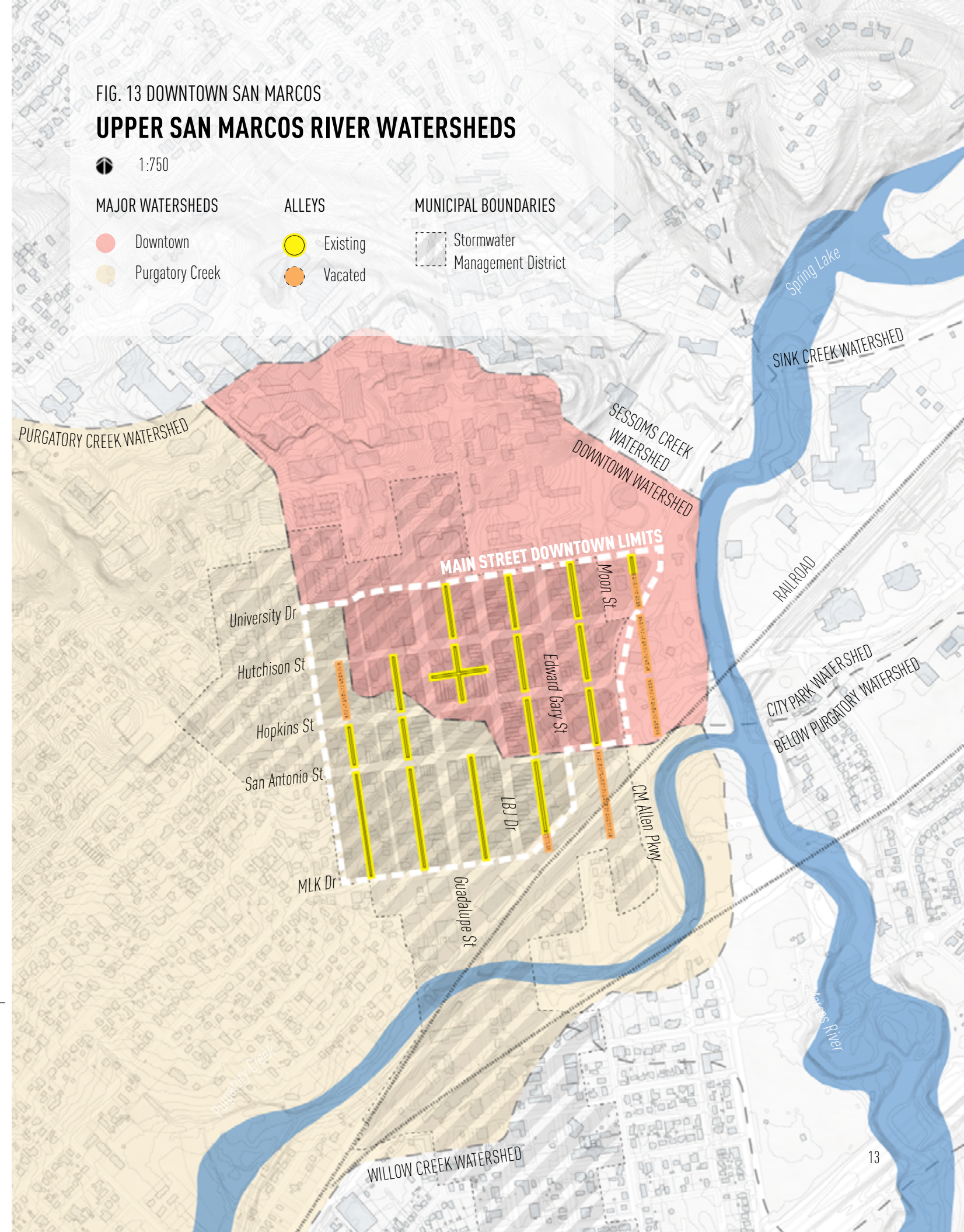
Following the tenets of Smart Growth, Downtown San Marcos is a designated Intensity Zone per the [2013 San Marcos Comprehensive Plan](#), which encourages mixed-use development patterns and increased residential units per acre to help reduce urban sprawl. Development can occur at 100% impervious cover per lot and associated stormwater impact fees are paid into a downtown Stormwater Management District, which helps fund more effective district-wide stormwater capture and filtration improvements.

Some of the benefits of urban development downtown include more environmentally responsible use of land regionally, reduced impervious cover and stormwater runoff *per capita*, and the potential for holistic stormwater controls (vs. piecemeal, lot by lot strategies). But with the adjacency to the River, finding opportunities to expand the network of district-wide stormwater controls is key to protecting this ecosystem from the negative impacts of urban runoff, typically polluted with oil and debris from automobiles, as well as dirt, chemicals, and fertilizers. Developing a green alley network can help build a healthier relationship between San Marcos' center and the Upper San Marcos River Watershed, with downtown alleys acting as an important pollutant-filtering mechanism.

Downtown San Marcos is located within the larger context of the Upper San Marcos River Watershed, which connects more immediately to the Blanco River Watershed before merging into the Guadalupe River and eventually flowing to the Gulf of Mexico.

FIG. 13 DOWNTOWN SAN MARCOS UPPER SAN MARCOS RIVER WATERSHEDS

- 1:750
- MAJOR WATERSHEDS
 - Downtown
 - Purgatory Creek
- ALLEYS
 - Existing
 - Vacated
- MUNICIPAL BOUNDARIES
 - Stormwater Management District



EXISTING DOWNTOWN ALLEYS

Of the original 20 platted downtown San Marcos alleys, 14 remain in use today along with Jack's Alley, the only alley that has been added since the original town was designed. These currently provide vital service access to the rear of most commercial lots and the businesses / residences that occupy them. For the purpose of this document, alleys without formalized names have been assigned alphabetic identification as noted below.



ALLEY A

Connecting University Dr & Hutchison St, between Guadalupe St & LBJ Dr
- Adjacent to N LBJ & University Square Shop Center



ALLEY B

Connecting University Dr & Hutchison St, between LBJ Dr & Edward Gary St
- Adjacent to N LBJ & Nelson Shop Center



ALLEY C

Connecting University Dr & Hutchison St, between Edward Gary St & Moon St
- Adjacent to University Plaza & Colloquium Books



ALLEY D

Connecting Hutchison St & Hopkins St, between Fredericksburg St & Guadalupe St
- Adjacent to First United Methodist Church



ALLEY E (KISSING ALLEY)

Connecting Hutchison St & Hopkins St, between Guadalupe St & LBJ Dr
- Adjacent to Central Fire Station



ALLEY F (JACK'S ALLEY)

Connecting Guadalupe St & N LBJ Dr, between Hutchison St & Hopkins St
- Adjacent to original San Marcos City Hall



ALLEY G

Connecting Hutchison St & Hopkins St, between LBJ Dr & Edward Gary St
- Adjacent to the Mobility Hub



ALLEY H

Connecting Hutchison St & Hopkins St, between Edward Gary St & CM Allen Pkwy
- Adjacent to The Local Downtown



ALLEY I (FELTNER ALLEY NORTH)

Connecting Hopkins St & San Antonio St, between Comanche St & Fredericksburg St
- Adjacent to The Price Center



ALLEY J

Connecting Hopkins St & San Antonio St, between Fredericksburg St & Guadalupe St
- Adjacent to the LBJ Museum



ALLEY K

Connecting Hopkins St & San Antonio St, between LBJ Dr & Edward Gary St
- Adjacent to the Hays Co Annex Bldg & Wells Fargo



ALLEY L

Connecting Hopkins St & San Antonio St, between Edward Gary St & CM Allen Pkwy
- Adjacent to Bank of America



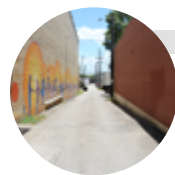
ALLEY M (FELTNER ALLEY SOUTH)

Connecting San Antonio St & Martin Luther King Dr, between Comanche St & Fredericksburg St
- Adjacent to the Calaboose Museum



ALLEY N (TELEPHONE ALLEY)

Connecting San Antonio St & Martin Luther King Dr, between Fredericksburg St & Guadalupe St
- Adjacent to Century Link



ALLEY O (RAILROAD ALLEY)

Connecting San Antonio St & Martin Luther King Dr, between Guadalupe St & LBJ Dr
- Adjacent to Aquabrew, facing South Courthouse



ALLEY P

Connecting San Antonio St & Martin Luther King Dr, between LBJ Dr & Edward Gary St
- Adjacent Lindsey Lofts and private Imagine Alley

FIG. 14 DOWNTOWN SAN MARCOS
ALLEY INVENTORY



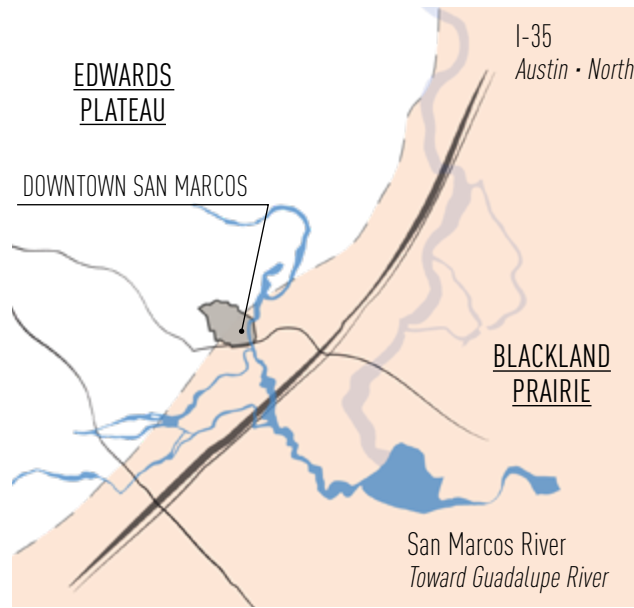


FIG. 15 CENTRAL TEXAS ECOREGIONS

NOT TO SCALE



FIG. 16 DOWNTOWN SAN MARCOS SOIL TYPES

NOT TO SCALE

Soil Type (Infiltration Rate)

- Clay (Very Low Infiltration)
- Sand (Very High Infiltration)
- Clay Loam (Low Infiltration)
- Sandy Loam (High Infiltration)

DOWNTOWN SOILS + STORMWATER INFRASTRUCTURE

Most of the land below downtown San Marcos is part of the Blackland Prairie ecoregion, characterized by dark, heavy clay soils with low permeability (Texas Parks and Wildlife Department, 2019). While not conducive to high rates of on-site infiltration, downtown's existing alley network has the capacity to temporarily detain and filter stormwater runoff before it connects to the stormwater system and flows into the River.

The existing stormwater sewer system, which captures runoff from downtown right-of-way and properties, already provides considerable potential connectivity with downtown alleys and is undergoing continual upgrades as part of the [City of San Marcos Capital Improvement Projects \(CIP\) Program](#). Drainage improvements in the LBJ Dr and Hutchison St areas of downtown were completed in the last ten years and storm drain upgrades along CM Allen Parkway are underway at the time of writing. Future projects determined by the City of San Marcos Stormwater Drainage Department and CIP Program will continue to address older and missing sections of the drainage system, improving potential for alley connectivity.

The City of San Marcos has plans to reconstruct all downtown alleys by 2025 / 2027 with the reconstruction of Kissing Alley from Hopkins Street to University Drive first on the horizon (Alleys A and E) to be completed by 2022. As these plans come to fruition, planning for the accommodation of green infrastructure in the alley network - such as permeable pavers, biofiltration, and increased native vegetation - is critical to expanding district-wide stormwater controls.

The low permeability of downtown soils and the presence of many existing buildings makes it necessary to collect and eventually transport most captured rainwater into the stormwater sewer system. As alleys are reconstructed, planning for the incorporation of underdrains that tie into existing storm drains, as well as the infill of gaps in the primary storm drain system, will help facilitate the flow of cleaner stormwater throughout downtown.

FIG. 17 DOWNTOWN SAN MARCOS STORMWATER FLOW MAP

1:375

- | SURFACE FLOW | EXISTING INFRASTRUCTURE | CONNECTIVITY - ALLEYS TO STORM DRAIN |
|--------------|-------------------------|--------------------------------------|
| Streets | Storm Sewer | Connection Opportunity |
| Alleys | Bioretention Pond | Minor Extension Required |
| | | Considerable Extension Required |



DOWNTOWN GROUNDWATER

In addition to soil conditions and stormwater systems, the proximity of Downtown San Marcos to the River requires consideration of the local groundwater table, or the underground boundary between unsaturated and saturated soil zones as subsurface water flows toward surface water features.

The topography of the Downtown area is characterized by a gradual slope towards the River on the east and Purgatory Creek towards the south, and running below this land surface is a map of groundwater levels at varying depths from the surface and with varying saturation depths, depending on proximity to these adjacent surface water features. Seasonal fluctuations between dry summer and wet spring and autumn conditions also result in changing water depths for single locations depending on the time of year.

For distributed green infrastructure systems that aim to collect rainwater in a decentralized network, often below the improved surface as is the case for permeable pavers and biofiltration features, there are different ways to design the system to address on-site conditions. As shown in the infiltration graphic (opposite page), groundwater levels should be located at least 2 feet below the bottom of the system profile to ensure minimal disruption to these flows (ICPI, 2018). This is particularly important in urban areas where contamination from business operations (dry cleaners, gas stations) is often present and disturbance of plumes is to be avoided. If known contamination hot spots are present, then an impermeable liner should also be utilized to prevent infiltration and plume disturbance (ICPI, 2018; City of San Marcos, 2019).

The height of the water table can be determined through water level measurements at installed piezometers, many of which are already located throughout downtown on both public and private property. Readings collected at 50 locations in 2020 show that the saturated zone being studied appears to be an unconfined system with seasonal variability. The water levels vary from 4 to 20 feet below ground with an average depth of 9.2 feet below ground observed. These depths are acceptable to provide the desired clearance demonstrated in the Infiltration graphic below.

Generally the height of the groundwater column appears to be much deeper closer to Purgatory Creek and the San Marcos

River, with thinner water layers at higher land surface elevations, such as near the Courthouse Square. However, in order to better understand annual average levels across the entire Downtown, the GAI recommends that these locations be measured at least quarterly and a ground water contour map of the levels plotted to show ground water presence and subsurface flow in this area. Collaborative use of all downtown piezometers could provide a better data set to make informed decisions for green infrastructure.

