Tulsa County

Multi-Hazard Mitigation Plan

July 23, 2010

Flanagan & Associates, LLC
Planning Consultants

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Acknowledgements

The *Tulsa County Multi-Hazard Mitigation Plan* was developed with assistance from a Pre-Disaster Mitigation (PDM) Grant from the Federal Emergency Management Agency through the Oklahoma Department of Emergency Management and local funding from Tulsa County. The Plan was prepared under the direction of the Tulsa County Commission and the Tulsa County Citizens' Advisory Committee. Numerous agencies, organizations and individuals participated in the study, including:

Tulsa County Commission

John Smaligo	District 1
Randi Miller	District 2
Fred Perry	District 3

Tulsa County Citizens' Advisory Committee

Barbara Bailey	Compliance Specialist, City of Tulsa Public Works
Gay Campbell	Environmental Safety, St. Francis Medical Center
Dennis Downing	Attorney, Retired
Marsha Goodson	Disaster Coordinator, St. John Medical Center
Steve Gund	Computer Specialist, Retired, Bixby
Tim Hoss	Safety Officer, Tulsa Regional Medical Center
Donald Karecki	K&M Publishing, Small Business Assoc.
Johnnie Munn	MERC Coordinator, EMSA
Henry Townsend	LosStop Consultants, Tulsa County LEPC

Tulsa County Technical Advisory Committee

Ray Jordan	County Engineer, Project Manager
Mike McCool	Director, TAEMA, Secondary Project Manager
John Campbell	Communications Warning Coordinator, TAEMA
Johnnie Munn	MERC Coordinator, EMSA
Nelson Sager	Fire Chief, City of Turley
Jeff Schippers	Plant Manager, Chemtrade Refinery Services
Teresa Tosh	Plans Examiner, Tulsa County Inspections
Terry West	Zoning Officer, Tulsa County Inspections

Consultants

R. D. Flanagan & Associates
Planning Consultants
2745 E. Skelly Drive, Suite 100
Tulsa, Oklahoma 74105
(918) 749-2696
Fax: (918) 749-2697
E-mail: rdflanagan@rdflanagan.com
Website: www.rdflanagan.com

Staff:
Ronald D. Flanagan, CFM, Principal
Greg Pollard
Graham Russell
Bob Roberts
John D. Flanagan
Nancy Mulcahy
David Wakefield

Executive Summary

Oklahoma's location at the intersection of the hot arid zone to the west, the temperate zone to the northeast, and the hot humid zone to the southeast make it subject to a wide variety of potentially violent weather and natural hazards.

Tulsa County's Technical Advisory Committee provided expertise in the development of the Multi-Hazard Mitigation Plan

Making people and businesses as safe as possible from a variety of natural and man-made hazards is the first step in making the area attractive for new residents and expanding businesses. The Tulsa County Multi-Hazard Mitigation Plan is a comprehensive effort to identify potential hazards and develop a sound plan to mitigate their impacts, with the goal of saving lives and property. This plan fulfills the requirements of the Pre-Disaster Mitigation (PDM) Grant Program of the Federal Emergency Management Agency (FEMA) and the Oklahoma Department of Emergency Management (ODEM).

In December 2005, the Multihazard Mitigation Council of the National Institute of Building Sciences completed a study to assess future savings from mitigation activities. Their findings reflected the fact that mitigation activities in general produced over $4 in savings for every $1 invested in mitigation actions, with the greatest savings in the areas of flood-related events (5:1) and wind-related events (3.9:1). In addition, the report concludes, *"Mitigation is most effective when carried out on a comprehensive, community-wide, and long-term basis. Single …activities can help, but carrying out a slate of coordinated mitigation activities over time is the best way to ensure that communities will be physically, socially, and economically resilient to future hazard impacts."*

Approval of this plan will qualify Tulsa County to apply for PDM funds, as well as Hazard Mitigation Grant Program (HMGP) funds following a federal disaster declaration, as required under Section 322 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 2000.

Background

Tulsa County is vulnerable to natural and man-made hazards. The Tulsa County Technical Advisory Committee (SSTAC) identified the 15 hazards most likely to affect the jurisdiction as a whole. These hazards included floods, tornadoes, high winds, lightning, hailstorms, severe winter storms, extreme heat, drought, expansive soils, urban fires, wildfires, earthquakes, transportation, hazardous materials events, and dam failures.

Purpose

The purpose of this plan is to:

- assess the ongoing mitigation activities within the jurisdiction;
- identify and assess the hazards that pose a threat to citizens and property;
- evaluate additional mitigation measures that should be undertaken;
- outline a strategy for implementation of mitigation projects.

The objective of this plan is to provide guidance for community activities for the next five years. It will ensure that Tulsa County implements activities that are most effective and appropriate for mitigating the 15 identified natural and man-made hazards.

Tulsa County Citizens' Advisory Committee

Citizens and professionals active in disasters provided important input in the development of the plan and recommended goals and objectives, mitigation measures, and priorities for actions. The Tulsa County Citizens' Advisory Committee (TCCAC) is comprised of citizen leaders of the community appointed by the County Commission.

The Planning Process

Planning for the Tulsa County Multi-Hazard Mitigation Plan followed a ten-step process, based on guidance and requirements of FEMA for the PDM grant program, HMGP, the Flood Mitigation Assistance (FMA) program, 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.

Plan Summary

The Tulsa County Multi-Hazard Mitigation Plan provides guidance to help citizens protect life and property from natural and man-made hazards. The plan identifies the hazards that are most likely to strike each jurisdiction, provides a profile and risk assessment of each hazard, identifies mitigation measures for each hazard, and presents an action plan for the implementation of the mitigation measures.

Chapter 1- Introduction provides a profile of Tulsa County. This chapter includes a community description including demographics, lifelines, and critical facilities.

Chapter 2- Existing Mitigation Strategies provides an overview and discussion of the County's existing resources and hazard mitigation programs.

Chapter 3- The Planning Process presents detailed information documenting the planning process, including citizen and agency involvement, a table describing how and why each hazard was identified, and methodologies used in the plan for damage estimates and risk assessments.

Chapter 4- Natural and Man-Made Hazards provides an assessment of 15 natural and man-made hazards. Each assessment includes a hazard profile, catalogs historical events, identifies the vulnerable populations, and presents a conclusion.

Chapter 5-Mitigation Goals and Objectives sets disaster-specific goals and objectives and organizes proposed mitigation strategies under six mitigation categories: public information and education, preventive activities, structural projects, property protection, emergency services, and natural resource protection.

Chapter 6- Action Plan outlines an action plan for the implementation of high priority mitigation projects, including a description of the project, the responsible party, anticipated cost, funding sources, and timelines for implementation.

Chapter 7- Plan Adoption and Maintenance provides a discussion of the plan maintenance process and documentation of the adoption. Plan maintenance includes monitoring, evaluating, and updating the plan with involvement of the public.

Appendix A- Glossary provides a glossary of terms commonly used in disaster management and hazard mitigation.

Appendix B- Mitigation Measures provides a more detailed description of potential Mitigation Measures outlined in Chapter 6, broken down by category.

Appendix C- Mitigation Committee Meetings provides the agendas from the Citizens Advisory Committee and the Technical Advisory Committee meetings.

Highest Priority Mitigation Measures

The following is a list of the top ten prioritized mitigation measures for Tulsa County as defined by the TCCAC. The complete list of recommended mitigation measures is found in Table 6–2, at the end of Chapter 6.

Rank	Hazard	Category	Mitigation Measure
1	Flood, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Urban Fires, Wildfires Earthquakes, Fixed Site Hazardous Materials Events, Dam Failures, Transportation Events	Structural Projects	Provide new/retrofit Facilities for the 911 Center and the Emergency Operations Center
2	Tornadoes, High Winds, Earthquakes	Preventive Measures	Provide employee shelters/safe-rooms at County Critical Facilities, such as Sheriff's Office, to protect first responders
3	Tornadoes, High Winds, Earthquakes	Public Information And Education	Educate residents, building professionals, and safe room vendors on the International Codes Council/National Storm Shelter Association's "Standard for the Design and Construction of Storm Shelters" and consider incorporating this Standard into current information and practices
4	Floods, Dam Failure	Preventive Measures	Prepare a comprehensive basin-wide Flood & Drainage Annex to the Hazard Mitigation Plan (FDAHMP) for all watersheds within the jurisdiction. The plan will identify all flooding problems within the county, and recommend the most cost-effective and politically acceptable solutions to the flooding problems.
5	Floods, Dam Failure	Property Protection	Acquire and remove floodplain and repetitive loss properties where the county's repetitive loss plan and Flood & Drainage Annex to the Hazard Mitigation Plan identifies acquisition as the most cost-effective and desirable mitigation measure.
6	Floods, Dam Failure	Property Protection	Continue Compliance with, and Participation in the National Flood Insurance Program (NFIP) and the Community Rating System (CRS)
7	Tornadoes, High Winds, Floods	Emergency Services	Evaluate, upgrade, and maintain community-wide outdoor omni-directional voice/warning system
8	Wildfires	Preventive Measures	Develop a Wildfire Susceptibility Analysis and Wildfire Mitigation Plan for the vulnerable Rural/Urban Interface areas of the County
9	Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat	Emergency Services	Develop an Emergency Back-up Generator Hazard Mitigation Plan Annex (EBGHMP) for the county, assessing and prioritizing generator needs for critical facilities, both public and private. Assessment should include generator needs, costs of installation for pads/transfer panels only, or for complete generator assembly installation
10	Floods, Tornadoes, High Winds, Lightning, Severe Winter Storms, Urban Fires, Wildfires, Earthquakes	Preventive Measures	Provide wiring and transfer switches to accommodate emergency generators during disaster power outages for critical facilities including Emergency Operations Centers, County Court House, Dispatch, Sheriff's Offices, Community Centers used for emergency housing during disasters, critical facilities, lift stations, and community medical facilities
11	Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat	Emergency Services	Obtain or Identify source of generators that are required as identified in the Emergency Back-up Generator Hazard Mitigation Plan Annex
12	Floods, Tornadoes, High Winds, Severe Winter Storms, Earthquakes, Dam Failures	Preventive Measures	Adopt and Implement a plan for continuity and restoration of power to the county and critical facilities as a result of power outages due to natural and manmade hazards, such as the McGuire plan

Rank	Hazard	Category	Mitigation Measure
13	Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat, Earthquakes	Preventive Measures	Identify and encourage Private Critical Facilities (Financial Institutions, Long-term Care Facilities, Designated/Potential Community Emergency Shelters, etc.) to have generator pad, wiring/transfer switches and Emergency Back-Up Generators, or Reliable Contracts to provide Back-Up Generators
14	Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat, Earthquakes	Preventive Measures	Identify and/or encourage key important private service facilities (gas stations, convenience stores, etc.) to have wiring/transfer switches and emergency back-up generators installed, or reliable contracts for the provision of back-up generators, in the event of disasters or power outages
15	Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat, Earthquakes	Emergency Services	Develop Memorandums of Understanding (MOUs) with private sector gasoline service facilities to provide priority fuel to emergency/critical vehicles (government, Police, Fire, ambulance, etc.) in times of emergency or power outage
16	Lightning	Preventative Measures	Provide lightning warning systems for outdoor sports areas, pools, golf courses, ball fields, parks, and Fairgrounds
17	Floods, Dam Failure	Public Information And Education	Develop and distribute flood and flash flood safety tips to inform citizens of the dangers of flood waters
18	Expansive Soils	Preventative Measures	Establish administrative procedures, and provide maps and information to inform builders about Expansive Soils when they apply for development and building permits
19	Expansive Soils	Preventative Measures	Educate builders on appropriate foundation types for soils with different degrees of shrink-swell potential. For example, using "post-tensioned slab-on-grade" or "drilled pier" vs. standard "slab-on-grade" or "wall-on-grade" foundations
20	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Expansive Soils, Urban Fires, Wildfires, Earthquakes, Fixed Site Hazardous Materials Events, Dam Failures, Transportation Hazards	Public Information And Education	Develop an all-hazard public information, education, and awareness strategy and program
21	Floods, Tornadoes, High Winds, Expansive Soils, Earthquakes, Fixed Site Hazardous Materials, Transportation Hazards, Dam Failures	Preventative Measures	Modify/Adopt the County Land Use Plan to: 1) Guide development away from hazardous areas, including Hazardous Materials sites. 2) Reduce population density in hazardous areas 3) Implement stronger development restrictions 4) Encourage Natural Resource Protection.
22	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Urban Fires, Wildfires, Earthquakes, Fixed Site Hazardous Materials Events, Dam Failures, Transportation Hazards	Public Information And Education	Develop and distribute a Family Emergency Preparedness Guide to all families
23	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Urban Fires, Wildfires, Earthquakes, Fixed Site Hazardous Materials Events	Public Information And Education	Educate the public on the importance of a Family Disaster Plan and Supply
24	Tornadoes, High Winds, Hail	Property Protection	When replaced, install break resistant glass in government offices, and critical facilities.

Rank	Hazard	Category	Mitigation Measure
25	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Expansive Soils, Urban Fires, Wildfires, Earthquakes, Fixed Site Hazardous Materials Events, Dam Failures, Transportation Events	Public Information And Education	Obtain funding for development and distribution of public information and education plans for responding to all-hazards to at-risk and vulnerable populations and contact agencies that distribute information to at-risk populations
26	Floods, Tornadoes, High Winds, Severe Winter Storms, Extreme Heat, Drought, Urban Fires, Wildfires, Earthquakes, Fixed Site Hazardous Materials Events, Dam Failures, Transportation Events	Emergency Services	Install a Mass Emergency Telephone Communication system, such as Reverse 911 or Black Board Connect, for mass call-outs to targeted areas of the community for emergency notification and/or information
27	Tornados, High Winds, Lightning, Severe Winter Storms, Earthquakes	Preventative Measures	Provide surge and lightning protection for computer-reliant critical facilities (e.g. County Offices, EOC, and Sheriff's Offices)
28	Floods, Tornadoes, High Winds, Lightning, Hail, Winter Storms, Extreme Heat, Drought, Expansive Soil, Wildfires, Earthquakes	Public Information and Education	Train/Educate builders, developers, architects and engineers in techniques of disaster-resistant homebuilding, such as the Fortified Home standards developed by the Institute for Business & Home Safety (IBHS), the Blueprint for Safety guidelines developed by the Federal Alliance for Safe Homes (FLASH)
29	Floods, Tornadoes, High Winds, Hail, Severe Winter Storms, Earthquakes	Preventative Measures	Develop/Review/Update the Debris Management Plan

Mitigation Action Plan

The mitigation action plan includes strategies for implementing the mitigation measures, including information on the responsible agency, time frame, cost estimate, funding sources, and a statement of the measurable results. The Action Plan is included in this document as Chapter 6.

For further information, contact:

Primary Contact:
Ray Jordan, Director
Tulsa County Engineering Department
500 S. Denver
Tulsa County, OK 74103
(918) 596-5730
engineers@tulsacounty.org

Secondary Contact:
Mike McCool, Director
Tulsa Area Emergency Management Agency
200 Civic Center, Basement
Tulsa, OK 74103
(918) 596-9890
MMcCool@ci.tulsa.ok.us

Chapter 1: Introduction

1.1 About the Plan


Tulsa County Commissioners

This document is the Multi-Hazard Mitigation Plan for Unincorporated Tulsa County. It is a strategic planning guide developed in fulfillment of the Hazard Mitigation Grant Program requirements of the Federal Emergency Management Agency (FEMA), according to the *Stafford Disaster Relief and Emergency Assistance Act*. This act provides federal assistance to state and local governments to alleviate suffering and damage from disasters. It broadens existing relief programs to encourage disaster preparedness plans and programs, coordination and responsiveness, insurance coverage, and hazard mitigation measures.

Included in this Chapter:

This plan is developed in accordance with and guidance from, and fulfills requirements for, the Hazard Mitigation Grant Program (HMGP) and addresses 15 natural and man-made hazards.

1.1.1 Purpose

The purpose of this plan is to:

- provide a description of the planning area (Chapter 1);
- assess the ongoing mitigation activities in Tulsa County (Chapter 2);
- describe the Multi-Hazard Mitigation Planning Process used to identify and select natural and man-made hazards, identify appropriate mitigation measures, and to develop the plan (Chapter 3);
- identify and assess the hazards that pose a threat to citizens, businesses and property (Chapter 4);
- establish Goals and Objectives for community mitigation measures (Chapter 5);

- evaluate mitigation measures that should be undertaken to protect citizens, businesses and property (Appendix B);
- identify and recommend an Action Plan for implementation of mitigation projects (Chapter 6);
- develop a strategy for the adoption, maintenance, upkeep, and revision of the Tulsa County Multi-Hazard Mitigation Plan (Chapter 7).

In December 2005, the Multihazard Mitigation Council of the National Institute of Building Sciences completed a study to assess future savings from mitigation activities. Their findings reflected the fact that mitigation activities in general produced over $4 in savings for every $1 invested in mitigation actions, with the greatest savings in the areas of flood-related events (5:1) and wind-related events (3.9:1). In addition, the report concludes, *"Mitigation is most effective when carried out on a comprehensive, community-wide, and long-term basis. Single activities can help, but carrying out a slate of coordinated mitigation activities over time is the best way to ensure that communities will be physically, socially, and economically resilient to future hazard impacts."*

The objective of this plan is to provide guidance for community activities for the next five years. It will ensure that Unincorporated Tulsa County and other partners implement hazard mitigation activities that are most effective and appropriate for the natural and man-made hazards that threaten the community. For additional information on Plan review and updating guidelines, see Chapter 7.

1.1.2 Scope

The scope of the Unincorporated Tulsa County Multi-Hazard Mitigation Plan includes the unincorporated areas of the county. It addresses all natural and man-made or technological hazards deemed a threat to the citizens of Unincorporated Tulsa County. Both short-term and long-term hazard mitigation opportunities are addressed, beyond existing federal, state, and local funding programs.

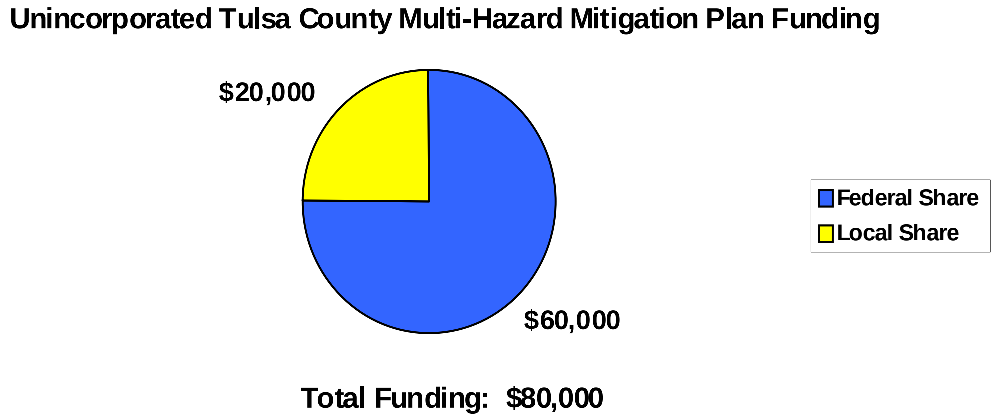
1.1.3 Authority

Section 322 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C. 5165, enacted under Section 104 the Disaster Mitigation Act of 2000, P.L. 106-390, provides new and revitalized approaches to mitigation planning. A major requirement of the law is the development of a local hazard mitigation plan. Section 322, in concert with other sections of the Act, provides a significant opportunity to reduce the nation's disaster losses through mitigation planning.

1.1.4 Funding

Funding for the development of the Tulsa County Multi-Hazard Mitigation Program (HMGP) is provided by grants from the Federal Emergency Management Agency (FEMA) and the Oklahoma Department of Emergency Management (OEM). A 75% FEMA grant through OEM, with a 25% local share, has been provided.

Figure 1–1: Tulsa County Funding Chart



1.1.5 Goals

The Staff and Hazard Mitigation Citizens Advisory Committee of Unincorporated Tulsa County developed the goals for the Unincorporated Tulsa County Multi-Hazard Mitigation Plan, with input from interested citizens. The local goals were developed taking into account the hazard mitigation strategies and goals of the federal and state governments.

National Mitigation Strategy and Goal

FEMA has developed ten fundamental principles for the nation's mitigation strategy:

1. Risk reduction measures ensure long-term economic success for the community as a whole rather than short-term benefit for special interests.
2. Risk reduction measures for one natural hazard must be compatible with risk reduction measures for other natural hazards.
3. Risk reduction measures must be evaluated to achieve the best mix for a given location.
4. Risk reduction measures for natural hazards must be compatible with risk reduction measures for technological hazards and vice versa.
5. All mitigation is local.
6. Emphasizing proactive mitigation before emergency response can reduce disaster costs and the impacts of natural hazards. Both pre-disaster (preventive) and post-disaster (corrective) mitigation is needed.
7. Hazard identification and risk assessment are the cornerstones of mitigation.
8. Building new federal-state-local partnerships and public-private partnerships is the most effective means of implementing measures to reduce the impacts of natural hazards.
9. Those who knowingly choose to assume greater risk must accept responsibility for that choice.
10. Risk reduction measures for natural hazards must be compatible with the protection of natural and cultural resources.

FEMA's goal is to:

1. substantially increase public awareness of natural hazard risks so that the public demands safer communities in which to live and work;
2. significantly reduce the risk of loss of life, injuries, economic costs, and destruction of natural and cultural resources that result from natural hazards.

State of Oklahoma Mitigation Strategy and Goals

The State of Oklahoma has developed a *Strategic All-Hazards Mitigation Plan* to guide all levels of government, business, and the public in reducing or eliminating the effects of natural, technological, and man-made disasters. The goals and objectives are to:

1. improve government recovery capability;
2. provide pre- and post-disaster recovery guidance;
3. protect public health and safety;
4. reduce losses and damage to property and infrastructure;
5. preserve natural and cultural resources in vulnerable areas;
6. preserve the environment;
7. focus only on those mitigation measures that are cost effective and provide the best benefit to communities.

The key measures to implement these goals include:

1. enhance communication between state and federal agencies and local governments to facilitate post-disaster recovery, and pre- and post-disaster mitigation;
2. coordinate federal, state, local, and private resources to enhance the preparedness and mitigation process;
3. ensure consistency between federal and state regulations;
4. protect critical facilities from hazards;
5. support legislation that protects hazardous areas from being developed.

Unincorporated Tulsa County's Goal:

To improve the safety and well-being of the citizens residing and working in Unincorporated Tulsa County by reducing the potential of deaths, injuries, property damage, environmental and other losses from natural and technological hazards in a manner that creates a disaster-resistant community, enhances economic development opportunities, and advances community goals and quality of life, resulting in a more livable, viable, and sustainable community.

Goals for mitigation of each of the hazards are presented in Chapter 5 and Appendix B.

1.1.6 Definition of Terms

Hazard Mitigation is defined as: "Sustained actions taken to reduce or eliminate long-term risk to human life and property from natural and technological hazards and their effects." Note that this emphasis on "long-term" risk distinguishes mitigation from actions geared primarily to emergency preparedness and short-term recovery.

A glossary of additional terms commonly used in hazard mitigation is included in Appendix A.

1.1.7 Point of Contact

Primary Contact:
Ray Jordan, Director
Tulsa County Engineering Department
500 S. Denver
Tulsa County, OK 74103
(918) 596-5730
engineers@tulsacounty.org

Secondary Contact:
Mike McCool, Director
Tulsa Area Emergency Management Agency
200 Civic Center, Basement
Tulsa, OK 74103
(918) 596-9890
MMcCool@ci.tulsa.ok.us

1.2 Community Description

The unincorporated area of Tulsa County is faced with a variety of hazards, both natural and man-made. In recent history, winter storms, dam releases, lightning, floods, wildfires and tornadoes have made the national headlines but, in fact, any part of the county can also be impacted by high winds, drought, hail, urban fires, hazardous materials events, and other threats. In some cases, such as flooding and dam failure, the areas most at risk have been mapped and delineated. A base map of Tulsa County with its major features and highways are shown in Figure 1-2 and Figure 1-3.

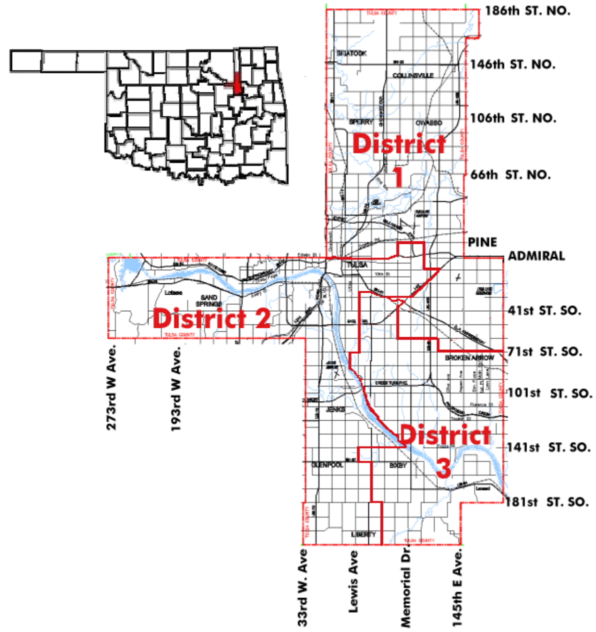


Figure 1–2: Tulsa County District Map

Tulsa County consists of 570.3 square miles of northeastern Oklahoma. Tulsa County had a Census 2000 population of 563,299, comprising 16.3% of Oklahoma's population. The County is growing and has an estimated 2007 population of 585,068.

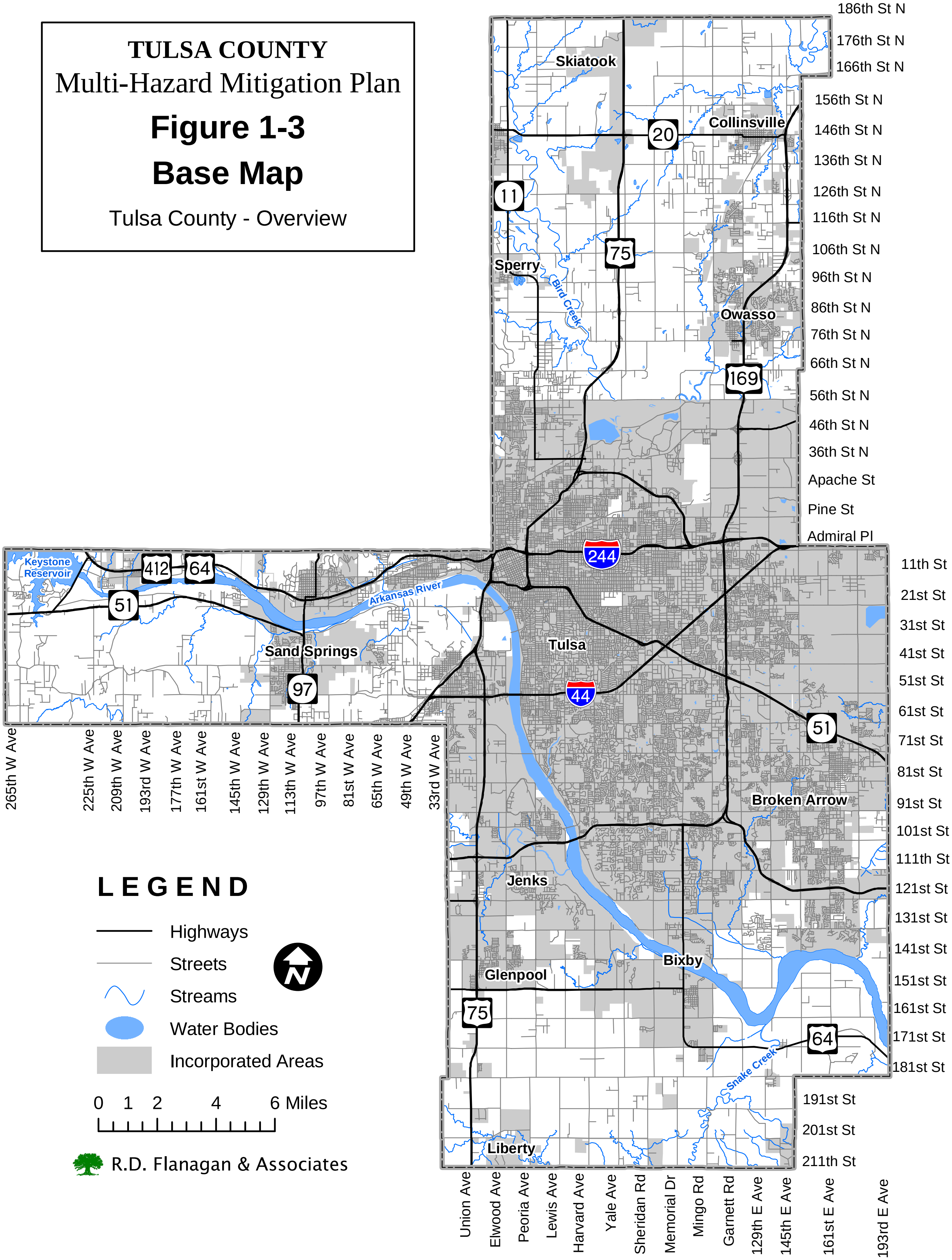
At the heart of the county is Oklahoma's second largest city, Tulsa. The Tulsa Metropolitan Area's growth trend is in Tulsa County, and experienced population growth of 12.9% from 1990 to 2000, with an annual average of 1.29%.Surrounding Tulsa is a ring of growing suburban cities, including Bixby, Broken Arrow, Jenks, Owasso and Sand Springs. A secondary ring of thriving rural communities includes Collinsville, Glenpool, Liberty, Mannford, Skiatook, and Sperry.

Table 1–1: Tulsa County Population
Source: 2000 Census

Community	Population	Community	Population
Bixby*	13,212	Mannford*	23
Broken Arrow*	68,451	Owasso*	18,564
Collinsville*	4,098	Sand Springs*	17,161
Glenpool	8,178	Skiatook*	1,695
Jenks	9,413	Sperry	981
Liberty*	96	Tulsa*	387,419
Lotsee	11	Unincorporated	33,997
Total Population			**563,299**

*Community population figures include only the portion of the population of each community that lives within Tulsa County.

TULSA COUNTY
Multi-Hazard Mitigation Plan
Figure 1-3
Base Map
Tulsa County - Overview



1.2.1 Geography

Latitude: 36.1167 N **FIPS Code:** 40143
Longitude: 95.9333 W

Tulsa County is located in northeastern Oklahoma and is part hills and riverine bluffs, and part wide prairie, marking the dividing line between the ridges of the Ozarks in the East and the broad plains of the West. Tulsa County's western tip reaches Lake Keystone, while the Arkansas River rolls southeastward across the county.

The view from Chandler Park in west Tulsa County looking north across the Arkansas River

Forty-two miles of the Arkansas River run through the jurisdiction. Several drainage basins containing tributary streams and rivers enter the Arkansas River within Tulsa County. These tributaries contribute to the Arkansas River's large floodplain and are a frequent source of flooding.

Cattle and horse ranches and rich farmland lie almost within the shadow of urban buildings. Oil and natural gas wells are common throughout the area. Transportation routes are critical to supporting economic development, but development decisions must regard the Arkansas River and the prominent 100-year floodplain as major land features. Tulsa County's land use is shown in Figure 1-4.

1.2.2 Climate

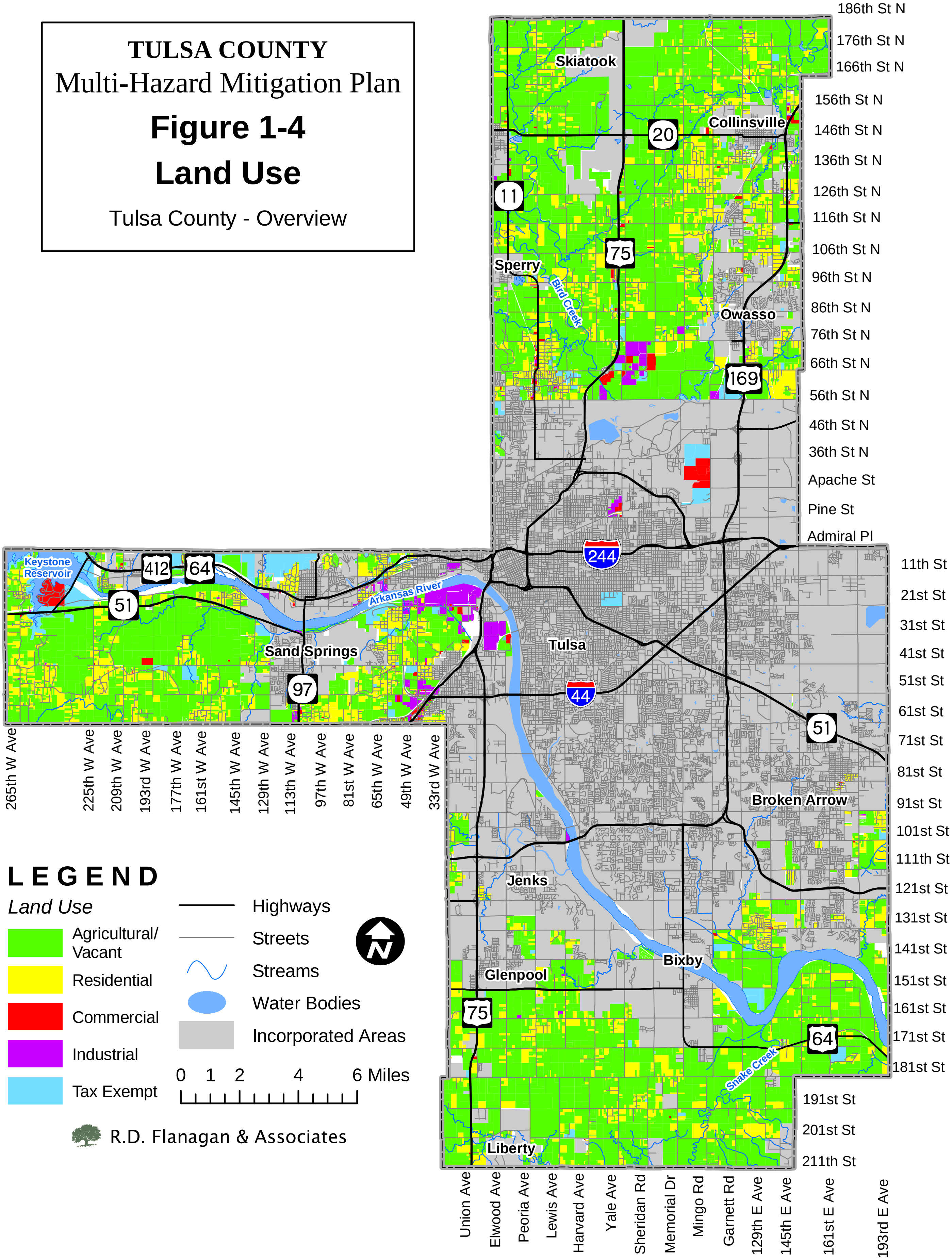
Tulsa County lies at an elevation of approximately 740 feet above sea level. It is far enough south to miss the prolonged, extreme cold of winter. The climate is essentially continental, characterized by rapid changes in temperature. The winter months are usually mild. Temperatures occasionally fall below zero, but such weather only lasts a short time. Temperatures of 100°F or higher are often experienced from late July to early September. January's average temperature is 35.1° F and July's average is 82.0° F.

Tulsa County receives a wide variety of precipitation during any given year. Rainfall averages 40.91 inches annually, and snow 7 inches. Most of this precipitation comes in the form of convective thunderstorms that produce heavy amounts of rain in a short duration. High winds, flash floods, and hail are all associated with these seasonal storms.

April, May, and June account for 55% of all severe weather during a typical year, with 77% of the severe weather occurring between March and July. June is the most active month of the year for hail, wind, floods, and tornadoes.

Prevailing surface winds for the area are from the South or South-Southeast during most of the year.

TULSA COUNTY
Multi-Hazard Mitigation Plan
Figure 1-4
Land Use
Tulsa County - Overview



1.2.3 History

Located on the Arkansas River on lands that were once part of the Creek and Cherokee Nations, Tulsa County was created at Oklahoma statehood and took its name from the town of Tulsa in the Creek Nation, Indian Territory.

The big oil strike at Glenpool in 1905 made Oklahoma and Indian Territory the center of oil speculation and exploration. At the time of statehood in 1907, Tulsa County's population was less than 35,000. The County's population had grown to 109,023 by 1920 and to 187,574 by 1930, primarily due to oil discoveries.

Tulsa, the city that oil built, seen from the southwest

During the 1930s and 1940s, the U.S. Army Corps of Engineers built levees along the Arkansas River, primarily to protect the critical oil refineries during the Second World War. During World War II, the City of Tulsa grew in importance as an aviation center, with the Spartan School of Aeronautics and the mile-long Douglas Aircraft plant, which produced bombers. Years later, McDonnell-Douglas and Rockwell International would contribute to the nation's space program and national defense.

The 1950s and 60s saw the city of Tulsa grow east and south into the watersheds of Mingo and Joe Creeks. Flooding on creeks and along the Arkansas River became increasingly severe as the city continued to expand. The Corps of Engineers completed the Keystone Dam on the Arkansas River in 1964. A more detailed discussion of Unincorporated Tulsa County's flood history is presented in Chapter 4.

1.2.4 Demographics

Demographics is the use of population characteristics (age and income distribution and trends, mobility, educational attainment, home ownership and employment status, for instance) for purposes of social studies.

As demonstrated during Hurricane Katrina in 2005, the vulnerability of a segment of the community to disasters will often vary according to demographic factors such as income level, age, race, language, education, disability and home ownership. For example, individuals and families in low-income areas often have less extensive safety nets (transportation, savings, credit, food supplies, and extended family networks) than those in high-income districts. Similarly, aging populations are more vulnerable to extreme heat and cold and often have fewer financial resources for evacuation or purchasing supplies. Knowing the size and geographical location of potential at-risk populations (such as small children, the elderly and the impoverished) are important to assessing a community's vulnerability to natural hazards.

In order to define demographics within the three main divisions of the unincorporated areas of Tulsa County – North, West, and South –Flanagan & Associates, LLC compiled information on the Census block level within a GIS environment. Census blocks were deemed to be unincorporated if the center of the block was outside an incorporated area. Using this methodology, the estimated 2000 population of the unincorporated areas of Tulsa County was 36,121, 6.4% of the Tulsa County's total population. The resulting demographic data is shown in Table 1-2. A map showing the percentage of the population 65 years of age and older by Census block groups is shown in Figure 1-5; low income areas are shown in Figure 1-6.

Table 1–2: Tulsa County Population Data
Source: 2000 Census

Subject	North	West	South	Total	County %	State %
Total Population	14,192	14,216	7,713	36,121	100.0	1.0
Under 18 years	3,729	3,622	2,020	9,371	26.0	25.9
65 years and over	1,726	1,914	908	4,548	12.6	13.2
White	11,016	11,831	6,531	29,378	81.3	76.2
African-American	789	283	126	1,198	3.3	7.6
American Indian	1,352	1,165	554	3,071	8.5	7.9
Hispanic	313	301	224	838	2.3	5.2

Note: County % and State % refer to the percentage per category of total population for the Unincorporated County and State respectively

1.2.5 Lifelines

Utility Systems

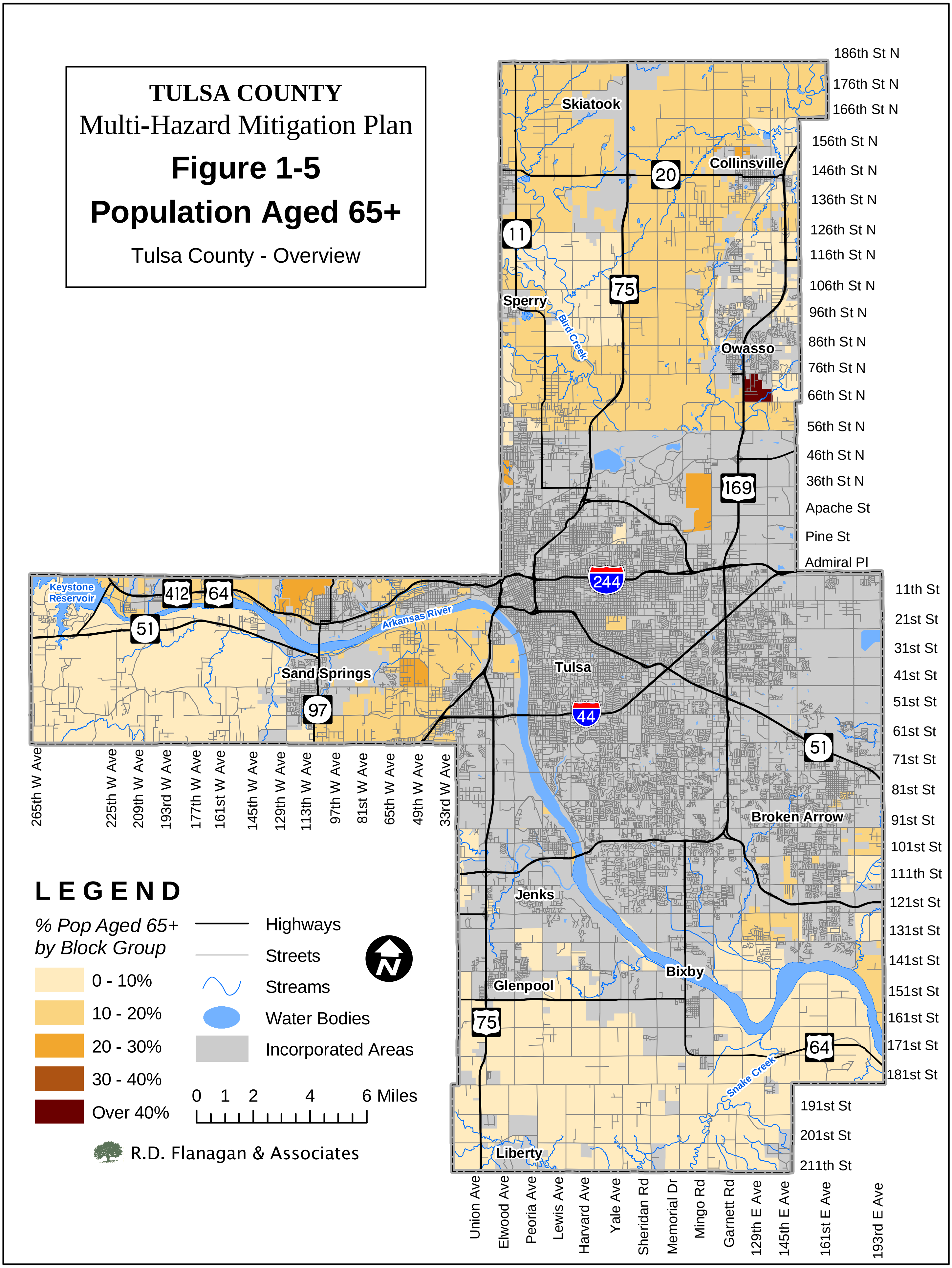
Table 1–3: Utility Suppliers for Unincorporated Tulsa County

Utility	Supplier	
Electric	East Central Electric Co-op Indian Electric	Oklahoma Gas & Electric Company AEP/Public Service Company of Oklahoma
Water	City of Tulsa City of Jenks City of Glenpool City of Broken Arrow Town of Collinsville Town of Skiatook City of Sand Springs	City of Owasso Wagoner County RWD Washington County RWD #3 Rogers County RWD #3 Okmulgee County RWD #6 Creek County RWD #2 Tulsa County WID #3
Sewage Treatment	City of Tulsa City of Jenks City of Glenpool City of Bixby City of Broken Arrow	Town of Collinsville Town of Skiatook City of Sand Springs City of Owasso Sperry Utility Authority
Natural Gas	Oklahoma Natural Gas Company Keystone RGD # Sperry Utility Authority	
Telephone	MCI SBC Bixby Telephone	Cimarron Telephone Valor

TULSA COUNTY
Multi-Hazard Mitigation Plan

Figure 1-5
Population Aged 65+

Tulsa County - Overview



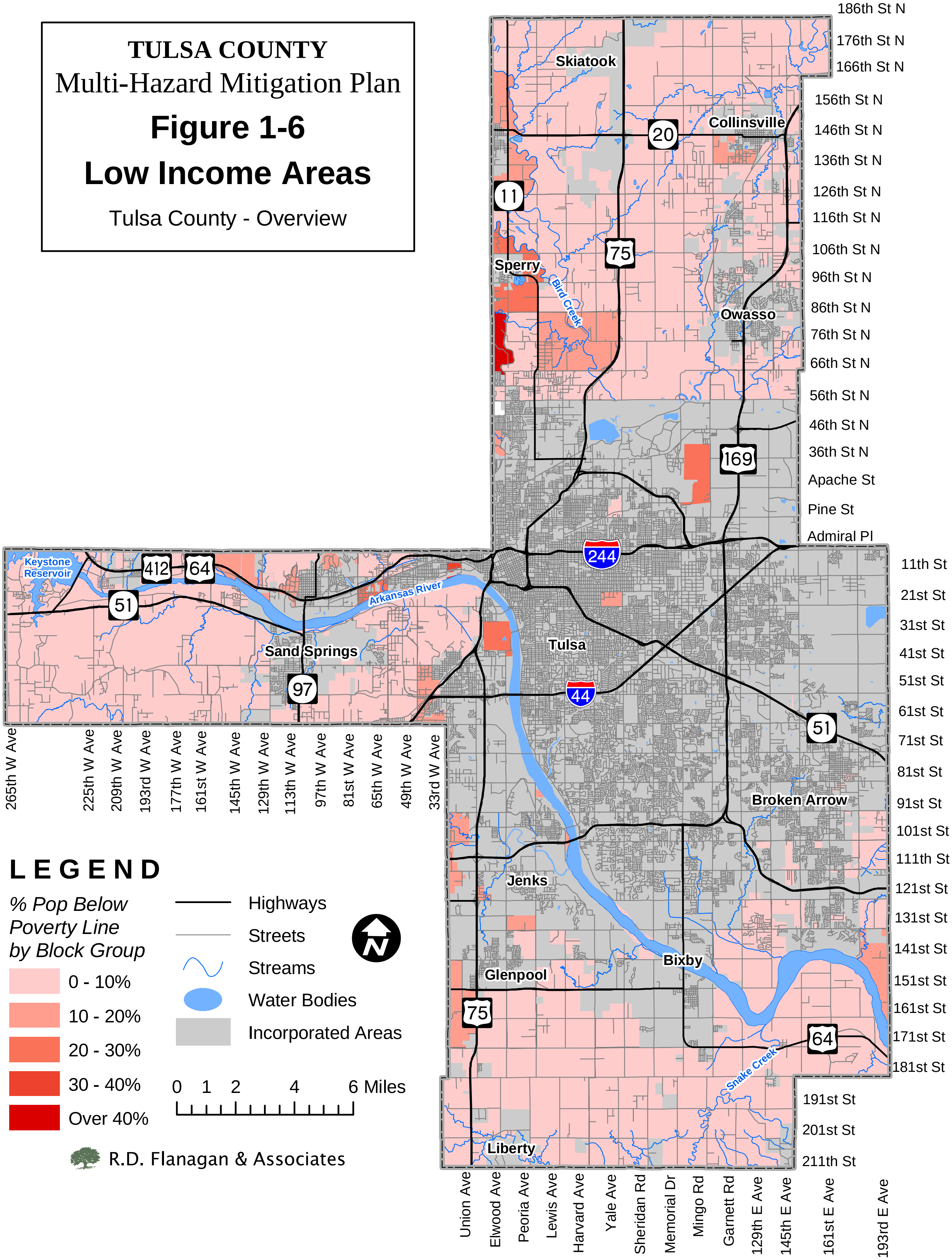
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 1-6

Low Income Areas

Tulsa County - Overview



Water

North Tulsa County

Northern Tulsa County is served by Washington County Rural Water District #3 south to about 76th St. North, excluding Owasso, Skiatook, Turley, Sperry and the extreme western portion of northern Tulsa County. Owasso, Sperry and western Tulsa County are served by City of Tulsa water. Skiatook is served by the Town of Skiatook water utility. Rogers County Rural Water District #3 serves an area of Tulsa County east and south of Owasso.

Turley is served by Tulsa County Water Improvement District #3, which receives its water from the City of Tulsa. Turley's water utility has adequate water supply, pressure, and distribution facilities.

Skiatook Water Department serves customers in a 4-square-mile area of northern Tulsa County. The utility draws its water from Skiatook Lake. To date, it has not been forced to impose water restrictions or rationing. Skiatook Lake also serves the communities of Sapulpa and Sand Springs, which have municipal water supplies (see below). Skiatook water utility has adequate water supply, pressure and distribution facilities.

Rogers County Rural Water District #3 serves 161 customers in a 5-square-mile area in northern Tulsa County east and south of the town of Owasso. RWD #3 draws its water from Oologah Lake and from the City of Tulsa. The RWD is building a new $6 million water treatment plant and a 1.5 MG water tank in the Stone Canyon area, which is experiencing rapid growth. Distribution lines and pressure are adequate for the service area in Tulsa County.

The unincorporated area between 56th St. North and 76th St. North, excepting the areas served by Turley and Rogers Co. RWD #3, along with portions of extreme western Tulsa County (including Sperry and a thin strip north of Skiatook), are served by the City of Tulsa.

West Tulsa County

Western Tulsa County is served by the City of Tulsa, Sand Springs, and the City of Sapulpa.

Sand Springs serves western Tulsa County from Berryhill west to the Creek County line, with the exception of a portion of a 4-square mile area served by the City of Sapulpa. Sand Springs draws its water from Skiatook Lake and Shell Lake. Its water supply is adequate, and the city has not been forced, in the past, to impose rationing or water restrictions. It does have some problems with low water pressure along the periphery of its service area during periods of peak use.

The City of Sapulpa serves customers in a 4-square mile area south of 51st St. and between 65th W. Ave. and 129th W. Ave. Sapulpa draws its water from Lake Sahoma and Skiatook Lake. Water supply and distribution facilities are adequate for current and projected needs.

The unincorporated areas of western Tulsa County are served by the City of Tulsa, which has adequate supply and distribution facilities.

South Tulsa County

The southern portion of Tulsa County is served by the City of Tulsa, the City of Jenks, the Town of Glenpool, the City of Broken Arrow, the City of Bixby, Creek County Rural Water District #2, Okmulgee County Rural Water District #6, and Wagoner County Rural Water District #8.

The City of Jenks and the Town of Glenpool receive their water from the City of Tulsa, directly, and maintain neither water treatment nor storage facilities.

Broken Arrow gets its water from the Mid-America Industrial District near Pryor, which draws from Grand Lake. Broken Arrow has a take-or-pay contract for 15 MGD, with a pumping capacity of 25 MGD. Its average use is 9 MGD and peak use 25 MGD. The City has a large pipeline that brings water from Mid-America to its treatment plant on the Verdigris River, where it is mixed with treated City water. Broken Arrow has a 7 MGD run-of-the-river allotment from the Verdigris, which it uses primarily for backup. Its water treatment plant has a capacity of 8 MGD. The City is planning to upgrade its Verdigris water plant, in order to meet a projected 50 MGD peak capacity over the next 25 years. The City's distribution lines are adequate for current and near-term needs. Broken Arrow has low vulnerability to drought.

Bixby's water comes from Bixhoma Lake and the City of Tulsa. The city has a water system capacity of 3 MGD, average usage of 1 MGD, and peak use of 1.4 MGD. The system has three storage reservoirs with a combined 2.35 MG capacity. The water supply is adequate for near-term future needs and has low vulnerability to drought.

Creek County RWD #2 draws its water from the City of Tulsa, the City of Sapulpa, and from the town of Kellyville. This area is experiencing rapid growth. The Water District is building a new water tower in the Kellyville area to beef up its distribution capacity.

Okmulgee County Rural Water District #6 draws its water from the City of Okmulgee, the City of Tulsa, and from the Town of Glenpool. This area is experiencing rapid growth. The RWD is currently encountering some problems meeting customer loads due to line size and elevation—particularly the area south of Bixby Ranch Estates. The 2-inch distribution lines in the area are inadequate, and the higher elevation of this part of the County makes it difficult to maintain pressure and flow.

Wagoner County Rural Water District #8 is supplied by Wagoner County RWD #4, from its plant on the Verdigris River. The RWD supplies 4 houses in Tulsa County, south of 171st St. and east of 150th E. Ave. There are no supply or distribution problems in this area.

Transportation Systems

Major Highways and Roads

Tulsa County has a number of major highways including:

- **Interstate 44**—runs SW-NE from Wichita Falls, TX to St. Louis, MO, a distance of 328 miles in Oklahoma. Most of I-44 is turnpike: the H.E. Bailey Turnpike from Texas to Oklahoma City, the Turner Turnpike from Oklahoma City to Tulsa, and the Will Rogers Turnpike from Tulsa to the Missouri border. Through Tulsa I-44 is also known as the Skelly Bypass and is routed alongside S. 51st St. It is a heavily traveled highway, including tourist, business, and commercial truck traffic. Linking, as it does, several turnpikes and expressways, I-44 carries a high volume of hazardous material traffic, including chemical and petroleum products, and in some cases, radiological materials.

- **US Hwy 412—**runs E-W and connects Siloam Springs, AR with Clayton NM, via Chouteau, Tulsa, Sand Springs, Enid, Woodward, Guymon and Boise City. It is 502 miles in length. From Flint to Chouteau US Hwy 412 is the Cherokee Turnpike, and from Westport, near Keystone Lake, to I-35 north of Perry, US Hwy 412 is the Cimmaron Turnpike. Through Tulsa County US Hwy 412 is four lanes and carries a substantial amount of traffic, both passenger and commercial. West of downtown, US Hwy 412 is known as the Keystone Expressway and duplexes with US 64 and OK 51.

US Hwy 412 and US Hwy 64 are duplexed with the Keystone Expressway in western Tulsa County

- **US Hwy 64—**at 589 miles in length, US Hwy 64 is the longest U.S. highway in Oklahoma. It runs from Clayton, NM through the Panhandle to Ft. Smith AR. It passes through Boise City, Guymon, Alva, Enid, Perry, Pawnee, Cleveland, Tulsa, Muskogee and Sallisaw before reaching the Arkansas border. In Tulsa County, US Hwy 64 (from northwest to southeast) joins US Hwy 412 at Westport, south of Cleveland, where it becomes the Keystone Expressway and passes through Sand Springs before reaching Tulsa. In Tulsa, US Hwy 64 becomes the Broken Arrow Expressway before branching off to the south with the Mingo Valley Expressway and US Hwy 169 to Memorial Blvd. at S. 96th St., and then on to Bixby and Leonard. US Hwy 64 is heavily traveled by commercial and commuter traffic.
- **US Hwy 75—**runs from the Dallas-Ft. Worth area through Tulsa to the Canadian border. US Hwy 75 is a four-lane divided highway from I-40, at Henryetta, to the Kansas border, and provides excellent access to I-44, the Muskogee Turnpike, Cimarron Turnpike and the Indian Nation Turnpike. The rapid growth of Southwest Tulsa, particularly Jenks, Glenpool and Bixby, has increased traffic on the southern section of US 75, while the Wal-Mart Distribution Center in Bartlesville (approximately 40 miles to the north of Tulsa), and the highway's intersection with both I-44 and I-40 combine to make this a particularly heavily traveled 4-lane highway.
- **OK Hwy 51—**is Oklahoma's third longest State highway at 330 miles in length. It runs from Higgins, TX across the plains of western Oklahoma through Stillwater, and on to Tulsa and eastern Oklahoma and Arkansas. OK Hwy 51 is four lanes from I-35 to Stillwater and two lanes from there to Sand Springs, where it joins the Keystone Expressway. It is duplexed with US Hwy 412 from Sand Springs to downtown Tulsa, from whence it branches off to the southeast,

becoming the Broken Arrow Expressway. At 193rd E. Ave., OK Hwy 51 breaks away from the Muskogee Turnpike and continues southeast through Coweta, Wagoner, Tahlequah and Stillwell. The highway carries a great deal of commuter and commercial traffic through Tulsa County.

- **Creek Turnpike—**connects the Muskogee Turnpike (US Hwy 51) in southeast Tulsa County with the Turner Turnpike (I-44) in the southwest, completely bypassing Tulsa to the south and east. It is 33 miles long and is heavily traveled by commercial and commuter traffic.
- **Mingo Valley Expressway—**travels north-south from Collinsville in northeast Tulsa County to the Creek Turnpike at about S. 96th and Garnett Rd. It is heavily traveled with both commercial and commuter traffic. The Mingo Valley Expressway is also US Hwy 169, which runs from Tulsa to Minnesota. US Hwy 169 begins at the U.S. Hwy 64 East interchange of the Creek Turnpike. U.S. 169 is freeway grade north to Collinsville.

Mingo Valley Expressway (US Hwy 169) at Creek Turnpike interchange

Traffic counts on these highways are presented in Table 1-4.

Table 1–4: Highway Traffic Counts

Highway	*Daily Traffic Counts*
Interstate 44 west Tulsa County (Creek County line)	65,000
Interstate 44 east Tulsa County (Rogers County line)	69,600
US Hwy 75 north Tulsa County (66th St. N)	34,700
US Hwy 75 south Tulsa County (Glenpool)	24,300
US Hwy 412 west Tulsa County (west Sand Springs)	25,700
US Hwy 412 east Tulsa County (225th E. Ave.)	39,800
US Hwy 64 west Tulsa County (Sand Springs)	25,700
US Hwy 64 southeast Tulsa County (Bixby)	25,900
OK Hwy 51 west Tulsa County (Lotsee)	11,200
OK Hwy 51 east Tulsa County (209th E. Ave.)	20,000
Creek Turnpike east Tulsa County (Mingo Rd.)	41,800
Creek Turnpike west Tulsa County (Riverside Dr.)	39,000
Mingo Valley Expy north Tulsa County (Apache Rd.)	55,614
Mingo Valley Expy south Tulsa County (S. 71st St.)	84,200
Broken Arrow Expy southeast Tulsa County (145th E. Ave.)	36,700

Future transportation for Tulsa County has been mapped out in *Destination 2030*, a long-range transportation plan that contains elements on roadways, public transportation, bicycle and pedestrian ways, and freight movements. *Destination 2030* is a joint product of the Indian Nation Council of Governments (INCOG), the Oklahoma Department of Transportation (ODOT) and the Metropolitan Tulsa Transit Authority (MTTA). For major highways, the Plan includes:

- expansion of US Hwy 169 from Owasso to I-244 from four to six lanes;
- expansion of I-44 from Sheridan Rd. to the Arkansas River from four to six lanes;
- expansion of US Hwy 75 from I-44 to 151st St. South from four to six lanes;
- extension of Gilcrease Expressway from Lewis Ave. to I-44.

