CITY OF Tulsa
A New Kind of Energy

All Hazard Mitigation Plan

MESHEK & ASSOCIATES, LLC

CITY OF Tulsa
A New Kind of Energy.

Planning and Coordination
ENGINEERING SERVICES DEPARTMENT

April 10, 2019

Mr. Matthew Rollins
State Hazard Mitigation Officer
Oklahoma Department of Emergency Management
P.O. Box 53365
Oklahoma City, Oklahoma 73152-3365

RE: City of Tulsa, Oklahoma
Hazard Mitigation Plan Update

Dear Mr. Rollins:

The City of Tulsa in fulfillment of the requirements of Title 44 Code of Federal Regulations (CFR) §201.6, is pleased to submit this Multi-Hazard Mitigation Plan Update with required FEMA Planning Review Tool for your review and approval.

The City of Tulsa will be responsible for project management of This plan, including any submissions and corrections or revisions during the approval process, and final distribution of the FEMA approved Plan to interested parties. Meshek & Associates, LLC was selected for completion of this 2019 Update and should be included on any requests for revision or notification of approval status.

If you have any questions, please contact Annie Vest by phone, 918-392-5620 or email at avest@meshekengr.com.

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Sincerely,

Gary McCormick, PE, CFM
City of Tulsa, Engineering Services

Cc: Annie Vest
Meshek & Associates, LLC

Enclosures:

City of Tulsa Multi-Hazard Mitigation Plan Update, 2019

Plan Table of Contents

Chapter 1: Introduction

1.1 Introduction

This document is the Multi-Hazard Mitigation Plan 2019 Update for the City of Tulsa. This plan update is developed in accordance with, and fulfills the requirements for, the Pre-Disaster Mitigation (PDM) and Hazard Mitigation Grant Program (HMGP). It also fulfills the requirements for the Flood Mitigation Assistance Program (FMA) and the Community Rating System Plan (CRS) from FEMA. The plan addresses natural and manmade hazards that can affect people and property in the City of Tulsa.

1.1.1 Purpose and Scope

Mitigation is most effective when it is based on a comprehensive, long-term plan that is developed before a disaster occurs. The purpose of mitigation planning is to identify local policies and actions that can be implemented over the long term to reduce risk and future losses from hazards. The objective of this plan is to guide mitigation activities for the next five years. It will ensure that the City of Tulsa implements hazard mitigation activities that are most effective and appropriate for the hazards that threaten the community. The scope of the City of Tulsa Multi-Hazard Mitigation Plan Update is citywide. The plan addresses both short-term and long-term hazard mitigation opportunities beyond existing federal, state, and local funding programs.

1.1.2 Goal

The overall goal of the City of Tulsa Hazard Mitigation plan is to create a disaster-resistant community and improve the safety and well-being of Tulsa by reducing deaths, injuries, property damage, environmental and other losses from natural and technological hazards in a manner that advances community goals, quality of life, and results in a more livable, viable, and sustainable community. Specific goals and the process by which they were developed are included in Chapter 5 of this plan.

1.1.3 The Planning Process

Planning for the City of Tulsa Multi-Hazard Mitigation Plan Update followed a ten-step process, based on guidance and requirements of FEMA[1] and the Community Rating System (CRS):

1. Organize to prepare the plan
2. Involve the public
3. Coordinate with other agencies and organizations
4. Assess the hazard
5. Assess the problem
6. Set goals
7. Review possible activities
8. Draft the action plan
9. Adopt the plan
10. Implement, evaluate, and revise

[1] https://www.fema.gov/hazard-mitigation-planning-process

1.1.4 Plan Organization

The Plan is organized into eight chapters based on the nine tasks identified in the *FEMA Local Mitigation Planning Handbook* and FEMA 10-step Planning Process. Some of the tasks and steps are combined into one chapter. Chapters 1-2 discuss the process and people needed to complete the remaining mitigation planning tasks and document the plan update process.

Chapter 1	• Introduction
Chapter 2	• The Planning Process
Chapter 3	• Capability Assessment
Chapter 4	• Risk Assessment
Chapter 5	• Mitigation Strategy and Action Plan
Chapter 6	• Implementation and Maintenance

1.2 Community Description

The City of Tulsa is primarily located in Tulsa County, in Northeast Oklahoma, 99 miles northeast of Oklahoma City, at the intersection of Interstate 44 and the Arkansas River. Tulsa has a total area of 200 square miles and had a 2017 Census population estimate of 401,800.

1.2.1 Governance

All legislative powers of the City of Tulsa, except for the rights of initiative and referendum reserved to the people of the City of Tulsa by the Constitution of Oklahoma, are exercised by a Council composed of nine Councilors elected by districts. The executive and administrative powers of the City of Tulsa and any executive and administrative powers conferred on the city by the Constitution or the laws of Oklahoma are exercised by the Mayor.

1.2.2 Geography

Tulsa is situated between the edge of the Great Plains and the foot of the Ozark Mountains in a generally forested region of rolling hills. The city touches the eastern extent of the Cross Timbers, an ecoregion of forest and prairie transitioning from the drier plains of the west to the wetter forests of the east. With a wetter climate than points westward, Tulsa serves as a gateway to "Green Country", a designation for northeast Oklahoma that stems from the region's green vegetation and relatively high number of hills and lakes compared to central and western areas of Oklahoma, which lie largely in the drier Great Plains region of the Central United States. Holmes Peak in the northwest corner of the city is the tallest point in five counties at 1,030 ft.

1.2.3 Climate

Tulsa has a temperate climate with a yearly average temperature of 61°F and an average rainfall of 39 inches. Weather patterns vary by season with occasional extremes in temperature and rainfall. Temperatures of 100° F or higher are often observed from July to early September, usually accompanied by high humidity brought in by southerly winds. The autumn season is usually short, consisting of pleasant, sunny days followed by cool nights. Winter temperatures, while generally mild, occasionally experience extremes below 0° while annual snowfall averages about 9 inches.

1.2.4 History

The city now known as Tulsa was first settled by the Lockapoka Creek Indians between 1828 and 1836. Driven from their native Alabama by the forced removal of Indians from southeastern states, the Lockapokas established a new home at a site near Cheyenne and S. 18th Street. The big oil strike at Glenpool in 1905, just 15 miles south of Tulsa, made Oklahoma and Indian Territory the center of oil speculation and exploration. At the time of statehood in 1907, Tulsa's population was 7,298. The 1950s and 60s saw Tulsa grow to the south and east, and into the watersheds of Mingo and Joe Creeks. Flooding on the inland creeks and along the Arkansas River became increasing problems as the town continued to expand. By 1980, Tulsa's population stood at 360,919, ranking it the thirty-eighth largest city in the nation. Threads of its Native American heritage and oil boom days are still visible in the city's historic fabric[2].

1.3 Community Assets

Community Assets are defined broadly to include anything that is important to the character and function of a community and can be described very generally in the following four categories: People, Economy, Built Environment, Natural Environment.

Although all assets may be affected by hazards, some assets are more vulnerable because of their physical characteristics or socioeconomic uses. This section describes community assets in the City of Tulsa.

1.3.1 People

Every person in the City of Tulsa is exposed to at least one of the 12 hazards identified in this plan. Following in the footsteps of resilience Tulsa, it was important for this plan update to focus on areas within Tulsa that may not be as quick to recover. Understanding who is being affected by disaster is important when preparing for future events. Social and economic characteristics map limit an individual's ability to understand their risk, respond to and recover from disasters.

These groups of people will be referenced throughout the vulnerability sections in Chapter 4, their locations are displayed on the following maps. A breakdown of socioeconomic information by Council District is included in Table 1-1. Data from the US Census and the US Bureau of Labor Statistics was used to illustrate the relationship between population and potential hazards in Tulsa. Further information on Tulsa's social vulnerability can be found in the risk assessment.

[2] http://tulsapreservationcommission.org/tulsa-history/

Figure 1-1 Percent of Population age 65 years & Over

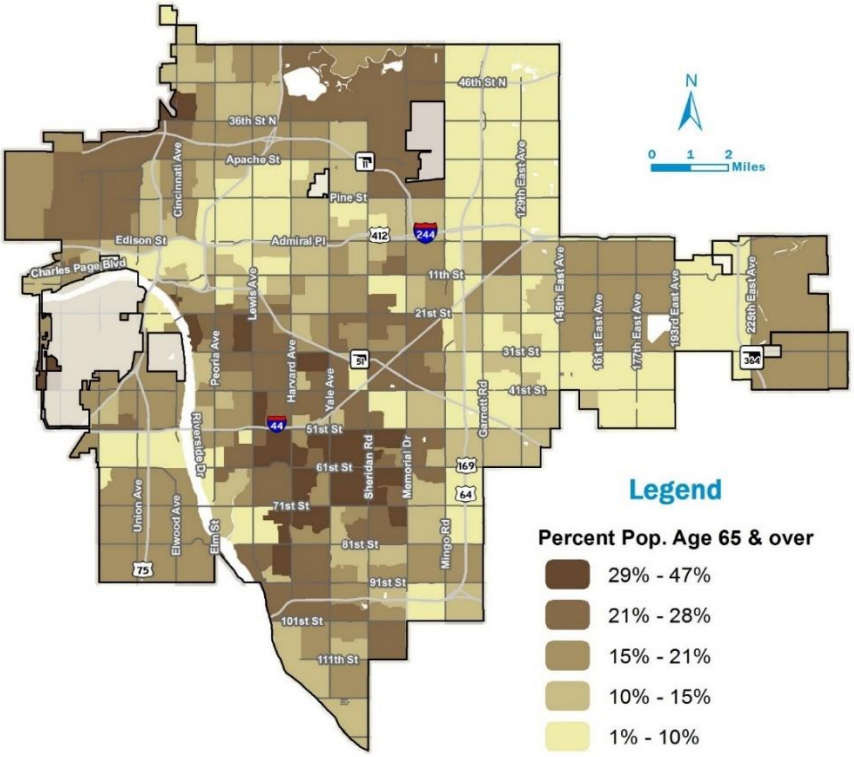


Figure 1-2 Percent of Population Below Poverty Level

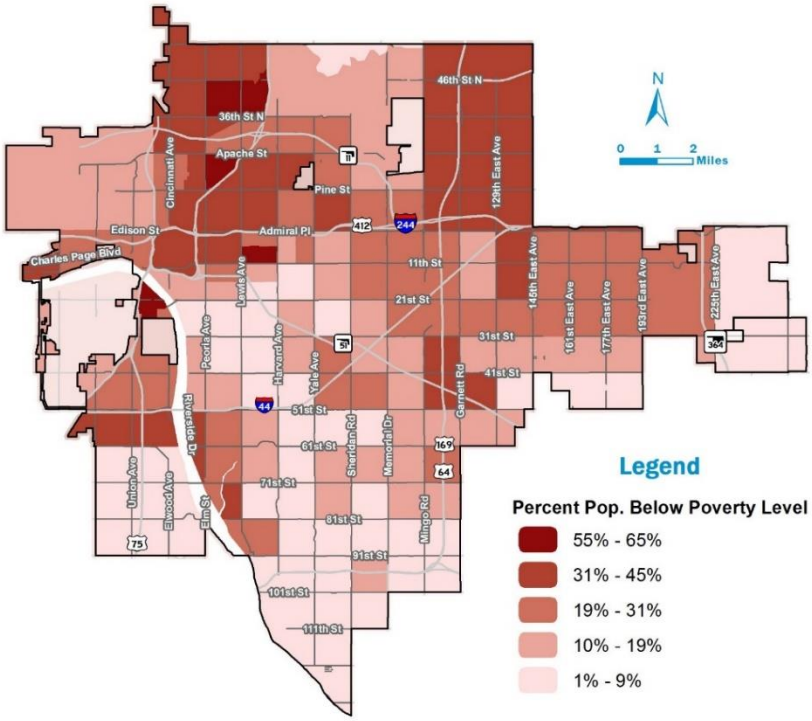


Figure 1-3 Percent of Population Non-English Spoken at Home

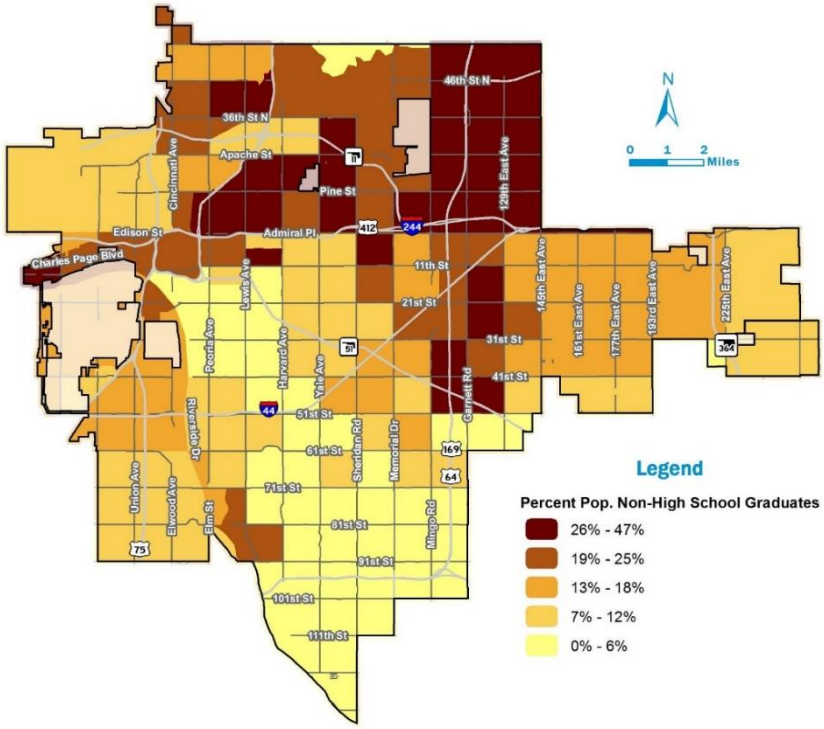


Figure 1-4 Percent of Population Non-High School Graduates

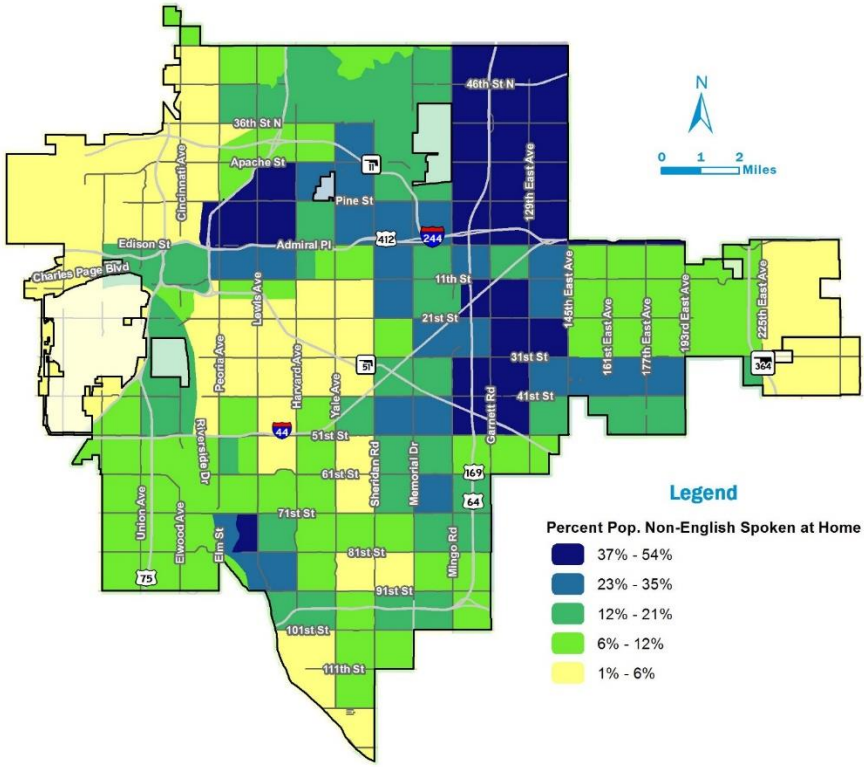


Figure 1-5 Percent of Population Under Age 5

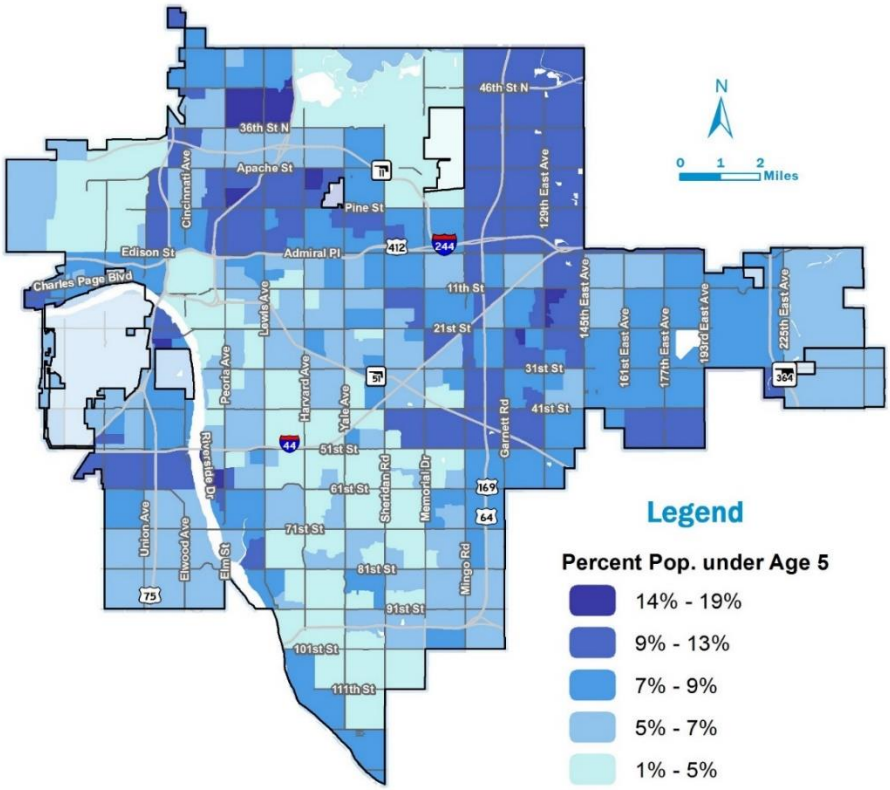


Table 1-1 City of Tulsa At Risk Populations by Council District

Jurisdiction	Age 65 & over	Under Age 5	Below Poverty Level	Non-High School Graduates	Non-English Language Spoken at Home
Council District 1	16%	8%	34%	18%	8%
Council District 2	15%	7%	25%	14%	14%
Council District 3	12%	9%	31%	28%	29%
Council District 4	16%	5%	18%	9%	11%
Council District 5	18%	7%	20%	15%	18%
Council District 6	10%	9%	18%	18%	28%
Council District 7	17%	6%	13%	8%	18%
Council District 8	21%	5%	6%	2%	8%
Council District 9	22%	5%	13%	6%	6%
City of Tulsa	16%	7%	20%	13%	15%
Source	*ESRI 2018 Demographics*		*US Census Bureau, American Community Survey (ACS) 2012-2016, Table B17020*	*US Census Bureau, American Community Survey (ACS) 2012-2016, Table S1501*	*US Census Bureau, American Community Survey (ACS) 2012-2016, Table S1601*

1.3.2 ECONOMY

After a disaster, economic resiliency drives recovery. Tulsa has specific economic drivers that are important to understand when planning to reduce the impacts of hazards and disasters to the local economy. Tulsa's major industries are aerospace, including aerospace manufacturing and aviation; health care; energy; machinery; and transportation, distribution and logistics. In the five-year period ending 2017, all sectors in the Tulsa economy but mining, information and air transportation showed positive average annual growth.[3]

1.3.3 Built Environment

The built environment includes existing structures, infrastructure systems, critical facilities, and cultural resources.

1.3.3.1 Existing Structures

All structures are exposed to risk, but certain buildings or concentrations of buildings may be more vulnerable because of their location, age, construction type, condition, or use. The total number of structures by type and estimated market value are included in Table 1-2.

Table 1-2 City of Tulsa Built Environment

Structure Type	Number	Est. Market Value
Residential Single-Family	108,496	$15,926,918,521
Residential Multi-Family	9,499	$2,444,388,739
Commercial	7,439	$8,320,803,789
Other	4,435	$221,055,048
Total	129,869	$26,913,166,098

1.3.3.2 Infrastructure

Infrastructure systems are critical for life safety and economic viability and include transportation, power, communication, and water and wastewater systems. Many critical facilities depend on infrastructure to function. For example, hospitals need electricity, water, and sewer to continue helping patients. As with critical facilities, the continued operations of infrastructure systems during and following a disaster are key factors in the severity of impacts and the speed of recovery. Oklahoma Natural Gas and Public Service Company of Oklahoma (PSO) provide gas and electric service to Tulsan's. Water, sanitary sewer, stormwater, trash, and EMSAcare are services provided by the city, and paid for by citizens. Hospitals and medical facilities are included on the list of critical facilities in Appendix A.

1.3.3.3 Critical Facilities

Critical facilities are structures and institutions necessary for a community's response to and recovery from emergencies. Critical facilities must continue to operate during and following a disaster to reduce the severity of impacts and accelerate recovery. When identifying vulnerabilities, consider both the structural integrity and content value of critical facilities and the effects of interrupting their services to the community. A complete list of public and private critical facilities is included in Appendix A.

[3] 2018 Economic Profile, Tulsa Regional Chamber, http://www.growmetrotulsa.com

1.3.3.4 Cultural Resources[4]

Tulsa is home to many cultural and historic assets that are unique or irreplaceable. Any asset that is important to the community can be considered a cultural resource. Tulsa has an amazing variety of arts and culture. Tulsa boasts the nationally recognized Tulsa Ballet, Tulsa Opera, and two orchestras, as well as numerous theatrical groups. Concert venues range from nightspots with live music to outdoor public spaces, and historic theaters to the 19,199 capacity BOK Center. World class museums like the Philbrook Museum of Art and the Gilcrease Museum allow visitors of all ages to take in the impressive cultural collections Tulsa has to offer. Tulsa is home to 23 public golf courses, 135 tennis courts, and 88 playgrounds. The Tulsa Drillers baseball team (Colorado Rockies AA farm club) draws legions of fans to ONEOK Field. The Tulsa Zoo and Living Museum, located in Tulsa's 2,800-acre Mohawk Park, one of the largest municipal parks in the country, features more than 1,500 animals representing 436 species.

Tulsa boasts one of the nation's most extensive collections of Art Deco architecture. The Downtown Deco District includes many representations of this distinctive style—the Philtower and Philcade buildings, the Atlas Life building, Tulsa Club, and Public Service Company of Oklahoma building, to name a few. Throughout the city you'll find Art Deco churches, schools, gas stations, dry cleaners, and residences designed by such masters as Bruce Goff, Francis Barry Byrne and Frank Lloyd Wright. On the south side of downtown stands one of the most celebrated examples of Tulsa's Art Deco treasures: Boston Avenue Methodist Church. The Tulsa Preservation Commission runs the City of Tulsa's historic preservation program. Commissioners and staff work with residents, building owners, neighborhood organizations, and City of Tulsa departments and officials to protect and enhance Tulsa's cultural and architectural heritage. The Tulsa Drillers baseball team (Colorado Rockies AA farm club) draws legions of fans to ONEOK Field. A few blocks away is the BOK Center, home to the Tulsa Oilers. Located in Tulsa's 2,800-acre Mohawk Park, one of the largest municipal parks in the country, the Tulsa Zoo and Living Museum features more than 1,500 animals representing 436 species.

1.3.4 Future Development

An effective way to reduce future losses is to avoid development in known hazard areas and to enforce the development of safe structures in other areas. In other words, keep people, businesses, and buildings out of harm's way from the beginning. Tulsa's Comprehensive Plan was updated in 2016. Information on this plan and others, and how mitigation was incorporated, is included in Chapter 3, *Capability Assessment.*

1.3.5 Natural Environment

Environmental assets and natural resources are important to Tulsa's identity and quality of life and support the economy through agriculture, tourism and recreation, and a variety of other ecosystem services, such as clean air and water. The natural environment also provides protective functions that reduce hazard impacts and increase resiliency. For instance, wetlands and riparian areas help absorb flood waters, soils and landscaping contribute to stormwater management, and vegetation provides erosion control and reduces runoff. Conservation of environmental assets may present opportunities to meet mitigation and other community objectives, such as protecting sensitive habitat, developing parks and trails, or contributing to the economy. Fifty miles of scenic biking/running trails run alongside Tulsa River Parks. Turkey Mountain is home to miles of hiking trails. Tulsa manages 135 parks covering roughly 6,000 acres. The Arkansas River Corridor is a big area for bird migration. The Gathering Place is home to over 1.2 million species of shrubs and over 6,000 trees and includes a wetland pond and garden.

[4] http://www.visittulsa.com/things-to-do/arts-and-culture/

Chapter 2 The Planning Process

2.1 Hazard Mitigation Planning and the Community Rating System

The planning for the City of Tulsa followed a ten-step process, based on the guidance and requirements of the FEMA Community Rating System. The ten steps are described on the following pages. The Local Mitigation Plan Review Guide, Local Mitigation Planning Handbook, and CRS Coordinators Manual, Activity 510, were used to ensure Local Mitigation Planning requirements and CRS Floodplain Management requirements were met.

2.1.1 Step One: Organize to Prepare the Plan

The City of Tulsa secured funding for this update through the Hazard Mitigation Grant Program. The planning process was formally created by a resolution of the City Council of Tulsa on August 8, 2018. The resolution designated the Tulsa Stormwater Drainage and Hazard Mitigation Advisory Board (SDHMAB) to serve as the Tulsa Citizens' Advisory Committee to oversee the planning effort. As done for the 2014 Hazard Mitigation Plan update, the SDHMAB decided to use the Program for Public Information Committee (PPI) as the Steering Committee for this project. Since adoption of the 2014 Hazard Mitigation Plan, the PPI Committee has and will continue to meet to evaluate progress and recommend changes to the plan. The PPI Committee consists of citizens, community leaders, government staff personnel, and professionals active in disasters. SDHMAB Committee and PPI Committee members and affiliation are listed below.

SDHMAB Committee Members

Crystal Kline - Consultant
Dr. David Williams - PE-USACE
Kyle Brierly - RotoRooter
Steve Walman - Commercial Developer
Terry Young - Former Mayor of Tulsa

PPI Committee Members

All SDHMAB Committee members
Brooke Caviness - COT Engineering Services, PE, CFM
Gary McCormick – COT Engineering Services, PE, CFM
Angela King – COT Engineering Services
Travis Hulse –Tulsa Planning Office at INCOG
Dustin Wright – COT Development Services
Lara Weber – COT Communications
Stan May – COT Fire Department
Michael Baker – COT Fire Department
Alisia Myers – COT WIN Liaison
Brian Lewis – COT Streets & Stormwater Department
Tracy Keeley – Oklahoma Insurance Commission
Joe Kralicek – TAEMA
Ron Flanagan – Flanagan & Associates
Tim Lovell – DRN
Sierra Massing – DRN
Dawn Seing – McGraw Realtors
Alfredo Madrid – Supreme Lending
Ed Rossman – USACE Retired
Melinda Belcher – Child Care Resource Center
Nicole Schlaefli – Tulsa City County Health Department
Nicole McGavock – NWS Tulsa
Julie Lehman – State Farm Insurance
Karen Hatfield – NWS Tulsa
Janet Meshek – Meshek & Associates
Annie Vest – Meshek & Associates
Bill Robison – Robison Consulting Services
Dee Robison – Robison Consulting Services
Barrett Waller – Propeller Communications
Jesse Boudiette – Propeller Communications

The SDHMAB and the PPI Committee met monthly at City of Tulsa offices to review preventative measures, property protection, natural resource protection, emergency services, structural flood control projects and public information. This review led to the development of the plan and recommend goals and objectives, mitigation measures, and priorities for mitigation actions. During the planning process the SDHMAB and the PPI Committee reviewed progress, identified issues, received task assignments, and advised the consultants. Staff from multiple City of Tulsa Departments were actively involved in the plan update process. Meeting dates and locations were posted by the City Clerk on the City of Tulsa website.

2.1.2 Step Two: Involve the Public

The PPI Committee undertook projects to inform the public of this effort and to solicit their input. All meetings of the SDHMAB and PPI Committee were posted and open to the public as required by ordinance. Two public meetings were held. The first public meeting held in July 2018 gave the public an opportunity to provide input on the natural hazards, problems and possible solutions to be included in the plan. The second public meeting held on April 18, 2019 gave the public an opportunity to provide input on the recommended/draft Hazard Mitigation Plan prior to adoption of the plan. Additionally, members of the PPI Committee attended a series of five community and neighborhood events to educate the public, provide a means for public input through personal interviews and a survey, and answer questions related to the planning process.

Throughout the duration of the plan update process, a webpage was made available on the City of Tulsa website with information on the plan and a short survey for the public. *https://www.cityoftulsa.org/residents/public-safety/hazard-mitigation.aspx* The website included the time and location of upcoming public mitigation meetings, explained Hazard Mitigation and the planning process, solicited public input through online surveys and emailed comments, a link to the previous Multi-Hazard Mitigation Plans and a GIS map showing site specific hazard data throughout the city. Completed surveys and public comments were used to draft the hazard assessments in Chapter 4 and the Mitigation Actions in Chapter 5. Draft chapters of the new hazard mitigation plan were posted on this website starting in October 2018.

2.1.3 Step Three: Coordinate with Other Agencies and Organizations

The PPI Committee contacted 45 entities, including neighboring communities, tribes, local, state and federal agencies, businesses and other private and non-profit organizations, hereafter referred to as Stakeholders, by email, letter, or phone. Stakeholders were personally interviewed to review their existing studies, reports and technical information and their needs, goals and plans for the area.

Four workshops were held throughout the planning process. At the first three workshops, attending Stakeholders reviewed the existing Tulsa Hazard Mitigation Plan and determined what was still relevant, assessed the identified hazards and resulting problems associated with each hazard, determined/developed appropriate mitigation measures and drafted an action plan. At the fourth workshop, attending Stakeholders reviewed the draft Hazard Mitigation Plan and provided final comments and recommendations prior to adoption of the 2019 Tulsa Hazard Mitigation Plan. 31 representatives of these Stakeholders attended one or more of these workshops. Other representatives provided input through emails. A private website was created where the draft plan was maintained so participating agencies and organizations could review and provide feedback as the plan was developed.

A list of stakeholders contacted, workshop invitations and workshop sign-in sheets are included in Appendix C .

Public and stakeholder meetings provided critical information on the vulnerability of the City to each hazard, which assisted creating the risk assessment. Input also facilitated creating and prioritizing mitigation strategies into the Action Plan. Public meetings are summarized in Table 2-1.

Table 2-1 Meeting Schedule

Meeting	Date	Purpose
Stakeholder Committee Workshop 1	July 2018	Introduction to plan process and organization. Collect information on Tulsa's existing mitigation practices and capabilities.
Public Meeting 1	July 2018	Collect Public comments on natural hazards, possible mitigation solutions, and related issues.
Stakeholder workshop 2	September 2018	Conduct a risk assessment for the City for each natural hazard.
Stakeholder Workshop 3	December 2018	Discuss possible hazard mitigation solutions for the identified natural hazards and criteria for an action plan.
Stakeholder Workshop 4	April 2019	Final discussion and comments for draft Hazard Mitigation Plan.
Public Meeting 2	April 2019	Introduce Mitigation Action Plan and collect public comments.

2.1.4 Step Four: Assess the Hazard

The PPI Committee collected data on the hazards from available sources, the 2014 Tulsa Hazard Mitigation Plan, and the 2014 State of Oklahoma Hazard Mitigation Plan. The Hazard Identification and Risk Assessment, Chapter 4, includes a description of the type, location, and extent of natural hazards that can affect Tulsa. The Plan includes information on previous occurrences of hazard events and the probability of future events. The Simple Planning Tool for Oklahoma Climate Hazards, produced by the Southern Climate Impacts Planning Program (SCIPP, www.southernclimate.org), was used for the hazard assessment. The Southern Climate Impacts Planning Program (SCIPP) is one of 11 National Oceanic and Atmospheric Administration (NOAA) Regional Integrated Sciences and Assessments (RISA) teams. Hazards from the 2014 plan were reviewed and updated in July. At the second stakeholder workshop in October 2018, worksheets from the FEMA Local Mitigation Planning Handbook were used to discuss the hazards.

2.1.5 Step Five: Assess the Problem

The hazard data was analyzed in light of what it means to public safety, health, buildings, transportation, infrastructure, critical facilities, the natural environment, endangered species and the economy.

Building footprints and property parcels were used to estimate potential losses from the site-specific hazards identified in Chapter 4 of the plan update. Building footprint polygons within the City of Tulsa were selected from computer generated building footprints covering all 50 US states released publicly by Microsoft in 2018. Polygons representing current parcel records from the Tulsa, Osage, and Wagoner County Assessors offices were obtained from INCOG. The following methodology was used to estimate the total number of structures impacted and the total market value of the properties impacted by each hazard. Property damage estimates were not calculated for the general area hazards.

Building footprint polygons that intersected spatially with each hazard were identified. The identified building footprints were then matched with their spatially coincident parcel record polygons. The total number of matching property parcel records was calculated to estimate the total number of properties impacted. The sum of the market value provided in the property parcel records was calculated to estimate the total value of properties impacted. Specific problem statements, or observations, are included for each hazard in Chapter 4.

2.1.6 Step Six: Set Goals

Project and community hazard mitigation goals and objectives for Tulsa were developed by the PPI to guide the development of the plan. The hazard mitigation goals are listed in Chapter 5.

2.1.7 Step Seven: Review Possible Activities

There were sixty-six mitigation actions identified in the 2014 mitigation plan. An annual report is prepared by Engineering Services under the direction of the PPI Committee on the status of existing Hazard Mitigation Plan mitigation actions and presented to the governing body of the City of Tulsa. This report includes the status of each mitigation action, whether or not the action is achieving expectations, and if not if it should be modified. The latest annual report is included in Appendix B. A review of the 2014 mitigation actions along with the latest annual report was completed by the planning team. Actions were evaluated with the intent of carrying over any not started, or continuous for the next five years. Actions with the same intent were combined into a general action item. Specific observations and problem statements, resulting in the actions listed in Chapter 5, are included at the end of each hazard section in Hazards, Chapter 4. Wide varieties of measures that can affect hazards or the damage from hazards were examined. A more detailed description of each category is located in *Chapter 5: Mitigation Actions.*

2.1.8 Step Eight: Draft an Action Plan

The planning team reviewed observations from the risk assessment and results of the capability assessment when considering different actions. The planning team evaluated and prioritized the most suitable mitigation actions for Tulsa to implement. The mitigation strategy analyzes actions and projects considered to reduce the impacts of hazards identified in the risk assessment and identifies the actions and/or projects that Tulsa intends to implement.

2.1.9 Step Nine: Adopt the Plan

The Draft *City of Tulsa Multi-Hazard Mitigation Plan Update 2019* was submitted to the Oklahoma Department of Emergency Management and FEMA Region VI for review and approval. The SDHMAB approved the final plan, adopted it as an amendment to the *Comprehensive Plan*, and submitted it to, and was approved and adopted by the Tulsa City Council.

2.1.10 Step Ten: Implement, Evaluate, and Revise

Adoption of the *Multi-Hazard Mitigation Plan* is only the beginning of this effort. Community offices, other agencies, and private partners will proceed with implementation. The SDHMAB and the PPI will continue to meet on a regular basis to monitor progress, evaluate the activities, and periodically recommend revisions to the Plan and Mitigation Action Items. These findings and recommendations will be included in the annual report prepared under the direction of the PPI Committee. The plan will be formally updated a minimum of every five years, as required by FEMA.