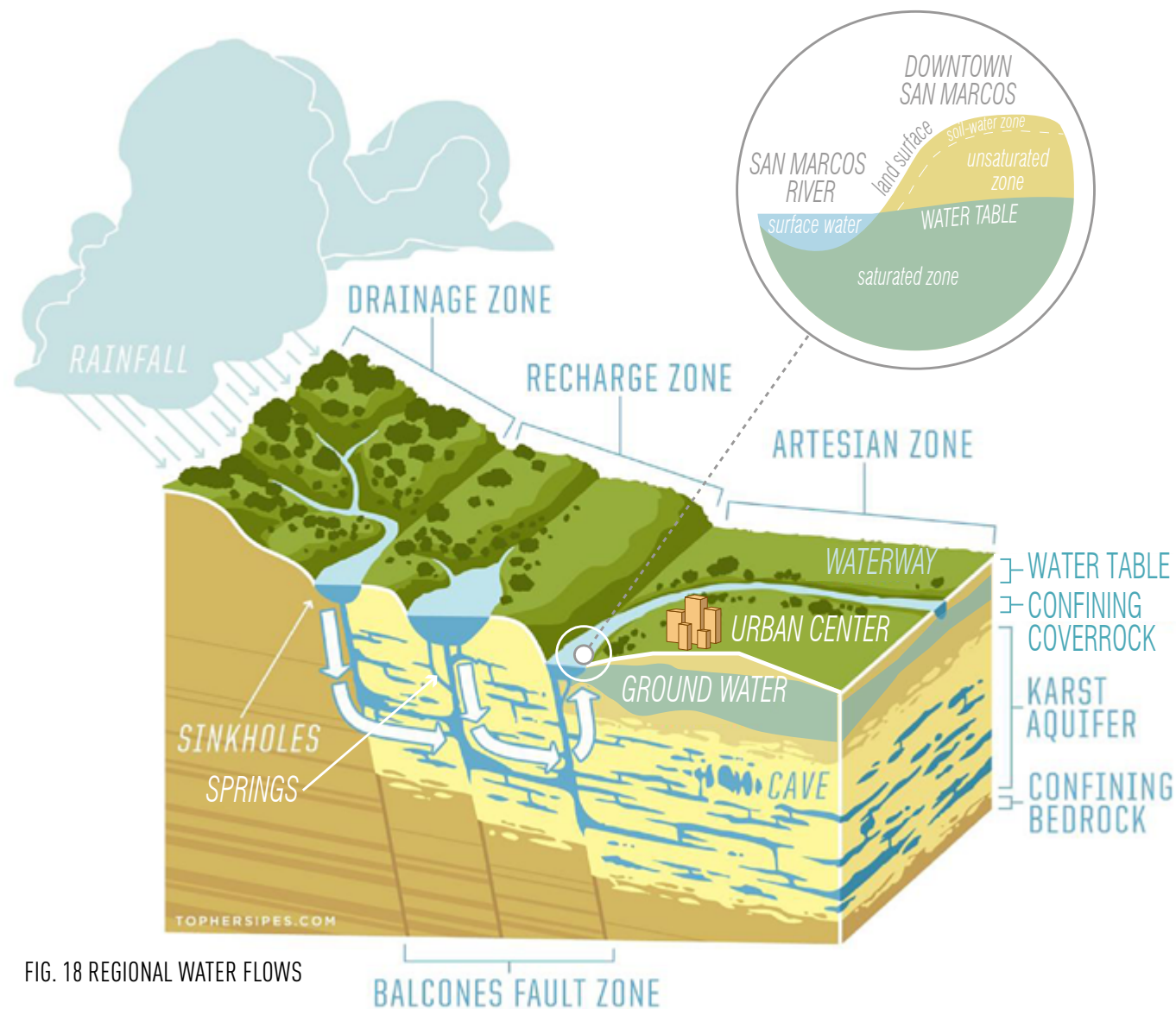
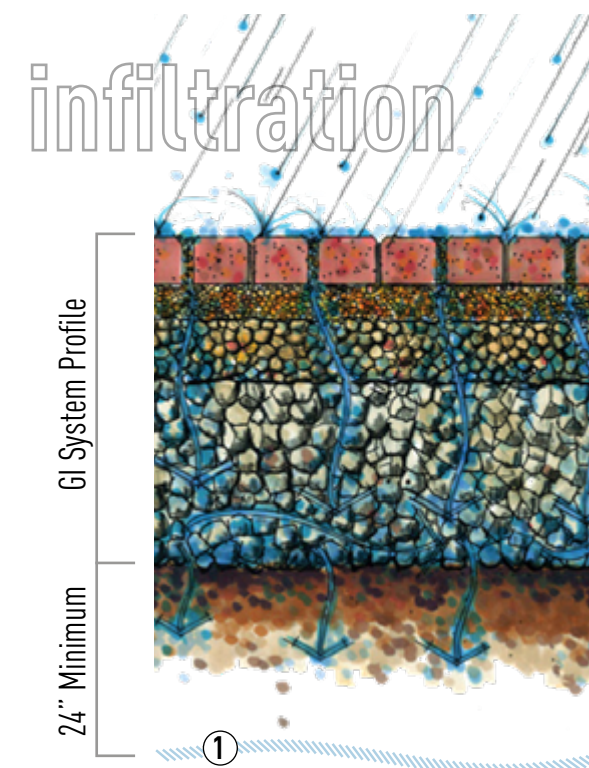
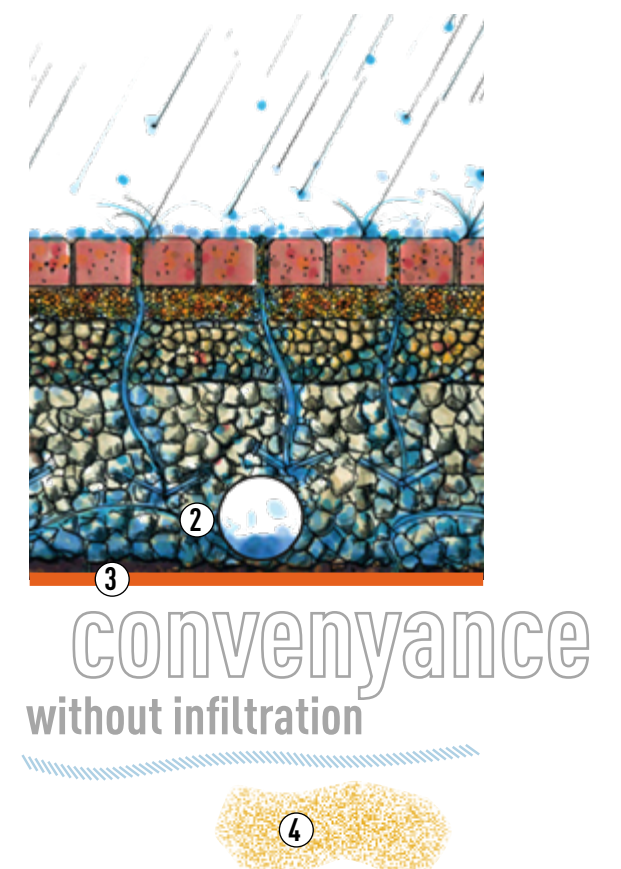


FIG. 18 REGIONAL WATER FLOWS



- 1 Groundwater Table - Minimum 2 Feet Below System Profile
- 2 Underdrain 3 Impermeable Liner 4 Contamination Hot Spot

UNLINED GREEN INFRASTRUCTURE FEATURE
Allows collected runoff to infiltrate into existing soils where appropriate permeability is present and known contamination hot spots are not present



LINED GREEN INFRASTRUCTURE FEATURE
Directs collected runoff to integrated underdrain tied into stormwater network where existing soils are not adequately permeable and known contamination hot spots are present

EXISTING ALLEY CONDITIONS

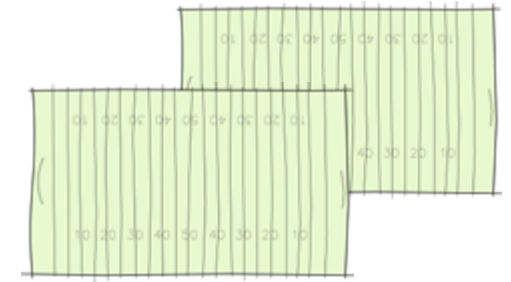
Based on a thorough inventory process and observations of current use and conditions, the alleys in downtown San Marcos were determined to fall into three existing categories: Vacated, Programmed, and Underperforming.

“...alleys should be seen as opportunities for initiating complete street renovations in creation of beneficial networks of connected public spaces, including streets, alleys, and sidewalks.

- TRUST FOR PUBLIC LAND, ALLEYS AMPLIFIED

2.5 acres

The approximate area covered by downtown alleys, equivalent to the area of almost two football fields!



Vacated alley in HEB parking lot



Kissing Alley



Alley behind the Nelson Center



Feltner Alley

VACATED

Vacated alleys are pieces of public right-of-way that existed in the original town plat of San Marcos but are today either absorbed by other uses or non-existent. When analyzing historic maps of the city and comparing them to existing property lines, six partially or fully vacated alleys have been identified in Downtown San Marcos, as demonstrated in the map on page 13. Two were previously located in the middle of blocks now characterized by parking lots (HEB and the former Broadway Bank), while others were never built and were instead absorbed into parkland.

PROGRAMMED

Kissing Alley is the only alley in Downtown San Marcos that has experienced any activation of note. Using thoughtful programming, art, and lighting, San Marcos' Main Street program was able to turn what would otherwise be considered an underperforming alley into the beloved location it has now become. Despite the current lack of green infrastructure, Kissing Alley provides a local example of how alleys can serve as important public space.

Kissing Alley is planned to be reconstructed by 2021; however, at the time of writing, no green infrastructure elements are yet confirmed in its design.

UNDERPERFORMING

Underperforming alleys are characterized by their sole dedication to access, prioritizing functionality for utilities, car parking, and waste service. Underperforming alleys feature impervious asphaltic ground surfaces that generate untreated runoff, little to no invitation for social interaction, poor lighting, an abundance of garbage containers, and often little plant life. These alleys can be placed into the following two subcategories based on the surrounding built form:

ENCLOSED / UNDERPERFORMING

Enclosed / underperforming alleys are situated in a mixed-use urban environment, and typically occur in close proximity to the historic courthouse square and within blocks that are more fully occupied by building footprints. Their central location generates natural pedestrian traffic, making these alleys suitable for both green infrastructure and public space amenities.

UNENCLOSED / UNDERPERFORMING

Unenclosed / underperforming alleys are situated in less urban conditions. They often separate private residential backyards, provide cross-block connectivity, or serve as parking lot driveways. Typically larger and more vegetated than others, these alleys are well-suited for green infrastructure but their location makes them less suitable for public space activation.

Refer to map on page 13

E (Kissing Alley)

A, B, C, D, F (Jack's Alley), G, I (Feltner Alley N), K, O (Railroad Alley), P

H, J, L, M (Feltner Alley S), N

BENEFICIAL CHARACTERISTICS

Analysis of downtown San Marcos' alleys focused on an observational inventory of existing elements that lend them either positive or negative character today. The presence of identification, lighting, plants, art, or building access demonstrates a public desire to use or improve the alley as inhabitable space and was observed on many alleys as shown on the following Table 1. Most of the existing beneficial characteristics are improvements to public space, and do not currently contribute to meaningful green infrastructure.

● *Public Space Consideration* ● *Green Infrastructure Consideration*



● *Alley Identification*

Naming alleys is essential to giving them identity and recognition in the community. A few alleys in San Marcos already have names and identification initiatives could be expanded across downtown to elevate these areas of Right-of-Way as vital components of San Marcos' city grid.



● *Lighting*

Lighting is important to encourage safe nighttime pedestrian use and lends ambiance to an alley. Building-mounted lights exist on most downtown alleys, and a few have street lighting, making them safe and inviting. Kissing Alley's string lighting creates atmosphere and a sense of place.



● *Proximity to the Square*

Due to the concentration of businesses near the historic square and the pedestrian traffic this generates, the alleys closest to the courthouse are good candidates for early pilot public space activation and prioritization.



● *Art / Murals*

Art and community programs help show that alleys are safe, cared for, and occupied. Almost half of San Marcos' downtown alleys already have notable art, murals, or public landmarks.



● *Existing Vegetation*

Native plants can make an alley inviting, provide micro-climatic shade, bird and insect habitat, and better air quality. Most of the alleys in San Marcos have some level of vegetation, ranging from volunteer grasses and shrubs to small trees and climbing wall vines.



● *Building Access*

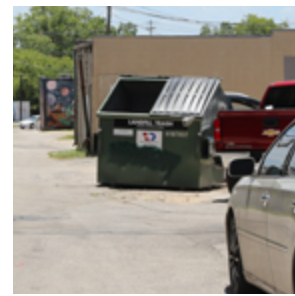
Transparency and access at building walls adjacent to alleys can help increase pedestrian traffic within them. A few downtown alleys currently provide direct public access to shops, bars, and restaurants and generally see greater pedestrian use as a result.

CHALLENGES + OPPORTUNITIES

A number of common functional and visual issues were observed throughout the existing alley network, including: disorganized and redundant waste collection locations as well as lack of recycling and compost collection; visual clutter of overhead electric lines and poles; excessive curb cuts between alley and private property boundaries; large amounts of unnecessary pavement within the alley corridors and at adjacent property boundaries; and, poor surface drainage conditions. An overall lack of meaningful vegetation, as well as places to sit or park a bike, were noted as deterrents to alley foot traffic.

Alley width and traffic flow are additional considerations for any future interventions. It is also important to ensure that local development requirements are modified to allow and support Green Alley solutions.

These more challenging characteristics demonstrate the need for improvements that enhance and continue delivery of basic services.



● *Waste Collection*

Waste containers, when prolific or poorly maintained, can discourage pedestrian use, so it is important that green alleys offer solutions for better waste collection. Half of San Marcos' downtown alleys currently contain waste containers, with most of them located in more commercial areas and unenclosed.



● *Existence of Utilities*

While necessary, utility and building service equipment do have a visual and spatial impact on alleys that must be taken into consideration. Buried electric lines, screens, and paint can help enhance their appearance but they must remain safe and accessible for shop owners.



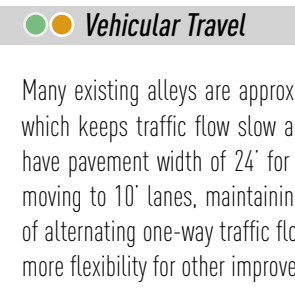
● *Pavement Condition*

The pavement in most downtown San Marcos alleys is in poor condition, and asphalt has been used systematically, making the alleys impermeable and prone to stormwater runoff. New surface treatments can have both positive ecological and aesthetic impacts. Alleys with particularly poor existing road conditions are good candidates for reconstruction.



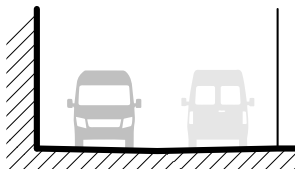
● *Storm Drain Connectivity*

Due to clay-heavy soils, drainage improvements to help capture and filter stormwater in alleys will likely require some level of stormdrain connectivity. A majority of alleys currently have proximity and good connectivity potential to the existing underground stormdrain system, while some will require extension of the existing storm drain system or other means of stormwater infiltration.

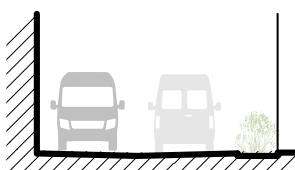


● *Vehicular Travel*

Many existing alleys are approx. 16' -20' wide and rely on yield movement, which keeps traffic flow slow and safe. Redeveloped alleys are required to have pavement width of 24' for alleys to accommodate two 12' lanes - but moving to 10' lanes, maintaining yield movement, or adopting an alley grid of alternating one-way traffic flow can all reduce pavement width and create more flexibility for other improvements.



Current standards: Two-Way, Highway Standard Lanes
no space granted for other improvements



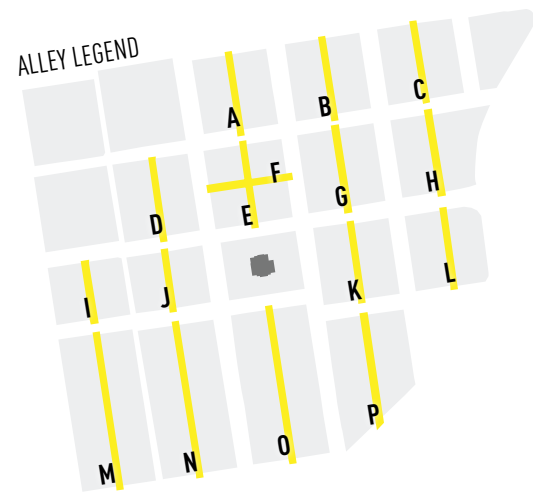
Suggested option: Two-Way, Right-Sized Lanes
some space granted for other improvements



Preferred option: One-Way or Yield Movement, Right-Sized Lanes + Slow Speeds
most space granted for other improvements

ASSESSED ALLEY CONDITIONS + POTENTIALS

TABLE 1 : Observations and characteristics of all downtown alleys made in the summer of 2019 were integrated into Table 1 to collectively analyze their current potential for both public space and green infrastructure activation. While many alleys are unlikely candidates for public space activation, all alleys can contribute to a green infrastructure network.



Alleys represent unrealized community assets that could be transformed...to simultaneously offer multiple ecological, economic, and social benefits...

- WOLCH ET AL, THE FORGOTTEN AND THE FUTURE: RECLAIMING BACK ALLEYS FOR A SUSTAINABLE CITY

ALLEY CONDITIONS

- Observed
- Notable

NEAR TERM POTENTIAL FOR ACTIVATION

- No potential
- Low
- Moderate
- Outstanding

ID	Alley Name	Alley Dimensions (Approximate)	Adjacent Building Form	Vehicular Travel	Proximity to the Square	Waste Collection	Public Utilities	Lighting	Building Access	Art / Murals	Vegetation	Pavement Condition	Existing Storm Drain Connectivity	NEAR TERM POTENTIAL FOR PUBLIC SPACE ACTIVATION	NEAR TERM POTENTIAL FOR GREEN INFRASTRUCTURE ACTIVATION
A		16 ft. x 340 ft. • 5,440 ft ²	Enclosed	Two way	1 block	●	●	Building			●	Fair		-	●
B		16 ft. x 345 ft. • 5,520 ft ²	Enclosed	Two way	2 blocks	●	●	None		●	●	Fair	●	●●	●●●
C		16 ft. x 345 ft. • 5,520 ft ²	Enclosed	Two way	3 blocks		●	None			●●	Poor	●	●	●●●
D		16 ft. x 350 ft. • 5,600 ft ²	Enclosed	One way	1 block	●	●	None		●	●	Fair		●	●
E	KISSING ALLEY	16 ft. x 340 ft. • 5,440 ft ²	Enclosed	One way	0 blocks		●	Street	●	●		Poor		●●●	●●
F	JACK'S ALLEY	(16 ft.+20 ft.) x 175 ft. • 6,300 ft ²	Enclosed	One way	1 block	●	●	Street		●	●	Poor	●	●	●●●
G		20 ft. x 350 ft. • 7,000 ft ²	Enclosed	Two way	1 block	●	●	Street	●●			Fair	●●	●●	●●
H		20 ft. x 350 ft. • 7,000 ft ²	Unenclosed	Two way	2 blocks	●	●	None			●	Good	●	-	●●
I	NORTH FELTNER ALLEY	20 ft. x 260 ft. • 5,200 ft ²	Enclosed	Two way	2 blocks		●	Building			●●	Fair	●	-	●●
J		16 ft. x 260 ft. • 4,160 ft ²	Unenclosed	One way	1 block		●	Street				Fair	●	●	●●
K		16 ft. x 345 ft. • 5,520 ft ²	Enclosed	Two way	1 block	●	●	Street	●		●	Fair	●	●	●●
L		16 ft. x 340 ft. • 5,540 ft ²	Unenclosed	Two way	2 blocks		●	Building			●●	Fair	●	-	●●
M	SOUTH FELTNER ALLEY	16 ft. x 690 ft. • 11,040 ft ²	Unenclosed	Two way	2 blocks		●	None				Poor	●	-	●●●
N		16 ft. x 670 ft. • 10,720 ft ²	Unenclosed	Two way	1 block		●	Street		●	●●	Good	●	-	●●
O	RAILROAD ALLEY	16 ft. x 680 ft. • 10,880 ft ²	Enclosed	Two way	0 blocks	●	●	Street	●●	●	●	Poor		●●●	●●
P		20 ft. x 460 ft. • 9,200 ft ²	Enclosed	Two way	1 block	●	●	Street		●●	●	Fair	●	●	●