The Plan encourages the development of bicycle-pedestrian trails, park-and-ride facilities and fuel-efficient automobiles. Regarding safety and congestion, the Plan supports the adoption of transportation incident management programs, the development of a regional Traffic Management Center, and the identification and abatement of high accident locations. Also recommended are infrastructure improvements at Tulsa International Airport (more air cargo facilities and better landside access) and the Port of Catoosa.

Railway

With a major switching station (Cherokee Yard) in West Tulsa, and stops including two major refineries in the county, the Burlington Northern & Santa Fe (BNSF) is the major rail carrier in the county. The Atchison, Topeka & Santa Fe, the earliest railway to lay track in this area, merged with the Burlington Northern in 1996 to dominate the regional service. The BNSF carries most goods, including coal, agricultural and forest products, chemicals, metals, and consumer goods.

The Union Pacific operates over the old Midland Valley line between Muskogee and BNSF's Cherokee Yard, alongside the Broken Arrow Expressway. UP cargoes through Oklahoma include grain bound for export, coal, cement and aggregates.

In addition to the UP and BNSF, the Tulsa-Sapulpa Union Railway, a Class III short line railway, operates in the county between Tulsa and Sapulpa and between Tulsa and Jenks. The TSU handles primarily silica sand for the glass plants (32%), pulp board for packaging (19%), as well as limestone, sodium carbonate, polyethylene plastics and resins, and iron/steel. The line serves St. Gobain Glass Plant, Prescor Inc., Greenbay Packaging Inc, Atlantis Plastics, CG Martin Company and Technotherm Corporation. The railway operates trackage between Tulsa and Jenks on behalf of the Union Pacific Railroad (UP) to serve Sinclair Oil Refinery, Kentube, Word Industries, Pepsi Cola Co., and Kimberly Clark Corporation.

A BNSF engine in the Cherokee Yard in Tulsa

TSU has a direct connection with the Union Pacific in Tulsa, and Burlington Northern Santa Fe (BNSF) railroad in Sapulpa.

Three other short line railroads operate in Tulsa County: the Sand Springs Line, the St. Louis Southwestern, and the South Kansas & Oklahoma (SKOL). The SKOL operates through Collinsville and Owasso to Tulsa and carries grain and grain products, cement, chemicals, steel and plastics.

Bus Lines and Taxi Service

Tulsa County is served by the Metropolitan Tulsa Transit Authority, which has routes to Broken Arrow and Sand Springs. Tulsa Transit does not serve the unincorporated areas of the county, or Sperry, Skiatook, Collinsville, Owasso, Liberty, Bixby, Mannford, Lotsee or Glenpool. Tulsa Transit operates a curb-to-curb lift program six days a week for persons with disabilities.

Tulsa is served by Greyhound bus, which has a central station at 3rd and S. Denver.

A number of taxi companies operate in Tulsa County, including Yellow Cab, Checker Cab, My Cab, American Taxi, Green Country Transportation, and Tulsa Airport Taxi.

Airports

Tulsa International Airport, in northeast Tulsa, is the largest commercial airfield in the county. TIA is a full service field with three/six runways, the longest having a length of 9,999 feet. Eleven major commercial carriers operate out of the airport, as do all major airfreight companies.

Tulsa County is served by several smaller, general aviation airports, including R. L. Jones, Jr. (Riverside) Airport in southwest Tulsa, Harvey Young Airport in east Tulsa, Pogue Airport in Sand Springs, and Skiatook Municipal Airport in north Tulsa County.

McClellan-Kerr Arkansas River Navigation System

Besides having access to excellent air, rail and highway transportation networks, Tulsa County benefits from access to two of five public port facilities on the 445-mile-long McClellan-Kerr Arkansas River Navigation System. The system connects the Port of Catoosa and the Port of Muskogee to cities on the Mississippi River system and New Orleans. Tonnage shipped on the system was 12,896,887 in 2004. Primary cargoes are chemical fertilizer, farm products, sand/gravel and rock, coke, iron and steel, fly ash, petroleum products, pipe, zinc, liquid asphalt, floor tile, wheat and soybeans.

Port of Catoosa on the McClellan-Kerr Navigation System

1.2.6 Economy

According to the 2000 census, 290,038 people in Tulsa County, including incorporated areas, over the age of 16 years (or 67.1% of the population) were in the labor force. Of this number, 289,697 (or 96.8%) were employed and 13,841 unemployed (3.2%). About 84% of the employed were private wage and salary workers, 9.4% were government workers, and 6.3% were self-employed in unincorporated businesses. The median household income in 1999 was $38,213, and the median family income was $47,489.

Unincorporated Tulsa County has several major industrial areas and many small parcels with industrial businesses located on them. The largest industrial area is the Cherokee Industrial Park, located north of the City of Tulsa at 66th Street North and Yale Avenue. Cherokee Industrial Park is the location of several of Tulsa's largest employers, including Whirlpool, Nordam Aeronautics, and Bama Industries.

The second, large industrial area is in southwest Tulsa County and contains two major oil refineries, Sinclair and Sunoco. These refineries are the locations of 127 of the 184 hazardous materials incidents that have occurred in Unincorporated Tulsa County between 1998-2007.

The third major industrial area is located near Oakhurst and the I-44 and I-244 interchange, in Southwest Tulsa County. Here are located Terex Unit Rig, Enduro Pipeline Services, Syntroleum, Norris Dover, Buske Logistics, and Sigma Stretch Plastic.

There are several smaller parcels of industrial uses in North, South, and West Tulsa County, most notably along West 21st Street, on West Charles Page Boulevard, and Avery Drive between Sand Springs and the Arkansas River. Discoveryland, which produces the stage play "Oklahoma" each summer, is in west Tulsa County at 195th and W. 41st St.

A selection of major employers located in Tulsa County are listed in Table 1-5 and are briefly described in the following paragraphs.

Table 1–5: Unincorporated Tulsa County Major Employers

Company	*Product/Services*	*# Employed*
Whirlpool	Oven and range assembly	1,500
The NORDAM Group	Aerospace components	1,400
Bama Industries	Food processing	200
Honeywell-LORI	Aerospace components	165
EDS	Electronic data systems	1,300
Alamo Car Rentals	Automobile rental service	572
Sinclair Oil Refinery	Oil refining	259
Sunoco Oil Refinery	Oil refining and processing	400
Terex Unit Rig	Truck manufacturing	15
Enduro Pipeline Services	Pipeline equipment manufacturing	72
Syntroleum Corp.	Synthetic fuel manufacturing	126
Norris Dover	Sucker rod manufacturing	270
Sigma Stretch Film	Plastic packaging film manufacturing	55
Discoveryland	Dramatic entertainment	58

- **Whirlpool Corp.-Tulsa** manufactures components for Whirlpool ovens and ranges.
- **Nordam Group** manufactures, overhauls and repairs airframe and engine parts, interior components, nacelles, and reversers for commercial and executive aircraft.
- **Bama Industries** manufactures fresh and frozen pies, biscuits, crusts and other baked goods for the home, retail and restaurant industry.
- **EDS (Electronic Data Systems)** provides information technology, applications and business process services, as well as information-technology transformation services.
- **Alamo Car Rental,** one of the nation's largest car rental companies, is headquartered in Tulsa and operates over 150,000 vehicles serving 15 million travelers a year.
- **Honeywell LORI Heat Transfer Center of Excellence** is a leading provider of Honeywell and non-Honeywell heat transfer and electric power repair and overhaul to the aviation and aerospace aftermarket.
- **Sinclair Refinery** in southwest Tulsa processes 60,000 barrels per day to produce high-octane gasoline.
- **Sunoco Refinery** processes 85,000 barrels of oil a day into fuels and lubricants, waxes and aromatic oils used in the automotive, mining, roofing, carpet manufacturing, candle, and food processing industries.
- **Terex Unit Rig** manufactures rear-dump haulage trucks, with payload capacities from 85 to 260 tons, and bottom-dump coal haulers with capacities of 180 to 270 tons.
- **Enduro Pipeline Services** offers pipeline cleaning and inspection products.
- **Syntroleum Corporation** is the leading provider of technology for converting natural gas into synthetic liquid hydrocarbons.
- **Norris Dover** produces special bar quality sucker rods.
- **Buske Logistics** is a trucking company headquartered in Edwardsville, IL.
- **Sigma Stretch Film** manufactures hand-blown plastic film for industrial wrap packaging.
- **Discoveryland** puts on dramatic performances of "Oklahoma" and "Seven Brides for Seven Brothers" between June and August each year. Attendance Monday through Friday is 350-500, and on weekends 1,100-1,500.

Besides industrial and economic enterprises located in unincorporated areas, Tulsa County, itself, has undertakings that are situated both on County property inside other jurisdictions, such as the Tulsa State Fairgrounds, and on property belonging to other jurisdictions, such as the Tulsa County Jail.

1.2.7 Development

According to the 2004 Tulsa County Assessor's data, there are 21,841 properties, including 13,978 with improvements, within the unincorporated areas of the county.

These properties have a total value, adjusted for fair market value, of $1,510,976,950. Numbers of properties with improvements (buildings, garages, pools, storage, and so forth), and improvement values, by type, are shown in Table 1-6 for all of Unincorporated Tulsa County. This information is broken down by region and shown in Tables 1-6a, 1-6b, and 1-6c. No land values are included.

Table 1–6: Unincorporated Tulsa County Properties & Values by Improvement Type
Source: Tulsa County Assessor's Office

Improvement Type	Count	Total Value
Single-family	11,738	$1,079,452,134
Multi-family	36	$15,537,743
Commercial	305	$112,454,940
Industrial	268	$246,580,298
Other	1,631	$56,951,835
Total	**13,978**	**$1,510,976,950**

Table 1–6a: North Uninc. Tulsa County Properties & Values by Improvement Type
Source: Tulsa County Assessor's Office

Improvement Type	Count	Total Value
Single-family	4,612	$416,239,412
Multi-family	13	$9,109,750
Commercial	121	$76,607,180
Industrial	70	$162,309,228
Other	773	$23,201,619
Total	**5,589**	**$687,467,189**

Table 1–6b: West Uninc. Tulsa County Properties & Values by Improvement Type
Source: Tulsa County Assessor's Office

Improvement Type	Count	Total Value
Single-family	4,489	$348,468,591
Multi-family	18	$2,320,253
Commercial	154	$31,426,460
Industrial	188	$83,161,000
Other	539	$22,863,770
Total	**5,388**	**$488,240,074**

Table 1–6c: South Uninc. Tulsa County Properties & Values by Improvement Type
Source: Tulsa County Assessor's Office

Improvement Type	*Count*	*Total Value*
Single-family	2,637	$314,744,131
Multi-family	5	$4,107,740
Commercial	30	$4,421,300
Industrial	10	$1,110,070
Other	319	$10,886,447
Total	**3,001**	**$335,269,688**

Tulsa County Assessor's data from 2004 was used to identify properties with mobile homes, as well as their respective values. There are a total of 1,778 properties with mobile homes in Unincorporated Tulsa County with a combined value, adjusted for fair market value, of $35,695,677. Table 1-7 details the number and values of mobile homes by region within Unincorporated Tulsa County. Locations of these mobile homes and mobile home parks are shown in Figure 1-7.

Table 1–7: Unincorporated Tulsa County Mobile Homes & Values
Source: Tulsa County Assessor's Office – 2004 Data

Area	*Count*	*Total Value*
North	754	$15,706,418
West	776	$13,926,240
South	248	$6,063,019
Total	**1,778**	**$35,695,677**

Future Development

The Tulsa Metropolitan Area is growing at 1.3%, the same as the national growth rate. Comparatively, the State of Oklahoma is growing at 1% annually.

Regional coordination is a key to future development that was mentioned at the Tulsa Mayor's Vision Summit 2002 (July 9, 2002). Leaders find it important that Tulsa expand its vision of development to include jurisdictions that surround Tulsa and to which the city is inextricably connected.

The floodplains of the future growth areas have been identified. Stormwater detention requirements have been established to ensure that no flooding will result from new development.

Growth Trends

According to the 2000 census, Unincorporated Tulsa County's population is 34,675. Projections put the population at 40,540 by 2030, a nearly 17% increase.

The majority of growth in Unincorporated Tulsa County is presently occurring in the North, South and West sections of the county. Owasso, in the north along US Hwy 169, is Oklahoma's fastest growing city, going from 11,151 in 1990 to 18,502 in 2000, an

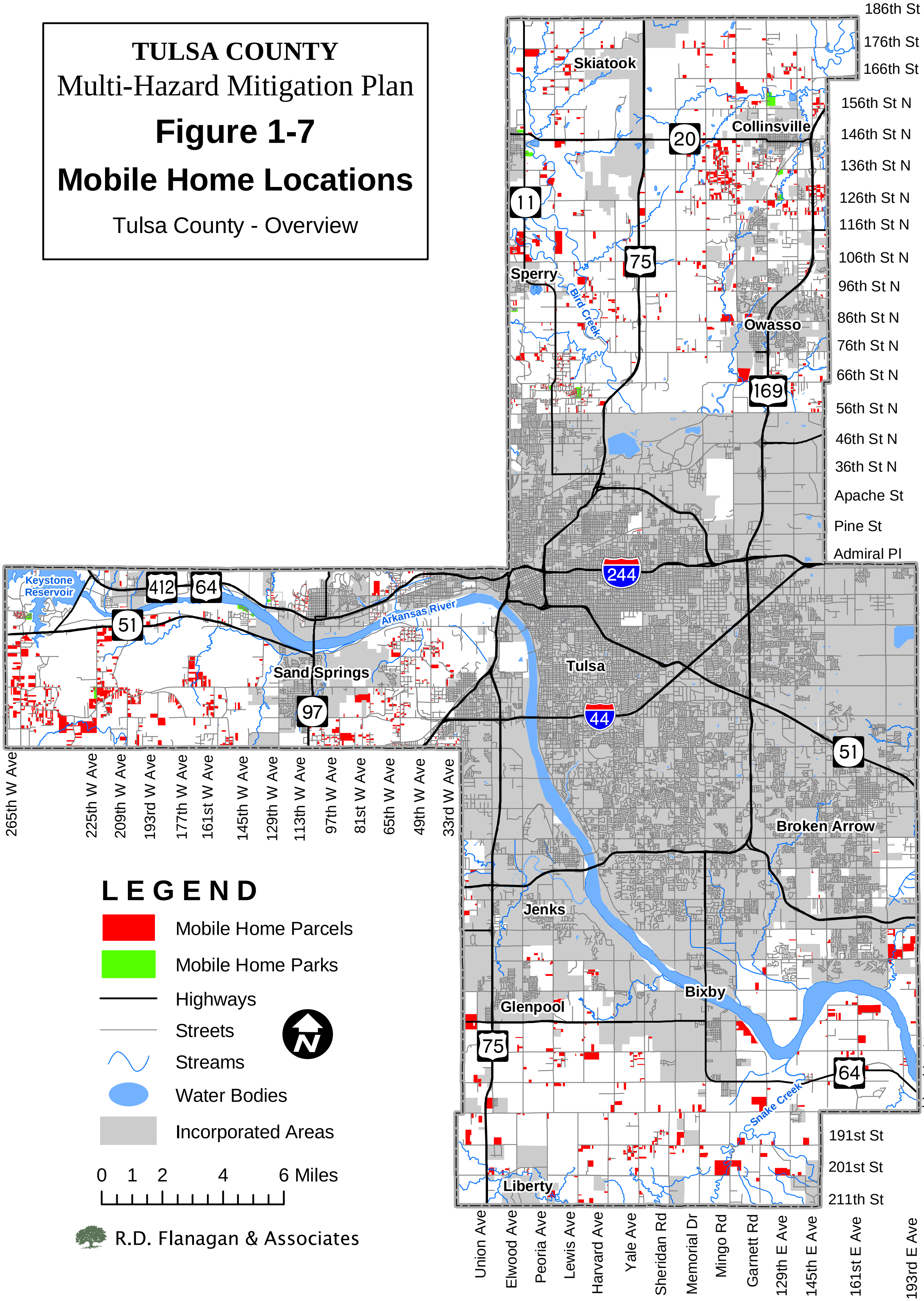
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 1-7

Mobile Home Locations

Tulsa County - Overview



increase of 65%. Future commercial development will expand along the transportation corridors of US 75 and US 169, as well as State Highways 51 and 20. Growth in these areas is due to the convenience of a major metropolitan area (Tulsa) and industrial facilities (Cherokee Industrial Park, Sun and Sinclair Refineries) located in north and west Tulsa County.

Residential development has extended in the unincorporated areas of North, South and West Tulsa County. This is particularly true of land around Collinsville and Owasso in the north, in the hills above Sand Springs and Berryhill in the west, and in the south around the growing communities of Jenks, Bixby, Glenpool, and Broken Arrow. Large tracts of undeveloped land remain in Tulsa County.

Future growth areas in Tulsa County are shown in Figure 1-8.

1.2.8 Critical Facilities

Critical facilities are defined differently by different organizations and agencies, but are usually classified as those facilities that, if put out of operation by any cause, would have a broadly adverse impact on the community as a whole.

FEMA includes the following:

- structures or facilities that produce, use or store highly volatile, flammable, explosive, toxic and/or water-reactive materials;
- hospitals, nursing homes, and housing likely to contain occupants who may not be sufficiently mobile to avoid death or injury during a disaster;
- police stations, fire stations, vehicle and equipment storage facilities, and emergency operations centers that are needed for disaster response activities before, during, and after an event; and
- public and private utility facilities that are vital to maintaining or restoring normal services to affected areas before, during and after an event.

This may also include buildings designated as emergency shelters, schools, childcare centers, senior citizen centers, major medical facilities, disability centers, and City Hall. Since 9/11, FEMA has also added banks and other financial institutions to their critical facilities list. Unincorporated Tulsa County’s critical facilities are listed in Table 1-8 and shown in Figure 1-9. Emergency service facilities are dealt with in detail in Section 2.6.

TULSA COUNTY
Multi-Hazard Mitigation Plan
Figure 1-8
Future Growth Areas
Tulsa County - Overview

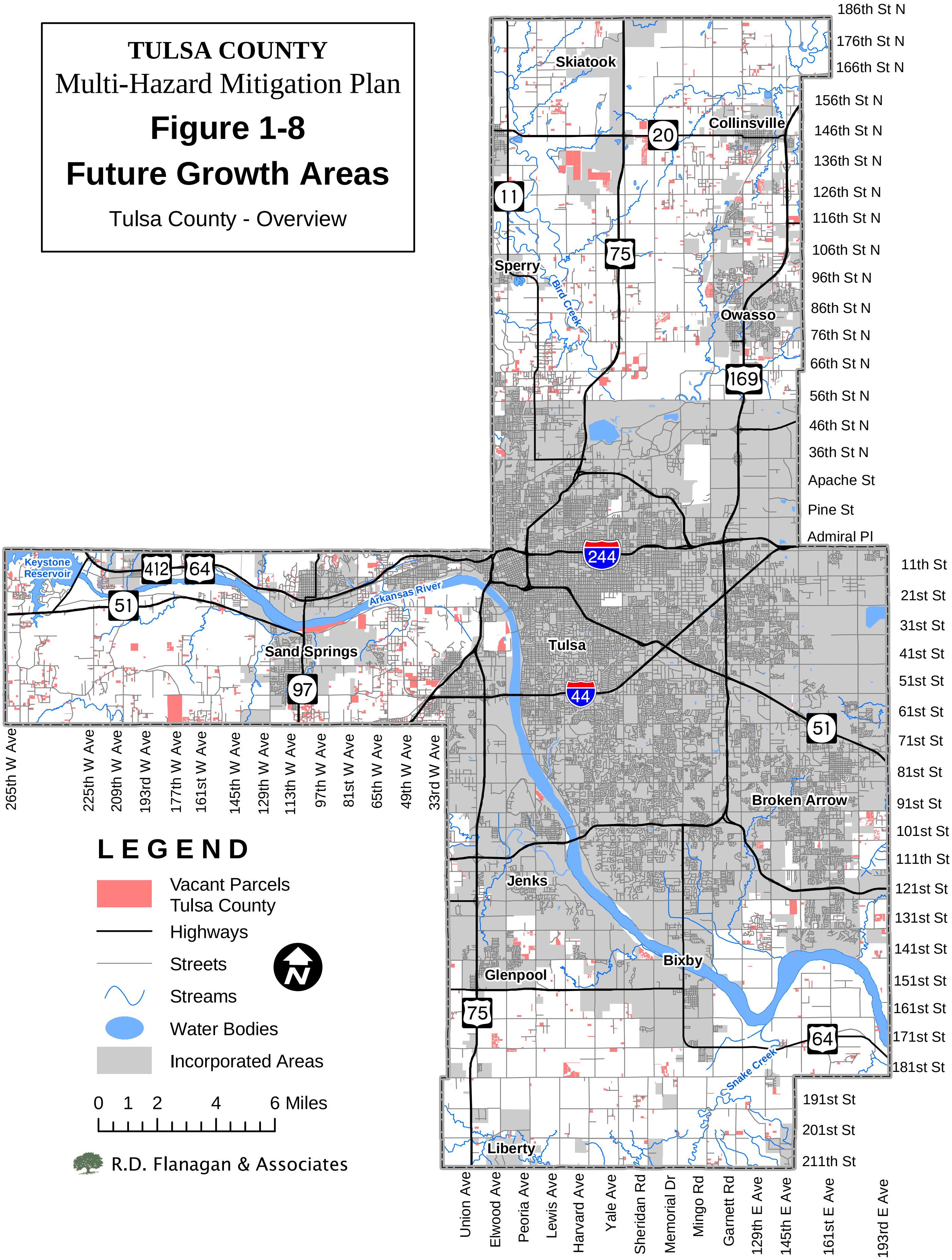


Table 1–8: Unincorporated Tulsa County Critical Facilities

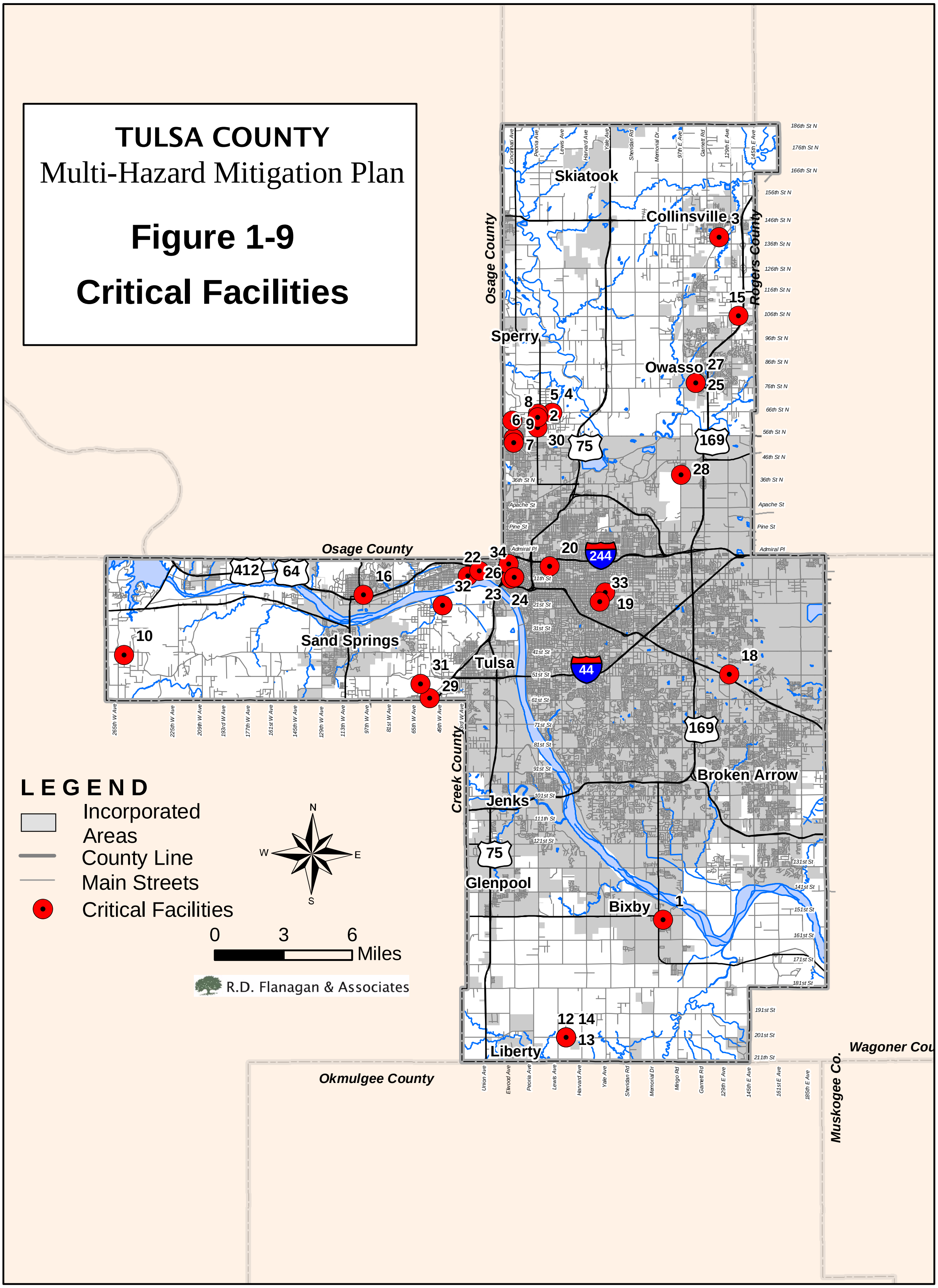
ID	Name	Address	Phone
1	Bixby Health Center	12 W. Dawes	366-8485
2	Cherokee Elementary School	6001 N. Peoria	833-8840
3	Collinsville Rural Fire Protection	1018 S. 12th St.	371-4854
4	Cornerstone Christian Academy	1821 E. 66th St. North,	425-6780
5	First Bank of Turley	6555 N. Peoria	425-1381
6	Gilcrease Intermediate School	5550 N. Cincinnati	746-9600
7	Gilcrease Middle School	5550 N. Cincinnati	595-2700
8	Greeley Elementary School	105 E. 63rd St. North	746-9680
9	Houston Elementary School	5402 N. Cincinnati	746-9020
10	Keystone Fire Dept.	25505 W. Coyote Tr.	363-8261
11	Liberty Daycare	RR1 Box 354	366-8490
12	Liberty Elementary School	2727 E. 201st St. South	366-8311
13	Liberty High School	2727 E. 201st St. South	366-8784
14	Liberty Middle School	2727 E. 201st St. South	366-8493
15	Rejoice Christian School	13413 E. 106th St. North	272-7235
16	Sand Springs Health Center	306 E. Broadway	591-6100
17	TAEMA Emergency Operations Center	600 Civic Center	596-9899
18	Tulsa City-County Health Dept, Main	5051 S. 129th East Ave.	583-2021
19	Tulsa City-County Health Department	4616 E. 15th St.	595-4140
20	Tulsa City-County Health Department	315 S. Utica	582-9355
21	Tulsa County Correctional Facility	300 N. Denver	596-8900
22	Tulsa County Deputy Sheriff	3240 Charles Page Blvd	587-8229
23	Tulsa County Offices	500 S. Denver Ave	596-5000
24	Tulsa County Sheriff	500 S. Denver Ave	587-8229
25	Tulsa County Sheriff Office	303 W. 1st St.	592-5601
26	Tulsa County Offices	500 S. Denver Ave.	596-5801
27	Tulsa County Sheriff Office	303 W. 1st St.	596-5601
28	OK Highway Dept Construction Division	4002 N. Mingo Expressway	836-7117
29	Oakhurst Fire Dept	5716 W. 60th St	445-1442
30	Turley Fire & Rescue Co	6404 N. Peoria	425-0716
31	Addams Elementary School	5325 S 65th West Ave	746-8780
32	Sooner Emergency Services	2131 S 49th West Ave	596-5971
33	Tulsa Co Fairgrounds	4802 E. 15th St.	744-1113
34	Tulsa County Juvenile Detention Center	315 S Gilcrease	596-5959

TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 1-9

Critical Facilities



Chapter 2: Existing Mitigation Strategies

2.1 About Hazard Mitigation Programs

Included in this Chapter:

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 warning systems, Emergency Operations Plans and EOCs, to purchasing fire trucks and ambulances and constructing large and small infrastructure projects like levees and safe rooms. Most communities have made considerable investments in such mitigation measures. The sections that follow in this Chapter survey the regulations, plans and infrastructure that the community has in place for avoiding or mitigating the impacts of natural hazards. This survey is based on FEMA's *State and Local Mitigation Planning How-to Guide* (FEMA 386-1, September 2002), and covers the following topics: Public Information and Education, Prevention, Structural Projects, Property Protection, Emergency Services, and Natural Resource Protection.

There are several national hazard mitigation programs developed by FEMA and other agencies that are designed to help communities organize their mitigation activities to achieve tangible results in specific areas, such as flood protection and fire hazard abatement. This section looks at Tulsa County's participation and progress in these national programs.

The Planning Team reviewed relevant community studies, plans, reports, and technical documents in the inventory, evaluation and plan phases of the Multi-Hazard Mitigation Plan development. The Comprehensive Plan was 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.

2.1.1 National Flood Insurance Program (NFIP)

For decades, the national response to flood disasters was simply to provide disaster relief to flood victims. Funded by citizen tax dollars, this approach failed to reduce losses and didn't provide a way to cover the damage costs of all flood victims. To compound the problem, the public generally couldn't buy flood coverage from insurance companies, because private insurance companies see floods as too costly to insure.

In the face of mounting flood losses and escalating costs of disaster relief to U.S. taxpayers, Congress established the National Flood Insurance Program (NFIP). The goals of the program are to reduce future flood damage through floodplain management, and to provide people with flood insurance. Community participation in the NFIP is voluntary. Tulsa County communities that participate in the NFIP are Bixby, Broken Arrow, Collinsville, Glenpool, Jenks, Owasso, Sand Springs, Skiatook, Sperry, City of Tulsa, and Unincorporated Tulsa County.

Community Rating System (CRS)

The CRS is a part of the National Flood Insurance Program that helps coordinate all flood-related activities of a community. It is a voluntary program that seeks to reduce flood losses, facilitate accurate insurance rating, and promote the awareness of flood insurance by creating incentives for a community to go beyond minimum floodplain management requirements. The incentives are in the form of insurance premium discounts. CRS ratings are on a 10-point scale, with residents of the community within FEMA’s Special Flood Hazard Areas (SFHA) receiving a 5% drop in flood insurance rates for every 1-point improvement in the CRS rating.

Unincorporated Tulsa County is in the NFIP, but does not participate in the Community Rating System. The City of Tulsa has a CRS rating of 2, the City of Sand Springs has a CRS rating of 6, and Broken Arrow has a CRS rating of 8.

2.1.2 Firewise Community

The Firewise Community certification is a project of the National Wildfire Coordinating Group. It recognizes communities that have gone through a process to reduce the dangers of wildfires along what is referred to as the Wildland-Urban Interface (WUI). A specialist from Firewise Communities USA will work with the local community to assess wildfire dangers and create a plan that identifies agreed-upon achievable solutions to be implemented. Additional information on the Firewise Community program can be accessed at www.firewise.org/usa. For more detail on the Firewise Program, see Appendix B, Section B.1.9.

Neither Tulsa County nor any communities in its jurisdiction are currently certified as Firewise Communities.

2.1.3 Fire Hazard Mitigation

Insurance Services Office’s (ISO) Public Protection Classification (PPC) program provides important information about municipal fire-protection services, which is used by insurance companies to establish fire insurance premiums. The program also helps communities plan for, budget, and justify improvements in order to mitigate the effects of the fire hazard.

A uniform set of criteria, which incorporates nationally recognized standards developed by the National Fire Protection Association and the American Water Works Association, is used to evaluate a community’s fire protection service and rate it on a scale from 1 to

10, where lower numbers indicate a better rating. The evaluation inventories and analyzes the following segments of fire protection resources:

- Fire Alarm and Communication Systems – including telephone systems and lines, staffing, and dispatching systems;
- The Fire Department – including equipment, staffing, training, and geographic distribution of fire companies;
- The Water Supply System – including condition and maintenance of hydrants, and a careful evaluation of the amount of available water compared with the amount needed to suppress fires.

There are 15 different Fire Departments operating in Tulsa County. Each community has its own individual fire insurance rating. Fire insurance ratings range from 1 to 10, where lower numbers indicate a better rating. On average, the fire insurance ratings in Tulsa County range from 5 to 8, with the City of Broken Arrow having a rating of 1, the City of Tulsa having a rating of 2, and Sand Springs having a rating of 5.

2.1.4 StormReady Community

StormReady is a nationwide community preparedness program that uses a grassroots approach to help communities develop plans to handle all types of severe weather—from tornadoes to tsunamis. The program encourages communities to take a new, proactive approach to improving local hazardous weather operations by providing emergency managers with clear-cut guidelines on how to improve their hazardous weather operations. To be officially StormReady, a community must:

- establish a 24-hour warning point and emergency operations center;
- have more than one way to receive severe weather warnings and forecasts and to alert the public;
- create a system that monitors weather conditions locally;
- promote the importance of public readiness through community seminars;
- develop a formal hazardous weather plan, which includes training severe weather spotters and holding emergency exercises.

Additional information can be found at www.stormready.noaa.gov.

Tulsa County has been certified in the National Weather Service *StormReady* Program since June 1999.

2.1.5 Business Continuity Mitigation and Planning Programs

The shutdown or permanent loss of businesses can be particularly devastating to a community for a number of reasons.

1. Loss of a business can negatively affect the tax base and revenue for a community. In 1993, a tornado struck in the area of Catoosa Oklahoma, destroying a number of residences and a major truck stop on the Interstate. The truck stop, and associated traffic and personnel it attracted, supported restaurants, clothing stores, motels, and multiple other businesses in the area. Overall, the loss

of the one business cost the community almost 50% of its tax base until the truck stop was able to reopen.

2. Closing of a business may eliminate jobs, not only for the employees of that particular company, but also for vendors for and customers of the affected business. Following a severe tornado in Oklahoma City in 2003 that affected large parts of the community, including a General Motors plant, hundreds of workers were temporarily unemployed, putting a severe strain on the social service agencies for the area.

While a great deal of the mitigation information in this document is applicable to residential, public, and business properties; when available, this plan will include business-specific information and strategies. For further discussion on business vulnerability and the importance of Business Continuity Planning (BCP), see Appendix B, Section B.1.10.

2.2 Public Information and Education

Public information and education strategies are an important part of any successful program to mitigate the loss of life and property from natural and man-made hazards. Examples of such strategies include outreach projects, hazard information distribution, and school age and adult education programs. This section examines the existing communications infrastructure in Tulsa County, and the programs and activities that the County currently has in place to serve this purpose. See Appendix B, Section B.1 for discussion of potential activities and programs within this category.

2.2.1 Public Information Infrastructure

Television and Cable TV

The Tulsa Metropolitan Area is a significant media market with all major networks represented. See Section 2.6.4 for a listing of television emergency information stations and channels in the area. Tulsa's television stations have consistently supported disaster safety information dissemination.

The major Cable TV outlet in the area is Cox Communications serving Tulsa, Broken Arrow, Bixby, Jenks, Owasso, Claremore, Coweta, Catoosa, Collinsville, Glenpool, Kiefer, Oakhurst, Sand Springs, Sapulpa and Sperry. Cox is the nation's third-largest cable television provider, with approximately 6.7 million customers.

Newspapers

The primary newspaper in the Tulsa County area is the *Tulsa World* which is published 7 days a week and reaches over half a million people. In addition, there are multiple local, regional and specialty newspapers in the area. These include:

- *Bixby Bulletin*
- *Broken Arrow Daily Ledger*
- *Catoosa Times*
- *Collinsville News*
- *Glenpool Post*
- *Jenks Journal*
- *Oklahoma Eagle*
- *Owasso Reporter*
- *Sand Springs Ledger*
- *Skiatook Journal*
- *Tulsa Beacon*
- *Tulsa County News*
- *Tulsa People*
- *Urban Tulsa*

Tulsa County Emergency Management and the other response organizations in the area have always maintained a very proactive relationship with the local newspapers and have frequent public relations campaigns with disaster safety information.

2-1-1 System

A community 2-1-1 system is to non-emergency assistance what 9-1-1 is for emergency response—a quick and easy way for people to access needed help by phone for information or social services. During times of severe weather or while people are preparing for emergencies, they may use 2-1-1 to access information. Ensuring that disaster safety information is available to the 2-1-1 operators is an easy and effective way to make sure disaster safety information is disseminated to people who need it. For more information on 2-1-1 in Oklahoma, refer to the Oklahoma 2-1-1 Advisory Collaborative, www.211oklahoma.org. Tulsa County is served by the ***2-1-1 Tulsa*** system.

2.2.2 Outreach Programs

The following is a summarization of some of the public information and education programs undertaken within Tulsa County:

- The Tulsa County Web site can be accessed at www.TulsaCounty.org.
- Tulsa County Sheriff's web site has a Tornado Safety page that explains the nature of tornadoes and what actions to take before, during and after such an event.
- Tulsa City-County Emergency Management officials speak regularly to schools, neighborhood groups and civic clubs.
- The Tulsa City-County Library system is given American Red Cross Disaster Safety information on a regular schedule. The information is seasonally specific and includes material in Spanish for the two libraries that serve the Hispanic population with information desks and other resources.
- The Tulsa Heat Coalition has been developed to distribute "just-in-time" extreme heat information (in the form of flyers, press releases, and, if needed, press conferences) when an extreme heat alert is issued by either the National Weather Service or Emergency Medical Services. The Tulsa Heat Coalition consists of Tulsa Emergency Management, the National Weather Service Tulsa Forecasting Office, EMSA, American Red Cross, the Tulsa Health Department, Tulsa County Social Services, and Community Service Council.
- McReady Oklahoma is a program coordinated by the Oklahoma Department of Emergency Management. The program (developed in the Tulsa Area) allows local governments to work hand-in-hand with their local McDonald restaurants to distribute disaster safety information at all restaurant outlets during each March at the beginning of storm season. In addition to existing literature, McReady specific materials and kids' activity sheets have been created.
- While there are no outreach activities that specifically target the unincorporated areas of Tulsa County, the residents receive the benefits of consistent ongoing efforts through metro media outlets that address disaster preparedness, among other topics.
- Many residents in unincorporated Tulsa County are on Tulsa City water service and receive utility mailer inserts delivered quarterly that address storm and wind safety, winter weather safety, and home fire safety, etc., during the appropriate season.
- Many Tulsa County communities, such as Broken Arrow, Jenks, Bixby, Owasso, and Sand Springs, have weekly newspapers that address disaster safety issues. Residents of the unincorporated areas in proximity to those suburban communities frequently subscribe to those publications.

Tulsa County Radio/TV Programs/Communications

- Local television override is used to alert county residents to natural hazard events and advise them of proper mitigation actions.
- Local television, radio and newspapers are consistently given disaster safety information for their use—primarily through the National Weather Service, American Red Cross, and Tulsa Public Works.

2.3 Preventive Measures

Preventive measures are defined as government administrative or regulatory actions or processes that influence the way land and buildings are developed and built. This section contains a summary of the current ordinances and codes that relate to land use, zoning, subdivision, and stormwater management in Tulsa County. See Appendix B.2 for discussion of potential activities and programs within this category.

2.3.1 Comprehensive Planning and Zoning

Planning in Tulsa County's unincorporated lands is guided by several documents. The purpose of these plans is to coordinate the County's physical development in accordance with present and future goals and objectives.

The *North Tulsa County Comprehensive Plan*, as an amendment to the *Comprehensive Plan for the Tulsa Metropolitan Area*, serves as a general policy document for the future physical development of North Tulsa County, and is the official master plan for the unincorporated area of North Tulsa County. It provides the framework within which individuals and governments can make development decisions.

INCOG and the Tulsa Metropolitan Area Planning Commission (TMAPC) are ultimately responsible for land-use and zoning questions within Unincorporated Tulsa County. However, issues that fall within fence lines of a county municipality will normally be submitted for review and recommendations to that community's Board of Adjustment or Planning Commission.

2.3.2 Floodplain and Stormwater Management

Tulsa County has been a National Flood Insurance Program community since September 16, 1982, number 400462.

Tulsa County has developed and/or updated several drainage basin Master Drainage Plans that identify existing and potential future drainage and flooding problems to public facilities and private property and will continue to develop/update MDPs in the future.

Flood and stormwater management are discussed in Chapter 4.

2.3.3 Building Codes

The building codes adopted by Tulsa County are as follows:

- International Building Code 2006
- International Residential Code 2006
- International Mechanical 2006
- International Plumbing 2006
- National Electrical Code 2008 *(with the exception of the code for 1-2 family dwellings, which mirrors the NEC 2005)*
- International Fuel and Gas Code 2006

- International Existing Building Code 2006

2.3.4 Capital Improvements Plan

In September, 2003, Tulsa County voters approved a one-penny 13-year increase in the Tulsa County Sales Tax for regional economic development and capital improvements. The package, called “Vision 2025: Foresight 4 Greater Tulsa,” was designed to provide economic and community infrastructure. The propositions included $50 million for capital improvements: $20.89 million for road projects; $6.56 million for a hydrology study of Bird Creek and other flood mitigation projects; $20 million for Phase 2 master plan improvements at Expo Square; and $2.53 million for county parks improvements.

In all, Vision 2025 includes 32 projects and an expenditure of $885 million. These projects were packaged into four propositions:

Proposition 1: Economic Development/Boeing - $350 Million (40% of a penny). Offered incentives for the Boeing Company to produce its new 7E7 commercial aircraft in Tulsa. *The proposition did not go into effect, since Boeing did not select Tulsa for this venture.*

Proposition 2: Capital Improvements/American Airlines - $22.3 Million (2.5% of a penny). An incentive package for American Airlines, a leading employer in Tulsa for more than 50 years, to retain existing jobs and attract new ones at the company’s Tulsa Maintenance Base by providing funds for capital improvements, equipment, tooling and training.

Proposition 3: Economic Development/Education, Health Care and Events Facilities - $350.3 Million (40% of a penny). Provides monies for OU-Tulsa, OSU-Tulsa, NSU-Broken Arrow, Langston-Tulsa, Tulsa Community College-Southeast Campus; common education funding for instruction material for the nearly 107,000 children attending Tulsa County public schools; an expansion for the Morton Health Center; a modernization of the Tulsa Regional Convention Center; a new Events Center; and Expo Square improvements.

Proposition 4: Capital Improvements/Community Enrichment - $157.4 Million (17.5% of a penny). Provides monies for parks, trails and community centers; the Arkansas River and attractions; and community infrastructure.

2.3.5 Construction Management

During planning of new Tulsa County structures, the GIS section of the County Engineer’s office does a thorough assessment of the land on which the structure will be built, to ensure that it is not in a 100-year floodplain, vulnerable to dam break or wildfire, on highly expansive soils, in an airport flight path, and located next to or near hazardous materials sites.

2.4 Structural Projects

Structural projects are usually designed by engineers or architects, constructed by the public sector, and maintained and managed by governmental entities. They may include such projects as stormwater detention reservoirs, levees and floodwalls, channel modifications, drainage and storm sewer improvements, and community tornado safe-rooms. The following section includes measures that are already in place or are already included in current planning. See Appendix B for discussion of potential activities and programs within this category.

2.4.1 Existing Structural Projects

Levees

The Tulsa-West Tulsa Levee flood protection project, which included the Sand Springs levees, was completed in 1945. Approximately 12.5 miles of levees were constructed on both sides of the Arkansas River, and were designed to provide three to four feet of freeboard with a discharge of 350,000 cubic feet per second—the equivalent to a 250-year frequency flood. The levees in Tulsa County, including those protecting Sand Springs, were extensively refurbished between 1991-2003.

2.4.2 Planned Structural Projects

The following projects are underway, funded in part by Tulsa County:

- improvements to the stormwater detention system at Expo Square;
- construction of stormwater detention ponds drainage channel improvements in North Tulsa County;
- installation of storm sewers in the Lake Station area of West Tulsa County;
- construction of a Haikey Creek Relief Channel by Tulsa County and the City of Bixby.

2.5 Property Protection

Property protection measures are used to modify buildings or property subject to damage from various hazardous events. The property owner normally implements property protection measures. However, in many cases technical and financial assistance can be provided by a government agency. Property protection measures typically include acquisition and relocation, flood-proofing, building elevation, barriers, retrofitting, safe rooms, hail resistant roofing, insurance, and the like. The following section includes examples of property protection measures which may have already been implemented within Tulsa County or which may be part of current projects. See Appendix B.4 for discussion of potential activities and programs within this category.

2.5.1 Existing Property Protection Projects

Three repetitive loss structures in Tulsa County have been purchased and cleared by the City of Tulsa.

2.5.2 Planned Property Protection Projects

The County will continue clearing repetitive loss structures as funding becomes available.

2.5.3 Critical Facilities Protection

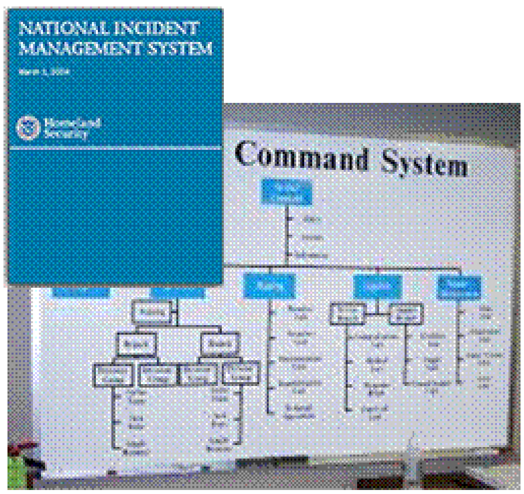
Tulsa County has taken steps to ensure that there are adequate backup facilities for the Emergency Operations Center and for the 9-1-1 Center, both of which are critical facilities. The new 9-1-1 Center has been built to resist up to an F-4 in critical interior areas, and a minimum of F-2 in all other areas. In addition, fire extinguishers have been strategically placed and properly maintained in all community facilities and critical communications facilities such as the 9-1-1 center have robust lightning/surge protection systems.

2.6 Emergency Services

In times of emergency, it is critical that a community have resources available to respond in an efficient manner to a hazard event. This section outlines the community's emergency management resources that are available for response.

2.6.1 National Incident Management System (NIMS)

In 2004, Homeland Security Presidential Directive #5 (HSPD-5) was issued stating that, in order to be eligible for certain Federal disaster mitigation funding, state, local, and tribal jurisdictions must incorporate the use of the National Incident Management System (NIMS) into their protocols.



A typical Emergency Operations Center ICS Assignment Board

The NIMS incorporates a system currently used called Incident Command System (ICS), a management system developed by the fire service used to provide a common language, common management protocols, and scalable incident response chains-of-command that can be applied to any emergency response, whether it be a single family fire or a major hurricane. ICS also allows for "unified command" for situations where multiple agencies may be in charge of various aspects of the operation

The NIMS enhances the ICS by establishing a single, comprehensive system for incident management to help achieve greater cooperation among departments and agencies at all levels of government.

For further information on integrating NIMS/ICS into an Emergency Operations Plan, refer to the NIMS Integration Center at www.fema.gov/emergency/nims/nims.shtm. Available information includes *Local and Tribal Integration: Integrating the National Incident Management System into Local and Tribal Emergency Operations Plans and Standard Operating Procedures*, available at www.fema.gov/pdf/emergency/nims/eop-sop_local_online.pdf.

Tulsa County as a whole, along with several communities in the county, is NIMS compliant and has incorporated NIMS/ICS into its response plans and other protocols.

2.6.2 Emergency Operations Plan (EOP)

Tulsa County's emergency procedures are contained in the Comprehensive Emergency Operations Plan for the City of Tulsa and the unincorporated portions of Tulsa County, adopted December 2003. In addition, most of the additional communities in the county, including Sand Springs, Broken Arrow, Bixby, Jenks, Collinsville and Owasso, have local plans in place. This comprehensive Plan defines who does what, when, where and how in order to mitigate, prepare for, respond to and recover from natural disasters, technological accidents, nuclear incidents and other major incidents/hazards. The plan is comprehensive in that it deals with mitigation and preparation activities, as well as response and recovery.

- Mitigation activities eliminate or reduce the probability of a disaster occurring.
- Preparation develops the response capabilities needed if an emergency does arise.
- Response provides emergency services during a crisis to reduce casualties and damage and speed recovery.
- Recovery is short-term and long-term. Short-term response restores vital services and provides for basic public needs; long-term response restores the community to a normal or improved state of affairs.

The plan establishes the Emergency Operations Center, lays out emergency tasks and responsibilities, direction and control, continuity of government, and administration and logistics. The plan is reviewed and tested at least once each year.

2.6.3 Emergency Operations Center (EOC)

During major emergencies, Tulsa County's government will be moved to the Emergency Operations Center (EOC). Tulsa County's primary EOC is also the City of Tulsa's EOC and is located in the basement of the Tulsa Police/Municipal Court's Building, 600 Civic Center, next to the County Courthouse. An alternate EOC is available at the American Red Cross, Tulsa Chapter, 10151 E. 11th St, which also has an operations room, communications center, and available offices. Radio equipped city- and county-owned vehicles may augment the alternate EOC requirements. The establishment and operation of the EOC is covered in detail in Tulsa County's *Emergency Operations Plan, Annex A.*

Tulsa Area Emergency Management Agency (TAEMA) Emergency Operations Center (EOC)

Emergency response is directed and executed by three operational groups. These are:

1. The Policy Group, made up of the Tulsa County Board of County Commissioners and each City/Town's Mayor and Council members or Trustees;
2. The Coordination Group, comprised of
    a. Chief of Operations (usually the Emergency Management Director);
    b. Law Enforcement (County Sheriff or local Police Chief);
    c. Fire/Rescue Service (Fire Chief);
    d. Health & Medical Services (Director of Tulsa Health Department);
    e. Shelter/Mass Care (American Red Cross Director)
    f. Resources Management (County Emergency Management Director);
    g. Public Works (County Engineer & Superintendents and the City Public Works Director);

h. Independent School District Services (Superintendent of Schools);
i. Public Utilities (managers of companies that provide natural gas, electricity, and telecommunications services within the county); and
j. Manpower Services appointed by the Emergency Management Director.

3. The Operations Staff composed of Officers-in-Charge of communications, damage assessment, public information, administration, transportation, warning, radiological protection, education & training, and shelter/evacuation.

During a disaster, it is the responsibility of the County Policy Group to contact Local Incorporated City/Town Policy Groups and request response resources that are not available within county government in order to manage events that occur in the unincorporated portions of the county. Local government has the primary responsibility for emergency management activities. When the emergency exceeds local government's capability to respond, assistance from the state government will be requested through the Oklahoma Department of Emergency Management.

The Emergency Management Director has overall responsibility for the operation of the EOC. The EOC has three stages of operation: Normal Peacetime Readiness, Increased Readiness, and Emergency Situation.

- **Normal Peacetime Readiness.** Ensure EOC is properly equipped and operationally ready; test warning system; review and revise Emergency Operation Plan; educate public as to warning signals; practice emergency operations with City/County officials and departments.
- **Increased Readiness.** Policy Group advised of emergency measures; prepare EOC for activation; review EOC procedures and brief EOC staff; obtain necessary supplies; test internal and external communications; coordinate EOC staff feeding.
- **Emergency Situation.** Sound warning system; activate EOC; establish security; establish internal/external communication; move essential County functions to EOC.

The EOC is equipped with an operations room, several offices and a communications center, communications equipment, and emergency generator. During an emergency, the EOC operates on a two-shift, around the clock basis. An incident command post (ICP) may be set up to coordinate activities at the scene of the disaster.

During an emergency, the EOC becomes the seat of County government. Day-to-day functions that do not contribute directly to response actions may be suspended for the duration of the emergency.

Tulsa City/County's EOC and alternate EOC both have diesel-powered generators that automatically power the EOCs in the event of a power outage. All computers at both locations are equipped with surge protectors and emergency battery power until the generators start.

Tulsa County has taken steps to ensure that there are adequate backup facilities for the Emergency Operations Center and for the 9-1-1 Center, both of which are critical facilities. The new 9-1-1 Center is resistant to tornadoes to an F-4 in interior critical areas, and a minimum of F-2 in all other areas. In addition, fire extinguishers have been strategically placed and properly maintained in all community facilities and critical communications facilities such as the 9-1-1 center have robust lightning/surge protection systems.

In addition to the main EOC, Tulsa County maintains a Medical Emergency Response Center (MERC) that can coordinate the responses of area hospitals, ambulance services, the health department, and other organizations involved in Public Health. The MERC is located in the same building as the Tulsa County EOC.

Individual community EOCs may be activated in addition to or in place of the Tulsa County EOC if that community is heavily involved or if the location is more appropriate for emergency response.

2.6.4 Emergency Notification and Warning Systems

Emergency Alert System (EAS) Communication

While the Emergency Alert System (EAS) was designed to give the president a means by which to address the American people in the case of a national emergency, it has been used since 1963 by local emergency management personnel for relay of local emergency broadcasts. EAS, which is controlled by the Federal Communications Commission (FCC), utilizes FM, AM, and TV broadcast stations, as well as cable and wireless cable providers to relay emergency messages. Following is a list of EAS broadcast stations in the Tulsa County area:

Table 2–1: Tulsa County EAS Broadcast Stations

Facility	Frequency	City	Facility	Frequency	City
EAS FM radio stations					
KHJM	100.3	Tulsa	**KNYD**	90.5	Broken Arrow
KXOJ FM	100.9	Tulsa	**KIZS**	92.1	Broken Arrow
KTBT	101.5	Collinsville	**KBEZ**	92.9	Tulsa
KRTQ	102.3	Sand Springs	**KEMX**	94.5	Tulsa
KJSR	103.3	Tulsa	**KWEN**	95.5	Tulsa
KJMM	105.3	Bixby	**KRAV**	96.5	Tulsa
KQLL	106.1	Owasso	**KMOD**	97.5	Tulsa
KHTT	106.9	Muskogee	**KVOO FM**	98.5	Tulsa
KWGS	89.5	Tulsa	**KXBL**	99.5	Tulsa
EAS AM radio stations					
KGTO	1050	Tulsa	**KTBZ**	1430	Tulsa
KFAQ	1170	Tulsa	**KXOJ**	1550	Sapulpa
KAKC	1300	Tulsa	**KRMG**	740	Tulsa
KTFX	1340	Sand Springs	**KCFO**	970	Tulsa
KMUS	1380	Sperry			
TV broadcast stations					
KWBT	19	Tulsa	**KPAX**	44	Tulsa
KJRH	2 (NBC)	Tulsa	**KWHB**	47	Tulsa

Facility	Frequency	City	Facility	Frequency	City
KOKI	23 (FOX)	Tulsa	**KOPE**	51	Tulsa
K39CW	39	Tulsa	**KGEB**	53	Tulsa
KTFO	41	Tulsa	**KOTV**	6 (CBS)	Tulsa
KTPX	44	Tulsa	**KTUL**	8 (ABC)	Tulsa
Cable TV					
Cox Cable of Tulsa (Local television override is available)					

Emergency Telephone and Paging Systems

Tulsa County and the City of Tulsa are considering the installation of a Reverse 911 system. The Oklahoma legislature's HB 1650 authorizes law enforcement and public health agencies in Tulsa to establish a reverse 911 system to allow the placing of outgoing emergency calls to notify the public of such things as floods, tornadoes, toxic spills and other hazards.

Radio and Television Communications

Tulsa area radio and televisions stations are ready to broadcast emergency warnings, either by interrupting regular programming or, as in the case of television, running emergency notices at the bottom of the television screen. See Table 2-1, above, for a list of EAS Broadcast stations.

Weather Warning Systems

Tulsa Area Emergency Management Agency has established emergency operations and warning procedures, including a specific warning point, multiple means of both receiving severe weather forecasts and providing warnings to alert the public, systems to monitor local weather conditions, promotion of public safety information, and a formal hazardous weather plan, which includes training severe weather spotters and holding emergency exercises.

There are five warning sirens located in unincorporated Tulsa County (See Figure 2-1).

Tulsa Area Emergency Management Agency has primary responsibility for monitoring weather information and activating warning sirens. When the sirens are activated, TAEMA staff notifies the Public Safety Response Center (PSRC) as soon as practical. If the PSRC receives a tornado warning for Tulsa County via the weather alert radio when the TAEMA director is not available and/or the EOC is not staffed, the PSRC supervisor is authorized to sound the warning system and then notify the TAEMA director and/or EOC.

The Police Department for each community in the county is responsible for activating the sirens in a security situation, such as an attack.

2.6.5 Fire Department Resources

Figure 2-2 illustrates the jurisdiction and coverage areas for each of the 17 different volunteer and full-time fire departments in Tulsa County. These are:

- Tulsa Fire Dept.
- Broken Arrow Fire Dept.
- Jenks Fire Dept.
- Bixby Fire Dept.