Chapter 3: Capability Assessment

3.1 Mitigation Capabilities

Communities can do a number of things to prevent or mitigate the impacts of natural disasters. Such actions range from instituting regulatory measures (e.g., building and zoning codes) and establishing Emergency Operations Plans (EOP) and Emergency Operations Centers (EOC), to purchasing fire trucks and ambulances and constructing large and small infrastructure projects like levees and safe rooms. The City of Tulsa has already made considerable investments in these critical areas. The sections that follow in this Chapter survey the regulations, plans and infrastructure that the City of Tulsa has in place for avoiding or mitigating the impacts of natural hazards. This survey is based on Task 4 of FEMA's Local Mitigation Planning Handbook and assesses Tulsa's existing authorities, policies, programs, and resources available to accomplish mitigation.

Tulsa has a unique set of capabilities, including authorities, policies, programs, staff, funding, and other resources available to accomplish mitigation and reduce long-term vulnerability. The planning team reviewed existing capabilities in Tulsa and identified capabilities that currently reduce disaster losses or could be used to reduce losses in the future, as well as capabilities that inadvertently increase risks in the community. The planning team used Worksheet 4.1 from the *Local Mitigation Planning Handbook* to review Tulsa's existing capabilities and gain a better understanding of relevant programs, regulations, resources, and practices across different departments within the City of Tulsa.

For this update, the Planning Team reviewed the information provided in *Chapter 2: Existing Mitigation Strategies* of the 2014 Plan and updated data as appropriate. Chapter 2 is renamed *from Existing Mitigation Strategies*, to Chapter 3 *Capability Assessment* herein. The Planning Team reviewed relevant community studies, plans, reports, and technical documents in the inventory, evaluation and planning phases of the Multi-Hazard Mitigation Plan development. The Comprehensive Plan and Small Area Plans were used to determine community growth patterns and identify areas of future development. The Capital Improvements Plan was used to determine priorities of public infrastructure improvements and timing of potential future development. These plans were used to identify areas of future growth and development so that hazardous areas could be identified, evaluated, planned for, and appropriate mitigation measures taken.

The Planning Team involved numerous stakeholders from neighboring communities, tribes, counties, agencies and non-profit organizations to determine if they had studies, plans or information pertinent to floodplain management that would affect and/or support Tulsa's HMP. See Chapter 2 for list of these stakeholders. In addition to local capabilities, there are several national hazard mitigation programs developed by FEMA and other agencies that are designed to help communities organize their mitigation activities. This section looks at Tulsa's participation and progress in these programs.

3.1.1 Types of Capabilities

The primary types of capabilities for reducing long-term vulnerability through mitigation planning are the following:

- Planning and Regulatory
- Administrative and Technical
- Financial
- Education and outreach

3.1.1.1 Planning and Regulatory:

Planning and regulatory capabilities are based on the implementation of ordinances, policies, local laws and State statutes, and plans and programs that relate to guiding and managing growth and development. Examples of planning capabilities that can either enable or inhibit mitigation include comprehensive land use plans, capital improvements programs, transportation plans, small area development plans, disaster recovery and reconstruction plans, and emergency preparedness and response plans.

3.1.1.2 Financial

Financial capabilities are the resources that a jurisdiction has access to or is eligible to use to fund mitigation actions. The costs associated with implementing mitigation activities vary. Some mitigation actions such as building assessment or outreach efforts require little to no costs other than staff time and existing operating budgets. Other actions, such as the acquisition of flood-prone properties, could require a substantial monetary commitment from local, State, and Federal funding sources.

Some local governments may have access to a recurring source of revenue beyond property, sales, and income taxes, such as stormwater utility or development impact fees. These communities may be able to use the funds to support local mitigation efforts independently or as the local match or cost-share often required for grant funding.

3.1.1.3 Administrative and Technical

Administrative and technical capability refers to the community's staff and their skills and tools that can be used for mitigation planning and to implement specific mitigation actions. It also refers to the ability to access and coordinate these resources effectively.

3.1.1.4 Education and Outreach

This type of capability refers to education and outreach programs and methods already in place that could be used to implement mitigation activities and communicate hazard-related information.

3.2 City of Tulsa Capabilities

This section documents what existing plans, studies, reports, and technical information were reviewed and how relevant information was incorporated into the mitigation plan. The City of Tulsa used the Capability Assessment Worksheet, below, to meet this requirement. Excerpts from applicable plans, rules, and regulations follow, which provide more detail on the existing policies related to hazard mitigation and highlight where the city has made efforts above and beyond the standard policies. Additionally, citations and footnotes throughout the document demonstrate incorporation of other plans.

3.2.1 National Flood Insurance Program (NFIP)

Tulsa joined the National Flood Insurance Program in 1971. All residents of Tulsa are eligible to purchase federal flood insurance. Tulsa's advances have earned its flood program one of the top ratings in the nation through the Community Rating System, which has allowed Tulsans to enjoy some of the lowest flood insurance rates in the nation.

The City of Tulsa will continue to meet minimum NFIP requirements and exceed those requirements by enforcing local Regulatory Floodplain Ordinances and by participating in the Community Rating System (CRS) program.

Qualified City staff is available at the Permit Center to discuss options and to help citizens plan and build a safe project while complying with City floodplain development policies. The City of Tulsa's permitting process is

designed to ensure that all construction in Tulsa is safe. A permit is required for all new construction and, most of the time, a permit must be obtained for repairing or replacing existing features.

In addition to regular building permits, special regulations apply to construction in floodways and the Regulatory Floodplain. No construction, including filling, is allowed in the mapped floodway without an engineering analysis that shows the project will not increase flood damage elsewhere. Any activity outside the floodplain but within a natural or man-made watercourse also requires a permit.

A floodplain watershed development permit must be obtained from the City of Tulsa before commencing construction, landfill, or excavation in the floodplain. New buildings in the floodplain must be protected from flood damage so our building code requires that new buildings be elevated at least one foot above the elevation of the City of Tulsa Regulatory Floodplain.

Elevation or floodproofing may be required prior to constructing a substantial improvement (the cost of the improvement or add-on is 50 percent of the value of the existing building). Permits also are required for a repair if it's more than just cleanup after a storm.

Experience has shown that the National Flood Insurance Program's minimum standard is insufficient for Tulsa. Therefore, the city's regulations exceed NFIP's standard in several important ways, as listed in the City of Tulsa Stormwater Management Plan and highlighted below:

Ultimate watershed urbanization. Runoff generally becomes deeper and faster, and floods become more frequent, as watersheds develop. Water that once lingered in hollows, meandered around oxbows, and soaked into the ground now speeds downhill, shoots through pipes, and sheets off rooftops and paving.

Insurance purposes require the NFIP floodplain maps to be based on existing watershed development. But unless plans and regulations are based on future watershed urbanization, development permitted today may well flood tomorrow as uphill urbanization increases runoff. Tulsa enforces the NFIP minimum regulations and maps, to retain eligibility for federal flood insurance. In addition, the City enforces its own more extensive maps and regulations, which are based on ultimate watershed urbanization as forecast in the comprehensive plan.

Watershed-wide regulation. Floodplains are only part of flood-management considerations. Water gathers and drains throughout entire watersheds, from uplands to lowlands. Each watershed is an interactive element of the whole. A change at one place can cause changes elsewhere, whether planned or inadvertent.

Stormwater detention. One way to avoid increased flooding downstream from new development is to provide stormwater detention basins throughout watersheds. New or substantially improved developments must detain the excess stormwater on site - unless they are exempted in master plans or allowed to pay a fee in lieu of on-site detention. Water from detention basins is released slowly downstream. In-lieu fees are allocated for regional detention facilities. In most instances, the City has found regional detention basins to function more satisfactorily than smaller, scattered on-site facilities.

Valley storage. Flood water cannot be compressed. It requires space. Encroachments into a channel or floodplain can dam, divert, or displace flood waters. Tulsa requires compensatory excavation if a development - including a flood control project - would reduce valley storage. Preserving or recreating floodplain valley storage is a keystone of the City’s program. Freeboard. NFIP regulations require finished floors of new development to be at or above the base flood elevation, based on existing watershed conditions. Tulsa includes freeboard as another margin of safety, requiring finished floors to be at least 1 foot above the regulatory flood elevation, based on ultimate watershed urbanization.

Erosion and sedimentation. Erosion and sedimentation rob hillsides of valuable topsoil, dam lowlands, clog streams, and pollute rivers. Builders must control site erosion from new development. Permits and performance standards. Tulsa requires a watershed development permit to be issued before developing, redeveloping, building, excavating, grading, regrading, paving, landfilling, berming, or diking of any property within the city.

There are five types of watershed development permits: floodway, floodplain, stormwater drainage, stormwater connection, and earth change permits. Individual residential lots outside the floodplain are exempted. Tulsa's regulations are based on adopted floodplain maps (both Tulsa and NFIP), watershed-wide master drainage plans, and development permits based on specific performance standards.

3.2.2 The Community Rating System (CRS)

The CRS is a part of the National Flood Insurance Program that helps coordinate all flood-related activities of the City. Tulsa has participated in the National Flood Insurance Program (NFIP) since 1971 and in the CRS since 1991. The CRS is a voluntary program that seeks to reduce flood losses, facilitate accurate insurance rating, and promote awareness of flood insurance by creating incentives for a community to go beyond minimum floodplain management requirements.

City of Tulsa CRS Activities

- Public Information Activities
- Mapping and Regulatory Activities
- Flood Damage Reduction Activities
- Flood Preparedness Activities

Tulsa advanced from a Class 5 to a Class 3 community on October 1, 2000. Tulsa advanced to a Class 2 community on October 1, 2003. The Class 2 rating allows Tulsa's SFHA residents a forty percent reduction in their flood insurance premium rates. All rates are based on where the structure is located in FEMA's Flood Insurance Rate Maps (FIRMs). New Digital Maps (DFIRMs) became effective in October 2012. A summary of City of Tulsa flood insurance policies, according to NFIP, as of May 31, 2018, is included in Table 2-1. Tulsa has 84 Repetitive Loss properties. Information about Repetitive Loss properties is included in Chapter 4.

Table 0-1 City of Tulsa Flood Insurance Policies

Flood Insurance	Amounts
Flood Insurance Policies in Force	1,432
Values of Insurance in Force	$363,945,900
Premiums in Force	$1,053,362
Total Losses	2,590
Flood Losses Paid	**$39,037,630**

Source: NFIP Claims Data

3.2.3 Flood and Stormwater Management

Tulsa has grown up with flooding. Unlike many communities, the City of Tulsa regulates to a higher standard in three categories of so-called "100-year" floodplain areas in order to reduce future flood losses. As a minimum standard, the FEMA Special Flood-Hazard Area (SFHA), or "100-year" floodplain, is an area that has a 1% chance of flooding in any given year. FEMA SFHA floodplains are designated on FEMA's Flood Insurance Rate Maps (FIRM). The SFHA identifies the National Flood Insurance Program's (NFIP) minimum national standard, which reflects only existing development conditions at the time of the study typically stopping where the contributing drainage area is one square mile.

City of Tulsa regulatory floodplain areas are calculated by a different standard. They take into account "100-year" flooding that would occur when contributing watersheds are fully developed and extend upstream to a

contributing drainage area of 40 acres rather than FEMA's standard of 1 square mile. Therefore, Tulsa regulatory floodplain areas may be wider than the FEMA floodplains and may extend farther up creeks and waterways. Floodways, generally the most dangerous center strip along a water course, is where water is apt to run faster and deeper. Tulsa applies more stringent regulations in floodways because of their higher risk. Throughout this report, "floodplain" will mean specifically the City of Tulsa regulatory floodplain, unless otherwise noted.

The SFHA deals with existing conditions and does not take the impacts of future urbanization into account in its modeling or floodplain map delineations. Therefore, buildings that have been permitted and built in accordance with the National Flood Insurance Program's (NFIP) minimum standards may flood in the future as the basins develop. This is why the City of Tulsa regulates to a higher standard, requiring that no insurable structure will be built that has its first finished floor less than 1 foot above the Base Flood Elevation (BFE).

Piping and paving for future urbanization and development can cause an increase in urban stormwater runoff and flood depths. In some instances, it could cause discharges to double and can widen the floodplain and cause increases in the Base Flood Elevation (BFE). Tulsa requires upstream detention of excess flows and compensatory storage to mitigate this problem.

Between 1980 and 2000, the City of Tulsa created master drainage plans for each of its major waterways. These serve as the framework for floodplain management planning and programs.

The first citywide master drainage plan was the *Flood and Stormwater Management Plan 1990–2005*. This plan prioritizes and coordinates the flood protection projects that are detailed in the city's 29 master drainage plans. The last revision of the plan was September 7, 2001. The plan summarizes the following:

- Capital Improvement Program (see next section)
- Non-Structural Mitigation/Acquisition Priority List

The City later developed the *Flood and Stormwater Management Plan 1999-2014*, published on September 10, 1998. It was developed in accordance with planning criteria from the Community Rating System (CRS), Flood Mitigation Assistance (FMA), and Hazard Mitigation Grant Program (HMGP). Although the 1999-2014 plan primarily dealt with flooding, it also addressed other natural hazards. The *Flood and Stormwater Management Plan* recommended stormwater capital improvement projects. Tulsa has established a stormwater utility fee dedicated to fund stormwater maintenance and mitigation projects.

3.3 Planning and Regulatory Capabilities

The following matrix lists the plans and ordinances and the department or agency that maintains them. A more detailed description of each plan or ordinance follows.

Summary of Plans by Agency

Plan & Regulatory	Agency or Department									
	COT Planning	COT Development Services	COT Engineering Service	COT Water & Sewer	COT Streets & Stormwater	TAEMA	Levee District 12	USACE Tulsa District	INCOG	
Comprehensive	X								X	
Capital Improvement			X							
Economic Development	X	X							X	
Emergency Operations			X		X	X	X	X		
Continunity of Operations	X	X	X	X	X	X	X	X		
Transportation	X				X				X	
Stormwater Management			X					X		
Brownsfields			X							
Dam Failure EAP			X	X		X		X		
Levee Failure EAP						X	X	X		
Debris Removal			X		X	X				
RL/Open Space			X							
2015 ICC Building Code		X	X							
Zoning Ordinance	X	X							X	
Subdivision Ordinance		X							X	
Floodplain Ordinance		X	X					X	X	
Flood Insurance Rate Maps		X	X					X	X	

3.3.1 Comprehensive Master Plan

Tulsa's comprehensive and neighborhood plans only focus on flooding as a hazard. Floodplains are used when doing mapping exercises to indicate areas inappropriate for growth. Sometimes development pressure is great enough to start pushing back against this work and the current regulations. Plans will support Capital Improvement Projects (CIPs) that address flooding when it is a threat to the planning area. All plans address the need for street trees to encourage pedestrian activity. This would make streets a little more resilient to heat hazards but wouldn't eliminate risk to them. Streetscape recommendations usually include burying overhead powerlines, which would reduce vulnerability to several hazards. However, there is no funding, incentives or the regulatory mechanisms to require burying powerlines throughout the city. Dam/Levee failure is discussed when appropriate, though planning efforts are not backed up by regulatory mechanisms like flooding. (Philip Berry, COT Planning). As the Comprehensive and Neighborhood Plans are updated, they should include a discussion of natural hazards and potential mitigation activities.

3.3.2 Capital Improvements Plan (CIP)

The City's Engineering Services Department maintains an extensive CIP program for Streets, Stormwater, Water and Sanitary Sewer projects. The CIP database is updated annually as projects are completed and new projects added. The projects are prioritized based on a point system scoring various items appropriate to each discipline. For flood control projects the items scored include: number of flooded structures, depth of flooding, critical

facilities, inundation of streets, Benefit vs Cost Analysis (BCA) and coordination with other projects such as street improvements. *(Gary McCormick, Engineering Services)* CIPs should be developed for other hazards such as tornadoes, high wind events, winter storms, etc. and a viable source of funding identified.

3.3.3 Economic Development Plan

Tulsa receives $3-4 million annually in *Community Development Block Grant* and *HOME* Funds by being recognized as an entitlement community. The application process takes place each year in May.

The *Fire Suppression Grant* rewards up to $8,000 for sprinkler connections and appurtenances located in the public right-of-way.

The *Small Business Capital Formation Tax Credit Act* authorizes an income tax credit of 20 percent of equity or near-equity investment for investors in qualified businesses, either by a qualified business capital company or by an investor. There are limitations on the amounts of investment to which credits apply. Earned credit may be taken in the year of investment or carried over for three additional years.

Tax Incentive Districts provide a five- to six-year abatement on local property taxes for specific development projects. Developers may apply to the City of Tulsa for tax abatement on projects constructed or rehabilitated within a designated Tax Incentive District. At this time, the City has one Tax Incentive District, covering real estate within the Inner Dispersal Loop (the interstate highways surrounding downtown). Additionally, projects in enterprise zones are eligible to receive the state enterprise zone investment/new jobs tax credit.

Tax Increment Financing, Oklahoma Local Development Act (1992) allows local governments to establish Tax Increment Financing (TIF) districts. Before a district can be established, a review committee consisting of representatives from each affected taxing entity and at-large public members must make a recommendation of the TIF plan. Once the committee reviews the plan, it's passed on to the City Council for a vote. The City may collect increment from ad valorem taxes, sales taxes and other local taxes. Tulsa currently has five TIF districts: Brady Village, North Peoria Avenue, Tulsa Hills, Santa Fe, and Tulsa Airport.

Economic Development Public Infrastructure Fund

Included in the Improve Our Tulsa package (2013) this fund was developed to assist, in a timely manner, with valid public infrastructure needs related to business retention, expansion and attraction. The voters approved $6.0 million over the term of the program towards these efforts based on an annual allocation approved by the Tulsa City Council as part of the City budgeting process. The criteria/objectives to be under consideration for this fund include:

- It is the objective of this fund to provide assistance with public infrastructure needs in those unique instances when this is the most appropriate program or resource.
- This fund is designed to assist in with the retention and expansion of jobs in manufacturing and office business sectors.
- If approved, the City of Tulsa will be responsible for constructing all improvements.
- It is not the intent of the policy to fund land acquisition.
- Where applicable cost sharing and potentially claw-back provisions will be negotiated.

The City of Tulsa recognizes that the most effective incentive for economic development is being a livable and vibrant community. It is recognized that Tulsa, like all cities in Oklahoma, is heavily reliant on sales tax revenues to support the City's General Fund. In order to provide the levels of programs and services necessary to remain a vibrant and livable community, the sales tax base must continue to grow. The goal of this policy is to ensure Tulsa

continues to be a great place to live and that continuing to be a regional retail center is supportive of that effort. This policy is intended to support commercial retail businesses. Minimum requirements for applicants:

- Stand-alone retail: Retailer must have projected annual gross retail sales of $20 Million by the third year of operation.
- At time of application, Retailer has no existing presence in MSA, or new development that is part of a regional retail project of at least 100,000 square feet.
- Multi business development: If the application is for a development with multiple businesses the project must contain at least 100,000 square feet.
- Underserved or distressed area: Location is within an enterprise zone, designated USDA food desert, adopted City of Tulsa Sector Plan or adopted City of Tulsa Small Area Plan.

The United States Army Corps of Engineers, Tulsa District has economists on staff at the district office that can assist with economic impact analysis in Tulsa. (Bill Smiley, USACE)

The Resilient Tulsa Strategy includes a strategy related to disaster resilience for small businesses. (Kian Kamas, COT Chief of Economic Development)

3.3.1.1 Local Partners in Economic Development

Tulsa Industrial Authority (TIA)

The Tulsa Industrial Authority (TIA) serves as a conduit in the issuance of 501 (c)(3) bonds and Industrial Development Revenue Bonds, which provide tax-exempt financing for qualified projects. TIA supplies comprehensive analysis of new issues and/or refunding opportunities and assists the borrower in finalizing a transaction strategy and structure. When a loan is passed through TIA, the IRS treats the loan as a local governmental agency special obligation. Eligible projects include those for non-profit entities (including health care), public or private colleges and universities, private high schools and grade schools, the Indian health care resource center, hospitals/nursing homes and various charities. TIA has financed or refunded over $1 billion in tax-exempt bonds.

Tulsa Development Authority (TDA)

The mission of the TDA is to improve Tulsa through programs and projects designed to utilize private and public resources that advance the physical, social and economic wellbeing of citizens and neighborhoods throughout the city. The primary objectives of the Tulsa Development Authority are to revitalize declining and underdeveloped areas, to encourage private investment and economic development, and improve the tax base through removal of slum and blight by redevelopment and rehabilitation.

Tulsa Economic Development Corporation (TEDC)

This non-profit Community Development Financial Institution was formed in 1979 as a catalyst for economic development. TEDC drives small business success through non-traditional lending programs and development services that help entrepreneurs start to expand a company. Branded as Creative Capital. TEDC uses public and private funds to make direct loans and participates with other institutions on projects that lack sufficient equity. Special considerations given to companies that create and retain jobs.

Tulsa Preservation Commission (TPC)

The City of Tulsa's Planning Department maintains a database of properties eligible for historic preservation incentives. Preservation Staff is happy to assist property owners with questions about historic status and National Register listing, historic preservation tax credits, and the International Existing Building Code's provisions for historic properties.

Downtown Coordinating Council (DCC)

The DCC provides support and advices making recommendations to the city regarding the coordination, planning and management of improvement efforts in Downtown Tulsa.

3.3.4 Local Emergency Operations Plan (EOP)

The City and other agencies maintain the following EOPs (Gary McCormick, Engineering Services):

- 2015 Flood Recognition and Response Plan – COT Engineering Services
- 2019 TAEMA Emergency Operations Plan – TAEMA
- 2011 Emergency Flood Plan – Levee District 12
- 2015 Keystone Lake EAP – USACE
- 2010 Lynn Lane Reservoir Dam Breach EAP – COT Engineering Services
- 2010 Yahola Lake Dam Breach EAP – COT Engineering Services
- 2013 Warrenton Lake Dam Breach EAP – Warren Professional Building Corporation

The USACE helps develop and update these plans through the Silver Jackets Program. (Bill Smiley, USACE)

These plans should all be consolidated into one plan and revised to include missing information:

- Key triggers
- Responsible parties
- Assets needed for response
- Time required for response
- Methods to disseminate warning messages to those in affected areas

3.3.5 Continuity of Operations Plan (COOP)

Each city owned facility/department maintains and updates their own COP. These plans identify hazards and describe appropriate actions for each hazard. Plans were last updated and reviewed in 2017. (Joe Kralicek, TAEMA, Director)

The USACE is available to help develop and update these plans through the Silver Jackets Program. (Bill Smiley, USACE)

3.3.6 Transportation Plan

Major Street and Highway Plan identifies present and future transportation corridors but does not identify HAZMAT Routes. A National HAZMAT Route registry is maintained by ODOT. (Viplava Putta, INCOG)

A Transportation Plan should be developed to include evacuation routes for known flooding areas. Additionally, the 911 system needs a way to identify flooded emergency vehicle access routes in real time.

3.3.7 Stormwater Management Plan

The Hazard Mitigation Plan identifies hazards and lists mitigation activities for each hazard. This plan is updated every 5 years as required by FEMA and is credited as the CRS Stormwater Management Plan. Each year an annual report is prepared on the status of the mitigation measures identified in the current plan. The report is presented to the mayor and city council and released to the local news media. The 2010 Citywide Master Drainage Plan consolidates the 29 Basin Master Drainage Plans to identify flooding problems and evaluate alternative actions/projects to eliminate the flooding problems. Projects identified, funded and/or completed are maintained in GIS format on a web viewer maintained by a consultant. (Gary McCormick, Engineering Services) The Citywide Master Drainage Plan should be updated to reflect the changes as shown on the GIS web viewer.

3.3.8 Repetitive Loss Area Plans (RLAP)

A repetitive loss property is a property that has received payments on 2 or more NFIP claims of $1,000 or more in a 10-year period. A repetitive loss area includes the surrounding properties with similar drainage characteristics. The owners of these properties either did not have flood insurance or chose not to file a claim. Many of these repetitive loss areas are not in the SHFA but suffer from local drainage issues like sheet flow or undersized storm sewers.

On October 21, 2017, the city of Tulsa adopted 60 Repetitive Loss Area Plans covering the 84 repetitive loss properties remaining in the city. A repetitive loss area questionnaire and letter were sent to all 667 property owners within the repetitive loss areas. Information received from these property owners along with information obtained from site visits and various Master Drainage Plans were used to determine the source of the flooding and possible solutions. The city is systematically updating each of the RLAP to evaluate and determine the best alternative for each, do a benefit/cost analysis to determine HMA grant eligibility, prepare conceptual plans as needed and develop capital improvement project requests. An annual report is presented to the mayor and city council on the status of the RLAP.

3.3.9 Other Special Plans

The North Tulsa Brownfields Plan considers floodplains, water features, topography, etc. to evaluate physical constraints on redevelopment. (Michelle Barnett, COT Engineering Services)

TAEMA participates with COT Streets and Stormwater Department in the debris removal planning process. The Debris Removal Plan is included in TAEMAs EOP. The plan is under review by FEMA for approval. (Joe Kralicek, TAEMA Director)

TAEMA maintains a long-term Recovery Plan which is included as an emergency support function in the TAEMA's EOP. (Joe Kralicek, TAEMA Director)

The USACE is available to assist with Disaster recovery planning. (Bill Smiley, USACE)

3.3.10 Building Codes, Permitting, and Inspections

Building Code: Tulsa is presently using the 2015 ICC Codes. Tulsa should consider adopting stricter codes to mitigate hazards such as flooding, high winds/tornadoes, hail, fire, etc.

BCEGS Score: 3/3

Fire Department ISO Rating: 2/9

Site Plan Review Requirements: Site plans are reviewed for drainage but lack adequate inspection. Better inspections on single family residential sites are needed to ensure grading conforms with the approved site plans.

3.3.11

Ordinance: Zoning Code does not address flooding or other hazards. (Susan Miller, INCOG)

Subdivision Ordinance: Subdivision regulations require floodplains be placed in a reserve area or ODE and are strictly enforced. They also encourage LID.

Floodplain Ordinance: The Floodplain Ordinance, Title 11-A, requires 1-foot freeboard on all new or substantially improved structures, no increase in rate or velocity of runoff and drainage systems be designed to convey the 1% flood event. This ordinance is in the process of being updated.

Flood Insurance Rate Maps: Tulsa is a FEMA Cooperating Technical Partner (CTP) that makes available federal funds to systematically update FIRMS for each basin in the city.

Acquisition of Land for Open Space and Public Recreation Uses: Significant portions of the floodplain are dedicated open space and the city has an active RL acquisition program. A significant portion of dedicated open space is reserved for natural and beneficial floodplain function.

HOW CAN THESE CAPABILITIES BE EXPANDED AND IMPROVED TO REDUCE RISK

- Plans should identify shortcomings
- Small area plans should describe needed improvements for drainage and other infrastructure.

3.4 Administrative and Technical Capabilities

The City of Tulsa has the following capabilities. These include staff and their skills and tools that can be used for mitigation planning and to implement specific mitigation actions.

Summary of Administrative, Staff & Technical by Agency

	Agency or Department									
	COT Planning	COT Development Services	COT Engineering Service	COT IT	COT Streets & Stormwater	TAEMA	Levee District 12	USACE Tulsa District	INCOG	SDHMAB
Planning Commission	X								X	
Mitigation Planning Committee			X			X				X
Maint. Programs to Reduce Risk					X		X			
Mutual Aid Agreements						X	X	X		
Chief Building Official		X								
Floodplain Administrator		X								
Emergency Manager						X		X		
Community Planner	X								X	
Civil Engineers		X	X					X	X	
GIS Coordinator	X			X				X	X	
Warning Systems/Services						X		X		
Hazard Data & Information	X	X	X	X		X		X	X	
Grant Writers	X		X			X				
HAZUS Analysis			X					X		

ADMINISTRATION

Planning Commission: The Tulsa Metropolitan Area Planning Commission (TMAPC) is part of INCOG which oversees zoning changes and assists with updating comprehensive planning for Tulsa and surrounding communities. TMAPC coordinates well with the communities and agencies it serves.

Mitigation Planning Committee: Mitigation planning is overseen by SDHMAB through the PPI Subcommittee. The HMP Update is being coordinated with numerous stakeholders in the community and surrounding jurisdictions.

Maintenance Programs to Reduce Risk: The Streets and Stormwater Department maintains creeks and other drainage systems and checks known problem areas after every significant rainfall event.

Mutual Aid Agreements: There is a statewide mutual aid compact in effect within Oklahoma that automatically allows the city of Tulsa to provide or request mutual aid to or from other jurisdictions. The City of Tulsa Police and Fire Departments have more formalized mutual aid agreements with surrounding communities' departments. Additionally, through the state of Oklahoma is an emergency mutual aid compact (EMAC) with other states that allows Tulsa to provide mutual aid if requested. (Joe Kralicek, TAEMA)

Chief Building Official: The City of Tulsa employs a full time Director of Development Services. The Development Services Department promotes safety, livability and economic growth through efficient and collaborative application of building and development codes.

City of Tulsa Engineering Services: The Engineering Services Department plans, designs and field-inspects public improvement and capital projects for the benefit of our city. Engineering Services provides and/or administers planning, engineering/architectural design and construction quality assurance services for projects involving water systems, wastewater systems, transportation, stormwater, parks and all City departments.

Grants: Grants Administration coordinates and oversees all aspects of the grant submissions and provides oversight to ensure ethical compliance. In addition, Grants Administration provides support to City departments to ensure the implementation of policies and practices are in compliance with applicable Federal, State, and local laws, regulations, and contract stipulations. Grants also provides expertise in budgeting, reporting and contract and compliance monitoring.

STAFF

****Note: All staff listed are full time employees. ****

Chief Building Official: The CBO is a CFM and receives CECs annually. All infrastructure development permits are reviewed by Development Services and inspected by Field Engineering.

Floodplain Administrator: The FPA is a CFM and receives CECs annually. The FPA reviews all private and public development plans within the floodplain.

Emergency Manager: TAEMA is trained in emergency response. TAEMA is understaffed per FEMA IS-775 suggested staffing levels for a community the size of the Tulsa Metro area. TAEMA is tasked with providing coordination for partners in all phases of a disaster. TAEMA also operates and maintains the Tulsa City/County Emergency Operations Center. (Joe Kralicek, TAEMA Director)

Community Planner: COT has a Planning Department with a staff of community planners including one CFM. Staff training covers the basics of flooding and other hazards. The CFM receives CECs annually. This department coordinates well with Engineering Services and Development Services.

Civil Engineer: COT Engineering Services and Development Services have numerous civil engineers. All who are responsible for stormwater review and planning are CFMs and receive CECs annually.

GIS Coordinator: The COT IT Department and Engineering Services have numerous GIS technicians whose primary role in hazard mitigation is mapping known hazard areas.

These capabilities can be expanded and improved by:

- Giving Building Inspectors responsibility and training for site grading and drainage inspections
- Continued coordination is needed between city departments
    - COT Planning Department, COT Office of Resilience and Equity and COT Engineering Services
    - COT Engineering Services, TAEMA and Levee District 12

TECHNICAL

Warning Systems/Services: TAEMA maintains an extensive siren network which is tested weekly and covers greater than 90% of the population of Tulsa County. COT IT Department maintains the siren hardware. COT Streets and Stormwater Department barricades streets when flooded. The Tulsa Police Department uses PA systems in vehicles for area specific warnings.

Hazard Data and Information: The HMP has extensive data and information on all hazards affecting the community. Hazard data is maintained in GIS format. Most mitigation measures in the plan are being implemented. (See Chapter TBD)

Grant Writing: The city has a Grants Department and has received numerous Hazard Mitigation Assistance grants. TAEMA has a finance and grant coordinator on staff who writes HMA grants.

HAZUS Analysis: The city utilizes HAZUS and BCA software to review projects for best alternatives and grant eligibility.

HOW CAN THESE CAPABILITIES BE EXPANDED AND IMPROVED TO REDUCE RISK

- The City should consider re-implementing a mass notification system such as Reverse 911.
- Grant applications should be prepared in advance for eligible projects for quick submittal when funding opportunities occur.

3.5 Financial Capabilities

The following is a list of funding resources for hazard mitigation the City of Tulsa has access to or is eligible for in the future.

FUNDING	USES
Capital Improvement Project	CIP funding is used for stormwater mitigation activities.
Fees for water, sewer, gas or electrical service	Utility fees are used to maintain and expand utility services.
Impact fees for new development	In some cases, developers can pay a fee in lieu of onsite detention. These fees are used for drainage improvements in the basin where the development is located.
Stormwater Utility fee	Utility fee is used to maintain and expand the stormwater drainage system.
Incur debt through General Obligation or special tax bonds	Bonds are used to fund specifically identified projects.
Community Development Block Grant	CDBG are typically used to enhance functional needs populations.
Hazard Mitigation Assistance Grant	HMA grants are used for mitigation projects whenever possible.
Federal Highway Administration Funding	FHWA funding is used for eligible transportation projects.
Oklahoma Water Resource Board Loans	OWRB loans are used for water and sewer projects through the Tulsa Metropolitan Utility Authority.

HOW CAN THESE CAPABILITIES BE EXPANDED AND IMPROVED TO REDUCE RISK

- The city needs a secure and ongoing source of funding for hazard mitigation projects besides stormwater projects
- CDBG could be used for mitigation activities serving functional needs populations

3.6 Education and Outreach Capabilities

The following education and outreach programs and methods are already in place and could be used to implement mitigation activities and communicate hazard-related information

PROGRAM/ORGANIZATION

Local Citizen Groups of Non-Profit Organizations Focused on Environmental Protection, Emergency Preparedness, Access and Functional Needs Population etc.

Disaster Resilience Network

The Disaster Resilience Network (DRN) (formerly Tulsa Partners, Inc.) empowers people, businesses and communities to reduce the impact of disasters. The DRN is a 501(c)3 nonprofit, overseen by a 15-member board. Representatives are from the Tulsa and OKC metros, Stillwater and Tahlequah. They do their work through three

core programs, each led by a multi-sector council which uses collaboration as a guiding principle for community outreach.

The **Disaster Resilient Business Council** assists small businesses and nonprofit organizations in business continuity and emergency planning. This includes providing symposia, workshops and presentations using volunteer subject-matter experts, including the signature “A Day Without Business Symposium” last held in September 2017. Other activities include providing small business Lunch and Learn seminars in conjunction with chambers of commerce and nonprofits in northeastern Oklahoma in the Spring 2018, with a planned "Test Your Plan" event for Fall 2018. In addition, members of the council regularly do speaker presentations on these topics.

The **Disaster Resilient Cross-Cultural Council** focuses on stakeholder led disaster preparedness outreach to diverse language and cultural communities, including development of the "Emergency Preparedness - Real Stories" video series in seven languages with the Tulsa Community College Center for Creativity. Recent activities include community meeting presentations in Tulsa of the “Real Stories” videos where people share their experience with disaster in their own language, with more presentations planned that includes a presentation in Oklahoma City in conjunction with the Guatemalan Consular Office. There is also a new Tornado Preparedness Card in Spanish and English for distribution at multi-cultural events developed by volunteers and printed by Public Service Company of Oklahoma in both card and 11x17 single sided posters. These were developed because Spanish language communities widely believe they should leave their homes during tornado warnings and go to big box stores or malls or their church. This council also participates in sharing information at multi-cultural festivals and community events.

The **Disaster Resilient Housing Council** promotes low impact development and disaster resilient residential construction, including the Insurance Institute for Business and Home Safety's (IBHS) FORTIFIED Home™ program. This last council provides a “resilience for all” approach, making sure that everyone, regardless of resources, has access to resilient housing strategies. Recent activities involve the promotion of the FORTIFIED Home High Wind/High Wind and Hail Programs across Oklahoma through presentations, lunch and learns, and exhibitor booths, as well as marketing upcoming IBHS FORTIFIED Wise workshops using IBHS trainers. They worked with local Habitat for Humanities in 2017 and the City of Tulsa HUD/CDBG Emergency Repair program in 2018 on developing pilot projects to bring the value of this program to all income levels.