SERVICE REQUIREMENTS

PUBLIC SPACE CRITERIA

GREEN INFRASTRUCTURE CRITERIA

4 / GREEN ALLEYS OF TOMORROW

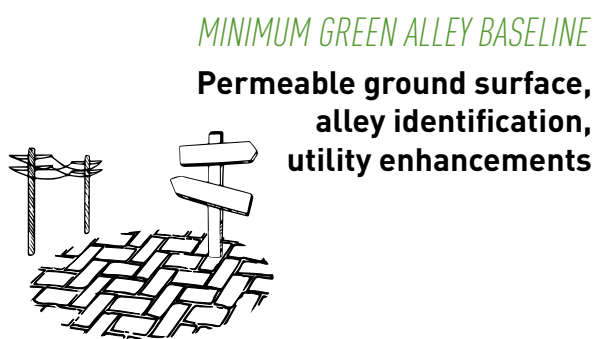
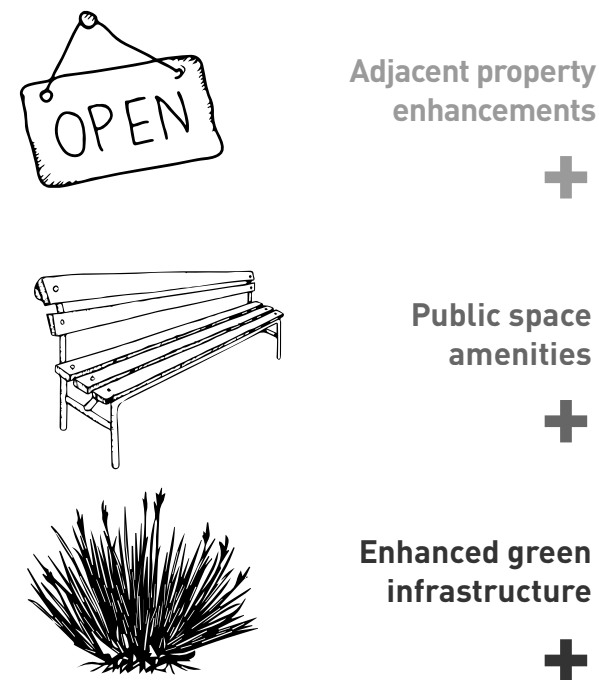
ACTIVATING GREEN INFRASTRUCTURE & PUBLIC SPACE DOWNTOWN

CONCEPTUALIZING A GREEN ALLEY NETWORK

Most of San Marcos' existing downtown alleys are not particularly well cared for today. But the emergence of Kissing Alley, as well as the recent spread of alley murals in San Marcos, demonstrates general community desire to realize greater potential of this important network of public right-of-way. Similarly, the long, outstanding commitment of river-oriented organizations reveals a deep concern and care for the local environment. These indications of community desire, combined with a review of the existing alley conditions and their potential for delivering green infrastructure and enhanced public space, provides reason and value for the initiation of a green alley network to deliver integrated urban solutions to downtown San Marcos.

As demonstrated by previous case studies and the visuals presented herein, green alleys can take many forms, ranging from a simple permeable strip of pavers to a verdant rear oasis fully outfitted with human-scaled seating, art, and more. The following pages put forth a vision to help demonstrate local possibilities, using an assembled toolkit for green infrastructure and public space components - both for city-led improvements as well as adjacent property owner contributions.

While the possibilities are many, the Green Alley Initiative envisions alley reconstruction in downtown San Marcos to start with a permeable ground surface, like permeable pavers, and alley identification as an infrastructural baseline. Utility enhancements, such as the burying of electric or cable lines, should also be completed as feasible. Additional green infrastructure components or public space enhancements can then be layered on top of this permeable ground surface based on deemed potential, as demonstrated in Figure 20. Adjacent property owners should then be incentivized to complete simultaneous improvements with streamlined processes and/or matching grant opportunities.



\$3.3 million
The approximate cost to install permeable pavers across all downtown alleys
High-end estimate with contingency, refer to Appendix B for full cost estimates

FIG. 20 DOWNTOWN SAN MARCOS
ALLEY ACTIVATION POTENTIAL

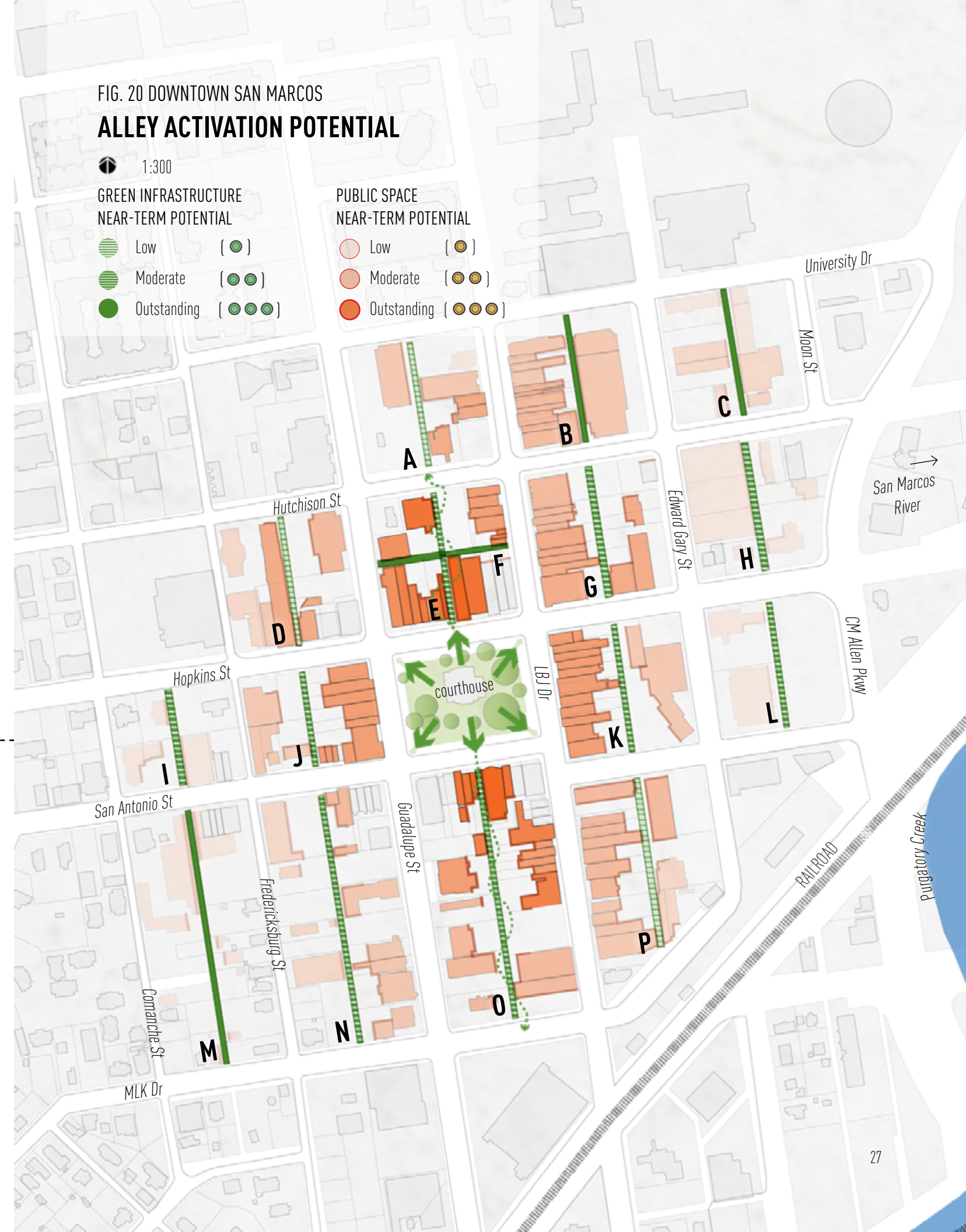
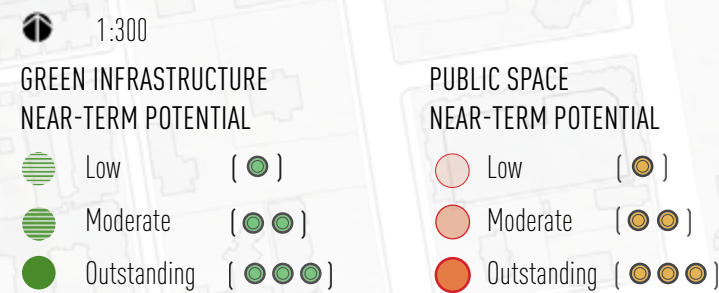


FIG. 21 DOWNTOWN SAN MARCOS
A GREEN ALLEY CATALYST

1:150

The centrally located Hays County Courthouse Square serves not only as the primary organizing space of downtown but also as a green heart with its heritage Pecan trees and considerable open space. Starting here at this existing vegetated center and weaving a connected green alley network outwards lays the foundation for ecological micro-corridors throughout downtown that can have meaningful impacts for the community and the Upper San Marcos River Watershed.

The following plans and images are intended to illustrate a vision for how a green alley framework could turn what are currently underperforming impervious rear alleys into a transformative and multi-functional ecological network in downtown San Marcos.

1 FIRE STATION NO. 1 GOES GREEN

The downtown fire station, a publicly-owned city asset, and the adjacent alley (Alley E) can help showcase many green infrastructure elements.

2 KISSING + JACK'S ALLEY IN FULL BLOOM

San Marcos' premier downtown alleys (Alley E, F) are the perfect space to invite visitors to learn about small but mighty green alleys.

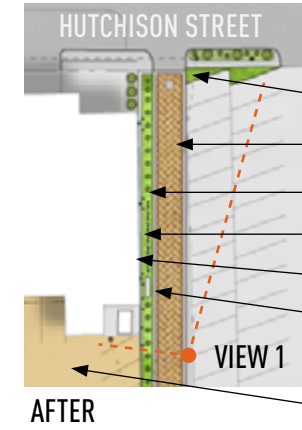
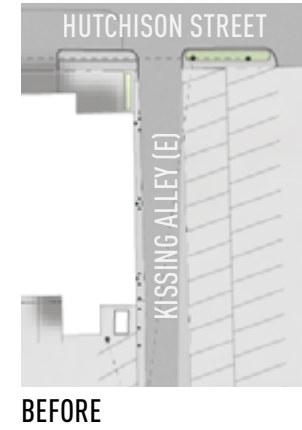
3 LIGHTING UP A SISTER ALLEY

The alley south of the Courthouse Square (Alley O) extends both public space amenities and integrated stormwater controls to the south end of downtown.

4 DEPAVE + DEFINE THE MIDBLOCK

Southward on Alley O at MLK Drive, defining rear lots through the removal of unnecessary impermeable cover reveals many greening opportunities that are common in downtown.

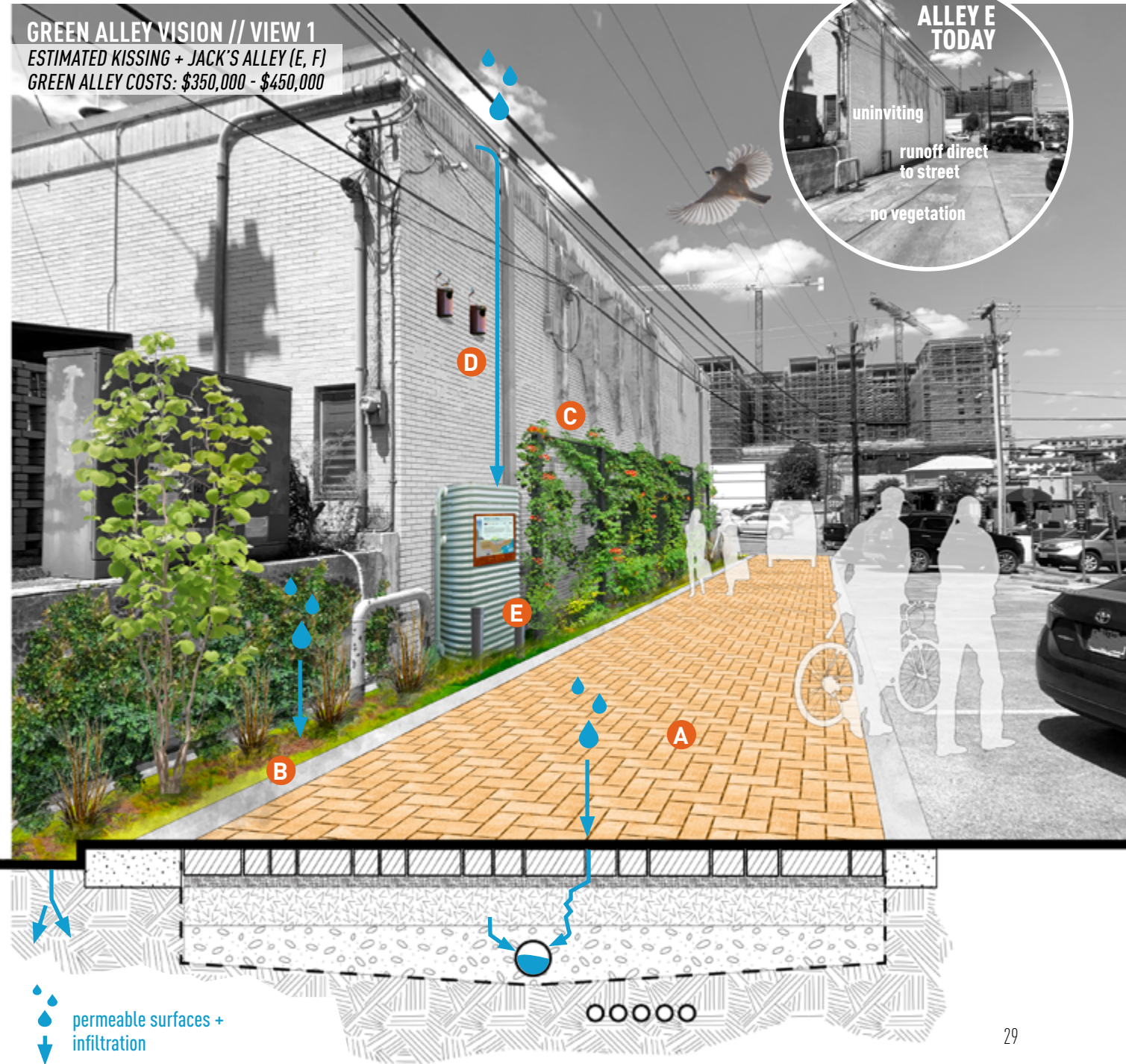
■ **Adjacent Long-term Hardscape Areas** suitable for **Simultaneous Green Alley Improvements**

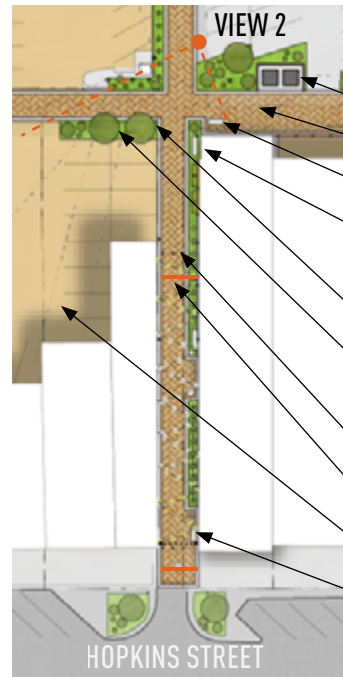
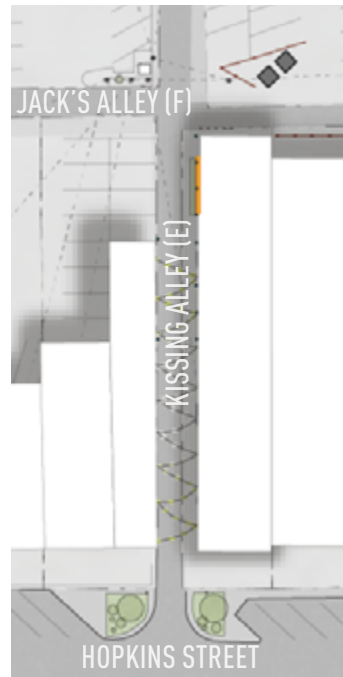


1 FIRE STATION NO. 1 GOES GREEN

- Depaved Asphalt for Native Plants
- A** High Albedo Permeable Pavers with underdrain
- B** Biofiltration Planter with native plants
- C** Freestanding Green Vine Wall
- D** Urban Bird Nesting Boxes
- E** Slimline Rain Barrel connected to existing downspout, serving biofiltration planter
- Adjacent Hardscape Improvement Areas

GREEN ALLEY VISION // VIEW 1
 ESTIMATED KISSING + JACK'S ALLEY (E, F)
 GREEN ALLEY COSTS: \$350,000 - \$450,000





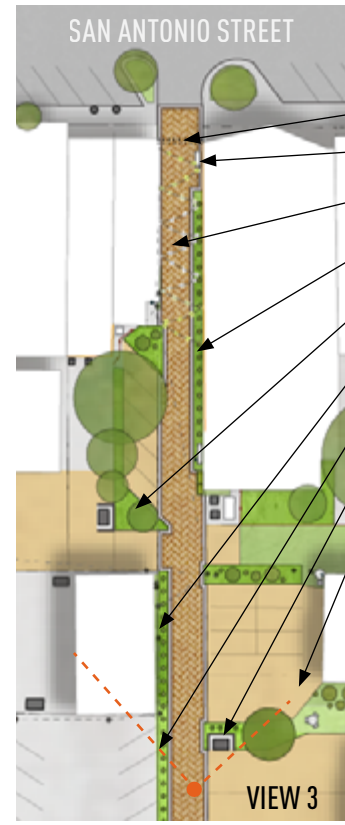
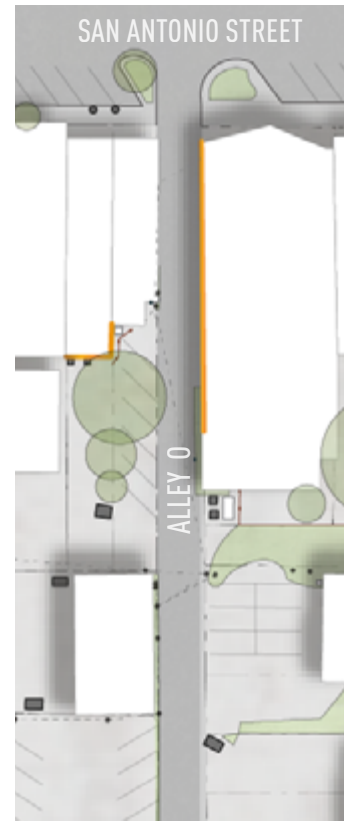
2 KISSING + JACK'S ALLEY IN FULL BLOOM