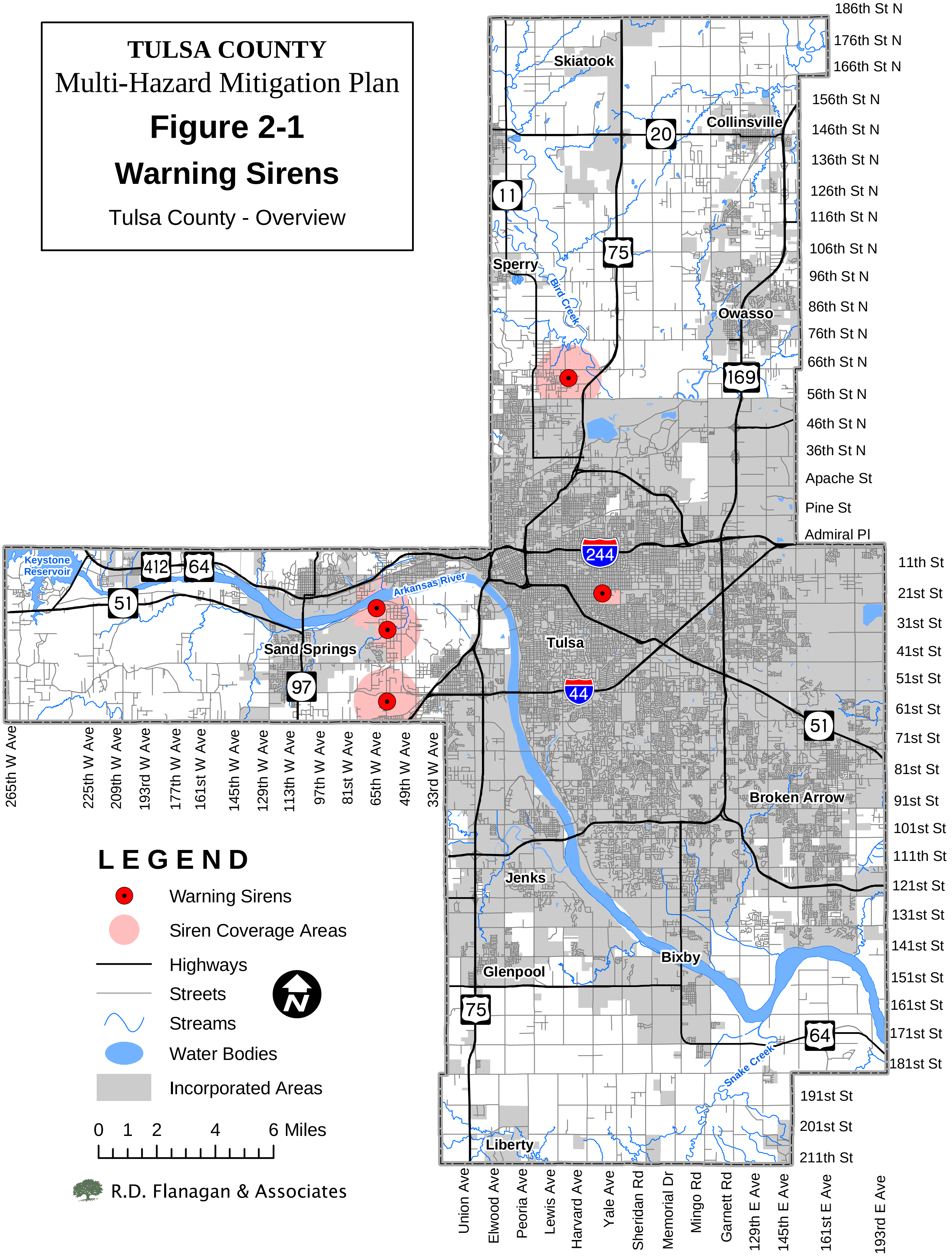
TULSA COUNTY

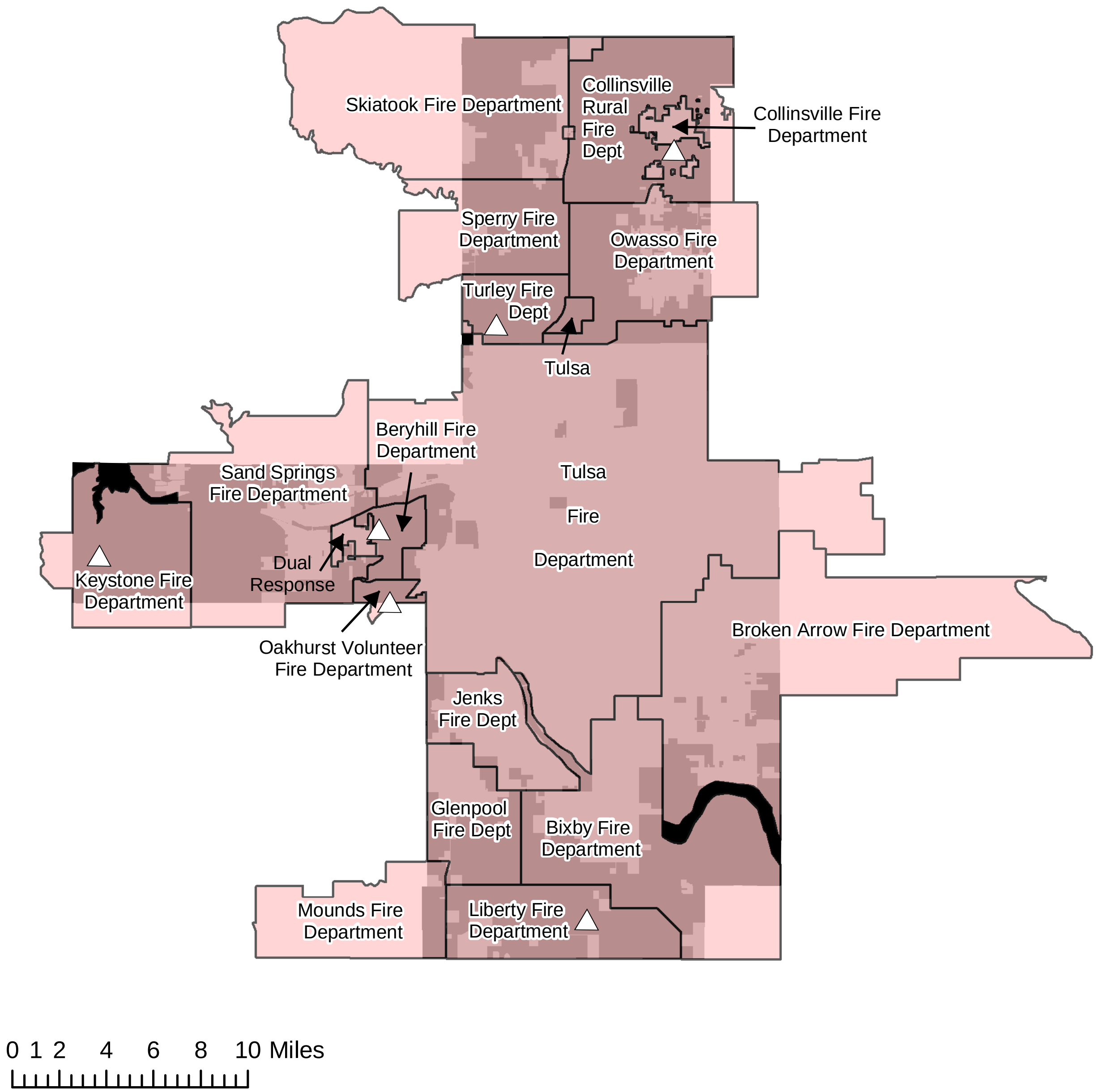
Multi-Hazard Mitigation Plan

Figure 2-1

Warning Sirens

Tulsa County - Overview





LEGEND

- Rural Fire Departments
- Fire District Boundary
- Unincorporated Area
- Incorporated Area
- Outside City Limits

R.D. Flanagan & Associates

TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 2-2
Fire Districts

Tulsa County - Overview

- Sand Springs Fire Dept.
- Owasso Fire Dept.
- Collinsville Fire Dept.
- Collinsville Rural Fire Dept.
- Sperry Fire Dept.
- Skiatook Fire Dept.
- Glenpool Fire Dept.
- Liberty Fire Dept.
- Keystone Fire Dept.
- Oakhurst Volunteer Fire Dept.
- Mounds Fire Dept.
- Berryhill Fire Dept.
- Turley Fire Dept.

The Fire Chief of the jurisdiction is responsible for the following activities:

- Fire suppression
- Fire prevention and education
- Supporting operation of warning system
- Search and rescue operations
- Hazardous materials operations
- Radiological, chemical and biological decontamination
- Radiological monitoring
- Assisting in damage assessment
- Communication system support

2.6.6 Tulsa County Engineer's Office and Resources

The Tulsa County Engineer's Office will coordinate with the City of Tulsa's Public Works department and the Public Works department of other communities in the County to support response in the unincorporated areas of the County. The County Engineer has the following responsibilities:

- Debris clearance
- Providing engineering advice
- Maintaining roads and bridges
- Assisting in damage assessment
- Hazardous materials operations
- Assisting Fire Department with radiological, chemical and biological decontamination.

2.6.7 Tulsa County Sheriff Department and Resources

The Tulsa County *Emergency Operations Plan* lists the emergency functions of the Sheriff's Office, located at the Tulsa County Courthouse at 500 S. Denver and at the Faulkner Building at 303 W. 1st St. in Tulsa, as follows:

- Maintains law and order;
- Traffic control;
- Access control of restricted areas;
- Security of vital facilities;
- Communication system support;
- Liaison with other law enforcement agencies;
- Search and rescue operation support;
- Assures security, protection, and relocation of inmates in the Tulsa County Jail.

The Tulsa County Sheriff's Office includes a uniformed division, Environmental Deputy (to monitor illegal dumping activities), Animal Control, Crisis Negotiations, Mounted and Bicycle Patrols, a Special Operations Team, Underwater Investigations/Water

Rescue Recovery Team, Disaster/Incident Stress Management Team, David L. Moss Correctional Center and Staff, and a full-time Chaplain's Corps.

Sheriff's Department resources that are available for emergency functions are shown in Table 2-2.

Table 2–2: Tulsa County Sheriff's Office Resources

Resource	***Quantity***	***Resource***	***Quantity***
Deputies	220	Rescue Boat	1
Office Staff	20	Air Boat	1
Reserves /Auxiliaries	150	Communications Van	5
Detention Staff	340	Hand-held radios	100
Vehicles with Radios	155	Portable Generators	4
EMTs	2	Aircraft (reserve)	5
Bomb Disposal	0	Mobile Crime Lab	1
Scuba Trained	8	Bull Horns	3
K-9 Units	1 bomb, 1 drug		

2.6.8 Health Care Facilities and Shelters

Medical and Care Facilities

Each community's Medical Coordinator, acting on behalf of the City/County Health Director, is responsible for coordinating all medical service activities within their respective cities. The Tulsa County Medical Coordinator is the Emergency Medical Services Authority (EMSA) Director, who will operate in accordance with the Tulsa Metropolitan Medical Response System (MMRS).

EMSA
EMERGENCY MEDICAL SERVICES AUTHORITY

The City/County Health Director is responsible for:

- inspecting food and water to ensure safe supplies of both;
- investigating sanitary conditions of emergency shelters and disaster relief operations to protect the health and safety of occupants and workers;
- controlling insects and rodents and employing other environmental health measures to prevent epidemics and the spread of disease;
- providing core public health services, such as immunization programs and other related medical services;
- disseminating public health information concerning safety issues and hazards;
- monitoring the community health status and reporting identified public health problems to appropriate agencies;
- provides limited hazardous materials emergency response capability;
- enforcing laws and regulations to protect public health and ensure safety.

The Tulsa Health Department maintains its own Emergency Operations Center in the basement of the Health Department headquarters at S. 129th Street and E. 51st Street in the City of Tulsa.

TULSA HEALTH DEPARTMENT
Gary Cox, J.D. Director
5051 S. 129th East Avenue
Tulsa, OK 74134
(918) 582-9355
Web Site: http://www.tulsa-health.org/

In the event of a disaster, the Tulsa Area Chapter of the American Red Cross is responsible for identifying and managing public shelters, in cooperation with other appropriate agencies.

2.6.9 Other City, County, State and Federal Response

Tulsa County Clerk is responsible for City administrative and fiscal duties.

Tulsa County District Attorney is responsible for legal and emergency information services and serves as a member of an advisory committee.

The Superintendents of Schools in the jurisdiction of the disaster provides public shelters and buses for transportation during relief operations.

State Medical Examiner's Office, *when committed*:

- establishes and coordinates a temporary morgue site, when necessary;
- coordinates recovery of and arranges transportation for deceased victims from scene;
- examines, identifies, and arranges for release of remains to the appropriate funeral home;
- coordinates interment of deceased victims caused by disaster;
- coordinates funeral home support of disaster operations;
- coordinates family information and notification operations at Family Assistance Center (FAC).

Tulsa City/County Health Department, *when committed:*

- investigates sanitation conditions and establishing safe standards for crisis location, emergency shelter or disaster relief operations;
- coordinates medical support and epidemic control;
- inspects food and water supplies;
- provides public health education.

Oklahoma Department of Human Services, *when committed:*

- provides provisions and funds for emergency aid;
- coordinates with the Red Cross and other volunteer agencies;

Oklahoma National Guard, *when committed:*

- assists in radiological, biological and chemical protection;
- assists in law enforcement and traffic control;
- assists in search and rescue operations;
- provides military engineer support and assistance in debris clearance;
- provides logistical support with supply, transportation, maintenance and food service;
- provides communication support.

Other State and Federal Agencies, *when committed*, assist with:

- public welfare;
- resources;
- law enforcement;
- health and medical support and supplies;
- debris clearance;
- public information and education.

2.6.10 Volunteer Support Organizations

The Tulsa Chapter of the American Red Cross provides emergency assistance, including fixed/mobile feeding stations, shelter, cleaning supplies, comfort kits, first aid, blood and blood products, food, clothing, emergency transportation, rent, home repairs, household items, counseling services and some medical expenses.

Salvation Army in Tulsa provides mass and mobile feeding, temporary shelter, counseling, missing person services, medical assistance, and distribution of donated food, clothing, and household items.

The Tulsa Area United Way provides financial assistance to local charities for such things as emergency food, clothing, shelter, utility bill assistance, counseling, literacy, advocacy and legal assistance.

Oklahoma Voluntary Organizations Active in Disaster (OkVOAD) may notify and assist with contacting various volunteer organizations to assist the local effort. OkVOAD may be contacted through the Oklahoma Department of Emergency Management. (For more information on member organizations of OkVOAD, see http://www.okvoad.org.

Tulsa CERT Team training

Community Emergency Response Team (CERT) Program. After a major disaster, local emergency teams quickly become overwhelmed. CERT is designed to have trained groups of citizens in every neighborhood and business ready to assist first responders (police, firefighters and EMS) during an emergency. CERT teams are also available to be used in mitigation activities, including public awareness and other non-structural community mitigation measures. Additional information on CERT is included in Chapter 4. For more information on the CERT program visit www.citizencorps.gov/cert. Several communities in Tulsa County coordinate CERT teams. In various communities, they may fall under the jurisdiction of Emergency Management or under the Fire Department.

Tulsa Citizen Corps maintains an identified and registered volunteer base of several hundred people who are utilizable by multiple organizations to support their operations. It includes the Medical Reserve Corps, a reserve pool of laypeople and medical professionals available to support surge capacity within area health resources.

The Tulsa Ministerial Alliance, made up of ministers from area churches, provides food, shelter, clothing, and utility bill assistance.

Police/Fire Chaplaincy Corps assists the Medical Examiner's office with death notifications, helps the Red Cross with out of town and out of state death notifications, coordinates activities of ministerial alliances and church groups, and provides crisis counseling.

The Tulsa Human Response Coalition (THRC), a collaboration of various mental health, human service, and faith-based organizations, can assist with providing mental health and long-term recovery following a disaster.

The Tulsa Repeater Organization (TRO), an amateur radio group, assists with storm spotting and emergency communications.

2.7 Natural Resource Protection

Natural resource protection activities are generally aimed at preserving and restoring the natural and beneficial uses of natural areas. In doing so, these activities enable the beneficial functions of floodplains and drainage ways to be better realized. The following is a review and summarization of the natural resource protection activities that have already been implemented in the community or are already in the planning stages. See Appendix B.6 for discussion of other potential activities and programs within this category.

- Tulsa County Building Code protects floodways from encroachments and development that would increase flood levels.
- The Tulsa County Code allows the use of floodways for such things as agricultural use, sports and recreation facilities, trails, gardens, and parking areas.
- Stream Teams, coordinated by INCOG, work with communities in Tulsa County to encourage responsible development, wetland preservation and water quality.
- Tulsa County has a "Dump No Waste—Drains to River" stenciling program to educate county and community citizens about pollution and water quality.
- The Tulsa County Sheriff's Office has an Environmental Program dedicated to the elimination of illegal dumping and littering in the County. Penalties include fines up to $1,000, County jail time for up to 30 days, and community service.
- Tulsa County Conservation District sponsors annual creek clean-ups throughout Tulsa County.
- Tulsa County participates in INCOG's regional Green Country Stormwater Alliance (GCSA), a coalition of cities and counties in Northeast Oklahoma dedicated to controlling stormwater pollution. The GCSA members implement education programs, perform inspections of construction sites and other potential pollution sources, and take local enforcement actions to stop pollution.
- Tulsa County Blue Thumb volunteers monitor water quality in rivers and streams throughout the county.

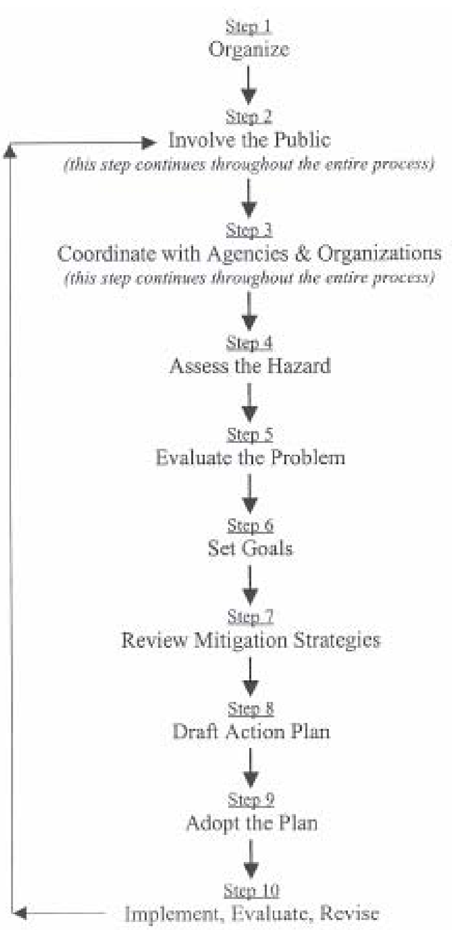
Chapter 3:
The Planning Process

The Tulsa County Multi-Hazard Mitigation Plan is a countywide effort to direct the multi-hazard planning, development, and mitigation activities of the unincorporated areas of Tulsa County. Tulsa County was responsible for overall coordination and management of the study.

Simply stated, a mitigation plan is the product of a rational thought process that reviews the hazards, measures their impacts on the community, identifies alternative mitigation measures, and selects and designs those that will work best for the community.

Included in this Chapter:

Mitigation Planning Process



This plan addresses the following hazards:

- Floods
- Tornadoes
- High Winds
- Lightning
- Hailstorms
- Severe Winter Storms
- Extreme Heat
- Drought
- Expansive Soils
- Urban Fires
- Wildfires
- Earthquakes
- Fixed Site Hazardous Materials Events
- Dam Failures
- Transportation Hazards

The planning for Tulsa County followed a ten-step process, based on the guidance and requirements of FEMA. The ten steps are shown in the graphic to the left, and described in the following sections.

3.1 Step One: Organize to Prepare the Plan

(September 2005 – January 2006)
Citizens, community leaders, government staff personnel, and professionals active in disasters provided important input into the development of the plan and recommended goals and objectives, mitigation measures, and priorities for actions.

The planning process was formally created by a resolution of the Tulsa County Commissioners. The resolution designated a sub-committee of the Tulsa County Local Emergency Planning Committee, along with representatives designated by each of the Commissioners, to serve as the Tulsa County Citizens' Advisory Committee (TCCAC) to oversee the planning effort.

The TCCAC members are as follows:

Tulsa County Citizens' Advisory Committee (TCCAC)

Barbara Bailey
City of Tulsa Public Works, Environmental Compliance Specialist

BS in Environmental Management from Northeastern State University. Member of CERT command staff and Tulsa LEPC. Twelve years experience with HazMat.

Gay Campbell
Environmental Safety
St. Francis Medical Center

BA in Medical Technology.
Co-chair of the LEPC.
Certifications in CHMM, REM, and MT(ASCP)

Dennis Downing

LLB in Law from University of Oklahoma. Retired.

Marsha Goodson
Disaster Coordinator, St. John Medical Center

Steve Gund
Self-Employed, Retired
BA in Computer Science from UCAT. President, Quark Computer Systems, Inc. Past member of the Board of Directors, Bixby Chamber of Commerce. Past President, Secretary/Treasurer, Board of Directors - Bixby Optimist Club. Served at Tulsa EOC during Tornado watches as radio operator for Amateur Radio spotters. Helped establish EOC center at City of Bixby.

Tim Hoss
Safety Officer, Tulsa Regional Medical Center

Certified Healthcare Environmental Manager and Hospital Safety Professional. Member LEPC and Medical Emergency Response Center. Chairman of Christ United Methodist Board.

Donald Karecki
Owner, K&M Publishing
BS in Economics, Syracuse University. AAS in Retail Business Management. President Elect of Oklahoma Small Business Association. Business Instructor at University of Tulsa. Board member of Oklahoma Emerging Small Business Association. Troop Comm Chair, Boy Scouts. Experience and knowledge of Emergency Management, Critical Incident Management, and Business Continuity.

Johnnie Munn
MERC Coordinator, EMSA
(Also serves on Technical Advisory Committee)

Paramedic. Member, Nat’l Academy of EMS Dispatch, Terrorism Early Warning Group, Mayor’s HS Task Force, Regional Medical Planning Group. On faculty of OU-Tulsa (Institute of Disaster & Emergency Medicine).

Henry Townsend
Owner, LosStop Consultants, Inc.

BBA in Economics from University of Miami. Chair of Tulsa County LEPC, Gov. Acting Chair of American Society of Safety Engineers, member of American Industrial Hygiene Association. Certified Safety Profession w/ experience in safety, health, and environmental compliance program management.

Supporting the Hazard Mitigation Citizens' Advisory Committee is the Tulsa County Technical Advisory Committee (TCTAC), which includes representatives of departments that have roles in hazards planning, response, protection, and mitigation. Most of the detail work was done by a management team of the following staff and consultants:

Tulsa County Technical Advisory Committee (TCTAC)

Ray Jordan
County Engineer, Project Manager

Mike McCool
Director, Tulsa Area Emergency Management Agency
Secondary Project Manager
MPH, Environmental Mgmnt from University of Oklahoma. BS, Business Management. Board member, Tulsa Partners Inc. and American Heart Assoc. Member, Mayor's Homeland Security Taskforce and LEPC. Certified Emergency Manager. Over 3,600 hours training in disaster, law enforcement, and EMT courses.

John Campbell
Communications/Warning Coordinator
Tulsa Area Emergency Management Agency
BBA in Finance, Northeastern State University and degree in Administrative Management, Tulsa Community College. Treasurer, Tulsa Area LEPC. Past President, Tulsa Repeater Organizations. Past President, Whiteside Recreation Center Council. Has taken various emergency management courses, including all ICS/NIMS.

Jeff Schippers
Plant Manager
Chemtrade Refinery Services

BS in Chemical Engineering from the University of Kansas and MBA from Oklahoma State University.

Teresa Tosh
Plans Examiner, Tulsa County Inspections

Certified Floodplain Manager. Vice-chair of Tulsa County Rural Water District #2 Board. Member of IBC Building Codes.

Terry West
Zoning Officer, Tulsa County Inspections

Certified Building Inspector, Certified Floodplain Manager. Member of Oklahoma Floodplain Management Association, International Code Council, OMIA, OPIA, and OBIA.

The TCTAC met periodically during the year's planning process. TCTAC members also attended all meetings of the Citizens' Advisory Committee and meetings with elected officials.

Consultant:

Ronald D. Flanagan, CFM

Principal Planner

R.D. Flanagan & Associates
Planning Consultants
2745 E. Skelly Dr., Ste. 100
Tulsa OK 74105

The Tulsa County Technical Advisory Committee (TAC) and Citizens Advisory Committee (CAC) met monthly at the Tulsa County offices at 2nd & Houston, Tulsa, during the planning process to review progress, identify issues, receive task assignments, and advise the consultants. A list of Committee meetings, and meetings and dates with governing bodies is shown in Table 3-1. Refer to Appendix C for meeting Sign-in Sheets.

Table 3–1: Tulsa County Advisory Committee Meetings and Activities

Date	Activity
August 26, 2005	Obligation Date
October 4, 2005	Tulsa County approves and executes Agreement with R. D. Flanagan & Associates, Planning Consultants, to assist Tulsa County in the development of a Multi-Hazard Mitigation Plan.
October 10, 2005	Project Start date
June 12, 2006	Meeting w/ Local Emergency Planning Committee (LEPC), present Tulsa County HM Plan process; Invite participation.
June 15, 2006	Initial meeting of Citizens' Advisory Committee (CAC). Review of planning process and the CAC role. Introduced Chapter 1.
July 20, 2006	Tulsa Co. TAC/CAC Meeting; Review Chapters 1, 2 and 3.
August 24, 2006	Tulsa Co. TAC/CAC Meeting; Review Ch. 1, 2 and 3. Introduced Chapter 4 hazards: Tornadoes, High winds, and Earthquakes
September 21, 2006	TAC/CAC Meeting; Review Chapters 1, 2 and 3. Chapter 4 hazards: Lightning, Hail, Extreme Heat and Winter Storms.
October 19, 2006	TAC/CAC Meeting; Presented Drought & Expansive Soils. Review Transportation Hazards.
Nov 16, 2007	TAC/CAC Meeting; Review Fires & Wildfires. Discussed FireWise program.
Jan 4, 2007	TAC/CAC Meeting; Review Dam Breaks and Arkansas River inundation maps.
Feb 12, 2007	TAC/CAC Combined meeting with LEPC to review Fixed Site Hazardous Materials hazards; Potential Mitigation Measures.
March 15, 2007	TAC/CAC Meeting; Review Floods, total size of basins, possibilities for flood insurance /NFIP information and education in County.
April 26, 2007	TAC/CAC Meeting; Reviewed goals and objectives and screening lists.
May 24, 2007	TAC/CAC Meeting; Submitted screening lists and top 10 lists to TAC/CAC. Review FEMA fundable projects.
June 28, 2007	TAC/CAC Meeting; Continue working on screening Mit. Measures lists. Review public involvement and public education efforts in County.
July 19, 2007	TAC/CAC Meeting; Review State HM/NOI lists, media inventory lists, & Critical Facilities. Prioritized Mitigation Measures.
August 30, 2007	TAC/CAC Meeting; Reviewed Extreme Heat mitigation activities currently being undertaken.
October 18, 2007	TAC/CAC Meeting; Reviewed voting list and prioritized measures.
Dec. 17, 2008	Meet w/ T. West, Discuss/review Future growth areas, Repetitive Loss.
January 9, 2009	Tulsa Co. Emergency Mgr., review of Mitigation Measures
January 20, 2009	Tulsa Co. Emergency Mgr., Prioritization of Mitigation Measures
Sept. 30, 2009	FEMA granted HMGP Plan performance extension until August 30, 2010.
July 12, 2010	County Commission Public Hearing on Tulsa County Multi-Hazard Mitigation Plan.
July 19, 2010	Tulsa County Board of County Commissioners Resolution adopting the Tulsa County Multi-Hazard Mitigation Plan.

3.2 Step Two: Involve the Public

(October 2005 – Ongoing)
In addition to the TCCAC, the management team of TCTAC undertook projects to inform the public of this effort and to solicit their input. All meetings of the TCCAC were publicly posted as required by ordinances and rules of the jurisdiction. Public meetings were held at the beginning of the planning process. Workshops were held to review the hazards and to develop and identify mitigation measures for each natural and technological hazard.

3.3 Step Three: Coordinate with Other Agencies and Organizations

(October 2005 – January 2006)
Many public agencies, private organizations, and businesses contend with natural and man-made hazards. Management team members contacted key entities in order to collect their data on the hazards and determine how their programs can best support the Tulsa County Multi-Hazard Mitigation planning program. A list of agencies contacted and a sample letter are included below.

Federal

US Army Corps of Engineers
US Fish and Wildlife Service
US Geological Survey
Federal Emergency Management Agency (FEMA)
National Weather Service (NWS)
Natural Resource Conservation Service (NRCS)

National Non-Profit

American Red Cross

State

Oklahoma Dept of Emergency Management
Oklahoma Water Resources Board
- National Flood Insurance Program Coordinator
- State Dam Safety Coordinator

Oklahoma Conservation Commission
Oklahoma Dept of Wildlife Conservation
Oklahoma Department of Labor
Oklahoma Geological Survey
Oklahoma Dept of Environmental Quality

Regional

Indian Nations Council of Governments

County

Tulsa County
Tulsa County Assessor
Tulsa City/County Health Department
Local Emergency Planning Committee

Academia

Tulsa Community College
Tulsa University

Local

Offices of the City Managers
Departments of Public Works
Fire Departments
Departments of Community Development
Police Departments

Mr. Gary Cox, J.D. November 10, 2005
Director
Tulsa County Health Department
5051 S. 129th E. Ave.
Tulsa, OK 74134-7004

Subject: Tulsa County, Oklahoma Multi-Hazard Mitigation Plan

Dear Mr. Cox:

The Oklahoma Department of Emergency Management and the Federal Emergency Management Agency have awarded Tulsa County a Hazard Mitigation Grant Program grant to develop a multi-hazard mitigation plan for their community.

The planning process began June 1, 2005, and is expected to be completed by May 31, 2006. A Hazard Mitigation Citizens Advisory Committee and a Staff Technical Advisory Committee have been appointed by Tulsa County to oversee the planning process.

You are invited to participate in the planning process, provide input, and receive any data produced during the planning process. A preliminary schedule of the planning process is included as an attachment. We, or our consultants, will contact your agency to solicit information and studies, which may be relevant to the development of our multi-hazard mitigation plan.

If you have any questions, or if we can be of further service to you, please contact the Hazard Mitigation Coordinator, Mr. Ray Jordan at (918) 596-5730.

Sincerely,

Ray Jordan
Tulsa County Engineering Department

3.4 Step Four: Assess the Hazard

(December 2005 – April 2006)

The management team collected data on the hazards from available sources. Hazard assessment is included in Chapter 4, with the discussion of each hazard.

Table 3–2: How and Why Hazards Were Identified

Hazard	How Identified	Why Identified
Dam Failures	▪ Input from US Army Corps of Engineers (USACE) ▪ Input from Oklahoma Water Resources Board, (OWRB), Dam Safety Division	▪ Population and buildings below a dam are very vulnerable in event of a release or dam failure. ▪ Dam break/release contingency plan needs updating. ▪ Warning systems need to be updated and refined. ▪ Various dam release rates should be GIS mapped, and properties at risk identified.
Drought	▪ Historical vulnerability to drought, the "Dust Bowl" era ▪ 2002 drought and water shortages in Bartlesville, just north of Tulsa ▪ Widespread Oklahoma drought of 2005-2006.	▪ Continuing mid-west and western drought and impacts on Oklahoma communities. ▪ Acute awareness of Oklahoma's population to the severe results of drought. ▪ Need to ensure adequate long-term-water resources for Tulsa County.
Earthquakes	▪ Historic records of area earthquakes ▪ Input from Oklahoma Geological Survey ▪ Input from USGS	▪ Tulsa County has a history of mild earthquakes. ▪ Tulsa County has experienced 5 earthquakes between 1978 and 2006.
Expansive Soils	▪ Input from Indian Nations Council of Governments ▪ Input from the County Inspections Department ▪ Review of Natural Resource Conservation Service data	▪ Expansive soils are prevalent in Tulsa County. ▪ Damage to buildings from expansive soils can be mitigated with public information and building code provisions.
Extreme Heat	▪ Review of number of heat-related deaths and injuries ▪ Review of data from National Climatic Data Center and National Center for Disease Control	▪ High percentage of poor and elderly populations at risk. ▪ 91 heat-related deaths in Oklahoma between 1995 and 2009. ▪ 5 extreme heat events in Tulsa County between 1995 and 2009.

Hazard	*How Identified*	*Why Identified*
Floods	▪ Review of FEMA and County floodplain maps ▪ Buildings in the floodplains ▪ Historical floods and damages (detailed in Chapter 4)	▪ 6.55% of Tulsa County is located in the floodplain. ▪ 1,033 structures located in 100-year floodplain. ▪ 119 flood events reported in Tulsa County between 1995-2009 resulting in approximately $3.7 million in damages and 2 deaths.
Hailstorms	▪ National Climatic Data Center and State Disaster Declarations	▪ 465 hail events in Tulsa County over the last 15 years with approximately $90.7 million in damages.
Hazardous Materials Events	▪ Input from Local Emergency Planning Committee (LEPC) ▪ Input from TAEMA ▪ Input from Oklahoma Dept. of Environmental Quality ▪ Input from Emergency First	▪ Many hazardous materials sites scattered throughout the jurisdiction. ▪ Major trafficways expose Tulsa County to potential traffic way hazardous materials incidents.
High Winds	▪ National Weather Service data ▪ Loss information provided by national insurance companies	▪ 317 high wind and storm-related events in Tulsa County in the last 15 years, over $8.2 million in reported damages and 56 injuries.
Lightning	▪ National Climatic Data Center information and statistics	▪ Oklahoma ranks 15th in the nation in lightning related casualties. ▪ 11 deaths and 76 injuries in Oklahoma due to lightning in the last 15 years. ▪ Lightning events in Tulsa County between 1995 and 2009 reported $2.3 million damages.
Severe Winter Storms	▪ Review of past disaster declarations ▪ Input from Tulsa Area Emergency Management Agency (TAEMA) ▪ Input from area utility companies	▪ Severe winter storms are an annual event in the area. ▪ Widespread economic disruption. ▪ May cause massive utility outages and cause people to use unsafe alternative heating sources. ▪ 29 snow and ice events in Tulsa County between 1995 and 2009 causing over $50 million in damages.
Tornadoes	▪ Review of recent disaster declarations ▪ Input from Emergency Manager ▪ Consensus of Hazard Mitigation Citizens' Advisory Committee ▪ Review of data from the National Climatic Data Center	▪ Tulsa County is located in "Tornado Alley". ▪ An average of 52 tornadoes per year strike Oklahoma. ▪ Thirteen reported tornado events in Tulsa County in the last 15 years with $2.5 million in reported damages. ▪ Oklahoma City tornado of 1999 killed 42 people and destroyed 899 buildings. ▪ All citizens and buildings are at risk.

Hazard	How Identified	Why Identified
Urban Fires	▪ Input from State Fire Marshal ▪ Input from area Fire Departments	▪ Older, deteriorating frame homes in Tulsa County with substandard heating create a significant risk. ▪ Single-family fires are the most common disaster causing loss of life and property.
Wildfires	▪ Input from area Fire Departments. ▪ Input from State Fire Marshal ▪ Oklahoma Emergency Management reports	▪ Fires of the urban/rural interface threaten Tulsa County properties. ▪ Several miles of Tulsa County's perimeter are exposed and vulnerable to wildfires. ▪ During 2005-6, almost 700,000 acres burned in Oklahoma (approximately 1.5% of the state land area). ▪ In the last 10 years, there have been 5 major wildfire events in Tulsa County causing a reported $1.9 million in damages and one death and 11 injuries.
Transportation	▪ Input from Oklahoma Department of Transportation ▪ Input from Bureau of Transportation Statistics ▪ Input from Federal Motor Carrier Safety Administration ▪ Input from National Transportation Safety Board (NTSB) database	▪ Population and property in transportation corridors are vulnerable to incidents. ▪ Hazardous material incidents are common in transportation incidents. ▪ Pipelines transporting hazardous chemicals are in Tulsa County. ▪ Plane crashes can occur at any location near airports or other air corridors. Tulsa County has had 45 accidents in the last 10 years with 11 fatalities.

3.5 Step Five: Assess the Problem

(May 2006 – November 2006)
The hazard data was analyzed in light of what it means to public safety, health, buildings, transportation, infrastructure, critical facilities, and the economy. Some of the work for Steps 4 and 5 had been initiated by Indian Nation Council of Governments (INCOG). They prepared several analyses using their geographic information system. The discussion of the problem assessment is addressed for each hazard in Chapter 4.

DAMAGE ESTIMATION METHODOLOGY

The following methodologies were used in the development of damage cost estimated for buildings and contents for flooding and tornado/high wind damage, used in the *Tulsa County Multi-Hazard Mitigation Plan:*

HAZUS Damage Estimation Model: FEMA's HAZUS Damage Estimation Models were used to calculate damages from Flooding and Earthquakes.

Structure Value: Value of buildings within Tulsa County was obtained from the Tulsa County Assessor's office.

For critical facilities, non-profit properties with structural improvements, such as churches, which are tax exempt and where no county assessor valuation was available, the buildings' footprints were measured using aerial photography, GIS, and field investigation to determine size, in square feet. The value of structure was obtained by calculating the square footage times the value per square foot obtained by using FEMA publication, "*State and Local Mitigation Planning: Understanding Your Risks: Identifying Hazards and Estimating Losses*", August 2001, Average Building Replacement Value per square foot, p. 3-10, source: HAZUS.

Contents Value: Value of contents for all buildings was estimated using "Contents Value as Percentage of Building Replacement Value" table, page 3-11, *Understanding Your Risks*.

Depth of Damage: Flooding damage estimates for building and contents were based on actual structures' estimated flood depth, determined by aerial topographic mapping, and field investigations. Maps of the floodplains are included in Chapter 4.

Flood damage curves, for structures (single-family, multi-family, office, commercial, industrial), and contents were estimated using Table A-3, Damage Factors, Economics Branch, Tulsa District, U.S. Army Corps of Engineers.

Flood depth of damage curve estimates were used for riverine flooding and dam failures (Chapter 4).

Tornado Damage: Damage estimates for the tornado scenario were based on:

1. Structure value: Tulsa County Assessor.
2. Contents: FEMA's Contents Value, Understanding Your Risks.
3. Damage to structure: based on percent damage experienced during typical events, using the Fujita Scale, damage characteristics, Table 4-9, below.

Damage estimates were based on a "worst case" scenario, assuming about 25% of the buildings in the tornado path would experience substantial damage or total destruction; 35% would suffer 50% damage, and 40% would suffer slight to moderate or average 25% damage.

Estimation of the value of tax-exempt structures, for which no county assessor valuation is available, was done using the same methodology as for flood damaged structures, described above—that is, using FEMA publication, *State and Local Mitigation Planning: Understanding Your Risks: Identifying Hazards and Estimating Losses*, August 2001, "Average Building Replacement Value per square foot," p. 3-10.

3.6 Step Six: Set Goals

(September 2006 – November 2006)
Project and community hazard mitigation goals and objectives for Tulsa County were developed by the TCCAC to guide the development of the plan. The hazard mitigation goals for the County are listed in Chapter 5 and Appendix B.

3.7 Step Seven: Review Possible Activities

(December 2006 – March 2007)
Wide varieties of measures that can affect hazards or the damage from hazards were examined. The mitigation activities were organized under the following six categories. A more detailed description of each category is located in "Appendix B: Mitigation Strategies."

1. **Public Information and Education—**Outreach projects and technical assistance;
2. **Preventive Activities**—Zoning, building codes, stormwater ordinances;
3. **Structural Projects**—Levees, reservoirs, channel improvements;
4. **Property Protection**—Acquisition, retrofitting, insurance;
5. **Emergency Services**—Warning, sandbagging, evacuation;
6. **Natural Resource Protection**—Wetlands and floodplain protection, natural and beneficial uses of the floodplain, and best management practices.

MITIGATION MEASURE PRIORITIZATION METHODOLOGY

The Tulsa County Technical Advisory and the Citizens' Advisory Committees, to determine and prioritize the most appropriate risk reduction strategies for the individual jurisdictions, developed mitigation measures for the county. The Mitigation Measures were adopted in Public Hearings as Amendments to the county's Comprehensive Plan, and adopted by the Tulsa County Commission.

Mitigation Measure Categories

During the course of the Planning Process, the TCCAC and TCTAC identified and analyzed those hazards likely to impact the county. Based on historical records and probability analysis (Hazards Analysis Matrix, page 3-6), the committees reviewed the previously listed six Mitigation Activity Categories for each hazard.

Possible mitigation activities for each hazard likely to affect the county were identified in each of the Mitigation Activity Categories. Each committee, after reviewing the list, screened and selected the measures they felt were applicable, feasible, cost effective, and politically acceptable to the county. These measures, specifically identified as potentially benefiting the county, were combined into a new, more county-specific list for review.

Benefit-Cost Analysis Methodology

Scientific methodology for the evaluation of benefit-cost ratios, of one mitigation alternative compared to another, was used when possible and practical. For example, where frequency of disaster events is well established, such as the 10, 50, 100, and 500-year flood events, accepted methodologies were used to evaluate building acquisition vs. other alternatives, such as channelization, flood proofing, or upstream detention ponds. Acquisition candidates, when the preferred alternative, were subjected to the FEMA Riverine Benefit-Cost Module. For other hazards where no scientific methodology exists--such as the evaluation of B/C of Public Information and Education—the desires of the committees were persuasive.

Establishment of Local Priorities

The Citizens' Advisory Committee, professional staff, and elected officials fully understood that acquisition of Repetitive Loss Properties is FEMA's and the State of Oklahoma's highest natural hazard mitigation priority, and that the State's second priority was construction of school safe rooms. It is understood that Public Information and Education about natural and man-made hazards is a State priority under the 5% initiative and would be funded when grant monies are available.

To prioritize the list of possible mitigation measures, sometimes consisting of over one hundred identified mitigation measures, the Citizens' Advisory Committee's members were given twenty votes each to select the individual measures they felt would best benefit the jurisdiction's efforts to reduce or eliminate the adverse impacts of hazards on lives and property. The votes were tallied, and the Mitigation Measures were ranked in descending order. Mitigation Measures that received no votes were considered being dropped from the list, but a simple request by a committee member could keep a measure on the list, albeit at the bottom. The Mitigation Measures selected and prioritized by the voting process, best reflected the values and goals of the jurisdiction. Mitigation priorities generally reflected the disaster and damage experience of the county.

The true challenge is to identify mitigation strategies and measures that represent the goals and political will of the county. Table 6-1, *Multi-Hazard Mitigation Measures, By Priority and Hazard*, is the comprehensive list of Mitigation Measures receiving at least one vote from the 20-vote selection process described above. After confirming the outcome with each advisory committee, the top ten priority measures became the focus for the next phase of the plan, the "Action Plan".

3.8 Step Eight: Draft an Action Plan

April 2007 – July 2008)

The top 10 high-priority Mitigation Measures constituted the Action Plan, and each Measure was further detailed to identify:

- a brief description of the Mitigation Measure (Action Plan Item);
- the lead agency responsible for implementation;
- anticipated time schedule for completion;
- estimated project cost;
- possible sources of funding; and
- the Work Product, or Expected outcome.

The Action Plan items should be developed in enough specificity to respond to a Notice of Intent/Interest (NOI) from the State when HMGP Funds become available, or to provide basic information to begin to put together a Pre-Disaster Mitigation Grant Application. The Draft Plan will be submitted to the state for review and to the Federal Emergency Management Agency for review and approval.

3.9 Step Nine: Adopt the Plan

(August 2008)
The TCCAC 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 County Commission.

3.10 Step Ten: Implement, Evaluate, and Revise

(September 2008 – Ongoing)
Adoption of the Multi-Hazard Mitigation Plan is only the beginning of this effort. Community and county offices, other agencies, and private partners will proceed with implementation. The TCCAC will monitor progress, evaluate the activities, and periodically recommend revisions to the Plan and action items, a minimum of every five years, as required by FEMA.

Chapter 4: Natural and Man-Made Hazards

Introduction

Included in this Chapter:

According to the Federal Emergency Management Agency (FEMA), a hazard is defined as an event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, or agricultural loss, among other types of loss or harm. Hazards are generally classed into two categories based on their source: natural hazards and man-made hazards. Each hazard has its own defining characteristics, such as time of year and geographic area of probable occurrence, severity, and risk level.

Natural phenomena, such as floods, tornadoes, severe drought, and wildfires, are natural hazards because they have the potential to destructively impact human settlements and activities. When damages from natural hazards are realized, the event is generally called a natural disaster.

Man-made hazards are broadly defined as a hazard that originates from accidental or intentional human activity. They can affect localized or widespread areas and are frequently unpredictable. This category of hazards includes such events as dam breaks and hazardous material events.

While Oklahoma communities can expect disaster-related losses, hazard assessments can be used to create proactive measures against likely events, and thereby significantly decrease or eliminate their impacts. Therefore, this chapter contains a risk identification and assessment for 15 hazards. The hazards addressed are those deemed most likely to impact Tulsa County. The hazards include:

1. Floods
2. Tornadoes
3. High Winds
4. Lightning
5. Hail
6. Severe Winter Storms
7. Extreme Heat
8. Drought
9. Expansive Soils
10. Urban Fires
11. Wildfires
12. Earthquakes
13. Fixed Site Hazardous Material Events
14. Dam Failures
15. Transportation

Each hazard is covered in a separate section, which will include the following information:

- **Hazard Profile –** Causes, effects, normal frequency (how often it is likely to occur at a particular location), and available scales or methods of measuring the severity of the events, if any; the geographical extent of the hazards; and the identification of any topographic or geological conditions that would make a particular area prone to the hazard.
- **Historical Events –** Notable past occurrences of the hazard, including national, state, and local examples, if any. Where available, historical losses, in terms of lives and property, are detailed.
- **Vulnerable Population –** The people, geographic locations, and types of property subject to the particular hazard are identified. For each hazard with a definable geographic location, such as floods and dam breaks, the number, types and value of buildings and contents are identified, along with the vulnerable populations.
- **Conclusion –** The information provided on each of the hazards is condensed into a brief summary/conclusion statement.

Hazards Summary

Floods The accumulation of water within a waterbody and the overflow of the excess water onto adjacent lands. The floodplains are the lands adjoining the channel of a river, stream, ocean, lake, or other watercourse or waterbody that is susceptible to flooding.

Floods have a frequent history of occurrence in Tulsa County. HAZUS estimates that there are 36,028 people, and 16,635 buildings valued at $2.2 Billion at risk in Tulsa County, which includes 57 Schools, 18 Fire Stations, and 10 Police Stations. The HAZUS-MH scenario estimates that during a 100-year flood, there will be 1,023 buildings with moderate damage, and 120 buildings will be destroyed. The scenario estimates that there will be $160 Million in damages, with moderate damage to 4 Schools, 1 Fire Station, and 1 Police Station

Tornadoes A rapidly rotating vortex or funnel of air extending to the ground from a cumulonimbus cloud. When the lower tip of a vortex touches earth, the tornado becomes a force of destruction.

Tulsa County has been hit by 80 tornadoes since the first recorded event of April 24, 1904. There have been 13 F3 and F4 tornado events, 23 F2 tornadoes, and 44 F1 events. According to the NCDC, Tulsa County has been impacted by 13 tornado events from 1995 to 2009, resulting in 0 deaths, 7 injuries and over $2.5 million in reported damages. These events included 9 F0 and 4 F1 tornado events.

If a major tornado were to strike in a NW-SE direction through West and North Tulsa County, it could affect up to 896 residential and 56 commercial and industrial properties, producing over $69 million in damages, placing the County in the “moderate” to “high” vulnerability category.

High Winds 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.

Tulsa County, as a whole, experienced 317 high wind events between 1995 and 2009, resulting in 1 death, 56 injuries, and over $8.2 million in damages. This averages to 3.7 wind events per year, causing an average of $546,667 in damages per year.

The people most vulnerable to high wind-related deaths, injuries, and property damage are those residing in mobile homes (see Figure 1-7 for location of mobile home parks) and deteriorating or poorly constructed homes. However, the entirety of Tulsa County is at risk from a high wind event due to possible structural and economic damages caused by downed trees and power lines. All future development areas are also at risk; and there is a high probability another disaster level incident will occur within the next decade.

Lightning Lightning is generated by the buildup of charged ions in a thundercloud. When that buildup interacts with the best conducting object or surface on the ground, the result is a discharge of a lightning bolt. The air in the channel of a lightning strike reaches temperatures higher than 50,000˚ Fahrenheit.

Oklahoma is vulnerable to frequent thunderstorms and convective weather patterns, and therefore its vulnerability to lightning is a constant and widespread threat during the thunderstorm season. The entire county is at risk from lightning-caused fires, damages and casualties, as indicated by the 12 reported events from 1995 - 2009, causing no known injuries or deaths and $2.34 million in reported damages. Tulsa County as a whole can expect 0.8 damaging lightning events every year, causing an average of $156,000 in damage. All future development areas are also vulnerable to lightning strikes and their associated damaging effects.

Hail A hailstorm is an outgrowth of a severe thunderstorm in which balls or irregularly shaped lumps of ice fall with rain. Extreme temperature differences from the ground upward into the jet stream produce strong updraft winds that cause hail formation. Hailstorms are usually considered "severe" when hail is larger than ¾" and accompanied by winds greater than 60 miles per hour.

Between 1995 and 2009, Tulsa County experienced 465 reported hailstorms, which did $90.7 million in damage. Because of multiple reporting of single events, the actual number of separate storm events is closer to 6 hailstorm events per year, with hailstones averaging 1 inch in diameter but reaching upwards of 3.5 inches in diameter in the County.

The entire population of Tulsa County is vulnerable, as well as all areas of future development. A hail event would likely affect more than 10% of the cities' property and/or population. A worst-case scenario of a hailstorm could affect up to 25% of the community, and there is a high probability a disaster level incident will occur within the next decade.

Severe Winter Storms

A severe winter storm is one that drops four or more inches of snow during a 12-hour period, or six or more inches during a 24-hour period. An ice storm occurs when freezing rain falls from clouds and freezes immediately upon contact with the earth, plants, roads, homes and other structures.

Winter storms are a significant hazard to Tulsa County, as they occur frequently and affect the entire community. Between 1995 and 2009, twenty-nine winter storm events hit Tulsa County and resulted in four Presidential Disaster Declarations. The County was also included in the Presidential Declaration for the storm of January 2007. Infrastructure vulnerability, transportation problems and secondary events, such as widespread utility failures, are consequences of winter storms.

Extreme Heat

Extreme summer weather is characterized by a combination of very high temperatures and exceptionally humid conditions. A heat wave occurs when such conditions persist over time. Tulsa County has experienced major heat waves 3 times in the past 10 years: in 1998, 2001 and 2006.

Extreme heat impacts the entire population of Tulsa County and can be expected every summer. The population at most risk to extreme heat is the 17.4% of the Tulsa County population aged 65 and above, the 19.2% of the population that is classified as low income, and that segment of the population that works outdoors. Property damage is also possible, but damage due to extreme heat is minimal.

Drought

A climatic dryness severe enough to reduce soil moisture and water below the minimum necessary for sustaining plant, animal, and human life systems. Duration and severity are usually measured by deviation from norms of annual precipitation and stream flows.

Droughts affect a large segment of the population, but are a minimal threat to property. Crop losses and mandatory water rationing are possible affects of severe drought. Three drought events have impacted Tulsa County in the last seven years, occurring in the years 2000, 2001 and 2005 to 2006. Though different areas of unincorporated Tulsa County are supplied water by differing suppliers, overall the County has substantial water supplies. Therefore, Tulsa County is considered to have a “Low” to “Moderate” vulnerability to the direct impacts of drought.

Expansive Soils Soils and soft rock that swell and shrink with changes in moisture content are commonly known as expansive soils. Expansive soils develop gradually and are seldom a threat to the population, but can cause severe damage to improvements built upon them.

With 78% and 66% of the soils within North and South Tulsa County being categorized as having “moderate” to “very high” shrink/swell potential, these regions have high vulnerability to the damaging effects of expansive soils. West Tulsa County is at low risk to expansive soils damage due to the high percentage of soils classified as having “low” shrink/swell potential. Increased damage to structures in Tulsa County could be expected during and following any period of extended drought, particularly for structures built during a drought.

Urban Fires A fire that burns a home or other improved structure. Fire generates a black, impenetrable, and sometimes toxic smoke that blocks vision, stings the eyes, and can produce rapidly diminished consciousness, making it often impossible to navigate and quickly evacuate the building on fire.

From 2004 through 2008, Tulsa County experienced an annual average of 1,270 structural fires, 45 casualties, and $24,107,000 in fire damage to all structures, excluding critical facilities. During the same period, the county averaged 38 fires in critical facilities causing $1,419,100 in damage.

Even though urban fires are to be expected multiple times per year, they affect a very small area or group of the population. Rural structure fires are typically more destructive than urban due to response times and limited water supplies. A number of additional factors such as the age of structures, strong existing community education programs, and the Fire Protection ratings of the various areas of the County would place Tulsa County’s threat from urban fires in the “moderate” category. As the most common type of disaster, efforts should remain strong to institute or maintain appropriate mitigation programs.

Wildfires A fire that burns along the ground, moving slowly and killing or damaging trees; a fire burning on or below the forest floor in the humus layer down to the mineral soil; a fire rapidly spread by wind and moves by jumping along the tops of trees.

Wildfires are a serious and growing hazard because people continue to move their homes into woodland areas. The value of the property exposed to wildfires is increasing more rapidly, especially in the western states. From 2004 through 2008, Tulsa County fire departments made an average of 965 wildfire runs per year. The fires burned a total of 8,486 acres per year, causing $458,604 annually in damages. As shown during the rash of wildfire in the winter of 2005-2006, the areas of Tulsa County that are in the wildland/urban interface are at moderate to high risk to wildfires, and at severe risk during times of high wind and drought.

Wildfires are to be expected multiple times per year. Wildfires may affect large areas, but only a small group of the population, due to their occurrence within the sparsely populated rural environment. One group that may be more heavily affected includes farmers and ranchers, due to the loss of crops and grazing land.

The areas of Tulsa County that are in the wildland/urban interface are at moderate to high risk of wildfires, and at severe risk during times of high wind and drought.

Earthquakes An earthquake is a sudden, rapid shaking of the ground caused by the fracture and movement of rock beneath the Earth's surface. Earthquakes, although seemingly trivial in Oklahoma, do occur. Although relatively safe from locally generated earthquakes, the region’s underlying geology exposes Oklahoma to some risk from a severe earthquake in the New Madrid Seismic Zone. However, almost all Oklahoma earthquakes are too small to be felt and cause no visible damage. Unfelt earthquakes can, however, adversely affect the integrity of local buildings, infrastructure, and lifelines.

In the last 25 years, the County has experienced 5 earthquakes, but none of them greater than 2.1 magnitude. Therefore, Tulsa County is at low risk from destructive earthquakes.

Fixed Site Hazardous Material Events Hazardous materials are chemical substances that, if released or misused, can pose a threat to the environment or human health. They come in the form of explosives, flammable and combustible substances, poisons, corrosives, and radioactive materials.

Tulsa County has 62 identified Tier II sites, and has experienced 219 hazardous materials incidents between 1998 and 2007. With an estimated 12,383 citizens and 3 critical facilities lying within a half-mile associated with at least one of the County’s Tier II sites, Tulsa County can be considered to have a “Moderate” vulnerability to a fixed-site hazardous material incident.

Dam & Levee Failures

The Federal Emergency Management Agency (FEMA) defines a dam as "a barrier constructed across a watercourse for the purpose of storage, control, or diversion of water." A dam failure is a collapse, breach, or other failure resulting in downstream flooding.

There are five dams in the Tulsa County area that would have a significant, negative impact on the community if a failure were to occur. The worst-case scenario would involve a breach of either Keystone Lake Dam or Skiatook Lake Dam. A failure of Keystone Lake Dam could impact a total of 2,510 properties in West and South Tulsa County, and cause a total of $155.9 million in damages. A breach of Skiatook Lake Dam could cause an approximate $163 million in damages to North Tulsa County properties.

Forced releases of large amounts of water can be a significant flood hazard. This was exemplified by the 1986 Keystone Reservoir water releases that caused downstream flooding.

A related threat to Tulsa County is posed by the Arkansas River levees, built in. Failure of the levees along the Arkansas River would have a devastating impact upon Tulsa County. It is likely that a major Keystone Dam release could cause these levees to overtop and subsequently fail.

Due to the potentially devastating impact, even though the likelihood of a major dam or levee failure is low, the overall risk to Tulsa County is rated as Medium to High.

Transportation

The physical movement of an object through components of a system and its subsystems. Transportation includes the use of aviation, highway, railroad, pipeline, and marine systems to convey movement of objects and people.

The transportation corridor covers over 53 square miles within unincorporated Tulsa County, which is 18.8% of the total land area. Nearly 7,000 residents, or 20% of the population of the unincorporated areas of the County, live within the transportation corridor. In addition, 12 of Tulsa County's 34 critical facilities are within the corridor. The County had 12 railroad accidents, 57 aviation accidents, and 40 reported mobile hazardous materials events occur within its jurisdiction in the 10 years between 1995 and 2004. With approximately 86 miles of highway, 100 miles of railroad, and 3 airports throughout the County, it is highly likely an event will occur within Tulsa County's transportation corridor.

Annual Average Damages

Although available data is limited, information on total damage to property, injuries and loss of lives for the 10-year period from 1995 through 2004 has been summarized in Table 4-1.

Table 4–1: Summary of Damages in Unincorporated Tulsa County from 1995 to 2004

Hazard	Events	Events/ Year	Total Property Damage	Property Damage/ Event	Property Damage/ Year	Injuries	Injuries/ Event	Injuries/ Year	Deaths	Deaths/ Event	Deaths/ Year
Floods	24	2.4	$416,000	$17,333	$41,600	0	0	0	0	0	0
Tornadoes	11	0	$2,227,000	$202,454		0	0	0	0	0	0
High Winds	212	21.2	$4,663,400	$21,997	$466,430	2	0	0	0	0	0
Lightning	8	0.2	$290,100			1	0	0	0	0	0
Hail	35	3.5	0	0	0	0	0	0	0	0	0
Winter Storms	16	1.6	$21,000	$1,312	$2,100	0	0	0	0	0	0
Extreme Heat	Insufficient Data										
Drought	Insufficient Data										
Expansive Soils	Insufficient Data										
Urban Fires*	5,345	1,069	$102,890,000	$96,248	$20,578,000	291	.05	58.2	27	.005	5.4
Wildfires*	5,522	1,104	$2,582,997	$467	$516,599	0	0	0	0	0	0
Earthquakes	5	0.5									
HazMat Events	88	10									
Dam Failures											
Transportation	109	10.9									

* Data for these events are from 1999-2003

Hazards Analysis: Probability and Vulnerability

The ODEM guidelines for hazard analysis provide a process for use in assessing and evaluating hazards and promotes a common base for performing the analysis by defining criteria and establishing a rating and scoring system. Table 4-2 shows the results of the hazard analysis for Tulsa County, including a probability and vulnerability analysis for each event. Probability is derived by dividing the total number of hazard events in a historical period by the number of years in the period. By examining the frequency of such events, the likelihood of an event occurring in the future can be established. Vulnerability is determined by the number of people and the amount of property affected by a potential event. Table 4-3 provides a summary of the ranking criteria and the scoring method.

Table 4–2: Tulsa County Hazard Analysis

Disaster	History (2)*	Vulnerability (5)*	Maximum Threat (10)*	Probability (7)*	Score
Winter Storm	High	High	High	High	240
Hailstorm	High	High	High	High	240
Tornado	High	High	Low	Medium	180
Flood	High	Medium	Medium	High	165
Dam Failure	Low	Medium	High	Low	159
Extreme Heat	High	High	Low	High	150
Lightning	High	High	Low	High	150
Urban Fire	High	High	Low	High	150
Transportation	High	High	Low	High	150
High Wind	High	Medium	Low	High	125
Expansive Soil	High	Medium	Low	High	125
Hazardous Materials	High	Medium	Low	High	125
Wildfire	High	Low	Low	Medium	125
Drought	Medium	Low	Low	Medium	60
Earthquake	Low	Low	Low	Low	44

* Criteria weighted by value in column title.