DRN also has other ad hoc collaborative activities. They offer an annual statewide Disaster Management for Long Term Care Facilities Workshop which was held in September/October 2017 in Tulsa and Oklahoma City with presentations from state and local experts. They helped Tulsa apply for the Rockefeller Foundation 100 Resilient Cities/Resilient Tulsa initiative and participated in the Oklahoma City Community Foundation Central Oklahoma Resiliency Project, offering on-going feedback on ways to promote community preparedness and resiliency. The Executive Director has served on the Tulsa Area Long Term Recovery Committees for the March 2015 and March 2016 tornadoes, and on the OK VOAD Community Preparedness Committee, in each case representing our organization. And they oversee a contract for the City of Tulsa Program for Public Information Committee tied to the National Flood Insurance Program Community Rating System. (Tim Lovell, Director, DRN)

Tulsa Ministerial Alliance
provides outreach and support to functional needs populations. Annual activities include the annual Back-to-School Bash, an effort to provide school supplies, school uniforms and food baskets to some 60 area schools the alliance has adopted. Other annual activities and programs include Thanksgiving and Christmas food basket giveaways, and college scholarships. The alliance is also involved with development of a youth center in north Tulsa, in collaboration with a number of partners. (Rev. Steve Whitaker, John 3:16 Mission)

Catholic Charities of Eastern Oklahoma
Catholic Charities Disaster Relief Services provides a range of services for families and individuals affected by disasters such as tornadoes, floods and wildfires. Catholic Charities offers individualized short-term response and long-term disaster case management services after a disaster has struck. Short-term response services may consist of providing food, clothing and emergency financial assistance, in addition to meeting the immediate emotional and spiritual needs of those impacted. Long-term disaster case management services guide an

individual or family through the financial and emotional difficulties after a disaster, which may last a long period of time.

Catholic Charities also has a preparedness program called *Plan, Prepare, Protect* comprised of a four-level program below. (MaryLynn Lufkin, Catholic Charities Director)

1. Prepare the people
2. Ready the resources
3. Prepare the plan
4. Ready the resilience

Community Service Council
The mission of the Community Service Council is to confront challenges to health, social, education and economic opportunities, and strategically advance effective community-based solutions. Their Child Care Resource Center focusses on emergency preparedness and provides the city up to date location information about child care programs in case of an emergency or disaster. Tulsa Weather Coalition helps citizens with no air conditioner, medical need and low income by providing free air conditioners and information on how to stay cool and what signs to watch for with heat related illness. 211 helpline is also under the umbrella of the Community Service Council and provides community resources and information to 37 counties in Oklahoma, including Tulsa County. During an emergency or a disaster, they are viewed as first responders to help with information sharing.

Ongoing Public Education or Information Program

- Program for Public Information promulgates extensive information on flooding and other hazards. (Tim Lovell, DRN Director)
- Stormwater Quality Assurance uses billboards, radio and TV advertisements that promote environmental stormwater quality. (Scott VanLoo, Stormwater Quality Assurance Manager)
- Tulsa Fire Department has outreach programs on fire safety, smoke detectors and the need for an emergency action plan. (Stan May, TFD PR)
- TAEMA has a Preparedness Application for Apple and Android devices called Tulsa Ready. The Tulsa Ready application helps people prepare for disasters by providing information on how to prepare go-bags and other important safety tips. (Joe Kralicek, TAEMA Director)
- Tulsa City/County Health Department has a robust emergency preparedness and response program which provides education and outreach related to preparedness and recovery for all hazards.
- Tulsa City/County Health Department conducts community assessments for public health response (CASPER) periodically. (Alicia Etgen, Tulsa City/County Health Department)

Natural Disaster or Safety Related School and Child Care Programs

- Child Care Resource Center provides training and technical assistance for emergency preparedness for child care programs.
- The **American Red Cross Pillowcase Project** is a free, interactive preparedness program designed for youth ages 8 to 11. The program aims to increase awareness and understanding of natural hazards and teaches safety, emotional coping skills, and personal preparedness.
- Tulsa Fire Department does fire safety shows at elementary schools.
- Tulsa Area Safe Kids teaches injury prevention training and pedestrian and bicycle safety in Tulsa public schools. (Melinda Belcher, Child Care Resource Center Manager)
- News on 6 Wild Weather Camp: News On 6 Chief Meteorologist Travis Meyer and the News On 6 WARN Team show students how to stay safe during lightning, tornadoes, and flash flooding. Students get to participate in interactive experiments that show just how powerful mother nature can be. **Trav's Wild Weather Camp** has made more than a dozen stops at elementary schools across Green Country.

StormReady Certification: Yes

Firewise Community Certification: There are some communities within the city of Tulsa that are Firewise Community certified, but not the city of Tulsa.

Public-private Partnership Initiatives Addressing Disaster-related Issues: USACE Silver Jackets Program has helped Tulsa develop outreach to levee protected areas, areas inundated by the 1986 floods and assistance with levee certification through the System Wide Improvement Framework (SWIF) program.

3.7 Smart Growth Audit

The purpose of a safe growth audit is to analyze the impacts of current policies, ordinances, and plans on community safety from hazard risks due to growth. This section assesses the impact of planning and regulator capabilities in the City of Tulsa. The following is intended to inform citizens and decision makers about important safety issues.

3.7.1 Comprehensive Master Plan

Land Use

The overall Comprehensive Plan primarily maps land use by type of development; i.e. single family, multi-family, commercial, etc. The future land use map uses floodplains when being created but does not identify other natural hazard areas. The Small Area Plans go into more detail and map areas in floodplain, environmental concerns/brownfields, etc. The land use policies within the Comprehensive Plan do not address natural hazards. This is covered in the Subdivision and Development Regulations. The Comprehensive Plan provides space for future growth outside natural hazard areas. The Park/Open Space Land Use was added to identify areas that are inappropriate for development due to hazards. (Philip Berry, COT Planning)

Transportation

Capacity projects identified in the Regional Transportation Plan (RTP) consider all environmental issues including HAZMAT, industrial or other areas that are environmentally sensitive. Projects involving federal funds also document these issues using the NEPA process. RTP takes into consideration land uses planned, using forecasts that identify developable parcels to avoid flood zones, industrial areas or other areas that are environmentally sensitive. The RTP does not address evacuation routes but emergency vehicle access is evaluated and considered. (Viplav Putta, INCOG) TAEMA has identified various evacuation routes along the Arkansas River. (Joe Kralicek, TAEMA)

Environmental Management

Some environmental systems, such as flood related or water supply systems, are identified and mapped. Watersheds are protected and enhanced. Tulsa's natural and sensitive areas are protected and conserved. Policies to support this goal are:

- Ecological sensitive areas are identified and prioritized.
- Natural and sensitive areas are protected and preserved.
- Sensitive areas are protected by regulating development on affected sites.

Planning and development of parks and trails are coordinated with the Comprehensive Plan and Parks Plan. Stormwater is captured and cleaned through landscape design, downspout disconnection and other environmentally friendly techniques. Non-point source pollution is reduced through Low Impact Development (LID) principles, creative building practices and smart site design that can retain and treat stormwater generated on-site. (Philip Berry, COT Planning)

Public Safety

Several goals of the Comprehensive Plan overlap with mitigation topics. There are development policies related to flood and fire safety. (Philip Berry, COT Planning)

3.7.2 Zoning Ordinance

The zoning ordinance conform to the comprehensive plan in terms of discouraging development and redevelopment within natural hazard areas. Floodplains are taken into account when rezoning cases are considered. (Philip Berry, COT Planning)

3.7.3 Subdivision Regulations

The Subdivision Regulations require that all floodplains be placed in a reserve area or overland drainage easement prohibiting construction of insurable structure or anything that will block the flow of water. (Susan Miller, INCOG)

3.7.4 Capital Improvements Program and Infrastructure Policies

The Capital Improvement Program and Infrastructure Policies do not limit expenditures on projects that would encourage development in areas vulnerable to natural hazards. The program provides funding for Hazard Mitigation projects identified in the Hazard Mitigation Plan; i.e., flood control, acquisition, water and sewer systems and fire protection. (Gary McCormick, COT Engineering Services)

3.7.5 Other

- Small Area Plans identify natural hazard areas, review existing infrastructure, and avoid or mitigate these areas. (Philip Berry, COT Planning)
- Current building code requires all structures be designed to withstand 115mph winds and all critical facilities be protected from the 0.2% (500 year) flood event. (Michael Ling, COT Development Services)
- The Evacuation Plans are included in the Tulsa City/County EOP. TAEMA maintains and reviews the EOP annually.
- The Mass Care Plan is overseen by TAEMA, with the American Red Cross taking the lead role and supported by other agencies. (Joe Kralicek, TAEMA)

Chapter 4: Risk Assessment

The risk assessment helps communicate vulnerabilities, develop priorities and inform decision-making for both the hazard mitigation plan and for other emergency management efforts. Expert and community leaders obligated themselves to countless hours of stakeholder workshops, steering committee meetings, and data collection and analysis. The 2019 risk assessment provides the factual basis for developing a mitigation strategy for the city. This assessment is designed to provide the city a deeper understanding of specific hazards. The results should be integrated into future emergency management planning and recovery, and future development efforts. For the 2019 update, Tulsa envisioned that the risk assessment be more easily understood and used as a tool. With that in mind, a web-based version of the risk assessment may be found online at maps.meshekgis.com/tulsahazards

Developing the 2019 Risk Assessment

The 2014 risk assessment included assessments of each individual council district. For the 2019 update, the city found it unnecessary to profile the council districts individually, and the risk assessment was consolidated into one city-wide assessment to eliminate redundancy. The risk assessment was updated and enhanced to provide the most current and robust data and information for quantifying the cost-effectiveness of potential hazard mitigation projects. A GIS Analysis was conducted to include any new/modified/updated information (including hazard, land use, and development trends), findings, research, and risk data. New, readily available, credible technical data was incorporated into the analysis as appropriate.

Hazard Identification

Tulsa considered a full range of hazards that could affect the city for the 2019 HMP Update. The process included a review of the 2014 HMP, a review of the state hazard mitigation plan, a review of previous events and losses, as well as information on the frequency, magnitude and costs associated with hazards that have struck Tulsa or could do so. Extensive outreach was conducted to subject-matter experts to ensure the appropriate elements of each hazard were included and best-available data was used for the risk assessment.

Hazards of Concern

At a meeting on July 24, 2018, a group of 50 Stakeholders participated in the first of four Stakeholder workshops for the plan update. Considering the 16 hazards identified in the 2014 Hazard Mitigation Plan, the stakeholders decided all hazards remained valid, but some should be combined to reduce redundancy. The planning team considered hazards addressed in the State of Oklahoma Hazard Mitigation Plan. The hazards of concern evaluated for the 2019 HMP Update are presented below; the order of the listing does not indicate the hazards' relative severity:

- Dam & Levee Failure
- Drought
- Earthquake
- Expansive Soils
- Extreme Heat
- Fire
- Flooding
- Hail
- Hazardous Materials
- Lightning
- Tornado/High Wind
- Severe Winter Storm

Tornado and High Wind; Dam Failure and Levee Failure; Wildfire and Urban Fire; HazMat and Transportation, were separate hazards in the 2014 HMP but are profiled together in the 2018 update

Hazards Summary

The classifications for probability, and overall significance, as defined on Worksheet 5.1 in the FEMA Local Mitigation Planning Handbook, met Tulsa's needs and methods, and were used in the 2019 risk assessment.

Definitions for Classifications:

Probability of Future Events

Unlikely: Less than 1 percent probability of occurrence in the next year or a recurrence interval of greater than every 100 years.

Occasional: 1 to 10 percent probability of occurrence in the next year or a recurrence interval of 11 to 100 years.

Likely: 10 to 90 percent probability of occurrence in the next year or a recurrence interval of 1 to 10 years •

Highly Likely: 90 to 100 percent probability of occurrence in the next year or a recurrence interval of less than 1 year.

Overall Significance

Low: The event has a minimal impact on the planning area.

Medium: The event's impacts on the planning area are noticeable but not devastating.

High: The criteria consistently fall in the high classifications and the event is likely/highly likely to occur with severe strength over a significant to extensive portion of the planning area.

Table 4-1: Summary of Hazard Probability and Overall Significance

Hazard	Probability	Overall Significance
Flooding	Highly Likely	High
Severe Winter Storm	Likely	High
Tornado	Likely	High
Dam & Levee Failure	Occasional	High
Extreme Heat	Highly Likely	Medium
Fire	Highly Likely	Medium
Hail	Highly Likely	Medium
Hazardous Materials	Likely	Medium
Drought	Highly Likely	Low
Expansive Soils	Highly Likely	Low
Lightning	Highly Likely	Low
Earthquake	Unlikely	Low

Disaster History

Of the 173 federal disasters declared in the State of Oklahoma from 1955 to September 2018, Tulsa County received 27 major disaster declarations (DR) and five fire management assistance declarations (FM).Table 4-2 outlines each FEMA declarations including Tulsa County since 1955. It should be noted that declarations prior to 1964 do not contain county data as it is not available (FEMA 2018). FEMA DR-4222 is the only disaster declared since the 2014 hazard mitigation plan.

Table 4-2: City of Tulsa Disaster Declarations[1]

Disaster Number	Title	Year of Declaration Date
314	HEAVY RAINS & FLOODS	1971
317	SEVERE STORMS & FLOODING	1972
392	SEVERE STORMS, FLOODING, & TORNADOES	1973
419	HEAVY RAINS & FLOODING	1974
453	SEVERE STORMS & FLOODING	1974
441	SEVERE STORMS & FLOODING	1974
491	SEVERE STORMS & TORNADOES	1975
504	SEVERE STORMS & FLOODING	1976
709	SEVERE STORMS & FLOODING	1984
704	SEVERE STORMS & TORNADOES	1984
778	SEVERE STORMS & FLOODING	1986
987	SEVERE STORMS & TORNADOES	1993
991	SEVERE STORMS, TORNADOES & FLOODING	1993
3118	EXTREME FIRE HAZARD	1996
1272	OK, TORNADOES 5/3/99	1999
3158	SEVERE WINTER AND ICE STORM	2000
1355	SEVERE WINTER ICE STORM	2001
1401	SEVERE WINTER ICE STORM	2002
3219	HURRICANE KATRINA EVACUATION	2005
1623	EXTREME WILDFIRE THREAT	2006
2628	SPERRY FIRE	2006
3280	SEVERE WINTER STORMS	2007
1735	SEVERE WINTER STORMS	2007
1678	SEVERE WINTER STORMS	2007
3272	SEVERE WINTER STORMS AND FLOODING	2007
3308	SEVERE WINTER STORM	2010
1876	SEVERE WINTER STORM	2010
2946	265TH WEST FIRE	2011
3316	SEVERE WINTER STORM	2011
1985	SEVERE WINTER STORM AND SNOWSTORM	2011
2944	TURLEY FIRE	2011
4222	SEVERE STORMS, TORNADOES, STRAIGHT-LINE WINDS, AND FLOODING	2015

[1] www.fema.gov

4.1 Flood

4.1.1 Hazard Description

A flood is the partial or complete inundation of water over normally dry land. Common impacts of flooding include damage to personal property, buildings, and infrastructure; bridge and road closures; service disruptions; and injuries or even fatalities. There are three common types of flooding in Tulsa: riverine flooding, flash flooding, and urban flooding.

Riverine flooding occurs from excessive rainfall in upstream areas that forces rivers and streams to rise and overflow their banks, inundating the adjacent floodplains. Riverine flooding is usually a gradual process, with several hours to several days of warning time for downstream communities. This type of event usually remains in flood for a longer period than flash or urban flooding, and often causes more damage due to the length of time structures are inundated, the velocity and depth of water, and floating debris.

Flash flooding is associated with large convective thunderstorms that frequent the region and can drop between 1 and 5 inches of rain in the course of an hour. When the soil is already saturated, rainfall from such storms can converge in creeks and streams suddenly, with little warning. Flash floods can reach peak flows within a few minutes. Waters from flash floods move with great force and velocity and can tear out trees, carry away houses and outbuildings, and destroy roads and bridges. These walls of water often carry large amounts of debris, sewage and pollutants. Although potentially hazardous to life and destructive of property, flash flooding usually lasts only a matter of hours.

Urban flooding occurs when heavy rainfall runs off of structures, parking lots and streets and converges in culverts and drainage ways often clogged with debris. This causes streets to flood and storm sewers to back up.

4.1.1.1 Location

Tulsa's 213 square miles contain 56 creeks and watersheds, which directly or ultimately drain into either the Arkansas River or into Bird Creek, a tributary to the Verdigris River. A major ridgeline runs diagonally through Tulsa, from northwest to southeast. Watersheds to the southwest of the ridge generally flow to the Arkansas River, and those to the north and east into Bird Creek FEMA and Tulsa have identified those areas within the watersheds of Tulsa's streams that have a 1% (100-year) chance of flooding in any given year.

The City of Tulsa adopted a *City of Tulsa Regulatory Floodplain* based on a 1% or 100-year flood under the maximum level of planned ultimate development under fully urbanized conditions that is anticipated within the drainage basin. These floodplains are extended upstream in the drainage basin to a point where there is approximately 40 acres of drainage compared to the SFHA floodplains which only extend to a point where there is approximately one square mile of drainage area. It is important to note that while FEMA digital flood data is recognized as best available data for planning purposes, it does not always reflect the most accurate and up-to-date flood risk. Flooding and flood related losses often do occur outside of delineated special flood hazard areas. Tulsa flood problems are widely dispersed and could be divided into several categories:

- Floods along major waterways with very large drainage basins, such as the Arkansas River and Bird Creek;
- Flash floods along tributary creeks and water ways that ultimately drain into the Arkansas River or Bird Creek;
- Floods that impact streets and transportation systems;
- Localized drainage and nuisance flooding problems.

The master drainage plans identified the “problem areas” within each basin, analyzed alternative solutions to those problems and provided recommended solutions, many of which are on the City’s CIP list. As noted in this section, nearly all areas of Tulsa are at risk to the flood hazard. For this plan update the planning team found it important to focus on mitigating flood risk in recurring problem areas. The areas are identified on the floodplain map in Figure 4-1 and described in Table 4-3.

Figure 4-1: City of Tulsa FEMA Floodplains and Areas of Concern

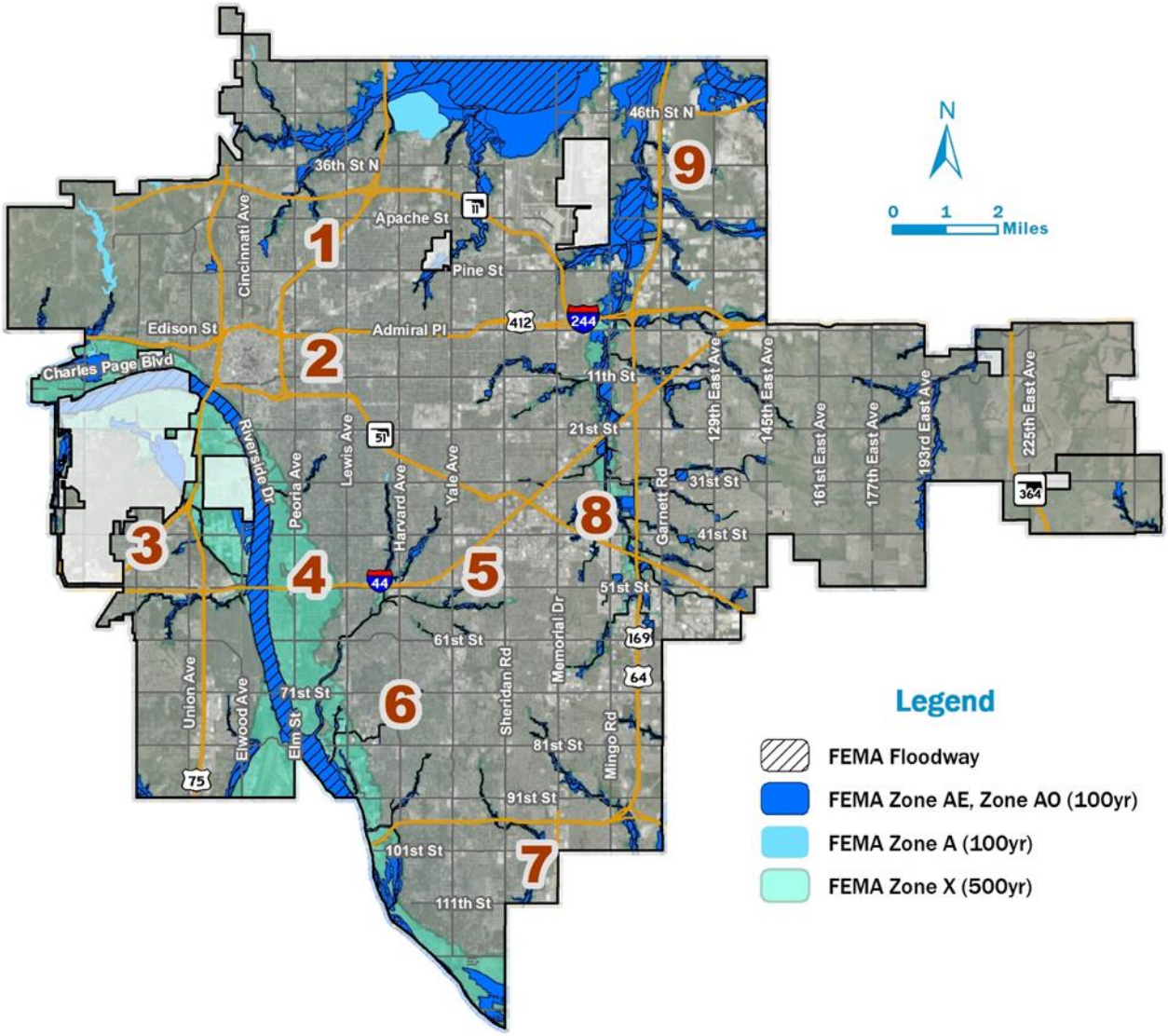


Table 4-3: Flood Location Descriptions

Area	Source	Description	Location
1	Dirty Butter Creek, Tributary RB1	High level of flooding of public & private property. Apache Street overtopping	NW Corner of Pine and Xanthus
2	Elm Creek	Flooding of residential and commercial properties and streets due to an undersized storm sewer system.	Elm Creek from E. 3rd St. to approximately E. 10th St. between Peoria Ave. and Lewis Ave.
3	Red Fork Creek	Flooding of Crystal City Shopping Center and surrounding buildings	Between Southwest Boulevard and I-244 east of 33rd West Ave.
4	Perryman Ditch	Flooding of streets and residential properties.	East and West of Rockford Ave. north from I44 to approximately E. 46th St.
5	Little Joe Creek	Flooding of the Thorton YMCA and residential properties and streets.	On S. Hudson Ave. and S. Irvington Ave. from E. 50th St. to E. 46th St.
6	Fred Creek	Overtopping of Harvard Ave.	Harvard Ave. south of 73rd St.
7	Fry Ditch No. 2	Severe erosion threatening streets and residences.	From 101st St. between 76th E. Ave and 77th E, Ave., south to approximately 106th St.
8	Fulton Creek	Flooding of residences and severe erosion of the creek threatening buildings.	From approximately 38th St and 86th E. Ave., north to the confluence with Bell Creek near 33rd Pl. and 89th E. Ave.
9	Little Creek	Flooding of 36th Street, 1/2 mile	36th St. North between Garnett Road and 129th E. Ave.

4.1.1.2 Extent

Floodplain Management is based on the “1% or 100-year flood”, which is a flood that has a one percent (1%) chance of occurring in any given year. FEMA has established the Special Flood Hazard Area (SFHA), more commonly referred to as the 1% or 100-year flood level, as the base flood elevation (BFE) for planning and development along waterways. As a part of its regulatory function the National Flood Insurance Program (NFIP) has established zones which are used in Flood Insurance Rate Maps (FIRM). These zones have a direct bearing on the flood insurance rates paid by the owner of a structure in the respective zones. Table 4-4 lists zones identified for use in regulating construction in the floodplain and for determining insurance rates for properties located in the floodplain. It is estimated that the average structure in the SFHA will experience 2 feet of flooding, which will result in 25% damage to the structure

and 25% damage to contents. The maximum non-creek floodplain is 6-feet in depth, in an overland flow area of Joe Creek.

Table 4-4: FEMA Flood Insurance Rate Map Flood Zones[2]

Zone A	**The 100-year or Base Floodplain. There are six types of A zones**:	
	A	The base floodplain mapped by approximate methods, i.e., BFEs, are not determined. This is often called an unnumbered A zone or an approximate A zone.
	A1-30	These are known as numbered A zones (e.g., A7 or A14). This is the base floodplain where the FIRM shows a BFE (old format).
	AE	The base floodplain where base flood elevations are provided. AE zones are now used on new format FIRMs instead of A1-30 zones.
	AO	The base floodplain with sheet flow, ponding, or shallow flooding. Base flood depths (feet above ground) are provided.
	AH	Shallow flooding base floodplain. BFE's are provided.
	A99	Area to be protected from base flood by levees or Federal flood protection systems under construction. BFEs are not determined.
	AR	The base floodplain that results from the de-certification of a previously accredited flood protection system that is in the process of being restored to provide a 100-year or greater level of flood protection.
Zone V and VE	**V**	The coastal area subject to velocity hazard (wave action) where BFEs are not determined on the FIRM.
	VE	The coastal area subject to velocity hazard (wave action) where BFEs are provided on the FIRM.
Zone B and Zone X (shaded)	Area of moderate flood hazard, usually the area between the limits of the 100-year and the 500-year floods. B zones are also used to designate base floodplains or lesser hazards, such as areas protected by levees from the 100-year flood, or shallow flooding areas with average depths of less than one foot or drainage areas less than one square mile.	
Zone C and Zone X (unshaded)	Area of minimal flood hazard, usually depiction FIRMs as exceeding the 500-year flood level. Zone C may have ponding and local drainage problems that do not warrant a detailed study or designation as base floodplain. Zone X is the area determined to be outside the 500-year flood.	
Zone D	Area of undetermined but possible flood hazards.	

4.1.1.3 Previous Occurrences

In Tulsa, floods have accounted for many of the most frequent and most costly weather disasters. In the 15 years between 1970 and 1985, Tulsa County experienced nine major floods, serious enough to be declared federal disasters – the most federal flood disasters on record for any community in the nation at that time. Extent of the 1984 and 1986 floods are shown in Figure 4-2. Flood events have continued to impact Tulsa in recent years. The NCEI Storm Events Database includes reports of 27 flood events in the City of Tulsa since 2000, 14 of which are after approval of the previous hazard mitigation plan. Narratives of some previous flood events in the jurisdiction are included in Table 4-5.

[2] Understanding Your Risks, Identifying Hazards and Estimating Losses, FEMA 386-2

Figure 4-2 Tulsa 1984 and 1986 Flood Extents

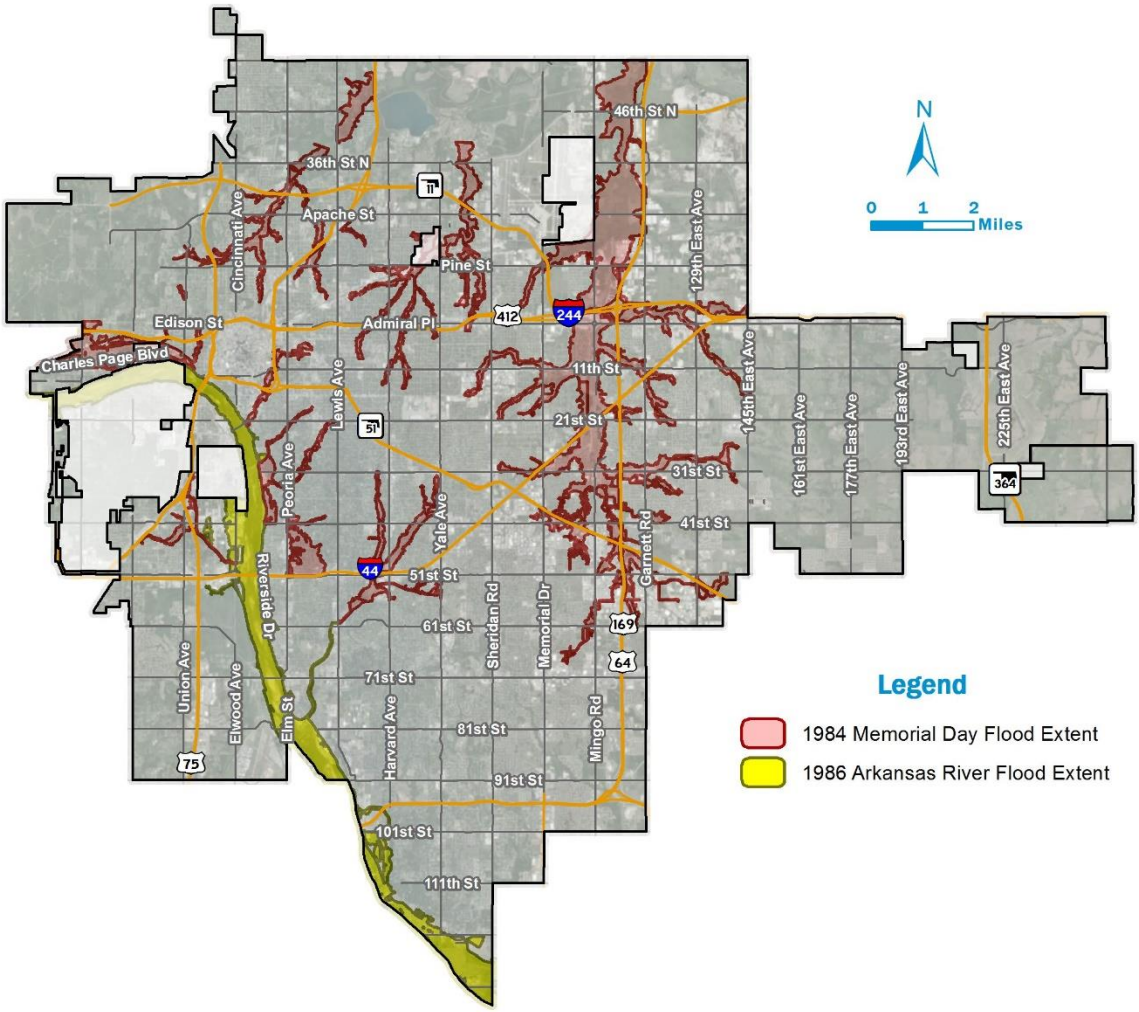


Table 4-5: Flood Event Narratives[3]

Date	Event Narrative
May 10, 1970.	The Mother's Day Flood in Tulsa caused $163,000 in damages on rapidly developing Mingo and Joe Creeks.
April, May and September 1974	April and May floods left $744,000 in damages on Bird Creek. Violent storms and tornadoes June 8 caused widespread flooding on Joe, Fry, Haikey and Mingo Creeks in Tulsa County, with more than $18 million in damage.
May 31, 1976.	On Memorial Day, a 3-hour, 10-inch deluge centered over the headwaters of Mingo, Joe and Haikey Creeks in Tulsa caused a flood that killed three and caused $40 million in damage to more than 3,000 buildings.

[3] NCEI Storm Events Database

Date	Event Narrative
May 26-27, 1984	**The 1984 Memorial Day Flood,** the worst in the city's history, was Tulsa's watershed point. After a muggy Sunday afternoon, a stalled cool front produced some 15 inches of midnight rain, centered over Mingo Creek but also extending across most of the city. The results were disastrous. The 1984 Memorial Day Flood killed 14, injured 288, damaged or destroyed nearly 7,000 buildings, and left $180 million in damage ($257 million in 1994 dollars). Mingo Creek alone accounted for $125 million of the damage. The newly elected mayor and street commissioner had been in office for only 19 days, but both knew the issues well. In the darkest hours of the city's worst disaster, they pledged to ensure that such a disaster would never be repeated. Before daylight, they had assembled the City's first Flood Hazard Mitigation Team to develop the community's strategy. Within days, a new approach to Tulsa flood mitigation, response and recovery was developed. As ultimately implemented, the program included the relocation of 300 flooded homes and a 228-pad mobile home park, $10.5 million in flood control works, and $2.1 million in master drainage plans. The total capital program topped $30 million, mostly from local capital sources, flood insurance claim checks, and federal funds.
October 1986	**The 1986 Arkansas River Flood** was a first test of the new stormwater management program. It also served as a reminder of the finite protection of Keystone Dam. Between September and October 1986, Keystone Reservoir filled to capacity, forcing the Corps to release water at the rate of 310,000 cubic feet per second. Downstream flooding was inevitable. At Tulsa, a private west bank levee failed, causing $1.3 million in damage to 64 buildings. The city fielded its hazard-mitigation team and cleared 13 substantially damaged structures.
May 29,1994	Heavy rainfall resulted in flash flooding in the west and south parts of Tulsa. Hager Creek overflowed its banks, and some homes were evacuated. Some structures near 81st Street South and Elwood Avenue had 2 to 4 feet of water in them, and houses were also flooded near 71st Street South and Harvard Avenue. A total of 8 to 12 homes were flooded in the city. Numerous roads were closed due to the flooding, including Interstate 44 from 33rd West Avenue to Union Avenue. Water was waist deep on the access road to I-44, and 1 foot deep on the interstate itself.
October 5, 1998	Major street flooding in Tulsa included the areas of 31st and Yale, 96th and Sheridan, and two feet of water over the road at 28th and 129th East Avenue. Damages were estimated at $30,000.
August 26, 1999	More than 20 streets in Tulsa had to be closed. Tulsa police responded to 39 vehicles that were stalled in high water. Lower Mingo Creek overflowed, flooding undeveloped areas near 36th Street North. Lower Haikey Creek at 101st Street also escaped its banks. Northern Tulsa County had flooding along the Bird Creek. Damages for the countywide event were estimated at $40,000.

Date	Event Narrative
May 6, 2000	Over 6 inches of rain fell over Tulsa County, causing widespread flooding. Damage to roads, bridges and infrastructure was estimated at $200,000, while countywide it was about $3 million. One fatality occurred when a woman attempted to cross a street flooded by a nearby stream.
October 13, 2012	Three teenagers were playing near rain-swollen Coal Creek in north Tulsa. Two of the three teenagers got out of the water safely, but one was washed downstream and drown by the flood waters. He was found the following morning about a mile and a half downstream from where they were playing. Several cars were reported stranded in high water from downtown Tulsa north to around Mohawk Park. Property damage was reported to be $20,000.
May 8, 2015	Sections of I-44 were closed due to water covering the roadway. Several cars were stalled in the flood water. Widespread heavy rainfall resulted in moderate flooding of Bird Creek near Sperry and Owasso.
May 20-23, 2015	Widespread flooding occurred in Mohawk Park with access roads inaccessible. Extensive flooding also occurred near Mingo Road and 56th Street North and 66th Street North. Portions of E 51st Street were flooded between Harvard Avenue and Yale Avenue. Portions of S Sheridan Road were flooded between E 41st Street and E 51st Street. Roads were flooded near the intersection of E 41st Street and S Yale Avenue. Major flooding in east Tulsa with three feet of water over 90th East Avenue and S 33rd Street. Roads and yards were flooded near the intersection of E 26th Street and S 139th E Avenue. The Broken Arrow Expressway underpass was impassable due to flooding near the vicinity of E 31st Street and S Yale Avenue. Portions of S Utica Place were flooded. Major flooding occurred at E 49th Street and S 72nd E Avenue. Flood water inundated a bridge on E 51st Street. Several retention ponds in the vicinity of Highway 51 and Highway 169 were nearly full and threatened to overtop their banks. Streets were flooded near N Delaware Avenue and E 46th Street N. Roads were flooded near the intersection of E 61st Street and S Utica Avenue. Flooding near E 21st Street and S Utica Avenue closed roads.
December 27, 2015	Eight to ten inches of rain fell across much of northeastern Oklahoma. This excessive rainfall caused moderate flooding of the Polecat Creek near Sapulpa, moderate flooding of the Caney River near Collinsville, and moderate flooding of the Bird Creek near Sperry and Owasso. Bird Creek near Owasso rose above its flood stage of 18 feet at 2:45 am CST on December 27th. The river crested at 23.51 feet at 5:30 pm CST on the 28th, resulting in moderate flooding. Extensive flooding occurred in Mohawk Park with access roads inaccessible. Mingo Road between 56th Street north and 66th Street North was closed. The river fell below flood stage at 10:30 am CST on the 29th.