- New Waste Enclosure
- A** High Albedo Permeable Pavers with Green Alley Marker
- B** Public Bench
- C** Slimline Rain Barrel connected to existing downspout, serving Raised Pollinator Planters
- D** Interpretive Signage
- E** Depaved Asphalt for new Stormwater Tree Wells and Native Plants
- F** Street Closure Bollards
- G** Overhead Alley ID Signage
- H** Adjacent Hardscape Improvement Areas
- I** Event Backdrop with Green Vine Wall

BEFORE AFTER



GREEN ALLEY VISION // VIEW 2
 ESTIMATED KISSING + JACK'S ALLEY (E, F)
 GREEN ALLEY COSTS: \$350,000 - \$450,000



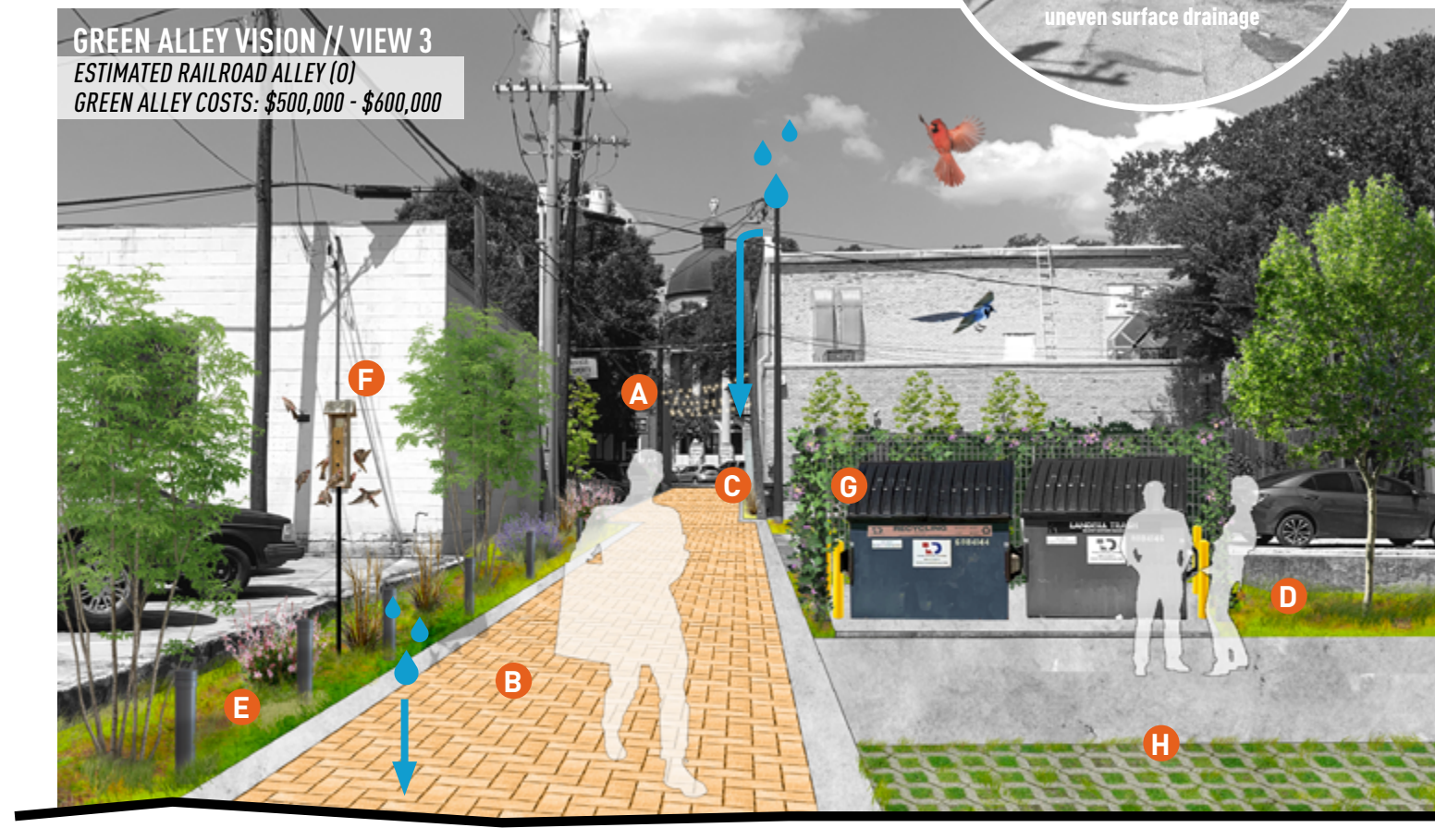
3 LIGHTING UP A SISTER ALLEY

- A** New Alley Identification with LED Lighting
- Public Bench
- B** High Albedo Permeable Pavers with underdrain
- C** Biofiltration Planter with Rainwater Capture
- D** Depaved Asphalt with Native Trees
- E** Native Plant Bed with protective bollards
- F** Urban Bird Feeder
- G** Waste Enclosure with Native Vines
- H** Adjacent Hardscape Improvement Areas

BEFORE AFTER

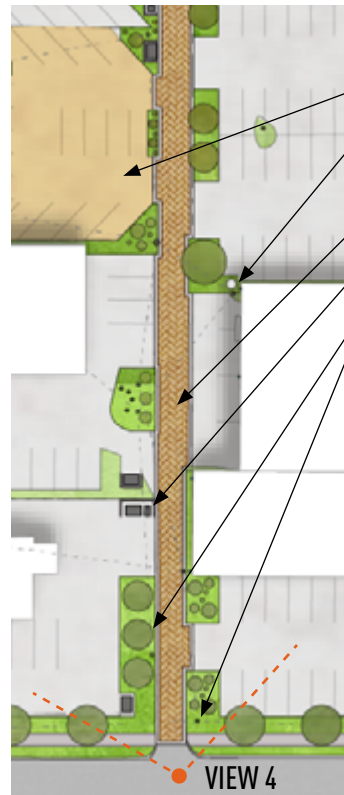


GREEN ALLEY VISION // VIEW 3
 ESTIMATED RAILROAD ALLEY (O)
 GREEN ALLEY COSTS: \$500,000 - \$600,000





BEFORE



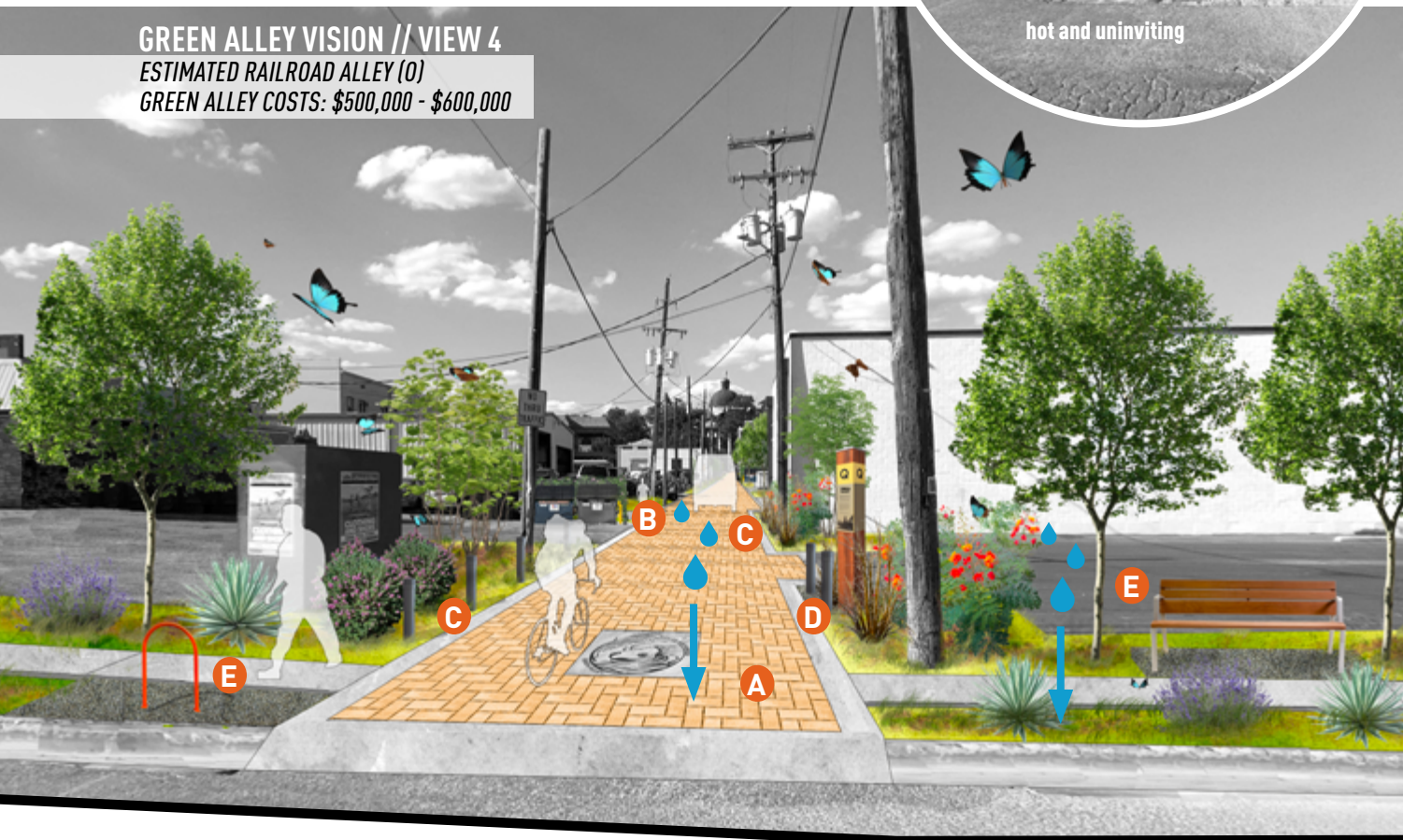
AFTER

4 DEPAVE + DEFINE THE MIDBLOCK

- Adjacent Hardscape Improvement Areas
- Rain Barrel connected to existing downspout, serving Rain Garden with Native Tree and Plants
- A** High Albedo Permeable Pavers with underdrain
- B** New Waste Enclosures
- C** Depaved Asphalt and Native Planters
- D** Interpretive and Wayfinding Signage
- E** Street Furniture including Bike Rack + Bench



GREEN ALLEY VISION // VIEW 4
 ESTIMATED RAILROAD ALLEY (0)
 GREEN ALLEY COSTS: \$500,000 - \$600,000



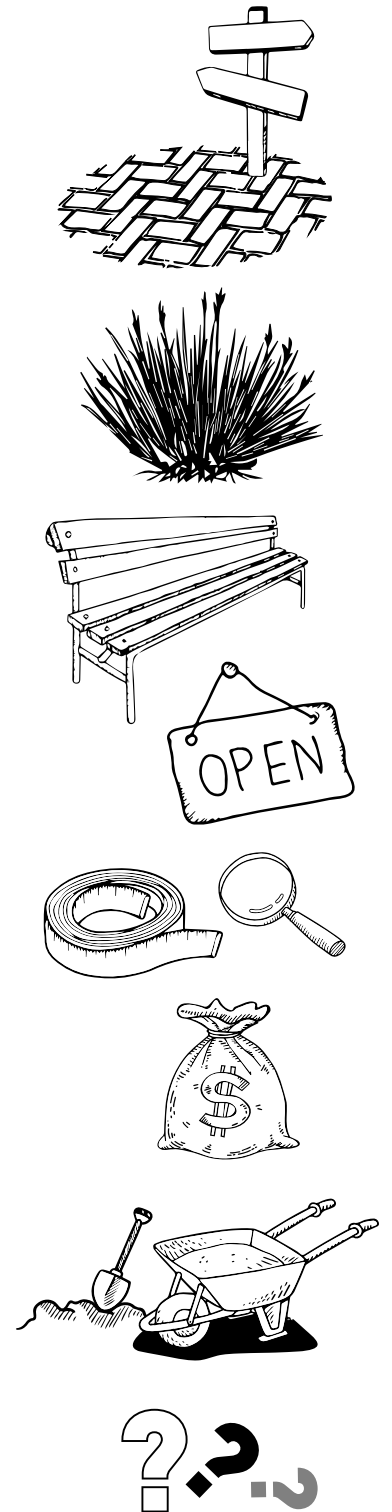
5 / GREEN ALLEY TOOLKIT

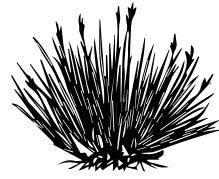
RESOURCES FOR IMPLEMENTING GREEN ALLEYS IN SAN MARCOS

BUILDING A TOOLKIT

So how do we get from today to tomorrow? To help make the previous visualizations a reality, Green Alleys must incorporate a system-wide layering of elements both in the right-of-way and on adjacent properties. Supplemental funding such as grants will also likely be required, as will a demonstration of benefits and outcomes to help make the case for such an undertaking. The following pages contain recommendations for components in the categories of Green Infrastructure, Public Space, and Adjacent Properties, along with helpful information on metrics, funding resources, relevant industry contacts. A collection of Frequently Asked Questions has also been included for reference.

- GREEN INFRASTRUCTURE TOOLKIT
- PUBLIC SPACE TOOLKIT
- ADJACENT PROPERTIES TOOLKIT
- METRICS + OUTCOMES
- POTENTIAL FUNDING SOURCES
- INDUSTRY CONTACTS + RESOURCES
- FREQUENTLY ASKED QUESTIONS





GREEN INFRASTRUCTURE TOOLKIT

As already noted, all alleys can contribute to positive environmental outcomes for Downtown San Marcos, and at a minimum, can help provide cleaner stormwater, reduce runoff flow to the River, and boost economic activity downtown. **System-wide integration of permeable ground surfaces, like permeable pavers, should be standard for all alley reconstructions with other components being integrated as viable and desired.**

Each component noted here can be utilized singularly or combined with other components to create more sophisticated water flows, urban ecosystems, and enhanced aesthetics.

For further information, see the following resources:

- For suggested native and adapted plants suitable for the Central Texas climate, as well as wet/dry conditions common to GSI, refer to the [City of San Marcos' published Preferred Plant List](#) and the [City of San Marcos Technical Stormwater Manual](#).
- For grants related to green infrastructure, refer to the Potential Funding Sources section.
- For a list of relevant manufacturers and knowledge sources, refer to the Industry Contacts section.

GREEN ALLEY INITIATIVE OBJECTIVES SUPPORTED BY GREEN INFRASTRUCTURE

 IMPROVED STORMWATER QUALITY + REDUCED FLOODING

 AIR QUALITY + URBAN HEAT ISLAND MITIGATION

 INCREASED URBAN BIODIVERSITY + QUALITY OF LIFE



Fig. 24

HIGH ALBEDO PERMEABLE PAVERS

ALLEYS • PARKING LOTS • SIDEWALKS • PATIOS

Permeable pavers reduce stormwater runoff, filter pollutant loads, enable groundwater recharge, and provide a durable, attractive ground surface that helps to reduce the urban heat island effect and localized flooding. Full system installs include pavers over open base with underdrain and liners as required.

\$16 - \$30 / SF INSTALLED (FULL SYSTEM)

Monthly sweeping and seasonal vacuuming. Impermeable liner and underdrain required when adjacent to building foundations.



Fig. 25

NATIVE PLANTS

GRASSES + SHRUBS + PERENNIALS

Native plants adapted to the climate require minimal water, help to lessen the urban heat island effect, improve urban aesthetics, and support urban wildlife, including birds and pollinators.

\$3 - \$50 PER PLANT

Once established, typical native plant care.



Fig. 26

GREEN SCREENS + WALLS

FREESTANDING • WALL-MOUNTED

Green walls are comprised of native vines or vertically-mounted planters that provide unique aesthetic and ecological value, attract pedestrians, reduce air and noise pollution, and help insulate buildings from heat / cold.

LOW COST DIY - \$200 / VERT. SF PREFAB

Once established, typical native plant care. Plants can be supported directly on a wall or on an independently supported screen.



Fig. 27

NATIVE TREES

STORMWATER WELL • TREE CELLS • POROUS PAVE

Native trees provide shade, CO2 sequestration, and air/noise pollution reduction. Trees in biofiltration wells can capture / filter sizable volumes of stormwater on-site. Products like tree cells (Silva Cells) and porous pavement (Porous Pave) can help protect roots and reduce maintenance.

\$500 DIY INSTALL - \$15,000 TREE WELL

Once established, typical native tree care. Impermeable liner and underdrain required when adjacent to building foundations.



Fig. 28

RAINWATER HARVESTING

CISTERNS • SLIMLINE TANKS • RAIN CHAINS, ETC.