Values:	
High	10
Medium	5
Low	1

Table 4–3: Summary of Hazard Analysis Ranking Criteria

Criteria	Description	Scoring
History	If a certain kind of disaster occurred in the past, conditions causing the event can occur again.	Number of events in last 100 years: 0-1 Low 2-3 Medium 4+ High
Vulnerability	The number of people and value of property in jeopardy determine vulnerability. Vital facilities, such as hospitals, office buildings and emergency facilities, and population groups of special concern should be included in vulnerability determination.	Population exposed: < 1% Low 1%-10% Medium >10% High Property damaged or destroyed: < 1% Low 1%-10% Medium >10% High
Maximum Threat	Maximum threat is the worst-case scenario of a hazard. Its impact is expressed in terms of human casualties and property loss. Secondary events need to be factored in where necessary.	Area of city impacted: < 5% Low 5%-25% Medium >25% High
Probability	Probability is the likelihood an event will occur. History and probability are similar; however two criteria are used to distinguish between newly developing hazards and hazards with a lack of historical information.	Chance per year of disaster: < .1% Low .1%-10% Medium >10% High

Secondary Events

Many disasters set off other types of events in a cascade of effects that lead to a highly complex situation. It is generally more useful to consider all secondary events as a part of the overall situation created by the primary event. Table 4-4 identifies secondary events that are related to each of the 15 natural and technological hazards studied in this report.

Table 4–4: Secondary Hazard Events

Primary Event	**Dam Failure**	**Drought**	**Expansive Soil**	**Flood**	**Haz. Material Event**	**Power Failure**	**Urban Fire**	**Trans-portation**	**Water Supply Failure**	**Wild-fire**
Flood	●				●	●	●	●	●	
Tornado					●	●	●	●		
High Wind					●	●	●	●	●	●
Lightning					●	●	●	●		●
Hail						●				
Winter Storm						●	●	●		
Extreme Heat		●	●			●				
Drought			●						●	●
Expansive Soil									●	
Urban Fire					●	●				●
Wildfire					●	●	●	●		
Earthquake	●				●	●	●	●	●	
HazMat Event							●			●
Dam Failure				●	●	●		●	●	
Transportation					●	●	●			●

Vulnerability Assessment

Tulsa County is vulnerable to all fifteen hazards studied in this report.

4.1 Floods

Flooding is defined as the accumulation of water within a waterbody and the overflow of the excess water onto adjacent floodplain lands. The floodplains are the lands adjoining the channel of a river, stream, ocean, lake, or other watercourse or waterbody that is susceptible to flooding.

4.1.1 Hazard Profile

Flooding is the most common and widespread weather hazard in the United States.

Most flood dangers and deaths are caused in flash floods. Flash floods usually result from intense storms dropping large amounts of rain within a brief period. The two key elements are rainfall intensity and duration, but topography, soil conditions and ground cover play important roles also.

Flash floods occur with little or no warning and can reach peak flow within a few minutes. Waters from flash floods move with great force and velocity and can roll boulders, tear out trees, destroy buildings, and sweep away bridges. These walls of water can reach heights of 10 to 30 feet and generally carry large amounts of debris.

Location

Tables 4-3a through 4-3c show the location of the floodplains in Tulsa County.

Measurement

The probable future impact of flooding can be assessed by mapping urban development, soil conditions, and the 100-year floodplains; researching the extent of past floods; looking at historical rainfall data and the condition of drainage ways and stormwater facilities; and estimating the likely contribution to flooding from recent and future development. A computerized modeling and assessment tool named HAZUS was used to estimate damages within Tulsa County from a 100-year flood event. Hazard rankings for floodplain lands are typically based on the frequency, depth, duration, and velocity of anticipated floods.

Extent

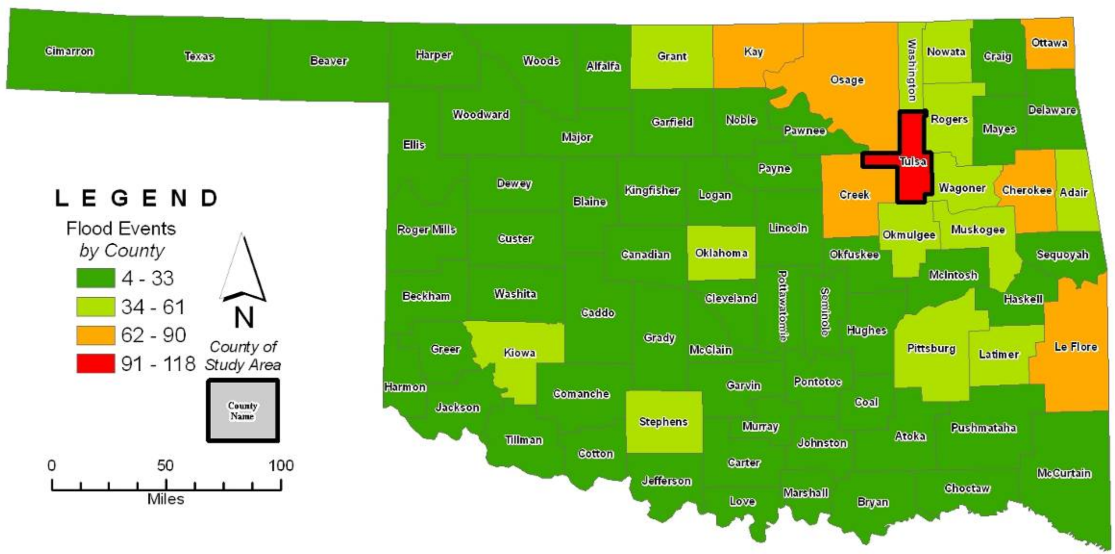
Tulsa County rainfall averages 39 inches per year, but thunderstorms can, and have, dumped more than half that amount in a few hours, causing widespread flooding and devastating flash floods.

Tulsa County flood problems are widely dispersed and can 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.

Over the years, flooding has been one of Tulsa County's most frequent, disruptive, and damaging disasters. Up until the closure of Keystone Dam in 1964, Tulsa County experienced some damaging flood every few years along the Arkansas River, Bird Creek, and/or their many tributary streams. Arkansas River flooding became less frequent after partial levees were built during World War II, and the completion of Keystone Dam and Kaw Reservoir near Ponca City.

Figure 4–1: Floods in Oklahoma from 1989-2009



Source: National Climatic Data Center U.S. Storm Events Database
Flanagan & Associates, LLC

Along tributary creeks and waterways, the frequency and magnitude of flooding have been greatly reduced, but not eliminated, by significant advances in Tulsa County and City floodplain management over recent decades. Nonetheless, the County is still vulnerable to localized flooding, floods along rivers and creeks, and catastrophic flooding along the Arkansas River. Bird Creek, for example, continues to flood almost annually. Its floodplain is sparsely developed but includes important assets such as the Mohawk Park Zoo.

Arkansas River flood issues are complex for Tulsa County. Although the construction of Keystone Dam and Kaw Reservoir upstream from Tulsa County has greatly reduced the frequency of seasonal riverine flooding, the dams have not eliminated the potential for catastrophic flooding on the Arkansas and Caney Rivers, as shown in the 1986 floods that were caused by forced emergency releases from Keystone, Hulah, and Copan Dams due to torrential rains.

Plans to build low-water dams on the Arkansas River at Tulsa, Sand Springs, and Jenks will spur development along the river, but also present management and development challenges, based on the river's flooding potential.

Additional information about the Arkansas River is contained in the section on dams and levees.

Currently, Tulsa County has 1,033 structures located in the 100-year floodplain. The HAZUS model determined that a 100-year flood would result in $160 Million in

Building-Related Loss, with moderate damage to 4 schools, 1 Fire Station, and 1 Police Station.

Tulsa County is experiencing development in all its quadrants, as urban growth spills out of the boundaries of its major cities and towns. In 2004-2006, Tulsa County issued an average of 3,077 building permits per year, almost all of them for owner-occupied, single-family residences. Most of this development is occurring in north, south and west Tulsa County.

Although the cities of Sand Springs, Tulsa, Bixby and Jenks zone and regulate the FEMA SFHA, it is not possible to accurately predict the effects of a 100-year and 500-year flood on future development or to future buildings and development that have been permitted to the minimum standard without master drainage plans for the Arkansas River and its major tributaries. The preparation of a Flood & Drainage Annex to the Hazard Mitigation Plan for all watersheds within the community has been included as an Action Item in Tulsa County's mitigation measures. (See Table 6-1, Multi-Hazard Mitigation Measures, by Priority and Hazard.)

There are three common types of flooding: 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. Tulsa County considers a river rise of one foot above the SFHA to be a minor severity and a major severity is the 500-year event.

Flash flooding is associated with large convective thunderstorms and can drop between one and five inches of rain in the space of an hour. When the soil is already saturated, rainfall from such storms can converge in creeks and streams suddenly, with little warning. 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 suddenly in culverts and drainage ways, often charged with debris, causing streets to flood and storm sewers to back up.

Tulsa County considers a rainfall of one inch in an hour to be a minor severity and a five inch rainfall in one hour to be a major severity for both Urban and Flash Flooding.

Frequency

Frequent floods have haunted Tulsa County throughout its history. Today, the frequency and magnitude of other flood problems have been greatly reduced by better floodplain management practices. Nonetheless, relatively minor and localized flooding occurs every year, most frequently affecting the transportation systems. Some of these recent flood events are described in the following paragraphs. Although smaller floods occur much less frequently, the potential continues for catastrophic flooding - despite a widespread community belief that flooding is a past problem. As can be seen in the following flood frequency map for Oklahoma, Tulsa County experienced more floods than any other county between 1989 and 2009.

Table 4-5 lists areas identified on FEMA's Flood Insurance Rate Maps (FIRM) for use in regulating construction in the floodplain, and for determining insurance rates for properties located in the floodplain.

Table 4–5: FEMA Flood Insurance Rate Map Flood Zones

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 1 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.	
Source: Understanding Your Risks, identifying hazards and estimating losses, FEMA 386-2		

Impact

The impact of this hazard occurs during times of flooding and inundation. Roads become impassible, homes and businesses are inaccessible, and response to an emergency becomes limited or impossible. Roads that become impassible create a financial and time hardship to citizens; school districts and others in that they must find alternate routes around flooded areas.

4.1.2 History/Previous Occurrences

Table 4-6 lists the number of events, number of deaths, number of injuries, number of events that reported damages, and the amount of property damage reported to the NCDC for Tulsa County and Oklahoma

Table 4–6: Floods in Oklahoma and Tulsa County from 1995-2009
From NOAA National Climatic Data Center http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Location	Events	Deaths	Injuries	Damage Events	Property Damages
Tulsa County	119	2	0	24	$3,760,000
Oklahoma	1,971	25	25	355	$79,668,000

The following paragraphs summarize some of the major floods recorded since 1900, including historic Tulsa County floods.

In Tulsa County and throughout Oklahoma over recorded history, 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 that were serious enough to be declared federal disasters – the most federal flood disasters on record for any community in the nation to that time. The following are some historic flooding events on record in Tulsa County and Oklahoma. *(Dollar damages are not adjusted for inflation)*.

- May 28, 1908. The fourth greatest recorded flow on the Arkansas River peaked at 21.8 feet and caused $250,000 in damage in Tulsa (1908 dollars).
- June 11-13, 1923. Floodwaters destroyed Tulsa's waterworks and forced the evacuation of 4,000 people.
- April 6-7, 1927. Heavy rainfall in southeastern Kansas resulted in an 8- to 10-foot wall of water—with registered flows of 750,000 cubic feet per second—roaring down the Arkansas River valley below Muskogee and emptying into the Mississippi River. Nearly every levee from Fort Smith to the Mississippi was destroyed. Losses totaled $4,000,000.
- May 18-22, 1943. A deluge that dumped 24 inches of rain in six days on the area between McAlester to Muskogee resulted in the flood of record for many communities along the Arkansas River, including Tulsa.
- May 16-21, 1957. The wettest May in Oklahoma history caused widespread flooding on the Arkansas, Cimarron and Canadian Rivers.
- May 10, 1970. The Mother's Day Flood in Tulsa caused $163,000 in damages on rapidly developing Mingo and Joe Creeks.
- April, May, June 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 damages. On September 19, Mingo Creek flooded again.
- 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 damages to more than 3,000 buildings.
- May 26-27, 1984. More than 12 inches of rain fell in Tulsa, causing extensive flooding, especially on Mingo Creek but also on many other area creeks such as Joe, Flat Rock, Dirty Butter, and Bigheart. Fourteen people were killed, 6,800 homes and more than 7,000 vehicles were damaged.

- 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 extensive, with $1.3 million in damage to 64 buildings in Tulsa. Garden City in West Tulsa was flooded to the rooftops, and low-lying homes along the river in northwest Tulsa were under 6 feet of water. One levee in Sand Springs was breached, but plugged with sandbags before serious damage occurred. Total damages in the Tulsa region were more than $63 million.
- May 8-11, 1993. Near record flooding of 7 to 12 feet above flood stage occurred along Bird Creek in Osage and Tulsa Counties. In addition to major flooding of crops and pasturelands along Bird Creek, approximately 40 homes and 18 businesses in Skiatook had flooding to a depth of 1 to 5 feet. Approximately 15 homes were evacuated in Sperry due to flooding.
- 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 homes near 81st Street South and Elwood Avenue had 2 to 4 feet of water in them, and homes were also flooded near 71st Street South and Harvard Avenue. Eight to 12 homes were flooded in the Tulsa area. 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 the interstate, and 1 foot deep on the interstate itself.
- October 5, 1998. Serious flooding took place throughout Tulsa County. In Jenks, several roads were closed due to street flooding. Jenks schools were closed for the day. Water entered three downtown businesses. In Tulsa, many street intersections were flooded, including 31st and Yale, 96th and Sheridan, and 2 feet of water over the road at 28th and 129th East Avenue. There was major street-flooding across the City of Tulsa. The basement of the Southwestern Bell telephone building in downtown Tulsa took on water, causing the loss of phone service across much of Tulsa for several hours and temporarily disabling 911 emergency services. Cell phones, pagers, and 911 emergency services also experienced interrupted service across much of eastern Oklahoma due to the flooding at the Southwestern Bell building. In Broken Arrow, many city streets were flooded and impassable. One woman had to be rescued from her car on a bridge near 101st and Garnett when her car stalled in four feet of water. Two other women had to be rescued when they tried to cross a swollen creek on foot on 81st Street near the Oak Creek subdivision. In Glenpool, several streets were closed by high water, including 121st at US Hwy 75, 131st at US Hwy 75, and Caspar from 146th to 148th Streets. A woman and her daughter had to be rescued when their car stalled in high water near 141st and Fern. Two cars stalled out at US Hwy 75 and 201st Street, where only the cars' roofs were visible. Several residents had to be evacuated, and two downtown businesses received flood damage. Several rivers rose above flood stage, including the Bird Creek at Sperry and Owasso.
- April 26, 1999. More than twenty streets in Tulsa had to be closed. Tulsa police responded to 39 vehicles that were stalled in high water. Mingo Creek overflowed, flooding undeveloped areas near 36th Street North. Lower Haikey Creek at 101st Street also overflowed its banks. In Glenpool, water seeped into five homes, and

firefighters had to free passengers from vehicles in two separate incidents. Street closings included 121st Street and Elwood, and 181st Street west of US Hwy 75. Flooding of homes and streets was reported at Jenks and Bixby. Low-lying rural roads near Owasso also experienced flooding. Northern Tulsa County had flooding along the Bird Creek. In Sand Springs, a daycare center on 177th West Avenue north of Shell Creek Lake Dam had to be evacuated. In Broken Arrow, several streets were flooded, including Kenosha and Midway, Kenosha and Shelby Lane at Covington, Kenosha and 234th, Washington and 23rd, and New Orleans at 23rd. There was also water over 23rd and Tucson. Haikey Creek west of Olive experienced flooding problems. One vehicle became stranded on Midway south of Kenosha.

- May 3, 1999. Heavy thunderstorms brought a large tornado outbreak, torrential rains and flooding to much of Oklahoma. The storm caused damage in Sapulpa and southwestern portions of Tulsa County and millions of dollars in damage. Flooding occurred in Collinsville and the City of Tulsa. OK Hwy 11 north and south of Skiatook was closed by high water.
- May 6, 2000. Over 6 inches of rain fell over Tulsa County, causing widespread flooding. The most damage was in Meadow Valley subdivision in Sand Springs, where 115 homes were flooded by Fisher Creek. Flood damage was also reported in Jenks, Bixby, Glenpool, south Tulsa and Broken Arrow. Numerous roads and intersections were flooded. Highway 75 near Glenpool, Highway 11 at 86th Street North and Highway 51 at 137th West Avenue were all closed due to flooding. Damage to roads, bridges and infrastructure was estimated at $200,000. In addition, there was one fatality.
- May 30, 2001. A quick two inches of rain caused widespread street flooding in Tulsa County. A few small streams in the county flowed out of their banks and crossed roads. For example, along Snake Creek in Bixby at 191st Street and Mingo Road a car which was driven around a barricade was swept away by flood waters.
- August 30, 2003. Heavy thunderstorm rains totaling 6.10 inches in Jenks, 5.62 inches in Bixby and 4 inches across much of Tulsa County produced localized flooding.
- May 13, 2004. Between two and four inches of rain fell across nearly all of Tulsa County, causing excessive street flooding. Street and small stream flooding were reported in Collinsville, Bixby and Jenks.

Probability/Future Events

Currently flood planning is based on what are termed “100-year floods” or “500-year floods.” That terminology is somewhat misleading and is changing to floods being referred to as having a 1% chance of occurring in any given year.

Depending on the extent of the rainfall, such larger storms could be expected to inundate floodplain lands and the roads, bridges, buildings, and other structures thereon. The frequency and magnitude of floods that could threaten people or property depends, in large part, on the magnitude and location of the rain and the condition of the receiving systems. For example, on-the-ground conditions such as debris in creeks could exacerbate flooding problems.

4.1.3 Tulsa County Rivers and Streams

Several significant rivers and streams pass through Tulsa County's 587 square miles of fenceline. Chief among these is the Arkansas River. Other important waterways are the Caney River, Bird Creek, and Polecat Creek. These rivers and creeks and their tributaries are listed in Table 4-7 and shown in Figure 4-2.

Table 4–7: Tulsa County Drainage Basins

Basin	***Total Drainage Area in (sq. mi.)***
Arkansas River Main Stream	63.27
Arkansas River / Haikey Creek	25.33
Bird Creek	77.43
Caney River	35.68
Cimarron River / Keystone Lake	3.55
Duck Creek	44.5
Hominy Creek	3.99
Keystone Reservoir	6.95
Polecat Creek	22.36

North Tulsa County Rivers and Streams

The major drainage basin in North Tulsa County is Bird Creek, with its major tributaries Hominy Creek, Delaware Creek and Mingo Creek. The Caney River, although a significant stream in its own right whose flooding impacts Collinsville, only passes through two miles of the extreme northeast corner of the county.

Caney River. The Caney River originates in southern Kansas and flows generally southeast through Collinsville and the northeast corner of Tulsa County before joining the Verdigris River south of Oologah Lake. The drainage area at Collinsville is 2,046 square miles. The stream slope through the county is 1 fpm, and the floodplain is broad and flat. The major tributaries of the Caney River in Tulsa County are Horsepen Creek and its tributaries Cherry Creek and Blackjack Creek, both of which flow through Collinsville. Horsepen Creek drains an area of 32.7 square miles. To the east of Collinsville, East Creek flows north along the boundary of Tulsa and Rogers Counties for 5 miles before joining the Caney River.

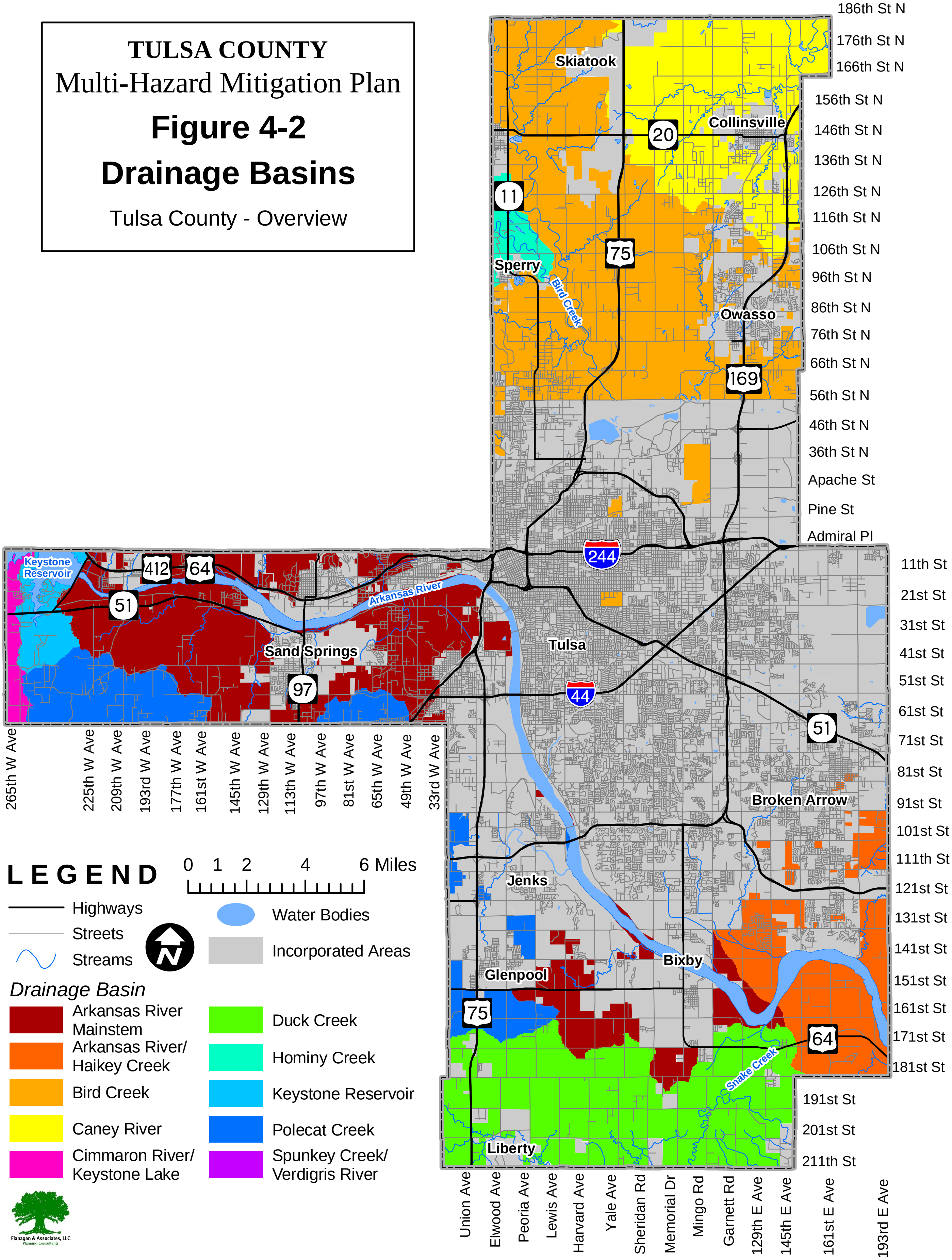
Bird Creek. Bird Creek originates in Osage County, northwest of Pawhuska, and flows 149 miles generally southeast past Sperry and Owasso to join the Verdigris River near Catoosa. Stream mile 9 through 43 are in Tulsa County. The Bird Creek drainage basin above Skiatook is 461 square miles, above Sperry 900 square miles, and above Owasso 1,023 square miles. Bird Creek's major tributaries in Tulsa County are Hominy Creek, Delaware Creek, Flat Rock Creek, Coal Creek and Mingo Creek.

TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-2
Drainage Basins

Tulsa County - Overview



Hominy Creek flows generally southeast through Skiatook Lake, and joins Bird Creek about 2 miles east of Sperry. Hominy Creek has a drainage area of 415 square miles.

Delaware Creek, which drains 51.6 square miles, flows east out of Osage County and joins Bird Creek just south of Sperry.

Flat Rock Creek, which drains 23 square miles, flows east from Osage County to join Bird Creek just north of Lake Yahola and the Tulsa City Zoo. Its major tributary is Dirty Butter Creek.

Coal Creek flows north from the Tulsa State Fairgrounds for 6 miles and drains an area of 10.4 square miles. Mingo Creek, which drains 61 square miles, flows north from about S. 61st St. and Mingo Rd. to join Bird Creek on the south side of Owasso, just west of US Hwy 169. Historically, Mingo Creek has been one of Tulsa's most flood-prone streams, due to the rapid development of its floodplain in the years following World War 2.

West Tulsa County Rivers and Streams

Arkansas River. The dominant waterway in West Tulsa County, by far, is the Arkansas River. The Arkansas flows southeast through Tulsa County for approximately 25 miles. The 1,460-mile-long river—the fourth longest in the US—has a drainage area of approximately 74,500 square miles above Keystone Dam. Since the 1960s, flows on the river have been controlled by Kaw (1976) and Keystone (1968) Dams. The unregulated drainage area between Keystone Dam and the Wagoner County line is approximately 650 square miles.

In West Tulsa County, almost all streams flow south or north out of steep, rugged terrain into the eastward flowing Arkansas River. The primary tributary streams on the south bank of the river are (from west to east) Mud Creek, Fisher Creek, Anderson Creek, Pratt Creek, Redfork Creek, and Berryhill Creek. On the north bank, the primary streams are Little Sand Creek, Sand Creek, Shell Creek, Euchee Creek, Hamilton Creek, Sand Springs Lake Creek, Bigheart Creek, and Harlow Creek. All of these streams, except for Mud, Fisher, Berryhill, Bigheart and Harlow Creeks are within the Sand Springs fenceline.

Since much of West Tulsa County is not developed, the primary flooding in this area is from the Arkansas River, and backflows from the river into tributary streams. This is particularly so along Fisher Creek, where the Meadows subdivision has been repeatedly inundated by a combination of flash flooding from Fisher and Anderson Creeks, and backflows from the Arkansas—as happened most dramatically during the October 1986 flood.

South Tulsa County Rivers and Streams

Although the Arkansas River is the dominant waterway in South Tulsa County, it is fed by 15 left and right bank tributary streams. On the right bank are Cherry and Mooser Creeks in West Tulsa, Polecat Creek (with its feeder streams Nickel and Hager Creek) in Jenks, Posey Creek, and Snake Creek, with its tributaries Duck Creek and Eagle Creek, in Bixby and Broken Arrow.

On the left bank of the Arkansas are, from north to south, Elm Creek, Swan Creek, Crow Creek, Joe Creek, Fred Creek, Vensel Creek, Fry Creek, Haikey Creek, Aspen Creek and Broken Arrow Creek.

In the eastern part of South Tulsa County are several right bank (westward-flowing) tributaries to Mingo Creek, including Cooley, Brookhollow, Sugar, and Ford Creeks. The southeastern part of Tulsa County also provides the headwaters for two eastward-flowing tributaries to Bird Creek and the Verdigris River—these are Spunky Creek and Adams Creek.

4.1.4 Vulnerabilities

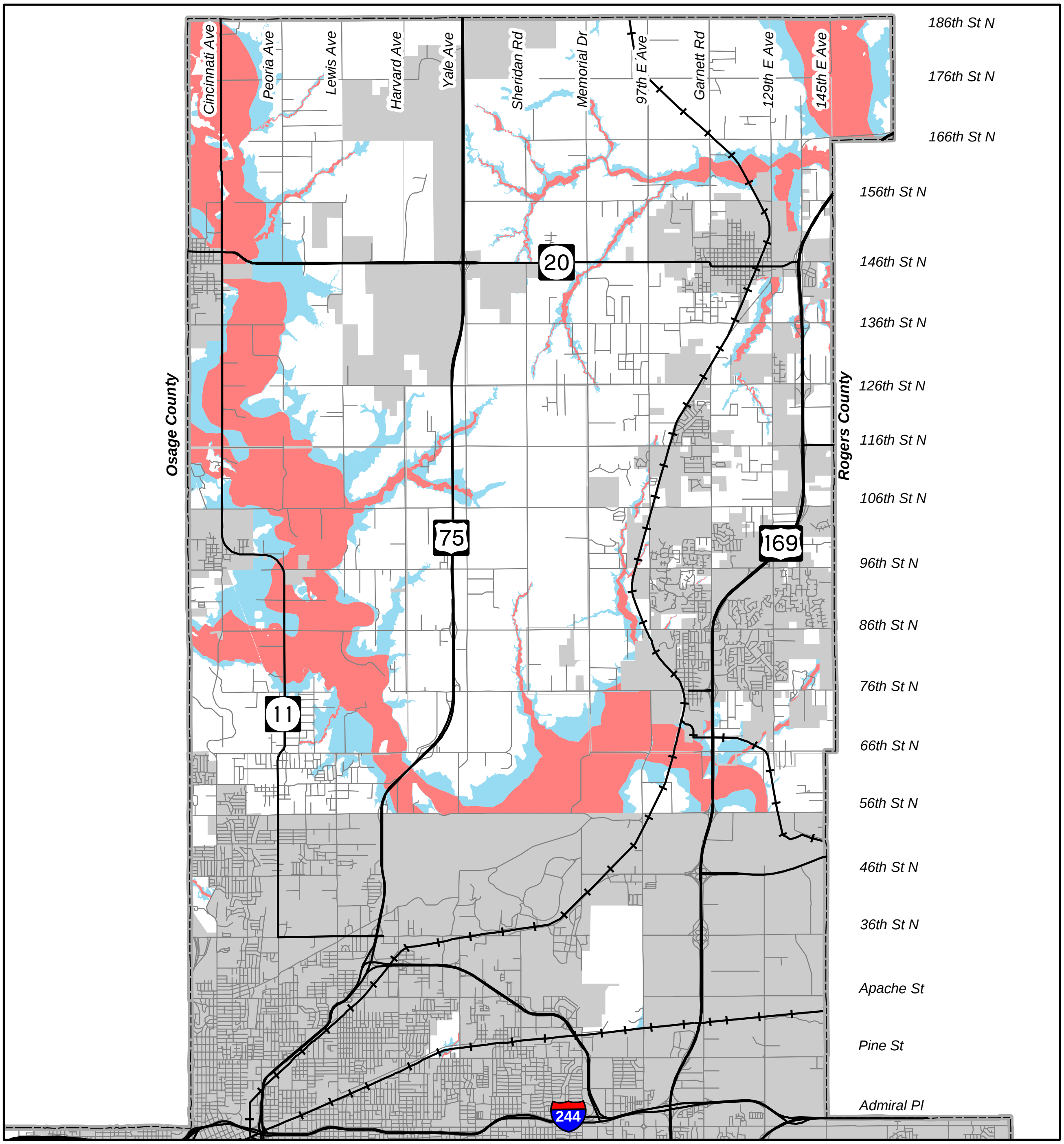
FEMA and this study have identified those areas within the watersheds of the streams within Tulsa County that have a one-percent chance of flooding in any given year. These areas, commonly referred to as the 100-year floodplain, are designated as the Special Flood Hazard Area (SFHA) on FEMA's Flood Insurance Rate Maps (FIRM). The SFHA identifies the National Flood Insurance Program's (NFIP) minimum national standard, and reflects development conditions at the time of the study. Figures 4-3a, 4-3b and 4-3c delineate the 100- and 500-year floodplains in North, West and South Tulsa County.

Structures/Buildings

Tulsa County has a total of 1,033 structures located in the 100-year floodplain as listed in Table 4-8, and shown in Figures 4-4a, 4-4b and 4-4c. Structural values used in the assessment were from the Tulsa County Assessors Office. It is estimated that the average structure will experience 3 feet of flooding, which will result in 28% damage to the structure and 25% damage to contents. A percentage of the total structural and content values were applied to damages from the 100-year flood to two large commercial structures only partially located in the floodplain.

Table 4–8: Tulsa County Floodplain Building Vulnerability

Structures in 100-Year Floodplain	
Structures in the Floodplain	1,033
Value of Structures in the Floodplain	$197,217,622
Value of Structure Contents	$197,217,622
Total Value of Structures in the Floodplain	$394,435,244
100-Year Flood Damage Estimate	
Damage to Buildings from 100-Year Flood	$55,220,934
Damage to Contents from 100-Year Flood	$49, 304,405
Total Damages from 100-Year Flood	$104,525,339
Flood Insurance as of 4/30/06	
Policies in Force	99
$ Flood Insurance in Force	$16,851,800
Paid Premiums	$67,033
Total Number of Losses Paid	84
Loss Payments	$1,741,293



LEGEND

0 1 2 Miles

Floodways

100 yr. Floodplains

Streets

Railroads

County Line

Incorporated Areas

Flanagan & Associates, LLC
Planning Consultants

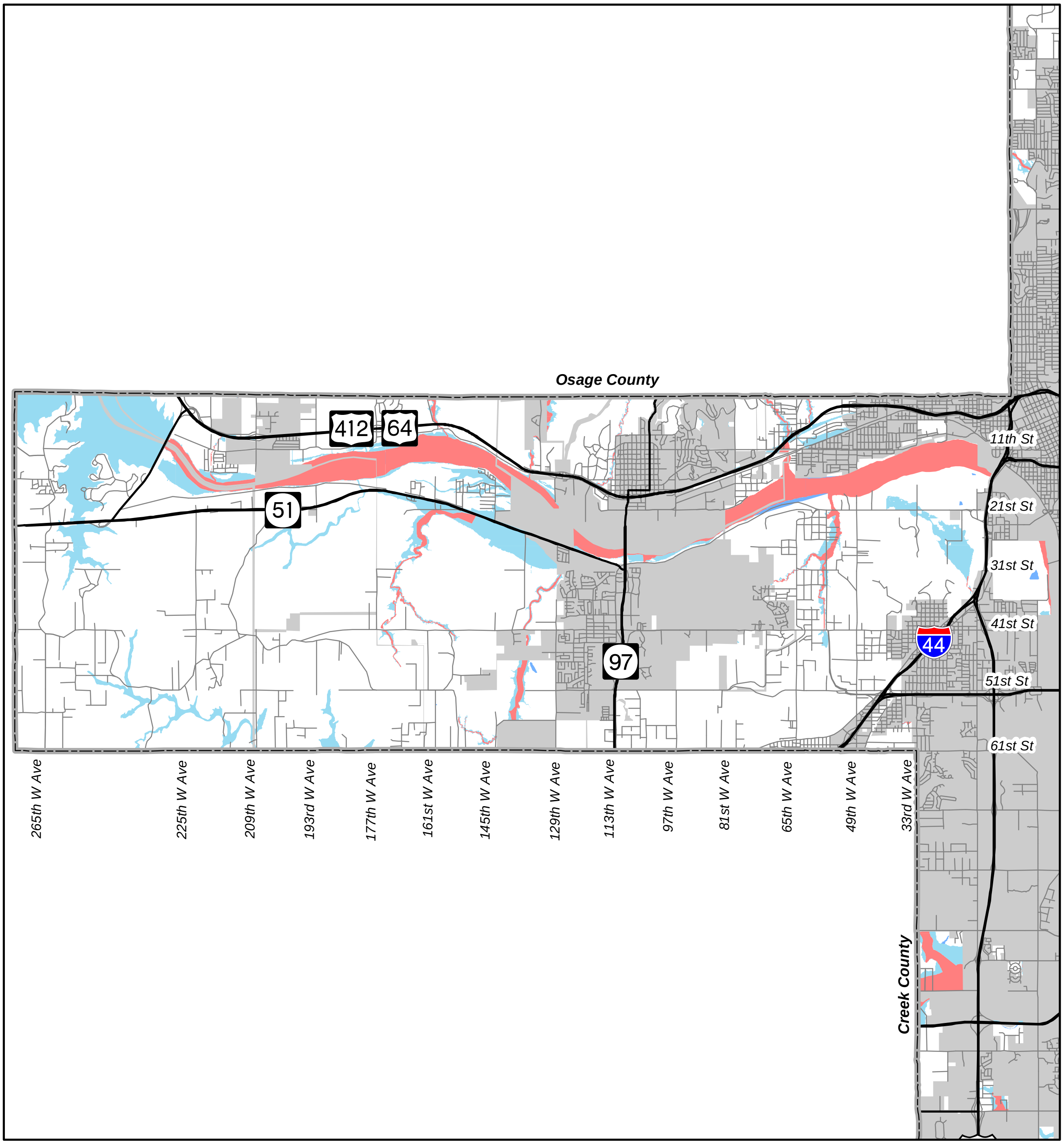
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-3a

100 yr. Floodplains

Tulsa County - North



LEGEND

0 1 2 Miles

- Floodways
- 100 yr. Floodplains
- Streets
- Railroads
- County Line
- Incorporated Areas

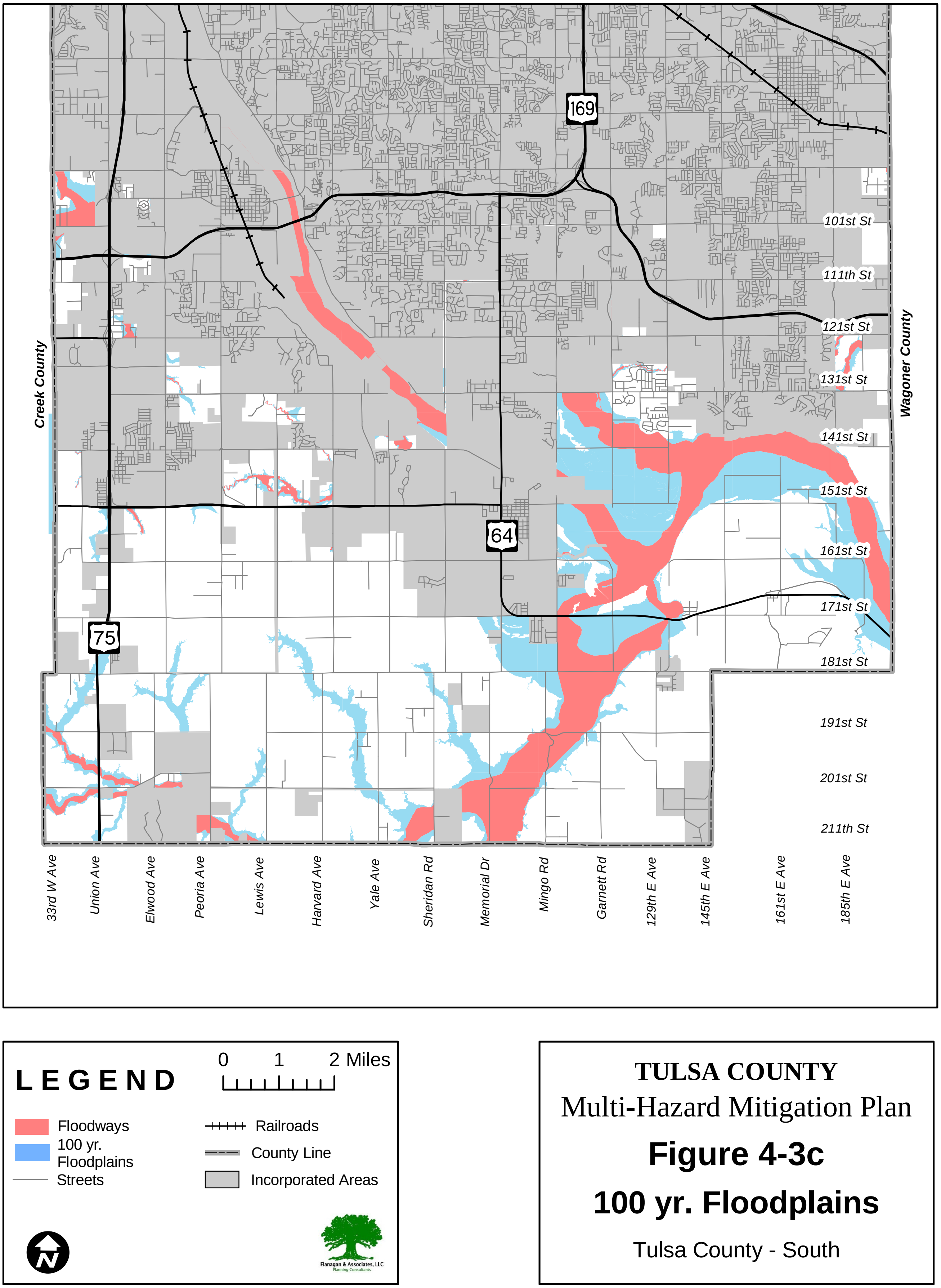
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-3b

100 yr. Floodplains

Tulsa County - North



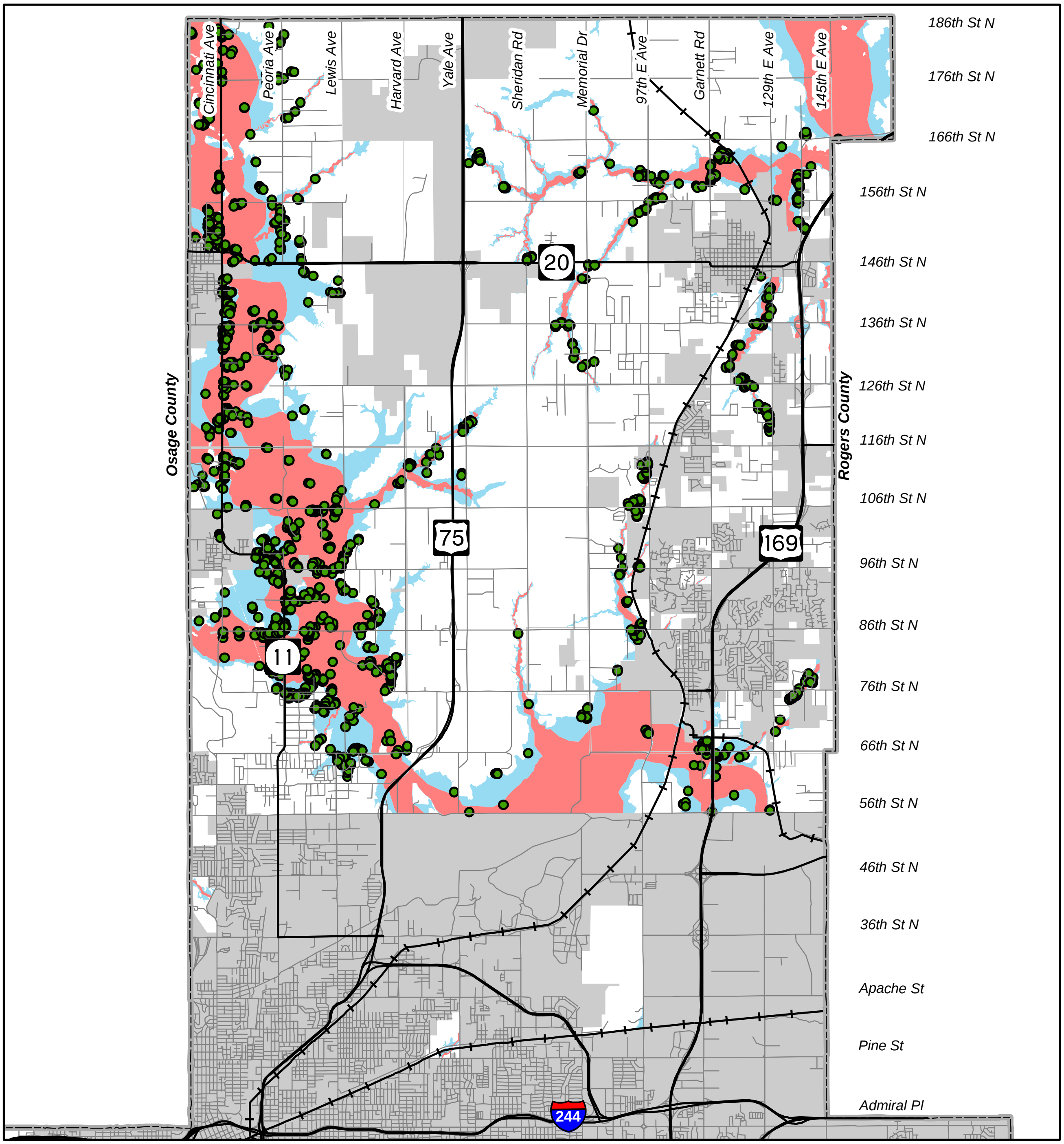
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-3c

100 yr. Floodplains

Tulsa County - South



LEGEND

0 1 2 Miles

- 100 yr. Floodplain Structures
- Floodways
- 100 yr. Floodplains
- Streets
- Railroads
- County Line
- Incorporated Areas

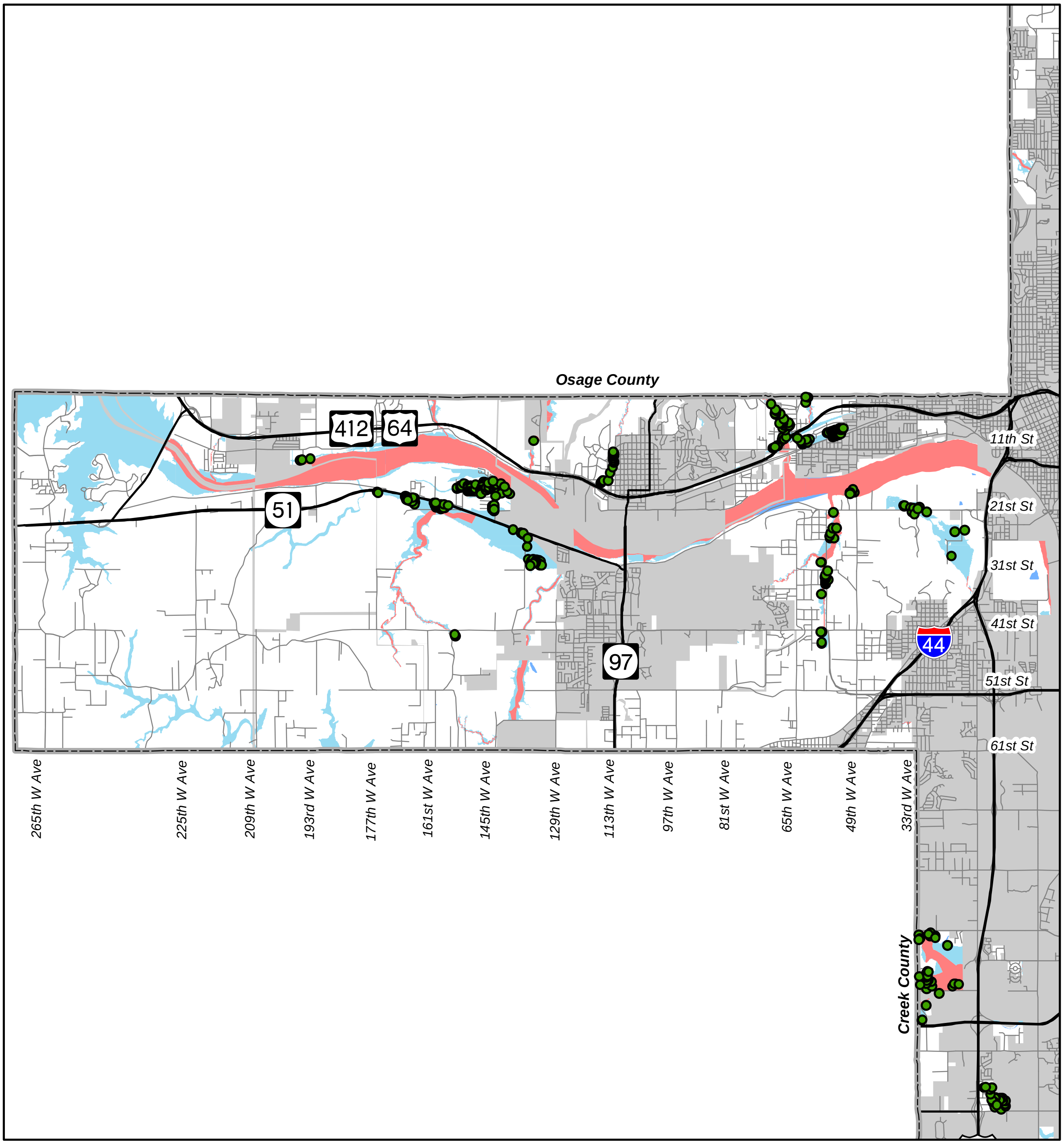
R.D. Flanagan & Associates

TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-4a
100 yr. Floodplains & Structures

Tulsa County - North



LEGEND

0 1 2 Miles

- 100 yr. Floodplain Structures
- Floodways
- 100 yr. Floodplains
- Streets
- Railroads
- County Line
- Incorporated Areas

R.D. Flanagan & Associates

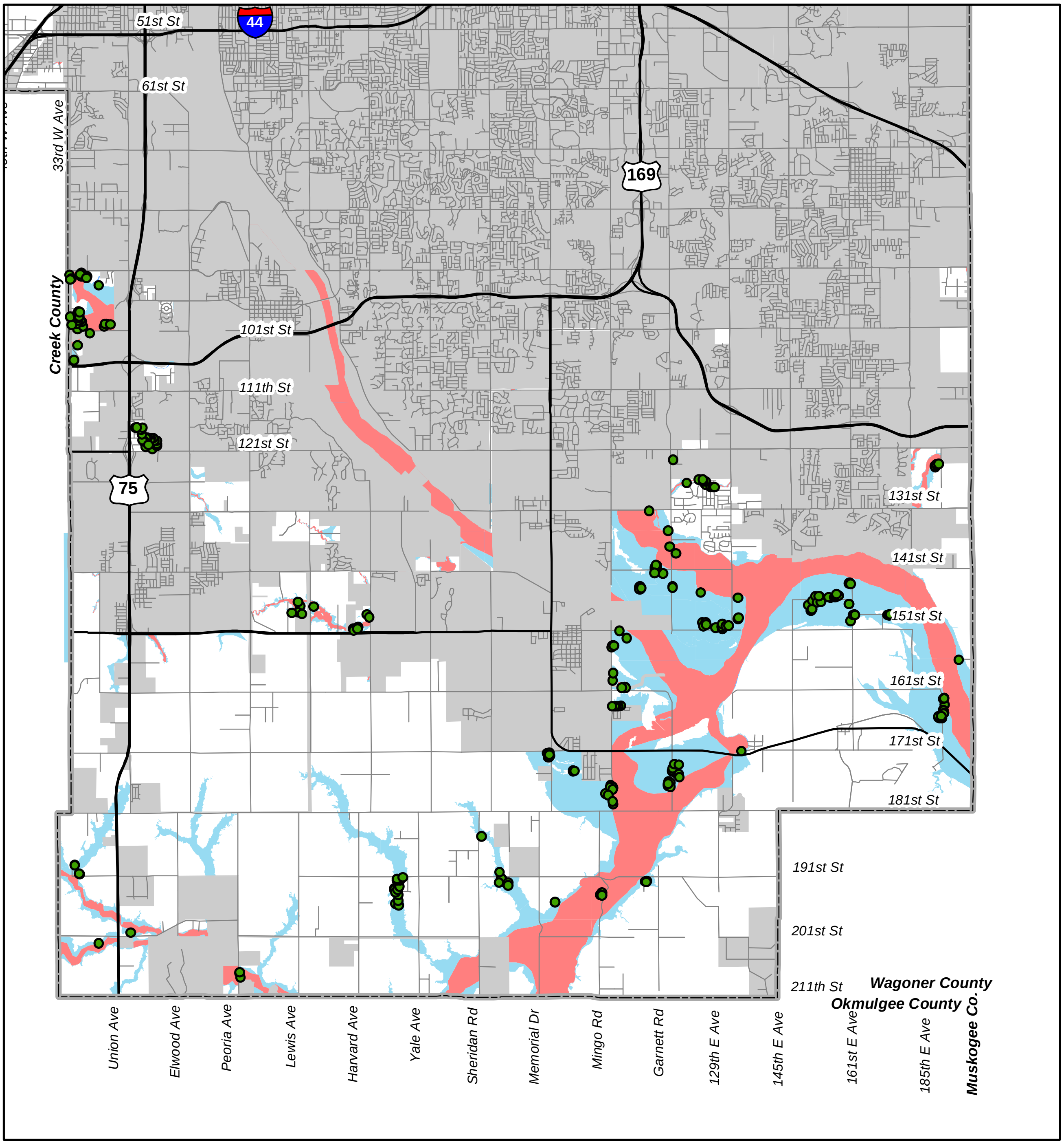
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-4b

Floodplains & Structures

Tulsa County - West



LEGEND

0 1 2 Miles

- 100 yr. Floodplain Structures
- Floodways
- 100 yr. Floodplains
- Streets
- Railroads
- County Line
- Incorporated Areas

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TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-4c
Floodplains & Structures

Tulsa County - South

Critical Facilities

There are two of Tulsa County's critical facilities located in 100-year floodplains. Names and contact information for these facilities can be found in Table 4-9.

Table 4–9: Tulsa County Critical Facilities in the 100-Year Floodplain

ID	Name	Address	Phone
32	Sooner Emergency Services	2131 S 49th West Ave	918-583-2021
22	Tulsa County Deputy Sheriff	3420 W. Charles Page Blvd.	918-587-0138

Repetitive Loss Properties

A repetitive loss property is defined by FEMA as "a property for which two or more National Flood Insurance Program losses of at least $1,000 each have been paid within any 10-year period."

Tulsa County currently has 35 properties on its FEMA Repetitive Loss list. There are three properties listed that are in incorporated areas. Fifteen of the properties have been mitigated, including one of the properties in the incorporated areas. This leaves 18 properties that are in the County jurisdiction that are not mitigated.

The locations of Tulsa County's repetitive loss properties are shown on the map in Figure 4-5.

Infrastructure

Water Treatment – Most significant effect during most major events would be from loss of electrical power. Flooding in the watershed could impact water quality in the lakes accessed by the City/County water system. The impact could range from minor to significant, depending on the nature of the flooding, pollutants released to the watershed, and the location of the release and the impact on the water system's intakes. Deposition of sediments, nutrients and other contaminants by flooding could have a long-term effect on the City/County's water supply lakes.

Wastewater Treatment – Most significant effect during most major events would be from loss of electrical power. Additionally, localized flooding at or near the access road to lift stations could prevent access to such facilities during an emergency.

Utilities – The primary utility providers for Tulsa County's jurisdiction is AEP/PSO (electricity) and ONG (natural gas). Electricity: The largest threat to the delivery of electrical service would be the damage to, or loss of, power poles/lines.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Roadway inaccessibility would be the largest vulnerability posed to the transportation system during a Flood event. Several intersections within the County's jurisdiction face repeated flooding during heavy rain events. Most situations are short-lived, but do create potential life safety issues due to stranded motorists and inaccessibility to safety vehicles. Additionally, bridges in typical high water areas could be compromised in their integrity, especially if of older construction.

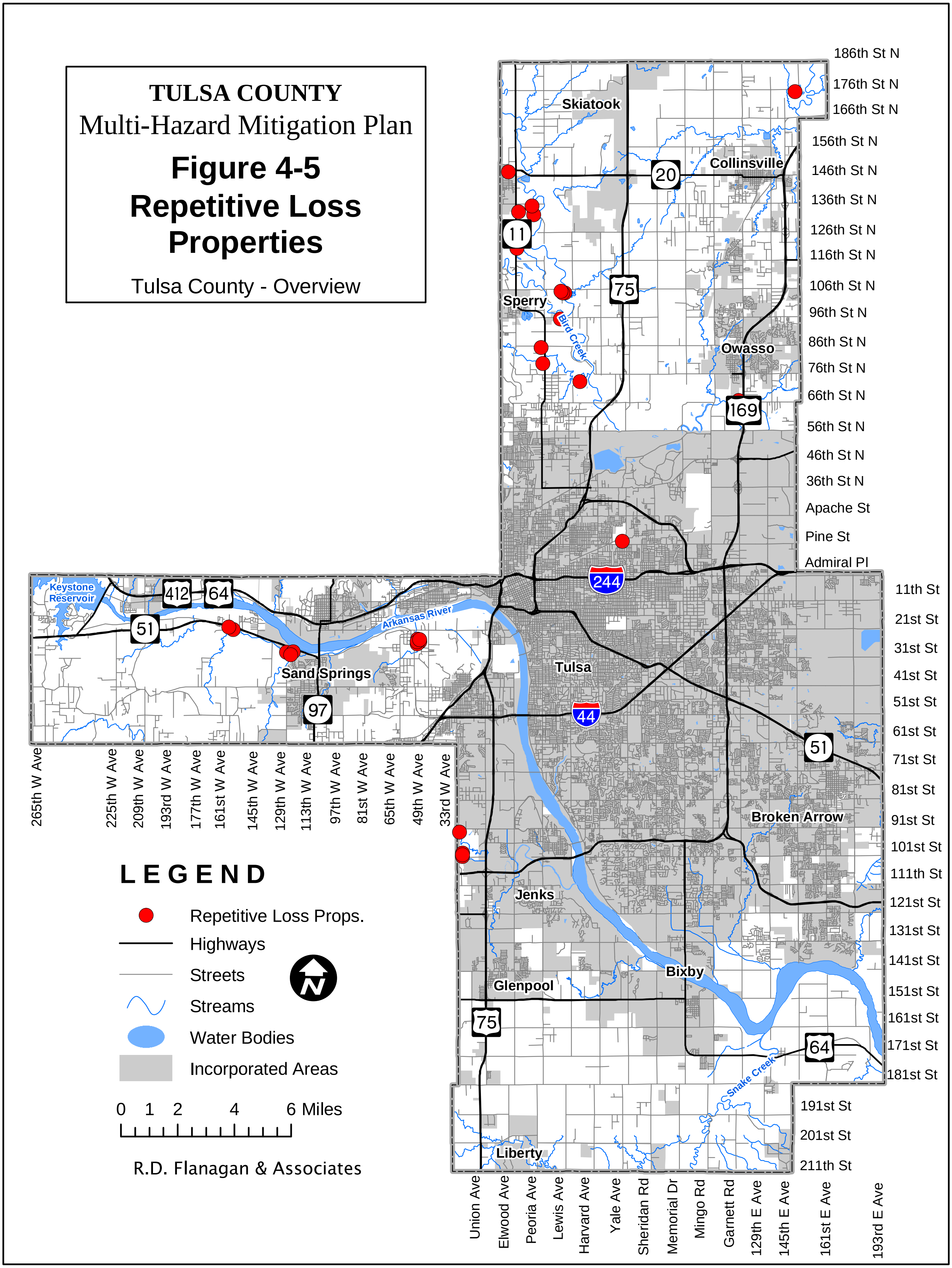
Emergency Services- Fire, Police and Medical Services would all be similarly at risk to effects of a Flood event. Flood/Flash Flood events create a larger call load for all

TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-5 Repetitive Loss Properties

Tulsa County - Overview



emergency response agencies, presenting various challenges to the agencies, in addition to the posed hazards to the agencies' personnel performing these services. During many of the events resulting in street and road flooding, law enforcement and fire personnel are stationed at intersections to ensure the safety of motorists who may try to enter these barricaded areas. This could potentially affect response time if the event is widespread enough requiring a large number of County resources.