Date	Event Narrative
July 2, 2017	Storms developed into eastern Oklahoma during the late afternoon and early evening. The strongest storms produced damaging wind gusts and locally heavy rainfall. Portions of S Lewis Avenue were flooded between E 61st Street and E 71st Street. A car was driven into the water, where it stalled. The roadway was flooded in and around the intersection of E 41st Street and S Sheridan Road. Several cars were driven into the water, where they stalled.
August 15, 2017	Thunderstorms developed during the afternoon of the 15th across northeastern Oklahoma in advance of a cold front that moved into the region. Heavy rain occurred across portions of Tulsa County, resulting in localized flooding. Portions of W 21st Street S were flooded between Chandler Park and the Arkansas River bridge.

4.1.1.4 Probability of Future Events

Overall Probability Rating based on Classifications in Table 4-1: Highly Likely. Based on the 27 flood events that occurred from 1998 through 2018, the City of Tulsa should expect an average of two or three minor flood events each year and major flood events on a less frequent basis.

4.1.2 Vulnerability and Risk Assessment

Overall Significance based on Classifications in Table 4-1: High: The criteria consistently fall in the high classifications and the event is likely/highly likely to occur with severe strength over a significant to extensive portion of the planning area.

4.1.2.1 People

In Tulsa, 1,863 residential single-family structures, 200 residential multi-family structures, and 347 commercial structures are touched by the SFHA floodplains. In a citywide 1% or 100-year flood, over 31,000 individuals could be displaced by flooding within or near the inundation areas. HAZUS estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. The model estimates 5,539 households will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 15,551 people (out of a total population of 391,906) will seek temporary shelter in public shelters.

People are affected by flooding in numerous ways. These include life, safety and health problems as well as financially by damage to structures and personal property. More people die from flooding than any other natural disaster. The majority of these deaths are the result of driving through flooded areas. Early warning systems help reduce the number of these fatalities. There are both short- and long-term health risks associated with flooding. Flood waters are contaminated with e-coli and fecal coliforms from sanitary sewer overflows and animal waste as well as hazardous chemicals which can cause immediate health problems. There is also a long-term health risk from mold remaining in flooded structures.

For the plan update it was important to the planning team to take a closer look at who was specifically at risk to flooding. Knowing the size and geographical location of potential at risk populations (such as small children, the elderly and the impoverished) are important to assessing areas of highest vulnerability, and prioritizing actions for risk reduction.

Poverty-stricken neighborhoods in Tulsa experience flooding frequently. One example is Problem Area 1 in **Error! Reference source not found.**, located at NW Corner of Pine and Xanthus in north Tulsa. In this area there is a high level of flooding of public and private property, and Apache Street overtops. According to 2018 ESRI census information, between 55% and 65% of the population in this area live below the poverty level. Figure 4-3 maps floodplains and poverty levels by census tract. Tulsa should implement recommendations of the Master Drainage Plan to alleviate flooding in this area.

Another example is the Bell Fulton Area, identified as number 5 in **Error! Reference source not found.**. This area is in need of increased detention to reduce flooding of residential structures. The average household income is between $20,737 and $54,311, and the majority of Tulsan's in this area are over the age of 65. In a 100-year event, several residential structures in this area may be inundated with 3ft-5ft of water. Residents in this area are less likely to afford the cost of recovery and may have a more difficult time evacuating. Mitigating flood losses in low-income areas is consistent with Goal 2.3 of the Resilient Tulsa Strategy, *"Prepare all Tulsans, particularly socially, and economically vulnerable populations, to weather adverse events."*[4] Figures 4-4 and 4-5 map additional populations that may be a higher risk during a flood event.

4.1.2.2 Economy

Flooding causes significant economic losses. Disruption to transport causes business interruption; damage to business contents; vehicle damages; and extensive damage to infrastructure. Flooding of roads, and key transportation routes can have significant impacts on the economy. The Tulsa International Airport (TUL) and the Tulsa Port of Catoosa, the nation's most inland seaport, connect the region with international trade and transportation. The Port of Catoosa suffered significant impacts as a result of the 2015 flood event when strong water flows and silt buildup along the navigation system, called shoaling, which limits the required 9-foot depth of the channel for water transport. As a result, barges were unable to enter or leave the port for most of May and June. The cost to clear a single shoal was $1 million.[5]

[4] 2017 Resilient Tulsa Strategy
[5] https://stateimpact.npr.org/oklahoma/2015/07/06/record-rains-leave-oklahomas-inland-seaport-damaged-and-dangerous/

Figure 4-3: Percent of Population Below Poverty Level in FEMA Floodplain

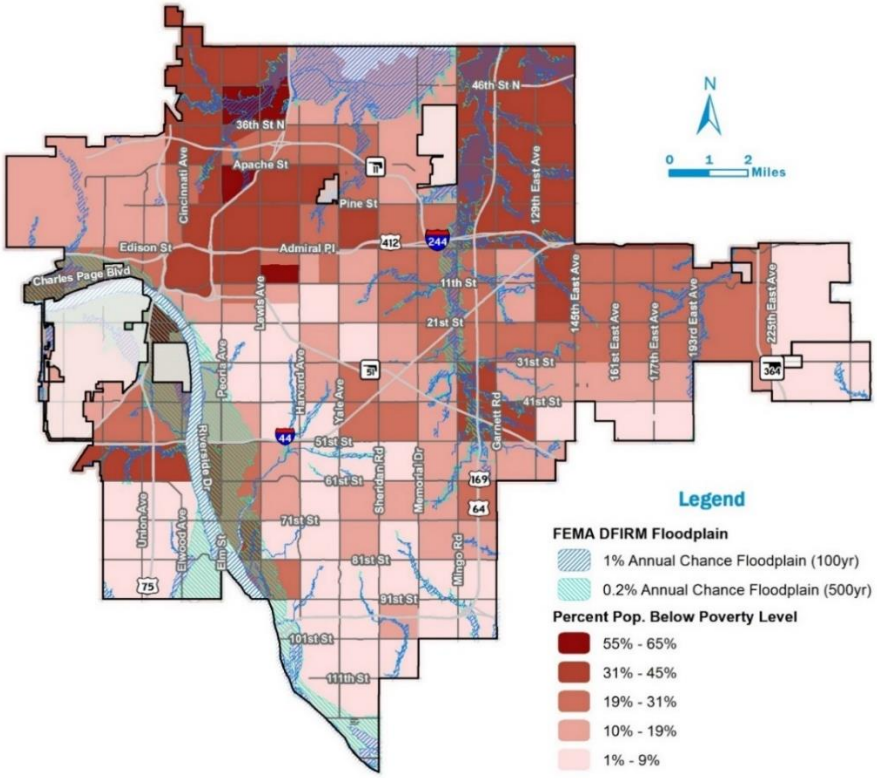


Figure 4-4: Percent of Population Age 65 & Older in FEMA Floodplain

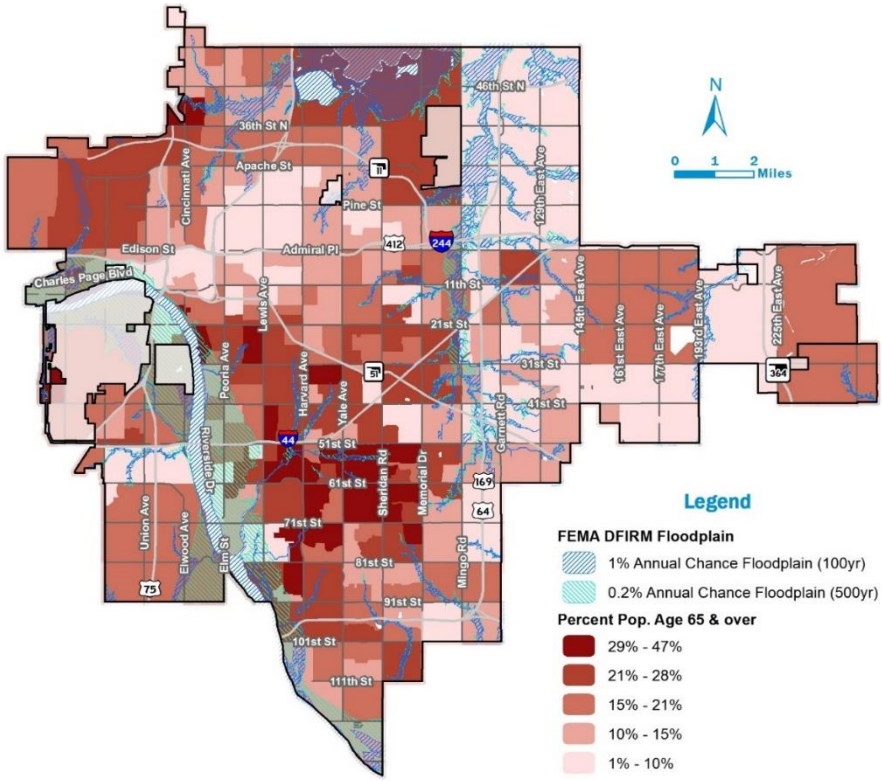
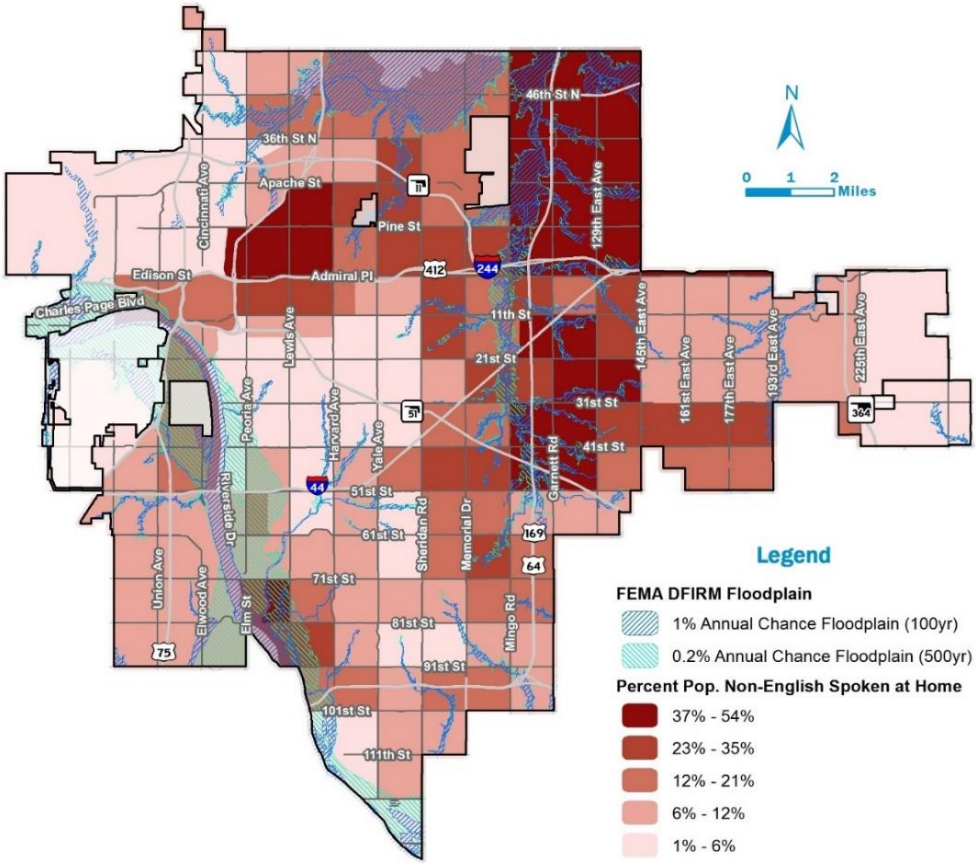


Figure 4-5: Percent of Population Non-English Speaking in FEMA Floodplain



4.1.2.3 Built Environment

Existing Structures In order to assess flood risk, a GIS-based analysis was used to estimate exposure to flood events using local tax assessor records in combination with building footprint data. The determination of assessed value at-risk (exposure) was calculated using GIS analysis by summing the improved values for parcels and structures that were confirmed to be located within an identified floodplain. Table 4-4 presents the potential at-risk property. Building footprint data allows for a significantly more accurate estimate of the structures inside the SFHA. As shown in Table 4-4 below, of the 7,226 parcels touched by the SFHA only 2,506 of these parcels have the structure touched by the floodplain. Structural values used in this assessment were from the Tulsa County Assessor's Office. It is estimated that the average structure will experience 2 feet of flooding, which will result in 25% damage to the structure and 25% damage to contents. HAZUS estimates that about 1,788 buildings will be at least moderately damaged. This is over 61% of the total number of buildings in the scenario. There are an estimated 188 buildings that will be completely destroyed.

There are 84 Repetitive Loss (RL) properties broken into 60 Repetitive Loss Areas (RLAs), shown on Figure 4-6. These are areas with building flooding for which the owners have filed NFIP claims. To be a repetitive loss property, the owners must have filed at least 2 claims of $1,000 or more within any rolling ten-year period. In 2017, the City of Tulsa adopted RLA plans for each of the RLAs which evaluated the source of flooding and the appropriate mitigation actions for each. NFIP data and more information on the RLA plans is contained in Chapter

3, Capability Assessment. The City continues to mitigate these RLAs through acquisition or structural measures which has resulted in a reduction from 93 in the 2014 HMP to 84 currently.

Table 4-46 2018 Structures and Parcels Touched by SFHA[6]

	2018 Building Footprints		2018 Parcel Boundaries	
Improvement Type	Number	Est. Market Value	Number	Est. Market Value
Residential Single-Family	1,863	$176,218,014	3,784	$482,331,838
Residential Multi-Family	200	$106,694,500	641	$383,972,907
Commercial	347	$179,152,543	949	$948,327,891
Other	196	$2,144,345	1,852	$23,513,381
Total	*2,506*	*$464,209,402*	*7,226*	*$1,838,146,018*

Infrastructure Tulsa's most likely ongoing threat from flooding would be a flash flood event. During a storm event that is producing a large amount of rainfall over a short period of time, it is highly likely that several roadway intersections will become inundated and impassable. With this in mind, plans being developed or implemented for street and/or roadway improvements within the jurisdiction should consider mitigation measures to reduce flooding of these roads and intersections. The City's Watershed Master Drainage Plans (MDPs) were developed for all of the watersheds affecting the City of Tulsa to identify flood risk within the City. They have recommendations, including stormwater detention facilities, roadway culverts and bridges adequately sized to safely store and/or convey the 1% (100-year) flood. Additionally, those MDP's have recommendations for changes or additions to the creek channels, storm sewer systems and areas where floodplain buyouts are the best solution. All City of Tulsa infrastructure improvement projects are subject to recommendations within the respective master drainage plan for the area.

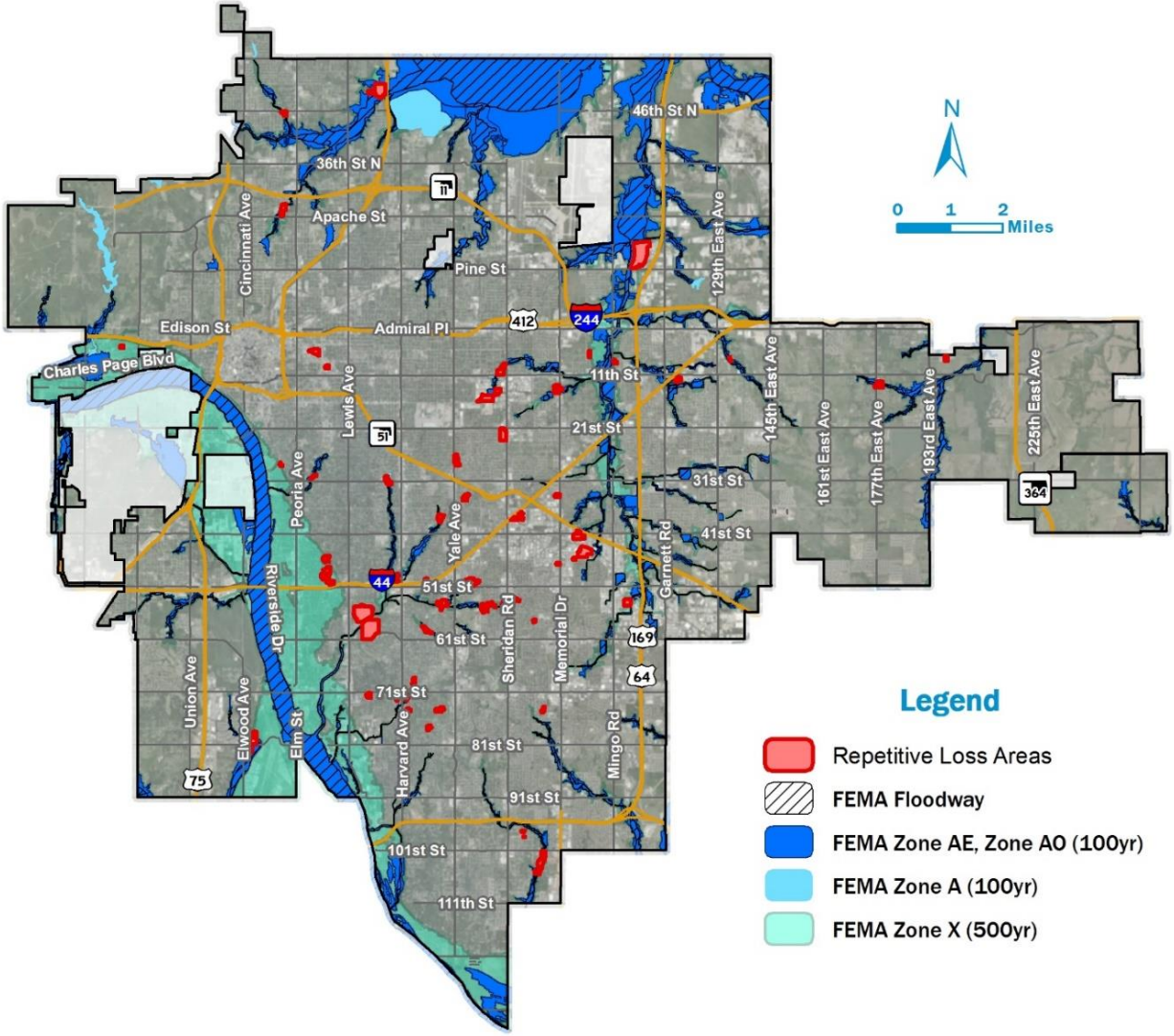
Critical Facilities Tulsa has 26 critical facilities touched by or adjacent to the city's floodplains. Critical facilities located in the floodplains pose a problem for the community since, in the event of a flood, the impacts reach beyond the flooding of the facility Tulsa's currently adopted building code requires that all new critical facilities be protected to the 0.2% or 500-year level of flooding. HAZUS estimates five essential facilities will be moderately damaged, buildings will be at least moderately damaged; one will sustain substantial damage; and seven will have total loss of use. This is over 61% of the total number of buildings in the scenario. There are an estimated 188 buildings that will be completely destroyed.

Cultural Resources There are no historic buildings that intersect with the 100-year floodplain. Of the Historic Districts in the city of Tulsa, only one intersects with the 100-year floodplain, Ranch Acres Historic District, located between 31st and 41st street, from Harvard to Yale.

Future Development As development in new areas and revitalization of existing ones continue, locations and building techniques should be closely examined. With Tulsa's strong commitment to maintaining current flood plain zoning guidelines, it is not anticipated that any new critical facility development will occur within flood-prone areas of the jurisdiction. Any renovations or improvements made to existing critical facilities in the 100-year floodplain should be evaluated to ensure the prescribed improvements will help mitigate potential damage from a future flood event. Plans being developed or implemented for street and/or roadway improvements within the jurisdiction should consider mitigation measures to reduce flooding of these roads and intersections.

[6] 2018 Microsoft Structure Data, 2018 Tulsa County Assessor Data

Figure 4-6: Repetitive Loss Areas



Natural Environment Flood events can provide both negative and positive impacts on the environment. As a natural occurrence, flooding helps trigger life processes such as migration, and seed dispersal in flora and fauna. Negative impacts on the environment are generally a result of sedimentation and debris. Since the 1970's Tulsa has had an extensive Repetitive Loss acquisition program. Over 1,000 properties have been acquired to date. Figure 4-6 shows the repetitive loss areas. All of the properties acquired are preserved as open space to prevent redevelopment and future flood losses. In some instances, especially in the Mingo Creek Basin, entire neighborhoods were acquired. These large tracts of land are now utilized as parks and recreation areas.

The City also requires all new development to dedicate the entire floodplain in an overland drainage easement or reserve area with no habitable structures allowed. In addition to preventing flood losses this serves as a buffer zone along the creeks which improves water quality. The City owns and maintains over 2,700 acres of open space in a natural state to provide the natural and beneficial function of the floodplain.

4.1.3 Summary of Observations and Recommendations

Observation(s)	Recommendation	Action
Tulsans rely on warning sirens as primary source of weather notifications.	Educate the public on purpose of outdoor warning sirens and promote NOAA weather radios.	6
Some areas of Tulsa are less equipped to prepare for or recover from hazard events.	Create community facilities (resilience hubs) that can serve as gathering places during emergencies and interruptions in services, and outfit such facilities with access to key services, including water, electricity for charging cell phones, etc. Such capabilities could be integrated into schools and other existing community facilities.	29
Tulsa experiences flood events on an annual basis. As development continues, and the frequency and severity of flooding increases, it is important for all citizens to understand the benefits and costs of flood insurance.	Tulsa should continue annual floodplain notifications and educate the public on the importance of flood insurance.	17
Tulsa prioritizes stormwater projects with a positive BCA, in the CIP and HMP for implementation.	Tulsa should review the CIP projects for opportunities to leverage available FEMA funding on an annual basis.	19,21
Thousands of structures are located in the SFHA, and 88 RL properties remain.	The city should continue to acquire flood prone properties using FEMA Hazard Mitigation Assistance Funds.	19
Multiple jurisdictions have authority for response and recovery during and after a flood, dam, or levee event in the Arkansas River Corridor.	The City of Tulsa should partner with neighboring jurisdictions and stakeholders, including state, Tribal, and Federal partners to develop a comprehensive response and recovery plan for the Arkansas River.	20
Several critical facilities are located within the inundation area at risk of flooding.	Consider relocating facilities based on level of risk, or mitigating flood risk through elevation or floodproofing	21
Some areas of Tulsa are less equipped to prepare for or recover from hazard events.	Apply for HMGP funds and build to higher standards in future recovery efforts. CDBG can match HMGP.	2
Some areas of Tulsa appear to be out of range of an outdoor warning siren	Install, update, and maintain warning sirens.	5

4.2 Severe Winter Storms

4.2.1 Hazard Description

A winter storm is a winter weather event that produces impactful accumulations of freezing rain (ice), sleet and/or snow. (NWS 2018. Winter storms may include heavy snowfall, blowing and drifting snow, high winds, extreme cold or ice storms. Among the most significant hazards associated with winter storms are traffic accidents. The most extreme instance is a blizzard, which is defined as winds greater than 35 mph, visibility less than ¼ mile, lasting at least 3 hours. New snowfall is not necessary for a blizzard; blowing snow can similarly obscure visibility. Winter storms are measured by snowfall accumulation or ice thickness. Winter storms occur in Tulsa between November and March and are usually created by large low-pressure systems moving rapidly across the country. In Tulsa, ice storms are a greater threat than blizzards. Access to moisture from the Gulf of Mexico falling over shallow cold air near the surface can produce ice accumulations of two inches or greater with tremendous damage to power distribution.

4.2.1.1 Location

The risk of this hazard is uniform over the entire City of Tulsa.

4.2.1.2 Extent

During the winter months, Tulsa occasionally experiences snowfall combined with high winds, freezing rain or ice storms. Total seasonal snowfall averages around 8 inches. Greatest annual snowfall was 36.3 inches. The greatest daily snowfall was 14 inches. The snowfall season usually runs from November to April. Tulsa has experienced ice accumulation of up to 3 inches thick in some areas during ice events. 1/4 to 1/2 inch accumulations can break small branches and weak limbs, while 1/2 to 1-inch accumulations can cause larger branches to snap off.

The Sperry-Piltz Ice Accumulation Index, shown in Figure 4-7, is a tool used to predict the types of damage that may occur before a winter storm striking. The Sperry-Piltz Ice Accumulation Index, or SPIA Index, can accurately predict the location, timing, and severity of ice storm impacts days in advance. The tool allows corporations, and other entities better prepare for severe ice events.

Figure 4-7 Sperry Piltz Ice Accumulation Index

The Sperry-Piltz Ice Accumulation Index, or "SPIA Index" – Copyright, February, 2009

ICE DAMAGE INDEX	DAMAGE AND IMPACT DESCRIPTIONS
0	Minimal risk of damage to exposed utility systems; no alerts or advisories needed for crews, few outages.
1	Some isolated or localized utility interruptions are possible, typically lasting only a few hours. Roads and bridges may become slick and hazardous.
2	Scattered utility interruptions expected, typically lasting 12 to 24 hours. Roads and travel conditions may be extremely hazardous due to ice accumulation.
3	Numerous utility interruptions with some damage to main feeder lines and equipment expected. Tree limb damage is excessive. Outages lasting 1 – 5 days.
4	Prolonged & widespread utility interruptions with extensive damage to main distribution feeder lines & some high voltage transmission lines/structures. Outages lasting 5 – 10 days.
5	Catastrophic damage to entire exposed utility systems, including both distribution and transmission networks. Outages could last several weeks in some areas. Shelters needed.

(Categories of damage are based upon combinations of precipitation totals, temperatures and wind speeds/directions.)

Tulsa may experience a winter storm event with wind surface winds gusting over 30 mph and over a foot of snow accumulation. Tulsa may experience an ice storm with greater than 3 inches of ice accumulation and a rating of 5 on the SPIA.

4.2.1.3 Previous Occurrences

The NCEI Storm Events Database includes reports of severe winter storm events on a regional basis. Severe winter storms are, by nature, not isolated events – therefore it could be stated that winter weather events affecting Tulsa County also had some impact on the City of Tulsa. The NCEI database includes reports of 26 winter weather events between 1998 and 2018. Severe winter weather resulted in four Presidential Disaster Declarations, in Tulsa. The most significant ice storm in Oklahoma took a devastating toll on Tulsa in 2007, and in 2011 record snowfall shut down the Tulsa World newspaper for the first time in its history. These events are summarized below.

December 2007

FEMA DR-1735

One to two inches of ice accumulated on trees and power lines. Tulsa began to lose power on December 9, 2007. The peak of the outage was Dec. 10 at 5:15 p.m. when 262,128 homes and businesses had no power. That was half of the customer base. The Red Cross opened 34 shelters in Tulsa County with more than 1,800 people registering to spend the night. In Tulsa alone, there were 2.7 million cubic yards of debris. The event caused six fatalities (4 fire fatalities, 1 traffic fatality, 1 hypothermia fatality); Tulsa International Airport closed to incoming/departing flights for 24+ hours; three Tulsa hospitals were forced to rely on emergency generators. The total countywide per capita impact for Tulsa County was $5.92 million. As a result of the storm, over 1,000 distribution poles and approximately 150 transmission poles broken, approximately 9,000 meter enclosures damaged and approximately 1,000,000 miles of power lines repaired/replaced (not all in Tulsa). Additionally, 5,500 restoration workers were utilized (as opposed to 800 in normal operations) working nearly 80,000 man-hours per day, with support staff handling more than 512,600 calls pertaining to the event.

February 2011

FEMA DR-1985

Oklahoma was hit by the "Groundhog Day Blizzard" that dumped a record 14 inches of snow on Tulsa, with more snow following on February 4th and 7th. Tulsa International Airport was closed, as was I-44 between Stroud and Miami, along with the Creek, Indian Nations and Muskogee Turnpikes. In the early phase of the "back-to-back blizzards", temperatures dropped into the single digits and remained below freezing during the day. High winds dropped the wind-chill temperatures as low as 36˚ below zero in some parts of the state. Water mains broke. For the first time in 111 years, the Tulsa World cancelled its print editions for three days. Tulsa's public schools were closed for eight days due to this series of winter storms. A Presidential disaster declaration was declared for Tulsa County, Tulsa's 14" snowfall broke the record for the most snow for the date, the most snow ever for February, and the most from a single storm. Schools, businesses, government agencies, and even Interstate highways were closed.

4.2.1.4 Probability of Future Events

Overall Probability Rating based on Classifications in Table 4-1: Highly Likely

According to the SCIPP Simple Planning Tool, years consisting of a large number of snowfall days declined significantly across the southern United States between 1930 and 2007. Models suggest that although the number of snowfall events will likely continue to decrease given overall atmospheric warming when snow does occur, accumulations will be greater due to increases in atmospheric moisture (Krasting et al. 2013). There is significant uncertainty surrounding the future of ice storms in Tulsa. Observational data limitations and the complexity of the events themselves make it difficult to determine with much specificity whether patterns have and/or will change. Models show that by mid-century there will generally be a northward shift of the rain, sleet

and snow dividing line across the central United States. This shift will add to the complexity of determining precipitation type for winter events (rain, ice or snow) in Oklahoma, however, the increase in atmospheric moisture may bring an increase to the amount of precipitation that does fall (Easterling et al. 2017).

4.2.2 Vulnerability and Risk Assessment

Overall Significance based on Classifications in Table 4-1: High, the criteria consistently fall in the high classifications and the event is likely/highly likely to occur with severe strength over a significant to extensive portion of the planning area.

4.2.2.1 People

The entire population is exposed to severe winter storm events. Thirty-two deaths were linked to the historic ice storm in December 2007: 19 related to traffic accidents, eight succumbed to hypothermia, and three caused by accidental falls on ice. The city of Tulsa works closely with VOADs to open shelters as necessary in the event of power outages. These shelters are different than social services offered to homeless populations year-round, addressed below.

Transportation Accidents: Snow packed hills and slick road surfaces increase the frequency and impact of traffic accidents for the general population, resulting in personal injuries. Trouble spots for Tulsa include the hilly terrain of South Tulsa, which causes a lot of trouble for drivers. Tulsa police identify three specific areas of concern: 61st and Sheridan, Yale between 81st and 91st, and 111th between Sheridan and Memorial. These roads have been closed for several hours in the past due to the number of vehicles stuck. There is potential for injury during every winter weather event. When winter precipitation is forecast, Tulsa Police Department activates Operation Slick Streets. When activated, officers will not respond to non-injury accidents. If weather analysis forecasts sleet or a light mist before snow or ice, Tulsa will pre-treat the roads. Pre-treatment applies mostly to bridges and hills, with a few exceptions dependent on conditions. There is no pre-treatment with heavy rains before a storm transitions to snow or ice. Rain will wash away the salt material.

Hypothermia: Hypothermia is a potentially dangerous drop in body temperature caused by prolonged exposure to cold temperatures. Victims of hypothermia are most often elderly people with inadequate food, clothing, or heating; babies sleeping in cold bedrooms; and people who remain outdoors for long periods Older adults are especially vulnerable. Being outside or in a cold house can cause an older person's body temperature to drop below 95 degrees and cause many health problems, even death.

Vulnerable Populations: Tulsans with low incomes may not have access to housing or their housing may be less able to withstand cold temperatures. They may resort to alternate methods of heat such as space heaters or using the oven as a heat source. Additionally, subsidies are available through the Low-Income Home Energy Assistance Program (LIHEAP) to help low-income households meet the cost of home energy. All LIHEAP assistances are subject to available funding by the Federal government.

Homeless populations face the risk of freezing to death in the absence of shelter, especially during winter weather events. There are several warming stations throughout Tulsa, including John 3:16 Mission, the Equality Center, Tulsa County Social Services, and the Salvation Army. Some are even open 24 hours per day. These facilities plan for overflow during winter weather events.

4.2.2.2 Economy

One of the biggest hits the economy takes during a winter storm event is in the form of lost wages, and sales at places like restaurants and retailers.

4.2.2.3 Built Environment

Existing Structures A direct threat to structures/buildings from a severe winter event is excessive snow/ice accumulation onto flat or low-grade sloped roofing surfaces. This is especially true of older structures that were not constructed to withstand this type of stress. Commercial structures face the same impacts of winter weather as residential properties. More indirect threats to structures/buildings would be from power outages causing interruption to heating and refrigeration (loss of supplies, food, sensitive equipment), frozen water pipes (excessive flooding causing damage to interior and sensitive electronic equipment if pipes break), and fires (caused by power lines being torn away from structure or power surges as lost power is restored).

Infrastructure

Electric: The most severe consequence of a winter storm on Tulsa's infrastructure is damage to power lines caused by the added weight and surface area of ice accumulation, combined with the additional stress of wind. These two factors can cause devastation to the power supply.

Gas: During winter events, Oklahoma Natural Gas (ONG) experiences a variety of challenges in meeting the needs of the Tulsa jurisdiction, including: damage to gas meters from ice accumulation, falling power lines or tree debris, inaccessibility to underground gas meters from falling debris, danger to field employees related to road conditions, downed power lines, extreme temperatures.

Water/Wastewater: The most significant threat to the operation of Tulsa's four wastewater treatment plants during a winter storm would be power outages. All four plants and lift stations have either double feeds or generators.

Transportation: All manner of transportation would be at risk during a winter event in the Tulsa jurisdiction. Road closures due to ice/snow accumulation can result in loss of retail trade, wages, and tax revenue. Such closures often exceed $10 million/day in the eastern part of the country. The inability of public transportation (to function after a winter event can also contribute to increased risk to the population if it hampers access to necessary medical care or safe shelter.

The City of Tulsa is responsible for clearing snow and ice from certain segments of the Tulsa expressway system and all arterial (main) streets. Other expressway segments in Tulsa are the responsibility of the Oklahoma Department of Transportation. Severe winter weather could result in the interruption of normal operations at Tulsa's International Airport and the city's private business airports. Significant ice or snow accumulations can impact runway safety and result in cancellation or major delays in regular flight schedules.

Critical Facilities All critical facilities in the City of Tulsa are susceptible to the potential impacts of a winter storm event. Among other things, power outages interrupt vital services, and snow/ice accumulation or debris from damaged trees result in inaccessibility due to road closures or blockages. During the December 2007 ice storm, three of Tulsa hospitals were dependent on generator power for an extended time, and one nursing home was evacuated. Additionally, only one Tulsa Police Substation had an operational fuel station. Tulsa Fire Department reported that 13 of their stations were without power (some without heat) and they were running low on oxygen bottles. Tulsa should ensure private medical facilities, such as urgent care and nursing homes, are educated on the importance of backup power capabilities in the event of a power outage. Tulsa could also consider a generator rebate program, through the FEMA Hazard Mitigation Grant Program, to assist facilities with the cost of backup generators.

Cultural Resources All cultural institutions in Tulsa are exposed to winter weather. The most likely effect of this hazard on cultural resources would be structural damages caused by heavy snow loads.

Future Development All future development is exposed to winter storm events. Powerlines in areas of future development should be buried to avoid power loss. Generators should be installed at all critical facilities.