Rain barrels store rainfall from adjacent roofs, providing peak flow mitigation by delaying runoff. This helps to conserve water resources by using gray water for irrigation and when paired with nearby planters can also provide runoff filtration.

\$100 - \$3,500 PER CISTERN

Annual downspout debris removal and vector prevention.



Fig. 29

RAISED PLANTERS

FIXED + MOBILE BEDS • COMMUNITY GARDENS

Raised planters with native or edible species can support biodiversity, contribute to pollinator corridors, enhance aesthetics and provide recreational and educational opportunities. They can also be used to block vehicle access during events.

\$50 - \$100 / LF INSTALLED

Once plants are established, typical raised bed care.



Fig. 30

WILDLIFE SUPPORT

BIRD + POLLINATOR SHELTERS • FEEDERS

Nesting boxes, wildlife feeders, and water sources in alleys can help supplement urban habitat for local species of birds and pollinators that help to control disease-transmitting vectors and support human food systems.

\$20 - \$200 PER SHELTER OR FEEDER

Annual / seasonal nesting box cleaning; regular feeder and shelter maintenance.



Fig. 31

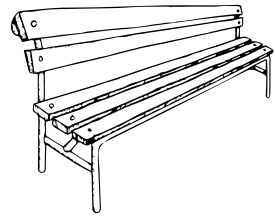
BIOFILTRATION PLANTERS

LINEAR DRAINAGE BEDS

Biofiltration planters offer high capacity stormwater water quality treatment and peak flow rate reduction in areas of impervious cover, while also introducing native plants and greenscape in urban areas.

\$25 - \$50 / SF

Once established, typical native plant care with periodic debris clearing. Impermeable liner and underdrain required when adjacent to building foundations.



PUBLIC SPACE TOOLKIT

Not all alleys are destined to become active spaces for community engagement (see Table 1 and Figure 20), but they should all at least be given identity and recognized for any integration of sustainable features to help educate residents and visitors about their role in the city. Depending on an alley's proximity to the square, commercial activity, and existing public space, some alleys may integrate additional toolkit components to support enhanced public gatherings and alternative transportation.

Public input should be sought for the incorporation of any public art or amenities. **In particular, the San Marcos community should be engaged in a process to name all downtown alleys as they are reconstructed as Green Alleys to help build awareness and support.**

For further information, see the following resources:

- For grants related to public space infrastructure, refer to the Potential Funding Sources section.
- For a list of relevant manufacturers and knowledge sources, refer to the Industry Contacts section.

GREEN ALLEY INITIATIVE OBJECTIVES SUPPORTED BY PUBLIC SPACE IMPROVEMENTS



SUPPORTED SERVICES + CULTURAL ACTIVITIES



HUMAN SCALE DISCOVERY + EXPLORATION



WALKABLE, BIKEABLE ACCESS + CONNECTIVITY



EDUCATION + AWARENESS



Fig. 32

INTERPRETIVE SIGNAGE

EDUCATIONAL DISPLAYS + MARKERS

Educational signage, displays, and markers help spread awareness of green alleys for both visitors and residents alike. Integrating references to existing campaigns like [Sally the Salamander](#) are important to connect the impacts of downtown to the River.

\$200 - \$1000 PER SIGN

No physical maintenance when rated for outdoor conditions.



Fig. 33

STREET CLOSURE FEATURES

MOBILE PLANTERS • REMOVABLE BOLLARDS

Flexible street closure devices enable multifunctional and adaptable use of public right-of-way while ensuring pedestrian safety and comfort during programmed events. These features can also serve as seating or planters.

\$100 - \$1000+ PER FEATURE

Little to no maintenance for removable bollards. See Raised Planters as another street closure alternative.



Fig. 34

ALLEY IDENTIFICATION

ALLEY GATEWAYS • GROUND + WALL MARKERS

A few San Marcos alleys already have names and this effort should be expanded across downtown as reconstructed. Public input and historic references should be integrated and signage can range from street or wall signs to gateways.

\$200 - \$1000 PER SIGN

Once installed, little to no maintenance.



Fig. 35

BIKE SUPPORT

BIKE RACKS • REPAIR STATIONS

Bike racks and bike repair stations encourage people to access downtown using sustainable transportation, help cultivate a more connected cycling network, and support downtown access and parking supply while improving human health and well-being.

\$100-\$1500+ PER RACK

Once installed, bike racks require no maintenance.



Fig. 36

PUBLIC ART

WALL MURALS • OVERHEAD + INTERACTIVE ART

With neighborhood involvement, murals and public art can simultaneously build community and beautify an alley. Art also shows that a space is cared for and occupied, and can deter graffiti and vandalism.

COST VARIES BY TYPE

Once installed, little to no maintenance.



Fig. 37

STREET FURNITURE

PUBLIC BENCHES • SHADING • POTTED PLANTS

Street furniture invites pedestrian activity by providing shade and seating, and creating places for downtown visitors to gather, rest, people watch, and talk.

\$500 - \$1000+ PER BENCH / SHADE

Durable coatings and materials require little to no maintenance.



Fig. 7

PROGRAMMED EVENTS

GREEN ALLEY TOUR • COMMUNITY EVENT

With low traffic and intimate character, alleys lend themselves to community events, such as concerts, art walks, block parties, etc. Kissing Alley is a good example, which is now a notable downtown gathering space largely due to regular programming.

COST VARIES DEPENDING ON ACTIVITY

Ongoing management of event requests, reservations, and road closures.

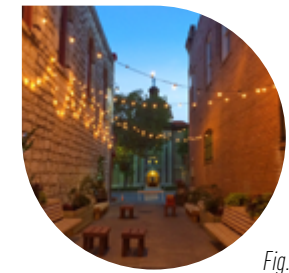


Fig. 38

SUSTAINABLE PUBLIC LIGHTING

DARK-SKY COMPLIANT • SOLAR-POWERED • LED

Lighting enables safe night-time use and traffic through an alley, and sustainable technologies like dark-sky compliant fixtures, LEDs, and solar-powered fixtures, help to minimize energy draw and disruption to flora and fauna.

COST VARIES BY TYPE, ENERGY DRAW

If set on light-sensing timers, little maintenance beyond periodic bulb replacements, which is infrequent with LEDs.



ADJACENT PROPERTIES TOOLKIT

While the City of San Marcos can make improvements to the public right-of-way, much of the character of the downtown alleyways is actually defined by adjacent private property. **As alley reconstruction is undertaken by the city, property owners should also be engaged and incentivized to seize the opportunity to improve the rear of their lots.**

Private projects can be geared to boost not only economic activity but can just as easily contribute to the environmental and social goals of the Green Alley Initiative.

As noted in the case studies, some cities have assessed property owners a minority percentage cost share (15%) to incorporate improvements that benefit their lot. Others have offered 25% matching grants for private improvements undertaken on adjacent lots during the time of alley reconstruction. Some of the toolkit components may also qualify for other grants, such as the [Business Improvement and Growth \(BIG\) grants](#) offered by the City of San Marcos.

For further information, see the following resources:

- For private improvement grants, refer to the Potential Funding Sources section.
- For a list of relevant manufacturers and knowledge sources, refer to the Industry Contacts section.



Fig. 39

WASTE ENCLOSURES

RECYCLING, COMPOST, + LANDFILL MANAGEMENT

Enclosing serviced waste containers and transitioning to side-loading waste containers should be prioritized to improve the overall appearance and function of alleys. Green walls utilizing concrete masonry units, wood, or metal screens should be promoted for enclosures.

COST VARIES BY MATERIAL + SIZE

No additional maintenance required beyond waste collection itself.



Fig. 40

DE-PAVING

INFILTRATION · AESTHETICS · AIR QUALITY

Most parking lots have more impermeable cover than necessary. Removing these areas of asphalt and concrete helps to reverse associated environmental damage (polluted runoff, urban heat island effect, etc.) by allowing for ground surface revegetation.

\$2 TO \$5 / SF OF ASPHALT OR CONCRETE

Both asphalt and concrete can be recycled for reuse in road or building construction projects.



Fig. 41

BUILDING ACCESS

ENTRIES · WINDOWS · AWNINGS

Opening up previously closed entries and windows or creating new building access or space utilization via alleys can increase pedestrian traffic and overall economic vitality of downtown. City grants may be available for such business improvements.

COST VARIES BY BUILDING CONDITION

After install, typical building maintenance.



Fig. 42

RAIN GARDENS

LARGER BIOFILTRATION + POLLINATOR HABITATS

When planted with native grasses and flowering perennials, rain gardens can be a beautiful, cost effective way to provide stormwater treatment and reduce runoff. Rain gardens lend themselves to larger, irregular spaces and can also double as "[Monarch Waystations](#)" for butterflies.

\$10 - \$30 / SF INSTALLED

Once established, typical native plant care and regular debris removal.



Fig. 43

OUTDOOR PATIOS + FURNITURE

SEATING · TABLES · SHADING · LIGHTING

Businesses - from cafes to retail stores - can occupy underutilized outdoor space by extending their business outdoors with seating, tables, shade, and sustainable lighting for patron and employee use.

\$50 - \$1000+ PER ITEM

Typical furniture maintenance.



Fig. 44

GREEN + COOL ROOFS

GREEN ROOFS · HIGH ALBEDO ROOF / COATINGS

Cool roofs with high solar reflectance as well as planted green roofs reduce the urban heat island effect as well as energy costs by insulating from outdoor conditions. Green roofs can also retain and filter stormwater and improve air quality.

\$5/SF COOL ROOF - \$20+/SF GREEN ROOF

Typical roof maintenance for cool roofs. Once established, typical plant care for green roofs.



Fig. 45

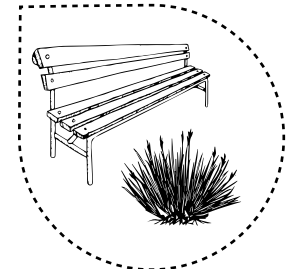
BUSINESS SIGNAGE

WALL, BLADE + HANGING SIGNS · LIGHTING

Signage and wayfinding helps to guide potential patrons to business locations and human-scaled signs with appropriate lighting on alleys can also help boost general pedestrian traffic. Associated lighting should be dark-sky compliant and energy efficient.

\$100 - \$1000+ PER SIGN

Once installed, little to no maintenance.



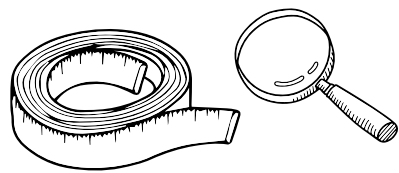
OTHER TOOLKIT COMPONENTS

GREEN INFRASTRUCTURE · PUBLIC SPACE

Most components within the other presented toolkits can be employed by adjacent property and business owners to incrementally contribute to environmental and social improvements downtown.

SEE OTHER COMPONENTS FOR COSTS

See other toolkits and components for maintenance / notes.

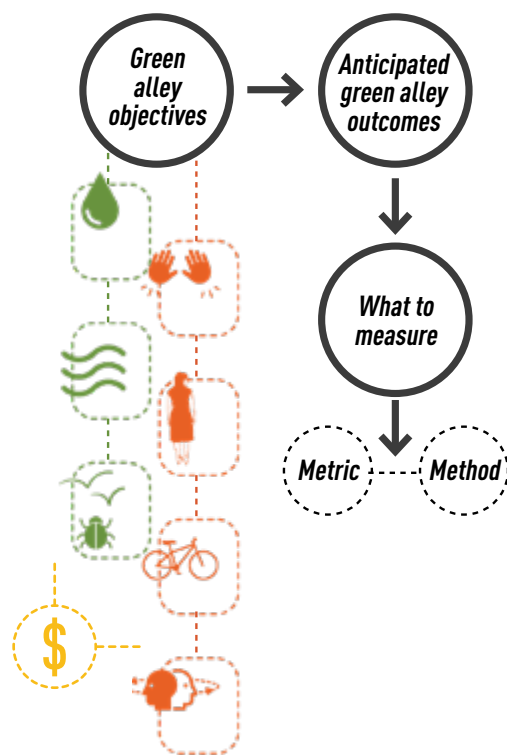


METRICS & OUTCOMES

The interventions proposed by the Green Alley Initiative are intended to have beneficial outcomes for the environment, the downtown economy, and quality of life for humans and wildlife alike - but it is only by both qualitative and quantitative measurement that these impacts are truly acknowledged and then proliferated.

The following points of measure and information gathering, noted in the Landscape Architecture Foundation's Evaluating Landscape Performance (Canfield, Yang, Whitlow, 2018), are recommended for collection and study as San Marcos' Green Alleys are built out. These points of study also provide partnership opportunities for the City of San Marcos with various Texas State University departments and community groups.

Initial performance assessments are optimally performed one to five years after project construction is complete. This allows time for natural processes, site programming, and user behaviors to stabilize, yet ensures that institutional memory about the goals and design intent of the project has not been lost.



HELPFUL COMPARISONS

before
after Comparing a given metric before and after a specific intervention; requires the gathering of baseline information prior to project implementation.

conventional
sustainable Comparing a project metric to the same in a conventional project; requires a comparable space, actual or hypothetical

benchmark
project Comparing a project metric to an accepted standard or average value; requires precedents or historic measurements.

COMMON ENVIRONMENTAL METRICS

Stormwater:

- Annual volume and percent of total runoff retained on site
- Runoff retained for a design storm
- Reduction in peak discharge / runoff rate for a design storm
- Reduction in stormwater fees, infrastructure, or treatment costs (conventional gray infrastructure versus green)

Flooding:

- Reduction in frequency of localized flooding
- Reduction in peak discharge at an outlet point

Temperature & Urban Heat Island:

- Air temperature (degrees or percent);
- Surface temperature (of a bench, a window, etc.);
- Increase in reflectivity of materials;
- Area covered by shade

Biodiversity:

- Increased bird or pollinator sightings
- Increased native plant species

COMMON SOCIAL METRICS

Recreational or community value:

- Visits or use to a project site
- Quality of experience (via user survey)
- Increased conservation values and awareness (via user survey)

Transportation:

- Increase in walking or biking use
- Reduction in distance traveled by car within Downtown
- Associated health or time allocation trends (time spent outdoors downtown)

COMMON ECONOMIC METRICS

Increased localized revenue-generating activity

Avoided Costs Due to Delivered Ecological and Social Services

ANTICIPATED GREEN ALLEY POLLUTANT REMOVAL

TABLE 2: An example of one outcome of Green Alleys is the filtration of stormwater. Permeable pavers can remove considerable pollutants from runoff, providing cleaner water flowing into the River. The table below demonstrates approximate pollutant capture and removal should all downtown alleys be reconstructed with permeable pavers.

- **What is TSS?** Total Suspended Solids, commonly comprised of dust, grime, decomposed asphalt and dirt.
- **What is TN?** Total nitrogen, commonly from fertilizers, lawn runoff, parks, and commercial business activities.
- **What is TP?** Total phosphorus, found in fertilizer and identified as the target chemical to control for river and aquifer health (WQPP, 2017)

ALLEY ID	ALLEY NAME	WATER STORAGE VOLUME (gallons*)	TSS REMOVED (lbs / year**)	TN REMOVED (lbs / year**)	TP REMOVED (lbs / year**)
A		23,501	530	3.19	1.03
B		23,846	538	3.23	1.04
C		23,846	538	3.23	1.04
D		24,192	545	3.28	1.06
E	Kissing Alley	23,501	530	3.19	1.03
F	Jack's Alley	27,216	614	3.69	1.19
G		30,240	682	4.10	1.32
H		30,240	682	4.10	1.32
I	Feltner Alley N	22,464	506	3.04	0.98
J		17,971	405	2.44	0.78
K		23,846	538	3.23	1.04
L		23,933	540	3.24	1.04
M	Feltner Alley S	47,693	1,075	6.46	2.08
N	Telephone Alley	46,310	1,044	6.28	2.02
O	Railroad Alley	47,002	1,060	6.37	2.05
P		39,744	896	5.39	1.74

GREEN ALLEY TOTALS: **475,546 gals** of stormwater storage volume **10,720 lbs** of Suspended Solids removed annually **64 lbs** of Nitrogen Removed annually **21 lbs** of Phosphorus removed annually

Potential annual

See appendix for full calculations

* Based on 21 inches of open base with a 33% porosity. With an open base of 21 inches, the pavers can absorb a 6.3 inch rain, equivalent to more than a 2-year 24-hour rain event using Atlas 14 data for Austin, TX. If the open base is increased to 30 inches, they can absorb a 25-year 24-hour storm event.

** Based on an average annual rainfall of 33 inches for San Marcos

“ Permeable pavers can remove 93% Total Suspended Solids (TSS).

- CITY OF SAN MARCOS
STORMWATER TECHNICAL MANUAL, 2019



POTENTIAL FUNDING SOURCES

Supplemental federal, state, or local monies can help make green alley projects feasible. Below is a list of funding sources available for both green infrastructure and public space improvements.