4.1.5 Future Trends

Future urbanization and development will cause an increase in urban stormwater runoff and flood depth, widen floodplains, and cause increases in the Base Flood Elevation (BFE).

The Federal Emergency Management Agency's (FEMA) Special Flood Hazard Area (SFHA) is Tulsa County's regulatory floodplain. The SFHA, the national minimum standard, deals with existing conditions and does not take the impacts of future urbanization into account in its modeling or floodplain map delineations.

Tulsa County zones and regulates the FEMA SFHA, ensuring that no insurable structure will be built with its First Finished Floor below the Base Flood Elevation (BFE) of its major waterways. However, 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. Figures 4-4a, 4-4b and 4-4c identify structures in the FEMA floodplains of North, West and South Tulsa County, respectively.

Between the years 1980-2000, the City of Tulsa created master drainage plans for each of its major waterways. The City of Sand Springs is currently (2007) in the midst of developing master drainage plans for the streams within its jurisdiction. Until the other jurisdictions in the county undertake similar modeling and analysis of their drainage basins, it is not possible to accurately predict the impacts of future development in the unincorporated areas of Tulsa County, or to estimate the damage such development will have on future buildings that have been permitted to the minimum standard.

Nevertheless, several generalizations can be made about the future flood hazard.

Population

With recreational opportunities such as River Parks being developed along the banks of the Arkansas River, there will naturally be an increase in population taking advantage of those areas. People unfamiliar with waterway recreation are often unaware of the dangers of swiftly moving water. In times of heavy rains and flood conditions, the Arkansas River flows at a much deeper level, producing a swifter and stronger current, even along the banks. These factors create an increase in the number people vulnerable to the secondary flood risk of wading into, or getting too close to, swift moving waters.

News reports have shown that even with aggressive campaigns to alert people to the dangers of flash floods, there are those that continue to defy the odds and attempt to drive through standing water on roadways. Without stronger penalties for disregarding road barriers and warning signs, this trend will most likely continue, putting that group of drivers and their passengers at risk during flash flood conditions.

Structures/Buildings

As development in new areas and revitalization of existing areas continues, locations and building techniques should be closely examined. Increasing urbanization, without slowing runoff, can create flooding conditions in areas not previously at risk. This has been demonstrated in the Broken Arrow, an area that has experienced a phenomenal rate of recent growth. Such areas previously experienced heavy rains that pooled and caused no damage – because no homes were there at the time. Now these same areas are dotted with new homes and there are huge housing additions currently under construction.

Additionally, development in areas along the perimeters of the County in areas that have been identified as potential flood risk zones could have a substantial impact on the integrity and capacity of existing drainage systems. Current systems are frequently overwhelmed during heavy rainfall because of the volume of water or debris in the storm drains. An aggressive and ongoing public awareness program should be maintained to ensure new and existing development complies with flood ordinances and best practices.

Critical Facilities

With Tulsa County's strong commitment to zoning and regulating the FEMA SFHA, it is not anticipated that any new development of critical facilities will occur within flood-prone areas of the jurisdiction.

Any renovations or improvements made to critical facilities already located in a flood hazard area should be evaluated to ensure that future improvements also mitigate potential flood damage.

Infrastructure

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Currently, the County's most likely ongoing threat from flooding would be a flash flood event. Storms that produce a large amount of rainfall over a short period of time will likely flood roadway intersections. Plans being developed/implemented for County street/roadway improvements should take the mitigation of flash flooding into account.

4.1.6 Flood Scenario

HAZUS-MH

Three HAZUS-MH runs were performed for the flooding scenarios for North, South, and West Tulsa County. The following table displays the information that HAZUS-MH determined was at-risk for each area, as well as the results of what was damaged during a 100-year scenario event.

Table 4–10: Tulsa County HAZUS-MH Flood Analysis Chart

Occupancy Type	North	South	West	Total
At Risk				
Population	14,106	7,713	14,209	36,028
# of Buildings	6,586	3,451	6,598	16,635
Percent of Residential Buildings	93.2%	94.4%	93.0%	93.0

Occupancy Type	North	South	West	Total
At Risk				
Replacement Value (2006 dollars)	$875 Million	$512 Million	$854 Million	$2.2 Billion
Schools	23	12	22	57
Fire Stations	7	8	3	18
Police Stations	4	3	3	10
HAZUS-MH Scenario				
Buildings w/ Moderate Damage	320	107	596	1,023
Buildings Destroyed	56	11	53	120
Building-Related Loss	$61.63 Million	$28.97 Million	$69.88 Million	$160 Million
Schools (Moderate Damage)	0	1	3	4
Fire Stations (Moderate Damage)	0	0	1	1
Police Stations (Moderate Damage)	0	1	0	1

4.1.7 Conclusion

Over the past 20 years, progress has been made in protecting the lives and property of the citizens of Tulsa County from flooding. Tulsa County joined the National Flood Insurance Program in 1974. Although the County does not participate in the Community Rating System, the Cities of Tulsa, Sand Springs, Broken Arrow and Bixby are participants. All residents of Tulsa County are, however, eligible to purchase flood insurance. Much work remains to be done to make Tulsa County safe from flooding.

To protect citizens at risk from flooding, this study has identified several flood mitigation measures to be implemented. These recommended projects are discussed in the Action Plan in Chapter 6.

Data Limitations

While rain events and the extent of flooding produced can be reasonably predicted, other sources of floodwater, such as snowmelt, waterline breaks, or blocked storm drains cannot be as accurately defined and predicted. They are, however, relatively less common than flooding caused by rainfall.

4.1.8 Sources

Extreme Weather and Climate Events at National Climatic Data Center website: http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms.
FEMA Flood Insurance Statistics at Website: www.fema.gov/cis/OK.pdf.

4.2 Tornadoes

A tornado is a rapidly rotating vortex or funnel of air extending to the ground from a cumulonimbus cloud. When the lower tip of a vortex touches earth, the tornado becomes a force of destruction. The path width of a tornado is generally less than a half-mile, but the path length can vary from a few hundred yards to dozens of miles. A tornado moves at speeds from 30 to 125 mph, but can generate winds exceeding 300 mph.

4.2.1 Hazard Profile

Severe thunderstorms produce about 1,000 tornadoes each year in the United States. FEMA reports that 106 federal disaster declarations over the past 20 years have included tornado damage.

The width of a tornado path averages about 200 yards and therefore can have a substantial impact on human life and property. Damage from the average tornado includes roof surfaces, mobile homes pushed off their foundations, and automobiles pushed off the road. More severe tornadoes can lift 300-ton objects and toss homes more than 300 feet.

Each year Oklahoma has more tornado events per square mile than any other state

Location

Oklahoma, along with Texas, Arkansas, Missouri, and Kansas, is located in "Tornado Alley," the most tornado-prone area of the nation. The entire jurisdiction of Tulsa County is considered to be vulnerable to the effects of a tornado event. See Figure 4-6 for the number of tornado events per county in Oklahoma.

Measurement

It should be noted that the observable size of a tornado is not an indicator of its severity. A thin "rope" tornado can have very high internal wind speeds and produce extraordinary damage, while a twister 100's of yards across might generate relatively low wind speeds. While traditionally, the Fujita scale has measured tornadoes, the National Weather Service has recently adopted an "Enhanced Fujita Tornado Scale." The new scale is based on a broader set of degrees of damage to a wider variety of structures. A description of the Fujita Scale and comparison to the Enhanced Fujita Scale (EF) are included in Table 4-11. Additional information on the Enhanced scale is available at www.spc.noaa.gov/efscale. Almost 70% of all tornadoes are measured F0 and F1 on the Fujita Tornado Scale, causing light to moderate damage, with wind speeds between 40 and 112 miles per hour. F4 and F5 tornadoes are considerably less frequent, but are the big killers. Sixty-seven percent of all tornado deaths were caused by F4 and F5 storms, which represent only 1% of all tornadoes.

Table 4–11: Fujita Scale and Enhanced Fujita Scale

Fujita Scale			EF Scale	
Category	***Wind Speed (mph)***	***Current Damage Indicators***	***Category***	***3 Second Gust (mph)***
F0	Gale (40-72)	***Light***: Damage to chimneys, tree branches, shallow-root trees, sign boards	EF0	65-85
F1	Moderate (73-112)	***Moderate***: Lower limit is beginning of hurricane wind speed--surfaces peeled off roofs, mobile homes pushed off foundations or overturned, cars pushed off roads	EF1	86-110
F2	Significant (113-157)	***Considerable***: Roofs torn off frame houses, mobile homes demolished, boxcars pushed over, large trees snapped or uprooted, light-object missiles generated	EF2	111-135
F3	Severe (158-206)	***Severe***: Roofs and some walls torn off well-constructed houses, trains overturned, most trees in forest uprooted, cars lifted off the ground and thrown	EF3	136-165
F4	Devastating (207-260)	***Devastating***: Well-constructed houses leveled, structures with weak foundations blown off some distance, cars thrown and large missiles generated	EF4	166-200
F5	Incredible (261-318)	***Incredible***: Strong frame houses lifted off foundations and carried considerable distance to disintegrate, automobile-sized missiles fly through the air in excess of 100 yards, trees debarked	EF5	Over 200

The F-scale and Enhanced F-scales are a set of wind estimates (not measurements) based on damage. The Enhanced Scale uses three-second gusts estimated at the point of damage based on a judgment of 8 levels of damage to the 28 indicators listed below. These estimates vary with height and exposure.

Structures Used as Damage Indicators in the Enhanced Fujita Scale	
Small barns, farm outbuildings	One- or two-family residences
Single-wide mobile home (MHSW)	Double-wide mobile home
Apartment, condo, townhouse (3 stories or less)	Motel
Masonry apartment or motel	Small retail building (fast food)
Small professional (doctor office, branch bank)	Strip mall
Large shopping mall	Large, isolated ("big box") retail building
Automobile showroom	Automotive service building
School - 1-story elementary (interior or exterior halls)	School - middle or senior high school
Low-rise (1-4 story) bldg.	Mid-rise (5-20 story) building
High-rise (over 20 stories)	Institutional building (hospital, govt. or university)
Metal building system	Service station canopy
Warehouse (tilt-up walls or heavy timber)	Transmission line tower
Free-standing tower	Free-standing pole (light, flag, luminary)
Tree - hardwood	Tree - softwood

Extent

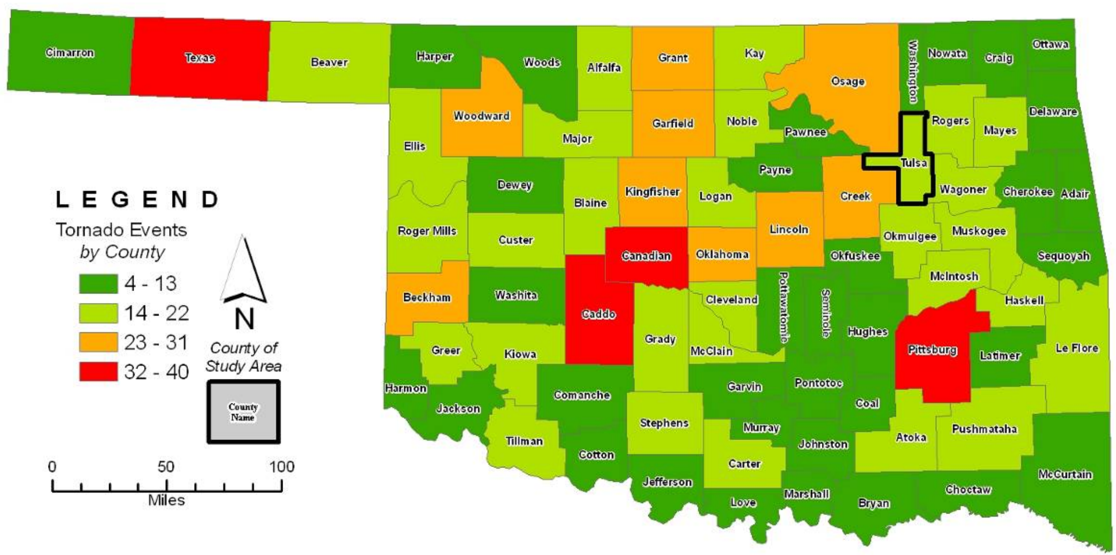
Tulsa County may experience a tornado ranging from EF0 to EF5 on the Enhanced Fujita Scale shown in Table 4-11.

In a ranking of the Top Ten Costliest Oklahoma Tornadoes (1950 – 2008), Tulsa has the 6th most costly event for the April 19, 1981 tornado with damages estimated at $75-$100 Million. The top-ranking event is listed as the May 3, 1999 tornado outbreak with damages topping the $1 Billion mark.

In a ranking of the Top Ten Costliest U.S. Tornadoes (1950 – 2007), Oklahoma has two entries: May 3, 1999 ranked #3 ($1.24 Billion), and May 8, 2003 ranked #8 ($416.8 Million). These figures have been adjusted to reflect 2007 dollars.

The Storm Prediction Center's ranking of the 25 Deadliest U.S. Tornadoes shows two entries for Oklahoma. The Woodward Tornado of April 9, 1947 is ranked as the 6th deadliest tornado with 181 fatalities and 970 injuries, and the Snyder Tornado of May 10th, 1905 caused an estimated 97 deaths.

Figure 4–6: Tornadoes in Oklahoma from 1989-2009



Source: National Climatic Data Center U.S. Storm Events Database

Flanagan & Associates, LLC

On April 21, 1996, Fort Smith, AR was hit by an F3 tornado that struck in the dead of night with no warning. 3 deaths, 89 injuries, nearly 500 homes destroyed and severe damage to the city's courthouse/jail-wing building bringing the estimated damages to over $300 million.

To the south, Fort Worth, TX experienced a devastating blow on March 28, 2000 when a low-end F3 tornado passed through the west side of the city just after 6:15pm. In all, 15 of the downtown buildings were destroyed (7 actually collapsed from the storm), 63 damaged, 93 homes destroyed – 203 suffered major damage. Two fatalities and 80 injuries were also reported. Damages were estimated at $450 million.

Just to the North, Greensburg, KS was hit by an EF5 tornado that struck at 9:45 p.m. CDT on May 4, 2007. The tornado was estimated to be 1.7 miles (2.7 km) in width and traveled for nearly 22 miles (35 km). Ninety-five percent of the city was confirmed to be destroyed, with the other five percent being severely damaged. The National Weather Service estimated winds of the tornado to reach 205 mph (330 km/h). This was the first tornado to ever be rated EF5 since the update of the Fujita scale. The Tornado had caused

EF5 Damage to at least one well built home in Greensburg, and also is the first "5" classification since May 3, 1999, when an F5 tornado ripped through Moore, OK.

Tulsa County considers a minor severity to be an F1 or lower on the Enhanced Fujita Scale and a major severity to be an F2 or higher.

Frequency

Between the years 1950 – 2006, the National Weather Service reported 3,028 tornadoes (an average of 53 tornadoes each year) for Oklahoma, with 69 of these being in Tulsa County (an average of 1.2 tornadoes each year). The National Climatic Data Center reports of 57 tornadoes per year over the past 25 years. Between 1983 and 2008, there were 17 major disaster declarations for tornado related events in the state. Oklahoma experiences more tornadoes each year on average than does any other state, except Texas. Texas has twice as many, but is also more than twice the size of Oklahoma.

Tulsa County has been hit by 13 tornadoes in the last 15 years. From 1995 to 2006, Tulsa County had 12 reported tornadoes, four in 1999 and three in 2000. Between 1990 and 2004, Tulsa County ranked 15th among Oklahoma counties in total number of tornadoes. Number of tornadoes by county from 1989 to 2009 is shown on the following page. Table 4-12 lists the number of events, number of deaths, number of injuries, number of events that reported damages, and the amount of property damage reported to the NCDC for Tulsa County and Oklahoma based on Fujita Class reported.

Table 4–12: Casualties and Damages Caused by Tornadoes from 1995 to 2009
From NOAA National Climatic Data Center http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Location	Events	Deaths	Injuries	Damage Events	Property Damages
Tulsa County – F0	9	0	0	4	$102,000
Tulsa County – F1	4	0	7	4	$2,450,000
Tulsa County – F2	0	0	0	0	$0
Tulsa County – F3	0	0	0	0	$0
Tulsa County – F4	0	0	0	0	$0
Tulsa County – F5	0	0	0	0	$0
Oklahoma – F0	589	0	14	136	$3,672,000
Oklahoma – F1	268	0	40	229	$50,104,000
Oklahoma – F2	93	5	88	81	$92,723,000
Oklahoma – F3	27	5	116	26	$403,211,000
Oklahoma – F4	7	29	514	7	$650,500,000
Oklahoma – F5	2	23	332	2	$540,000,000

Data from the National Weather Service demonstrates that the most active months for tornadoes in Oklahoma are April and May. Of the 3,028 tornadoes reported for Oklahoma from 1950 to 2006, reports show 1,132 occurring in May and 605 in April. It is important to point out that there are tornadoes reported in every month of the year in that period.

Impact

The impact of this hazard occurs during times of Severe Storms. Storms that generate tornadoes also have the ability to cause lightning, hail, high winds, and flooding damage. This can result in the direct loss of homes, businesses, and lives and indirectly cause the loss of income, medical care, and the ability for the government to respond to the disaster.

4.2.2 History/Previous Occurrences

Oklahoma has a long history of deadly and damaging tornadoes. Some of the deadliest tornado events include:

May 8, 1882- Twenty-one people died in a McAlester tornado.

April 25, 1893- Thirty-eight people died in the 10 Mile Flats area near Norman in the worst recorded tornado disaster of the 19th century in Oklahoma.

May 10, 1905- Ninety-seven people died when an F-5 tornado hit Snyder, causing $250,000 in damage to more than 100 homes.

May 2, 1920- Seventy-one people died and 100 were injured when an F-4 tornado hit Peggs in Cherokee County. The town's wooden jail was left standing, while a store made of concrete block next door was leveled.

November 19, 1930- Twenty-three people died and 125 were injured when a tornado hit Bethany in Oklahoma County.

April 27, 1942- Fifty-two died in a tornado that traveled from Claremore in Rogers County to Pryor in Mayes County.

June 12, 1942- Thirty-five died in an Oklahoma City tornado.

April 12, 1945- 102 people died in a violent series of tornadoes. Sixty-nine died in Antlers, 13 in Muskogee, including many at the Oklahoma School for the Blind. Eight people died at Tinker Air Force Base, five in Roland, four near Hulbert, and three in Latimer County.

April 9, 1947- Oklahoma's deadliest tornado killed 184 people. Texas and Kansas lost 68 people, and 116 died in Oklahoma. The tornados traveled 221 miles from White Deer, Texas, through Oklahoma, destroying a large portion of Woodward, to St. Leo, Kansas.

May 5, 1960- Three separate tornadoes killed a total of 26 people, including 16 people from the tornado which tracked from Wilburton to Keota, five from the Shawnee to Tulsa event, and 5 when a tornado hit Roland. An F-5 tornado reportedly touched down in southern Creek County and traveled 29 miles northeast, crossing Sapulpa. No injuries or deaths occurred, but $2.5 million in property damages were accrued throughout the county.

May 5, 1961- Sixteen people were killed when a tornado tracked from Reichert to Howe in LeFlore County.

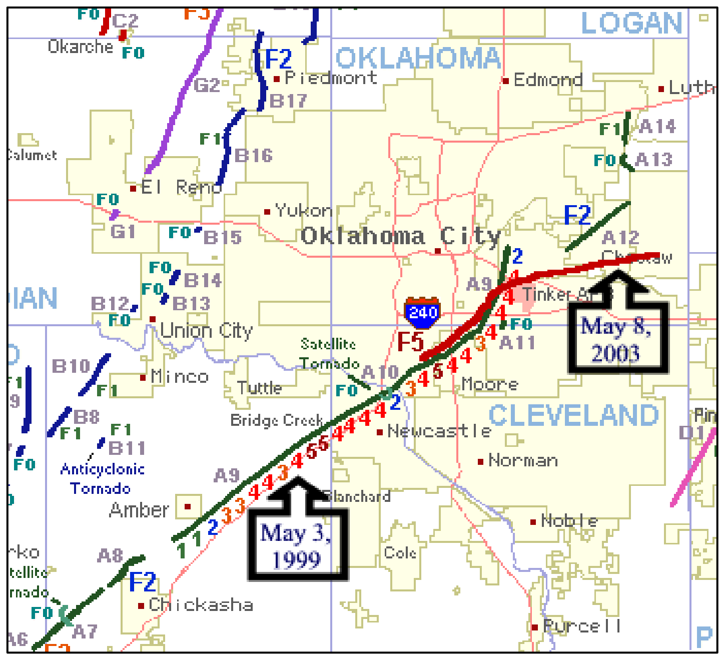
May 24, 1973- Six injuries, 22 demolished homes, 18 demolished trailers, and 49 damaged buildings resulted from a tornado crossing Union City. The tornado was a quarter-mile wide and stayed on the ground for 28 minutes. Damage was approximately

$2 million. It was the first tornado to leave a "velocity signature" on radar and produced a breakthrough in severe storm forecasting. It was also the first tornado intercepted and photographed by storm chasers.

June 8, 1974- Eighteen people were killed, including three in Tulsa, and 1,400 buildings were damaged when some 25 to 30 tornadoes formed in 19 Oklahoma counties. The same storm system spawned an F-4 tornado in southern Kansas that killed six, and injured 220.

According to the NCDC, there were 45 tornado-related fatalities from 1995 to the year 2000, and 42 of those occurred in1999 during the worst tornado incident in recent Oklahoma history. (The Oklahoma Department of Emergency Management states in their Multi-Hazard Mitigation Plan, that 46 fatalities occurred from tornadoes in 1999).

Figure 4–7: May 3, 1999 and May 8, 2003 Oklahoma Tornadoes



The May 3, 1999 tornadoes caused over $1 billion in damage. The May 8, 2003 tornado path (shown in red) caused $100 million.

May 3, 1999- A series of severe thunderstorms swept out of the southwest, and produced many tornadoes that greatly intensified as they moved across the state. The map shows tornado touchdowns, paths, and direction of movement. The visual representation makes it clear that this incident was indeed a huge outbreak.

One of the tornadoes in the outbreak was an F5, which tracked for 38 miles for four hours along a path from Chickasha through the south Oklahoma City suburbs of Bridge Creek, Newcastle, Moore, Midwest City and Del City. Wind was measured at 318 mph, the fastest wind speed ever recorded for a tornado. This storm was the first F5 tornado to affect metropolitan Oklahoma City. The path included 6.5 miles of continuous F4 damage as well as several areas of F5 level destruction. Several homes were completely removed from their slabs. This tornado originated two miles south-southwest of Amber, about three miles north of Chickasha.

The National Weather Service reported that 57 tornadoes were recorded in the state during the outbreak. The Oklahoma Hospital Association reported 742 people were treated at 30 hospitals, and 44 people were killed. Approximately 10,000 homes and businesses were affected by the storms, with total losses exceeding $1 billion. The state Department of Emergency Management reported that in Oklahoma, 3,009 homes, 117 businesses, and 10 public buildings were destroyed, including 645 in Oklahoma City, 6 in Tulsa and 95% of the town of Mulhall. Sixteen Oklahoma counties were declared Federal disaster areas. The series of funnels finally collapsed after entering western Tulsa County and damaging several homes and an elementary school.

May 8, 2003- At about 5 pm, the path of the estimated F-4 tornado hit Moore, Midwest City, Del City, Stroud and Oklahoma City, many of the same areas damaged by the killer tornado of May 3, 1999. The National Weather Service estimated the tornado's path to be 19 miles long. Local hospitals reported 145 injuries. Initial estimate of damage include 432 homes destroyed and another 2,457 damaged. About 20 businesses were destroyed. The 4 million square-foot Oklahoma City General Motors automobile plant sustained substantial damage and was knocked out of production, and five schools were damaged. In addition, the City of Moore reported three churches destroyed, and damage to a fire station and elementary school. The Lincoln National Bank in Oklahoma City was leveled. Oklahoma Gas and Electric reported that 4,000 customers in Oklahoma City, Moore, and Midwest City were without power. The Insurance Commissioner estimated damage at more than $100 million.

March 8, 2010 - A tornado identified as an F-1 touched down south of Hammon Oklahoma. Damage assessments reported 4-5 homes destroyed or with major damage, in addition to a county barn and numerous out buildings. Gas and water were affected and numerous power lines were down. Over 900 homes lost power, although most were restored by the following morning.

Historic Tulsa County Tornado Events

Tulsa County has been hit by 80 tornadoes since the first recorded event of April 24, 1904. There have been 13 F3 and F4 tornado events, 23 F2 tornadoes, and 44 F1 events. The major events, in terms of Fujita-scale intensity (F3 and F4), are listed.

April 24, 1904 – An F3 tornado, 700 yards wide and 70 miles long, touched down 10 miles south of Broken Arrow and lifted northeast of Vinita, killing three and injuring 20.

May 27, 1912 – An F4 tornado, 300 yards wide and 7 miles long, hit the southwest edge of Skiatook, killing seven and injuring 30, and destroying 20 homes.

May 4, 1934 – An F4 tornado, 200 yards wide and 15 miles long, moved NE from Jenks to south of Catoosa. Three people were killed, 11 injured, and 20 homes destroyed. Damage was estimated at $80,000 (in 1934 dollars).

February 26, 1936 – An F3 tornado, 100 yards wide and 5 miles long, struck the west edge of Turley, injuring 18 and destroying three homes.

May 2, 1942 – An F4 tornado, 400 yards wide and 55 miles long, moved ENE from Cushing to north of Owasso, killing 7 people and injuring 20. Most of the $65,000 damage (in 1942 dollars) was done in Tulsa County.

November 25, 1944 – An F3 event, 70 yards wide and 1.5 miles long, touched down near Collinsville, injuring five people and damaging 25 homes.

May 5, 1960 – An F3 family of tornadoes, 400 yards wide and 110 miles long, began in Cleveland County and swept across Pottawatomie, Lincoln and Creek Counties before lifting 4 miles west of Sand Springs. En route, 15 homes were destroyed or damaged.

June 8, 1974 – A family of F4, F3 and F2 tornadoes swept across Tulsa, Wagoner, Rogers, Mayes and Craig Counties, killing three people and injuring 122. One F3, 100 yards wide and 20 miles long, moved ENE from Sapulpa to Tulsa, Broken Arrow and

Inola to Choteau, injuring 35 people and doing extensive damage to Oral Roberts University. At the same time, another F3 tornado touched down west of Tulsa and moved NE to Catoosa, Claremore and Big Cabin. The combination of tornadoes and flooding made this one of the worst natural disasters in Tulsa history.

December 5, 1975 – An F3/F4 tornado, 700 yards wide and 2 miles long, moved NNE through NE Tulsa, injuring 38 people and causing $25 million in damage. Two trailers, 35 homes, six businesses, 29 apartments and 20 aircraft were destroyed, and 132 houses, 81 apartments, seven businesses and 20 aircraft damaged.

April 19, 1981 – A family of F3 tornadoes struck south Tulsa, causing $250 million in damage. One event, 200 yards wide and 5 miles long, injured seven people and damaged 50 businesses in an industrial park and about 500 expensive homes. Another F3 twister, 800 yards wide and 12 miles long, moved ENE from near Glenpool to Bixby, killing five people and injuring 49, and doing $2.5 million in damage.

July 2, 1992 – An F3 event, 100 yards wide and 1 mile long, did $250,000 in damage near Collinsville.

Lesser Intensity, More Recent Tulsa County Tornado Events

The most recent tornadoes to strike Tulsa County have not been of F4 or F3 intensity, but have caused considerable damage nonetheless. Among these lesser tornadoes are the following:

October 4, 1998 – The worst October tornado outbreak spawned 22 tornadoes throughout Oklahoma, seven of which were in the northeast. One of these, 50 yards wide and 1 mile long, struck 3 miles northwest of Collinsville.

March 8, 1999 – An F1 tornado, 50 yards wide and 1 mile long, touched down in Broken Arrow, damaging the roofs of 62 homes and three apartment buildings.

May 3, 1999 – An F1 tornado, 150 yards wide and 2 miles long, touched down on the north side of Sapulpa and traveled northeast into Tulsa County, where it did over $2 million in damage to several neighborhoods in southwest Tulsa, including the Carbondale Assembly of God Church, Remington Elementary School, and West Tulsa City-County Regional Library.

February 25, 2000 – An F1 event, 100 yards wide and less than 1 mile long, struck southeast of Tulsa International Airport, doing $100,000 in damage.

April 1, 2006 – An F1 tornado 80 yards wide and less than 1 mile long, touched down just west of Tulsa International Airport, injuring seven people and severely damaging a hotel, covered parking facilities at the airport, and 75 automobiles.

For maps of Tulsa County tornadoes, see Figures 4-8a through 4-8c.

Probability

Oklahoma is vulnerable to frequent thunderstorms and convective weather patterns, and therefore its vulnerability to tornadoes is a constant and widespread threat especially during the spring months. Tornadoes can, and do appear in nearly all months of the year at all hours of the day, so it is important that even in “light activity” years, education and preparations continue to move forward.

4.2.3 Vulnerability

The National Weather Service advises that tornadoes strike at random, and therefore all areas within Tulsa County jurisdictions are vulnerable. All future development areas are also at risk from tornadoes.

Population

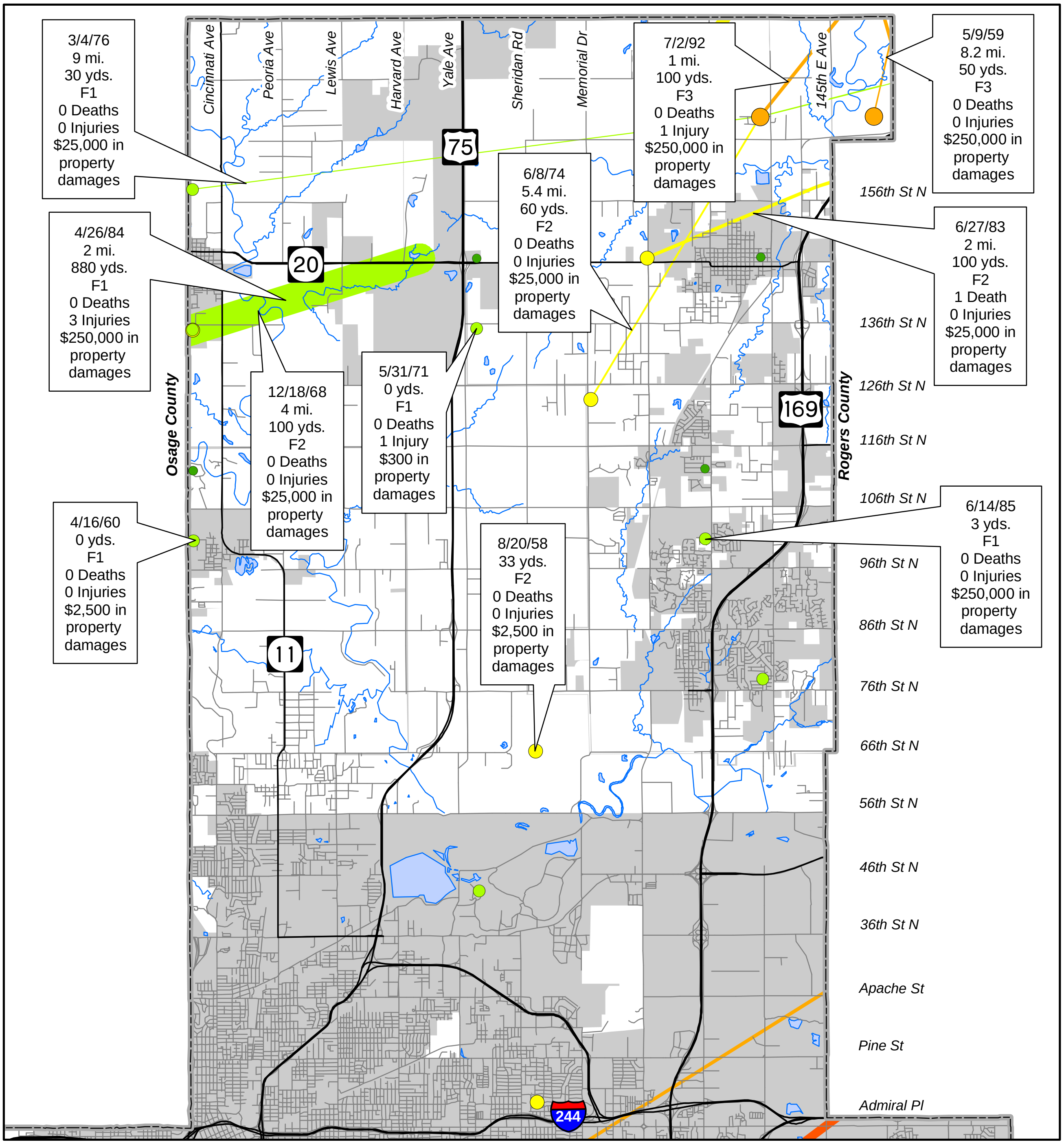
Table 4-13 shows the numbers of tornado-related fatalities in the United States for each year from 1995 to 2004 and where the deaths occurred. It illustrates that those who live in mobile homes are significantly more vulnerable to the effects of a tornado than any other identifiable population. While the number of mobile homes is a small fraction of total residential dwellings, the number of deaths in mobile homes significantly exceeds the number of deaths associated with inhabitants of permanent homes. In fact, more than 43% of all tornado deaths during that ten-year period occurred in mobile homes.

Table 4–13: Tornado Fatalities in the United States
Source: National Weather Service Storm Prediction Center

Year	Permanent Home	Mobile Home	Business	School	Vehicle	In the Open	Other	Total for Year
1995	15	8	0	0	4	3	0	**30**
1996	8	14	0	0	2	0	1	**25**
1997	38	15	3	0	3	7	1	**67**
1998	46	64	1	0	16	3	0	**130**
1999	39	36	3	0	6	9	1	**94**
2000	7	28	0	0	4	2	0	**41**
2001	15	17	3	0	3	2	0	**40**
2002	15	32	0	1	4	2	1	**55**
2003	24	25	0	0	0	3	2	**54**
2004	15	8	10	0	2	0	0	**35**
Totals	***222***	***247***	***20***	***1***	***44***	***31***	***6***	***571***

Structures/Buildings

Tornado damage is a factor of severity and location, both on a landscape scale – rural/urban areas – and on a structure-by-structure scale. An F4/F5 tornado in an urban area will create phenomenal damage, as experienced with the tornadoes that struck Greensburg, KS (F5, 5/4/2007) and Picher, OK (F4, 5/10/2008), but damage to structures will vary depending on how they are constructed. For example, mobile homes are more easily damaged than permanent structures; buildings with crawl spaces are more



LEGEND

0 1 2 Miles

- Highways
- Streets
- Streams
- Water Bodies
- Incorporated Areas

Fujita Scale

Start *Path*

F0
F1
F2
F3
F4

Tornado path represents reported width

Flanagan & Associates, LLC Planning Consultants

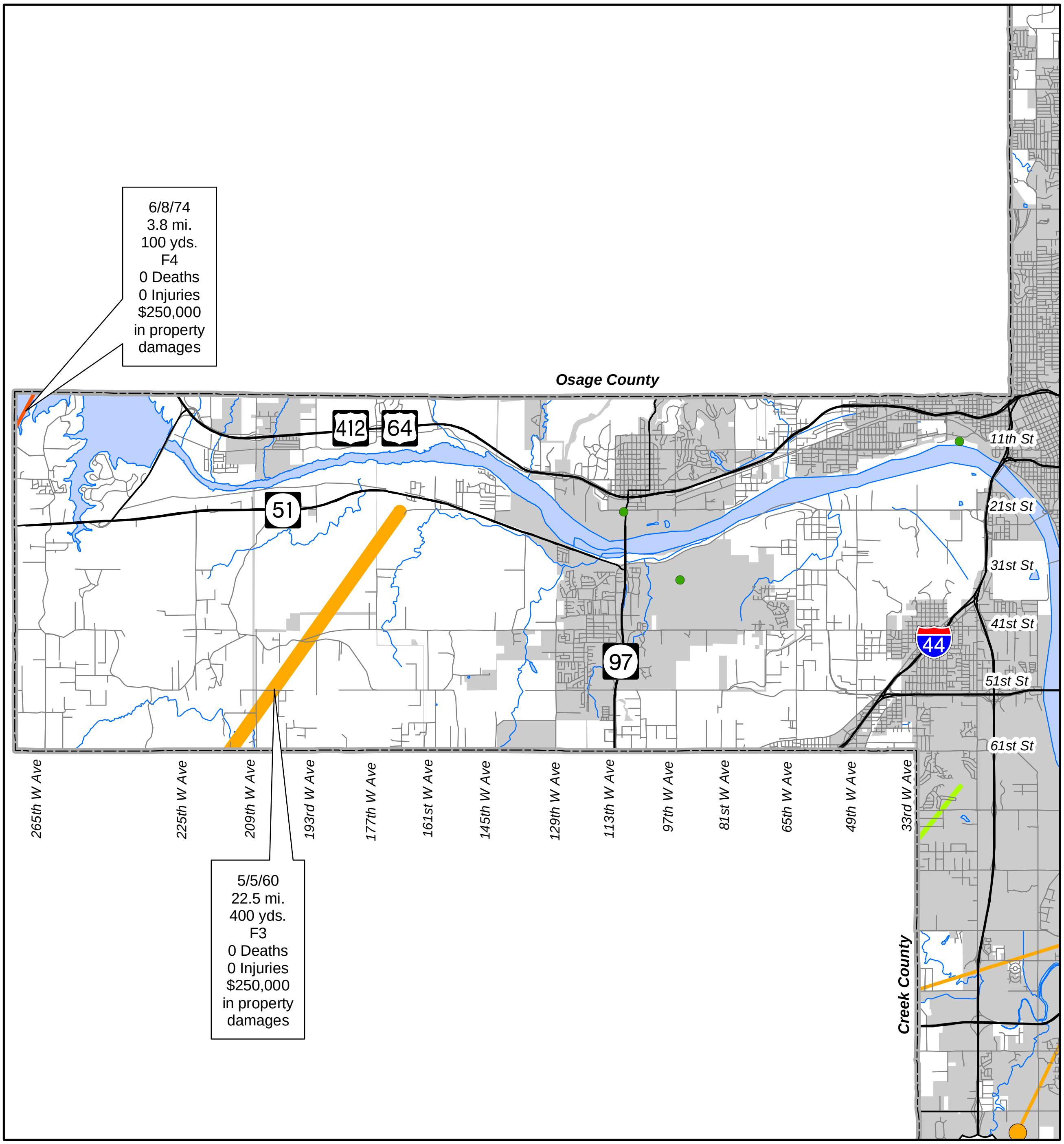
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-8a

Historic Tornadoes

Tulsa County - North



LEGEND

- Highways
- Streets
- Streams
- Water Bodies
- Incorporated Areas

0 1 2 Miles

Flanagan & Associates, LLC
Planning Consultants

Fujita Scale

Start		*Path*
	F0	
	F1	
	F2	
	F3	
	F4	

Tornado path represents reported width

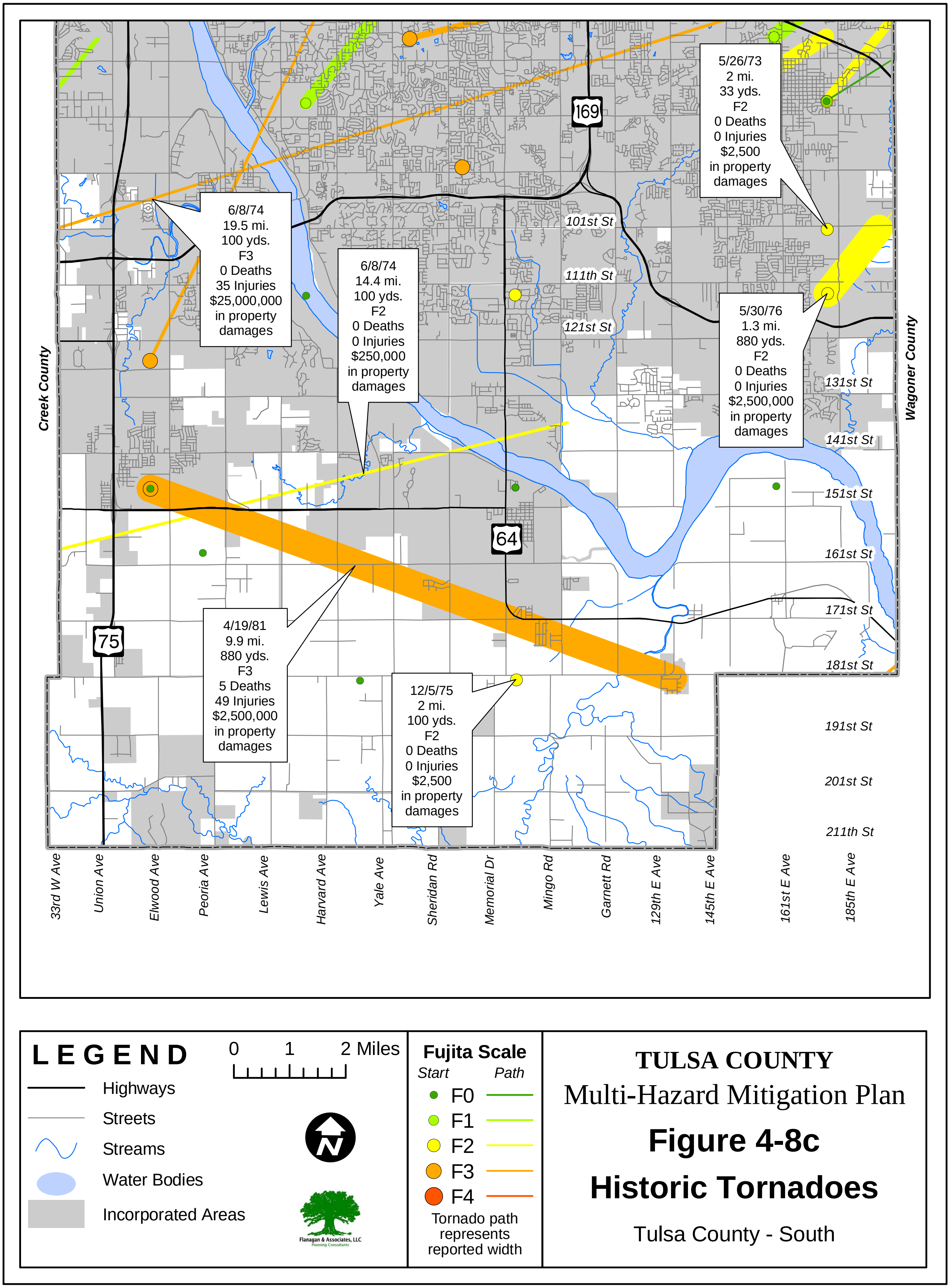
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-8b

Historic Tornadoes

Tulsa County - West



TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-8c

Historic Tornadoes

Tulsa County - South

susceptible to lift, and foundation and roof construction can increase or decrease the structure's vulnerability.

Structures utilizing more modern-looking building materials (reflective glass facades, open breezeways between wings, etc.) should be considered more vulnerable to the potential damage from a tornado. Wind-driven debris (wood, metal, other larger items picked up by larger funnels) can cause catastrophic damage to buildings – as witnessed in the tornadoes that struck downtown Fort Worth in 2000 or Atlanta in May, 2008.

Critical Facilities

All critical facilities within Tulsa County should be considered vulnerable to the effects of a tornado event. Structural integrity may be compromised if in the direct path of the storm, in addition to any secondary issues presenting such as power disruption, water damage from accompanying rain, injury to workers/residents, etc.

Future Development

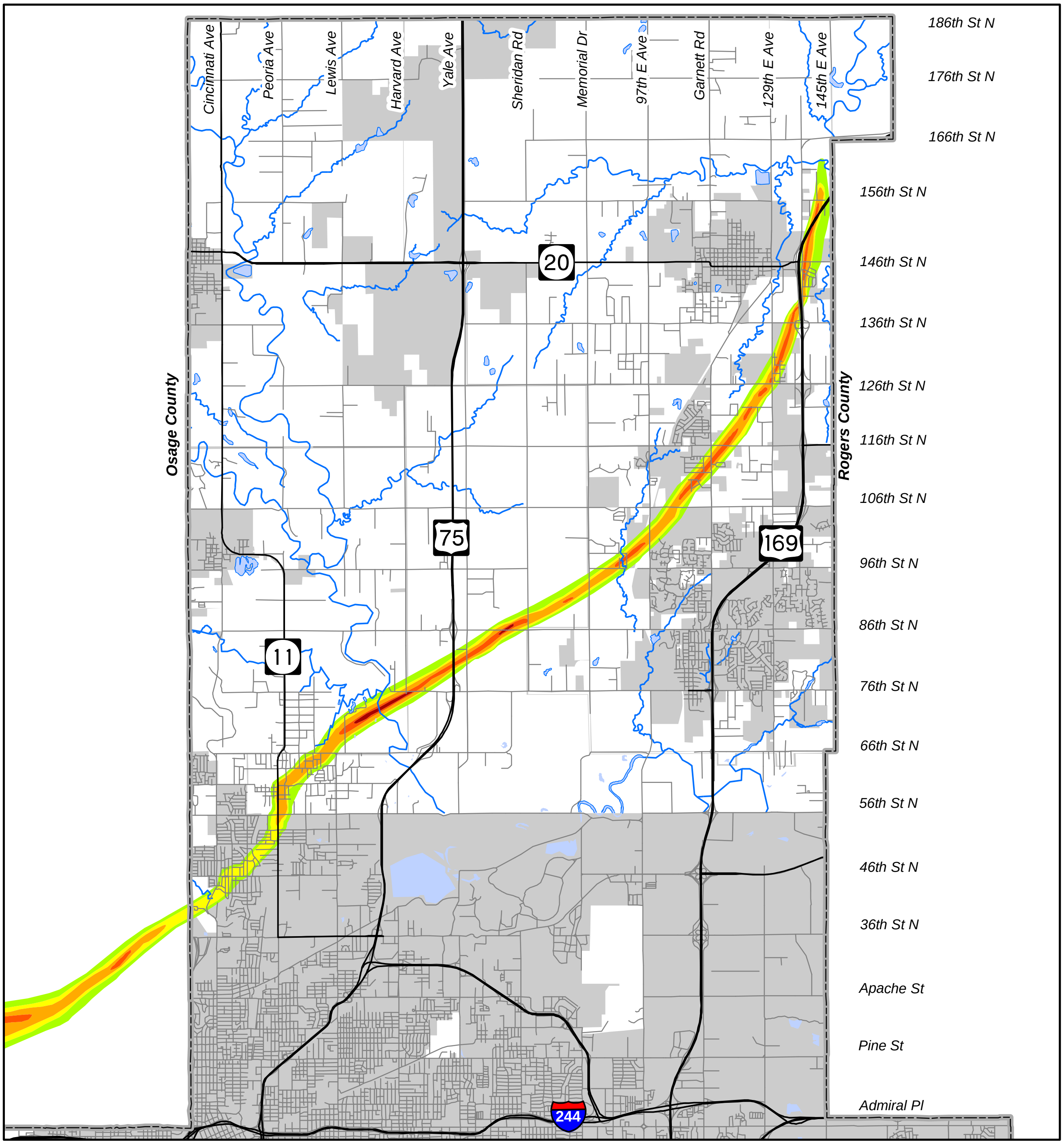
Due to the county-wide incidence of the tornado hazard, any and all future development areas will be vulnerable to a tornado event.

4.2.4 Tornado Scenario

To anticipate the damage from a worst-case tornado event, the "A9" tornado from the May 3, 1999 Oklahoma tornado outbreak was placed on the County. The scenario tornado runs from just outside the westernmost border with Creek County and exits just north of the City of Sand Springs before reentering the county at 41st St N and the county line. The tornado continues its track to the northeast before dissipating to the east of the City of Collinsville at 161st St N and the Rogers county line. See Figures 4-9a and 4-9b for a spatial representation of the tornado path.

Within a GIS environment, the structures of Unincorporated Tulsa County lying within the tornado path were identified and classified according to the Fujita Scale contours as delineated after the "A9" tornado. Values for these structures were taken from parcel data provided by the Tulsa County Assessor and damages were calculated based on damage factors associated with the Fujita Scale for both improvement and contents values.

There are 952 improved properties within the tornado path with a combined improvement value of nearly $70 million and contents value of $40 million. This includes 46 commercial/industrial properties and 896 residential properties. In total, the scenario tornado would cause over $52 million in damages to structures and contents – $45.6 million to residential properties and $2.5 million to commercial/industrial properties. The damage by building type, contents, and percent damage to each building, is summarized in three tables - Tables 4-14a, 4-14b, and 4-14c – one for each of the regions of the county impacted by the scenario event and a summary table.

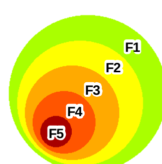


LEGEND

0 1 2 Miles

- Highways
- Streets
- Streams
- Water Bodies
- Incorporated Areas

Fujita Scale



Path represents
Tornado A9
from May 3, 1999

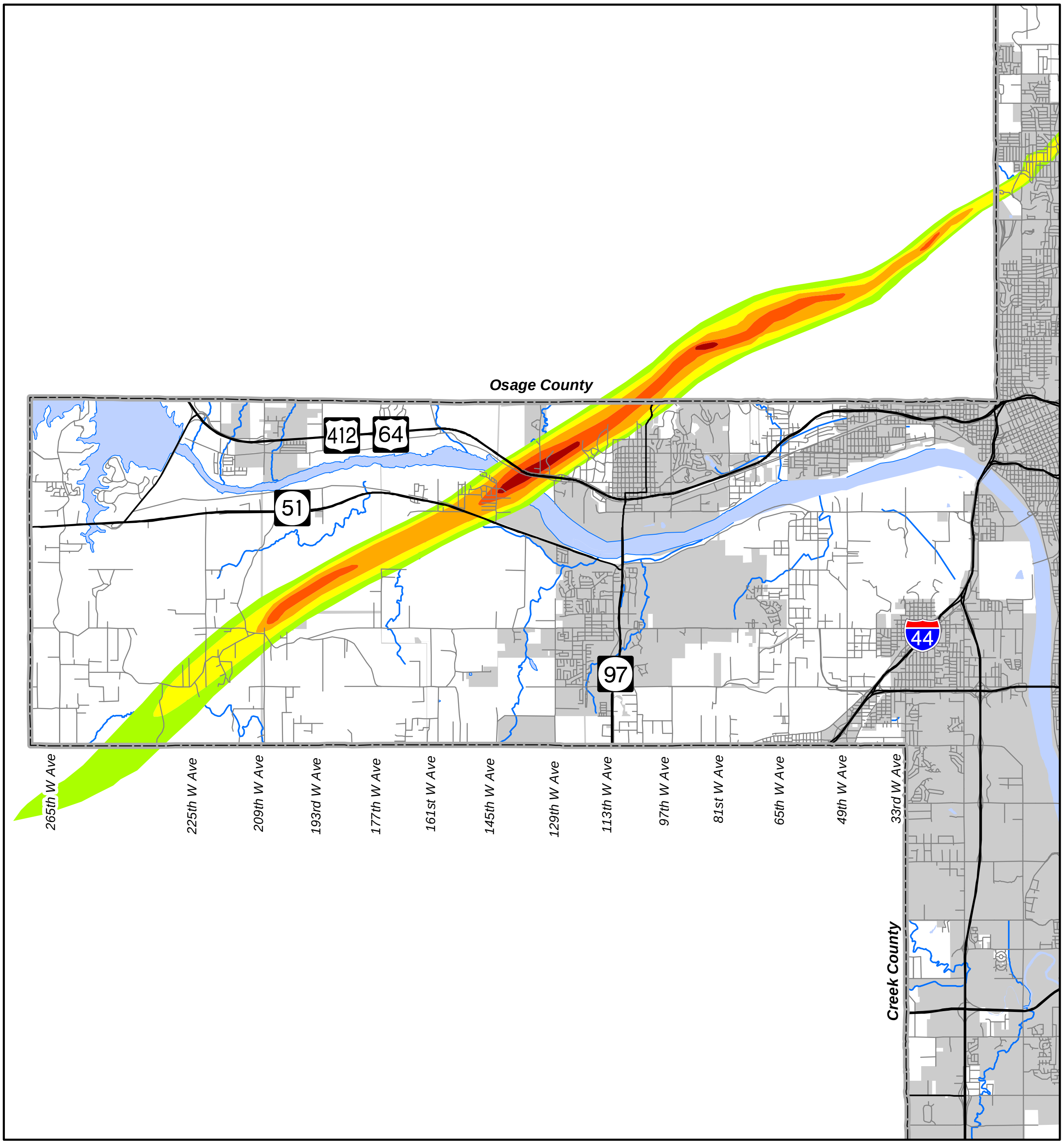
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-9a

Tornado Scenario

Tulsa County - North



LEGEND

0 1 2 Miles

- Highways
- Streets
- Streams
- Water Bodies
- Incorporated Areas

Fujita Scale

F1 F2 F3 F4 F5

Path represents Tornado A9 from May 3, 1999

TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-9b

Tornado Scenario

Tulsa County - West

Table 4–14a: Tulsa County Tornado Scenario Damages - West

F-Scale	Count	Market Value	Damage Factor	Structure Damage	Contents Value	Damage Factor	Contents Damage
Residential Properties							
1	123	$8,117,109	0.10	$811,711	$4,058,554	0.10	$405,855
2	134	$9,238,593	0.40	$3,695,437	$4,619,297	0.40	$1,847,718
3	184	$17,690,270	0.80	$14,152,216	$8,845,135	0.80	$7,076,108
4	104	$8,309,080	1.00	$8,309,080	$4,154,540	1.00	$4,154,540
5	37	$2,349,750	1.00	$2,349,750	$1,174,875	1.00	$1,174,875
Total	*582*	*$45,704,802*	-	*$29,318,194*	*$22,852,401*	-	*$14,659,096*
Commercial / Industrial Properties							
1	4	$3,057,860	0.10	$305,786	$4,177,550	0.05	$208,879
2	10	$3,483,480	0.40	$476,034	$4,626,050	0.20	$298,579
4	1	$34,320	1.00	$34,320	$17,160	1.00	$17,160
5	1	$5,200	1.00	$5,200	$2,600	1.00	$2,600
Total	*16*	*$6,580,860*	-	*$821,340*	*$8,823,360*	-	*$527,218*
Total Residential, Commercial & Industrial Tornado Scenario Damages							
Total	*598*	*$52,285,662*	-	*$30,139,534*	*$31,675,761*	-	*$15,186,314*

Table 4–14b: Tulsa County Tornado Scenario Damages - North

F-Scale	Count	Market Value	Damage Factor	Structure Damage	Contents Value	Damage Factor	Contents Damage
Residential Properties							
1	117	$5,591,820	0.10	$559,182	$2,795,910	0.10	$279,591
2	55	$2,823,015	0.40	$1,129,206	$1,411,508	0.40	$564,603
3	130	$6,460,064	0.80	$5,168,051	$3,230,032	0.80	$2,584,025
4	12	$1,139,463	1.00	$1,139,463	$569,732	1.00	$569,732
Total	*314*	*$16,014,362*	-	*$7,995,902*	*$8,007,182*	-	*$3,997,951*
Commercial / Industrial Properties							
1	7	$459,290	0.10	$45,929	$459,290	0.05	$22,965
2	13	$353,990	0.40	$141,596	$353,990	0.20	$70,798
3	19	$304,590	0.80	$243,672	$304,590	0.40	$121,836
4	1	$251,290	1.00	$251,290	$251,290	1.00	$251,290
Total	*40*	*$1,369,160*	-	*$682,487*	*$1,369,160*	-	*$466,889*
Total Residential, Commercial & Industrial Tornado Scenario Damages							
Total	*354*	*$17,383,522*	-	*$8,678,389*	*$9,376,342*	-	*$4,464,840*

Table 4–14c: Tulsa County Tornado Scenario Damages - Summary

Property Type	Count	Market Value	Structure Damage	Contents Value	Contents Damage
Commercial/Industrial	56	$7,950,020	$1,503,827	$10,192,520	$994,107
Residential	896	$61,719,164	$37,314,096	$30,859,582	$18,657,047
Total	*952*	*$69,669,184*	*$38,817,923*	*$41,052,102*	*$19,651,154*

A number of critical facilities and mobile home parks were impacted by the scenario event. The critical facilities include Cherokee Elementary School and Cornerstone Christian Academy. These are identified in Table 4-15.

Table 4–15: Critical Facilities in the Tornado Path

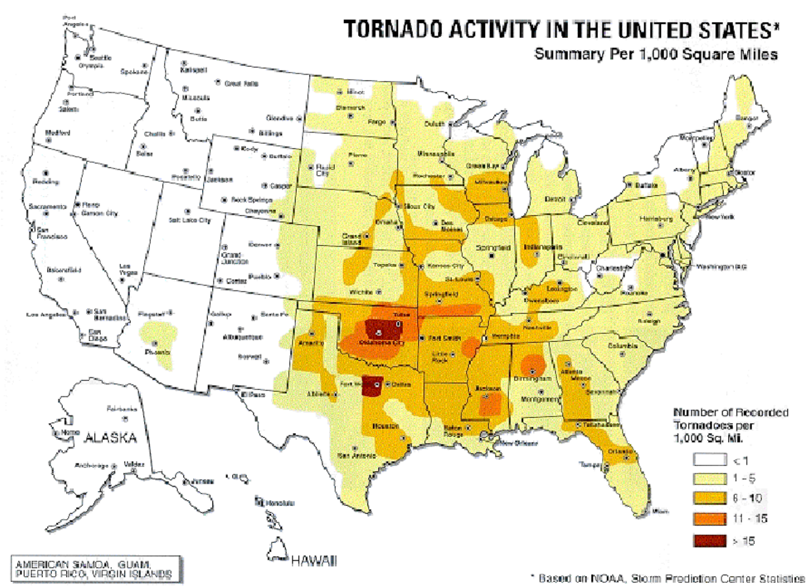
ID	Name	Address	Type
2	Cherokee Elementary School	6001 N. Peoria	School
4	Cornerstone Christian Academy	1821 E. 66th St. N	School

4.2.5 Conclusion

Depending on the severity of the tornado, damage can range from light damage to trees and roofs (Fujita Category F0) to complete destruction of well-built houses (Fujita Category F4 and F5). Mobile homes and houses with crawl spaces are more susceptible to lift and are therefore at the greatest risk of damage.

Oklahoma is located in "Tornado Alley," the most tornado-prone area of the United States. In the last 50 years, there have been over 200 fatalities and over 2,000 injuries from tornadoes. According to the National Climatic Data Center, Tulsa County was impacted by 61 tornado events in the last 55 years, resulting in property damages exceeding $369 million and causing eight deaths.