Natural Environment The City of Tulsa's urban forest includes over 5.2 million public and private trees. The Tulsa Urban Forest Master Plan includes strategies for a resilient urban forest that is safe and maintained. Tree loss is almost **inevitable** in ice events such as the 2007 storm. There is no official estimate on the number of trees lost to the ice storm. However, it is estimated about 1 million years in tree growth was lost to the storm. To insure integrity of the tree count, Re-Green Tulsa, a privately funded drive, was established to fund 20,000 trees.

4.2.3 Summary of Conclusions and Recommendations

Observation	Recommendation	Action
High percentage of low-income population are elderly and unable to afford adequate heating leading to hypothermia.	Educate the public on locations of shelters and energy assistance programs.	1, 4
Nearly every hazard can cause power outages. During the 2007 ice storm, 13 fire stations lost power. Additionally, a hospital had to rely on backup power for a short period.	Tulsa should assess the need for generators at critical facilities and implement as funding becomes available.	14
The occurrence of an ice storm will result in substantial amounts of debris, blocking roads and isolating areas of Tulsa.	Tulsa should be prepared to remove debris post-disaster and be ready to request Federal assistance when warranted.	7
Tulsa fire reports higher incidences of fires and carbon monoxide during winter weather due to improper use of alternate heating methods.	Educate the public on winter weather preparedness and safety.	1
Small businesses may not be able to afford the installation of a generator on site.	Develop a generator rebate program and fund through the FEMA Hazard Mitigation Grant Program.	14

4.3 High Wind and Tornado

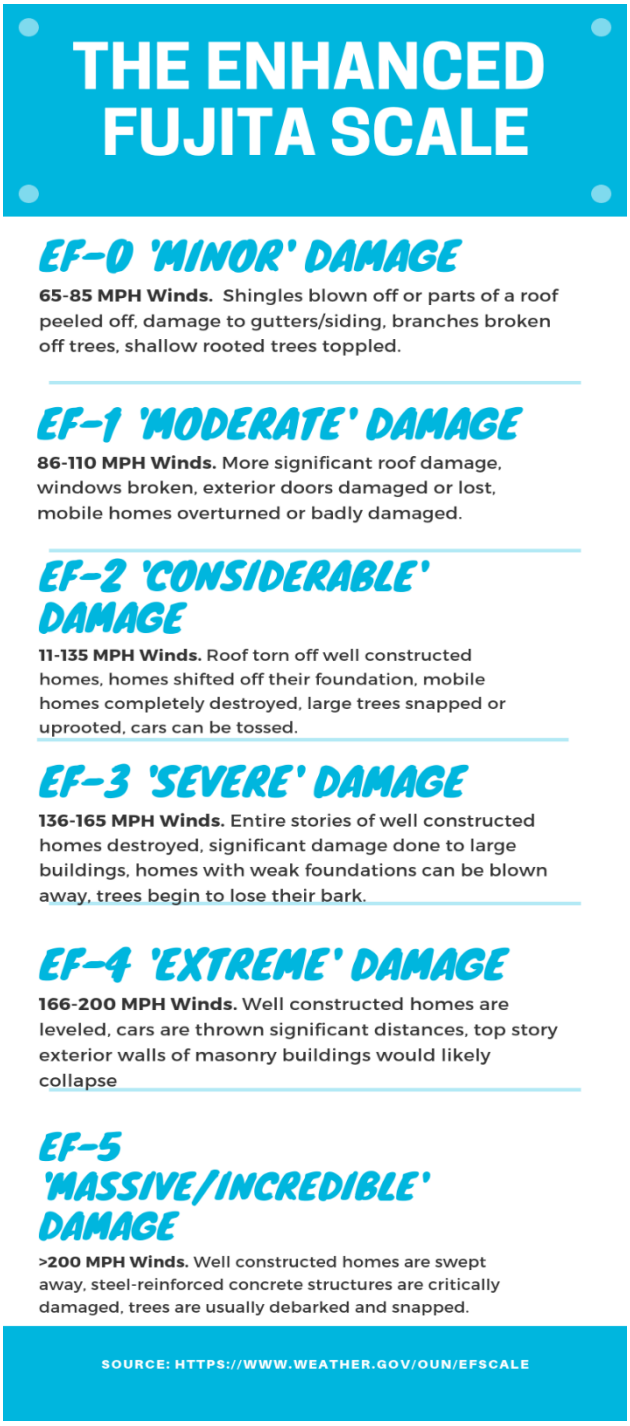
4.3.1 Hazard Description

High Wind: Wind is the motion of air relative to the earth's surface. Extreme windstorm events are associated with cyclones, severe thunderstorms, and accompanying phenomena such as tornadoes and downbursts. High winds can result from thunderstorms, strong cold front passages, or gradient winds between high and low pressure. Damaging winds are often called "straight-line" winds to differentiate the damage they cause from tornado damage. Downdraft winds are a small-scale column of air that rapidly sinks toward the ground, usually accompanied by precipitation as in a shower or thunderstorm. A downburst is the result of a strong downdraft associated with a thunderstorm that causes damaging winds near the ground. Damaging winds exceed 50-60 mph.

Tornado: According to the National Weather Service, a tornado is a violently rotating column of air, usually pendant to a cumulonimbus, with circulation reaching the ground. Tornadoes generally form from severe thunderstorms, mainly supercell thunderstorms – those that are isolated with the unimpeded inflow of moisture and enhanced by wind shear. Tornadoes may also develop along squall lines or in bands of storms associated with hurricanes. Tornadoes require moist air, instability (warm air rising), a source of lift such as a front, dryline, or heating, and wind shear (change in wind direction and speed with height). It is often difficult to separate windstorms and tornado damage when winds get above 73 mph.

4.3.1.1 Location

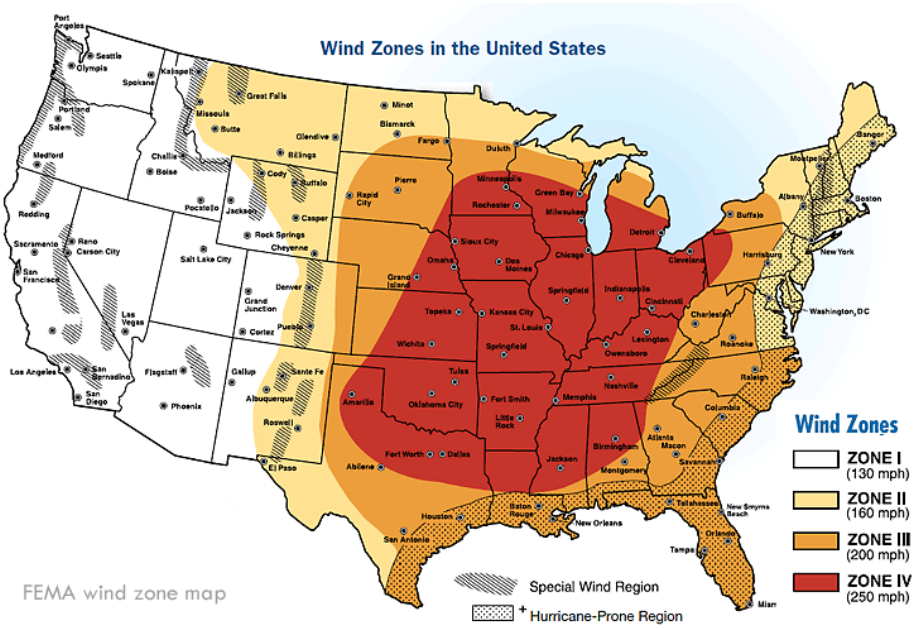
Both wind and tornado events can occur in the City of Tulsa. Tornado events are usually localized. However, severe thunderstorms may result in conditions favorable to the formation of numerous or long-lived tornadoes. The risk of this hazard is uniform over the entire City of Tulsa.



4.3.1.2 Extent

The Enhanced Fujita Scale or EF Scale, which became operational on February 1, 2007, is used to assign a tornado a 'rating' based on estimated wind speeds and related damage. The EF Scale was revised from the original Fujita Scale to reflect better examinations of tornado damage surveys to align wind speeds more closely with associated storm damage. The City of Tulsa is located in Zone IV on the FEMA Wind Zone Map, Figure 4-8, and may experience wind speeds of 250mph or a tornado with a rating of EF5 on the Enhanced Fujita Scale. According to the National Weather Service, sustained winds at 40-50mph can cause isolated wind damage. During strong thunderstorms, Tulsa may experience straight-line winds exceeding 100 mph.

Figure 4-8: FEMA Wind Zone Map

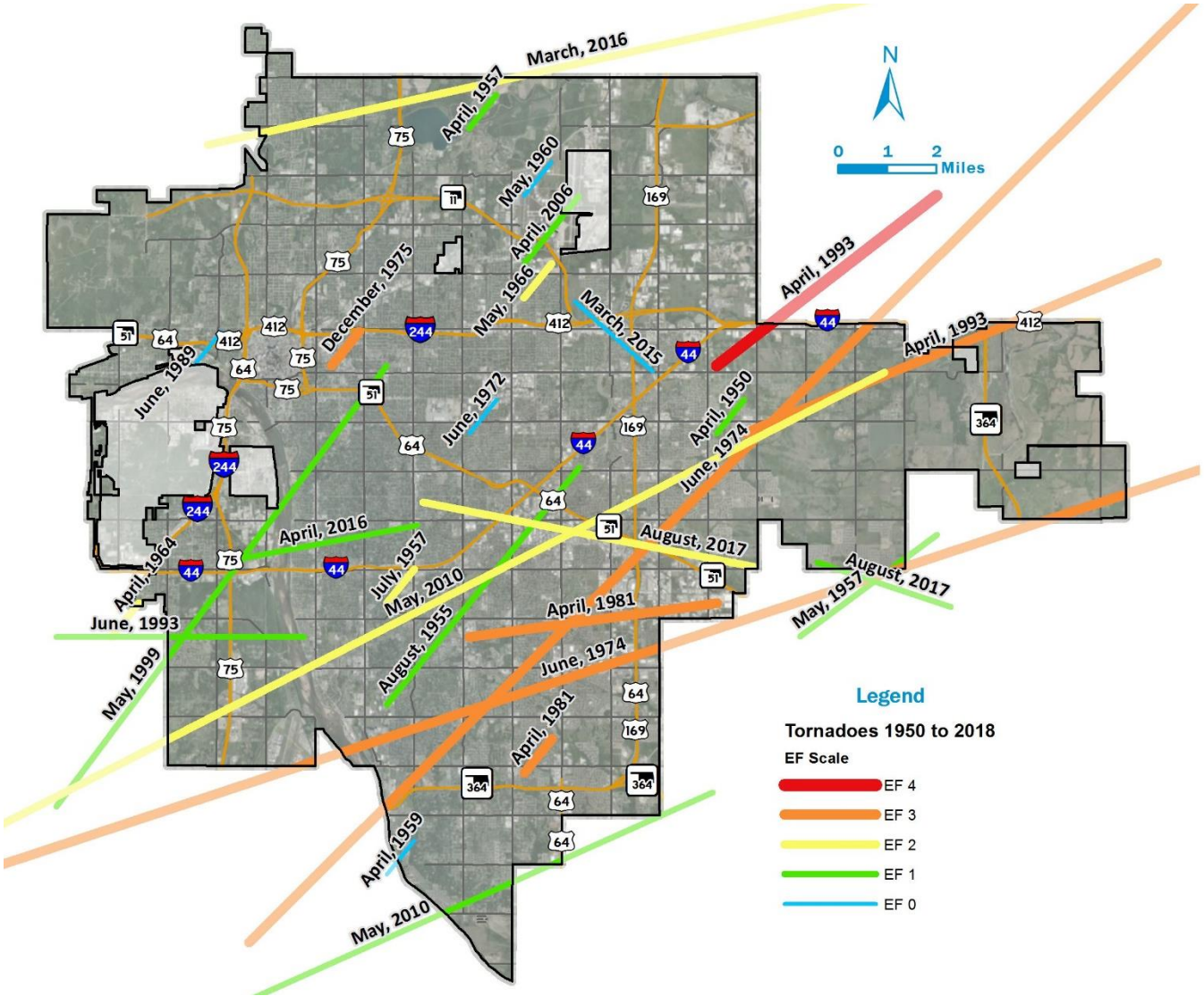


4.3.1.3 Previous Occurrences

High Wind and Tornado events have occurred in the City of Tulsa. The NCEI Storm Events Database includes reports of 122 High Wind events with wind speeds of greater than 57 mph and 24 tornado events since 1998. During the plan maintenance period, Tulsa experienced high wind events on an annual basis. The total damage from these events was almost $1,000,000 not including losses from tornado events during the same timeframe. The highest sustained wind speed during this period was 90 mph on March 25, 2015. The same storm system produced a tornado.

Before the 2015 Sand Springs tornado that crossed into Tulsa proper, few damaging tornadoes had touched down in the city limits of Tulsa. The most significant tornado in Tulsa's history was an F4 which ripped through Catoosa in 1993. In 1974, two F3 tornadoes damaged Brookside and parts of south and east Tulsa. This event damaged thousands of homes. The tornado traveled across the intersection of 71st and Memorial, one of the busiest in Tulsa. At the time, this area was not developed. If the 1974 tornado hit this area today thousands of homes would be affected, and a large portion of the Tulsa sales tax base. Since 1974, the Tulsa metro has increased from a sparsely populated total land area of 175.71 sq miles to 186.8 sq miles of relatively dense population. Increased development has made Tulsa a larger target for tornados. During the plan update period, Tulsa was affected by a damaging tornado on an almost annual basis. Summaries of damages associated with 2015, 2016, and 2017 tornadoes are shown in Figure 4-9.

Figure 4-9: City of Tulsa Tornado History and Summary of Recent Events



March 25, 2015

EF-0 AND EF-2 TORNADOES TOUCH DOWN IN NORTH TULSA

The tornado moved into Tulsa County at W Archer Road to the east of S 209th W Avenue. The roofs of several homes were damaged and trees were uprooted as it crossed S 193rd W Avenue. The tornado moved southeast crossing Highway 412, where it snapped or uprooted numerous trees and blew a tractor trailer off the road. A doughnut shop was destroyed at S 177th W Avenue, homes were damaged, and trees and poles were snapped. It crossed the Arkansas River and moved through the River Oaks Estates Mobile Home Park where it destroyed 58 mobile homes and two permanent homes. One fatality and about 30 injuries occurred in this park. The tornado crossed the Arkansas River again as it moved east-southeast toward Sand Springs, uprooting numerous trees before dissipating on the south side of Sand Springs, south of Highway 412 and just west of Highway 97.

March 30, 2016

EF-2 TORNADO WITH WIND SPEEDS OF MORE THAN 100 MPH TOUCHES DOWN IN NORTH TULSA

Seven people reportedly were injured and multiple homes and other structures were damaged or destroyed March 30, 2016 when a storm system spun up a tornado that caused damage from the northern part of Tulsa and eastward through Owasso, Verdigris and Claremore.

August 6, 2017

EF-2 TORNADO STRIKES MIDTOWN TULSA SHORTLY AFTER 1:00 AM

An EF-2 with winds up to 130 mph is responsible for damaging dozens of businesses and homes over a 4.2-mile path through midtown and east Tulsa. The tornado touched down in a neighborhood east of Harvard and south of 36th Street. Large tree limbs snapped and homes were damaged. As the tornado moved east-southeast crossing Yale, a number of trees and power poles were snapped and businesses were damaged or destroyed between Yale and Sheridan along 41st Street. Roofs were blown off structures, exterior walls were torn off buildings and several vehicles were rolled. About 26 injuries occurred in the area. The tornado continued toward Broken Arrow, causing roof, wall and window damage between Sheridan and Highway 169. Power poles and trees were downed. The storm turned easterly and moved along 51st Street before dissipating just before reaching 145th East Avenue.

4.3.1.4 Probability of Future Events

Overall Probability Rating based on Classifications in Table 4-1: Likely., 10 to 90 percent probability of occurrence in the next year or a recurrence interval of 1 to 10 years Based on previous occurrences, Tulsa should expect to experience damaging straight-line wind events on an annual basis. The probability of a tornado occurring within Tulsa was derived using the Tornado Risk Assessment Tool from the Storm Prediction Center[7]. A historical analysis was run to determine the annual probability of a tornado striking any single point within the City of Tulsa. This value is calculated by comparing the mean area affected by tornadoes each year with the total circular area of the search. The search area for this analysis was a 15km radius from the intersection of I-44 and US Highway 51. Based on this method the City of Tulsa has a 0.308% chance of experiencing a tornado in any given year. The most likely month the City of Tulsa should expect to experience a tornado is the month of May.

4.3.2 Vulnerability and Risk Assessment

Overall Significance based on Classifications in Table 4-1: High, the criteria consistently fall in the high classifications and the event is likely/highly likely to occur with severe strength over a significant to extensive portion of the planning area.

4.3.2.1 People

All the population of Tulsa is exposed and at risk for experiencing this hazard. Adequate warning systems are essential to public safety during high wind and tornado events. Though the purpose of outdoor warning sirens is to provide a warning for people participating in outdoor activities, many Tulsans rely on them as their primary notification. Tulsa should educate the public on alternate means of severe weather alerts, such as NOAA radios, the TulsaReady App, and IPAWS notification.

Major determinants that play into effects of this hazard on the population include social vulnerability. Areas in Tulsa with a higher income disparity are more vulnerable to high wind and tornadoes than areas with a higher per capita income. Quality of housing, language barriers, and education level play a role in increased vulnerability to this hazard and the level of resilience post-event. The *Resilient Tulsa Strategy* focuses on the goal to equip all Tulsans to overcome barriers and thrive; this includes providing even the most vulnerable of Tulsans with the information and resources necessary to prepare for and respond to disasters. Focusing future

LESSONS LEARNED

Tulsa has gained experience and knowledge about the effects of Tornados on their community.

In 2015, the City faced more challenges because it was the first time in recent years a tornado directly impacted the citizens. The Tulsa Long Term Recovery Committee, lead much in part by local, state, and nonprofit organizations, assisted in the recovery efforts. A Federal disaster was not declared for this area.

In 2016, when the tornado devastated an area in north Tulsa, partners were already lined up based on their experiences assisting with the recovery efforts from the prior year. The area most impacted in 2016 had a poverty rate of two to four times the poverty rate of Tulsa County.

The City Council and Tulsa Development Authority authorized Tulsa's Working in Neighborhoods program to prioritize CDBG funds for recovery. Use of these funds for recovery was written into the CDBG grant request and is referenced by the State of Oklahoma as the most innovate existing programming at the local level.

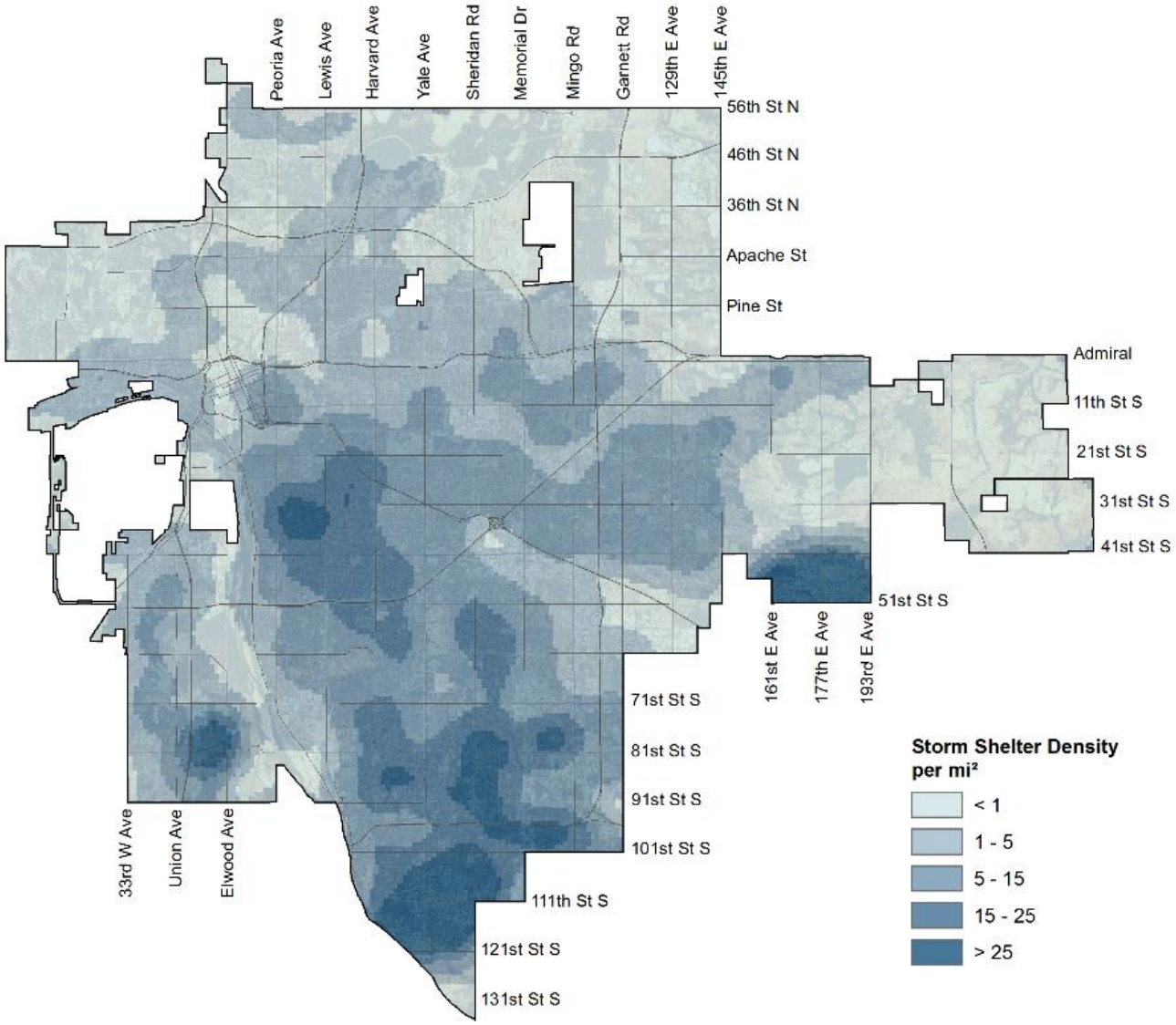
a 25mi radius circle to the total domain area.

[7] *Source: Tornado Risk Assessment Tool, Storm Prediction Center, https://www.spc.noaa.gov/climo/online/probs/*

mitigation grant money on low-income populations would assist in closing this gap. Low-income residents are less likely to afford the cost of a residential safe room.

Using data from the City of Tulsa's Storm Shelter Registry[8], a heat map was created to show areas of Tulsa with the highest concentration of safe rooms. A heat map was used for privacy reasons, Figure 4-10. Actual point data indicates a significant disparity in the number of individuals with safe rooms in north Tulsa compared to south

Figure 4-10 Registered Storm Shelters in Tulsa



Tulsa.

The City of Tulsa/Tulsa County Emergency Operations Plan, advises citizens to plan and prepare for shelters in or near their homes. Local government facilities should not be relied upon for shelter. The best option is for Tulsans to install Safe Rooms in their home, which provide near-absolute protection to wind events of at least 250mph.

[8] Source, City of Tulsa GIS Dept

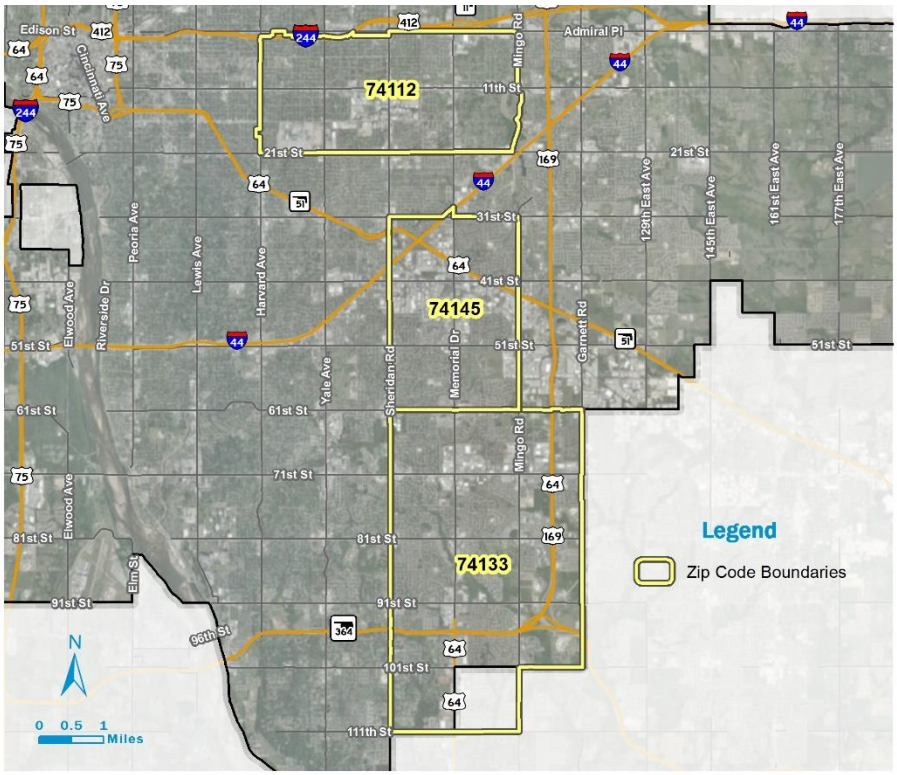
One ongoing problem with Safe Rooms is the need for the public to understand not all safe rooms are created equal. Lack of adequate safe room design can cause the unit to fail.

4.3.2.2 Economy

While forecasting and early warning have decreased the number of fatalities associated with wind events, little has been done to address economic losses. After the August 2017 tornado event, Tulsa distributed a point in time survey to business owners affected by the incident. Business owners did not complete a flow-up study, so data limitations on the actual impacts the event had on the businesses, aside from physical implications, are limited. High wind and tornado events will cause direct and indirect losses to the economy anytime businesses are affected and closed for a period.

In November 2017 the *Resilient America Program* of the National Academies of Sciences, Engineering, and Medicine presented initial findings of research on sales tax revenue and discussed what these initial findings could indicate about resilience in Tulsa; specifically, as they relate to tornados. The analysis shows three main zip codes as the primary sources of sales tax revenue in the City of Tulsa: 74145, 74133, and 74112, Figure 4-11. Based on this information, one can assume damaging high wind or tornado events in these zip codes would cause a more significant economic loss than other areas of Tulsa. The findings of this report are based on early research, and in need of more detailed study and analysis.

Figure 4-11 Primary Sources of Sales Tax in Tulsa



4.3.2.3 Built Environment

Existing Structures The residential building stock in Tulsa is diverse in the type of construction, age, and size of the building. Mobile homes or manufactured homes are the most vulnerable and make-up 1.5% of housing units in Tulsa. The federal government established standards in 2007 requiring all new manufactured homes to meet the requirement for installation and anchoring in accordance with its structural design and windstorm standards. Even anchored mobile homes can be severely damaged when winds gust over 80 mph.

Damages to residential properties depend on the tornado's wind-speed and the level of wind resistance the property has been constructed to withstand. Houses with crawl spaces are more susceptible to lift. The manner in which foundations and roofs are constructed can affect a structure's ability to withstand wind pressure.

Homes constructed to be more wind resistant, meeting high wind design requirements, such as the Insurance Institute for Business and Home Safety's (IBHS) fortified home construction recommendations, are less

vulnerable to tornado damage. Homes constructed to this structural capacity can withstand winds up to 130 mph, which is 95% of tornadoes.

Older homes are especially vulnerable to tornado events. About 13% of residential structures in the City of Tulsa were built before 1969. These older homes in the jurisdiction are generally more vulnerable to tornado damage than more recently built homes constructed to higher standards.

Infrastructure Tornadoes in Tulsa can cause significant damage to infrastructure. Tulsa should be prepared to face the loss of power, and damage to critical infrastructure (e.g., storage tanks, hydrants, residential plumbing fixtures, distribution system) due to hail, wind, debris and flash flooding, resulting in loss of service and/or reduced pressure throughout the system. Restricted access to the facility due to debris and damaged roads is likely. Loss of power and communication lines will require alternate methods of communication until cellular service or landlines can be restored.

Critical Facilities It is impossible to predict the geographical area of impact of high wind and tornadoes. All critical facilities in Tulsa are exposed to this hazard. Tulsa should consider the purchase and installation of generators at essential critical facilities. The only critical facility with a storm shelter is the underground TAEMA Emergency Operations Center.

Cultural Resources Loss of structures listed on the National Historic Register, or of one of Tulsa's many museums, would be devastating. All are vulnerable to high wind and tornados. Structural mitigation measures should maintain the historical integrity of National Register eligible or listed properties. For example, impact resistant glass systems in windows and doors should match the period and style of a historic structure.

Future Development The City of Tulsa, adopted the ICC International Building Code, 2015, and the ICC International Residential Code for One and Two-Family Dwellings, 2015 Edition. The City of Tulsa should be prepared to focus beyond the apparent clean-up and repair/rebuild post-event. Future development is assumed to be less vulnerable to high wind events because of the higher building standards in place. In 2018, insurance companies began offering discounts on homes built or retrofitted to certain tornado-resilient standards since a law went into effect April 1 requiring them. The general public should be educated on the advantage of having a stronger home, such as more affordable insurance rates, higher resale value and a house that can withstand up to an EF2 tornado. Tulsa should work with the Oklahoma Insurance Department to educate the public, building professionals, and insurance agents about these benefits. Additionally, Tulsa should consider a program to train building officials as IBHS Home Evaluators. There is a shortage of evaluators in Tulsa, and a need so homes may be evaluated, and homeowners may receive insurance discounts if their company offers them.

Natural Environment The effects of damaging wind from high wind events or tornadoes on the natural environment are not always obvious or immediately apparent. Debris from damaged or destroyed homes can result in asbestos being deposited. Hazardous household waste, such as cleaning and automotive products, becomes an issue to animals and plants in the area, and can also contaminate water and soil. During severe thunderstorm events in Tulsa, flash flooding is a common occurrence. Household and industrial waste can spread into animal habitats, stormwater, rivers, and lakes. Tulsa should address these issues with the Department of Environmental Quality during the recovery period, and plan for proper disposal of debris in advance of wind or tornado events.

4.3.3 Summary of Observations and Recommendations

Observation	Recommendation	Action
City Council and Tulsa Development Authority authorized use of CDBG funds to assist with recovery in non-federal events	Plan to apply for HMGP funds and build to higher standards in future recovery efforts. CDBG can match HMGP.	2
Some areas of Tulsa are less equipped to prepare for or recover from high wind and or tornado events	Create community facilities (resilience hubs) that can serve as gathering places during emergencies and interruptions in services, and outfit such facilities with access to key services, including water, electricity for charging cell phones, etc. Such capabilities could be integrated into schools and other existing community facilities.	29
Essential facilities in Tulsa need back-up generators.	Tulsa should assess the need for generators at critical facilities and implement as funding becomes available	14
Tulsans rely on warning sirens as primary source of weather notifications.	Educate the public on purpose of outdoor warning sirens and promote NOAA weather radios, IPAWS, and the TulsaReady App.	1
Tulsa has an established Long-Term Recovery Program and plan in place.	Tulsa should continue maintain the recovery plan for post-disaster recovery, including a process for efficient damage assessments, mitigation action items and funding opportunities.	2
Many Tulsans do not have adequate sheltering options in their homes. There is a disparity in the number of safe rooms in north Tulsa compared to south Tulsa.	Educate the public on importance of Safe Rooms and implement individual safe room program. Priority of safe room program could focus on low-income populations.	8
The TAEMA office is underground, but aside from this we were unable to determine which other, if any, critical facilities had adequate sheltering options for high wind and tornado events.	Safe rooms that meet or exceed the requirements of FEMA P361 and 320 should be installed in new critical facilities to protect first responders and city officials from severe weather.	10
The general public, and even insurance agents, are unaware of the benefits associated with disaster resistant construction and discounts on insurance premiums.	Tulsa should work with the State Department of Insurance to educate the public on better building practices.	11

Observation	Recommendation	Action
Though interest in building to IBHS Fortified Standards is increasing, there are few fortified inspectors in Oklahoma.	Tulsa should work with the State Department of Insurance, IBHA, and the HBA to train home builders on disaster resistant construction techniques and encourage certification as fortified inspectors.	12
Critical facilities are at risk to all modes of severe weather, and possible impacts.	Hazard vulnerability should be considered when constructing new critical facilities. If damaged, critical facilities should be repaired to high building standards.	13
Some areas of Tulsa appear to be out of range of a warning siren.	Install, update, and maintain warning sirens.	5
High wind or tornado events may result in heavy amounts of debris, blocking roads and isolating areas of Tulsa.	Tulsa should be prepared to remove debris post disaster and be ready to request Federal assistance when warranted.	7

4.4 Dam/Levee Incidents

Section 4.4 Dam and Levee Incidents:
Portions of the City of Tulsa Hazard Mitigation Plan Update are considered confidential and not for release to the public. The information in this section is covered under the Privacy Act of 1974 (5 U.S.C. Section 552a).

4.5 Extreme Heat

4.5.1 Hazard Description

Extreme heat is marked by unusual hot weather (maximum, minimum, daily average) over a region persisting for at least two consecutive days during the hot period of the year based on local climatological conditions, with thermal conditions recorded above given thresholds (WMO 2015). Note: There is no universally-recognized metric for what constitutes a heat extreme. The World Meteorological Organization recommends characterizing a heat wave by its magnitude, duration, severity, and extent.

4.5.1.1 Location

Tulsa is located in an area known for its hot, humid summers, with temperatures often reaching above 100°F for extended periods. Due to its location, extreme heat is a hazard that impacts the entire planning area.

4.5.1.2 Extent

The Heat Index and Heat Disorders table, Figure 4-20, relates index ranges with specific disorders, particularly for people in the higher risk groups. The Heat Index and Disorders Table displays varying degrees of caution depending on the relative humidity combined with the temperature. The shaded zones on the chart indicate varying symptoms or disorders that could occur depending on the magnitude or intensity of the event. "Caution" is the first level of intensity where fatigue due to heat exposure is possible. "Extreme Caution" indicates that sunstroke, muscle cramps or heat exhaustion are a possibility, whereas a "Danger" level means that these symptoms are likely. "Extreme Danger" indicates that heat stroke or sunstroke is highly likely. According to the State Climate Extremes Committee, the Tulsa has experience 115-degree temperatures in the month of August.

Figure 4-20: Heat Index and Heat Disorders Table

Relative Humidity (%)

Air Temperature (°F)

°F	40	45	50	55	60	65	70	75	80	85	90	95	100
110	136												
108	130	137											
106	124	130	137										
104	119	124	131	137									
102	114	119	124	130	137								
100	109	114	118	124	129	136							
98	105	109	113	117	123	128	134						
96	101	104	108	112	116	121	126	132					
94	97	100	102	106	110	114	119	124	129	136			
92	94	96	99	101	105	108	112	116	121	126	131		
90	91	93	95	97	100	103	106	109	113	117	122	127	132
88	88	89	91	93	95	98	100	103	106	110	113	117	121
86	85	87	88	89	91	93	95	97	100	102	105	108	112
84	83	84	85	86	88	89	90	92	94	96	98	100	103
82	81	82	83	84	84	85	86	88	89	90	91	93	95
80	80	80	81	81	82	82	83	84	84	85	86	86	87

Heat Index
(Apparent Temperature)

With Prolonged Exposure and/or Physical Activity

- Extreme Danger: Heat stroke or sunstroke highly likely
- Danger: Sunstroke, muscle cramps, and/or heat exhaustion likely
- Extreme Caution: Sunstroke, muscle cramps, and/or heat exhaustion possible
- Caution: Fatigue possible

4.5.1.3 Previous Occurrences

The average high temperature for July and August in the City of Tulsa is 93.5° F, with an average humidity of 56%, putting the area in the "Extreme Caution" category on the National Weather Service (NWS) Heat Index

scale. When temperature and humidity rise higher, as they often do in July and August, conditions can reach the "Danger" and even "Extreme Danger" categories.