URBAN GREENING + COOLING

- **Environmental Protection Agency (EPA)**
Office of Sustainable Communities
// **Greening America's Communities Program**
EPA program to help cities develop an implementable vision that incorporate innovative green infrastructure.
www.epa.gov/smartgrowth/greening-americas-communities
Application Timeline: Periodic and varies
Eligibility: Public entities, local governments
- **National Science Foundation**
// **Environmental Sustainability Program Grant**
Promotes sustainable engineered systems that support human well-being and natural (environmental) systems.
www.nsf.gov/funding/pgm_summ.jsp?pims_id=505695
Application Timeline: Accepted year round
Eligibility: Non-profits, state and local governments, higher education institutions
- **Environmental Fund of Texas**
Grants that fund projects primarily dealing with the following areas: water, natural areas, native wildlife, environmental education and awareness, and collaboration.
www.efundtexas.org/donate-1
Application Timeline: Accepted year round
Eligibility: 501c3 Non-profits, eligibility quiz required
- **Foundation for Sustainability and Innovation Grant**
Funded projects orient toward use of resources in sustainable ways, technology, economics, and community development that is harmonious with the natural world.
www.fsifoundation.com/grants
Application Timeline: Two rounds per year, spring and fall
Eligibility: Non-profits

- **Keep Texas Beautiful // Native Gardens Grant**
Provides affiliate communities with funds to create and maintain native plant demonstration gardens.
www.ktb.org/native-garden-grants
Application Timeline: Year round
Eligibility: Keep San Marcos Beautiful (affiliate)
- **Tree Fund // Rotating Research Grants**
Awards grants to empower tree care professionals, their customers, and the communities in which they live and work.
www.treefund.org/researchgrants
Application Timeline: Ongoing annual grant opportunities
Eligibility: Varies; individuals, public entities, etc.

STORMWATER CAPTURE + TREATMENT

- **Texas Water Development Board (TWDB)**
// **Clean Water State Revolving Fund**
The Clean Water State Revolving Fund, authorized by the Clean Water Act, provides low-cost financial assistance for planning, acquisition, design, and construction of waste water and stormwater infrastructure.
www.twdb.texas.gov/financial/programs/CWSRF/index.asp
Application Timeline: Opens in January and due by March for project evaluation for the Intended Use Plan
Eligibility: Cities, counties, river authorities, public and private entities
- **Texas Water Development Board (TWDB)**
// **Flood Infrastructure Fund**
Recently approved in 2019, \$793 million in grants and low interest rate loans dedicated for infrastructure to reduce flooding, including GSI.
www.twdb.texas.gov/flood/grant/index.asp
Application Timeline: Submissions accepted year round
Eligibility: Cities, counties, river authorities, public and private entities
- **Texas Outcomes-Based Finance Challenge**
// **Flood Infrastructure Fund**
Collaboration with Quantified Ventures to structure an Environmental Impact Bond (EIB) or other outcomes-based financial vehicles to deliver nature-based and resilience-focused solutions to communities.
www.quantifiedventures.com/texas-challenge
Application Timeline: Submissions due November 13, 2020
Eligibility: Cities, counties, river authorities, local government entities

- **Environmental Protection Agency (EPA)**
// **319 Clean Water Act Fund**
Funds projects that address water quality concerns through the implementation of management measures and practices; distributed through the TCEQ.
www.epa.gov/nps/319-grant-program-states-and-territories
Application Timeline: Submissions due once a year, summer (July)
Eligibility: Non-profits and state agencies
- **Environmental Protection Agency (EPA)**
// **Urban Waters Small Grants Program**
The grants are competed and awarded every two years, with individual award amounts of up to \$60,000.
www.epa.gov/urbanwaters/urban-waters-small-grants
Application Timeline: Periodic and varies
Eligibility: Non-profits, state and local governments, universities
- **National Fish and Wildlife Foundation (NFWF)**
// **Five Star and Urban Waters Restoration Grant Program**
Modest assistance to diverse local partnerships for river, forest, and wildlife conservation.
www.nfwf.org/fivestar
Application Timeline: Submissions due once a year, winter (January)
Eligibility: Public and private entities, preference for organizations who are directly connected to a community and can monitor / sustain projects for five years or more
- **Federal Emergency Management Agency (FEMA)**
// **Flood Mitigation Assistance Grant Program**
FEMA provides funding to local communities for projects and planning that reduces or eliminates long-term risk of flood.
www.fema.gov/flood-mitigation-assistance-grant-program
Application Timeline: Varies, fall - winter typical
Eligibility: State Emergency Management Agencies or office that holds primary floodplain management responsibility
- **Federal Emergency Management Agency (FEMA)**
// **Building Resilient Infrastructure & Communities (BRIC) Program**
BRIC program funding aims to shift federal focus away from reactive disaster spending toward research-supported, proactive investment in community resilience. Up to \$500 million funds available.
www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities
Application Timeline: September - January 2020-2021
Eligibility: States that have experienced major disasters in last seven years; local governments eligible as subapplicants to eligible states

TRAVEL, SAFETY + MANAGEMENT

- **America Walks**
// **Community Change Grants**
Micro grants to support innovative, engaging, and inclusive programs that promote walking and create change at a community level.
www.americawalks.org/community-change-grants/
Application Timeline: Annual submissions in the fall
Eligibility: Advocacy groups, non-profits, and municipalities
- **American Association of Retired Persons (AARP)**
// **Community Challenge Funds**
Part of the Liveable Communities Initiative, these grants help jump start long-term change through immediate projects in communities.
www.aarp.org/livable-communities/community-challenge/
Application Timeline: Annual submissions in the fall
Eligibility: Non-profits, government entities, and other organizations
- **Texas Department of Transportation (TXDOT)**
// **Transportation Alternatives Set Aside (TASA) Program**
Funds locally sponsored bicycle and pedestrian infrastructure projects in Texas communities with populations less than 200,000.
www.txdot.gov/inside-txdot/division/public-transportation/bicycle-pedestrian.html
Application Timeline: Annual call for submissions
Eligibility: Local governments, local / regional transportation agencies, non-profits responsible for local transportation safety programs

COMMUNITY OUTREACH + BUSINESS DEVELOPMENT

- **City of San Marcos// Business Improvement and Growth (BIG) Grant**
Designed to impact San Marcos properties in need of revitalization, resulting in improved exterior visibility and presentation of a property as well as enhanced occupant safety.
Application Timeline: Year round
Eligibility: Commercial property owners or tenants in the Downtown Character District (CD5-D) zoning area
- **Lions Club Community Impact Grants**
Funds awarded can be used to support specific humanitarian activities in local chapter communities.
www.lionsclubs.org/en/start-our-approach/grant-types
Application Timeline: Year round, at least 90 days prior to project start
Eligibility: Lions Club chapters that have qualified by donating a minimum of \$5,000 to LCIF within one fiscal year.



INDUSTRY CONTACTS + RESOURCES

The following list, while not exhaustive, provides some relevant manufacturer, installer, and informational contacts that can help deliver and service the Green Alley components included in this toolkit.

HIGH ALBEDO + PERMEABLE SURFACES

Keystone Hardscapes | San Marcos

www.keystonehardscapes.com

Material Contact: David Hasness, P.E. (dhasness@keystonehardscapes.com)

Gulf Coast Pavers | Austin, San Antonio, Houston

www.gulfcoastpavers.com/#permeable

Material Contact: Jimmie Hester (jimmie@gulfcoastpavers.com)

Tuscany Pavers | Austin

www.tuscanypaversaustin.com

Material Contact: Garrett Lindholm (tuscanypaversllc@gmail.com)

Cribley Enterprises, Inc. | San Antonio

www.cribleyenterprises.com

Installer Contact: Matt Renegar (mor-cei@sbcglobal.net)

Russell Boothe Construction | Austin

www.russellboothecc.com

Installer Contact: Rusty Boothe

Speedy Paving | Austin

www.speedy-paving.com

Installer Contact: Gabriel Garcia (512-751-4284)

Porous Pave | National Supplier

www.porouspaveinc.com

GREEN SCREENS + WALLS

Local general contractors, nurseries, + material suppliers

Natura | San Antonio

www.naturahq.com/green-wall-systems

Green Oasis Landscapes | San Antonio + Austin

www.greenoasis.com/live-green-walls

RAINWATER HARVESTING

Full Circle | New Braunfels

www.fullcircletx.com/index.php

Texas Native Rainwater | Driftwood

www.texasnativrainwater.com

Acer Water Tanks | San Marcos

www.acerwatertanks.com

Austin Drainage + Landscape Development | Austin

www.austindrainagespecialist.com

Construction EcoServices | Austin

www.constructionecoservices.com

Texas Metal Tanks | Austin

www.texasmetaltanks.com/services.htm

Poly-Mart Plastic Rainwater Tanks | Pflugerville

www.poly-mart.com/pflugerville-plastic-storage-tanks

Lakota Water Company | Dripping Springs

www.lakotawatercompany.com

Contact: Alan Rossing (877-652-5682, alan@lakotawatercompany.com)

Contain Water Systems Inc | Marble Falls

www.containwatersystems.com

WILDLIFE SUPPORT

Texas Parks & Wildlife Department // Biologists

www.tpwd.texas.gov/landwater/land/technical_guidance/biologists/

Texas Chapter of the Wildlife Society

www.tctws.org

Texas State Wildlife Society

<https://www.txstwildlife.com/>

National Wildlife Foundation Certified Wildlife Habitat

www.nwf.org/garden-for-wildlife/certify

NATIVE PLANTS & TREES

City of San Marcos Discovery Center Native Plant Sales

www.sanmarcostx.gov/1528/Native-Plant-Sale

Lady Bird Johnson Wildflower Center | Austin

www.wildflower.org

Hill Country Gardens | New Braunfels

www.hillcountrygardens.com

Fanick's Garden Center | San Antonio

www.fanicknursery.com

The Natural Gardener | Austin

www.tngaustin.com

Deep Root Silva Cells | National Supplier

www.deeproot.com/products/silva-cell.html

RAISED PLANTERS

Local general contractors, nurseries, + material suppliers

BIOFILTRATION PLANTERS + RAIN GARDENS

Austin Drainage + Landscape Development | Austin

www.austindrainagespecialist.com

Construction EcoServices | Austin

www.constructionecoservices.com

Filtrerra Stormwater Biofiltration Solutions | National

www.conteches.com/stormwater-management/biofiltration-bioretenion

INTERPRETIVE, IDENTIFICATION, + BUSINESS SIGNAGE

Local artisans and carpenters

Sign Crafters | San Marcos

www.signcrafters.net

Sign Arts | San Marcos

www.facebook.com/SignArtsSanMarcos

Blackout Signs | San Marcos

www.blackoutsign.com

ProGraphix | Austin

www.pgaustin.com

Ion Art | Austin

www.ionart.com

PUBLIC ART

Local artisans and carpenters

City of San Marcos Mural Arts Program

www.sanmarcostx.gov/1249/San-Marcos-Mural-Arts-Program

City of San Marcos Arts Commission

www.sanmarcostx.gov/484/Arts-Commission

PROGRAMMED EVENTS

City of San Marcos Main Street Program

www.sanmarcostx.gov/655/Main-Street

City of San Marcos Parks and Recreation

www.sanmarcostx.gov/1184/Special-Events

BIKE SUPPORT

Local and national bike rack suppliers

COSM Construction & Design Standards for Bicycle Racks

www.sanmarcostx.gov/DocumentCenter/View/2037/710s-Bicycle-Racks-PDF

The Hub Cyclery

www.bicyclelounge.com/articles/the-hub-cyclery-homepage-pg181.htm

STREET CLOSURE FEATURES + OUTDOOR FURNITURE

Local general contractors, material + furniture suppliers

SUSTAINABLE PUBLIC LIGHTING

Local electrical suppliers

International Dark Sky Association Resources

www.darksky.org/our-work/lighting/lighting-for-industry/fsa/fsa-products

Elliot Electric Supply | San Marcos

www.elliotelectric.com/locations/98/TX/San%20Marcos.aspx

Dealers Electric Supply | San Marcos

www.dealerelectrical.com

WASTE ENCLOSURES

Local General Contractors and material suppliers

BUILDING ACCESS

Local General Contractors; Window, Door + Awning Suppliers

Architectural Division 8 | Austin + San Antonio

www.archdiv8.com

DE-PAVING

Local demolition contractors

GREEN + COOL ROOFS

Local roofing contractors

Cool Roof Rating Council | North America

www.coolroofs.org/resources/home-building-owners

Green Roofs for Healthy Cities | North America

www.greenroofs.org

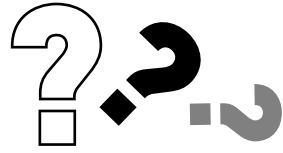
DOWNTOWN SAN MARCOS ADVOCACY GROUPS

San Marcos Downtown Association

www.downtownsanmarcos.org

Mermaid Society of Texas

www.mermaidsocietysmtx.com



FREQUENTLY ASKED QUESTIONS

As is common when adopting new technologies or evolving an approach, questions arise relating to implementation and outcomes. For reference, a few questions and answers relating to the Green Alley Initiative in San Marcos have been collected below.

BIG PICTURE: MAKING GREEN ALLEYS A REALITY

What will prioritize / qualify an alley to become a Green Alley?

One of the most important criteria will be the replacement of aging infrastructure prior to green alley activation. Since one of the largest water quality benefits is the use of permeable pavers over an open base to treat and slow down runoff, it is important that underground utilities be upgraded and replaced to ensure minimal disruption to surface improvements. This is a deciding criteria used by the City of Dubuque, Iowa where 88 alleys have been replaced with green alleys.

Is a Pilot Study advisable prior to implementing a Green Alley Initiative for all of San Marcos' downtown alleys?

Yes, and it is also recommended that conventional reconstruction of other downtown alleys be deferred until the completion of a pilot. A good pilot candidate is Kissing Alley since a complete utility upgrade is already planned followed by street reconstruction. It is also already partially activated for public use. Use of partnerships and grant funding is an option for a pilot program.

What is the economic case for implementing a Green Alley Initiative downtown? How can this be calculated?

All of the environmental and social benefits provided by Green Alleys can also meaningfully boost economic activity in a City but are hard to quantify because these services are not typically bought and sold. However, valuation techniques that quantify delivered ecosystem services, such as avoided costs, disaster mitigation, or cultural value, are useful in demonstrating economic benefits, as are more direct studies of the positive business impacts resulting from public space improvements. Contacting cities with robust Offices of Sustainability (i.e. Houston, Austin, San Antonio) for guidance is recommended, as is use of reference documents such as the Center for Neighborhood Technology's "The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental, and Social Benefits."

Who will design, construct, and fund Green Alleys?

It is envisioned that the Green Alley Initiative would be completed primarily under the direction of the City of San Marcos' Capital Improvements Plan, similar to how existing alleys are planned to be reconstructed. However, with the many environmental and social benefits that would accompany Green Alleys, supplemental grant sources as procured through organizational and community partnerships, such as those compiled in the "Potential Funding Sources" section of this document, can help fund their construction. Because Green Alley design benefits from the participation of adjacent private properties, business and land owners should be encouraged to join in Green Alley Initiative efforts with matching expenditure grants or by allocating a small percentage of cost-sharing based on frontage in exchange for rear-lot improvements.

What is a typical construction cost for an activated Green Alley and what is the basis of this cost estimate?

The Section 5 "Green Alley Toolkit" of this document provides typical costs for various green alley components and an example cost calculation table for several alleys is also provided in Appendix B. For permeable pavers, the cost of \$16-\$30/SF is based on a cross section of 21 inches of open stone, an impermeable liner, and an underdrain pipe topped by permeable interlocking concrete pavers (PICP). This unit cost also includes concrete edge restraints on either side of the alleys, and is derived from several local demonstration projects installed through local watershed partnerships with TCEQ (Plum Creek, Cypress Creek, and Alligator Creek). The installation of permeable pavers on a typical alley is estimated to range between \$150,000 - \$330,000; and any additional components, such as native plantings, signage, waste enclosures, etc. would be additive on top of this cost, as possible and appropriate.

IN THE WEEDS: GREEN ALLEY TECHNICAL DETAILS

Why should Green Alleys incorporate permeable pavers and surfaces instead of typical impermeable pavers or asphalt?

Unlike asphalt or conventional pavers, permeable pavers and earthen surfaces absorb and filter stormwater runoff on-site, which prevents pollutants from entering directly into streams and also reduces localized flooding.

What is the required maintenance and maintenance costs of permeable paver surfaces and Green Alleys, as a whole?

Permeable pavers require semiannual sweeping with a regenerative air sweeper and joint stone reinstatement when the gap reaches 1/3 to 1/2 inch deep (i.e. the spacer ridge on the paver is visible). This is anticipated to cost about \$500 per alley, per year. Green Alleys with increased vegetation and potential nesting habitat will also require seasonal maintenance, which would require further budgeting through city staff time and/or private maintenance contracts, as well as supplemented with organized volunteer time.

How does Green Alley maintenance compare to asphalt?

Asphalt requires crack sealing, seal coating, and pot hole repair annually or as needed, slurry seal on a 5-7 year cycle, and mill and overlay of the surface at a 15-20 year cycle. Use of hydrocarbon-based products containing heavy metals and polynuclear aromatic hydrocarbons (PAHs) are the industry standard for asphalt maintenance. As described previously, permeable paver maintenance is lower impact and the service life of maintained pavers is typically longer at 30-50 years versus asphalt or concrete at 25-30 years.

Are utilities hard to repair under permeable pavers?

No, utility repair is easier and less destructive than with asphalt or concrete - but just requires a different approach. Pavers can be "unzipped" by removing them along with the stone base, which can then be put back in place without much waste and no visible patch.

Won't pavers last longer if the surface doesn't absorb water?

No, the open graded gravel and stone retain strength when wet and are designed for infiltration so heaving and other maintenance issues associated with conventional pavers and water are prevented.

What techniques exist for alleys between historic buildings where water infiltration to adjacent basements is a concern?

Where buildings directly abut the alley, an underdrain pipe is recommended below permeable pavers to help collect and draw water out towards connecting storm drains or areas of soil infiltration. In addition, building foundations can be waterproofed to a depth of 4' feet or more as required with liquid or spray-applied products; and the open stone base can be isolated from the building with an impermeable liner. A 12" or greater concrete edge restraint also helps further isolate the pavers from adjacent surfaces or structures.

What does the presence of groundwater mean for Downtown San Marcos's use of green infrastructure?