Figure 4–10: Tornado Activity in the United States



If a worst-case Oklahoma tornado were to go through unincorporated Tulsa County, it would affect 952 improved properties and cause over $51 million in damages to structures and contents.

4.2.6 Sources

Bohr, Gregory S. *Oklahoma Tornado Outbreak*, p. 1-2. Southern Regional Climate Center at Louisiana State University, May 1999.

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Tornado Project Online, at Website: www.tornadoproject.com/front.htm. The Tornado Project, PO Box 302, St. Johnsbury, Vermont 05819.

National Weather Service Storm Prediction Center, at Website: www.spc.noaa.gov/climo/index.html.

4.3 High Winds

Wind is defined as 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. Winds vary from zero at ground level to 200 mph in the upper atmospheric jet stream at 6 to 8 miles above the earth's surface.

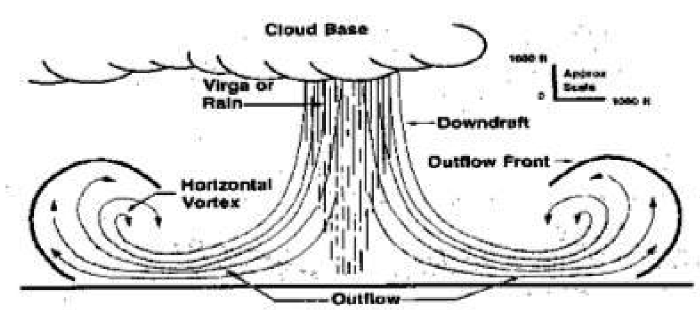
The mean annual wind speed in the mainland United States is reported by FEMA to be 8-12 mph, with frequent speeds of 50 and occasional wind speeds of greater than 70 mph. Tropical cyclone winds along coastal areas from Texas to Maine may exceed 100 mph.

4.3.1 Hazard Profile

Location

The entire jurisdiction of Tulsa County is at risk from damaging winds. Winds do not have to accompany a storm to be dangerous. Down-slope windstorms, straight-line winds, and microbursts can all cause death, injury, and property and crop damage.

Figure 4–11: Microburst Diagram



A Microburst is a particularly violent type of downburst that can generate winds up to 168 mph

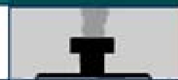
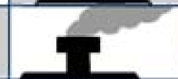
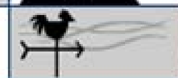
Property damage and loss of life from windstorms are increasing due to a variety of factors. Use of manufactured housing is on an upward trend, and this type of structure provides less resistance to wind than conventional construction. Not all states have uniform building codes for wind-resistant construction. Inferior construction practices result in buildings particularly susceptible to high winds.

Debris carried by extreme winds can directly contribute to loss of life and indirectly to the failure of protective building envelope components. (The building envelope consists of the walls, foundation, doors, windows, and roof – all surfaces that make up the barrier between the indoors and the outdoors.) Upon impact, wind-driven debris can rupture a building.

Measurement

Various wind scales and resultant damages include the Beaufort and the Fujita measurement scales. The table below contains the Beaufort Scale of Wind Strength showing what wind speeds produce various damages. (The Fujita Scale is presented as Table 4-11 in the section, "Tornadoes.")

Table 4–16: Beaufort Scale of Wind Strength

Beaufort number	Wind Speed (mph)	Seaman's term		Effects on Land
0	Under 1	Calm		Calm; smoke rises vertically.
1	1-3	Light Air		Smoke drift indicates wind direction; vanes do not move.
2	4-7	Light Breeze		Wind felt on face; leaves rustle; vanes begin to move.
3	8-12	Gentle Breeze		Leaves, small twigs in constant motion; light flags extended.
4	13-18	Moderate Breeze		Dust, leaves and loose paper raised up; small branches move.
5	19-24	Fresh Breeze		Small trees begin to sway.
6	25-31	Strong Breeze		Large branches of trees in motion; whistling heard in wires.
7	32-38	Moderate Gale		Whole trees in motion; resistance felt in walking against the wind.
8	39-46	Fresh Gale		Twigs and small branches broken off trees.
9	47-54	Strong Gale		Slight structural damage occurs; slate blown from roofs.
10	55-63	Whole Gale		Seldom experienced on land; trees broken; structural damage occurs.
11	64-72	Storm		Very rarely experienced on land; usually with widespread damage.
12	73 or higher	Hurricane Force		Violence and destruction.

Source: www.mountwashington.org

Extent

Wind is the fourth-leading cause of property damage. From 1981 to 1990, the insurance industry spent nearly $23 billion on wind-related catastrophic events. Out of the primary sources of high winds, severe local windstorms accounted for 51.3% of the expenditures. Table 4-17 lists the number of events, number of deaths, number of injuries, number of events that reported damages, and the amount of property damage reported to the NCDC for Tulsa County and Oklahoma.

Table 4–17: High Wind Events from 1995 to 2009

From NOAA National Climatic Data Center http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Location	*Events*	*Deaths*	*Injuries*	*Damage Events*	*Property Damages*
Tulsa County	317	1	56	83	$8,243,000
Oklahoma	9,174	8	196	2,525	$959,603,000

Cladding damage, especially glass damage, is not only costly but also threatens pedestrian safety; increases damage to interior contents, and lengthens business downtime.

In Oklahoma, wind events are generally associated with the huge convective thunderstorms that move through the region in the spring and fall months generating tornadoes, downbursts and high winds. It is not unusual for winds produced by these storms to reach speeds of 80-100 mph, with winds of 50-70 mph being commonplace. Downbursts, like the one that struck Tulsa on June 6, 2006, can topple trees, damage houses and power lines, and break up sidewalks and streets.

Tulsa County may experience a wind force of 9-12 as measured on the Beaufort Scale. Tulsa County considers a wind force on the Beaufort Scale of nine or below to be a minor severity and a wind force of ten and above to be a major severity.

Frequency

According to the National Climatic Data Center, Tulsa County experienced 424 high wind events between 1950 and 2006, resulting in 1 death, 8 people injured, and $8.4 million in damage. This data indicates that Tulsa County can expect around 8 thunderstorm/high wind events each year that generate winds of between 60 and 80 mph, and some that reach speeds of 100 mph. High wind is one of Tulsa County's most common natural hazards.

Impact

The impact of this hazard can result in damage to homes, businesses, and people; and can cause the loss of income.

4.3.2 History/Previous Occurrences

Over the past 20 years, 193 Federal disaster declarations involved wind-induced damage. From 1975 to 1994 in the United States, there were a total of 649 deaths and 6,670 injuries from disastrous winds. Wind is the fourth-leading cause of property damage.

In that 20-year period, deaths from winds in the United States were highest in 1975 with 103 deaths, 31 of them occurring on November 10 in Michigan. The second highest number was in 1983 with 98 deaths. There was also the highest number of wind-related injuries in 1983, totaling 622.

Major downburst did extensive damage in Midtown Tulsa in June 2006

From 1981 to 1990, the insurance industry spent nearly $23 billion on wind-related catastrophic events. Out of the primary sources of high winds, severe local windstorms accounted for 51.3% of the expenditures.

In Oklahoma, wind events are generally associated with the huge convective thunderstorms that move through the region in the spring and fall months generating tornadoes, downbursts and high winds. It is not unusual for winds produced by these storms to reach speeds of 80-100 mph, with winds of 50-70 mph being commonplace. Downbursts, like the one that struck Tulsa on June 6, 2006 (see below), can topple trees, damage houses and power lines, and break up sidewalks and streets.

Tulsa County Historic High Wind Events

Tulsa, along with most of Oklahoma, is often buffeted by high winds connected with convective thunderstorms. The National Climatic Data Center lists 420 thunderstorm and high wind events in Tulsa County between 1955 and 2006. Recent events include the following:

- **July 20, 1997 –** A severe thunderstorm moved slowly north-northwest through Tulsa County and produced large hail and damaging winds, gusting to 60 mph. Thunderstorm winds up to 70 mph downed trees, power lines, and fences and producing dime-size hail.
- **June 10, 1998 –** Severe thunderstorms that originally formed over north Texas weakened as they moved from central into northeast Oklahoma on the afternoon of June 10. Despite the fact that they produced no hail and little rain in northeast Oklahoma, these remnant thunderstorms produced copious amounts of wind along their wide track from Okemah through Tulsa and points northeast. As these storms moved through the Tulsa metro area, they knocked out power to 15,000 PSO customers and caused locally reduced visibilities due to blowing dust.
- **June 21, 1998 –** Strong winds caused considerable damage to the floating gas docks at the Pier 51 Marina on Lake Keystone. The restaurant on the second floor had to be closed for repairs. In addition, several large trees were blown over in Keystone State Park.
- **April 26, 1999 –** Strong winds flipped a mobile home just south of the Tulsa city limits.
- **August 1, 2003 –** Thunderstorm winds estimated at 70 mph blew down numerous large trees, tree limbs and power lines. Some cars were damaged by the debris and up to 38,000 customers lost power.
- **June 16, 2005 –** Thunderstorm winds estimated at 60 mph blew down large tree limbs. The downed tree limbs fell on power lines resulting in the loss of power to 26,000 homes.
- **June 6, 2006 –** A major downburst event struck Midtown Tulsa on June 6, 2006, causing major damage to Bell's Amusement Park at the Tulsa County Fairgrounds. The storm toppled trees, damaged houses and power lines, and broke up sidewalks and streets in a swath about half a mile wide and two miles long.

Tulsa County High Wind Events

According to the National Climatic Data Center, Tulsa County experienced 424 high wind events between 1950 and 2006, resulting in 1 death, 8 people injured, and $8.4 million in damage. Among these events were the following:

- **August 9, 1956-** A thunderstorm produced 86.4 mph winds in Tulsa.

- **May 16, 1960-** 88 mph winds were measured in Tulsa County.
- **July 27, 1960-** A thunderstorm produced 92 mph wind.
- **April 30, 1961-** Storm winds reached 86.4 mph.
- **July 7, 1961-** 80.6 mph winds were reported in Tulsa.
- **March 4, 1963-** Thunderstorm winds reached 86.4 mph.
- **June 8, 1974-** Winds in Tulsa County were measured at 115 mph.
- **August 21, 1979-** Thunderstorm winds reached 80.6 mph.
- **May 22, 1989-** Winds were measured at 80.6 mph.
- **June 19, 1992-** A thunderstorm produced 100-mph winds in Tulsa.
- **April 24, 1993-** Thunderstorm winds caused $500,000 in damage in Tulsa County.
- **May 17, 1993-** Thunderstorm winds pushed through Sand Springs and east into Sperry and northern Tulsa County, doing $50,000 in damage in the Skiatook area.
- **August 23, 1993-** Thunderstorm winds did $5,000 in damage west of Glenpool.
- **August 30, 1993-** An isolated severe thunderstorm in northern Tulsa County damaged a barn at 86th Street North and Delaware Street 5 miles west of Owasso, and a large tree was downed 3.5 miles west of Owasso. Golf ball-size hail fell just east of Owasso. Damage was estimated at $50,000.
- **June 2, 1996-** Thunderstorm winds measured at 90 mph did $4,000 in damage.
- **June 18, 1996-** Wind speeds of 80 mph were measured in Bixby.
- **July 22, 1996-** Thunderstorm winds did $110,000 damage in Tulsa County.
- **June 21, 1998-** Thunderstorm winds measured as high as 96 mph caused extensive damage in the county and throughout a large part of Tulsa. Strong winds caused considerable damage to the floating gas docks on Lake Keystone. Three or four trees were blown over in the Keystone State Park. Spotters estimated winds in Sand Springs at 70 mph, which blew down power lines in and north of Sand Springs, especially in the McKinley Hill area. In Sperry, a shed was blown down near 110th Street N. and 34th West Ave. The storm caused transformers to blow up in north Tulsa. Eventually, 70,000 PSO customers lost electrical service. Numerous power lines, including 27 distribution poles and 10 transmission poles as tall as 75 feet, were blown down. Spotters measured a 96 mph gust near US Hwy 75 and Apache. Around 245 AM CDT, winds tore the roof off of Houston Elementary School on North Cincinnati, and part of the roof of New Hope Baptist Church next door. Two large plate glass windows were blown out of the 400 S. Boston Building in downtown Tulsa. The glass was at least one-half inch thick. In Broken Arrow, thunderstorm winds of 80 mph were measured near 91st Street and 193rd East Ave. Tulsa Regional Medical Center admitted five patients for reasons related to the power outage.
- **November 22, 1999**- Thunderstorm winds estimated at 60 to 80 mph blew down 8 large electric transmission lines near 11th Street and 193rd East Avenue at the Tulsa-Wagoner county line.

- **March 8, 2002-** Thunderstorm winds estimated at 70 miles an hour blew a tractor trailer off the road near the intersection of Highway 169 and 136th street north, at Collinsville.
- **August 1, 2003-** Thunderstorm winds of 80 mph in Tulsa County blew shingles off several homes and interrupted electric power service.
- **June 2, 2004-** 80-mph thunderstorm winds blew glass windows out of the Adams Mark Hotel in Tulsa, and the nearby Wiltel building received structural damage to its northeast façade, including several broken glass windows. One person was injured by the breaking glass. Areas south of Tulsa and southeast of downtown suffered major power outages which took days to repair. As many as 70,000 Tulsa area customers were without power. Total damage was estimated at $4 million.
- **April 1, 2006-** Strong thunderstorm winds damaged four airplanes at Tulsa International Airport and broke out car windows. Damage was estimated at $500,000.
- **June 6, 2006-** A microburst with 85 mph winds did extensive damage north to south from 11th Street to 21st Street and from east to west from Yale to the Broken Arrow Expressway. A total of 1420 homes were damaged, two of which received major damage as large trees were blown down onto them. 13,000 residents near the damaged area were without power. There was extensive roof damage at the Tulsa County fairgrounds and Bell's Amusement Park. Two churches near the fairgrounds received roof damage. Four people were taken to the hospital with minor injuries. Damage was estimated at $2.5 million.

Probability/Future Events

With 212 events recorded within the Tulsa County in a 12-year period, and 26 of those producing reported economic damages, it is apparent that this is a very common event, and we can expect on the order of 8-9 events a year, with multiple events potentially producing economic loss. Deaths and injuries are more likely in tornadoes, the most severe wind events, but with 3 casualties recorded, deaths and injuries are a very real likelihood in future events.

4.3.3 Vulnerability

The Midwest is especially at risk from high winds because of the powerful thunderstorms that frequent the region.

The people most vulnerable to high wind-related deaths, injuries, and property damage are those residing in mobile homes and deteriorating or poorly constructed homes. Refer to Figure 1–7: Mobile Home Park Locations, in Chapter 1. However, as attested to by the historical records of damaging events and particularly the devastating downburst event of June, 2006, the unincorporated areas of Tulsa County are at risk from high winds, downbursts, toppled trees and fallen power lines.

Structures/Buildings

Property damage and loss of life from windstorms are increasing due to a variety of factors. Use of manufactured housing is on an upward trend, and this type of structure provides less resistance to wind than conventional construction. Not all states have uniform building codes for wind-resistant construction. Inferior construction practices result in buildings particularly susceptible to high winds.

The deteriorating condition of older homes and the increased use of aluminum-clad mobile homes will likely cause the impacts of wind hazards to increase. The general design and construction of buildings in many high wind zones do not fully consider wind resistance and its importance to survival. Near-surface winds and associated pressure effects exert pressure on structure walls, doors, windows, and roofs, causing the structural components to fail.

In particular, certain types of buildings, such as glass-clad office buildings, present increased vulnerability, as reported in the Source reference, *Performance of Glass Cladding of High Rise Buildings in Hurricane Katrina.*

Critical Facilities

Critical facilities are defined differently by different organizations and agencies, but are usually classified as those facilities that, if put out of operation by any cause, would have a broadly adverse impact on the community as a whole.

Some of these facilities may include (but not be limited to): structures or facilities that produce, use or store highly volatile, flammable, explosive, toxic and/or water-reactive materials; hospitals, nursing homes, and housing units for vulnerable populations; police stations; fire stations; vehicle and equipment storage facilities and emergency operations centers; public and private utility facilities. Since 9/11, FEMA has also added banks and other financial institutions to their critical facilities list. Tulsa County's critical facilities are listed in Table 1-8, and are mapped in Figure 1–9.

All critical facilities within Tulsa County should be considered vulnerable to the effects of a high wind event. Structural integrity may be compromised if in the direct path of the storm, in addition to any secondary issues presenting such as power disruption, water damage from accompanying rain, injury to workers/residents, etc.

Future Development

Due to the county-wide incidence of the high-wind hazard, any and all future development areas will be vulnerable to a high wind event.

4.3.4 High Wind Scenario

A microburst occurred in the City of Tulsa on June 6, 2006, at 4:45 am, with winds estimated at 85 mph, and was used as the worst-case scenario high wind event for unincorporated Tulsa County.

In that event, the Tulsa County Fairgrounds received an estimated $2.5 Million in damages. Two nearby churches experienced substantial roof damage, an estimated 1,420 homes experienced varying degrees of damage, primarily from damage to roofs/roofing material, and trees were uprooted destroying sidewalks/driveways. 13,000 customers were without power at the peak of the event, and four people were transported to the hospital for treatment of minor injuries.

Wind speeds in this event would have been the equivalent of an F-1 tornado with winds in the F-0 range on the perimeter. Damages encompassed approximately 2 sq. mi. For the worst-case scenario in north Tulsa County, the boundaries were placed on a cluster of primarily residential development directly north of the City of Tulsa. The scenario covers an area from N. Madison to N. Yale and from 59th Street North and 71st Street North.

For the worst-case scenario in west Tulsa County, the boundaries were placed in a cluster of residential development located near Tulsa County's westernmost border, approximately at 265th West Ave. east to 225th West Ave and from the approximate location of 41st Street south to 55th St.

For the worst-case scenario in south Tulsa County, the boundaries were placed in an area of moderate residential development near the city limits of Glenpool, Oklahoma. The scenario area approximately begins at U.S. Highway 75 and runs east to Lewis Ave. and from 161st Street south to approximately 176th Street.

Approximately 6,786 cubic yards of debris was picked up by the city after this event. With an estimated 1,420 homes affected by the event, this breaks down to approximately $159.68 per affected home in infrastructure expense and 4.77 cubic yards of debris per affected home. This figure was applied to the areas where the scenarios were placed in unincorporated Tulsa County.

Four minor injuries were reported for this event, none requiring hospitalization. This places the economic value of those injuries at $6,240, or $4.39 per affected residence.

At the height of this event, an estimated 13,000 customers were without power; by late in the day of the event, that number was down to 10,000; approximately 700 the following day, and full restoration expected two days after the event. The same time of service interruption and restoration should be expected for these scenarios as well.

Based on these calculations, the infrastructure damages in the proposed scenario would be as follows: ($159.68 x total houses affected) in expenses from various City Departments, and (4.77 cubic yards x total affected houses affected) cubic yards of debris to be collected.

Tables 4-18a-c detail the expected damages in each of the three areas of the County. Figures 4-12a-c show the area impacted by the high wind scenario.

Table 4–18a: High Wind Worst Case Scenario Damages - North

F-Scale	Parcel Count	Damage Factor	Averaged Damage	Parcel Count	Debris Factor	Averaged Debris (yds.)
Residential Properties						
0	466	$159.68	$74,410.88	466	4.77	2222.82
1	287	$159.68	$45,828.16	287	4.77	1368.99
Total	753	$159.68	$120,239.04	753	4.77	3591.81
Commercial Properties						
0	46	$159.68	$7,345.28	46	4.77	219.42
1	20	$159.68	$3,193.68	20	4.77	95.4
Total	66	$159.68	$10,538.96	66	4.77	314.82

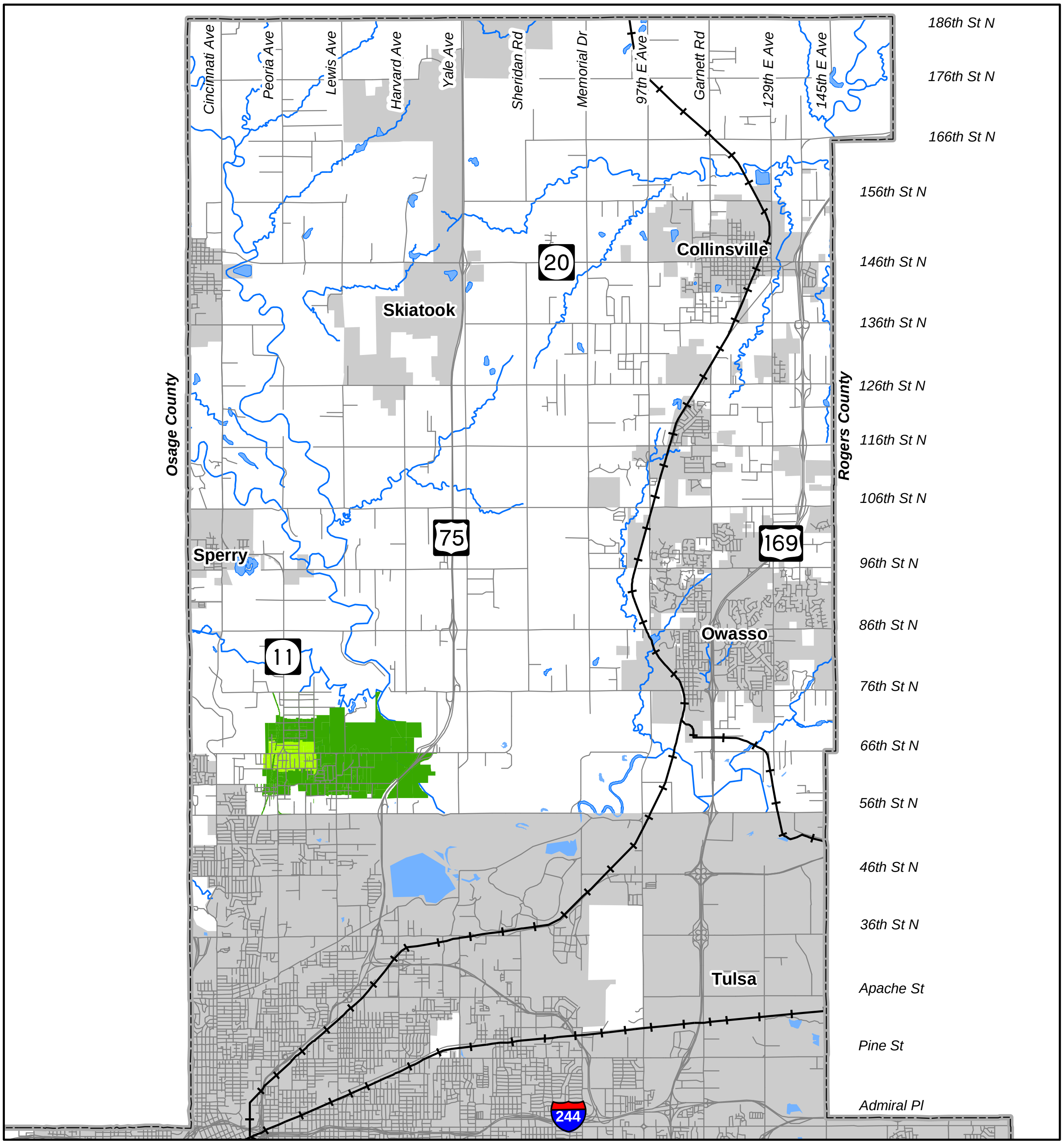
F-Scale	Parcel Count	Damage Factor	Averaged Damage	Parcel Count	Debris Factor	Averaged Debris (yds.)
Industrial Properties						
0	22	$159.68	$3,512.96	22	4.77	104.94
1	4	$159.68	$638.72	4	4.77	19.08
Total	26	$159.68	$4,151.68	26	4.77	124.02
Tax Exempt Properties						
0	12	$159.68	$1916.16	12	4.77	57.24
1	9	$159.68	$1437.12	9	4.77	42.93
Total	21	$159.68	$3,353.28	21	4.77	100.17
Totals						
	866	159.68	$138,282.88	866	4.77	4130.82

Table 4–18b: High Wind Worst Case Scenario Damages – South

F-Scale	Parcel Count	Damage Factor	Averaged Damage	Parcel Count	Debris Factor	Averaged Debris (yds.)
Residential Properties						
0	116	$159.68	$18,522.88	116	4.77	553.32
1	15	$159.68	$2,395.2	15	4.77	71.55
Total	131	$159.68	$20,918.08	131	4.77	624.87
Commercial Properties						
0	0	$159.68	$0	0	4.77	0
1	0	$159.68	$0	0	4.77	0
Total	0	$159.68	$0	0	4.77	0
0	0	$159.68	$0	0	4.77	0
Industrial Properties						
1	0	$159.68	$0	0	4.77	0
Total	0	$159.68	$0	0	4.77	0
Tax Exempt Properties						
0	0	$159.68	$0	0	4.77	0
1	0	$159.68	$0	0	4.77	0
Total	0	$159.68	$0	0	4.77	0
Totals						
	131	159.68	$20918.08	131	4.77	624.87

Table 4–18c: High Wind Worst Case Scenario Damages – West

F-Scale	Parcel Count	Damage Factor	Averaged Damage	Parcel Count	Debris Factor	Averaged Debris (yds.)
Residential Properties						
0	178	$159.68	$28,423.04	178	4.77	849.06
1	44	$159.68	$7,025.92	44	4.77	209.88
Total	222	$159.68	$35,448.96	22	4.77	1058.94
Commercial Properties						
0	2	$159.68	$319.36	2	4.77	9.54
1	0	$159.68	$0	0	4.77	0
Total	2	$159.68	$319.36	2	4.77	9.54
Industrial Properties						
0	0	$159.68	$0	0	4.77	0
1	0	$159.68	$0	0	4.77	0
Total	0	$159.68	$0	0	4.77	0
Tax Exempt Properties						
0	1	$159.68	$159.68	1	4.77	4.77
1	0	$159.68	$	0	4.77	0
Total	1	$159.68	$159.68	1	4.77	4.77
Totals						
	225	159.68	$35,928	225	4.77	1073.25



LEGEND

0 1 2 Miles

High Wind F-0 Parcels

High Wind F-1 Parcels

Streets

Railroads

County Line

Incorporated Areas

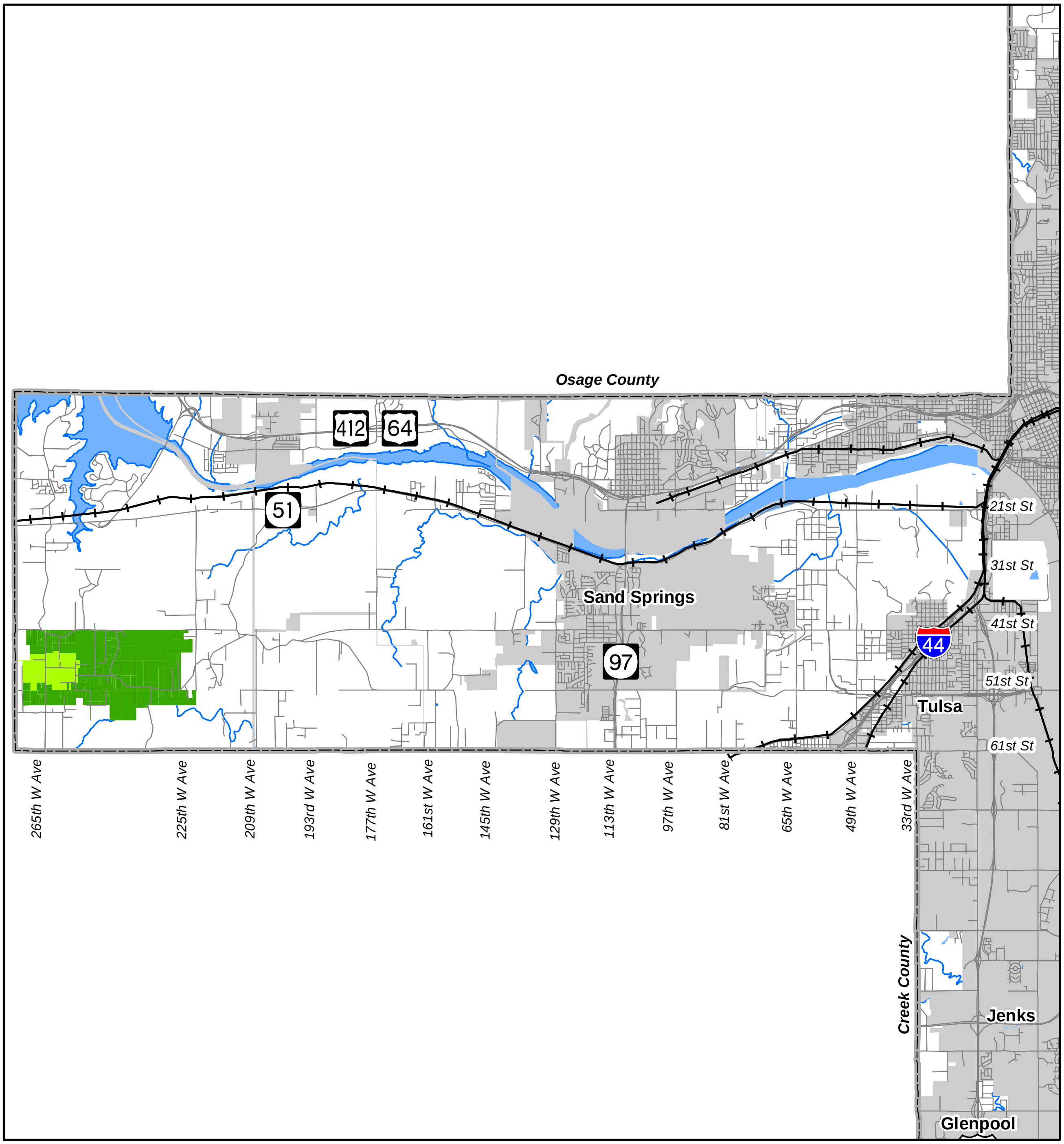
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-12a

High Wind Scenario

Tulsa County - North



LEGEND

0 1 2 Miles

- High Wind F-0 Parcels
- High Wind F-1 Parcels
- Streets
- Railroads
- County Line
- Incorporated Areas

Flanagan & Associates, LLC
Planning Consultants

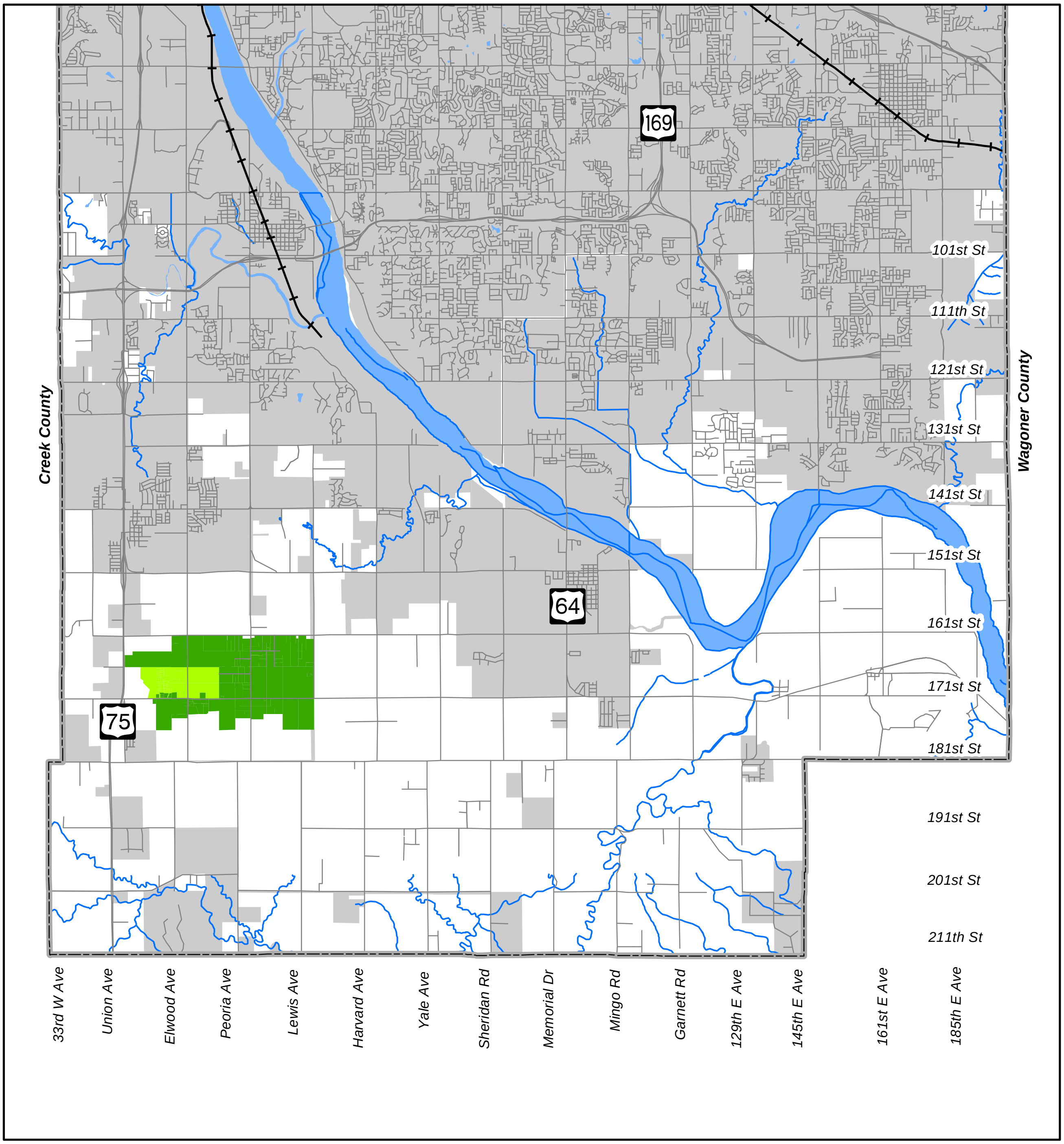
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-12b

High Wind Scenario

Tulsa County - West



LEGEND

0 1 2 Miles

- High Wind F-0 Parcels
- High Wind F-1 Parcels
- Streets
- Railroads
- County Line
- Incorporated Areas

Flanagan & Associates, LLC
Planning Consultants

TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-12c

High Wind Scenario

Tulsa County - South

4.3.5 Conclusion

Due to the very nature of Tulsa County's climate, severe thunderstorms and the high winds they frequently produce will remain a very real threat. The probability and accompanying risk of events occurring is "high." Recent events both in Tulsa County and in the surrounding areas serve as proof that sporadic, high winds events continue to produce life and property threatening conditions. Improved building technologies, advances in public communication capabilities, and opportunities for collaboration among community agencies should remain prominent in the planning and response communities' endeavors.

4.3.6 Sources

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National Weather Service: Office of Climate, Water, and Weather Services, at Web address: www.nws.noaa.gov/om/hazstats.shtml.

Wind and the Built Environment: U.S. Needs in Wind Engineering and Hazard Mitigation. National Research Council, 1993.

4.4 Lightning

Lightning is generated by the buildup of charged ions in a thundercloud. When the buildup interacts with the best conducting object or surface on the ground, the result is a discharge of a lightning bolt. Thunder is the sound of the shock wave produced by the rapid heating and cooling of the air near the lightning bolt. The air in the channel of a lightning strike reaches temperatures higher than 50,000° Fahrenheit.

4.4.1 Hazard Profile

Lightning is the most constant and widespread threat to people and property during the thunderstorm season. According to the National Lightning Safety Institute, an average of 58 people per year was killed each year by lightning between 1990 and 2003 in the United States. In addition, an Insurance Information Institute report in 1989 stated that five percent of all insurance claims are lightning-related, amounting to over $1 billion in reimbursements annually.

Lightning can strike 10 miles out in front of an advancing rain column.

Location

Lightning can strike ten miles out from the rain column, and lightning deaths often occur under a clear sky ahead of the storm. This is because people wait until the last minute to seek shelter—hoping to finish the game, the painting, or the yard work. As lightning is a by-product of thunderstorms, the entire jurisdiction of Tulsa County is subject to the exposure and effects of lighting events.

When a person is struck by lightning, serious burns or deaths are the obvious outcomes. On average, only 20% of lightning strike victims die from their injuries. However, injuries to survivors often lead to permanent disabilities. Seventy percent of lightning strike victims suffer from serious, long-term effects, which include memory loss, attention deficits, sleep disturbance, numbness, dizziness, stiffness in joints, irritability, fatigue, weakness, muscle spasms, depression, and an inability to sit for long periods.

Fire is a natural outcome from a cloud-to-ground lightning strike. The National Fire Protection Association reported that during the period from 1994 to 1998, lightning strikes responded to by municipal fire departments caused an average of 8,650 structure fires and $208.2 million in losses each year. An additional 26,200 outdoor fires were started, resulting in $14.3 million dollars in annual losses.

Lightning strikes can also cause high-voltage power surges that have the ability to seriously damage equipment and valuable data if surge protection devices are not installed. Property damage from power surges and resulting fires can destroy not only the electronics in private homes, but also unprotected PBXs, telecommunications equipment, wireless systems, and radio base stations.

Measurement

Lightning can be measured in a variety of ways: lightning flash frequency, flash intensity, and lightning impacts. One method, that is described below is to utilize the National Lightning Detection Networks information utilized by VAISALA to produce the free lightning explorer on the map at http://www.lightningstorm.com/explorer.html.

The U.S. National Lightning Detection Network is a network of about 105 antennae that are connected to a central processor that records the time, polarity, signal strength, and number of strokes of each cloud-to-ground lightning flash detected over the United States. A combination of time of arrival and direction finding technology is used to locate the flash. Depending on the location within the network, GAI claims a location accuracy of a few km, with a detection probability greater than 60%. The flash time is accurate to better than 2 milliseconds.

The 15 minute lightning product is made by binning the number of flashes that occur over a 15 min period to a pixel. A pixel is 0.0718954 degrees (latitude) by 0.0765027 degrees (longitude) (approximately 8 km by 8 km). The grid consists of 459 pixels in the North-South direction and 915 pixels in the East-West direction. Lightning flash values can range from 0-254. A value of 255 denotes 255 or more flashes occurred in the pixel during the 15 minute period. (Note: the maximum pixel value observed is about 100).

A daily product is also produced over the same area with the number of flashes occurring in each pixel during a 24 hr period (00 UTC to 00 UTC). The binned values are scaled by 5 such that a value of 1 corresponds to 1-5 flashes, 2 from 6-10, etc. A value of 255 indicates more than 1270 flashes occurred in the pixel over the 24 hr period.

Both the 15 minute and daily products are generated in realtime and the annotation (in the hdf file) identifies files run in realtime. Missing data occurs in the realtime data, so the raw data file is checked for completeness and data gaps are filled. The products (daily and 15 min) are then reprocessed and the annotation changed to denote that the files have been quality assured.

Extent

Between 1993 and 2008, Tulsa County experienced 15 lightning events, which killed one person, injured two, and did $2,895,000 in damage. None of these events was in North Tulsa County; six were in or near the City of Tulsa, four in Glenpool, two in Broken Arrow, and one each in Bixby, Sand Springs and Inola. By far the most serious of these events was the Glenpool strike of 2006, which hit a fuel storage tank and did $2 million in damage. Using these numbers, Tulsa County as a whole can expect about one damaging lightning event every year, which does about $60,000 damage. As development continues to spread into the unincorporated urban/rural interface of the county's major cities, the frequency of damaging lightning strikes is likely to increase.

Although the entire jurisdiction is at risk from lightning, the probable extent of a damaging strike often depends upon the age, condition and density of structures in the strike area, the community's fire response capability, and the presence or absence of lightning warning and protection systems.

Tulsa County considers a minor severity to be a lightning strike that does not cause bodily injury or cause less than $1,000 in damages and a major severity to be a lightning strike that causes bodily injury or causes more than $1,000 in damages.

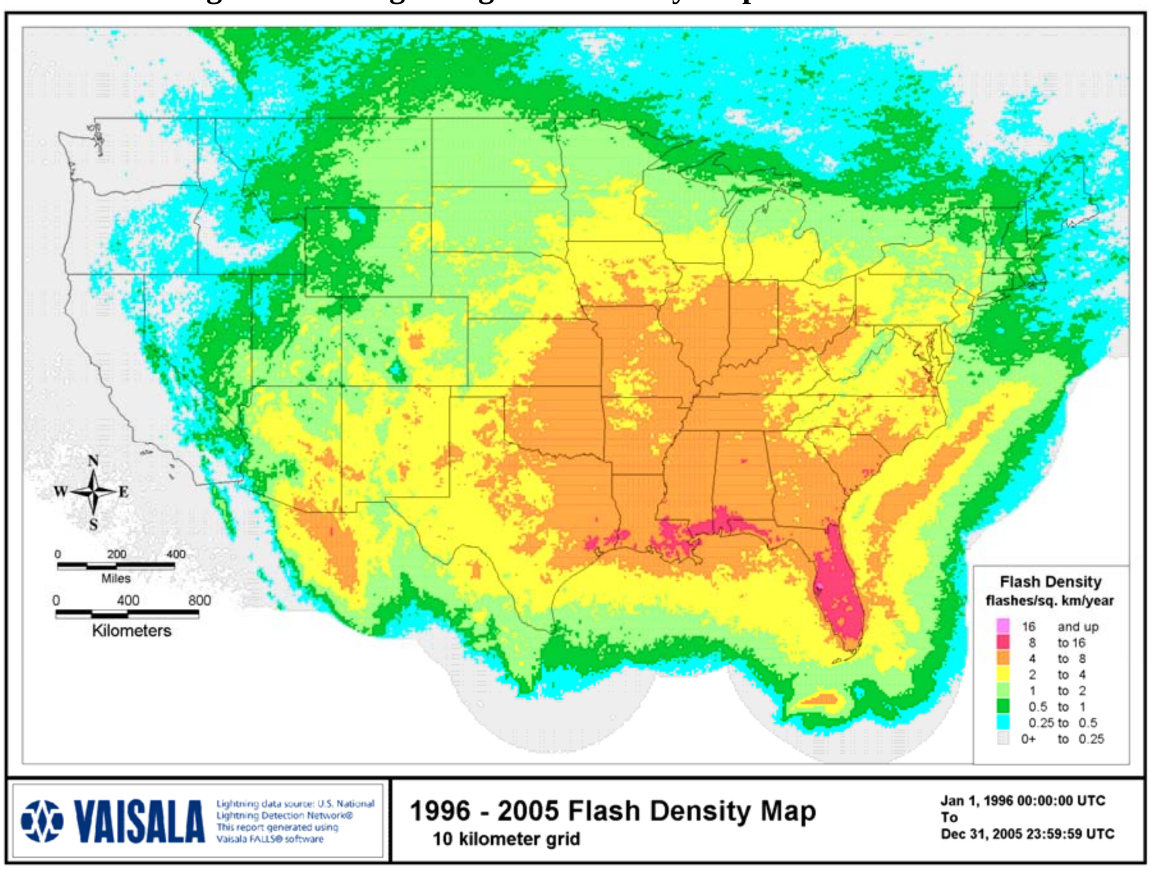
Frequency

National Geographic claims that lightning strikes the surface of the earth about 100 times every second. The National Lightning Detection Network states researchers have typically defined a flash as consisting of all cloud-to-ground discharges which occur within 10km of each other within a one second interval. Their research reveals:

- one lightning casualty occurred for every 86,000 flashes in the United States;
- one death occurred for every 345,000 flashes;
- one injury occurred for every 114,000 flashes.

Lightning casualties and damages increase gradually through the spring, when the thunderstorm season begins for most of the country, and peak during the summer months. The months most notorious for lightning incidents were June with 21% of the strikes, July with 30%, and August with 22%. Sunday, Wednesday, and Saturday are the days that the most injurious lightning strikes occur, and between the hours of 12:00 PM and 6:00 PM.

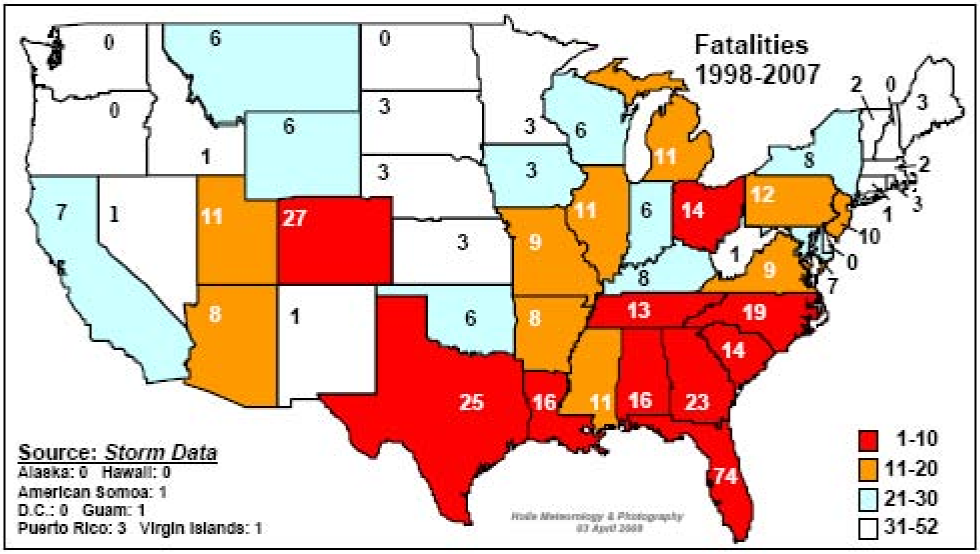
Figure 4–13: Lightning Flash Density Map from 1996-2005



Impact

The impact of this hazard could include people displaced from their homes and businesses being closed. The financial loss due to urban fire, wildfire and damaged electronic equipment can also be included.

Figure 4–14: Lightning Deaths by State from 1998-2007



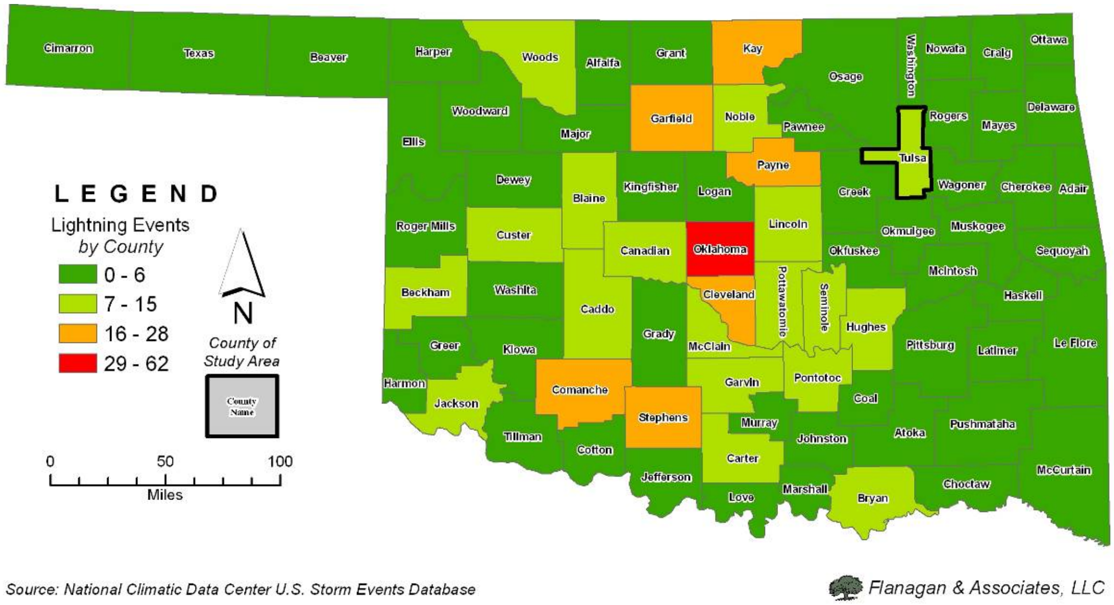
4.4.2 History/Previous Occurrences

From 1959 to 1995 in the United States, *Storm Data* reports that there were 3,239 deaths, 9,818 injuries, and 19,814 incidents of property damage attributed to lightning strikes. Among the largest damage reports were lightning-caused forest fires and strikes damaging manufacturing plants and agricultural facilities. Oklahoma ranked 15th among states in the total number of casualties during the 36-year period of their study, with 88 deaths and 243 injuries reported, and ranked fifth nationally in the number of damage reports with 826. In the 10-year period between 1995-2009, Tulsa County had 12 lightning events resulting in one death, two injuries and over $2 million in damage.

Table 4–19: Casualties and Damages Caused by Lightning from 1995 thru 2009
From NOAA National Climatic Data Center http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Location	Events	Deaths	Injuries	Damage Events	Property Damages
Tulsa County	12	1	2	9	$2,340,000
Oklahoma	374	11	76	301	$26,077,000

Figure 4–15: Lightning Events in Oklahoma 1989-2009



Tulsa County Lightning Events

Between 1956 and 2006, Tulsa County as a whole experienced 15 reported lightning events, which did over $2.87 million in damage. Among these were the following:

- **May 17, 1993-** A lightning strike at Glenpool did $50,000 in damage.
- **August 30, 1993-** Lightning in south Tulsa County resulted in $500,000 in damage.
- **April 22, 1995-** A house in Tulsa was set on fire by lightning, causing $50,000 in damage.
- **May 25, 1998**- Lightning split a tree which fell across 91st Street 2 blocks east of Yale Ave.
- **June 10, 1998**- A lightning strike during the early morning at the Frontier Terminal on the Arkansas River caused a pump to activate, spilling an estimated 11,000 gallons of asphalt oil and diesel fuel. One thousand gallons of the diesel fuel entered the river, affecting 5 miles of the river before it could be contained.
- **March 12, 1999-** A lightning strike caused a house fire in the 4800 block of South Victor Avenue. Damage was $10,000.
- **On April 22, 1999-** At 7:30 p.m., lightning struck a radio tower at the Troop C Headquarters of the Oklahoma Highway Patrol, destroying phone, computer and radio systems.
- **April 26, 1999-** Lightning struck a home on South Quince in Glenpool, starting two small fires and damaging household appliances. Damage was $5,000.
- **May 17, 1999-** Lightning struck a two-story house in Broken Arrow, sparking a fire that destroyed the entire second floor of the home. Lightning also struck a south Tulsa home, located near 111th St. between Yale and Sheridan Ave., which burned off the roof.

- **August 10, 2002-** Lightning struck two homes near Glenpool, starting fires that considerably damaged both houses.
- **June 10, 2003-** A 17-year-old boy was struck by lightning near 63rd and N. Denver Ave. He was taken by ambulance to a hospital for treatment.
- **July 23, 2005-** Two teenagers in Broken Arrow were hit by lightning when it struck a tree under which they were playing. Both teenagers went into cardiac arrest, but were revived and taken to the hospital. One of the teenagers later died from injuries, the other was released after prolonged hospitalization.
- **June 12, 2006 –** At 9:00 a.m., lightning struck a 5 million gallon unleaded gasoline storage tank at the Explorer tank farm in Glenpool causing a major fire that burned for 11 hours before being extinguished. Approximately 800,000 gallons of gasoline were burned. The fire was put out by early evening. Residents from five surrounding homes were voluntarily evacuated, and traffic on US Hwy 75 was rerouted for a time. Damage was $2 million.

Glenpool tank farm fire June 12, 2006

- **August 26, 2006-** Lightning struck a house 5 miles southwest of Bixby causing a fire in the attic. Damage was $25,000.
- **April 24, 2007 –** Lightning struck Apple Creek Apartments and started a fire in the attic of one of its residential buildings.

Probability/Future Events

Oklahoma is vulnerable to frequent thunderstorms and convective weather patterns, and therefore its vulnerability to lightning is a constant and widespread threat during the thunderstorm season. Tulsa City and County jurisdictions are no exception, as demonstrated by the deadly and damaging lightning strikes in 2005 (death of one teenager and lingering disability of another) and 2006 (a victim of a lightning-caused petroleum tank farm fire). Tulsa County has a high probability of future lightning strikes.

4.4.3 Vulnerability

The National Lightning Safety Institute reports that in 35 years of studying lightning fatalities, injuries, and damage reports in the United States, the reported locations of injurious lightning strikes broke down as shown in the following table.

Anyone out-of-doors during a thunderstorm is exposed and at risk to lightning. More people are killed by lightning strikes while participating in some form of recreation than any other incident, source, or location. The next largest group of fatalities involves people located under trees, then those in proximity to bodies of water. Other common incidents involve golfers, agricultural activity, telephone users, and people in proximity to radios and antennas.

Table 4–20: Locations of Injurious Lightning Strikes

Location	Percent
Not reported	40
Open fields and recreation areas (not golf courses)	27
Under trees (not golf courses)	14
Water related (boating, fishing, swimming)	8
Golfing and on a golf course under trees	5
Heavy equipment and machinery related	3
Telephone related	2.4
Radio, transmitter and antenna related	0.6

Structures/Buildings

Oklahoma is vulnerable to frequent thunderstorms and convective weather patterns, and therefore its vulnerability to lightning is a constant and widespread threat during the thunderstorm season. The City and County of Tulsa jurisdictions are no exception, as demonstrated by the 1 death, 2 injuries and $2+ Million in damages between the years of 1998 and 2008. The entire community is at risk to lightning-caused fires, damages and casualties.

Critical Facilities

All critical facilities within the jurisdiction of the City/County of Tulsa should be considered vulnerable to the effects of a lightning event. Power disruption and potential destruction of electronic equipment (computers, vital medical equipment, communication equipment, data storage, etc.) should be considered a primary threat to critical facilities. A list of the Critical Facilities in Tulsa County can be found in Table 1-8 and mapped in Figure 1-9.

Infrastructure

Lightning-caused problems are one of the most common troubles faced by American business today. A recent Carnegie-Mellon study showed that 33% of U.S. businesses are affected by lightning – and that more businesses are affected by lightning storms than by floods, fires, explosions, hurricanes, earthquakes, and violence.

Electronic equipment from computers to enterprise-level communications systems can be seriously damaged by power surges from lightning. Surge protection should be included in any electronic system to minimize the risk of damage from lightning. In addition, lightning warning/detection systems (such as ThorGuard© which is utilized by Northeastern State University) should be included in protection plans for critical components of the City/County of Tulsa's infrastructure. For additional information about lightning detection/alert systems, see Appendix B, Section B.2.10 and B.4.8.

Water Treatment – The most significant effect during a lightning event would be from loss of electrical power and damage to electrical equipment. The water plants experience power outages related to lightning and thunderstorms on a regular basis. Outages are usually short in duration and affect only a portion of the facility. Both of the City of Tulsa's water treatment plants have sustained equipment damage in the past that required repair or replacement are at continued risk to this type of event.

Wastewater Treatment – The most significant threat to the operation of Tulsa's 4 wastewater treatment plants during a lightning event would be power outages. All four plants and lift stations have either double feeds or generators.

Utilities- The primary utility providers for Tulsa County's jurisdiction are AEP/PSO (electricity) and ONG (natural gas). The service stations and substations for both of these providers would be vulnerable to the risks from a lightning event. Electricity: During a lightning event, providers of electrical service could experience damage to transformers or other transmission components, downed broken power lines, danger to workers from downed power lines, fallen debris from trees, and insufficient field and/or office staff to effectively handle the workload. Gas: During a lightning-caused outage, providers of gas service to a community could experience a variety of challenges, including downed power lines or tree debris, blocked access to underground gas meters from fallen debris, and insufficient field and/or office staff to effectively handle increased workloads from the event.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Transportations systems would experience the same vulnerability to lightning events as other County facilities.

Emergency Services- Fire, Police and Medical Services would all be similarly at risk to the secondary effects of a lightning event. Downed power lines or debris blocking city streets could hamper access to affected areas. A potential secondary effect on these services would be interruption of communication capabilities due to a lightning strike.

4.4.4 Lightning Scenario

Two lightning strike scenarios for Tulsa County would involve structures and their contents, and people.

About one-half of all damages from lightning result in damage of between $5,000 and $50,000, with 20% of all reported damages being between $50,000 and $500,000. This upper amount is usually related to forest fires or damage to business operations.

A typical lightning scenario for Tulsa County would be a strike on a county facility that damages the electrical wiring and electronic equipment, and knocking out the communication systems.

An example of such an event occurred in Holdenville, OK, on October 14, 2007, when lightning struck City Hall, crippling the community's 911 system and damaging the Police Department's radio system. Losses were approximately $26,600.

A worst case scenario for Tulsa County could involve the Tulsa County Sheriff's Office at 303 W. 1st St. The TCSO's Faulkner Building, valued at $1,500,000, houses 200 staff and $1,000,000 of electronic equipment. If a lightning burst were to hit the building in such a way as to enter the electronic circuitry, it could damage a significant percentage of the electronic equipment, and start fires within the building. The worst-case scenario could involve destruction of the building's circuitry and all its attached electronic equipment, and result in 20% fire damage to the facility itself. Considering only the damage to facilities and equipment, such a lightning strike could result in up to $2,500,000 loss to the County.

A similar lightning detector in use at a Bonaire GA football game had prompted officials to begin moving people off the field when lightning struck

The most frequently reported incidents involving injuries and/or deaths from lightning occur during common outdoor activities such as hunting, swimming, and outdoor team events such as soccer and football. According to the website "struckbylightning.org", in 2008 there were 27 deaths and 303 injuries by lightning in the United States.

One of these events occurred at a football game in Bonaire GA on September 11, 2008 at approximately 3:30 p.m. Officials had a hand-held lightning detector in use, and when it sounded an alarm, decided to call the game because of the approaching thunderstorm. They were in the process of moving players off the field when lightning struck. Thirteen individuals were injured, twelve sent to local hospitals, and one of the coaches remained in critical condition for several days.

A second event took place at a soccer game in Dorchester MA on July 20, 2008, also at approximately 3:30pm. There were 10 injuries reported, four critical. Seven players were knocked unconscious, and injuries ranged from burns to cardiac conditions. The victims were 13 – 41yrs old, all males.

These are a large number of football and soccer games played in Tulsa County both in the schools and as recreation in the parks. There are children as young as 5yrs old on soccer teams, as well as a range of adult leagues that gather on evenings and weekends for games. Football, too, is a popular activity in Tulsa County with teams for all ages, and sometimes huge spectator crowds that gather during the time of day when most lightning deaths and injuries occur—between 12:00 and 6:00 pm, with a peak of strikes around 4:00 pm.

Using the Bonaire, GA, event as a model, where 13 people were injured, and 12 taken to the hospital, and assuming those transported to the hospital were admitted overnight for observation, the economic cost of hospitalization, according to "What is a Benefit", would be $187,200 (12 patients x $15,600 each). The economic value of lost wages, according to the same source, would be $21.16/hour per person. If it is assumed that one coach and one teacher were among those injured, and their time off work totaled 10 working days (the time lost by the injured coach), total economic value of those lost wages would be $3,385.60. Using only these costs, total losses from similar lightning incident in Tulsa County would be $190,585.60.