According to the NCEI Storm Events Database, 32 separate extreme heat incidents were reported for the City of Tulsa in the 20-year reporting period 1998 through 2018, a frequency of about two extreme heat events every year. The reported events caused 11 deaths and 862 injuries. Summaries of most notable events are included below, Table 4-8.

Table 4-8: Extreme Heat Event Narratives

Date	Event Narrative
August 6-12, 2007	The combination of hot temperatures and high humidity resulted in daytime heat index values from 105 to 113 degrees across much of eastern Oklahoma. Overnight temperatures remained above 75 degrees, which didn't allow much relief from the heat. Two men died in Tulsa as a direct result of the heat; both men were 65 years of age or older. EMSA treated two hundred other people in Tulsa for heat related illnesses. Many of those victims were in attendance at the PGA Championship.
July 9-August 1, 2011:	High temperatures climbed to above 100 degrees on all but two days during the remainder of the month at the Tulsa International Airport, and July 2011 went down as the second warmest July on record for that area since records began in 1905. Three senior citizens died in their homes as a result of the excessive heat. Nearly three hundred other individuals were injured.

Periods of excessive heat have occurred on an annual basis since 2011 but have not caused nearly the number of deaths or injuries as the events in 2007 and 2011. Since the previous plan was approved, extreme heat has caused two deaths and 60 injuries. This improvement is a testament to the amount of investment made by the City of Tulsa, and its stakeholders in educating the public on the dangers of extreme heat.

4.5.1.4 Probability of Future Events

Overall Probability Rating based on Classifications in Table 4-1: Highly Likely, 90 to 100 percent probability of occurrence in the next year or a recurrence interval of less than 1 year.

The City of Tulsa should expect extreme heat events on an annual basis..

4.5.2 Vulnerability and Risk Assessment

Overall Significance based on Classifications in Table 4-1: Medium: The event's impacts on the planning area are noticeable but not devastating.

4.5.2.1 People

Extreme heat can take its toll on the all people in Tulsa, and even the most physically fit individuals can succumb to heat effects. However, certain segments of the population are at higher risk. These populations include the following:

- Individuals 65 years and older
- Children under five years old, especially infants
- Socially isolated individuals

- Mentally & mobility challenged individuals
- Obese individuals
- Individuals under the influence of alcohol or medications
- Individuals and families living below the poverty line
- Outdoor workers

Of particular concern are individuals over the age of 65 and below the poverty line. These are at the highest risk of loss of life due to extreme heat conditions. In the City of Tulsa, men aged 45 to 65 years of age account for the highest number of EMSA transports due to heat related illness each year. Though this demographic accounts for a high number of transports, many can walk away unscathed after treatment. Elderly populations account for less EMSA transport but are less likely to recover once they have succumbed to the impact of extreme heat.

Urban residents, such as Tulsans, face unique heat-related risks due to the Urban Heat Island effect. Temperatures typically rise from the outer edges of the city and peak in the center. This phenomenon can have a significant health impacts in urbanized areas. On sunny days during the summer, sunlight can heat dry and exposed urban surfaces, such as pavements and buildings, causing urban regions to become much warmer than their rural surroundings. As a result, an "island" of higher temperatures is formed in the landscape.

4.5.2.2 Economy

The biggest impact on the economy is the human toll associated with heat-related mortality and illness. Worker productivity decreases during heat waves. The slowdown is particularly acute in outdoor industries such as construction.

4.5.2.3 Built Environment.

Existing Structures Buildings are vulnerable to extreme heat in a limited way, such as in damage from expansive soils (see Section 4.13, Expansive Soils).

Infrastructure High temperatures directly affect Tulsa's infrastructure. Flight cancellations, deteriorating roads and rail lines, and energy demands are among the impacts. During extreme heat, AEP/PSO could experience any combination of the following challenges in meeting the needs of the Tulsa jurisdiction: Failure of vital delivery components due to exposure to high heat and excessive/ simultaneous demand of supply, or insufficient field and office staff to effectively handle the workload.

Critical Facilities Critical Facilities face the same issues as other structures and buildings above. In addition, a great many city facilities, such as City of Tulsa recreation centers, may be designated as cooling centers for vulnerable neighborhoods. As such, these facilities need to include this ability in their plans.

Critical Facilities The many outdoor recreation areas in Tulsa are vulnerable to the effects of high temperatures. Community icons like Southern Hills Country Club, The Gathering Place, Philbrook, and Tulsa Botanical Gardens may be affected if water rationing is required,

Future Development Urban planning and design that incorporates more trees and parks, white roofs and alternative materials for urban infrastructure can help reduce the effects of urban heat islands. The City of Tulsa has over 33,000 Tree Canopy Acres according to the 2016 Tulsa County Urban Tree Canopy Report. The report includes consideration of site design and environmental factors to prioritize planting sites on both public and private property with the highest potential for return on investment, as young trees mature and provide substantial stormwater, heat island, and environmental benefits.

Natural Environment Extreme heat causes concern for the agricultural community due to crop loss. High temperatures and dry air can lead to heat stress in trees.

4.5.3 Summary of Observations and Recommendations

Observation	Recommendation	Action
During periods of extreme heat and drought the City of Tulsa experiences water line breaks due to expansive soils.	Tulsa should replace broken pipes in areas of high soil expansion, with piping more resistant to breakage.	28
Extreme heat can cause power disruptions due to high energy demands. Essential facilities in Tulsa need back-up generators.	Tulsa should assess the need for generators at critical facilities and implement as funding becomes available	14
Some areas of Tulsa are less equipped to prepare for or recover from hazard events.	Create community facilities (resilience hubs) that can serve as gathering places during emergencies and interruptions in services, and outfit such facilities with access to key services, including water, electricity for charging cell phones, etc. Such capabilities could be integrated into schools and other existing community facilities.	29

4.6 Fire

4.6.1 Hazard Description

This section combines the previous Wildfire and Urban (structure) Fire hazards from the 2014 update into one hazard profile.

Wildfire A wildfire is any outdoor fire that is not controlled, supervised, or arranged. Wildfire probability depends on local weather conditions; outdoor activities such as camping, debris burning, and construction; and the degree of public cooperation with fire prevention measures. Wildfires can result in widespread damage to property and loss of life. Wildfire vulnerability is found chiefly in wildland-urban interface (WUI) areas. Generally speaking, WUI refers to the zone of transition between unoccupied land and human development. It is the line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels. To determine the WUI, structures per acre and population per square mile are used. The WUI in the area is divided into two categories: intermix and interface. Intermix areas have more than one house per 40 acres and have more than 50-percent vegetation. Interface areas have more than one house per 40 acres, have less than 50-percent vegetation, and are within 1.5 miles of an area over 1,235 acres that is more than 75-percent vegetated (Stewart et al., 2006).

Structure Fire: A structure fire is one that burns a home or other improved structure. Fire generates a black, impenetrable smoke that blocks vision and stings the eyes, making it often impossible to navigate through or evacuate a building on fire.

4.6.1.1 Location

All structures in Tulsa have some level of risk to the fire hazard. There are some factors that affect the risk of a fire occurring in a given location. Average age of structures, type of construction, and location relative to fire stations and open woods or grassland can all influence the likelihood or extent of damage of structure fires.

Wildfire vulnerability in Tulsa is located largely on the periphery of north Tulsa, rural area of east Tulsa into Wagoner County, and heavily wooded areas of Turkey Mountain, just west of the Arkansas River. Areas of greatest concern, and historical occurrence, as identified by the Tulsa Fire Department during this planning process are identified in Figure 4-21.

Area 1 Wildfire is a concern in this area because of development intermixed with heavy and unmaintained fuels. Additionally, the longest response times for the TFD are located in east Tulsa.

Area 2 Station 12 coverage area stops at 41st West Avenue, where it meets the Berryhill Fire Protection District. Station 12 commonly responds to the west city limits of Tulsa, which is fence at 57th West Avenue. This area is a mostly rural, residential area and includes Rice hill, a residential area little known to most of Tulsa, but is significant to the Tulsa Fire Department. Rice hill is one of very few areas in Tulsa without water mains, where most homeowners have potable water delivered to personally owned tanks.

Area 3 The Turkey Mountain Urban Wilderness is a 300 acre wilderness areas with over 20 miles of trails where 15-20 times per year hikers or bicyclists become injured and require a search and rescue effort to rescue them. It has also been the scene of prolonged wildfires. The area is covered by TFD Station 3.

According to a representative from the Tulsa Fire Department, the northwest corner of Tulsa experiences the highest concentration of ***structural fires*** in a given year.

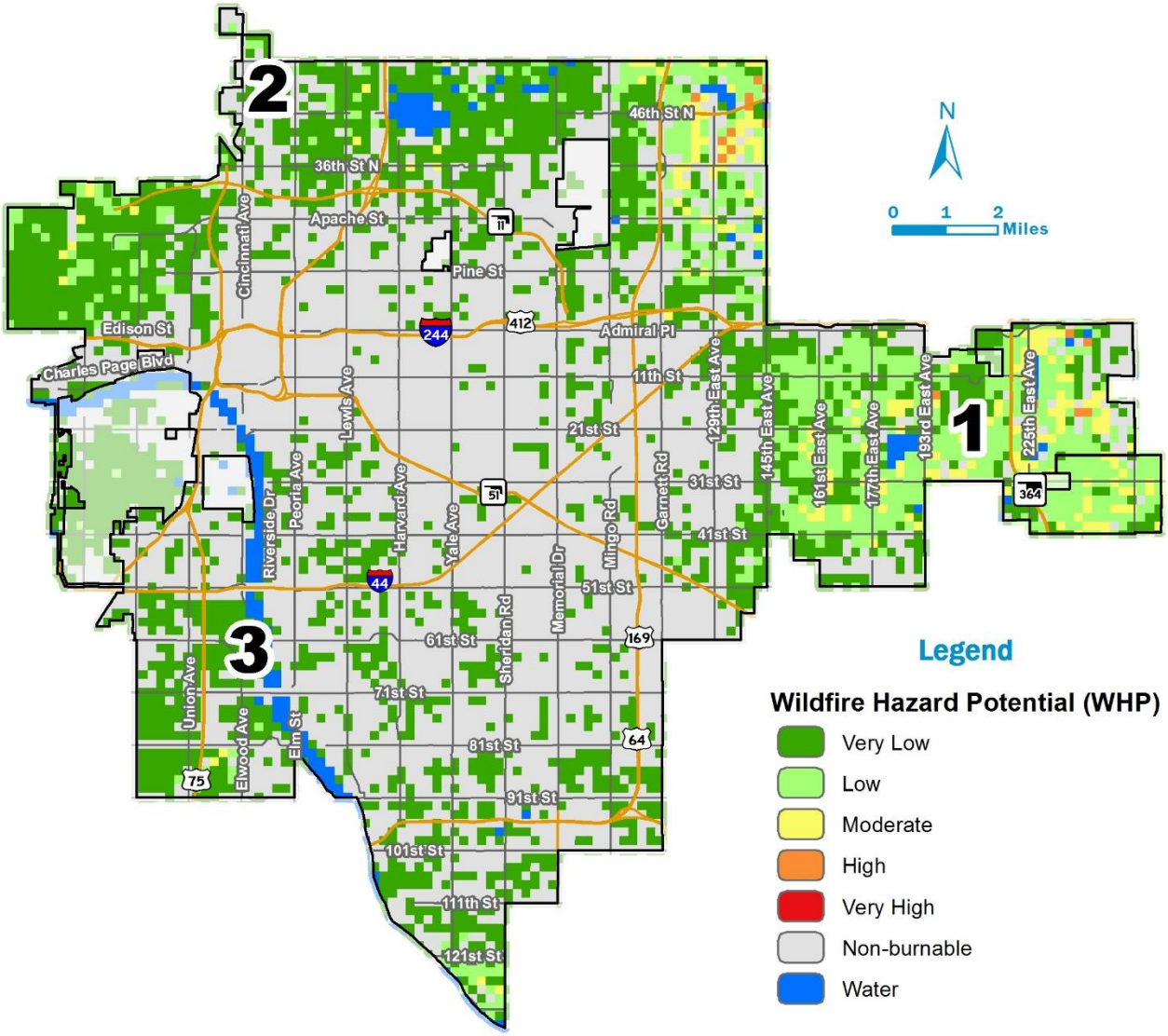
4.6.1.2 Extent

There are several tools available to estimate fire potential, extent, danger and growth including, but not limited to the following: These factors are contained in the Keetch-Byram Drought Index (KDBI), the Fire Danger Rating System, and the Burning Index (BI). The Keetch-Byram Index relates weather conditions to potential or expected fire behavior, using numbers from 0 to 800 to represent the amount of moisture that is present in soil and vegetation.

The Fire Danger Rating System, Table 4-9, combines the combustibility of vegetation and weather conditions to derive the easily understood Green-Blue-Yellow-Orange-Red fire danger alerts.

Tulsa may experience days of extreme fire danger on the Fire Danger Rating System. There is no scientific scale to measure the extent of a structural fire, however Tulsa may experience fires that cause total loss of a structure and contents. The most devastating events are those that cause loss of life.

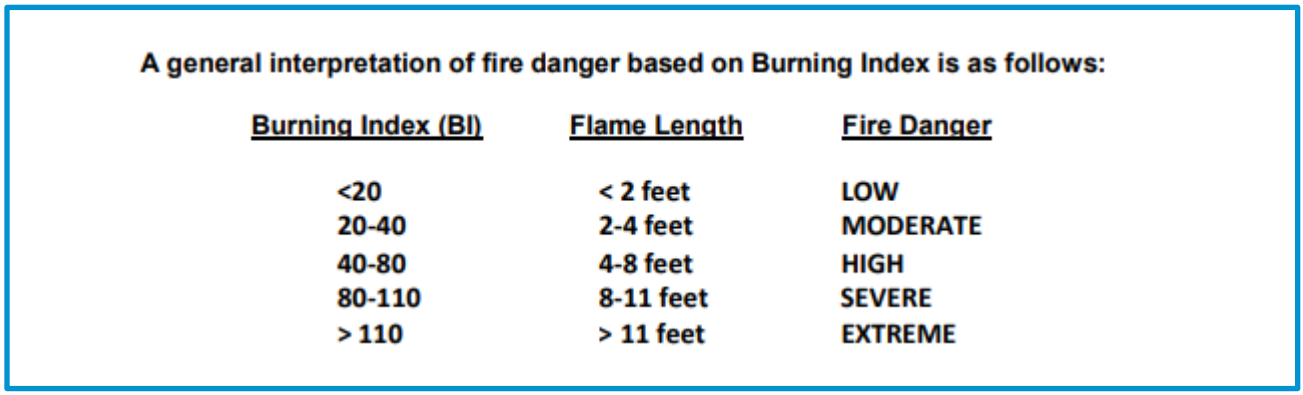
Figure 4-21: Wildfire Hazard Potential and Areas of Concern



According to the Oklahoma Mesonet, *"The most important of the fire danger indices produced by the Oklahoma Fire Danger Model is Burning Index (BI), which relates to the intensity of the headfire and its flame length.*

Besides being a function of weather and dead fuel moisture, BI is also strongly influenced by the type, amount, and greenness levels of the native surface fuels being modeled[12]."

Figure 4-22: Oklahoma Fire Danger Model Burning Index



A general interpretation of fire danger based on Burning Index is as follows:

Burning Index (BI)	Flame Length	Fire Danger
<20	< 2 feet	LOW
20-40	2-4 feet	MODERATE
40-80	4-8 feet	HIGH
80-110	8-11 feet	SEVERE
> 110	> 11 feet	EXTREME

Table 4-9: Fire Danger Rating System

Fire Danger Rating and Color Code	Description
Low (L) (Dark Green)	Fuels do not ignite readily from small firebrands although a more intense heat source, such as lightning, may start fires in duff or punky wood. Fires in open cured grasslands may burn freely a few hours after rain, but woods fires spread slowly by creeping or smoldering, and burn in irregular fingers. There is little danger of spotting.
Moderate (M) (Light Green or Blue)	Fires can start from most accidental causes, but with the exception of lightning fires in some areas, the number of starts is generally low. Fires in open cured grasslands will burn briskly and spread rapidly on windy days. Timber fires spread slowly to moderately fast. The average fire is of moderate intensity, although heavy concentrations of fuel, especially draped fuel, may burn hot. Short-distance spotting may occur, but is not persistent. Fires are not likely to become serious and control is relatively easy.
High (H) (Yellow)	All fine dead fuels ignite readily and fires start easily from most causes. Unattended brush and campfires are likely to escape. Fires spread rapidly and short-distance spotting is common. High-intensity burning may develop on slopes or in concentrations of fine fuels. Fires may become serious and their control difficult unless they are attacked successfully while small.
Very High (VH) (Orange)	Fires start easily from all causes and, immediately after ignition, spread rapidly and increase quickly in intensity. Spot fires are a constant danger. Fires burning in light fuels may quickly develop high intensity characteristics such as long-distance spotting and fire whirlwinds when they burn into heavier fuels.
Extreme (E) (Red)	Fires start quickly, spread furiously, and burn intensely. All fires are potentially serious. Development into high intensity burning will usually be faster and occur from smaller fires than in the very high fire danger class. Direct attack is rarely possible and may be dangerous except immediately after ignition. Fires that develop headway in heavy slash (trunks, branches, and tree tops) or in conifer stands may be unmanageable while the extreme burning condition lasts. Under these conditions the only effective and safe control action is on the flanks until the weather changes or the fuel supply lessens.

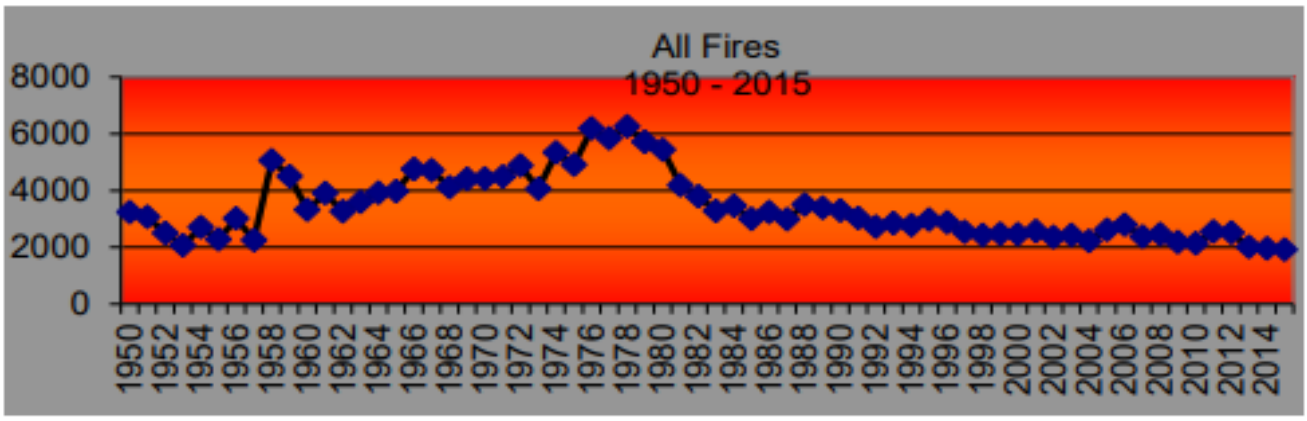
4.6.1.3 Previous Occurrences

Since the previous plan was approved, structure fires have continued to occur on an annual basis. According to the Tulsa Fire Department, while fires nationwide have shown a downward trend since the urban renewal days (1960's through the early 1980's), the Tulsa Fire Department is still a very active structural firefighting

[12] Oklahoma Mesonet (SOURCE)

department. Figure 4- shows the historic number of fires in Tulsa. In 2015, the department responded to 713 structure fires.

Figure 4-23: Structural Fires in Tulsa 1950-2015[13]



The most notable wildfire effecting the City of Tulsa in recent history remains the Turley fire of August 2011. Other fires have affected various areas of Tulsa County, but not within Tulsa city limits. Narratives of some notable wildfire events are included below in Table 4-10.

Table 4-10 Wildfire Event Narratives

Date	Event Narrative
November 2005-April 2006	Wildfires impacted areas in and around Tulsa County and the City of Tulsa. In neighboring Creek County, the Depew Fire Complex burned for than a thousand acres and threatened 1,450 homes in Bristow. The Wainwright Fire Complex in nearby Muskogee County burned more than 4,000 acres and threatened nearly 12,000 homes in the Town of Muskogee. The Shamrock Fire Complex in Creek County threatened more than 300 homes in Drumright and Shamrock, OK. More than 6,500 homes near Kellyville were threatened as a result of the Sapulpa Fire Complex in Creek County, which burned over 800 acres. The Prague Fire Complex in Lincoln and Okfuskee Counties burned more than 640 acres and threatened 2,650 homes in eight communities.
August 2011-Turley	On August 2, 2011, very dry, hot, and breezy conditions, along with extremely dry fuels as a result of long-term drought, promoted the rapid spread of wildfire just outside of Tulsa city limits near Turley, OK. The fire burned from 56th St. N. to 66th St. N., and from Lewis Ave. to Peoria Ave. Losses from the fire were assessed at $491,200.00. The total included five total loss homes, eight damaged homes, loss of three mobile homes, eleven storage sheds, two barns, one plane hangar, 10 vehicles, one dump truck and $37,000 in miscellaneous losses.
May 2017-Tulsa County	Two wildfires burned in Tulsa and Creek County coming dangerously close to several homes. Keystone firefighters responded to a Tulsa County grass fire near 225th West Avenue and Highway 51, between Mannford and Sand Springs. Crews were initially concerned because there were some structures nearby, but firefighters said they were able to contain the fire without any losses.

[13] Tulsa Fire Department Resource Allocation Report, 2017

4.6.1.4 Probability of Future Events

Overall Probability Rating based on Classifications in Table 4-1: Highly Likely, 90 to 100 percent probability of occurrence in the next year or a recurrence interval of less than 1 year.

The Tulsa Fire Department currently responds to over 57,000 incidents annually. (Approximately 33,000 are EMS related). While structural fires occur on an annual basis, wildfires are less frequent. It is not likely Tulsa will experience wildfires on an annual basis, but at least one wildfire event is expected during the 5-year plan maintenance period.

4.6.2 Vulnerability and Risk Assessment

Overall Significance based on Classifications in Table 4-1: Medium: The event's impacts on the planning area are noticeable but not devastating

4.6.2.1 People

People residing structures located in areas of wildfire concern have the most exposure to loss of life and property as a result of a wildfire. Tulsa Fire Department (TFD) employs public education officers, who present educational programs to citizens across the community in schools, churches, day cares and other businesses about general safety and fire prevention. This service is a proactive program helping citizens of all ages learn how to keep themselves and their community safer. TFD public education officers also plan and direct smoke detector installation events, the juvenile firesetter program, and all-hazard community risk reduction programs.

4.6.2.2 Economy

Economic impacts of wildfires include the more obvious variables, such as acreage burned and number of lost personnel. The economic impact depends on the level of event. Tulsa has not, and likely will not, experience a catastrophic wildfire. Economic losses from wildfires are expected to remain low.

4.6.2.3 Built Environment

Existing Structures Tulsa, unlike many newer and smaller cities surrounding it, has significant risk due to older buildings and densely concentrated businesses and residences that were built prior to modern life safety measures. Due to age and other factors, it's not safe to assume that every building in Tulsa meets modern fire codes and that every high-rise has automatic fire sprinklers.

Infrastructure Fires have the potential community infrastructure, including highways, communication facilities, power lines, and water delivery systems.

Critical Facilities None of Tulsa's critical facilities are located in wildfire areas of concern.

Cultural Resources None of Tulsa's cultural resources, such as historic neighborhoods or structures, are located in wildfire areas of concern.

Future Development The Tulsa Fire Department provides fire code enforcement for the City of Tulsa. Code enforcement personnel ensure that public and private buildings meet or exceed current nationally recognized and legal fire codes. The department works with the City of Tulsa and community business owners to ensure proper fire safety is provided throughout Tulsa. The department's code enforcement efforts are a critical element in the success of fire prevention programs. Almost every aspect of a thorough fire prevention program is affected

by code enforcement in some way. It plays a major role in fire and life safety inspections, plans review, hazardous materials, code adoption, environmental investigations, and the issuance of fire prevention code permits.

Natural Environment Fire is a vital ecological process. Wildfires revitalize watersheds and renew soil when allowed to burn in areas where development is not impacted.[14]

4.6.3 Summary of Observations and Recommendations

Observation(s)	Recommendation	Action
Tulsans rely on warning sirens as primary source of weather notifications.	Educate the public on purpose of outdoor warning sirens and promote NOAA weather radios.	6
Some areas of Tulsa are less equipped to prepare for or recover from hazard events.	Create community facilities (resilience hubs) that can serve as gathering places during emergencies and interruptions in services, and outfit such facilities with access to key services, including water, electricity for charging cell phones, etc. Such capabilities could be integrated into schools and other existing community facilities.	29
Tulsa Fire Department identified Turkey Mountain, a heavily forested area, as a wildfire area of concern. There is limited access for emergency responders on Turkey Mountain.	Determine what actions can be taken, if any, to reduce the risk to wildland fires in this area. Implement actions requested by the Tulsa Fire Department to lessen response times.	
East Tulsa has higher ISO ratings, and an increased wildfire concern. Higher ISO ratings are because of longer response times in this area of Tulsa. .	A new fire station is planned in this area of Tulsa.	

[14] https://blog.suny.edu/2013/08/ask-an-expert-why-are-wildfires-good/

4.7 Hailstorm

4.7.1 Hazard Description

A hailstorm is an outgrowth of a severe thunderstorm in which balls or irregularly shaped lumps of ice fall with rain. Hail is formed in thunderstorms when the updraft is strong enough to hold freezing masses of water above the freezing level. Extreme temperature changes from the ground upward into the jet stream produce strong updraft winds that cause hail formation. Strong winds aloft promote the formation of larger stones which increase in size until they are heavy enough to fall out of updraft to the ground. Rotating thunderstorms, known as supercells, make the most significant hail. Hailstorms are usually considered “severe” when hail is larger than one inch in diameter and accompanied by winds greater than 58 miles per hour.

4.7.1.1 Location

The risk of this hazard is uniform over the planning area.

4.7.1.2 Extent

As shown in the Combined NOAA/TORRO Hailstorm Intensity Scale, Table 4-11, hail is considered “destructive” when it reaches 1.6 inches in diameter, or golf ball size. Tulsa may experience hail exceeding 4 inches in diameter.

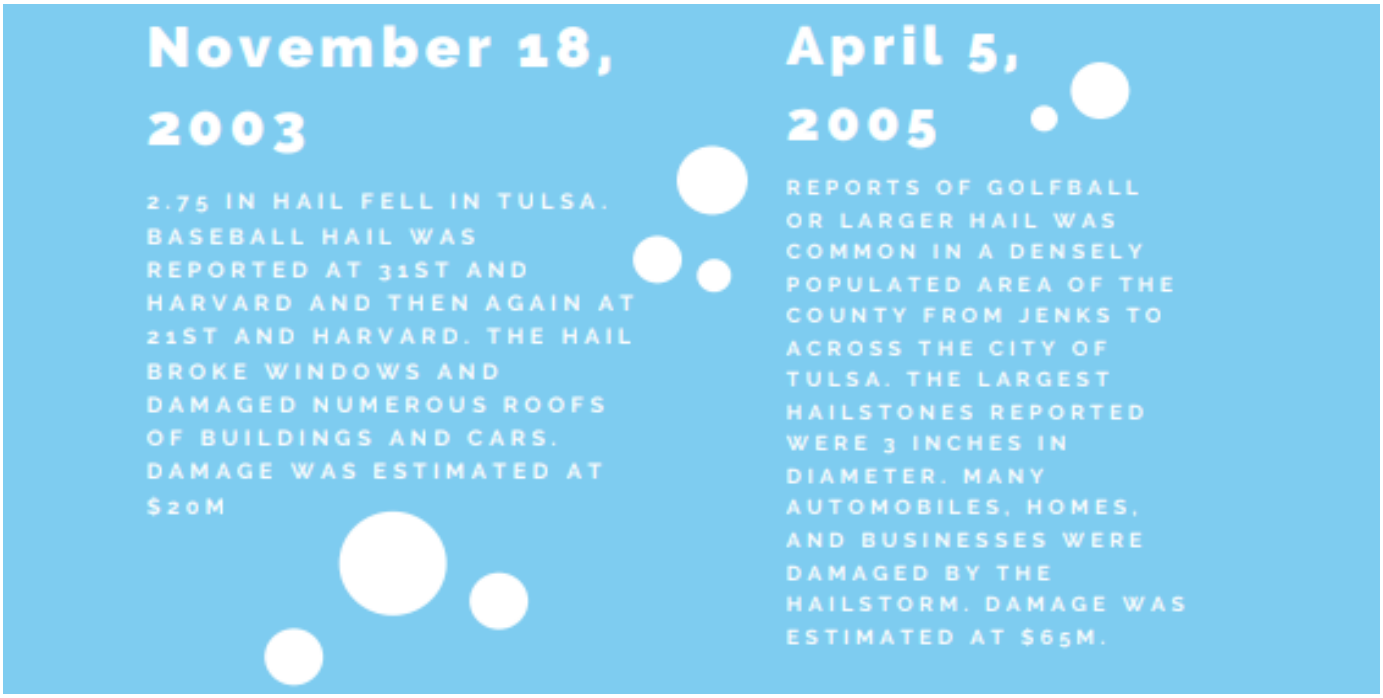
Table 4-11 Combined NOAA/TORRO Hailstorm Intensity Scales

Size Code	Intensity Category	Typical Hail Diameter (inches)	Approximate Size	Typical Damage Impacts
H0	Hard Hail	up to 0.33	Pea	No damage
H1	Potentially Damaging	0.33-0.60	Marble or Mothball	Slight damage to plants, crops
H2	Potentially Damaging	0.60-0.80	Dime or grape	Significant damage to fruit, crops, vegetation
H3	Severe	0.80-1.20	Nickel to Quarter	Severe damage to fruit & crops, damage to glass & plastic structures, paint & wood scored
H4	Severe	1.2-1.6	Half Dollar to Ping Pong Ball	Widespread glass damage, vehicle bodywork damage
H5	Destructive	1.6-2.0	Silver dollar to Golf Ball	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries
H6	Destructive	2.0-2.4	Lime or Egg	Aircraft bodywork dented, brick walls pitted
H7	Very Destructive	2.4-3.0	Tennis ball	Severe roof damage, risk of serious injuries
H8	Very Destructive	3.0-3.5	Baseball to Orange	Severe damage to aircraft bodywork
H9	Super Hailstorms	3.5-4.0	Grapefruit	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open

Size Code	Intensity Category	Typical Hail Diameter (inches)	Approximate Size	Typical Damage Impacts
H10	Super Hailstorms	4+	Softball & up	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open

4.7.1.3 Previous Occurrences

According to the NCEI the City of Tulsa reported 68 events with hail greater than 1.5 in diameter, since 1998. Hailstones in Tulsa County ranged from 0.75 to 4.25-inches in diameter during this time, causing an estimated $91 million in damages. Two events since 1998 caused greater than $1 million in damages. These events are summarized below:



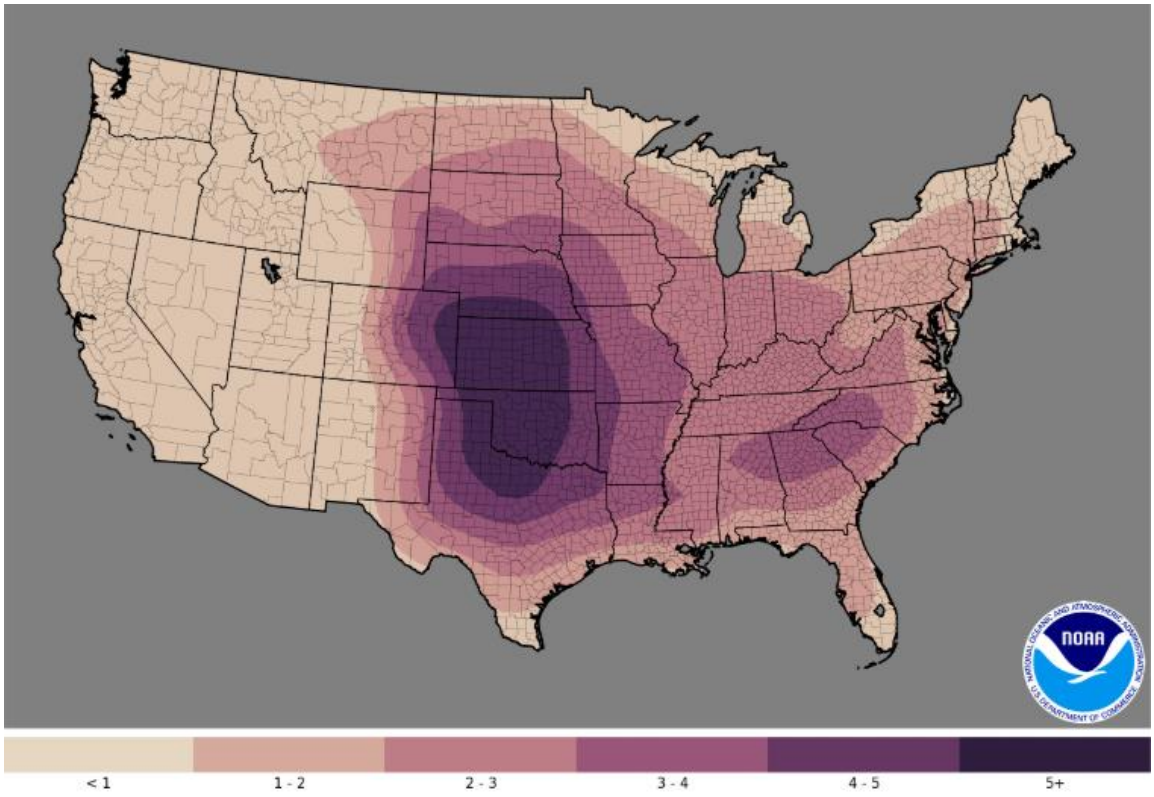
4.7.1.4 Probability of Future Events

Overall Probability Rating based on Classifications in Table 4-1: Highly Likely, 90 to 100 percent probability of occurrence in the next year or a recurrence interval of less than 1 year.

The map in Figure 4-24, provided by the *NOAA/National Weather Service Storm Prediction Center*, shows the average number of days per year in which severe hail reports were received in the Tulsa area during the period noted. Tulsa can expect to see severe hail, exceeding 1-inch in diameter, 4-5 times per year. According to the SCIPP Simple Planning Tool,[15] *"climate models project an increase in the frequency and intensity of severe thunderstorms, and events with large hail are projected to increase (Kossin et al. 2017). At the same time, models project an overall decrease in the number of days with hail per year (Brimelow et al. 2017). Confidence in the projections is currently low, however, due to the isolated and sporadic nature of hail events and limited comprehensive datasets which make it difficult to track long-term trends (Wuebbles et al. 2017a)."*

[15] Southern Climate Impact Planning Program, Simple Planning Tool 2015

Figure 4-24: Mean Number of Hail > 1.00" Days per Year 1986-2015



4.7.2 Vulnerability and Risk Assessment

Overall Significance based on Classifications in Table 4-1: Medium: The event's impacts on the planning area are noticeable but not devastating.

4.7.2.1 People

All the population of Tulsa is exposed and at risk for experiencing this hazard. Although not as common as structure and vehicle damage, personal injury can be caused by large hail driven by high winds. Baseball size hail falls at 100 mph. Those engaging in outdoor activities may find themselves in a situation where adequate shelter is unavailable and be seriously injured. All outdoor parks and recreation areas should be equipped with warning sirens to ensure sufficient time to seek refuge from hailstorms.