Designing systems to accommodate present groundwater is common with green infrastructure and just requires adequate separation between the water table and the bottom of the proposed profile. For permeable pavers, a separation of 2 feet minimum is recommended. Refer to the Downtown Groundwater section of this document for further details (pages 18-19).

What is the pollutant load potential of a Green Alley Initiative as compared to a regional stormwater management pond?

The potential load reduction for total suspended solids (TSS), nitrogen, and phosphorus is presented in Section 5 "Metrics and Outcomes" of this document. These reductions are preliminary and assume a 5:1 off site contributing drainage area from adjacent impervious cover. The percent removal for TSS is slightly higher for permeable pavers at 93% as compared to 89% for bioretention (Table 3.3 of the 2019 SW Tech Manual) and the flow through permeable pavers is faster than through engineered soil in the pond. Without a detailed analysis, a preliminary estimate is that a greater mass of TSS removal can be achieved by the pavers.

Can runoff also drain to rain gardens, biofiltration areas, or Focal Points in Green Alleys instead of permeable pavers?

Yes, rain gardens are another City-preferred Low Impact Development practice and provide infiltration of runoff, water storage and water quality much like the permeable pavers. Where space is constrained, they can be a challenge to locate but partnership with alley-adjacent properties can help provide solutions for placement.

Why is the cross section showing 21 inches of open base on the Appendices? How was this determined?

For the exercise of calculating water storage capacity and pollutant load reduction, a depth of 21 inches (4 inches of ASTM #57 stone and 17 inches of ASTM #2 stone) was used. This is based off of a 2019 Plum Creek Watershed Partnership permeable paver parking lot that was designed for regular car and delivery truck traffic and had features such as ribbon curbs, impermeable liner, and an underdrain system. The lot is over clays with high shrink and swell properties, not unlike much of downtown San Marcos. Current costs estimates and the ICPI model were used to calculate stone thickness for both hydraulic load and weight bearing load requirements.

6 / NEXT STEPS

MAKING GREEN ALLEYS A SAN MARCOS REALITY

BUILDING A GREEN ALLEY COMMUNITY

As this document hopefully demonstrates, Green Alleys in San Marcos can be powerful stormwater management systems, serving as useful corridors between local businesses while also collectively soaking up hundreds of thousands of gallons of runoff, removing tens of thousands of pounds of sediment annually, supporting urban biodiversity, and improving the downtown experience for its many visitors and residents.

But bringing this vision to fruition requires the support, commitment, and excitement of the entire San Marcos community. Overcoming the gravity of the status quo requires momentum and is one of the biggest hurdles for City staff and advocates alike. Municipality operations, particularly in the fields of utilities, stormwater management, and road infrastructure, are based upon repetition and depend upon engineered systems that have remained deeply unchanged for decades. This makes the introduction of new methods and technologies difficult, and green alleys are certainly unexplored for many city departments across the US, including San Marcos.

The Green Alley Initiative is just a first step in inspiring the creation of a green infrastructure network in Downtown San Marcos. The groundwork to facilitate the full life cycle of distributed green infrastructure, from conception to end of life, must be laid to increase not only familiarity but also the desire to work with these technologies amongst the groups of people that will oversee its design and long-term maintenance. Building a Green alley Community will require support from not only citizens, stakeholders, businesses, etc. but also from within the City as an organization itself.

As a concluding note, the following page includes ideas for different areas where City staff can positively impact the implementation and adoption of green infrastructure city-wide. And if you are a citizen reading this document and would like to see Green Alleys become a reality tomorrow, please reach out to city staff and elected leaders to let them know you support these ideas today.

inspire
support
create
fund



SUPPORT KNOWLEDGE BUILDING

The first and easiest step is to support knowledge building amongst the community and City of San Marcos staff. Ensuring widespread familiarity with and acceptance of green infrastructure concepts is critical to their successful deployment. All departments needed to design, execute, fund, and maintain green alleys and other GSI should have all necessary training available from industry standards and other municipalities advanced in these practices. Stormwater Management staff are natural candidates to guide interdepartmental knowledge building and should be granted the capacity to lead education and research efforts that help build greater understanding of San Marcos' local conditions and demystify concerns associated with green infrastructure. Texas State University's new School of Civil Engineering also presents opportunity for collaboration with faculty on research, as well. Some of these recommended efforts include:

- Green Infrastructure Technical Trainings: Career-building accreditations are available for staff to earn while becoming both capable and familiar with GSI technologies. Training is offered through organizations like the [National Green Infrastructure Certification Program \(NGICP\)](#), [Interlocking Concrete Pavement Institute \(ICPI\)](#), [San Antonio River Authority \(SARA\)](#), and more.
- Groundwater Mapping of Downtown Area: To better understand the flow and location of the groundwater table in the Downtown, efforts to map subsurface water levels should be undertaken to inform decisions for green infrastructure in this area.
- Stormwater Flow Modeling in Downtown Alley Ways: Quantifying anticipated precipitation and runoff, potential capture and conveyance by permeable systems in alleys, and avoided storm pipe upsizing costs across Downtown can help build both environmental and financial support for green infrastructure.

CREATE GREEN JOBS + MAINTENANCE PROTOCOLS

In 2020, San Marcos finds itself the midst of the Covid-19 Pandemic, a force that has highlighted the community's workforce vulnerability and overreliance on low-paying, unstable service industry jobs, many of which may be lost permanently. At the same time, the Pandemic has also revealed the importance of accessible and well-maintained outdoor public space as people seek ways to safely get outside their homes. Now more than ever is the time for the City to invest in green jobs to help improve the community's resilience. The creation of green infrastructure maintenance-based staff positions is an incredible way to do just that while also developing the much needed institutional knowledge and skills required to confidently steward projects into long-term functional life post-installation. Steps to achieve this should include:



Measuring the Water Levels at a Piezometer



Maintaining GSI



Kissing Alley Pilot Opportunity

- Create a Green Stormwater Maintenance Department: GSI maintenance requires a different skill set and direction than typical street or utility departments are accustomed to and more cities are seeing that this work warrants its own department to better serve the infrastructure investment.
- Develop GSI Maintenance Protocols: Parallel to the step above should be the creation of robust GSI maintenance standards. These typically require an understanding of natural systems and native plant care, invasive species or weed identification and removal, the ability to follow directions on plan sets or maintenance covenants, and use of small hand tools.

FUND OPPORTUNITY + SUCCESS

Funding is key for both the initial feasibility and long-term success of green infrastructure projects. Work that can be done today to help make green alleys a reality includes:

- Pursue Grants for a Green Alley Pilot + Beyond: Many potential funding sources (see pgs. 42-43) offer annual opportunities to unlock funding for CIP projects by integrating GSI into the scope. Aiming to secure funding for a pilot green alley is a great way to kickstart the program.
- Dedicate Revenue Stream for GSI Maintenance Funds: Identifying and dedicating a steady monetary source to be used exclusively for green alley and other GSI maintenance is necessary to ensure proper care for GSI investments.

REFERENCES

BIBLIOGRAPHY

- Beatley, Tim. *Biophilic Cities: Integrating Nature Into Urban Design and Planning*. Washington, D.C., Island Press, 2010.
- Canfield, J., Yang, B., Whitlow, W. *Evaluating Landscape Performance*. Landscape Architecture Foundation, 2018. Accessed September 2019 at landscapeperformance.org
- City of San Marcos. *Stormwater Technical Manual*. Accessed July 2019 from sanmarcostx.gov/DocumentCenter/View/13243/San-Marcos-Stormwater-Technical-Manual-PDF
- International Concrete Pavement Institute (ICPI), American Society of Civil Engineers (ASCE). *Permeable Interlocking Concrete Pavements, ASCE/T&D/ICPI 68-18*, 2018.
- Newell, J. P. et al. "Green Alley Programs: Planning for a sustainable urban infrastructure?" *Cities*, 2012.
- Texas Parks and Wildlife Department (TPWD). "Texas Ecoregions: Blackland Prairies." Accessed September 2019 at tpwd.texas.gov
- The Meadows Center for Water and the Environment, Texas State University. *The Upper San Marcos River Watershed Protection Plan*. September 2018.
- United States Environmental Protection Agency (EPA). *Being Prepared for Climate Change: A Workbook for Developing Risk-Based Adaptation Plans*. August 2014.
- Wolch, J. et al.. "The Forgotten and the Future: Reclaiming Back Alleys for a Sustainable City." *Environment and Planning*, Vol. 42, 2010, 2874-2896.

GREEN ALLEY RESOURCES

- City of Austin Downtown Commission (2013). "Activating Austin Downtown Alleys as Public Space." Retrieved from www.austintexas.gov
- City of Chicago Department of Transportation (2010). "The Chicago Green Alley Handbook." Retrieved from www.chicago.gov
- City of Melbourne (2016). "Laneway Visions and Greening Map." Retrieved from participate.melbourne.vic.gov.au/greenlaneways
- Fialko, M., Hampton, J.(2011). "Seattle Integrated Alley Handbook: Activating Alleys for a Lively City." Retrieved from greenfutures.washington.edu
- Global Shapers Community Portland (2019). List of Completed Alley Projects. Retrieved from pdxshapers.com/alley-project-ideas
- Trust for Public Land (2012). "Alleys Amplified: The South Los Angeles Green Alley Master Plan." Retrieved from www.lastormwater.org
- UCLA Luskin Center for Innovation (2014). "Avalon Green Alley Network Demonstration Project." Retrieved from www.lastormwater.org

CASE STUDY PROJECT SITES

- City Of Dubuque: Green Alley Reconstruction Program
cityofdubuque.org/1818/Green-Alley-Reconstruction
- City Of Roswell: Reimagining and Revitalizing Alleys in Downtown Historic Roswell
roswellgov.com/government/departments/community-development/plans-projects/east-west-alley-master-plan
- City Of Longmont: Alleyscape and Breezeway Project
www.downtownlongmont.com/about/ldda-projects-and-programs/alleyscape-development-project
- LA Green Alleys + South Park Neighborhood: The Avalon Green Alley Demonstration Project
www.tpl.org/green-alleys and <https://www.lastormwater.org/green-la/south-la-green-alley-master-plan/>

DATA + OTHER SOURCES

- City of San Marcos Downtown Master Plan. Broadus & Associates, October 2008. Accessed August 2019 from sanmarcostx.gov/918/Downtown-Master-Plan
- City of San Marcos Preferred Plant List. Accessed September 2019 from sanmarcostx.gov/DocumentCenter/View/6263/Plant-List-PDF
- City of San Marcos Public GIS Data. Accessed July 2019 from sanmarcostx.gov/761/GIS
- United States Environmental Protection Agency Stormwater Calculator. Accessed August 2019 from epa.gov/water-research/national-stormwater-calculator

LIST OF TABLES

All original tables created for use in this document are listed below.

Table #	(Page No.)	Table Title
Table 1	(P24-25)	Assessed Existing Alley Conditions + Potentials
Table 2	(P41)	Anticipated Green Alley Pollutant Capture + Removal

LIST OF FIGURES

All noted figures, including referenced images and original maps and visuals, are listed below. Any unreferenced images are originals created for use in this document.

Figure #	(Page No.)	Figure Title
Figure 1	(P1)	The Improved Three E's of Sustainability. Colorspace 2020.
Figure 2	(P2)	Green Alley visualizations. Colorspace 2020.
Figure 3	(P5)	San Marcos Town Plot, 1881. Texas General Land Office. Retrieved July 2019 from glo.texas.gov
Figure 4	(P7)	Washington, D.C.'s Q Street Green Alley. Retrieved November 2019 from rhiplaces.com/q-street-green-alley
Figure 5	(P8)	Green alley and trash collection in Chicago, IL. (City of Chicago, 2010).
Figure 6	(P8)	Photo of Kissing Alley Concert Series. San Marcos Downtown Association. Retrieved July 2019 from downtownsanmarcos.org
Figure 7	(P9)	Green alley walking and biking tour. (UCLA Luskin Center for Innovation, 2014).
Figure 8	(P10)	Before and after reconstruction of alley 62 in downtown Dubuque. City of Dubuque Retrieved July 2019 from dubuque.maps.arcgis.com
Figure 9	(P10)	Reimagined Alley Benefits the Roswell Community. Smith, G. Retrieved July 2019 from greshamsmith.com
Figure 10	(P1)	Permeable pavers in downtown Longmont alleys. City of Longmont. Retrieved July 2019 from engage.longmontcolorado.gov
Figure 11	(P1)	Avalon demonstration alley. Trust for Public Land. (Trust for Public Land, 2012).
Figure 12	(P12)	Upper San Marcos River Watersheds. Colorspace 2020.
Figure 13	(P13)	Downtown San Marcos, Upper San Marcos River Watersheds. Colorspace 2020.
Figure 14	(P15)	Downtown San Marcos, Alley Inventory. Colorspace 2020.
Figure 15	(P16)	Central Texas Ecoregions. Colorspace 2020.
Figure 16	(P16)	Downtown San Marcos, Soil Types. Colorspace 2020.
Figure 17	(P17)	Downtown San Marcos, Stormwater Flow Map. Colorspace 2020.
Figure 18	(P18)	Regional Water Flows, modified Edwards Aquifer Infographic. The Meadows Center for Water and the Environment / tophersipes.com
Figure 19		Not Used
Figure 20	(P27)	Downtown San Marcos, Alley Activation Potential. Colorspace 2020.
Figure 21	(P28-32)	Downtown San Marcos, A Green Alley Catalyst (Illustrative Plan and Visualizations). Colorspace 2019.
Figure 22-23		Not Used
Figure 24	(P34)	Permeable pavers. Chesapeake Environmental Communication. Retrieved August 2019 from chesapeakeedata.com
Figure 25	(P34)	Native bush Texas Sage. Lady Bird Johnson Wildflower Center. Retrieved August 2019 from wildflower.org
Figure 26	(P35)	Urban Farming Green Wall. A Green Roof. Retrieved August 2019 from agreenroof.com
Figure 27	(P35)	Rincon Heights Neighborhood - Parking Lot & Alley Retrofit. Watershed Management Group. Retrieved August 2019 from watershedmg.org
Figure 28	(P35)	Rainwater capture and planter. (City of San Marcos Stormwater Technical Manual, 2019)
Figure 29	(P35)	A DIY Planter Boxes. MymyDIY. Retrieved July 2019 from mymydiy.com/diy-planter-boxes
Figure 30	(P35)	Birdboxes as part of the Nest Project. Fieldwork Facility. Retrieved September 2019 from fieldworkfacility.com/projects/the-nest-project
Figure 31	(P35)	Chinatown Spofford Living Alley. San Francisco Water Power Sewer. Retrieved August 2019 from sfwater.org
Figure 32	(P36)	Interpretive Sign For Permeable Pavers. Chesapeake Environmental Communication. Retrieved August 2019 from chesapeakeedata.com
Figure 33	(P36)	Bronze bollards that double as benches. The Architect Newspaper. Retrieved August 2019 from archpaper.com/2005/10/breaking-ground-2
Figure 34	(P37)	Post Alley archway signage in Seattle. Getaway Travel. Retrieved September 2019 from getaway.travel
Figure 35	(P37)	San Marcos red sculptural bike racks. City of San Marcos Bike Map. Retrieved September 2019 from www.sanmarcostx.gov/317/Bicycling
Figure 36	(P37)	Aerial Sculpture across an Austin alley. (City of Austin Downtown Commission, 2013)
Figure 37	(P37)	Allegro Quinn Alley bike and seating improvements. Cafe Allegro, Seattle. Retrieved September 2019 from twitter.com/seattleallegro
Figure 38	(P37)	San Marcos Wedding In Kissing Alley. The Main Street Program. Accessed August 2019 from lovesmtx.blogspot.com
Figure 39	(P38)	Green wall waste enclosure. Faulkner, M. April 5, 2013. Retrieved August 2019 from midlifemeg.com/tag/color
Figure 40	(P38)	Rose's Ice Cream depave project. Depave, Portland. Retrieved September 2019 from depave.org
Figure 41	(P39)	Dairy Block alley renovation. BLDUP. Retrieved August 2019 from www.bldup.com/projects/zblock
Figure 42	(P39)	Rain garden with native plants. Kenzle, S. City of Austin Watershed Protection Department. Retrieved September 2019 from austintexas.gov
Figure 43	(P39)	Cafe seating at Daily Dose alley. Holmes, M. LA Eater. Retrieved September 2019 from la.eater.com
Figure 44	(P39)	Green roof on the Lady Bird Johnson Wildflower Center welcome kiosk. University of Texas at Austin. Retrieved September 2019 from wildflower.org
Figure 45	(P39)	Coffee shop signage on Tin Pan Alley in Bend, OR. Retrieved September 2019 from yelp.com

APPENDICES

APPENDIX A // GREEN ALLEY EXAMPLE COST ESTIMATES

DOWNTOWN SMTX GREEN ALLEYS

ESTIMATED PERMEABLE PAVER + ANNUAL MAINTENANCE COSTS

ALLEY CODE	ALLEY NAME	APPROXIMATE AREA (sqft.)	PERM PAVER RECONSTRUCTION COSTS (\$30 / sf) (a)	PERM PAVER MAINTENANCE COSTS (\$1,000 annually) (b)
A	x	5,440	\$163,200	\$1,000
B	x	5,520	\$165,600	\$1,000
C	x	5,520	\$165,600	\$1,000
D	x	5,600	\$168,000	\$1,000
E	Kissing Alley	5,440	\$163,200	\$1,000
F	Jack's Alley	6,300	\$189,000	\$1,000
G	x	7,000	\$210,000	\$1,000
H	x	7,000	\$210,000	\$1,000
I	Feltner Alley N	5,200	\$156,000	\$1,000
J	x	4,160	\$124,800	\$1,000
K	x	5,520	\$165,600	\$1,000
L	x	5,540	\$166,200	\$1,000
M	Feltner Alley S	11,040	\$331,200	\$1,000
N	Telephone Alley	10,720	\$321,600	\$1,000
O	Railroad Alley	10,880	\$326,400	\$1,000
P	x	9,200	\$276,000	\$1,000
TOTAL		110,080	\$3,302,400	\$16,000