In the Dorchester soccer match model, the value of hospitalizations for a similar event in Tulsa County would be $156,000. As there were several adult males injured, the economic value of lost wages (at $21.16/hour per person) for 10 days would be $8,464.00, for a total of $164,464.

4.4.5 Future Trends

Population

As the "baby-boom" generation moves into retirement, the number of people pursuing outdoor sports and/or social activities is likely to increase. Priority should be given to continuing the process of informing the public of the dangers associated with lightning. With the rising cost of fuel, it is also possible that families will begin looking for activities closer to home, in parks and other outdoor recreation areas.

As Tulsa County communities grow, outdoor construction workers, as well as County inspectors and road crews, will continue to be exposed to the dangers of lightning. These groups should be regularly informed of the dangers associated with thunderstorms and lightning, and in some cases equipped with lightning detectors.

Structures/Buildings

As new structures are built and existing ones renovated, actions should be taken to reduce the potential effects of lightning strikes. Surge protection should be recommended for phone lines and electrical circuits, and utility companies encouraged to bury above-ground utility lines.

Critical Facilities

As technology continues to advance, the need to protect power sources that support critical functions will also increase. Local utility companies should be encouraged to move above-ground utilities, such as phone and electrical service, underground, particularly those that support emergency functions.

Infrastructure

Ensuring County facilities are protected against the effects of lightning is an on-going endeavor. Tulsa County has been repeatedly honored as one of the nation's top 10 counties (above 500,000 population) in the effective use of technology. To ensure continued progress and continuity of government, priority should be given to ensuring that communications are not interrupted and the increasing amount of electronic equipment and data is protected.

4.4.6 Conclusion

Lightning is one of the most deadly and consistent hazards in the United States. People outside can have a false sense of security, thinking that they are safe because a storm front has yet to reach their location. In fact, lightning can strike ten miles out from the rain column, putting people that are still in clear weather at risk. The general rule of safety is that anyone outside during a thunderstorm should take cover.

Oklahoma is vulnerable to frequent thunderstorms and convective weather patterns, and therefore its vulnerability to lightning is a constant and widespread threat during the thunderstorm season. Tulsa County jurisdictions are no exception. The entire community is at risk to lightning-caused fires, damages and casualties. All future development areas are also vulnerable to lightning strikes.

Electronic equipment, from personal computers to enterprise-level communications systems, can be seriously damaged by power surges from lightning. Surge protection should be included in any electronic system to minimize the risk of damage from lightning.

The fatal lightning strike in Broken Arrow in 2003 and the damaging Glenpool tank farm fire of 2006 are examples of how vulnerable Tulsa County is to lightning. Particularly vulnerable are Tulsa County's oil and gasoline tank farms, and its industries with volatile products and processes.

In recent years, new technology has made it possible for communities and individuals to have better warning and alerts, increased surge protection, and more effective building protection. Nevertheless, the threat of injury, death, or property damage from lightning in Tulsa County remains high.

4.4.7 Sources

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NCDC Storm Event Database, at Web address: http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms. National Climatic Data Center.

"Strike Database 2008," Struckbylightning.org, http://www.struckbylightning.org/news/dispOldIncidentdb.cfm

4.5 Hailstorms

A hailstorm is an outgrowth of a severe thunderstorm in which balls or irregularly shaped lumps of ice fall with rain. Extreme temperature changes from the ground upward into the jet stream produce strong updraft winds that cause hail formation.

The size of hailstones is a direct function of the severity and size of the storm. High velocity updraft winds keep hail in suspension in thunderclouds. The greater the intensity of heating at the Earth's surface, the stronger the updraft will be. Higher temperatures relative to elevation result in increased suspension time, allowing hailstones to grow in size.

Hailstones can cause widespread damage to crops and automobiles and serious bodily injury.

4.5.1 Hazard Profile

Hail can occur in any strong thunderstorm, which means hail is a threat everywhere. Hail is one of the most destructive hazards to agricultural crops and animals, and the major natural cause of automobile damage.

Location

The states in the middle of the Great Plains, and particularly Oklahoma, are the most likely to have severe thunderstorms and have the most hail events. Oklahoma experiences an average of 869 hailstorms each year with hailstones measuring at least 0.75 inches in diameter. All buildings and agricultural areas in Tulsa County are at risk.

Measurement

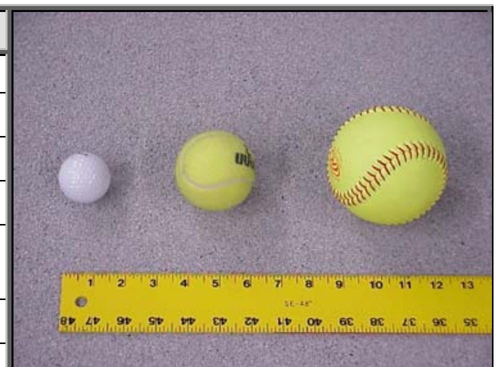
Hailstones are typically measured by their diameter. The damages expected from a hail event are a function of the diameter of the hailstones and wind speed, or velocity. There have been numerous instances of hailstones reaching four inches in diameter, or grapefruit size, in Tulsa County. When hailstones reach such dimensions, they can be extremely dangerous to property, agriculture and people caught outside, without shelter. Hailstorms are usually considered "Destructive" when hail reaches 2.75 inches in diameter and is accompanied by high winds.

Extent (Magnitude/Severity)

Generally, damages appear to increase sharply in Tulsa County with hail that is 1.75 inches in diameter or greater—H5, or "Destructive" on the Combined NOAA/TORRO Hailstorm Intensity Scale. Such an event can be expected every year in the jurisdiction. The most destructive hailstorm in Tulsa County was the storm of April 5, 2005, when up to 3-inch hail fell from Jenks into south Tulsa, doing $65 million in damage. Tulsa County has been hit by H8 "Very destructive" storms, with hail 3 inches or larger, six times since 1963– or once every 8 years. Damage from hailstorms appears to be increasing as car roofs and hoods are made of thinner material and insurance claims are more common.

Table 4–21: Common Sizes and Descriptions of Hail

Hail Size	Description	Hail Size	Description
0.25 inch	Pea Size	1.75 inch	Golf Ball Size
0.50 inch	Mothball Size	2.00 inch	Hen Egg Size
0.75 inch	Dime/Penny Size	2.50 inch	Tennis Ball Size
0.88 inch	Nickel Size	2.75 inch	Baseball Size
1.00 inch (Severe Criteria)	Quarter Size	3.00 inch	Teacup Size
1.25 inch	Half Dollar Size	4.00 inch	Grapefruit Size
1.50 inch	Walnut or Ping Pong Ball Size	4.50 inch	Softball Size



Source: National Weather Service, Tampa Florida

Table 4–22: 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 and crops, damage to glass and plastic structures, paint and 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
H10	Super Hailstorms	4+	Softball and up	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open

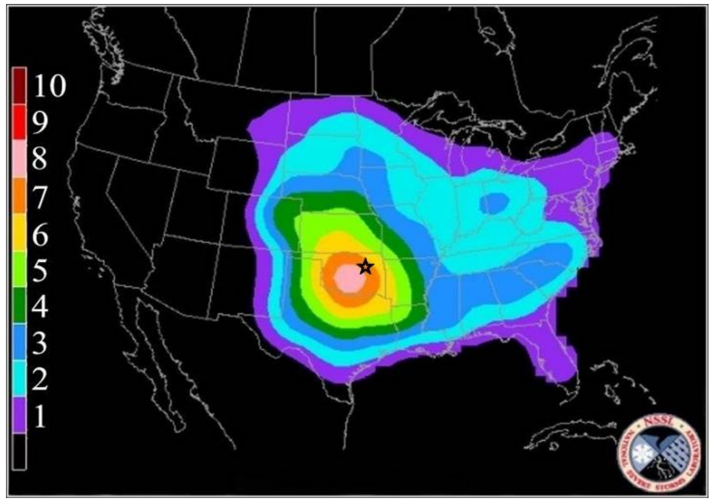
The damage expected from a hail event is a function of the diameter of the hailstones and wind speed, or hailstone velocity. When hailstones reach 2.75-inches in size (an H7 event with stones the size of baseballs) they can be extremely dangerous to property, agriculture and people caught outside without shelter. Such an event can be expected every three years in the jurisdiction. A worst-case event would be a sustained hailstorm with stones 4.0 inches in diameter. Such an event would result in some injuries; severe damage to houses, commercial buildings and automobiles; and tens, if not hundreds, of millions of dollars in damage.

Tulsa County considers a minor severity to be an H2 or lower on the Combined NOAA/TORRO Hailstorm Intensity Scales and a major severity to be an H3 or higher.

Frequency

Most localities within the United States, from the Great Plains eastward, experience hailstorms at least two or more days each year. The Great Plains, particularly the states of Oklahoma, Kansas, and Texas, are most frequently affected by hailstorms. These states can expect to receive hail between four and eight days per year. Multiple impacts of concurrent severe thunderstorm effects (high winds, tornadoes, and hail) are very likely within the Great Plains region

Figure 4–16: Hailstorm days per year from 1980-1999



About 2% of United States crop production is damaged by hail each year, and in the Great Plains States it has sometimes reached 20%. The development of hailstorms from thunderstorm events causes nearly $1 billion in property and crop damage each year.

Between 1995 and 2009, Tulsa County experienced 465 reported hailstorms, which did $90.8 million in damage. (It should be cautioned that this data often includes multiple reports of the same hailstorm—such as March 14, 1996, which generated 14 separate reports. The actual number of separate storm events is closer to 275 in 15 years, or about 18 hailstorm events per year.)

Impact

The impact of this hazard is mainly financial resulting in repairs to cars, roofs, walls, and windows. The loss of crops and livestock can be devastating to farmers and the economy in lost revenues.

4.5.2 History/Previous Occurrences

The Midwest hailstorm and tornado event in April 1994 lasted four days. According to Property Claims Services in Rahway, New Jersey, it produced 300,000 damage claims against insurers, more than Hurricane Andrew or the Northridge earthquake.

According to NOAA, the most expensive thunderstorm event in United States history occurred in April-May of 1995 in the Texas-Oklahoma region. Hailstones up to four inches in diameter caused 109 hailstone-related injuries and contributed to over $2 billion in damage in Fort Worth, Texas.

Between 1959 and 1992, Oklahoma reported 1,152 hailstorm events. These storms resulted in six injuries, $32 million in property damage, and $250,000 crop damage. If these seem to be conservative figures for a span of 43 years, keep in mind that these amounts only reflect damages that were reported. Most likely many more events had damages that were *not* reported.

In the state of Oklahoma, there were 725 severe hail events in 2006 (largest reported hailstone was 4.25" in Harmon County) with $832K in Property Damages and $176K in Crop Damage; 470 severe hail events in 2007 (largest reported hail was 4.25" in Harper County) with $167K in Property Damage; and for the first two months of 2008 there were 72 severe hail events reported with Property Damage reported of $45K.

On June 1, 2008, a large storm system moved across a large portion of the state, resulting in large hail reported in several locations. Perhaps the most devastating reports came from the small rural community of Mannford (Creek County), where city officials were estimating that every home in the community (approximately 1,100 structures) sustained some form of damage from hail ranging in size from golf balls to tennis balls. It was reported that approximately 600 homes had windows broken out and that every home suffered roof damage, with hailstones actually tearing through some of the roofs and landing inside the homes. Additionally, between 1,000 and 1,500 vehicles sustained heavy damage. Two non-life threatening injuries were reported in this community because of the hail event.

Tulsa County has reported 465 hail events from 1995 through 2009, with $90.8 million in reported damage from 29 of the events. Table 4-23 lists the number of events, number of deaths, number of injuries, number of events that reported damages, and the amount of property damage reported to the NCDC for Tulsa County and Oklahoma.

Table 4–23: Casualties and Damages Caused by Hail from 1995 to 2009
From NOAA National Climatic Data Center http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Location	Events	Deaths	Injuries	Damage Events	Property Damages
Tulsa County	465	0	0	29	$90,779,000
Oklahoma	12,722	0	2	239	$154,564,000

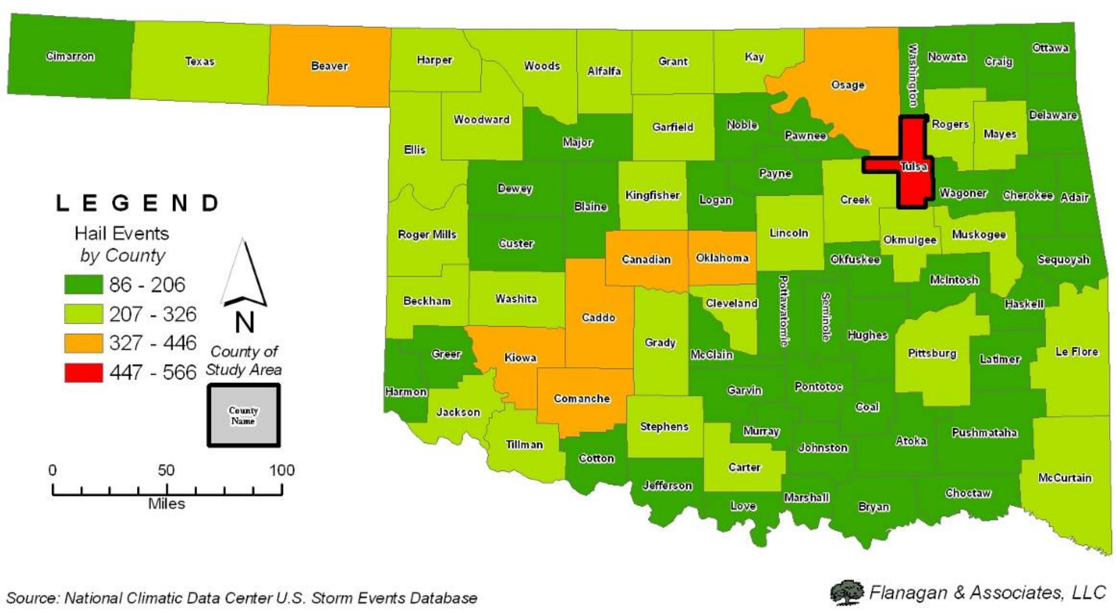
Tulsa County Hail Events

From 1995 through 2009, Tulsa County experienced a reported 465 hailstorms, which did $90.8 million in damage. Some of the more recent and significant events are as follows:

- **March 14, 1996-** 2.75-inch hail caused $50,000 in damage in Glenpool.
- **May 14, 1996-** Jenks reported 2.5-inch hail; Bixby and Broken Arrow, 2.75-inch hail.
- **June 18, 1998-** Hail up to 2.75 inches in diameter was reported at Glenpool. This storm produced the full gamut of severe weather including very large hail to the size of baseballs, damaging thunderstorm winds, and a brief tornado touchdown.

- **May 22, 1999-** There were numerous reports of dime to quarter-sized hail, and one report of tennis ball-sized hail, in southwest Tulsa and north Jenks. 4.5-inch hail fell at 71st and Riverside.
- **March 26, 2000-** Tennis ball size hail was reported near 101st street and Sheridan Ave. A large swath of large hail fell from downtown Tulsa through western and southern parts of the city. Hail damaged many cars and roofs and was driven by wind through numerous windows. Damage was estimated at $2 million.
- **May 5, 2000-** Baseball size hail fell at 81st and Yale, quarter size hail at 81st and Memorial, and golf ball size hail at 81st and Sheridan and 91st and Memorial. Damage was estimated at $1 million.
- **May 6, 2000-** Tennis ball size hail (2.75 inches) fell on the north side of Tulsa.
- **May 1, 2002-** Hail 3.5 inches in diameter fell in Leonard.
- **November 18, 2003-** Baseball hail was reported at 31st and Harvard and then again at 21st and Harvard. The hail broke windows and damaged numerous roofs of buildings and cars. Damage was estimated at $20 million.
- **April 5, 2005-** A supercell thunderstorm in Tulsa County produced a several mile wide swath of large, damaging hail. Reports of golf ball or larger hail were common in the county from Jenks to Tulsa. The largest hailstones reported were 3 inches in diameter. Many automobiles, homes, and businesses were damaged by the hailstorm. Damage was estimated at $65 million.

Figure 4–17: Hail Events in Oklahoma from 1989-2009



North Tulsa County Hailstorms

North Tulsa County (Sperry, Turley, Owasso, Skiatook, and Collinsville) was hit by 50 hailstorms between 1995 and 2009, with reported damage of $729k ($500,000 of this amount from a single, 1.75-inch hail event in Owasso on May 5, 2001). Only 11 of North Tulsa County's 50 hailstorms had stones 1.75 inch or larger, with only one event having 2-inch hailstones. From this data, it can be estimated that North Tulsa County will likely experience an average of 3.3 hailstorms per year, producing hailstones of about 1 inch in diameter, and one damaging hailstorm, with stones 1.75 inches or larger, every 1.4 years. A very severe hailstorm, with 3-inch diameter stones, can be expected once every 10 years.

West Tulsa County Hailstorms

Of the 25 separate hailstorms reported in West Tulsa County (which includes Sand Springs, Prue, Westport and Prattville), 5 storms produced hail 1.75 inches in diameter or larger. The storm of May 20, 2001, which produced hail 1.75 inches in diameter, did an estimated $100,000 in damage in Sand Springs. From this data, it can be estimated that West Tulsa County will likely experience an average of 1.6 hailstorms per year, with hailstones of about 1 inch in diameter. West Tulsa County can expect one damaging hailstorm, with stones 1.75 inches or larger, to impact the area every 3 years, and one very severe storm, with 3-inch hailstones, every 10 years.

South Tulsa County Hailstorms

South Tulsa County (which includes the communities of Jenks, Broken Arrow, Bixby, Glenpool, and Leonard) experienced 82 hailstorms between 1995 and 2009, causing a total damage of $65,295,000 ($65 million of this resulted from one event, on April 5, 2005). Of these events, 16 had hailstones over 1.75 inches in diameter, with the largest stones (3.5 inches, or softball size) falling in Leonard on May 1, 2002. Based on this data, South Tulsa County can expect 5.5 hail events per year, with hailstones of about 1.2 inches in diameter, that cause about $3,000 damage per event; one damaging hailstorm each year, with hail over 1.75 inches in diameter; and one very severe event every 10 years (with hail over 3 inches in diameter) that does million of dollars in damage.

Hail damage in Tulsa County is a function of hailstone size and wind speed. According to data gathered by the National Climatic Data Center, damage in Tulsa County is common once hailstones reach 1.75 inches in diameter—depending, of course, upon wind speed and the nature of the built environment. Because much of unincorporated Tulsa County is sparsely developed, the county is not as vulnerable to the hail hazard as its municipalities. However, the county’s critical facilities, rural residential homes, businesses and farms are vulnerable to hail, as are all future development areas.

Probability/Future Events

A hail is a direct by-product of the thunderstorms that sweep across the state from spring to autumn each year. The entire Tulsa County jurisdiction is subject to thunderstorms of varying severity, with hail present in many of these storms.

Based on history and previous occurrences from the past 10 years, Tulsa County can expect an average of 8.3 severe hail events each year.

4.5.3 Vulnerability

Hailstorms occur in every state of the continental United States, but most frequently in the Great Plains during the late spring and early summer when the jet stream migrates northward. This period coincides with the Midwest’s peak agricultural seasons for wheat, corn, barley, oats and rye, tobacco and fruit trees. Long-stemmed vegetation is especially vulnerable to damage by hail impacts and winds. Severe hailstorms also cause considerable damage to buildings and automobiles but rarely result in loss of life.

Reported damage figures are deceptive, since most losses are not reported through weather service or other government agencies, but through insurance companies. The insurance industry considers hail to be one of its most costly consistent annual disasters. (Source: Insurance Information Institute, www.iii.org.)

Population

Given the climatic environment in this jurisdiction, all demographic groups located within the Tulsa County jurisdiction are vulnerable to the effects and potential damages of hailstorm events. Particularly vulnerable are those pursuing farming and/or ranching activities, as crop damage is the highest percentage of reported hail damages. In addition, people engaged in outdoor recreational activities, such as team sports, golfing or camping, may find themselves without sufficient shelter.

Structures/Buildings

Severe hailstorms cause considerable damage to buildings and automobiles, but rarely result in loss of life.

Given its significant exposure to hailstorms, virtually all buildings and structures in the jurisdiction are at risk. The entirety of Tulsa County is vulnerable to the damaging effects of hail.

Critical Facilities

All critical facilities are vulnerable to hail damage (see Table 1-8 for a complete list of Tulsa County critical facilities). Hail, however, is unlikely to render a critical facility non-operational.

Infrastructure

Water Treatment – It is not anticipated that a hail event would cause a major disruption in the normal operation of the water treatment systems for Tulsa County.

Wastewater Treatment – It is not anticipated that a hail event would cause a major disruption in the normal operation of Tulsa County's wastewater treatment systems.

Utilities – The primary utility providers for Tulsa County are AEP/PSO (electricity) and ONG (natural gas). Neither service would suffer a major disruption from hail.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – During a hail event, public vehicles may sustain damage. If severe enough (such as the hail event on June 1, 2008 in Mannford, OK) there could be some loss of functionality, possibly disrupting normal County operations. During a major storm that is producing hail, it is reasonable to assume that flights leaving and arriving at Tulsa International Airport could be delayed. Aircraft on the runway during a significant event could potentially experience some damage if the hailstones are of a substantial size, and the event is prolonged.

Emergency Services – Fire, Police and Medical Services would all be similarly at risk to the secondary effects of a hail event. Response vehicles in the open would likely be exposed to window and/or windshield damages. A secondary effect could be an increased call and work volume for County services.

If a major hail event were to occur between 7:30 – 8:30 am or 5 – 6 pm on any weekday, the risk of commuters being caught in the event is substantially higher. The daytime population of Tulsa increases by over 74,000 people, as commuters from neighboring communities move over County roads into the city. Drivers seeking to pull under bridges to escape vehicle damage could cause accidents and injuries.

Oklahoma has significant exposure to hailstorms, and virtually all buildings and crops in the storm are at risk. Tulsa County is no exception. The entirety of each jurisdiction is vulnerable to the damaging effects of hail. Future development areas are also at risk.

4.5.4 Hail Scenario

Overview

On Sunday June 1, 2008, Mannford OK (Creek County, approximately 4 miles west of Tulsa County) experienced a major hail event. The storm struck at approximately 9 am, and lasted for nearly 20 minutes. Reports from the local City Manager revealed that every home (approximately 1,100 homes) was affected by this event. Nearly 600 homes sustained broken windows, and every home reportedly suffered roof damage – some so severe that the accompanying rain leaked inside causing further damage. Also damaged were between 1,000 and 1,500 vehicles. Two injuries were reported – neither requiring hospital admission.

The City of Mannford encompasses approximately 6.9 sq. miles, with an estimated housing density of 165 houses-condos/square mile (according to 2005 housing demographics). Considering the number of housing units reporting damage, this would indicate that the storm blanketed the entire city limits ground area.

Tulsa County Comparison

By using these storm coverage figures, and applying them to housing density figures from the same period for Tulsa County, certain conclusions regarding the projected impact of a similar event on this jurisdiction may be drawn.

According to 2008 housing demographics, Tulsa County contained 428 houses-condos per square mile. Based on this information, a storm the size and severity of the June 1, 2008 event could be calculated to affect 2,953 residential structures in a major residential area within the county. With an estimated average repair cost of $4,500 per structure (damages ranging anywhere from a couple of windows damaged with minor damage to shingles, to several windows damaged and/or destroyed and total roof replacement), this would result in total housing damages of $13,288,500.

Comparing the housing density of Mannford to that of Tulsa County (165 vs. 428 units per square mile), it is noted that Tulsa’s density is approximately 2.6 times that of Mannford. Applying that same rate of increase to the number of vehicles potentially affected could mean that approximately 3,250 vehicles would sustain some form of damage. By applying an average repair cost of $500 to each vehicle (mostly broken out windows/windshields, some with very heavy body damage), an average vehicular damage cost of $1,625,000 could be expected.

Utilizing these same comparison methods, Tulsa could expect to see 5 injuries of like nature reported. When applying the values provided in the publication "What is a Benefit?" the total cost of 5 minor injuries (not requiring hospitalization) amounts to $7,800 ($1,560 per injury).

Table 4–24: Hail Scenario Damages

Damage Type	Number of Units	Damage $
Housing	2,953	$13,288,500
Vehicles	3,250	$1,625,000
Injuries	5	$1,560
TOTAL		**$14,915,060**

Scenario Conclusions

This methodology, and the data applied, provides a conservative estimate of damages that could occur in Tulsa County should it experience a hail event of the same scope and duration as the one seen in Mannford. The total for the estimated damages approaches $15 million. This analysis does not include the economic value of time lost working with cleanup, insurance companies, etc., or estimated damages for businesses in the area.

Hail events historically do not receive the depth of reports and information sharing common with other natural hazards. Many homeowners do not report minor claims to their insurance companies, and detailed reports are generally unavailable from insurance carriers because of proprietary information concerns. These factors make it difficult to estimate the actual economic impacts from such events.

4.5.5 Future Trends

For maps of Tulsa County's potential future growth areas, see Figure 1-8.

Population

Because deaths or injuries from hail events are extremely rare, and all areas of the county are equally exposed to hailstorms, the vulnerability of populations in newly developed areas is similar or equal to the vulnerability of already established populations.

Structures/Buildings

In all areas being considered for future development, the construction of new structures/buildings should include plans to employ impact resistant materials and components when available. As buildings are being considered for renovation or converted from one purpose to another, emphasis should be placed on making use of impact resistant materials in roofing and windows.

Critical Facilities

Any future development and renovation of critical facilities should include consideration of the use of disaster resistant materials to improve the community's sustainability. Hail resistant materials should become standard on critical facilities, along with the use of protective screens for external equipment (i.e., air filtration/conditioning systems, backup generators, communication terminals, etc.) to help protect them from damaging weather events.

Infrastructure

As the use of bio-fuels becomes more common, strong consideration should be given to the cultivation of crops supporting this technology. Since agriculture is potentially quite vulnerable to hail damage, the widespread cultivation of bio-fuel crops could create potentially high economic impact from this hazard.

4.5.6 Conclusion

The states in the middle of the Great Plains, particularly Oklahoma, are the most likely to have severe thunderstorms and hail events. The peak season for hail events is in the late spring and early summer. Oklahoma experiences an average of 869 hailstorms each year with hailstones measuring at least 0.75" in diameter, and sometimes as large as softballs.

Tulsa County is vulnerable to the hail hazard, as evidenced by the damaging hailstorm of April 2005, which produced 3-inch diameter stones that did $65 million in damage to cars and structures. All cars, buildings and crops in the county are at risk.

Hailstorms can be expected every year. A severe hail event would likely affect more than 10% of the county's unincorporated property and/or population. A worst-case scenario of a hailstorm could affect up to 25% of the jurisdiction. There is a high probability a disaster level incident similar to the April 2005 event will occur within the next decade.

Measures that can reduce vulnerability to hail damage are the installation of hail-resistant roofing, siding and windows on public buildings and critical facilities, and the provision of roofed shelters for public vehicles.

4.5.7 Sources

Institute for Business and Home Safety, at Web address: www.ibhs.org. Institute for Business and Home Safety, Tampa Florida, August 1999.

Multi-Hazard Identification and Risk Assessment, p. 56–60. Federal Emergency Management Agency, 1997.

NCDC Storm Event Database, at Web address: http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms. National Climatic Data Center.

National Weather Service: Office of Climate, Water, and Weather Services, at Web address: www.nws.noaa.gov/om/hazstats.shtml.

4.6 Winter Storms

A severe winter storm is one that drops more than 2 inches of snow or more than ¼ inch of ice. An ice storm occurs when freezing rain falls from clouds and freezes immediately upon contact.

The National Weather Service (NWS) in Tulsa issues a winter weather advisory when one to three inches of new snow is expected or icing which makes driving and walking hazardous. A winter storm warning is issued when a variety of hazardous conditions are forecast to occur across the area, or when there is difficulty in determining the type of conditions which will predominate.

4.6.1 Hazard Profile

A winter storm can range from moderate snow over a few hours to blizzard conditions with blinding wind-driven snow that lasts several days. Many winter depressions give rise to exceptionally heavy rain and widespread flooding. Conditions worsen if the precipitation falls in the form of snow because it occupies seven to ten times more space than the same quantity of rain. The aftermath of a winter storm can impact a community or region for weeks, and even months.

Tulsa County is vulnerable to ice storms produced by warm, moist Gulf air colliding with arctic air from Canada.

Winter storms are associated with the following hazards:

- Extreme cold causing wind chill factors dangerous to humans and animals;
- Snow accumulation causing blocked transportation routes;
- Reduced visibility and slick surfaces causing hazardous driving and walking conditions;
- Reduced ability of emergency response organizations, such as fire, law enforcement, or medical, to respond quickly;
- Power lines and tree limbs coated with heavy ice causing power and telephone service disruptions;
- People using unsafe heating or electrical generation thus putting themselves and emergency or utility personnel at risk.

Winter storms cause great inconvenience, injuries and deaths. Everyone is affected by the loss of mobility. Streets and highways are slick and hazardous and even walking from house to car can be dangerous. Public transportation is often blocked. Residents, commuters, travelers and livestock may become isolated or stranded without adequate food, water and fuel supplies. People are often inconvenienced or at risk of physical harm from loss of power to their homes. Above-ground electrical and telephone lines and tree limbs are often coated in a heavy build-up of accumulating ice and can break when under the stress of sufficient weight. Falling trees also often down power lines. When electrical lines are damaged, other utilities, such as natural gas, can become inoperable.

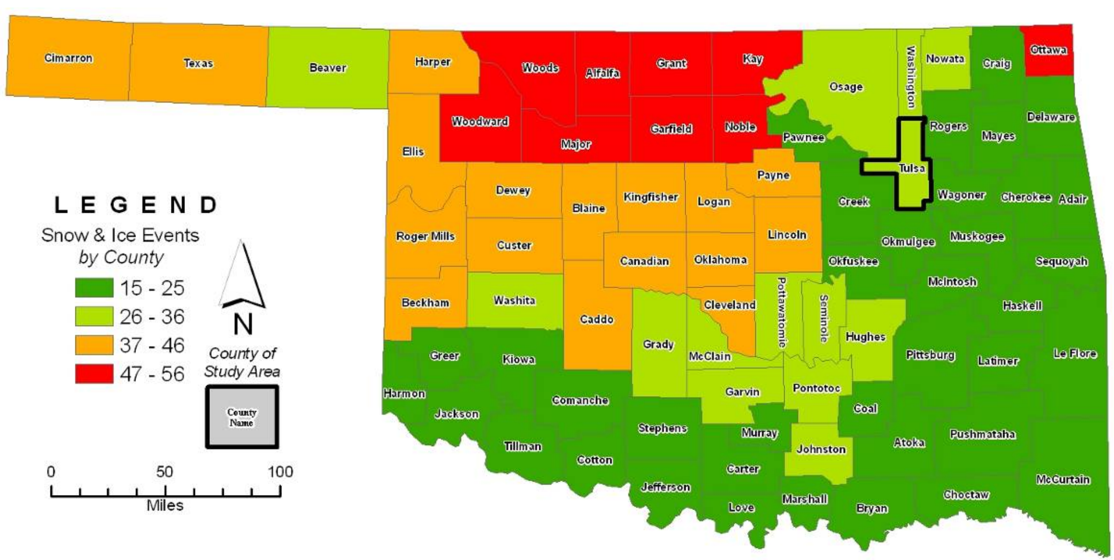
Winter storms are deceptive killers because most deaths are indirectly related to the storm. While approximately 70 percent of deaths from winter storms occur due to traffic accidents, other risks may include:

- cold temperatures that accompany winter storms create the threat of hypothermia, primarily in the elderly;
- slips and falls due to slippery walkways;
- back injuries or heart attacks may occur during snow removal or debris cleanup;
- house fires which occur more frequently in winter. This is due to lack of proper safety precautions when using alternate heating sources, i.e. unattended fires, improperly placed space heaters, etc. Fires during winter storms present a great danger because frozen water supplies may impede firefighting efforts.
- improper hookup of home generators which may cause “back feed” into electrical transmission lines thought to be disconnected, threatening utility workers;
- carbon monoxide from improperly located or vented generators or other heating sources.

Location

The northeast corner of Oklahoma experiences the periodic collision of warm, moist Gulf air and arctic air from the Canadian Shield. Because of this climatic positioning, Tulsa County experiences winter weather ranging from extreme sub-zero temperatures, snow and freezing rain to mild, spring-like days. Therefore the jurisdiction of Tulsa County is considered vulnerable to the effects of a severe winter ice/snow event.

Figure 4–18: Snow and Ice Events in Oklahoma from 1989-2009



Source: National Climatic Data Center U.S. Storm Events Database *Flanagan & Associates, LLC*

Measurement

The *Wind Chill* temperature is a measure of how cold the wind makes real air temperature feel to the human body. Since wind can dramatically accelerate heat loss from the body, a blustery 30° day would feel just as cold as a calm day with 0° temperatures. The index was created in 1870, and on November 1, 2001, the National Weather Service released a more scientifically accurate equation, which is used today. (Note that the chart is not applicable on calm days or when temperatures are over 50°.)

Table 4-26 gives four physical intensity level categories of winter storms, the conditions associated with each level, and their potential impacts on Tulsa County.

Table 4–25: NOAA's Wind Chill Chart

Source: National Weather Service and NOAA

Wind Chill Chart

Wind (mph)	Temperature (°F)																	
	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	29	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Table 4–26: Balthrop's Winter Storm Physical Intensities

Source: State of Oklahoma Hazard Mitigation Plan

Event Level	Conditions	Impacts
Level 1 – Nuisance Event ***No Major Impact***	Little snow/ice accumulation. Roads not hazardous	Little to no effect on the Jurisdiction.
Level 2 – Minor Event ***Caution Advised***	Dusting to 2 inches of snow. No measurable ice. ***Winter Weather Advisory***	Untreated roadways may become hazardous and slick. Livestock may need additional supplemental feed.
Level 3 – Major Event ***Isolated Emergency Conditions In the Jurisdiction***	Significant Snow Accumulations 2-8 inches. Ice Accumulations of ¼" to ½". Reduced visibility. Wind causing drifting snow. ***Winter Storm Warning***	Widespread hazardous road conditions. Travel discouraged. Areas isolated because of drifting snow. Isolated power outages because of down power lines from ice accumulation. Tree damage. Livestock loss potential increases, supplemental feed necessary.
Level 4 – Extreme Event ***The Jurisdiction is Under a Full State of Emergency***	Crippling Event. Snow accumulations over 8 inches. Winds over 35 mph. Drifting snow, little to no visibility. Ice Accumulations of more than ½ inch. ***Blizzard Warning***	Road conditions hazardous to impassable. People and livestock isolated. Widespread power and utility outages. Infrastructure damage. High potential for loss of livestock. Structures threatened from accumulating snow and ice. Communications infrastructure lost from ice accumulation. May be a long lasting event.

Table 4–27: The Sperry-Piltz Ice Accumulation Index (SPIA Index)

Source: NOAA

ICE DAMAGE INDEX	RADIAL ICE AMOUNT (inches)	WIND (mph)	DAMAGE AND IMPACT DESCRIPTIONS
1	0.10-0.25 0.25-0.50	15-25 <15	Some localized utility interruptions possible, typically lasting a few hours. Roads may become slick and hazardous.
2	0.10-0.25 0.25-0.50 0.50-0.75	25-35 15-25 <15	Scattered utility interruptions expected, typically lasting less than 12 hours. Roads and travel conditions may be extremely hazardous due to ice accumulation.
3	0.10-0.25 0.25-0.50 0.50-0.75 0.75-1.00	>=35 25-35 15-25 <15	Numerous utility interruptions lasting up to 5 days. Some damage to main feeder lines expected.
4	0.25-0.50 0.50-0.75 0.75-1.00 1.00-1.50	>=35 25-35 15-25 <15	Prolonged and widespread utility interruptions lasting 5-10 days. Extensive damage to main distribution feeder lines and possibly some high voltage transmission lines.
5	0.50-0.75 0.75-1.00 1.00-1.50 >1.50	>=35 >=25 >=15 any	Catastrophic damage to entire exposed utility systems, including both distribution and transmission. Outages could last several weeks in some areas. Shelters needed.

Extent

Physical damage to homes and facilities can occur from wind damage, accumulation of snow, ice, and sleet. Even small accumulations of snow can wreak havoc on transportation systems, due to a lack of snow clearing equipment and experienced drivers. (OEM King County)

Winter storms are deceptive killers because most deaths are indirectly related to the storm. While approximately 70 percent of deaths from winter storms are due to traffic accidents, other risks may include:

- cold temperatures that accompany winter storms create the threat of hypothermia, primarily in the elderly;
- slips and falls due to slippery walkways;
- back injuries or heart attacks may occur during snow removal or debris cleanup;
- House fires occur more frequently in winter due to lack of proper safety precautions when using alternate heating sources, i.e. unattended fires, improperly placed space heaters, etc. Fires during winter storms present a great danger because frozen water supplies may impede firefighting efforts.
- Improper hookup of home generators may cause "back feed" into electrical transmission lines thought to be disconnected, threatening utility workers;
- Carbon monoxide from improperly located generators or other heating sources may threaten residents.

The extent of a winter storm in Oklahoma can vary greatly, influenced by a variety of factors. The local weather conditions can influence the extent of a storm, as can the way ice and snow accumulate. Even a relatively minor winter storm, with ice buildup on elevated roadways and bridges, can become dangerous, interfering with the mobility of the public, power company officials, first responders and emergency management officials due to slick, hazardous and/or impassable roads. There can also be catastrophic winter storms in Oklahoma which impact multiple jurisdictions because of downed power lines and trees due to ice accumulation on wires and branches. Ice damage to trees and power lines can lead to days, if not weeks, of isolation from the power grid, thus greatly expanding the extent of this natural hazard. The extent of the impact of a winter storm can be lessened by identification of at risk populations, by weather warnings and notifications, by the establishment of warming rooms and utility bill assistance programs, road condition alerts, ensuring backup electric power generation is available for critical facilities, burying power lines, and so forth.

January 30, 2002, a winter storm caused widespread damage in Stillwater.

Tulsa County considers a minor severity to be no loss of function of transportation, no loss of life, and no loss of electrical or water service and a major severity to be loss of function of transportation, loss of life, or loss of electrical or water service.

Frequency

Oklahoma averages 14 winter storm events each year. Occurrences of daily low temperatures below freezing range from an average of 140 days per year in the western panhandle to 60 days in the Red River plain in extreme southeastern Oklahoma. Occurrences of daily high temperatures below freezing range from an average of 15 days per year in portions of north central and northwest Oklahoma to 3 days per year in the southeast.

Tulsa County experienced 29 snow and ice events during the period 1995 to 2009. Given this frequency, Tulsa County can expect two winter storm events each year.

The winter storm of January 2007 left thousands in southeastern Oklahoma without power for over a week.

Impact

The impact of this hazard can affect a region for weeks and even months. Houses, roads, electrical poles and lines, water systems, people and cattle are all vulnerable to severe winter storms. Houses are damaged from the weight of the ice, roads buckle and or become slick and hazardous, electrical poles and lines break, and people loose electricity and heat, water lines freeze and burst due to the cold weather and people and livestock have no water. People and livestock are susceptible to frostbite and death from exposure.

4.6.2 History/Previous Occurrences

Between 1995 and 2009, 245 deaths were attributed to severe winter storms in the United States. The super storm of March 1993, considered among the worst non-tropical weather events in United States history, killed at least 79 people, injured more than 600, and caused $2 billion in property damage across portions of 20 states and the District of Columbia.

The National Climatic Data Center reported 29 snow and ice events for Tulsa County between 1995 and 2009. Particularly noteworthy was the December 2000 storm and the winter storms of January and December 2007. By far the most devastating storm was that of December 9-10, 2007, probably the most destructive ice storm in Tulsa history.

Table 4–28: Casualties and Damages Caused by Winter Storms from 1995 thru 2009
From NOAA National Climatic Data Center http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Location	*Events*	*Deaths*	*Injuries*	*Damage Events*	*Property Damages*
Tulsa County	29	0	0	3	$50,154,000
Oklahoma	345	1	6	66	$730,134,000

In Oklahoma, the National Climatic Data Center reported 345 winter storm events with snow, ice, sleet, freezing rain and drizzle during the 15-year period from January 1995 to November 2009. There was more than $730 million of property damage because of these winter storms.

Recently, Oklahoma has been slammed by major severe winter storms resulting in Federal Disaster Declarations. On Christmas Day, 2000, Oklahoma was hit by one of the most costly natural disasters in its history. Where the precipitation fell as freezing rain, ice accumulations were around one inch. Thousands of homes and vehicles were damaged by falling trees and ice, while thousands of trees and utility poles were damaged or destroyed. Statewide, nearly 170,000 residents were without electricity, many for nearly a week. Six indirect fatalities were associated with this storm: three individuals were killed in motor vehicle accidents, two women died after falling on the ice, and a utility worker was electrocuted while attempting to restore electrical power. As of December 2001, $122.26 million in disaster aid was sent to Oklahomans to facilitate recovery from this storm. Tulsa County was included in the disaster declaration, and had more than 1800 homes affected with 12 shelters in operation. According to Mike McCool, three NCDC events from December 11th, 2000 through January 10th 2001 were included in Disaster FEMA-1355-DR-OK.

The terrible power of severe winter weather was demonstrated again in Oklahoma on January 30, 2002, when another record-breaking ice storm hit the state. In many areas, freezing rain continued for 12 to 24 hours, with ice accumulations of 1 to 2 inches common. As the end of the storm neared, freezing rain transitioned to sleet and snow. The worst damage resulting from ice accumulations occurred near Ponca City, Blackwell, Red Rock, Perry, and in Stillwater. The damage was catastrophic in places, with thousands of utility poles brought down by the weight of ice, along with thousands of trees. Dozens of towns were left without power for days, with some residents without power for up to six weeks. At one point, nearly 250,000 residents were without power. In addition to several traffic-related fatalities during the storm, an elderly woman died from hypothermia in her home when electricity to her house was knocked out. Total damage across the state was in the hundreds of millions of dollars, exceeding the damages from the Christmas Day storm of 2000. The Governor declared 44 counties a disaster area. Tulsa County was included.

A severe winter storm hit Oklahoma again during the week of January 15, 2007. Freezing rain and snow blanketed much of the State, with counties in the east part of the state being particularly hard hit, among them Muskogee County. The city of McAlester was without power for over one week, and there were portions of Muskogee that were also without power for as long as two weeks. In all, 23 people died as a result of the storm between January

In terms of damage and power outages, the winter storm of December 2007 was the worst in Tulsa history, and resulted in a Presidential Disaster Declaration.

12-18, 2007. Tulsa County had one shelter open and operating during this event, with the Tulsa Airport suffering damages of $193,000, Tulsa Public Schools suffering damages of $524,000, and the City of Tulsa suffering damages of $2,470,000.

An ice storm hit Oklahoma again on December 9-10, 2007, causing widespread damage to trees and structures and resulting in 12 deaths in Tulsa County and 25 throughout the state, most of them from automobile accidents on icy roads and downed power lines. Mike McCool reported that the Tulsa MSA had 260,000 power outages for this event. Many homes and businesses were without power for over a week. The cleanup effort required federal assistance and took months to complete.

Damage for this storm was estimated at $50 million. Cleanup of the tree debris from the storm took months, and in Tulsa created 2.79 million cubic yards of debris. Among the impacts of this event were power outages to 226,000 homes in Tulsa; 12 deaths in Tulsa; Tulsa International Airport was closed to incoming/departing flights for 24+ hours; and 3 Tulsa hospitals were forced to rely on emergency generators. PSO called on power companies in 14 other states to assist in servicing the electric grid in Tulsa. There were 5,000 additional workers, of which 2,500 were linecrew, 2,000 were vegetative, and 500 were support crew.

4.6.3 Vulnerability

Population

A broad spectrum of any community's population is vulnerable to the effects of winter storms. People who travel in winter storms are at the most risk. 70% of winter storm-related deaths occur in cars, more than the number of people caught out in the storm. The elderly are also at risk due to poor health and frequent isolation. People over 60 years of age account for half of all exposure-related deaths. According to NOAA, 50% of hypothermia cases occurred in people over the age of 60. In addition, more than 75% of all hypothermia victims were found to be male. Exhaustion and heart attacks caused by overexertion are also likely causes of winter storm-related deaths.

Tulsa has four shelters providing refuge for the homeless population. During the December 2007 ice storm, all shelters were reporting operation at or above capacity. The homeless population is also a high-risk population to the effects of a severe Winter Event.

As witnessed to by the 29 snow and ice events during the period 1995 to 2009, and the four Presidential Disaster Declarations for Tulsa County, the Tulsa area has a high vulnerability to winter storms. This vulnerability applies to all future development areas in the county.

Structures/Buildings

A direct threat to structures/buildings from a severe winter event would be excessive snow/ice accumulation onto flat or low-sloped roof surfaces. This would be especially true of older structures not built to withstand that type of stress. Indirect threats to structures/buildings would be power outages causing interruption to heating (loss of supplies, food, sensitive equipment) and frozen water pipes (excessive flooding causing damage to interiors and sensitive electronic equipment if pipes break) and; fires caused by power lines being torn away from structure, or from power surges when lost power is restored. During the peak period of the December 2007 Ice Storm, Tulsa Fire Department responded to more than 200 structure fires in 5 days.

Critical Facilities

During a winter event, all critical facilities in the Tulsa jurisdiction would be susceptible to the same potential effects. Power outages causing interruption of vital services and inaccessibility due to road closures or blockages from ice/snow accumulation or debris from damaged trees. A map of vulnerable facilities is located on page 28.

During the December 2007 ice storm, 3 Tulsa hospitals were dependent on generator power for an extended time, and a nursing home in Collinsville was forced to evacuate its 90 residents because of power outages. In addition, 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.

Infrastructure

Water Treatment – Most significant effect during a winter event would be from loss of electrical power, delays to chemical deliveries (road inaccessibility), personnel and staffing issues. Both of the City of Tulsa's water treatment plants (which supply most of Tulsa County) would be vulnerable to these risks.

During the 2007 ice storm, the Mohawk Water Treatment Plant was offline for a period of approximately 4 days. Due to the severity of the storm, electric power from both feeds to the plant was interrupted. The A.B. Jewell plant was able to provide water during the event and meet the baseline needs of much of the jurisdiction. Due to widespread power outages, the overall water demand was significantly reduced.

Wastewater Treatment – 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. In the December 2007 ice storm no outages were reported at any of the stations.

Utilities: Damage to utilities infrastructure can result in damages of up to $2 billion per winter storm event. The primary utility providers for Tulsa County are AEP/PSO (electricity) and ONG (natural gas). The service stations and substations for both of these providers would be vulnerable to the risks from a severe winter event.

Electricity - During a winter event, providers of electrical service could experience any combination of the following challenges in meeting the needs of the jurisdiction: Destruction of distribution and transmission poles, downed broken power lines, staffing issues due to the inclement weather (some workers may not be able to get out of their homes), danger to workers from downed power lines, hazardous road conditions and fallen debris from trees, and insufficient field and/or office staff to effectively handle the workload.

As a result of the December 2007 ice storm, AEP/PSO reported 226,500 customers without power (78% of their Tulsa County customer base), 750-800 distribution poles broken, approximately 150 transmission poles broken and countless miles of power lines repaired/replaced. Additionally, 4,600 restoration workers were employed (as opposed to 600 in normal operations) working 73,600 man-hours per day (4,600 workers putting in 16-hour days) with support staff handling more than 512,600 calls pertaining to the event.

Gas – During a winter event, providers of gas service to a community could experience a variety of challenges in meeting the needs of Tulsa County customers, including: damage to gas meters from ice accumulation, fallen power lines or tree debris, inaccessibility of underground gas meters from fallen debris, danger to field employees related to road conditions, downed power lines, extreme temperatures, and insufficient field and/or office staff to effectively handle workloads generated by such an event.

During the December 2007 ice storm, ONG reported that there were approximately 50 above-ground gas meters damaged due to downed power lines and tree debris; several underground meters inaccessible due to debris, and several instances where field employees had to practice extra caution while working in areas affected by fallen electric lines and tree limbs. Fortunately, ONG reported no customer outages related to the storm.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – All manner of transportation would be at risk during a winter event in Tulsa County. Road closures due to ice/snow accumulation can result in loss of retail trade, wages and tax revenue. The inability of public transportation (taxis, buses) to function during and after a winter event can also put the population at risk if it hampers access to necessary medical care or safe shelter. Fortunately, Tulsa's public bus system (MTTA) experienced only minor disruptions in their operations during the December 2007 ice storm, and was able to provide essential services to the local Emergency Operations staff.

Flight delays cost an average of $3.2 billion annually for air carriers in the United States. Severe winter weather could result in the interruption of normal operations at Tulsa's International Airport and the private business airports in the county. Major ice or snow accumulations can impact runway safety and result in cancellation or major delays in flight schedules. December 2007's storm resulted in cancelled flights by all airlines servicing TIA for over 24 hours. In addition to delaying the transportation of goods and materials, passengers were stranded with no real timeline for resumption of services. The impassability of roads in the area stranded many travelers at the airport.

Emergency Services – Fire, Police and Medical Services are all vulnerable to the impact of winter storms. Staffing issues due to workers not being able to travel, danger to workers from downed power lines, hazardous road conditions and fallen debris, and insufficient field and/or office staff to effectively handle increased workloads would be expected in all areas.

Downed power lines and fallen trees can also make roads impassable or in other ways cause delays of emergency personnel, reducing both fleet resources and manpower (injuries). During the December 2007 ice storm, the Tulsa Police Department reported 11 cars damaged during the event.

4.6.4 Winter Storm Scenario

Overview

The Eastern portion of Oklahoma experienced two major winter storm events in 2007. The first occurred in January, hitting Muskogee and surrounding counties the hardest. The second came in December, wreaking havoc across much of Oklahoma, but having its greatest impact on Tulsa County. Both of these events resulted in an Emergency Declaration by the Governor of Oklahoma for all 77 counties in the state. The major impact from both storms was widespread and prolonged power outages, which had a profound impact on both residential and business communities.

The response phase of the January 2007 winter event was longer in duration than for the December event, largely because of the temperatures were lower both before and after the precipitation, roads were inaccessible longer, people required shelter longer, and smaller, rural communities experienced severe potable water issues due to power outages at pump stations.

Daytime temperatures during the January event remained at or near freezing, with nighttime temperatures dropping into the teens and twenties for several days. By contrast, the temperatures during the December event remained well above freezing during the day and fell into the upper twenties and lower thirties at night. The higher daytime temperatures allowed roadways and power lines to be cleared of ice and recovery to begin more quickly.

The two events are difficult to compare, because the first storm impacted mainly small rural communities around Muskogee, and the second metropolitan Tulsa. However, by applying key assumptions such as (a) Equivalent Temperature Conditions, (b) Equivalent Ice Accumulations, and (c) Equivalent Resource Response, some very basic correlations between the January and December events may be made. Tulsa County and City officials have acknowledge that an event as widespread as the December storm, combined with the frigid temperatures of the January storm, would seriously hamper the ability of the communities to recover from the damage.

To examine the impact of such an event, an analysis of key points of data was performed and applied to the base information from Tulsa's event. Data utilized for this analysis was gathered from Daily Situation Reports from the State of Oklahoma Department of Emergency Management, the NOAA National Climatic Data Center and the National Weather Service Forecast Office. The SitReps reviewed for the Muskogee event provided data for 11 days, so this time frame was applied to the scenario.

Summary of Muskogee Event – January 2007

SitReps, including information for the Muskogee area, began on January 13th with an initial reporting of 11,095 customers without power, and concluded with a final report on

January 23rd showing 92 customers still without power. The rate of restoration, shown as a percentage of the customer base, is presented in Table 4-29.

Table 4–29: Summary of Muskogee Event – January 2007
Source: National Climatic Data Center

Date	Daily High	Daily Low	Customers Without Power	% increase / decrease restoration
13-Jan	41	25	11,095	--
14-Jan	30	25	10,062	-9.31%
15-Jan	31	24	8,587	-14.66%
16-Jan	26	16	9,156	6.63%
17-Jan	21	16	9,277	1.32%
18-Jan	30	20	9,039	-2.57%
19-Jan	33	22	7,267	-19.60%
20-Jan	40	23	6,497	-10.60%
21-Jan	38	32	3,564	-45.14%
22-Jan	37	31	322	-90.97%
23-Jan	35	19	92	-71.43%

Oklahoma Highway Patrol reported nearly 700 motor vehicle accidents (injury/non-injury/fatal) over that period across the state. 19 fatalities were attributed to traffic accidents. Oklahoma Department of Transportation discouraged travel on many roadways due to the presence of “black ice”. ODOT resumed normal operations on January 21st.

There were 8 fatalities related to hypothermia, 2 to smoke inhalation and 3 as a result of falls, bringing the statewide total to 32. Oklahoma State Department of Health reported that nearly 4,000 people were treated at Oklahoma hospitals for various injuries related to winter storm conditions.

On January 21st, the American Red Cross reported 4,742 overnight stays in the various shelters established throughout the state for this event. Assuming shelters began operating on the night of January 12th and ran through the night of January 20th, this would equate to approximately 526 shelter residents per night. Many of those without power and heat chose to remain either in their own homes or those of family members/friends, citing their fear of looting as a primary reason. The Red Cross and the Salvation Army served approximately 70,000 meals at mobile and fixed feeding sites.

Prolonged freezing temperatures created a largely undocumented side effect – ruptured water lines. Many older, less insulated homes experienced frozen water lines that ruptured pipes. Depending on where the breaks occurred, this could cause anywhere from minimal to catastrophic damage to a residence. No official data on this damage has been made available to date.

Summary of Tulsa Area Event – December 2007

The first SitRep reporting customer power outages for Tulsa County was issued on December 10th with a total of 75,000 customers without power, however as precipitation continued to fall, that number rose to 225,769 the following day. For the purpose of this scenario, the December 11th report will serve as the starting point. On December 21st, the SitRep stated that power had been restored to all structures that could safely receive power. Table 4-30 demonstrates the rate of restoration.

For the duration of this event, the daytime temperatures did not dip below freezing – and actually were reported in the upper 50's / lower 60's within one week. This warming trend contributed greatly to the elimination of ice accumulation on streets, power lines, and trees, allowing the recovery phase to begin quickly. Crews were able to begin almost immediately to clear toppled trees and broken/downed power poles/lines.

Twenty-nine fatalities were reported for this event: 16 were related to motor vehicle accidents, 9 to house fires, 2 to carbon monoxide poisoning and 2 to hypothermia. One injury was reported in the SitReps, a lineman who was injured on duty and hospitalized.

Table 4–30: Summary of Tulsa Area Event – December 2007
Source: National Climatic Data Center

Date	Daily High	Daily Low	Customers Without Power	Percent Restored
11-Dec	36	32	225,769	--
12-Dec	*35*	*32*	178,507	20.93%
13-Dec	*34*	*31*	169,724	3.89%
14-Dec	*41*	*30*	81,000	39.30%
15-Dec	*38*	*25*	62,454	8.21%
16-Dec	*44*	*20*	42,145	9.00%
17-Dec	*55*	*25*	30,205	5.29%
18-Dec	*56*	*35*	8,344	9.68%
19-Dec	*62*	*27*	2,000	2.81%
20-Dec	*61*	*36*	1,000	0.44%
21-Dec	*65*	*31*	--	0.44%

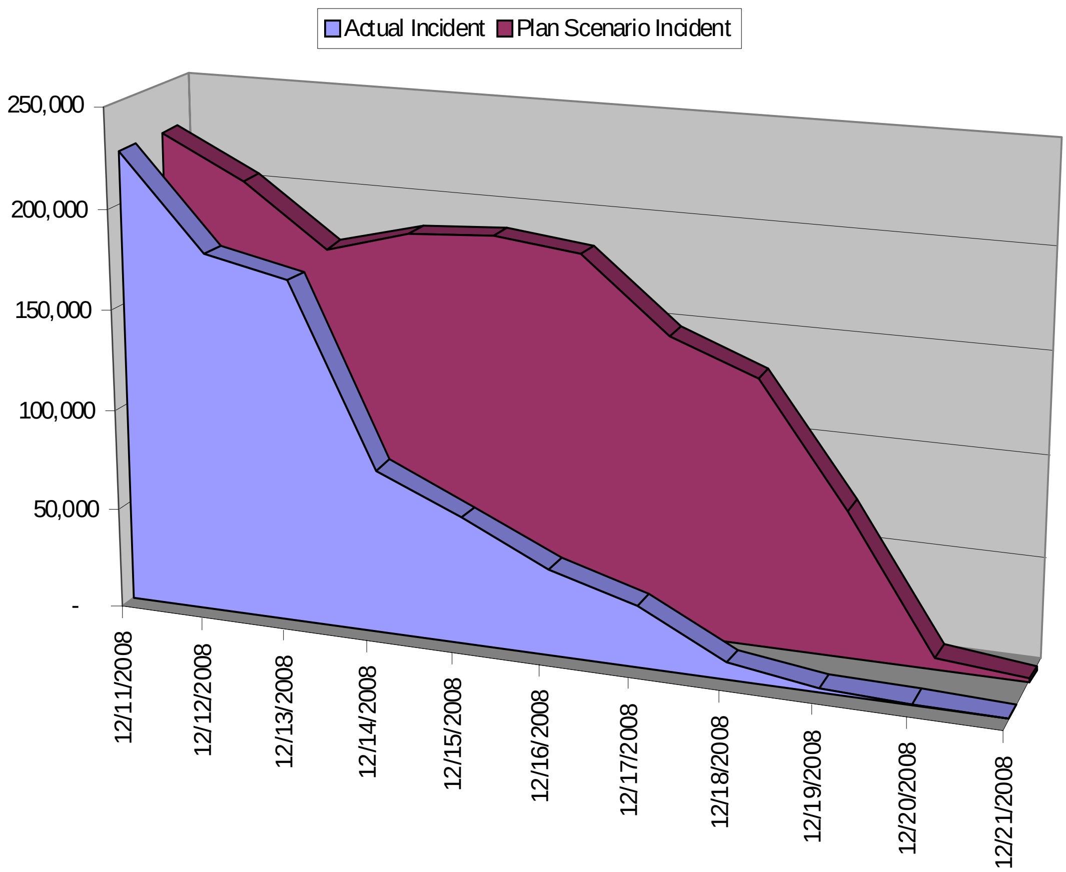
People who sought shelter during this event were much greater than in January. The American Red Cross reported a shelter population of over 2,000 on December 11th, 860 on the 17th, and 30 on the 19th, with all shelters closed the following day—an average of 1,836 shelter residents per night. But as noted above, the shelter populations fell off sharply the last three days of operation.