Low-income populations are less likely to be able to recover entirely from a destructive hailstorm. Resources, such as CDBG, should be available to help these populations recover as needed. Tulsa could also consider applying for a FEMA grant to mitigate residential properties from hail damages.

4.7.2.2 Economy

The economic impacts associated with this hazard are primarily agricultural related and not applicable to Tulsa. Most losses to businesses are covered by insurance.

4.7.2.3 Built Environment

Existing All structures are exposed to this hazard. Hail damages occur on an annual basis in Tulsa causing insured losses to residential and commercial properties and automobiles. Hail can cause bruises, punctures, and

leaks on roofing systems. The amount of damage depends on the size of the hail, and the age, material, and surface temperature at the time of the event. Substantial hail damage may result in the need for an entirely new roofing system. Large hail driven by high winds can break through windows, doors, and skylights that are not impact resistant, allowing rainwater to enter buildings. When building a new home or replacing the roof, homeowners should consider using hail-resistive roofing products.

Infrastructure Disruption of electric power, water treatment systems, gas service, or the local municipal authorities is not anticipated. Fire, Police and Medical Services would all be similarly at risk to the secondary effects of a hail event. Response vehicles in the open during a hail event would all face the same risk of damage, most likely to windows and windshields.

Critical Facilities All critical facilities in Tulsa are exposed to this hazard. It is unlikely a hailstorm would render a building non-operational.

Cultural Resources Large hail could cause significant impacts on properties listed on the National Register of Historic Places. The Tulsa Preservation Commission ensures proper design standards are met when required in the six historic overlay districts.

Future Development The City of Tulsa adopted the ICC International Building Code, 2015, and the ICC International Residential Code for One and Two-Family Dwellings, 2015 Edition. The City of Tulsa should incorporate disaster-resistant construction to increase the likelihood that homes, workplaces, and essential public buildings can survive a hailstorm. Tulsa should continue to work with the Oklahoma Insurance Department to educate both insurance agents and consumers of the discounts offered for building to higher standards.

Natural Environment Large pieces of hail can damage branches and take down tree limbs. There are 40.7 trees per acre in Tulsa, a total tree population of 5.2 million.[16] A hailstorm could devastate the tree population.

4.7.3 Summary of Observations and Recommendations

Observation(s)	Recommendation	Action
Tulsans rely on warning sirens as primary source of weather notifications.	Educate the public on purpose of outdoor warning sirens and promote NOAA weather radios.	6
Some areas of Tulsa are less equipped to prepare for or recover from hazard events.	Create community facilities (resilience hubs) that can serve as gathering places during emergencies and interruptions in services, and outfit such facilities with access to key services, including water, electricity for charging cell phones, etc. Such capabilities could be integrated into schools and other existing community facilities.	29
Hail causes damage to all structure types on an annual basis.	Educate the public on the benefits of disaster resistant construction.	1

[16] The Complete Tulsa Urban Forest Master Plan, https://www.upwithtrees.org/about-trees/master-plan/

Observation(s)	Recommendation	Action
The general public, and even insurance agents, are unaware of the benefits associated with disaster resistant construction and discounts on insurance premiums.	Tulsa should work with the State Department of Insurance to educate the public on better building practices	11
Though interest in building to IBHS Fortified Standards is increasing, there are few fortified inspectors in Oklahoma.	Tulsa should work with the State Department of Insurance, IBHA, and the HBA to train home builders on disaster resistant construction techniques and encourage certification as fortified inspectors	12
Some areas of Tulsa are less equipped to prepare for or recover from hazard events.	Apply for HMGP funds and build to higher standards in future recovery efforts. CDBG can match HMGP.	2
Some areas of Tulsa appear to be out of range of an outdoor warning siren	Install, update, and maintain warning sirens.	5

4.8 Hazardous Materials

4.8.1 Hazard Description

Hazardous substances include materials and wastes that are considered severely harmful to human health and the environment, as defined by the United States Environmental Protection Agency (EPA) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (commonly known as Superfund). Many hazardous materials are commonly used substances which are harmless in their normal uses but are quite dangerous if released in concentration. The EPA designates more than 1,300 substances as hazardous and subject to the reporting requirements under the Emergency Planning and Community Right-to-Know Act (EPCRA), CERCLA, and/or Clean Air Act (CAA). This number does not include all hazardous chemicals for which material safety data sheets are required (EPA 2015). Because relevant legislation uses the term "hazardous substance," but the emergency management and response community typically use the term "hazardous materials," for this hazard profile, "hazardous materials" and "hazardous substances" are used interchangeably. Hazardous materials sites, for regulatory purposes, are divided into two general categories, fixed sites, and transportation facilities:

Fixed-site hazardous substances (materials and waste) incidents are the uncontrolled release of materials from a fixed-site capable of posing a risk to health, safety, and property as determined by the Resource Conservation and Recovery Act (RCRA). It is possible to identify and prepare for a fixed-site incident because federal and state laws require those facilities to notify state and local authorities about what is being used or produced at the site. The EPA regulates hazardous materials at fixed-sites. Hazardous substances, as listed, are generally materials that, if released into the environment, tend to persist for long periods and pose long-term health hazards for living organisms. Extremely hazardous substances, while also generally toxic materials, represent acute health hazards that, when released, are immediately dangerous to the lives of humans and animals and cause serious damage to the environment. When facilities have these materials in quantities at or above the threshold planning quantity (TPQ), they must submit Tier II information to appropriate state and/or local agencies to facilitate emergency planning.

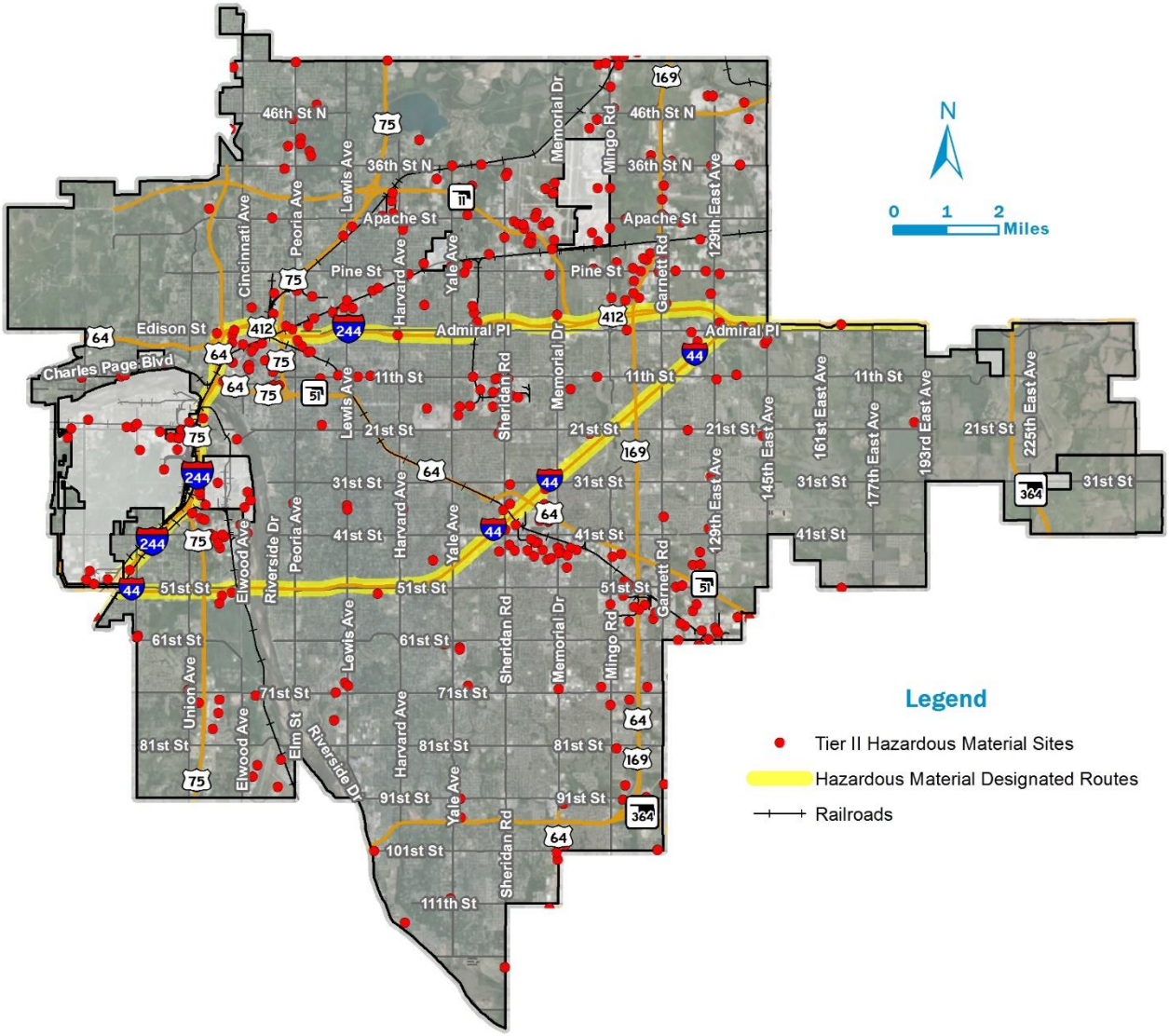
Transportation of Hazardous Materials incidents are any events resulting in the uncontrolled release of materials during transport that can pose a risk to health, safety, and property as defined by the U.S. Department of Transportation (U.S. DOT) Materials Transport regulations. The U.S. DOT regulates hazardous materials in transit and transportation of hazardous waste is regulated by the Oklahoma Dept of Transportation. The U.S. DOT regulations define hazardous materials as a substance or material that the Secretary of Transportation has determined is capable of posing an unreasonable risk to health, safety, and property.

4.8.1.1 Location

Hazardous materials are widely stored and transported throughout Tulsa. An event involving hazardous materials release could occur anywhere. The location of a hazardous materials release is classified as either being at a fixed site or in-transit. Due to the sensitivity of this information, a detailed list of Tier II facilities is not provided in this plan. Under 49 United States Code (U.S.C.) 5112, sections (a)(2) and (b), States and Tribal governments are permitted to designate and limit highway routes over which hazardous materials (HM) may be transported, provided the State or Tribal government complies with standards prescribed by the Secretary of Transportation (the Secretary) and meets publication requirements in section 5112(c). Highways listed on the National Hazardous Materials Route Registry (NHMRR) reported to the Federal Motor Carrier Safety Administration (FMCSA), Department of Transportation (DOT). as of March 31, 2018, are shown in Figure 4-25. The NHMRR is a

listing, as reported by States and Tribal governments, of all designated and restricted roads and preferred highway routes for transportation of highway route-controlled quantities (HRCQ) of Class 7 radioactive materials (RAM) (HRCQ/ RAM) and non-radioactive hazardous materials (NRHMs). Figure 4-25 illustrates the Tier II facilitates and Hazardous Material Routes, in Tulsa.

Figure 4-25: Tier II Sites and Transportation Routes



4.8.1.2 Extent

The extent of a hazardous substance release will depend on whether it is from a fixed or in-transit (mobile)source, the volume of substance released, duration of the release, the toxicity, and properties of the substance, and the environmental conditions (for example, wind and precipitation, terrain, etc.). Hazardous substance releases can contaminate air, water, and soils, possibly resulting in death and/or injuries. The dispersion can take place rapidly when the hazardous substance is transported by water and wind. While often accidental, releases can occur as a result of human carelessness, intentional acts, or natural hazards. When caused by natural hazards, these incidents are known as secondary events. Such releases can affect nearby

populations and contaminate critical or sensitive environmental areas. With a hazardous substance release, whether accidental or intentional, several potentially exacerbating or mitigating circumstances will affect its severity of the impact. Mitigating conditions are precautionary measures taken in advance to reduce the impact a release on the surrounding environment. Primary and secondary containment or shielding by sheltering-in-place measures protects people and property from the harmful effects of a hazardous substance release. Exacerbating conditions, characteristics that can enhance or magnify the effects of a hazardous substance release, include:

- Weather conditions, which affect how the hazard occurs and develops (such as wind speed and direction)
- Micro-meteorological effects of buildings and terrain, which alters the dispersion of hazardous substances in compliance with applicable codes (such as building or fire codes)
- Mechanical failures (such as fire protection and containment features), which can substantially increase the damage to the facility itself and to surrounding buildings
- Land use, population and building density will be factors contributing to the extent of exposure and impacts incurred.

The severity of a hazardous material incident is dependent not only on the circumstances described above, but also with the type of substance released, distance from the release, and the related response time for emergency response teams to stabilize and contain the release. Generally, areas closest to a release are at the greatest risk, due to their exposure to higher concentrations of the substance and the limited warning time before being impacted. However, depending on the substance/material, a release can rapidly travel great distances or remain present in the environment for long periods of time (e.g. centuries to millennia) allowing for greater dispersal, increasing the spatial extent of the impact.

4.8.1.3 Previous Occurrences

From January 1, 2012, to December 31, 2017, there were 411 fixed-site hazardous materials incidents in the City of Tulsa and Tulsa County reported to the National Response Center; nearly twice as many events as reported in the previous plan. Almost all of these were harmless, but reportable, releases of petrochemical processing gasses that would normally be flared (or burned). Common causes of releases to air were unplanned power outages, compressor failures, and high winds. The Pipeline and Hazardous Materials Safety Administration (PHMSA) tracks in-transit hazardous material releases through its nationwide database. Regulations in 49 CFR 171.15 and 171.16 govern situations where hazardous materials are released and the resulting required notifications and reporting. Unless they are properly reported, it is difficult to identify and track past hazardous materials releases that occur in transit.

4.8.1.4 Probability of Future Events

Overall Probability Rating based on Classifications in Table 4-1: Likely

The vast majority of events occurred in the oil and gas transportation, processing and refining industry, primarily located in West Tulsa. Tulsa should expect multiple hazardous materials incidents on an annual basis. The Tulsa Fire Department states that an average of one to two incidents each year will require some level of evacuation of a neighborhood or facility.

4.8.2 Vulnerability and Risk Assessment

Overall Significance based on Classifications in Table 4-1: Medium: The event's impacts on the planning area are noticeable but not devastating.

4.8.2.1 People

The greatest danger is to the populations working and living in the areas near Tier II facilities. Persons at heightened risk include those with mobility or severe health issues that would limit their ability to evacuate quickly and people who speak a language other than English, limiting their ability to receive warning messages.

The occurrence of a transportation incident involving hazardous materials in Tulsa is also a concern. The complexity of this hazard has much to do with the location of an event and materials involved. The mixing of chemical materials during an event can intensify the threat of loss of life and or injury. Contamination of the air and/or water can cause a major public health concern.

A rail or truck tank rupture would be a worst-case scenario if large quantities of hazardous materials are released in a short amount of time, especially one involving the release of anhydrous ammonia, which would have toxic effects on residents that breathed the vapor. Depending on the amount of material spilled, and the time it takes to contain the incident, populations more than ¼ mile downwind of a release could be impacted. Effort should be made to educate all residents in Tulsa about shelter in place and evacuation procedures.

The Risk Communication and Management Department of the Oklahoma DEQ provides information and technical support to citizens, local emergency planning committees (LEPCs), and industry concerning hazardous chemicals. The Tulsa County LEPC is working with INCOG on a commodity study to consider rerouting hazardous materials and minimize the population exposed. Results of this study will be incorporated into future updates of this plan.

4.8.2.2 Economy

Economic effects of this hazard have not been observed or reported in Tulsa.

4.8.2.3 Built Environment

Existing Structures An explosion at any Tier II facility may create off-site collateral damage. Adjacent structures and properties are most vulnerable. Hazardous material releases can damage and destroy public, commercial, and private property. Losses include both direct and indirect costs. Direct costs can be defined as the cost of materials, property damage, response cost, and remediation/cleanup cost for a specific release. Similar to the fixed-site hazardous materials release, the greatest risk to population and the built environment would be from an explosion from hazardous materials in transport. Proximity, intensity and the structural integrity of the building itself are all factors in the subsequent vulnerability and expected damage.

Infrastructure Water treatment plants use large amounts of liquid chlorine for purifying drinking water. A liquid chlorine spill at a water treatment plant could force the evacuation of the facility and a temporary stop of operations. Wastewater treatment plants process not only contaminated waste, but also use hazardous chemicals. A hazardous substance spill at a plant could force the shutdown of the facility. In addition, a malfunction at the plant could cause the spill of contaminated wastes into rivers and streams. A traffic incident involving hazardous materials would cause significant traffic delays. Damages to transportation infrastructure and their closure are not uncommon following a hazardous materials release.

Critical Facilities Potential losses to critical facilities caused by a hazardous materials release are difficult to monetize. The degree of damages to the asset depends on the scale of the incident. Critical facilities need to remain in operation before, during and after disaster events. Loss of use will impact the services they provide to the city which may have public safety and economic implications.

Cultural Resources site remediation efforts following a hazardous material release can result in adverse impacts to archeological resources and sensitive cultural areas in the attempt to remove and/or excavate contaminated sediments from an affected area.

Natural Environment A hazardous substance release, whether fixed-site or in-transit can negatively impact the natural environment. Depending on the nature and amount of the substance, the release may contaminate the air, water, or soil potentially causing concern for direct human and animal exposure, recreational usage, and fish and wildlife consumption. Water contamination, whether surface water or groundwater, is an immediate concern from a hazardous material release potentially impacting potable water supplies, wildlife, and recreational activities. Hazardous material releases could also significantly impact soils including agricultural lands. Depending on the characteristic of the hazardous material and/or the volume of product involved, the affected area can be as small as several square feet or as large as many square miles that require soil remediation. Such environmental damage can linger for decades and result in extensive remediation costs.

4.8.3 Summary of Observations and Recommendations

Observation	Recommendation	Action
Tulsans rely on warning sirens as source of emergency notification, and very few know the different sounds for other types of hazard events.	Educate the public on the various siren tones used by the city of Tulsa, and promote NOAA weather radios, IPAWS, and the TulsaReady App	2
Hazardous materials incidents are likely to occur on an annual basis.	The general public should be aware of what to do when notified a HazMat incident has occurred.	1
Essential facilities in Tulsa need back-up generators.	Tulsa should assess the need for generators at critical facilities and implement as funding becomes available	14
Tulsans rely on warning sirens as primary source of weather notifications.	Educate the public on purpose of outdoor warning sirens and promote NOAA weather radios, IPAWS, and the TulsaReady App.	1
Some areas of Tulsa are less equipped to prepare for or recover from hazard events	Create community facilities (resilience hubs) that can serve as gathering places during emergencies and interruptions in services, and outfit such facilities with access to key services, including water, electricity for charging cell phones, etc. Such capabilities could be integrated into schools and other existing community facilities.	29

4.9 Drought

4.9.1 Hazard Description

A drought is a period of unusually persistent dry weather that persists long enough to cause deficiencies in the water supply (surface or underground). Droughts are slow-onset hazards, but, over time, they can severely affect crops, municipal water supplies, recreational resources, and wildlife. If drought conditions persist over many years, the direct and indirect economic impacts can be significant. High temperatures, high winds, and low humidity can worsen drought conditions and also make areas more susceptible to wildfire. In addition, human actions and demands for water resources can accelerate drought-related impacts.

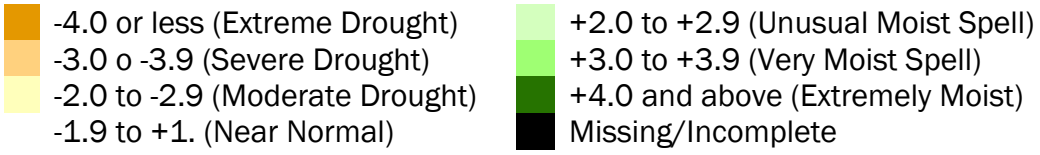
4.9.1.1 Location

Drought is a widespread hazard that affects the entire planning area.

4.9.1.2 Extent

The Palmer Drought Severity Index (PDSI), Figure 4-26, depicts prolonged (months, years) abnormal dryness or wetness. It is a standardized index that spans -10 (dry) to +10 (wet). Based on the Palmer Drought Index, Tulsa drought conditions can range from 4 to –4. This value is adjusted weekly through the Climate Prediction Center.

Figure 4-26 Palmer Drought Severity Index



4.9.1.3 Previous Occurrences

The City of Tulsa experiences Drought to some extent on an annual basis. Tulsa is fortunate to have a plentiful supply of good, reliable water that's available for ready use to residents and businesses. The last time Tulsa had mandatory water rationing from drought was in the 1980's. In more recent history, notable events include the following periods of drought in Table 4-12:

Table 4-12: Drought Event Narratives

Date	Event Narrative
December 2005-April 2006:	In Tulsa, only 1.59 inches of precipitation fell during December, January, and February. The winter of 2005-2006 was the driest ever in Tulsa. On average 5.36" of precipitation falls during the winter months in Tulsa County.
January 2011-November 2011:	July 2011 was officially the hottest month on record locally and nationally. High temperatures were over 100° F for almost the entire month. The City of Tulsa restricted water use for the first time since the 1980's during this summer due to the high demand for water

Date	Event Narrative
Summer 2012	Scorching temperatures combined with a lack of measurable rainfall resulted in significantly worsening drought conditions across all of eastern Oklahoma during July. Much of northeastern Oklahoma received less than 25 percent of average precipitation. The USDA declared all counties in eastern Oklahoma disaster areas due to the drought. Monetary damage estimates resulting from the drought were not available. The City of Tulsa initiated voluntary water restrictions in the summer of 2012

4.9.1.4 Probability of Future Events

Overall Probability Rating based on Classifications in Table 4-1: Highly Likely. Based on drought occurrences over the past 15 years, the City of Tulsa can expect to experience the effects of a severe drought cycle about every 5 to 10 years.

4.9.2 Vulnerability and Risk Assessment

Overall Significance based on Classifications in Table 4-1: Low, the event has a minimal impact on the planning area.

4.9.2.1 People

All the population of Tulsa is exposed and at risk for experiencing this hazard. NOAA Weather Radios are one way to keep the general public informed of drought conditions.

Tulsa's drinking water comes from two sources: Lakes Spavinaw and Eucha on Spavinaw Creek and Lake Oologah on the Verdigris River. Lakes Spavinaw and Eucha are owned and operated by the City. Lake Oologah is operated by the U.S. Army Corps of Engineers. A third emergency source of water is available from Lake Hudson on Grand River. Water is treated at two treatment plants: Mohawk and A.B. Jewell.

At the time of this plan update, the water supply is adequate to meet the current needs in the City of Tulsa. There is no concern drought would cause lack of drinking water. One potential impact of drought in Tulsa, mentioned by Tulsa Ministerial Alliance, is the effect on rural communities surrounding Tulsa. During periods of drought, Tulsa sees an influx in the request for meals at shelters. Drought conditions can cause prices for food to increase because of a drop-in supply. If people are not able to afford increasing prices during drought conditions, it is possible for them to suffer health problems because of the lack of healthy food. This is especially true in areas identified as having a high vulnerability in Tulsa based on their socio-economic status.

4.9.2.2 Economy

According to the University of Nebraska's Drought Monitor, the primary impact currently to the Tulsa area is the effect on wheat production, although other factors listed above may come into play for individual homeowners and businesses.

4.9.2.3 Built Environment

Existing Structures Drought's primary threat to structures within the City of Tulsa is from its contribution to the shrinkage of expansive soils. More information on this hazard is available in **Section 4.10,** below.

Infrastructure During periods of drought the City of Tulsa experiences water line breaks.

Critical Facilities Critical facilities in the City of Tulsa have no specific vulnerability to the Drought hazard—other than from expansive soils.

Cultural Resources The primary threat to historic properties and cultural resources within the City of Tulsa lies in the effect of its contribution to the shrinkage of expansive soils.

Future Development The 2012 TMUA comprehensive assessment recommends the following as Tulsa continues to develop:

Distribution Needs: The cumulative system upgrades relative to the current (2011) water distribution system required to meet the needs of the anticipated 2030 water system include: 10.9 miles of 72-inch waterline; 8.9 miles of 48-inch waterline; 13.3 miles of 24-inch waterline." Tulsa Utilities Comprehensive Assessment Executive Summary, August 2012.

Natural Environment Drought has many negative effects on the natural environment. The effects of drought on the ecosystem is one Tulsa should be concerned with. Specifically, tree mortality, wind erosion, insect infestations, plant disease and loss of migratory bird populations.

4.9.3 Summary of Observations and Recommendations

Observation	Recommendation	Action
Though water supply is adequate, Tulsans should be prepared for future drought conditions.	WatersSense is program sponsored by the U.S. Environmental Protection Agency (EPA), is both a label for water-efficient products and a resource for helping save water. Tulsa should implement aspects of the WaterSense program.	
Tulsa has adequate water supply. Even in historic drought conditions, water restrictions remained voluntary. The population is projected to increase over the next 20 years.	Tulsa should plan for population growth and additional water supply needs.	
Essential facilities in Tulsa need back-up generators. Nearly every hazard can cause power outages.	Tulsa should assess the need for generators at critical facilities and implement as funding becomes available.	14
Some areas of Tulsa are less equipped to prepare for or recover from hazard events.	Create community facilities (resilience hubs) that can serve as gathering places during emergencies and interruptions in services, and outfit such facilities with access to key services, including water, electricity for charging cell phones, etc. Such capabilities could be integrated into schools and other existing community facilities.	29

4.10 Expansive Soils

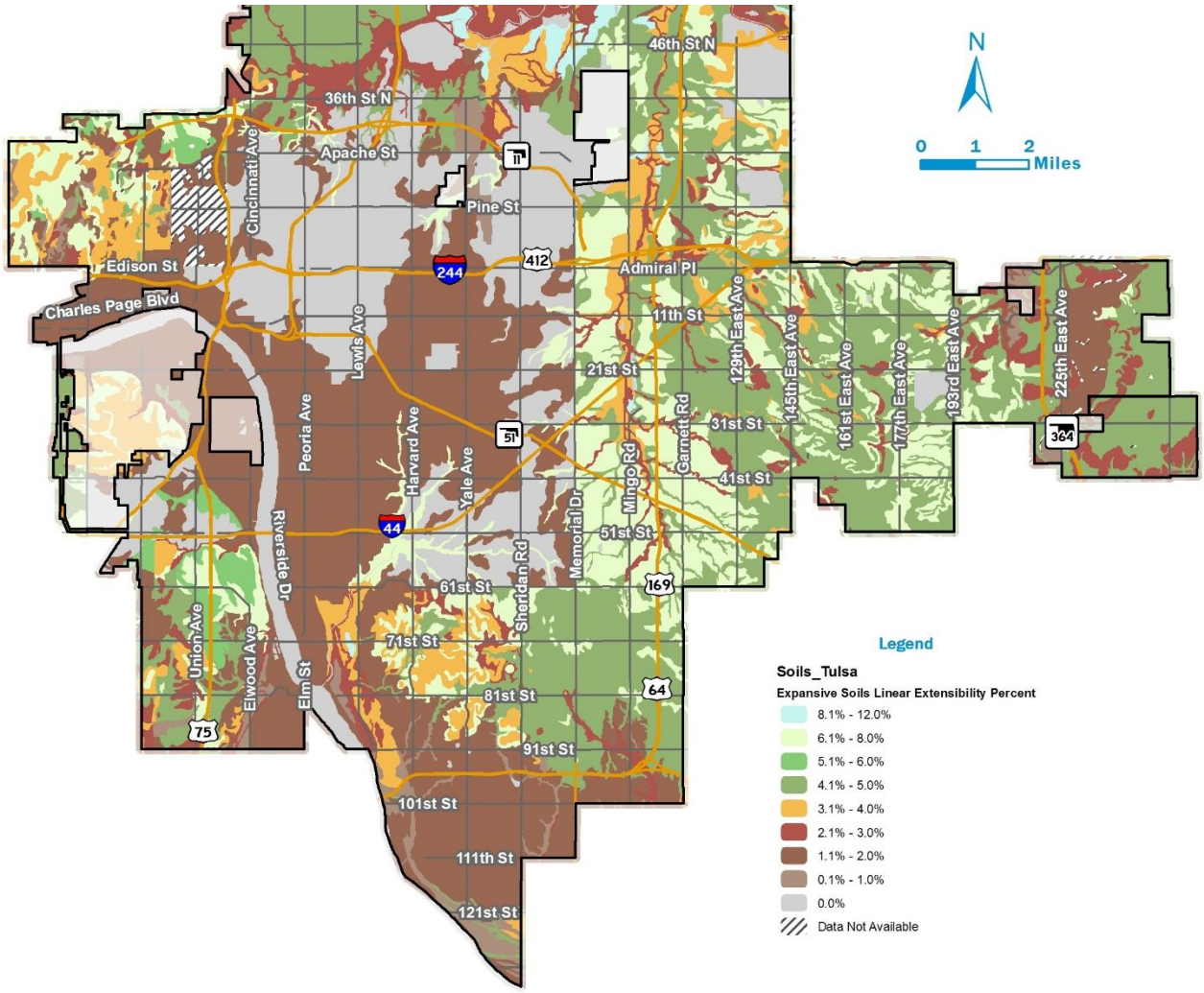
4.10.1 Hazard Description

Soils and soft rock that tend to swell or shrink due to changes in moisture content are commonly known as expansive soils. Expansive soils are often referred to as swelling clays because clay materials attract and absorb water. Dry clays will increase in volume as water is absorbed and, conversely, decrease as they dry. These movements lead to cracking and buckling of the infrastructure built on or in expansive soils and result in billions of dollars of damage annually.

4.10.1.1 Location

Based on surveys of underlying soils, Figure 4-27 shows a generalized map of the areas of Tulsa where soils have low to very high expansive qualities. Generally, many Tulsa lowlands along the river and waterways have low shrink-swell soils. Many higher elevations have moderate to a high potential, including large areas of central and east Tulsa.

Figure 4-27: Location of Expansive Soils, Tulsa



4.10.1.2 Extent

The extent to which soil expansion is present in an area or site can be measured using the Soil Expansion Potential standard (ASTM D-4829). An "Expansion Index" associated with the standard provides a range of scores that are used to test soil and determine the extent of expansion. Tulsa is underlain by soils with very high expansion potential as identified on the ASTM Expansion Index. Based on the expansion potential rating, mitigation may be required for building construction or repairs. As an example, the Uniform Building Code (UBC) mandates that "special [foundation] design consideration" be employed if the Expansion Index is 20 or higher. Table 4-13 compares the Linear Extensibility Percent, as shown in Figure 4-27, with the associated expansion potential.

Table 4-13: Soil Expansion Potential

Linear Extensibility %	Potential Expansion
0%	Water
<3%	Low
3%-6%	Medium
6%-9%	High
>9%	Very High

4.10.1.3 Previous Occurrences

There have been no federally-declared disasters for expansive soils. Historical records including scientific study data for this hazard is either sparse, not readily available, or does not exist in summary form. There may have been instances of expansive soils causing damage but have not been reported. Damage of varying degrees of severity occurs on an ongoing and seasonal basis. The frequency of damage from expansive soils can be associated with the cycles of drought and heavy rainfall and also reflect changes in moisture content based on typical seasonal patterns. Published data summarizing damages specific to Tulsa is not available, but it is acknowledged that a certain degree of damage to property and infrastructure occurs annually.

4.10.1.4 Probability of Future Events

Overall Probability Rating based on Classifications in Table 4-1: Highly Likely

Analyses of future probability have not been prepared because of the nature of this hazard, which is consistent with other geologic events that occur rarely or slowly over time. It could be assumed that shrink-swell soils in Tulsa will continue to cause localized problems in areas of high to very high expansive soils, similar to those experienced in the past. Tulsa is considered to have a high probability of experiencing losses associated with this hazard in the future.

4.10.2 Vulnerability and Risk Assessment

Overall Significance based on Classifications in Table 4-1: Low, the event has a minimal impact on the planning area.

4.10.2.1 People

Direct threats to life or personal injury have not generally been documented for expansive soils, due to the nature of the hazard. Indirect threats to populations in Tulsa include economic damages in residential structures. Public

health concerns arise from this hazard when the shrinking and swelling of soils cause water or sewer lines to break, which often occur in critical times such as periods of extreme heat and drought.

4.10.2.2 Economy

Neither the City nor insurance companies monitor damage to structures from expansive soils as the impact of a specific natural hazard. The City treats all such damage as a maintenance issue. According to City Engineers, the expansive soil hazard is routinely taken into account in engineering studies and construction practices for infrastructure projects, but not specifically documented.

4.10.2.3 Built Environment

Existing Structures The increase in soil volume can cause damage to foundations. The most obvious manifestations of damage to buildings are sticking doors, uneven floors, and cracked foundations, floors, walls, ceilings, and windows. If damage is severe, the cost of repair may exceed the value of the building. It does not take much movement to damage buildings. As little as a differential movement of 0.25 inches between adjacent columns can cause cracking in load-bearing walls of a 2-foot-wide bay. A total of 22, 920 improved parcels in Tulsa are underlain by soils with High to Very High shrink-swell potential, with an estimated market value of $6.5 Billion.

Infrastructure Damage to the built environment results from differential vertical movement that occurs as clay moisture content adjusts to the changed environment. In a highway pavement, differential movement of 0.4 inches within a horizontal distance of 20 feet is enough to pose an engineering problem if high standards for fast travel are to be maintained.

Critical Facilities Of the facilities identified as critical by the city of Tulsa, 166 are built upon soils classified as having high or very high shrink-swell potential.

Cultural Resources It is not anticipated this hazard would have great impacts on cultural resources.

Future Development Because the level of structural damage that is often incurred as a result of building on soils with high to very high shrink-swell potential, it is imperative for builders to identify soil types at proposed sites before they are developed

Natural Resources It is not anticipated this hazard would affect natural resources in the city of Tulsa.

4.10.3 Summary of Conclusions and Recommendations

Observation(s)	Recommendation	Actions
During periods of extreme heat and drought the City of Tulsa experiences water line breaks due to expansive soils.	Tulsa should replace broken pipes in areas of high soil expansion, with piping more resistant to breakage.	28
Many Tulsans are unaware of the impacts associated with high and very high expansive soils.	Tulsa should educate the public on the importance of identifying soils types when purchasing or building a new home.	1

4.11 Lightning

4.11.1 Hazard Description

Lightning is a discharge of electrical energy that results from the buildup of positive and negative charges in a thunderstorm, which creates a "bolt" when the buildup of charges becomes strong enough. Lightning can occur between a cloud and the ground (Cloud-to-Ground Lightning), between two clouds (Intercloud Lightning), or within the same cloud (Intracloud Lightning). Lightning can strike 10 miles out from the rain column.