DOWNTOWN SMTX GREEN ALLEYS

ESTIMATED EXAMPLE GREEN ALLEY COSTS (AS VISUALIZED ON PGS. 26-30)

ALLEY ELEMENTS	ELEMENT COST (PSF / PLF / Each)	ALLEY E / F ELEMENTS	ALLEY E + F ELEMENT COST	ALLEY O ELEMENTS	ALLEY O ELEMENT COST
Permeable Pavers (sf)	\$30.00	9,222	\$276,660	9,975	\$299,250
Permeable Ground (sf)	\$10.00	3,300	\$33,000	10,085	\$100,850
Trees (ea)	\$750.00	6	\$4,500	20	\$15,000
Shrubs (ea)	\$75.00	30	\$2,250	40	\$3,000
Perennials, Grasses (ea)	\$25.00	60	\$1,500	75	\$1,875
Vertical Green Wall (LF)	\$25.00	65	\$1,625	0	\$0
Raised Planter (LF)	\$50.00	20	\$1,000	0	\$0
Rain Barrels (ea)	\$1,500.00	3	\$4,500	1	\$1,500
Benches (ea)	\$500.00	2	\$1,000	2	\$1,000
String Lighting (LF)	\$5.00	Existing	-	300	\$1,500
In-Ground Lighting (ea)	\$250.00	10	\$2,500	10	\$2,500
Dumpster Enclosure (ea)	\$3,000.00	4	\$12,000	7	\$21,000
Alley Signage (ea)	\$7,500.00	2	\$15,000	1	\$7,500
SUBTOTAL			\$355,535		\$454,975
10% Contingency			\$35,554		\$45,498
ALLEY E / F EST. LOW COST			\$391,089	ALLEY O EST. LOW COST	\$500,473
25% Contingency			\$88,884	25% Contingency	\$113,744
ALLEY E/F EST. HIGH COST			\$444,419	ALLEY O EST. HIGH COST	\$568,719

General Disclaimer: All assumed costs are estimates only based on industry approximations and do not constitute a qualified construction estimate. Utility improvement costs are not included.
 (a) PICP installed cost with 21 inch open base, concrete edge restraints, underdrain, and impermeable liner
 (b) Based on approximate annual per alley costs of \$500 for quarterly sweeping and \$500 for top stone replacement

APPENDIX B // POTENTIAL GREEN ALLEY STORM EVENT + POLLUTANT REMOVAL CALCULATIONS

DOWNTOWN SMTX GREEN ALLEYS

BASE GREEN ALLEY VOLUME CALCULATIONS

ALLEY CODE	ALLEY NAME	APPROXIMATE AREA (sqft.)	APPROXIMATE AREA (ACRES)	OPEN BASE DEPTH (inches)	POROSITY (%)	WATER STORAGE VOLUME AVAILABLE (FT3)	WATER STORAGE VOLUME AVAILABLE (gal)
A	x	5,440	0.125	21	0.33	3,142	23,501
B	x	5,520	0.127	21	0.33	3,188	23,846
C	x	5,520	0.127	21	0.33	3,188	23,846
D	x	5,600	0.129	21	0.33	3,234	24,192
E	Kissing Alley	5,440	0.125	21	0.33	3,142	23,501
F	Jack's Alley	6,300	0.145	21	0.33	3,638	27,216
G	x	7,000	0.161	21	0.33	4,043	30,240
H	x	7,000	0.161	21	0.33	4,043	30,240
I	Feltner Alley N	5,200	0.119	21	0.33	3,003	22,464
J	x	4,160	0.096	21	0.33	2,402	17,971
K	x	5,520	0.127	21	0.33	3,188	23,846
L	x	5,540	0.127	21	0.33	3,199	23,933
M	Feltner Alley S	11,040	0.253	21	0.33	6,376	47,693
N	Telephone Alley	10,720	0.246	21	0.33	6,191	46,310
O	Railroad Alley	10,880	0.250	21	0.33	6,283	47,002
P	x	9,200	0.211	21	0.33	5,313	39,744
TOTAL		110,080	2.53	-	-	63,571	475,546

DOWNTOWN SMTX GREEN ALLEYS

STORM EVENT CAPACITY POTENTIAL (a)

Storm duration: 3 hours	AVERAGE RECURRENCE INTERVAL	PRECIPITATION (inches)	GI CAPACITY (%)
	2 yr.	2.70	38.96%
25 yr.	5.56	80.23%	
100 yr.	7.83	112.99%	
Storm duration: 6 hours	AVERAGE RECURRENCE INTERVAL	PRECIPITATION (inches)	GI CAPACITY (%)
	2 yr.	3.17	45.74%
	25 yr.	6.77	97.69%
100 yr.	9.78	141.13%	
Storm duration: 12 hours	AVERAGE RECURRENCE INTERVAL	PRECIPITATION (inches)	GI CAPACITY (%)
	2 yr.	3.64	52.53%
	25 yr.	7.83	112.99%
100 yr.	11.30	163.06%	
Storm duration: 24 hours	AVERAGE RECURRENCE INTERVAL	PRECIPITATION (inches)	GI CAPACITY (%)
	2 yr.	4.14	59.74%
	25 yr.	8.85	127.71%
100 yr.	12.70	183.26%	

(a) Based on Atlas 14 rainfall data for the Austin, Texas station

DOWNTOWN SMTX GREEN ALLEYS
BASE GREEN ALLEY VOLUME CALCULATIONS

ALLEY CODE	ALLEY NAME	APPROXIMATE AREA (sqft.)	APPROXIMATE AREA (ACRES)	OPEN BASE DEPTH (inches)	POROSITY (%)	WATER STORAGE VOLUME AVAILABLE (FT3)	WATER STORAGE VOLUME AVAILABLE (gal)	WATER CAPTURED WITH 1.6 INCHES STORM (gal)(a)
A	x	5,440	0.125	21	0.33	3,142	23,501	5,425
B	x	5,520	0.127	21	0.33	3,188	23,846	5,505
C	x	5,520	0.127	21	0.33	3,188	23,846	5,505
D	x	5,600	0.129	21	0.33	3,234	24,192	5,585
E	Kissing Alley	5,440	0.125	21	0.33	3,142	23,501	5,425
F	Jack's Alley	6,300	0.145	21	0.33	3,638	27,216	6,283
G	x	7,000	0.161	21	0.33	4,043	30,240	6,981
H	x	7,000	0.161	21	0.33	4,043	30,240	6,981
I	Feltner Alley N	5,200	0.119	21	0.33	3,003	22,464	5,186
J	x	4,160	0.096	21	0.33	2,402	17,971	4,149
K	x	5,520	0.127	21	0.33	3,188	23,846	5,505
L	x	5,540	0.127	21	0.33	3,199	23,933	5,525
M	Feltner Alley S	11,040	0.253	21	0.33	6,376	47,693	11,011
N	Telephone Alley	10,720	0.246	21	0.33	6,191	46,310	10,691
O	Railroad Alley	10,880	0.250	21	0.33	6,283	47,002	10,851
P	x	9,200	0.211	21	0.33	5,313	39,744	9,175
TOTAL		110,080	2.53	-	-	63,571	475,546	109,786

DOWNTOWN SMTX GREEN ALLEYS
TP LOAD REDUCTION POTENTIAL

ALLEY CODE	TP CONC INITIAL (mg/L) (b)	TP CONC FINAL (mg/L) (c)	TP REMOVED (mg/L)	ANNUAL RAINFALL HAYS (IN)	TP REMOVED (LB/YEAR)(d)
A	0.396	0.09	0.306	33	1.03
B	0.396	0.09	0.306	33	1.04
C	0.396	0.09	0.306	33	1.04
D	0.396	0.09	0.306	33	1.06
E	0.396	0.09	0.306	33	1.03
F	0.396	0.09	0.306	33	1.19
G	0.396	0.09	0.306	33	1.32
H	0.396	0.09	0.306	33	1.32
I	0.396	0.09	0.306	33	0.98
J	0.396	0.09	0.306	33	0.78
K	0.396	0.09	0.306	33	1.04
L	0.396	0.09	0.306	33	1.04
M	0.396	0.09	0.306	33	2.08
N	0.396	0.09	0.306	33	2.02
O	0.396	0.09	0.306	33	2.05
P	0.396	0.09	0.306	33	1.74

21

(a) 1.6 inches for a rainfall event is the design rainfall for the San Marcos River Corridor and Edwards Aquifer Recharge Zone in Table on page 3-26 of the City of San Marcos Stormwater Technical Manual and is considered the most conservative. This standard also requires 89% TSS reduction.

(b) City of Austin Environmental Criteria Manual, Sept 7, 2018 Table 1-10
(c) Users Guide to the BMP SELECT Model, 2013, WERF, Table 4 for permeable pavement
(d) Average annual load (pounds) removed per year = (influent conc-effluent conc) x contributing area (acres) x average annual rainfall Hays County x runoff coefficient based on impervious cover (COA Table 1-9 adjusted for 33 inches instead of Austin's 31 inches) x 0.226 (conversion factor to yield pounds per year)

DOWNTOWN SMTX GREEN ALLEYS
TN LOAD REDUCTION POTENTIAL

ALLEY CODE	TN CONC INITIAL (mg/L) (b)	TN CONC FINAL (mg/L) (c)	TN REMOVED (mg/L)	ANNUAL RAINFALL HAYS (IN)	TN REMOVED (LB/YEAR)(d)
A	2.22	1.27	0.95	33	3.19
B	2.22	1.27	0.95	33	3.23
C	2.22	1.27	0.95	33	3.23
D	2.22	1.27	0.95	33	3.28
E	2.22	1.27	0.95	33	3.19
F	2.22	1.27	0.95	33	3.69
G	2.22	1.27	0.95	33	4.10
H	2.22	1.27	0.95	33	4.10
I	2.22	1.27	0.95	33	3.04
J	2.22	1.27	0.95	33	2.44
K	2.22	1.27	0.95	33	3.23
L	2.22	1.27	0.95	33	3.24
M	2.22	1.27	0.95	33	6.46
N	2.22	1.27	0.95	33	6.28
O	2.22	1.27	0.95	33	6.37
P	2.22	1.27	0.95	33	5.39

64

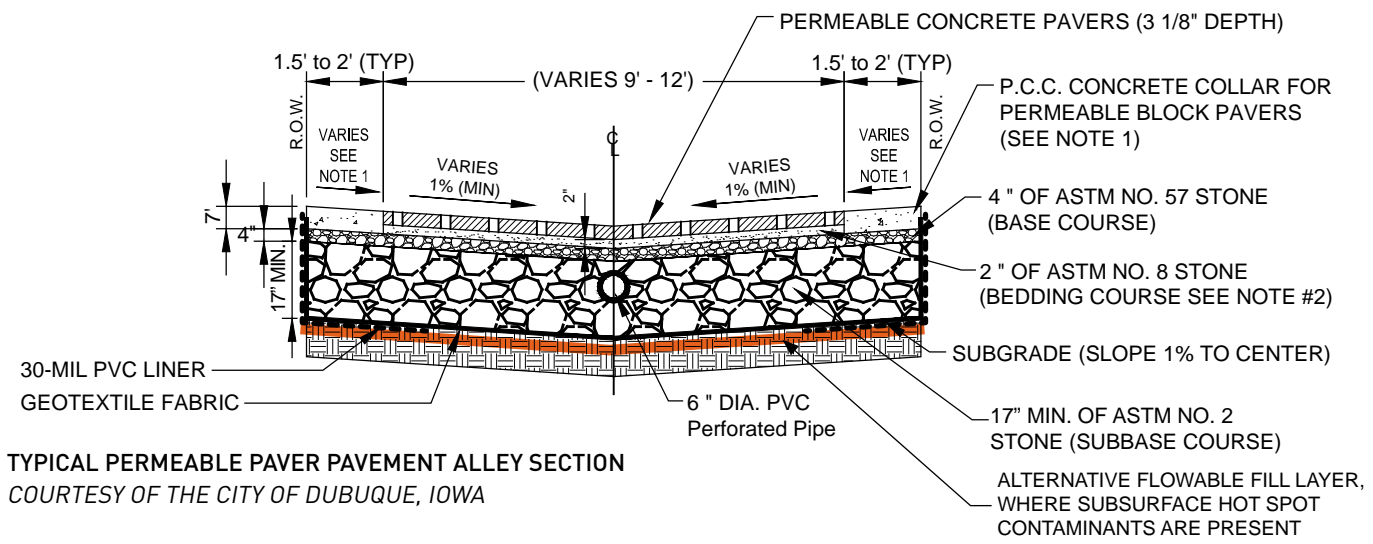
DOWNTOWN SMTX GREEN ALLEYS
TSS LOAD REDUCTION POTENTIAL

ALLEY CODE	TSS CONC INITIAL (mg/L) (b)	TSS CONC FINAL (mg/L) (c)	TSS REMOVED (mg/L)	ANNUAL RAINFALL HAYS (IN)	TSS REMOVED (LB/YEAR)(d)
A	170	12	158	33	530
B	170	12	158	33	538
C	170	12	158	33	538
D	170	12	158	33	545
E	170	12	158	33	530
F	170	12	158	33	614
G	170	12	158	33	682
H	170	12	158	33	682
I	170	12	158	33	506
J	170	12	158	33	405
K	170	12	158	33	538
L	170	12	158	33	540
M	170	12	158	33	1075
N	170	12	158	33	1044
O	170	12	158	33	1060
P	170	12	158	33	896

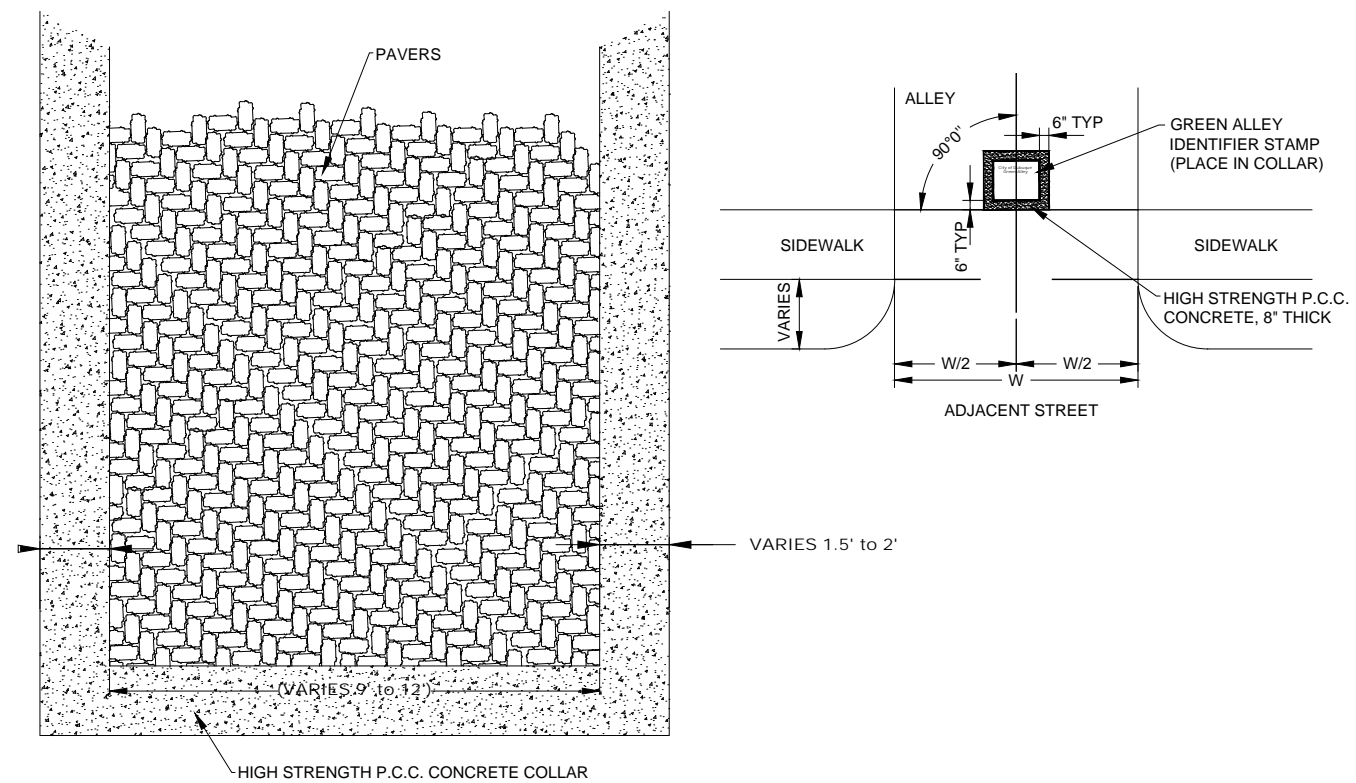
10720

Calculations based on similar methodology for The Upper San Marcos Watershed Protection Plan, and Cypress Creek WPP QAPP dated April 4, 2019 pp 32-38, and a 5:1 offsite to onsite drainage area.

APPENDIX C // EXAMPLE TECHNICAL DETAILS



TYPICAL PERMEABLE PAVER PAVEMENT ALLEY SECTION
COURTESY OF THE CITY OF DUBUQUE, IOWA



TYPICAL ALLEY PERMEABLE PAVER ALLEY PLAN
COURTESY OF THE CITY OF DUBUQUE, IOWA