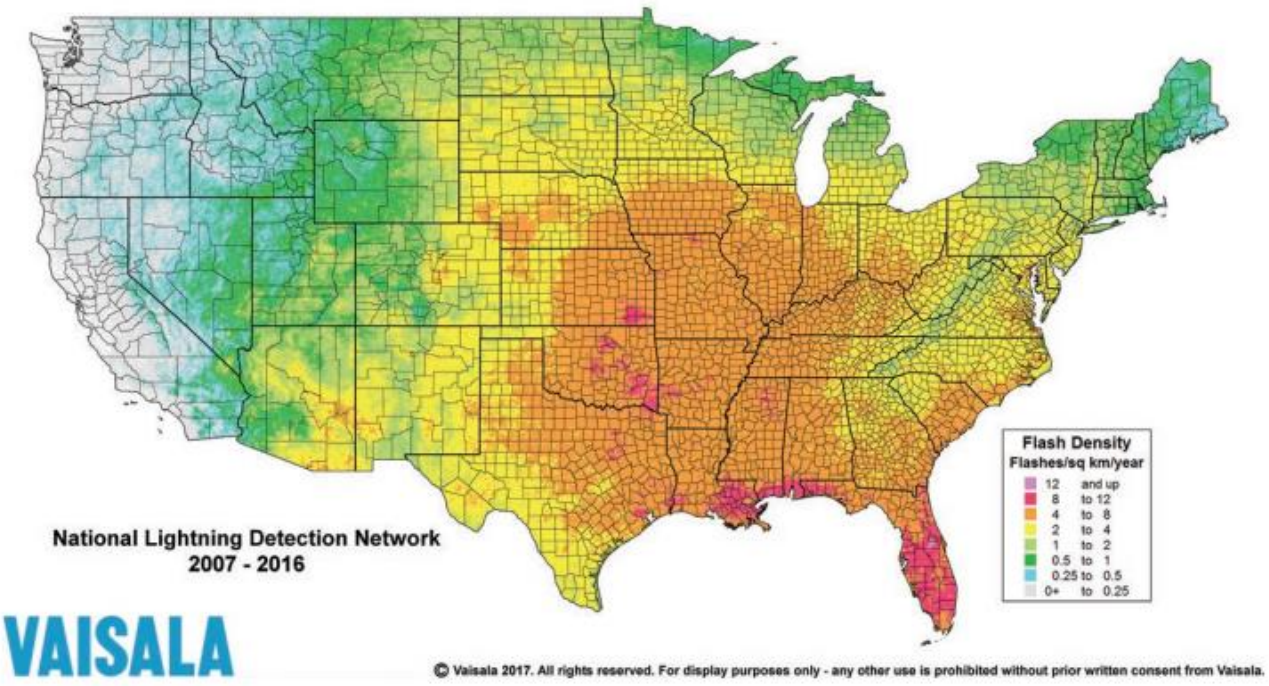
4.11.1.1 Location

As lightning is a by-product of thunderstorms, all areas of Tulsa are subject to the exposure and effects of lightning events. The risk of this hazard is uniform over the planning area.

4.11.1.2 Extent

The Vaisala Flash Density Map, Figure 4-28, indicates that the City of Tulsa may experience between 4 and 8 lightning flashes per sq km per year, or between 3,108 to 4,144 lightning flashes within the jurisdiction each year (4 to 8 flashes x 518 sq. km/yr).

Figure 4-28 VISALA Flash Density



4.11.1.3 Previous Occurrences

The NCEI Storm Events Database includes reports of seven damaging lightning events since 1998. The low number of reported incidents does not mean lightning only occurred seven times in the city. Based on information provided by the Vaisala Flash Density Map, Tulsa likely experienced between 4 and 8 lightning flashes per sq km per year, or between 3,108 to 4,144 lightning flashes within the jurisdiction each year (4 to 8

flashes x 518 sq. km/yr) since the previous plan was approved. Narratives of several damaging lightning events in Tulsa are below in Table 4-14.

Table 4-14: Lightning Event Narratives

Date	Event Narrative
May 9, 2000	One mile to the east of Tulsa, lightning strikes burned out two power pole phases causing power outages to approximately 550 residents.
March 20, 2012	March 20, 2012: Computer records indicate a single "super bolt" struck in the heart of South Tulsa just after 3:30 AM. It woke Tulsans and set off car alarms. Many thought it was an earthquake. A super bolt is a positively charged cloud-to-ground stroke of lightning. No damage from the super bolt was reported (source: KRMG Tulsa)
July 23, 2013:	Lightning struck the Union 8th Grade Center, igniting a fire that severely damaged the roof of the building.
August 6, 2017	Lightning struck Holy Apostles Orthodox Christian Church at 15th and Peoria. The lightning strike hit the cross on top of the church and blew a hole in the cupola ceiling. A lightning rod was installed after the event to prevent future strike damage.
May 3, 2018:	Lightning believed to be the cause of structure fire in Midtown Tulsa home.

4.11.1.4 Probability of Future Events

Overall Probability Rating based on Classifications in Table 4-1: Highly Likely, 90 to 100 percent probability of occurrence in the next year or a recurrence interval of less than 1 year.

Tulsa should expect future lightning events to fall in line with the NLDN data from previous years, with a high probability of lightning occurring on an annual basis.

4.11.2 Vulnerability and Risk Assessment

Overall Significance based on Classifications in Table 4-1: Low, The event has a minimal impact on the planning area.

4.11.2.1 People

All the population of Tulsa is exposed and at risk for experiencing this hazard. The City of Tulsa includes over 9,000 acres of total park space and several prestigious golf courses. Lightning events could place park visitors in imminent danger, potentially park evacuation. Injuries and deaths associated with lightning are highly preventable. Areas of Tulsa of most concern are those with higher concentrations of people who do not have a way to receive severe weather alerts, especially low-income and non-English speaking populations. Mitigation of the action associated with this hazard includes public education and outreach. Additionally, Tulsa could install lightning detection systems to keep park visitors safe from lightning when storms approach.

4.11.2.2 Economy

Economic impacts of this hazard are primarily related to loss of power and business interruption. The amount of impact on the economy depends on the length of time until service restoration.

4.11.2.3 Built Environment

Existing Structures All structures and buildings within the City of Tulsa are vulnerable to the impact of a lightning event. A bolt of lightning can explode walls of brick and concrete and cause fires to ignite within facilities.

Infrastructure The most severe consequence of a lightning strike on Tulsa's infrastructure is from loss of electrical power and communications. Lightning has caused damage to transformers and downed lines in the past, resulting in outages in the service area.

Critical Facilities All critical facilities in Tulsa are exposed to this hazard. Lightning can cause extensive damages to facilities. Tulsa should equip critical facilities with lightning solutions to lessen the impact of a direct strike.

Cultural Resources All cultural institutions in Tulsa are exposed to lightning. Many of these institutions keep records or are considered to be historic. Loss of any historic resources because of fire as a result of lightning would be devastating.

Future Development All future development is exposed to the lightning hazard. Tulsa should consider integrating lightning protection solutions in future growth.

Natural Environment Lightning does not pose a significant threat to the natural environment. The main concern would be a grassland fire caused by lightning during dry conditions. Summary of Observations and Recommendations

4.11.3 Summary of Observations and Recommendations

Observation(s)	Recommendation (s)	Action(s)
Populations involved in outdoor activities are at risk from severe weather events.	Notify the public of the risks associated with severe weather.	1
Tulsa benefits from having many outdoor recreation areas. Unless directly connected to a mobile device with severe weather alerts, patrons of these areas may be unaware of lightning risks.	Tulsa should consider installing lightning detection and warning systems at parks to keep guests safe from lightning when storms approach.	15
Lightning strikes have caused service disruption to businesses and critical facilities in Tulsa. Lightning can cause extensive damages to facilities.	Tulsa should equip critical facilities with lightning protection solutions to lessen the impact of a direct strike.	16

4.12 Earthquake

4.12.1 Hazard Description

An earthquake is a sudden release of energy that creates a movement in the Earth's crust. Most earthquake-related property damage and deaths are caused by the failure and collapse of structures due to ground shaking. The level of damage depends upon the extent and duration of the shaking. Most severe earthquakes take place where the vast tectonic plates that form the Earth's surface collide and slide slowly over, under, and past each other. They can also occur along any of the multitudes of fault and fracture lines within the plates themselves.

4.12.1.1 Location

All of Tulsa is equally susceptible to an earthquake as they are not limited to one specific geographic area. An earthquake occurring in an entirely different state could affect Tulsa County, and consequently the City of Tulsa. The risk of this hazard is uniform over the entire planning area.

4.12.1.2 Extent

Two standard measures are used to classify an earthquake's extent: magnitude and intensity. These measures are sometimes referred to as the Richter Scale (magnitude) and the Modified Mercalli (intensity). As more seismograph stations were installed around the world, it became apparent that the method developed by Richter was strictly valid only for certain frequency and distance ranges. Because of the limitations of all three magnitude scales (ML, Mb, and Ms), a new, more uniformly applicable extension of the magnitude scale, known as moment magnitude, or Mw, was developed. In particular, for very large earthquakes, moment magnitude gives the most reliable estimate of earthquake size. Earthquakes are classified in categories ranging from minor to great, depending on their magnitude. Table 4-15 shows the list the USGS uses to classify earthquakes:

Table 4-15: USGS Earthquake Magnitude Scale[17]

Class	Magnitude
Great	8 or more
Major	7-7.9
Strong	6-6.9
Moderate	5-5.9
Light	4-4.9
Minor	3-3.9

4.12.1.3 Previous Occurrences

The USGS and Oklahoma Geological Survey report earthquakes with a magnitude of 3.0 or higher. Earthquakes are not felt until they reach a magnitude of 3.0 on the Richter Scale. No earthquakes with a magnitude of 3.0 or higher have occurred. The 5.6 Magnitude earthquake on November 5, 2011 near Prague, OK was felt within Tulsa limits. Another 5.6 magnitude quake occurred near Pawnee, OK on September 3, 2016. Both events were felt in Tulsa; where no injuries were reported, and damages were limited to unsecured items falling and cracks to drywall. Events near Tulsa are mapped in Figure 4-29.

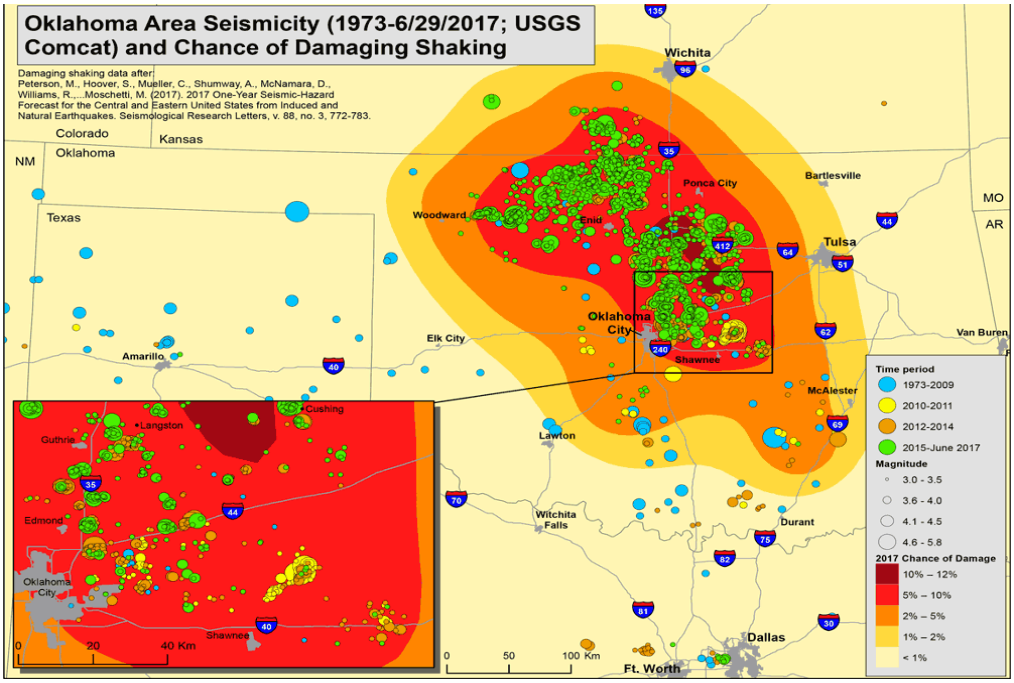
[17] http://www.geo.mtu.edu/UPSeis/magnitude.html

4.12.1.4 Probability of Future Events

Overall Probability Rating based on Classifications in Table 4-1: Unlikely

According to the 2017 Hazard Map published by the USGS[18], Tulsa is located in an area with a 2%-5% chance of damaging shaking on an annual basis.

Figure 4-29: 2017 Hazard Map (includes hazard from induced seismicity)



4.12.2Vulnerability and Risk Assessment

Overall Significance based on Classifications in Table 4-1: Low, the event has a minimal impact on the planning area.

4.12.2.1 People

Most earthquake injuries and fatalities occur within buildings from collapsing walls and roofs, flying glass, and falling objects. As a result, the extent of a community's risk depends not just upon its location relative to a known fault, and its underlying geology and soils, but also on the design of its structures. Those populations who do not know how to respond when an earthquake occurs remain vulnerable to potential earthquakes. All people in the City of Tulsa should be made aware of what actions to take during an earthquake event. Contents in a home can be as or more dangerous and damage-prone than the structure itself. Any unsecured objects can move, break, or fall, as an earthquake shakes, are potential safety hazards and potential property losses.

[18] *Source: USGS, https://earthquake.usgs.gov/earthquakes/byregion/oklahoma.php*

4.12.2.2 Economy

Earthquakes felt in Tulsa are not likely to directly affect the economy. Even so, small business owners should make their businesses safer to be in during earthquakes and more resistant to earthquake damage by assessing its structure and contents and correcting any weaknesses.

4.12.2.3 Built Environment

Existing Structures Depending on when and how it was designed and built, a structure may have weaknesses that make it more vulnerable to earthquakes. Common examples include structures not anchored to their foundations or having weak crawl space walls, unbraced pier-and-post foundations, or unreinforced masonry walls or foundations. It is not likely an earthquake would cause major structural damage to any City of Tulsa facilities.

Infrastructure It is not likely the City of Tulsa's infrastructure will be impacted by an earthquake, as the city is located in an area of low seismicity.

Critical Facilities Critical facilities face the same potential impacts to earthquakes as other structures/buildings in the City of Tulsa. Of particular concern are the design and construction of critical facilities, such as hospitals and transportation facilities, oil and gas pipelines, electrical power and communication facilities, and water supply and sewage treatment facilities and lines.

Cultural Resources Earthquakes could cause minor structural damages to historic structures. A more significant concern is the contents of structures, such as museum collections. Tulsa could consider a program to stabilize irreplaceable pieces in museums, highly susceptible to damage from even minor earthquake events.

Future Development The City of Tulsa adopted the ICC International Building Code, 2015, and the ICC International Residential Code for One and Two-Family Dwellings, 2015 Edition. There is no reason to believe that any future development will be impacted to any degree greater than existing development.

Natural Environment Earthquakes can cause land subsidence, either directly related to an earthquake or provoked by shaking.

4.12.3 Summary of Observations and Recommendations

Observation	Recommendation	Action
Shaking from earthquakes outside the Tulsa metro may still affect structures within the City.	Tulsa should educate the public on ways to make their property safe from earthquakes, and proper response	2
Damage associated with earthquakes in Tulsa is generally minor. Citizens notice smaller impact such as pictures falling off walls, or small cracking. Properties in Tulsa were not constructed with earthquakes in mind.	Critical facilities should be constructed or repaired, to resist the effects of earthquakes.	29
Earthquakes could cause minor structural damages to historic structures. A more significant concern is the contents of structures, such as museum collections.	Tulsa could consider a program to stabilize irreplaceable pieces in museums, highly susceptible to damage from even minor earthquake events.	

Chapter 5 Mitigation Strategy

This chapter identifies the hazard mitigation strategy and goals set by the City of Tulsa and discusses the mitigation projects, or measures, to be taken to achieve those goals. The mitigation strategy describes how the community will accomplish the overall purpose, or mission, of the planning process. The mitigation strategy is made up of three main required components: mitigation goals, mitigation actions, and a plan for implementation. These provide the framework to identify, prioritize, and implement actions to reduce risk to hazards.

5.1 Mitigation Goals

Initially, Goals from the 2014 City of Tulsa Hazard Mitigation Plan were reviewed and evaluated by the Program based on both progress and actions taken in the plan maintenance period, and on development or review of other pertinent City of Tulsa plans. Goals that were deemed to be effective and pertinent to the current plan were retained and incorporated into the 2019 plan.

5.1.1 Mission Statement

To create a disaster-resistant community and improve the safety and well-being of Tulsa by reducing deaths, injuries, property damage, environmental and other losses from natural and technological hazards in a manner that advances community goals, quality of life, and results in a more livable, viable, and sustainable community.

5.1.2 Mitigation Goal

To identify community policies, actions and tools for long-term implementation in order to reduce risk and future losses stemming from natural and technological hazards that are likely to impact the community.

5.1.3 Goals for All Hazards

- Minimize loss of life and property from natural hazard events;
- Protect public health and safety;
- Increase public awareness of risk from natural hazards;
- Reduce risk and effects of natural hazards;
- Identify hazards and assess risk for local area;
- Ascertain historical incidence and frequency of occurrence;
- Determine increased risk from specific hazards due to location and other factors;
- Improve disaster prevention;
- Improve forecasting of natural hazard events;
- Limit building in high-risk areas;
- Improve building construction to reduce the dangers of natural hazards;
- Improve government and public response to natural hazard disasters.

5.2 Recommended Mitigation Actions

A mitigation action is a specific action, project, activity, or process taken to reduce or eliminate long-term risk to people and property from hazards and their impacts. A review of the 2014 mitigation actions identified in the previous plan was completed by the planning team. Actions were evaluated with the intent of carrying over any not started, or continuous for the next five years. Actions with the same intent were combined into a general action item to allow more opportunity for FEMA funding. Specific observations and problem statements, resulting in the actions listed below, are included at the end of each hazard section in the Risk Assessment, Chapter 4.

Stakeholders reviewed actions to mitigate against the observations identified in the risk assessment at a meeting on December 13, 2018. Potential mitigation actions were prioritized using the evaluation criteria recommended on Worksheet 6.1 in the *FEMA Local Mitigation Planning Handbook* and developed, an Action Plan for the actions determined to be highly effective and feasible. Certain mitigation measures are recommended for multiple hazards.

Table 5-1 Evaluation Criteria

Life Safety	How effective will the action be at protecting lives and preventing injuries?
Property Protection	How significant will the action be at eliminating or reducing damage to structures and infrastructure?
Technical	Is the mitigation action technically feasible? Is it a long-term solution? Eliminate actions that, from a technical standpoint, will not meet the goals.
Political	Is there overall public support for the mitigation action? Is there the political will to support it?
Legal	Does the community have the authority to implement the action?
Environmental	What are the potential environmental impacts of the action? Will it comply with environmental regulations?
Social	Will the proposed action adversely affect one segment of the population? Will the action disrupt established neighborhoods, break up voting districts, or cause the relocation of lower income people?
Administrative	Does the community have the personnel and administrative capabilities to implement the action and maintain it or will outside help be necessary
Local Champion	Is there a strong advocate for the action or project among local departments and agencies that will support the action's implementation?
Other Community Objectives	Does the action advance other community objectives, such as capital improvements, economic development, environmental quality, or open space preservation? Does it support the policies of the comprehensive plan?

The types of mitigation actions reviewed to reduce long-term vulnerability include:

- Preventative Activities
- Floodplain Management Regulatory/Current & Future Conditions
- Property Protection Activities
- Natural Resource Protection Activities
- Emergency Services Activities
- Structural Projects
- Public Information Activity

Action 1	**Develop and fund hazard preparedness, education, information, and awareness programs.**
Responsible Agency	TAEMA, Engineering Services
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	All
Type of Action	Public Information Activity

Action 2	**Develop a city-wide disaster recovery and reconstruction plan.**
Responsible Agency	TAEMA, Engineering Services
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	All
Type of Action	Post-Disaster Mitigation Policies and Procedures

Action 3	**Inventory and maintain an active list of disaster resources available in Tulsa.**
Responsible Agency	TAEMA, Engineering Services, Tulsa Health Dept
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	All
Type of Action	Emergency Services Activity

Action 4	**Develop an emergency preparedness and mitigation website**
Responsible Agency	TAEMA, Engineering Services
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	All
Type of Action	Public Information Activity

Action 5	**Evaluate, upgrade and maintain outdoor warning systems.**
Responsible Agency	TAEMA
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	High Wind/Tornado, Flood, Dam/Levee Failure
Type of Action	Preventative Activity

Action 6	**Purchase and distribute NOAA weather radios.**
Responsible Agency	TAEMA
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	High Wind/Tornado, Flood, Winter Storm
Type of Action	Preventative Activity

Action 7	**Maintain debris management plan and update as required/needed**
Responsible Agency	TAEMA
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	Winter Storms, High Winds/Tornado, Floods, Dam/Failure, Earthquakes, Wildfire
Type of Action	Emergency Services Activity

Action 8	**Initiate an individual safe room rebate program**
Responsible Agency	TAEMA
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	High Winds/Tornado
Type of Action	Structural Project

Action 9	**Maintain safe room inventory and GIS database**
Responsible Agency	TAEMA
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	High Winds/Tornado, Floods
Type of Action	Emergency Services Activity

Action 10	**Provide safe rooms at critical facilities**
Responsible Agency	TAEMA
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	High Winds/Tornado
Type of Action	Structural Project

Action 11	**Educate the public on benefits of disaster resistant construction**
Responsible Agency	Engineering Services, TAEMA
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	All
Type of Action	Public Information Activity

Action 12	**Train/Educate on techniques of disaster-resistant homebuilding**
Responsible Agency	Engineering Services, TAEMA
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	All
Type of Action	Public Information Activity

Action 13	**Retrofit critical facilities to with stand hazard events.**
Responsible Agency	Engineering Services, TAEMA
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	High Winds, Tornadoes, Hail, Earthquakes
Type of Action	Property Protection Activity

Action 14	**Install generators at critical facilities.**
Responsible Agency	Engineering Services, TAEMA
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	All
Type of Action	Emergency Service Activity

Action 15	**Purchase and install lightning warning systems**
Responsible Agency	Engineering Services, TAEMA, Tulsa County Parks
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	Lightning
Type of Action	Preventative Activity

Action 16	**Construct lightning rods or air terminals for protection of critical facilities.**
Responsible Agency	Engineering Services
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	Lightning
Type of Action	Preventative Activity

Action 17	**Educate the public on the importance of flood insurance**
Responsible Agency	Engineering Services
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	Flood, Dam/Levee Failure
Type of Action	Public Information Activity

Action 18	**Update Master Drainage Plans when conditions warrant.**
Responsible Agency	Engineering Services
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	Flood, Dam/Levee Failure
Type of Action	Floodplain Management Regulatory

Action 19	**Acquire properties in the FEMA Floodplain, Tulsa Regulatory Floodplain and Repetitive Loss/Severe Repetitive Loss properties.**
Responsible Agency	Engineering Services
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	Flood, Dam/Levee Failure
Type of Action	Property Protection Activity

Action 20	**Develop emergency plan for the Arkansas River Corridor.**
Responsible Agency	Engineering Services
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	Flood, Dam/Levee Failure
Type of Action	Emergency Services Activity

Action 21	**Implement recommendations of the City of Tulsa Master Drainage Plans.**
Responsible Agency	Engineering Services
Potential Resources	Local/General, FEMA HMA
Timeframe	Annually, 2019-2024
Hazards Addressed	Flood, Dam/Levee Failure
Type of Action	Structural Project

Action 22	**Repair the levees based on recommendations from USACE.**
Responsible Agency	Engineering Services
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	Flood, Dam/Levee Failure
Type of Action	Structural Project

Action 23	**Notify the general public of their risk living within the floodplain, levee, or dam inundation area.**
Responsible Agency	Engineering Services
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	Flood, Dam/Levee Failure
Type of Action	Public Information Project

Action 24	**Construct additional fire stations in outlying areas.**
Responsible Agency	Tulsa Fire Department
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	Fire
Type of Action	Preventative Activity, Emergency Services Activity

Action 25	**Replace inadequately sized water lines with lines of sufficient size to provide proper fire protection to annexed and existing areas.**
Responsible Agency	Engineering Services, Water Dept.
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	Fire
Type of Action	Preventative Activity

Action 26	Implement mitigation actions to reduce fire access issues
Responsible Agency	Tulsa Fire Department
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	Fire
Type of Action	Preventative Activity

Action 27	Implement Water Sense Program.
Responsible Agency	Water/Sewer
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	Drought
Type of Action	Public Information/Natural Resource Protection/Preventative

Action 28	Replace broken pipes in areas of high soil expansion, with piping more resistant to breakage.
Responsible Agency	Water/Sewer
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	Drought, Extreme Heat, Expansive Soils
Type of Action	Structural Project

Action 29	Create community resilience hubs
Responsible Agency	Resilient Tulsa
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	All
Type of Action	Public Information Activity

Action 30	Develop and implement an air conditioner loan program
Responsible Agency	TAEMA, Community Service Council
Potential Resources	Local/General, FEMA HMA
Timeframe	2019-2024
Hazards Addressed	All
Type of Action	Preventative Activity

5.3 Financial Assistance for Hazard Mitigation Projects and Planning

Currently, FEMA administers three programs that provide funding for eligible mitigation planning and projects that reduce disaster losses and protect life and property from future disaster damages. The three programs are the Hazard Mitigation Grant Program (HMGP), the Flood Mitigation Assistance (FMA) Program, and the Pre-Disaster Mitigation (PDM) Program.

- HMGP assists in implementing long-term hazard mitigation planning and projects following a Presidential disaster declaration
- PDM provides funds for hazard mitigation planning and projects on an annual basis
- FMA provides funds for planning and projects to reduce or eliminate the risk of flood damage to buildings that are insured under the National Flood Insurance Program (NFIP) on an annual basis

HMGP funding is generally 15% of the total amount of Federal assistance provided to a State, Territory, or federally-recognized tribe following a major disaster declaration. PDM and FMA funding depends on the amount Congress appropriates each year for those programs. Individual homeowners and business owners may not apply directly to FEMA. Eligible local governments may apply on their behalf.

The intent of this section is to identify projects already identified in the City of Tulsa Capital Improvements Program or Master Drainage Program, eligible for FEMA Hazard Mitigation Assistance. The list may be expanded as additional projects are identified. Implementation will be based on the availability of funds.

Applications submitted to FEMA must meet the minimum eligibility criteria for all submittals. All applications submitted must include, but are not limited to, a scoping narrative (scope of work, work schedule, and detailed cost estimate) and forms. All mitigation project sub-applications must also include, proof of cost-effectiveness, feasibility and effectiveness, documentation of compliance with Environmental and Historic Preservation laws and forms. If there is not enough information to submit an application, Tulsa should consider applying for Advance Assistance through either HMGP or PDM. Advance Assistance may be used for the following activities.

- Obtain staff or resources to develop cost-share strategy and identify potential match funding;
- Evaluate facilities or areas to determine appropriate mitigation actions;
- Incorporate environmental considerations early into program decisions;
- Collect data for benefit cost analyses, environmental compliance and other program requirements;
- Scope and prioritize hazard mitigation projects to incorporate sustainability, resilience and renewable building concepts;
- Develop hazard mitigation projects, including engineering design and feasibility actions
- Conduct meetings, outreach and coordination with potential sub-applicants and community residents to identify potential participants for property acquisition and demolition or relocation projects;
- Conduct engineering design and feasibility studies for larger or complex community drainage projects or critical facility retrofits (such as for Phased Projects);
- Conduct hydrologic and hydraulic studies for unmapped flood zones or approximate A zones areas where communities propose to submit hazard mitigation projects;
- Perform professional cost estimation services to aid consistency in project budgeting across sub-applications;
- Perform services to address data consistency needs for other project application categories, such as environmental and historic preservation (EHP), cost sharing mechanisms and work schedules;

Project 1 Bell Fulton Flood Mitigation

Action Number: 21

Project Type: Localized Flood Risk Reduction Projects

Estimated Cost: $7,700,000

Advance Assistance Recommended: Yes

Project Description: This project is recommended in the **Bell-Fulton Master Drainage Plan, updated in November 2017**, as Problem Area 4, Alternative 3a. The project will construct two stormwater detention facilities on Fulton Creek in an area that floods frequently. The project will require acquisition of 16 properties, 12 of which are impacted by the 1% (100-year) floodplain. It also includes the replacement of downstream bridge at S. 93rd E. Ave. that causes nearly 5 feet of surcharge upstream. The two project elements in combination will remove 117 properties from the 1% (100-year) floodplain downstream from 38th St.

Project 2 Springdale Flood Mitigation

Action Number: 21

Project Type: Localized Flood Risk Reduction Projects

Estimated Cost: $4,300,000

Advance Assistance Recommended: No, projects is fully scoped and are ready to be submitted.

Tulsa should work with FEMA Region VI on an alternate approach to the BCA. The studys included Benefit Cost Analyses that were completed using the Corps of Engineers Flood Damage Reduction Analysis (HEC-FDA) program. We were not able to obtain reliable results from the FEMA Benefit Cost Analysis (BCA) program due in part to the large number of structures that were included in the analyses and the fact that part of the downstream reaches are storm sewered. FEMA representatives were contacted in an effort to resolve the technical issues with the BCA program and the consultant was told that the issues could not be addressed.

Project Description: This project was recommended in the **Dirty Butter Creek Master Drainage Plan completed in 1987**. The project itself was updated in 2018 by Swift Water Resources LLC to determine current project benefits. It is located on Tributary RB1. The properties within the pond footprint were purchased by the City of Tulsa following completion of the original Master Drainage Plan. Downstream from the pond, the inadequate storm sewer causes overflow at E. Virgin Street to the north, flooding 76 residential and 4 commercial/church buildings. The project removes 53 residential and 1 church structure from the 1% (100-year) floodplain. The project cost is $4,300,000 with nearly $5,000,000 in benefits.

Project 3 Coal Creek Flood Mitigation

Action Number: 21

Project Type: Localized Flood Risk Reduction Projects

Estimated Cost: $10,200,000

Advance Assistance Recommended: Yes:

Independence and Hughes Ponds – These two ponds are recommended in the **Coal Creek Master Drainage Update, updated in July 2018**. These two ponds cost $10,200,000 with projected benefits of over $20,000,000. They are located on RB1 (Hughes), a stream reach with 58 residences and 10 commercial buildings in the 1% floodplain, and RB2 (Independence), a stream reach with 185 residences and 2 commercial buildings in the 1% floodplain.

Project 4 Proposed Detention Sites No. 4 and 5, Joe Creek East Branch.

Action Number: 21

Project Type: Localized Flood Risk Reduction Projects

Estimated Cost: TBD

Advance Assistance Recommended: Yes

These ponds are recommended in the **Joe Creek East and West Branches Master Drainage Plan, prepared in 1989**. Site 4 requires the purchase of 18 floodplain properties while Site 5 is located within an existing City park. The combined storage capacity of the 2 ponds is 57 acre-feet. Together they provide $1,218,000 in 1989 dollars. The ponds are currently being re-evaluated in the Joe Creek Master Drainage Plan Update but are still considered to be viable projects.

Chapter 6: Plan Maintenance and Adoption

6.1 Introduction

This chapter includes a discussion of the plan maintenance process and documentation of the adoption of the plan by the Tulsa City Council. The City of Tulsa will ensure that a regular review and update of the Multi-Hazard Mitigation Plan occurs. The Stormwater Drainage and Hazard Mitigation Advisory Board (SDHMAB) will continue to meet on a monthly basis, to oversee and review updates and revisions to the plan. The City of Tulsa Lead Engineer, Stormwater Projects Coordinator will continue to head the Program for Public Information and oversee the day-to-day implementation of the plan. The Plan will be updated and resubmitted to the State and FEMA for approval prior to the 5-year approval period expiration, as per FEMA requirements.

6.1.1 Monitoring the Plan

Monitoring of the Plan, the Action Plan, and Mitigation Measures is the responsibility of the Emergency Manager, Special Projects Engineer, and Floodplain Administrator. Departments responsible for implementation of the Action Plan and the Mitigation Measures will update their Progress Reports on an annual basis, and report to the SDHMAB on progress and/or impediments to progress of the mitigation measures.

Evaluating the Plan- The City of Tulsa Multi-Hazard Mitigation Plan will be continually evaluated by the Project Manager, and a report will be made to the SDHMAB monthly. The evaluation will assess:

- Adequacy of adopted Goals and Objectives in addressing current and future expected conditions;
- Whether the nature and magnitude of the risks have changed;
- Appropriateness of current resources allocated for implementation of the Plan;
- To what extent the outcomes of the Mitigation Measures occurred as expected;
- Whether agencies, departments and other partners participated as originally anticipated.

Many Action Items recommended in this plan have already been incorporated into the City's Capital Improvements Plan process. These programs will continue to be monitored and updated on an annual basis, if not more often.

6.1.2 Updating the Plan

The City of Tulsa Multi-Hazard Mitigation Plan will be updated according to the following schedule:

- Revise and Update- the City will incorporate revisions to the plan document identified during the monitoring and evaluation period, as well as items identified in the previous Planning Tool.
- Submit for Review- the revised plan will be submitted to OEM and FEMA through the State Hazard Mitigation Officer for review and approval, and to FEMA no later than six (6) months prior to the plan expiration date.
- Final Revision and Adoption- if necessary, the plan will be revised per OEM and FEMA remarks, adopted by the Tulsa City Council, and the updated plan sent to FEMA prior to the expiration of the 5-year approval period.

6.1.3 Public Involvement

The City of Tulsa is committed to involving the public directly in updating and maintaining the Multi-Hazard Mitigation Plan. Copies of the Plan will be maintained at the public library, and the plan will be placed on the website of the City of Tulsa.

Small area-specific meetings will be held on no less than a semi-annual basis at Public Libraries or other public venues. A public meeting will be held prior to submission of the update of the *City of Tulsa Multi-Hazard Mitigation Plan*. This meeting will be advertised to the general citizenry. This meeting will be held to update citizens on the progress that has been made in implementing the plan and related capital projects. The meetings will also be used to distribute literature and inform and educate citizens as to actions they can take to mitigate natural hazards, save lives, and prevent property damage. Input from the citizens will be solicited as to how the mitigation process can be more effective.

The City of Tulsa established the Program for Public Information (PPI) for CRS Credit. The program focuses on outreach projects, and other types of information delivery under the following activities:

- Activity 330 (Outreach Projects),
- Activity 340 (Hazard Disclosure),
- Activity 350 (Flood Protection Information),
- Activity 360 (Flood Protection Assistance),
- Activity 420 (Open Space Preservation), educational materials in natural areas, and
- Activity 540 (Drainage System Maintenance), publicizing dumping regulations.

Target areas are focus areas or priority areas Tulsa with concerns related floods, floodplains, and other hazards. The areas include parts of the community with similar flooding, building, and population characteristics. The PPI committee works closely with the WIN department to ensure the public is educated about the various hazards that may impact them. These outreach efforts allow for the general public to be involved with the hazard mitigation efforts in Tulsa on an ongoing basis.

6.1.4 Incorporating the Multi-Hazard Mitigation Plan

The Hazard Mitigation Planning Committee recognizes the importance of fully integrating hazard mitigation planning and implementation into existing local plans, regulatory tools, and related programs; this process was used for the integration of the 2014 City of Tulsa Multi-Hazard Mitigation Plan.

The City of Tulsa's local planning mechanisms available for incorporating the recommendations and requirements of the Hazard Mitigation Measures are listed below. The Project Manager and PPI Committee will ensure annual review of specific plans, ordinances, and codes identified in Chapter 3, to incorporate the requirements of this plan and hazard mitigation practices, into those documents whenever feasible.

The City of Tulsa Multi-Hazard Mitigation Plan will be adopted by the Tulsa Metropolitan Area Planning Commission and the Tulsa City Council as an amendment to the City's Comprehensive Plan. The Tulsa City Council will adopt the plan as a guide to City mitigation activities. Appropriate Action Items and Mitigation Measures from the plan will be incorporated into the following plans and codes:

- Capital Improvements Plan and planning process
- City of Tulsa Building Code
- Tulsa Emergency Operations Plan
- City of Tulsa Water and Sewer Plan
- City of Tulsa Comprehensive Plan

The Stormwater Drainage and Hazard Mitigation Advisory Board in conjunction with the PPI Committee will oversee the implementation of this plan once adopted. The process to include the adopted Mitigation Measures into other local planning mechanisms includes the following:

1. Mitigation Measures will be assigned to the appropriate departments for planning and implementation.
2. The responsible departments will report the progress made on each measure, identifying successes and impediments to their implementation to the PPI Committee.

To be included on the following pages of this chapter are the Resolution of Adoption of the City of Tulsa:

1. Tulsa Metropolitan Area Planning Commission
2. Tulsa City Council

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