Introduction to Proposed Scenario

By applying the Rate of Restoration determined for the Muskogee/January event to the initial number of affected customers for the Tulsa/December event, a comparison of certain Economic Values can be made. A comparison of the Tulsa rate of restoration to the Scenario rate of restoration is shown in the figure below.

What this demonstrates is that under the scenario conditions, the number of customers without power is higher for longer. For the 11 days used in this analysis, the actual Tulsa reported outages averaged 80,114 customers/day without power. For the same time period under the Scenario rate, the average increases to 138,663 customers/day.

Figure 4–19: December 2007 Ice Storm Scenario



This can be translated into an economic value of loss for utilities. Assuming the average cost of electricity in Oklahoma (as of April 2009) is $0.0747 per kilowatt hour (kWh), and the average household use is 1,000 kWh per month (or 33 kWh/day), the average lost revenue to utilities per day can be found by multiplying the average number of households without power by the number of days, by the cost of 33 kWh (or $2.49/day). (See "What does electricity cost?" at http://michaelbluejay.com/electricity/cost.html) Using these numbers, the average revenue losses for electric utilities would be $345,270 per day during the 11-day outage, or a total loss of about $3,797,970. These numbers are conservative, since electricity use in winter would normally be considerably above average usage. (While for the City of Tulsa, the numbers would be an average loss of $199,483 per day, or a total loss of about $2,194,322.)

The same comparison can be made regarding the Economic Value of the Interruption of Daily Activities. When people have been affected by any disaster, there are scores of tasks and chores to be dealt with: evacuation, cleanup of damaged property, meeting with insurance representatives, emergency officials and social service agencies, arranging alternate daycare schedules and transportation, and so on. The time spent dealing with these issues is "time lost" from normal occupations and earnings. This "time lost" is valued at $21.16 per person, per hour, per day. For the purposes of this scenario, the total number of *customers* is used—a conservative figure, since time lost for actual customers is probably twice that number, since in most cases a customer represents a household or small business rather than a single individual. By multiplying the average number of customers without power (138,663) by $21.16, and the product by the number of hours lost (12 in this scenario), we arrive at the Value of Interruption of Daily Activities, which is an average of $35,209,308 per day. As for total losses, the 11-day Winter Storm Scenario for Tulsa County would produce $3,798,000 losses for utilities, and $387,304,000 in lost earnings for the community as a whole.

The following chart provides comparisons between the Actual and Scenario Economic Values for both of these categories.

Table 4–31: Actual vs. Projected Economic Losses for Tulsa Winter Storm Scenario

	Scenario Event Economic Values			Tulsa Actual Event Economic Values		
Dates	Customers	Economic Value of Loss of Utilities ($0.0747/kwh)	Economic Value of Interruption of Daily activities ($21.16 x customers x12hrs)	Customers	Economic Value of Loss of Utilities ($0.0747/kwh)	Economic Value of Interruption of Daily activities ($21.16 x customers x12hrs)
11-Dec	225,769	$ 562,164	$ 57,327,264	225,769	$ 562,164	$ 57,327,264
12-Dec	204,750	$ 509,827	$ 51,990,120	178,507	$ 444,482	$ 45,326,497
13-Dec	174,734	$ 435,087	$ 44,368,457	169,724	$ 422,612	$ 43,096,318
14-Dec	186,318	$ 463,931	$ 47,309,866	81,000	$ 201,690	$ 20,567,520
15-Dec	188,778	$ 470,082	$ 47,934,509	62,454	$ 155,510	$ 15,858,319
16-Dec	183,926	$ 457,975	$ 46,702,489	42,145	$ 104,941	$ 10,701,458
17-Dec	147,877	$ 368,213	$ 37,548,927	30,205	$ 75,210	$ 7,669,653
18-Dec	132,202	$ 329,182	$ 33,568,731	8,344	$ 20,776	$ 2,118,708
19-Dec	72,526	$ 180,589	$ 18,415,801	2,000	$ 4,980	$ 507,840
20-Dec	6,549	$ 16,307	$ 1,662,922	1,000	$ 2,490	$ 253,920
21-Dec	1,871	$ 4,658	$ 475,084	-	$ -	$ -
Total	1,525,300	$ 3,798,015	$ 387,304,170	801,148	$ 1,994,855	$ 203,427,497

Conclusions / Additional Considerations

These comparisons are just two of the many areas to consider in this type and scope of event. But looking at these numbers, there is an increase of 47% in Economic Value under the scenario utilizing a prolonged Rate of Recovery. Some other considerations would include:

- With lower temperatures prevailing for 4 days or more, clearing of fallen trees would have been delayed. This could trickle down to the delay of accessibility to homes for wellness checks. Many homebound, elderly, socially-isolated individuals were unable/unwilling to leave their homes. First responders were able to go door-to-door to check on these residents – thus ensuring their wellbeing and their awareness of possible resources for shelter and meals almost immediately after the December storm passed. Not being able to address this critical service in an expeditious manner could potentially result in a higher fatality rate due to exposure.

- Without the warmer daytime temperatures melting the ice so quickly, more damage to trees and power lines/poles could occur. Again, this could create secondary effects of larger numbers structures damaged, power outages lasting even longer, greater numbers of injuries caused by falling debris, more house fires (more trees down translates to more power lines pulled from structures which leads to greater potential for power surges during the restoration process), etc.
- Under actual conditions, residents of Tulsa were able to travel to nearby convenience stores to obtain daily food and supplies, and to intermingle with others similarly affected…a true benefit to a community dealing with such a widespread crisis. With bitter temperatures prevailing at night, with near/below freezing temperatures during the day, streets and sidewalks would have become impassable for several days. This would have effectively isolated many residents in their homes. Aside from the impact of not being able to get out to care for basic needs, stress from that isolation would have settled in on an already stressed population.
- Additionally, those very same retail outlets would have experienced a further economic blow from a reduced customer flow. The Chamber of Commerce reported that 50% of the Tulsa businesses surveyed after the ice storm reported power outages. The median length of service interruption was 4.5 days, resulting in an average of $5,100 lost in income. Again, larger numbers affected for longer times would be experienced with lower temperatures. This of course would translate into more businesses reporting larger losses.

4.6.5 Future Trends

For a map of Tulsa County's potential future growth areas, see Figure 1-8.

Population

Increasing energy costs combined with the increase in cost of basic necessities will continue to put a strain on those in the jurisdiction already struggling to take care of their most basic needs. A steadily increasing population relying on fixed incomes could very easily translate into an increasing population unable to provide heat for their homes in times of severe winter weather.

Additionally, more and more elderly are choosing to remain in their homes rather than move into assisted/progressive living situations – many of them with some type of special needs that may be exacerbated during such an event. Any populations with special needs will require additional planning considerations.

Structures/Buildings

All residential, commercial and industrial buildings added to the County's inventory should take certain planning precautions. For all new construction, attention to the placement of trees and large shrubs is necessary to reduce the risk of power line interference. Burying of electrical power lines when possible is most favorable. Commercial and industrial projects should include adequate backup power systems to protect critical equipment and data storage.

Critical Facilities

All considerations for Structures/Buildings above also apply to critical facilities. Several mitigation measures included in this plan address the issue of power outages at Tulsa County fueling stations and water/wastewater plants. In addition, due to the extremely widespread power outages in December of 2007, this plan includes a mitigation measure addressing the development of a Comprehensive Master Generator Plan which reviews the capabilities of all County facilities, their role in the response and recovery process, their current capabilities to keep up and running during an extended power outage, and the costs of retrofitting them to a sustainable level.

Infrastructure

Since many new residential subdivisions are including buried power lines as part of their planning, it is hopeful that this mitigation measure will produce a measurable effect on future winter storms in currently undeveloped areas.

4.6.6 Conclusion

Severe local winter storms are probably the most common widespread hazard. In latitudes and locations subject to northern winter jet streams pulling arctic air into their area, severe winter storms have the potential to cause significant loss of life, property damage, transportation problems, and utility service failure over a large area.

Secondary effects of winter storms include house fires from increased and improper use of alternate heating sources. Frozen water supplies can impede firefighting efforts.

Oklahoma has its share of severe winter storms accompanied by ice because of its location between the Gulf of Mexico and the arctic jet stream. Warm, wet air from the south interacts with the cold arctic air to create freezing rain. Tulsa County is vulnerable to the negative effects of winter storms.

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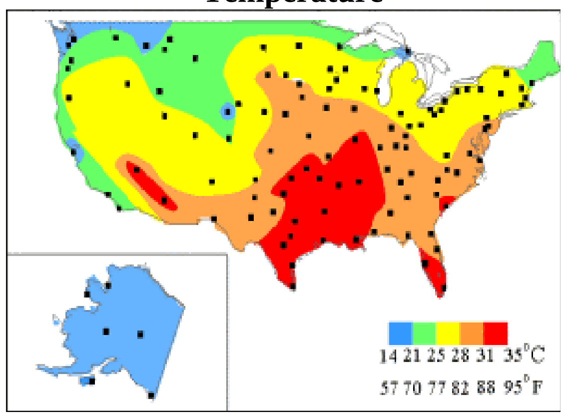
4.7 Extreme Heat

Extreme summer weather is characterized by a combination of very high temperatures and exceptionally humid conditions. A heat wave occurs when such conditions persist over long periods. A lack of nighttime cooling can exacerbate the conditions when community infrastructure fails to release ambient heat increases gained during the day.

Tulsa County has experienced major heat waves five times in the past 10 years: in 1998, 2001, 2006, 2007 and 2008. Extreme heat impacts the entire population of the county and can be expected every summer. The population at most risk to extreme heat is the 12.6% of the Tulsa County population aged 65 and above, the 20.2% of the population classified as low income, and that segment of the population that works outdoors. Property damage is also possible, but minimal.

4.7.1 Hazard Profile

Figure 4–20: U.S. Average High Temperature



Tulsa County's average high temperature in July is 94° Fahrenheit.

Each year in the United States, approximately 200 people have their cause of death listed as heat-related[1], although some estimates of heat-attributable mortality run as high as 1,000 per year. Despite the history of adverse effects, there is consensus that most of these deaths are preventable. Extreme summer temperatures are also hazardous to livestock and crops, can cause water shortages, increase fire hazards, and prompt excessive demands for energy. Even roads, bridges, and railroad tracks are susceptible to damage from extreme heat.

Human bodies dissipate heat by varying the rate and depth of blood circulation and by losing water through the skin and sweat glands. Perspiration is about 90% of the body's heat dissipating function. Sweating, by itself, does nothing to cool the body unless the water is removed by evaporation. High relative humidity retards evaporation, so under conditions of high temperature (above 90° Fahrenheit) and high relative humidity, the body is pressed to maintain 98.6° Fahrenheit.

When heat gain exceeds the level the body can remove, or when the body cannot compensate for fluids and salt lost through perspiration, the temperature of the body's inner core begins to rise and heat-related illness may develop. Heat-related illnesses include the following:

[1] In most communities in the United States, the cause of death is listed as "heat-related" when the body core temperature is determined to have been above 105° Fahrenheit at the time of death. In recent years, some communities have adopted a broader criterion, declaring a heat-related death when a body is found "in an enclosed environment with a high ambient temperature without adequate cooling devices and the individual had been known to be alive at the onset of the heat wave." When the City of Philadelphia adopted the more general standard, reported heat-related deaths jumped from 20 in 1991 to 105 in 1993.

- **Heat Cramps:** muscular pains and spasms due to heavy exertion. They usually involve the abdominal muscles or legs. It is generally thought that the loss of water from heavy sweating causes the cramps.
- **Heat Exhaustion:** typically occurs when people exercise heavily or work in a warm humid place where body fluids are lost through heavy sweating. Blood flow to the skin increases, causing blood flow to decrease to the vital organs. This results in a form of mild shock. The skin will be cool and moist, and could appear to be either pale or flushed. The victim may have a headache and/or be suffering from nausea. There may also be some dizziness.
- **Heat stroke:** the most serious heat emergency. It is life threatening. The victim's temperature control system, which produces sweating to cool the body, stops working. The body temperature can rise so high that brain damage and death may result if the body is not cooled quickly.

Another extreme heat hazard is air pollution. During the summer months, consistent high temperatures and stagnant airflow patterns cause a build-up of hydrocarbons to form a dome-like ceiling over large cities. The abundance of factories, automobiles, lawn equipment, and other internal combustion machines emit high particulate matter that builds and worsens with the increase in temperature. The resulting stagnant, dirty, and toxic air does not move away until a weather front arrives to disperse it.

When the particulate matter reaches a pre-determined level, cities issue ozone alerts and implement measures to reduce the use of cars and the output of the offending chemicals. Ozone alerts usually include advisories for the elderly and those with breathing difficulties to stay indoors in air-conditioned environments.

Damage to property during extreme heat is more a factor of expanding and contracting soil and is covered in the section, "Expansive Soils."

Location

Sustained high temperatures are a hazard that impacts the entire jurisdiction of Tulsa County, but particularly the aged, the poor, the obese, those with heart problems, and people who work out of doors. See Figures 1-5, and 1-6 for demographic data on locations of elderly and low income in Tulsa County.

Measurements

The Heat Index and Heat Disorders Table, Table 4-32, relates index ranges with specific disorders, particularly for people in the higher risk groups. The heat index illustrates how the human body experiences the combined effects of high temperature and humidity. It more accurately reflects what the body experiences than simply measuring the air temperature. For example, when the air temperature is 98° Fahrenheit and the relative humidity is 50%, the human body experiences the discomfort and stress equivalent to 113° Fahrenheit.

Extent

The extent of the extreme heat hazard is largely dependent on the weather conditions occurring across the jurisdiction. High heat events typically will not affect property as adversely as vulnerable populations.

Table 4–32: Heat Index and Heat Disorders

Relative Humidity (%)

Heat Index (Apparent Temperature)

Air Temperature (°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

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

Over the past ten years, the average high temperature for July and August in the Tulsa County area has been 94 degrees F with an average humidity of 56%, which puts the area in the "Extreme Caution" category on the National Weather Service (NWS) Heat Index scale, without factoring in relative humidity.

Sustained high temperatures are a hazard that impacts the entire community, but particularly the aged, the poor, the obese, those with heart problems, and people who work out of doors. The impact of the extreme heat hazard can be mitigated by notifications and warnings to vulnerable populations, the establishment of cooling rooms, utility cost assistance programs, backup electric generation for critical facilities, Medical Reserve Corps training, and similar measures.

Extreme heat also puts pressure on electrical grids as people crank up air conditioners, often resulting in widespread power outages. Blackouts and brownouts from overloaded grids can further increase the risk of heat-related injuries and deaths among the vulnerable populations.

Tulsa County considers a minor severity to be a heat index of 95 or less and a major severity to be a heat index greater than 95.

Frequency

Tulsa County has experienced major heat waves five times in the past 10 years: in 1998, 2001, 2006, 2007 and 2008. Based on this limited data, sustained periods of temperatures above 100 degrees Fahrenheit can be expected at least once every 2 years.

Impact

The impact of extreme heat is primarily the danger to people and the increased risk of wildfire and drought. Muscle cramps, nausea, heat exhaustion, heat stroke, and death can be the results of extreme heat.

4.7.2 History/Previous Occurrences

In Oklahoma, July is generally the hottest month of the year, closely followed by August. The NWS compiled a 106-year record of monthly and annual average temperatures in Oklahoma, and the dust bowl years of 1921, 1931, and 1936 show the highest average temperatures across a 12-month period for the past 100 years.

In the 40-year period from 1936 through 1975, nearly 20,000 people were killed in the United States by the effects of heat. In the summer of 1936, temperatures across two-thirds of the United States rose well above 110 degrees Fahrenheit, and to as high as 121 degrees in some places. The heat wave lasted for 13 days, killing about 5,000 people in the U.S., and nearly 800 in Canada. In the disastrous heat wave of 1980, more than 1,250 people died.

The Central Plains and Corn Belt States experienced a heat wave July 15 through 19, 1995, when temperatures climbed above 120° Fahrenheit. A significant portion of the Eastern States was in the danger category during the same period, with temperatures ranging from 105° to 120° Fahrenheit. This heat wave caused 670 deaths, 465 of them in Chicago alone.

In July 1998, a blistering heat wave struck the south-central part of the nation – including much of eastern Oklahoma – causing five heat-related deaths. A drought also accompanied the heat wave in southeast Oklahoma resulting in devastating crop damage.

The table below shows that 13 deaths resulted from extreme heat episodes from 1995 to 2009 in Tulsa County compared with 91 deaths in Oklahoma. Table 4-33 lists the number of events, number of deaths, number of injuries, number of events that reported damages, and the amount of property damage reported to the NCDC for Tulsa County and Oklahoma. These were the events listed as Excessive Heat in the Temperature Extremes event type from the NCDC Storm Events database.

Table 4–33: Deaths from Extreme Heat from 1995 to 2009

From NOAA National Climatic Data Center http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Location	Events	Deaths	Injuries	Damage Events	Property Damages
Tulsa County	16	13	52	0	$0
Oklahoma	47	91	157	1	$10,000

Extreme heat does not limit itself to local jurisdictions and historical data often only identifies impacted counties. Events where temperatures exceed 100° F for extended periods during the summer months are common. Tulsa County experienced daily temperature means 4-5 degrees above normal from July 4-31, 2001. This heat wave caused eight deaths in Central Oklahoma. The event was combined with an average of about one-third normal rainfall, resulting in a simultaneous drought.

During 2005-2006, Oklahoma experienced the worst drought in its history–a result of months of high temperatures and low precipitation. One result was a record number of wildfire outbreaks (see Section *4.8 Drought* and *4.11 Wildfire*).

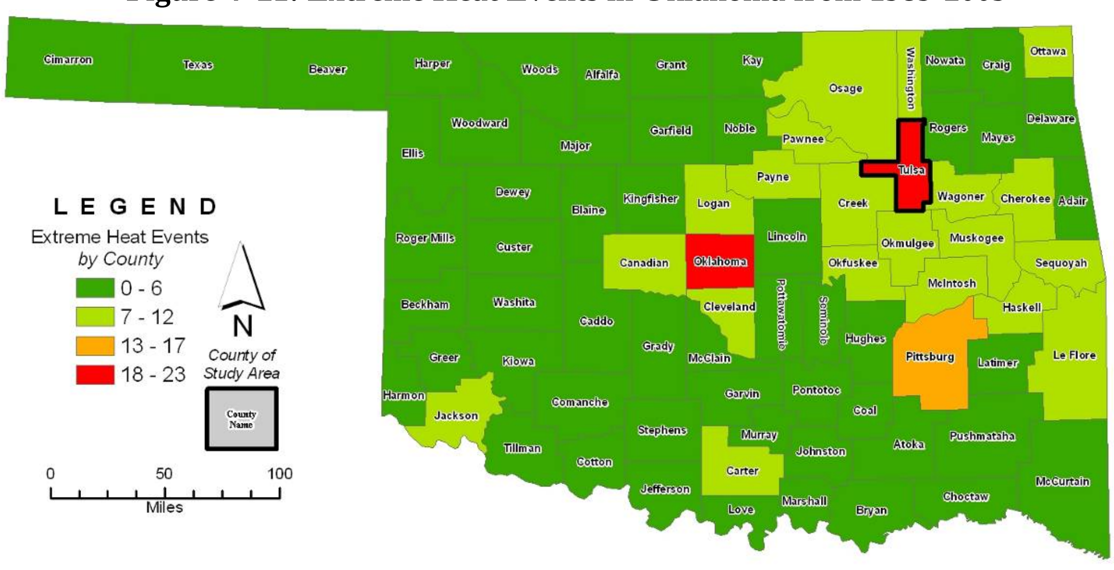
Tulsa County Extreme Heat Events

Tulsa County has reported five extreme heat events since 1993. These were:

June-July 1998 - A blistering heat wave struck the south-central part of the nation during July 1998, including much of eastern Oklahoma. A drought accompanied the heat wave in southeast Oklahoma, causing devastating crop damage. Temperatures in some portion of southeast Oklahoma rose above 100 degrees on all but two days of July, with heat indexes hovering around 115 degrees. At McAlester, 100+ degree temperatures were recorded on 24 out of 31 days during July. In fact, there were 15 consecutive days above 100 degrees from the 17th through the 31st, and the mercury rose to at least 105 degrees every day from the 23rd through the 31st, climbing as high as 107 on three days. The average high temperature for the month of July in McAlester was 102.0 degrees. Further north at the Muskogee, conditions were similar as temperatures reached at least 100 degrees on all but one day from the 18th through the 31st. The temperature rose as high as 107 on the 26th. In Tulsa, weak cold fronts put a damper on the extreme heat for two to four days at a time, but temperatures reached at least 100 degrees eight times in July. The temperature rose as high as 106 on the 30th. Five deaths in eastern Oklahoma during July are blamed on the heat, not including a 40-year old Tulsa man who suffered a heat stroke in on July 10.

July 4-31, 2001- An extended period of excessive heat affected all of western and central Oklahoma, with most areas experiencing temperatures at or above 100 degrees, particularly western and north central Oklahoma. Tulsa County experienced daily temperature means 4-5 degrees above normal from July 4-31, 2001. The event was combined with an average of about one-third normal rainfall, resulting in a simultaneous drought. Eight fatalities resulted from the heat.

Figure 4–21: Extreme Heat Events in Oklahoma from 1989-2009



Source: National Climatic Data Center U.S. Storm Events Database

Flanagan & Associates, LLC

July-August, 2006- Temperatures reached triple digits across the state starting in mid-July and August, reaching 105 to 111 degrees F in many locations. The heat caused 10 fatalities, most of which occurred outside or in homes that did not have fans or working air conditioners. One was a 28-year-old Tulsa man who collapsed while exercising outdoors. The heat also caused a strain on several power grids causing local authorities to ask for people to minimize the consumption of power during the hottest parts of the day to prevent brown outs.

August, 2007- A 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. Two men died in Tulsa County as a direct result of the heat, and 200 others were treated by EMSA in Tulsa County for heat related illnesses. Many victims were attending the PGA Championship.

August, 2008- A prolonged period of excessive heat occurred across much of eastern Oklahoma, with daytime high temperatures reaching the 100 to 105 degree range, daily maximum heat index values the 105 to 115 degree range and morning low temperatures in the upper 70s to lower 80s. Two direct fatalities resulted in Tulsa County, with dozens of others treated for heat by EMSA.

Probability/Future Events

It is a given that extreme heat will continue to be a vulnerability for Tulsa County. Due to aggressive heat plans in the City/County of Tulsa Emergency Operations Plan, the impact of these heat waves has been greatly reduced. The impact of future events will be directly related to the continuation of this aggressive program, and other mitigation measures that may be incorporated into the community to reduce the effect of the urban heat.

4.7.3 Vulnerability

Every person is subject to health problems during a heat wave. However, the following groups are more likely to suffer:

- elderly (65 years of age or older);
- infants (under 1 year of age);
- homeless;
- low income;
- people who are socially isolated;
- people with mobility restrictions or mental impairments;
- people taking certain medications (i.e., for high blood pressure, insomnia, or depression);
- people engaged in vigorous physical exercise or outdoor labor;
- people under the influence of drugs or alcohol.

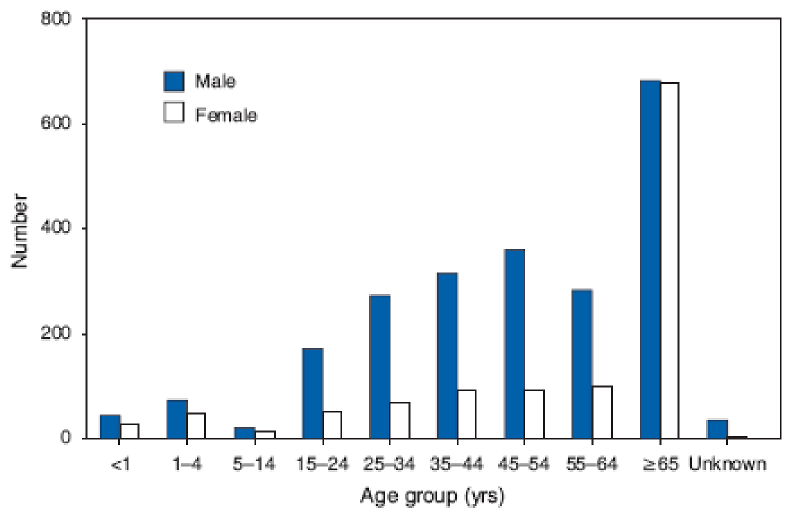
In general, the poor and elderly populations of a community are less able to afford high utility bills and air conditioning units, leaving them with an increased vulnerability to extreme heat events. Another segment of the population at risk is those whose jobs consist of strenuous labor outside exposed to high temperatures and humidity.

Studies indicate that, all things being equal, the severity of heat disorders tend to increase with age. Sweating is the body’s natural mechanism for reducing high body temperature, and the body temperature at which sweating begins increases with age. Therefore, heat cramps in a 17-year-old may become heat exhaustion in a person who is 40 and heat stroke in a person over 60. This age-related vulnerability is shown graphically in the following table, which shows number of heat-related deaths, by sex and age group, in the

US from 1999 to 2003. The dramatic rise in heat related deaths in the over 65 age group is clearly indicated.

More deaths from extreme summer weather occur in urban centers than in rural areas. The masses of stone, brick, concrete, and asphalt that are typical of urban architecture absorb radiant heat energy during the day and radiate that heat during what would be otherwise cooler nights. This phenomenon is referred to as the "Urban Heat Island" (UHI) effect. Tall buildings may effectively decrease wind velocity, thereby decreasing the contribution of moving air to evaporative and convective cooling.

Table 4–34: Deaths from Extreme Heat (by Age Group)



*** Exposure to extreme heat is reported as the underlying cause of or a contributing factor to death.**

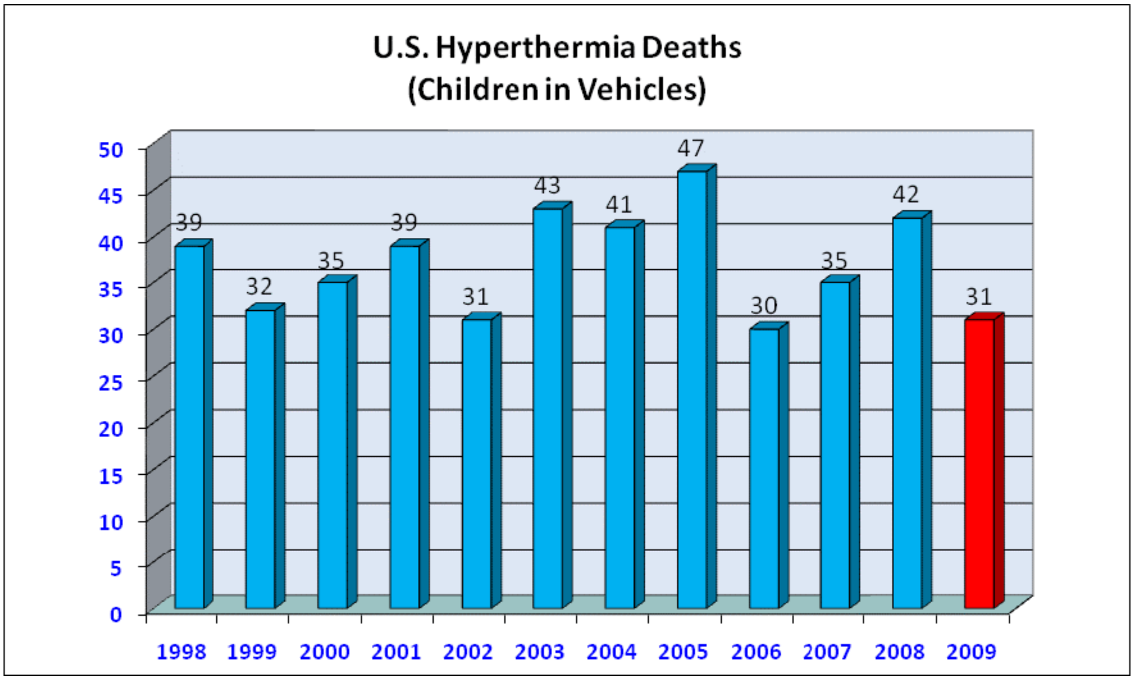
All of unincorporated Tulsa County is vulnerable to extreme heat in summer, including all areas of future development. This is especially true of the 17.4% of the population aged 65 and above and the 19.2% of the population living in poverty within Tulsa County. The average high temperature in Tulsa County for July is 93° Fahrenheit, with an average afternoon humidity of 57%. This calculates to a heat index of 105° Fahrenheit, putting the area in the "Danger" category on the National Weather Service (NWS) Heat Index scale. This indicates that with prolonged exposure and/or physical exertion, heat related maladies are likely.

Tulsa County Emergency Management has developed an Extreme Heat Action Plan Annex to the Tulsa County Emergency Plan. It is based on a system of defining a heat emergency both through climatological parameters and heat-related emergency medical transports, followed by an aggressive system of public education, press releases, and identification of cooling station locations throughout the area.

There has been an increase in the US in number of heat-related deaths for children under the age of 13 years locked in cars. Between 1990 and 1992, ten such deaths were reported. For 2004 through 2006, 110 deaths were reported related to children left in vehicles. This represents an increase of approximately 14 more deaths in this population group every two years. If this trend continues that number could escalate to 138 nationwide by the end of 2008.

Comparatively, between 2004 and 2006, Oklahoma reported 8 heat-related fatalities for children under the age of 13 left in vehicles. One of these deaths was reported in Tulsa County (2005). Examination of these figures in comparison to the national numbers suggests that Tulsa could possibly expect to have at least one fatality for this demographic group during a prolonged extreme heat event.

Table 4–35: Deaths from Extreme Heat (Children in Vehicles)



Structures/Buildings

During an extreme heat event, it is likely to be hotter in cities than in surrounding rural areas, especially at night. Temperature typically begins rising at the outer edges of a city and peaks in the centre (UHI effect). A number of factors cause this urban/rural temperature difference.

- **Thermal properties** of building and road materials, the height and spacing of buildings and air pollution levels. These factors result in more of the sun's energy being captured, absorbed and stored in urban surfaces compared to rural surfaces during the day and a slower loss of this energy at night, thus resulting in comparatively higher air temperatures.
- **Less evaporation and shading**, with the consequent reduction in associated cooling, takes place in the typically drier urban areas as there is less vegetation.
- **Greater inputs of heat** as a result of the high density of energy use in cities. All this energy, for example from buildings and transport, ultimately ends up as heat.

Strategic planning is therefore required which takes account of the above factors, particularly in the context of climate change. At a local scale these include the modification of surface properties, for example, "cool roofs," "green roofs" and "cool pavements." Planting trees and vegetation and the creation of green spaces to enhance evaporation and shading are other options, as temperatures in and around green spaces can be several degrees lower than their surroundings.

Critical Facilities

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

Of especially high vulnerability would be the medical care and long-term care facilities. During an extreme heat event, power outages are not uncommon. While the larger medical treatment facilities in the urban areas are equipped with dependable, redundant generator backup systems, an alarming number of long-term care/nursing home facilities are not. In July 2006, a Grove area nursing home was forced to evacuate 84 patients when power at the facility failed. Temperatures in parts of the state ranged from 101–109 degrees F at the time.

Infrastructure

Water Treatment – Water demand during extreme heat increases significantly, and in some areas of Tulsa County, demand could possibly exceed treatment capacity. Ordinances for several of Tulsa County's communities restrict outdoor and non-essential water use during drought or in times of emergency.

Given that extreme heat conditions also increase the demand for electricity, power outages could be a potential secondary effect. However, the water treatment plants are a high priority customer and would not be impacted by any planned rolling outages.

Wastewater Treatment – The most significant threat to wastewater treatment plants in Tulsa County would be power outages. The City of Tulsa's four plants and lift stations have either double feeds or generators, so would most likely continue to operate during electrical outages.

Utilities: The primary utility providers for Tulsa County communities are AEP/PSO (electricity) and ONG (natural gas).

Electricity - During extreme heat, providers of electrical service could experience any combination of the following challenges: Failure of vital delivery components due to exposure to high heat (such as lines sagging into trees); excessive/simultaneous demand of supply; or insufficient field and/or office staff to effectively handle the workload.

During typical workweek schedules, it has been noted that demand for electrical power spikes in the hours of 4-7pm as workers are returning to their homes and adjusting thermostats. The result is an overwhelming demand placed on power station and transformer components, sometimes resulting in power outages across the jurisdiction.

Gas – No significant vulnerabilities in the delivery of natural gas supply during extreme heat events have been reported.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Increase in passengers utilizing local public transportation systems as a way of staying out of the heat during peak danger hours is expected.

Emergency Services- Fire, Police and Medical Services would all be similarly at risk to the effects of an Extreme Heat Event. Fire and Medical Services typically receive a higher volume of heat-related call requests, therefore taxing the response capabilities of both services. Fire and Police services could be considered at risk to secondary effects of this type of event due to the added physical stressors of working in extreme heat events. While not an immediate threat to delivery of these services, the demand for additional personnel could potentially increase the cost for these resources.

4.7.4 Heat Scenario

During the summer of 1980, the state of Oklahoma was one of several states heavily impacted by a major heat wave. Across the United States, reported heat-related fatalities exceeded 1,700. In Oklahoma, 37 fatalities were reported, with 12 of those from Tulsa County. Eight of those fatalities were Tulsa County residents, while four were transported to Tulsa hospitals where they passed away. The ages of the eight Tulsa residents ranged from 54 to 87. Fifty percent were over the age of 65.

Between June 25 and September 19, 1980, Tulsa International Airport reported 58 days with temperatures reaching 100 degrees F or higher. Twenty-eight of those days were in the month of July, which was particularly brutal. For seventeen consecutive days the temperatures did not dip below 80 at night, and the daytime temperatures reached 108-109 degrees. The average daytime high for July was 103.6 degrees. These relentless conditions provided no relief to those most vulnerable to the cumulative effects of extreme heat, and prompted local social service agencies to examine measures to reduce vulnerability during such times.

Tulsa's Community Service Council developed the "Weather Coalition Air Conditioner Loan Program," which provides window air conditioners to the vulnerable populations during extreme heat events, particularly the homebound elderly, those with medical conditions placing them at a higher risk, and people on fixed incomes.

Tulsa's LIFE Senior Services (LSS) is another resource. LSS currently provides adult day service for senior citizens at three area locations (one in Broken Arrow, two in Tulsa) as well as two separate senior centers in Tulsa. These locations provide safe, cool places for seniors to go during extreme heat events.

Tulsa County has experienced several extreme heat periods since 1980, but none quite as severe or long lasting. Two periods examined are the summers of 1998 and 2008.

The summer of 1998 delivered a heat wave and accompanying drought that led to one hundred 73 heat-related deaths in the country and 28 in Oklahoma. Three of those fatalities were recorded in Tulsa County, all three being males in their 40s in varying circumstances. The year 1998 has been ranked number eight in Tulsa's top ten 100-degree days (since 1938). The first 100-degree day was recorded on July 19, and the last one for the year was recorded on September 22—a total 22 days with temperatures at or above 100 degrees. The average daytime high for that July was 95.7degrees.

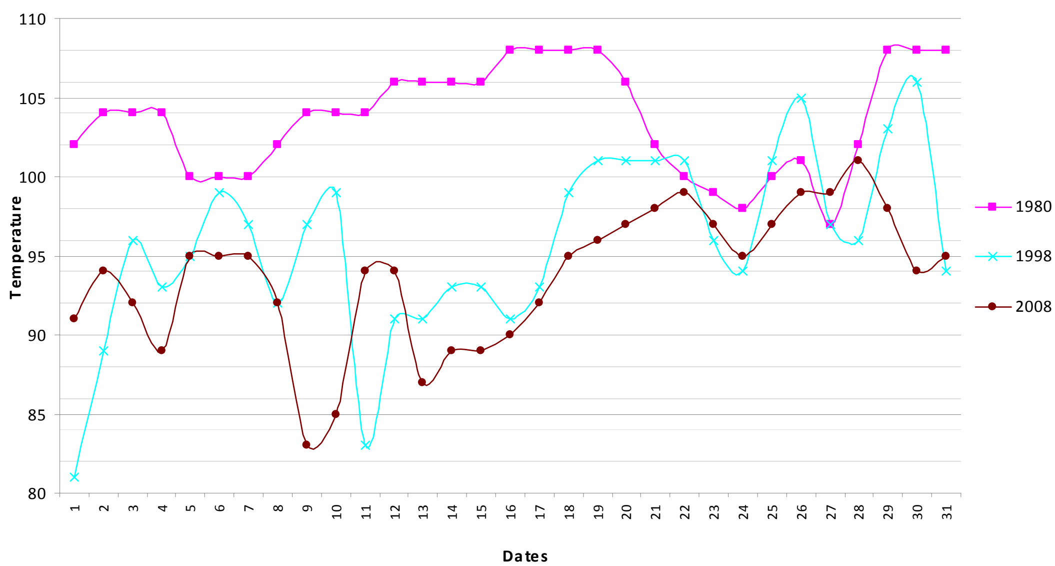
The summer of 2008 has presented its own level of heat-related concerns for Tulsa County. Nationwide, approximately 50 people had died from heat-related illness by August 1. Tulsa International Airport only reported one day with temperatures above 100 degrees for Tulsa, but there were several days with temperatures hovering between 95 and 99 degrees in the daytime, yet not dipping below 78 degrees overnight. This small fluctuation paired with the humidity created a ripe environment for heat related illnesses.

Tulsa's Emergency Medical Services Authority (EMSA) reported 64 heat-related calls from July 11 through July 31. The average age of patients involved in these calls was 41.1 years of age, with a variance between male and female patients. Two heat-related fatalities were reported for Tulsa between mid-July and mid-August.

A worst-case scenario for Tulsa County would be a repeat of an extreme heat event with the severity and length of the one in 1980.

Tulsa's Weather Coalition has consistently provided between 200 and 220 window air conditioning units to qualified members each year– a service that was not available during the summer of 1980. Review of the heat-related fatalities reported for the City of Tulsa would support the conclusion that the Tulsa Weather Coalition Program has had a positive impact in preventing deaths among the most vulnerable population. Without this program, or others that like it, two hundred additional people would be placed at grave risk in the event of a heat wave like that in 1980.

Figure 4–22: Daily High Temperatures for July



The statistics from the previous years' extreme heat events would suggest that, should Tulsa experience a heat wave similar to that of 1980, without the existing programs and with current social trends in place, it could be reasonably assumed that the number of fatalities could reach four over the age of sixty-five, three between the ages of thirteen and sixty-five, and one below the age of thirteen.

4.7.5 Future Trends

For a map of Tulsa's potential future growth areas, see Figure 1-8. Tulsa County is expected to grow by 17% by 2030. Residential development is increasing in the unincorporated areas of North, South and West Tulsa County, particularly around Collinsville and Owasso in the north, in the hills above Sand Springs and Berryhill in the west, and around the growing communities of Jenks, Bixby, Glenpool, and Broken Arrow in the south.

According to NOAA, future extreme heat events are likely to be even worse—more frequent, longer lasting, and more intense.

Population

With the rising cost of fuel and related travel expenses, more people are opting for vacations and/or recreational entertainment at local venues such as public parks, close to home. As the number of people making use of local outdoor venues increases, vulnerability to heat-related illness also increases.

Also at risk is the homeless population. With the recent home mortgage crisis and other economic stressors on those struggling to meet financial obligations, the number of homeless may well increase. Facilities designated as shelters (either daytime only or residential) will likely be further stretched to meet that need.

It is also probable that an increasing number of people in the more vulnerable population (elderly, fixed income, compromised health situations) will be less able to afford the cost of cooling their homes—due to economic conditions and the relative increase in the number of elderly in the population.

Care should be exercised to ensure that the vulnerable populations in the county, including outdoor workers, are informed about how to avoid extreme heat illnesses.

Structures/Buildings

While structures and buildings are only vulnerable in a limited way, such as in damage from expansive soils, development in Tulsa County needs to take into account the potential adverse health impacts of the “urban heat island,” where large quantities of dense materials, such as stone, concrete, asphalt, and other construction materials, absorb and store heat rather than reflect it. These materials act as “storage units” for the energy, and continue to radiate it at night, keeping the ambient temperature from dropping to a level which could provide relief from harmful effects.

Critical Facilities

Any future development or renovation of existing critical facilities should include plans for dependable backup systems for delivery of critical power in the event of electrical grid collapse or rolling blackouts.

Infrastructure

As areas of the county continue to age, the water line systems will also continue to deteriorate, increasing the likelihood of line ruptures from peak usage during extreme heat events. Any development in areas facing this possibility should be closely monitored to ensure existing water lines are capable to handle the additional load – and replaced as necessary.

Sporadic power outages are commonplace during prolonged periods of high temperatures in any community. As Tulsa County develops, burden on power delivery systems will continue to grow also. Developers working in previously undeveloped areas should remain in constant contact with utility companies to prevent unnecessary overloading of current power stations.

Data Limitations

The state Medical Examiner's office and the state Health Department have no standardized protocols for defining a "heat-related" death, relying on the judgment of the individual physician attending. This could result to substantially lower mortality/morbidity figures. In addition, death by other causes such as cardiac arrest, with heat as a "contributing factor," can further confound the final statistics for heat-related deaths and injuries.

4.7.6 Conclusion

Oklahoma can expect to be hit by the hazard of extreme heat every summer. The severity of the hazard is dependent on a combination of temperature, humidity, and access to air conditioning. The most vulnerable groups are:

- the elderly;
- the poor;
- those with health-related issues, particularly heart problems;
- the obese;
- those who work outside.

While the documented deaths and medical transports appear to have been reduced based on the above-mentioned Extreme Heat Action Plan, heat will continue to be an ongoing threat in Tulsa County, although the risk factors are less for the unincorporated areas than for the major urban "concrete islands" due to less heat retention during the nighttime hours.

4.7.7 Sources

Heat-related deaths - four states, July-August 2001, and United States, 1979-1999. Morbidity and Mortality Weekly Report 51(26): 569-570.

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4.8 Drought

Drought is a normal, recurrent feature of climate, although many erroneously consider it a rare and random event. It occurs in virtually all climatic zones, but its characteristics vary significantly from one region to another. Seattle's Emergency Management Office defines drought as "climatic dryness severe enough to reduce soil moisture and water below the minimum necessary for sustaining plant, animal and human life systems." Drought is caused by a deficiency of precipitation, which can be aggravated by high temperatures, high winds, and low relative humidity. Duration and severity are usually measured by deviation from norms of annual precipitation and stream flows.

4.8.1 Hazard Profile

The "Dust Bowl" of the 1930s, the greatest natural disaster in Oklahoma history, drove over 800,000 people off the land.

Drought is an insidious hazard of nature, characterized as a "creeping phenomenon." It is often difficult to recognize the occurrence of drought before being in the middle of one. Drought analysis is more subjective than that for floods, because droughts do not occur spontaneously. They evolve over time as certain conditions are met and are spread over a large geographical area. Drought severity depends on its duration, intensity, geographic extent, and the regional water supply demands made by human activities and vegetation. This multi-dimensional nature makes it difficult to define a drought and to perform comprehensive risk assessments. This leads to the lack of accurate, reliable, and timely estimates of drought severity and effects, and ultimately slows the development of drought contingency plans.

Adverse consequences of drought occur because of deficiencies in the following:

- public and rural water supplies for human and livestock consumption;
- natural soil water or irrigation water for agriculture;
- water for hydroelectric power, forests, recreation, and navigation;
- water quality.

The most direct impact of drought is economic rather than loss of life or immediate destruction of property. Drought affects water levels for use by industry, agriculture, and individual consumers. Water levels can have both a direct and indirect effect on hunting, fishing, and other recreational activities that may have a significant place in a community's revenue.

Water shortages affect fire-fighting capabilities through reduced water flows and pressures. Drought also affects power production, since when water levels drop; electric companies cannot produce enough inexpensive hydropower to meet demand and are forced to buy electricity from other, usually more costly sources. Communities that rely on hydroelectric vs. coal/gas-fired generating plants may be more vulnerable.

Most droughts dramatically increase the danger of wildland fires. When wildlands are destroyed by fire, the resulting erosion can result in the heavy silting of streams, rivers, and reservoirs. Serious damage to aquatic life, irrigation, and power production then occurs.

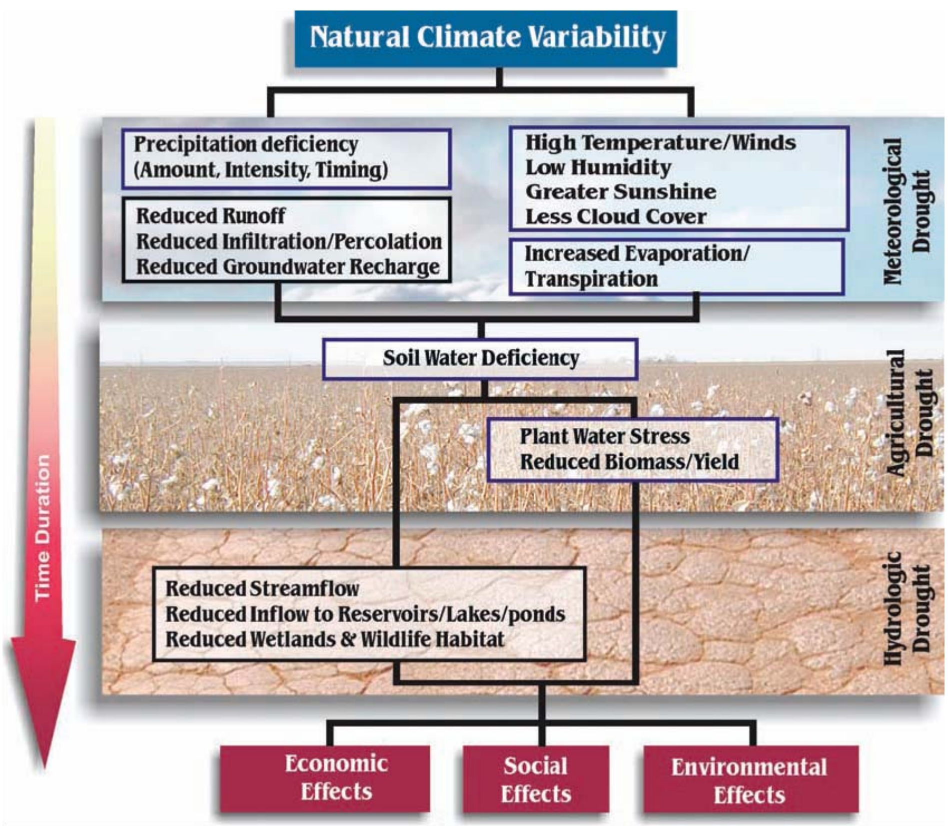
Drought is often accompanied by extreme heat. Wildlife, pets, livestock, crops, and humans are especially vulnerable to high heat accompanying drought. When temperatures reach 90° Fahrenheit and above, people and animals can suffer sunstroke, heat cramps, and heat exhaustion. During droughts, crops do not mature, wildlife and livestock are undernourished, land values fall, and unemployment increases.

Generally, in times of severe drought, states rely on the Federal Government to provide relief to drought victims when water shortages reach near-disaster proportions. Forty separate drought relief programs administered by 16 Federal agencies provided nearly $8 billion in relief because of the series of drought years in the mid-1970s. Federal assistance efforts totaled more than $5 billion in response to the 1987–1989 drought. However, since the mid-1970s, most states have taken a more active role and drought contingency plans are now in place in at least 27 states.

Location

Drought is a widespread phenomenon that occurs over broad regions encompassing not only multiple communities, but frequently multiple states. Tulsa County is at risk from Drought.

Figure 4–23: Natural Climate Variability



Measurements

Different methods are used to predict the severity and impact of droughts, but each one measures different aspects or types of drought. Any single index cannot describe everything about the original data, and the indices are only approximations of real-world phenomena.

Palmer Drought Severity Index (PDSI)

The Palmer Index, the most familiar and widely used, measures the departure from normal precipitation.

The objective of the Palmer Drought Severity Index (PDSI), as this measure is called, is to provide a standardized yardstick for determining moisture conditions, so comparisons can be made between different locations over time. It is based on precipitation, temperature and moisture in the soil, and can be applied to any site for which sufficient data is available. The Index does not allow an abnormally wet month in the middle of a long-term drought to have a major impact on the index, or a series of months with near-normal precipitation during a prolonged and serious drought to indicate that the drought is over.

Weekly Palmer Index values are calculated for the Climate Divisions during every growing season and are on the World Wide Web from the Climate Prediction Center. (See http://drought.unl.edu/whatis/indices.htm)

Table 4–36: Palmer Drought Severity Index (PDSI)

PDSI Classifications for Dry and Wet Periods	
4.00 or more	Extremely wet
3.00 to 3.99	Very wet
2.00 to 2.99	Moderately wet
1.00 to 1.99	Slightly wet
0.50 to 0.99	Incipient wet spell
0.49 to -0.49	Near normal
-0.50 to -0.99	Incipient dry spell
-1.00 to -1.99	Mild drought
-2.00 to -2.99	Moderate drought
-3.00 to -3.99	Severe drought
-4.00 or less	Extreme drought

Keetch-Byram Drought Index

The Keetch-Byram Drought Index (KBDI) is a mathematical system for relating current and recent weather conditions to potential or expected fire behavior. This system was originally developed for the southeastern United States and is based primarily on recent rainfall patterns. The KBDI is the most widely used drought index system by fire managers in the south. This Index is covered in greater detail in Section 4.11 Wildfire, below.

Extent

Because of the gradual nature of drought's onset, and its uneven impacts, it is often difficult to determine the beginning, end and extent of a drought event. The complexity of the drought phenomenon also makes it difficult to predict drought probabilities. Drought evolves over time and can spread over a large area, but has widely differing impacts in specific areas, depending upon duration, intensity, water supplies, and the demands made upon water supplies by human activities and vegetation. The impacts of related hazards, such as extreme heat, expansive soils and wildfires, can be intensified during periods of drought. Drought impacts can be both environmental and economic, and include the following:

- reduced crop, rangeland;
- increased livestock and wildlife mortality;
- reduced income for merchants, farmers and agribusiness;
- increased fire hazard;
- reduced water supplies for municipal/industrial, agricultural and power uses;
- damage to fish and wildlife habitat;
- increased food prices;
- reduced tourism and recreational activities;
- unemployment;
- reduced tax revenue due to reduced expenditures;
- foreclosures on bank loans to farmers and businesses.

Tulsa County has experienced drought two times in the past 7 years, characterized primarily by crop damage and wildfire. Although Tulsa County's municipal water supply is strong, drawing as it does from Tulsa's abundant resource, economic damage due to crop loss and wildfire remains a significant threat to the community. Property and crop damage due to drought in Oklahoma between 2000 and 2006 reached $594 million ($32.5 million to property and $561.6 million to crops). The impacts of drought can be lessened by early warning and notification systems, backup sources of water supply, cooperative agreements with neighboring jurisdictions, local ordinances for rationing water use, clearing brush and Eastern Red Cedar from structures in the urban/rural interface, and participating in the national Firewise program.

Tulsa County considers a minor severity to be a -2 to 0 on the Palmer Drought Index and a major severity to be -2 to -4.

Frequency

Given that six major drought events have occurred in Oklahoma over the past 50 years and that nine notable droughts have occurred nation-wide in the twentieth century, one may logically conclude that Oklahoma can expect a drought every decade and that droughts will occur more frequently in Tulsa County than in the country as a whole. However, long-term forecasts of droughts are difficult and inexact. There is no commonly accepted way of determining the probability that is analogous to the 100-year or 1-percent-annual flood chance.

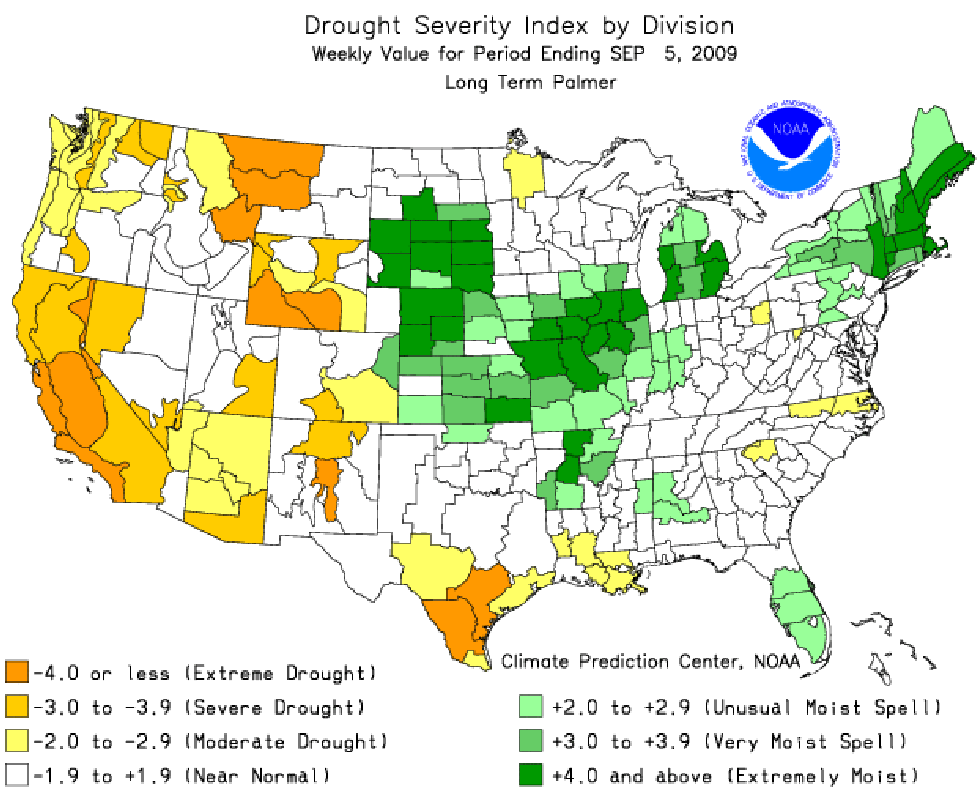
The U.S. Army Corp of Engineers (USACE) is preparing the *National Drought Atlas* to provide information on the magnitude and frequency of minimum precipitation and stream flow for the contiguous United States. On average, the July-to-January period is the lowest six-month period of stream flow throughout the U.S. and is used to characterize drought. The mean monthly flow from July to January has a once-in-20-years chance of falling below a level that would classify it as a drought. In other words, the average occurrence of drought is once every twenty years. Oklahoma, with one per ten years over the past fifty years, is obviously at a greater than normal risk from drought.

The region has gone through alternating wet and dry cycles since the early 1900s, with the latest being an almost 20-year period of wet weather lasting from about 1983 to 2003 (see Annual Rainfall History figure 4-27). If these trends continue, and the recent wet cycle is followed by a more or less equal number of dry years, then Tulsa County may well be facing a period of prolonged drought in the coming decades.

Impact

The impact of this hazard primarily affects agriculture and livestock. Wildfire and Expansive Soils are impacted by drought as well.

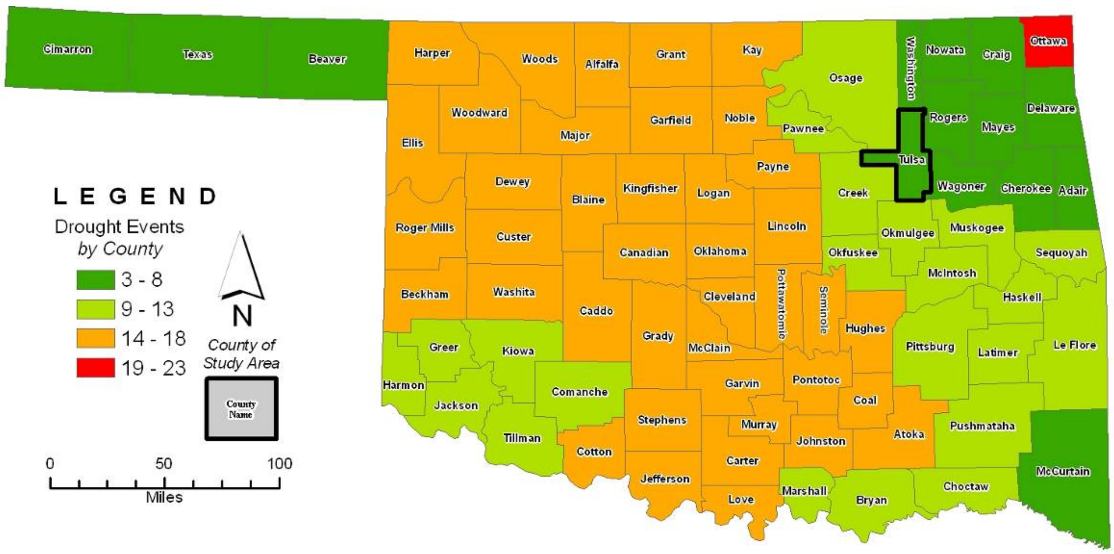
Figure 4–24: Drough Severity Index by Division ending September 5, 2009



4.8.2 History/Previous Occurrences

The National Weather Service's drought monitor map illustrates the pervasive nature and degrees of dryness and prolonged drought in several areas of the country. The current Drought Monitor map for the U.S., which is updated weekly, is shown on the next page.

Figure 4–25: Drought Events in Oklahoma from 1989-2009



Source: National Climatic Data Center U.S. Storm Events Database

Flanagan & Associates, LLC

There have been nine notable droughts in the United States during the Twentieth Century. Damage estimates are not available for most; however estimates indicate that the 1976-1977 drought in the Great Plains, Upper Midwest, and far Western States caused direct losses of $10-$15 billion. The 1987-1989 droughts cost $39 billion including agricultural losses, river transportation disruption, economic impacts, water supply problems, and wildfires.

Table 4-37 lists the number of events, number of deaths, number of injuries, number of events that reported damages, and the amount of property and crop damage reported to the NCDC for Tulsa County and Oklahoma.

Table 4–37: Casualties and Damages Caused by Drought from 1995 to 2009
From NOAA National Climatic Data Center http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Location	*Events*	*Deaths*	*Injuries*	*Damage Events*	*Property/Crop Damages*
Tulsa County	8	0	0	0	$0
Oklahoma	51	0	4	21	$1,129,669,000

From a USA Today article, based on data from the NWS Climate Prediction Center. The nationwide drought that has had farmers, communities and entire states fighting to conserve water has reversed in the most dramatic turnaround since federal scientists began keeping records. More than 92% of the country is drought-free — the nation's best showing since 1999. "The lack of drought is extraordinary," said Douglas Le Comte, a meteorologist with the federal Climate Prediction Center. At the worst of the USA's most recent drought – in August 2007 – almost 50% of the country was involved. Currently, about 7% of the country is in a drought, according to federal scientists.

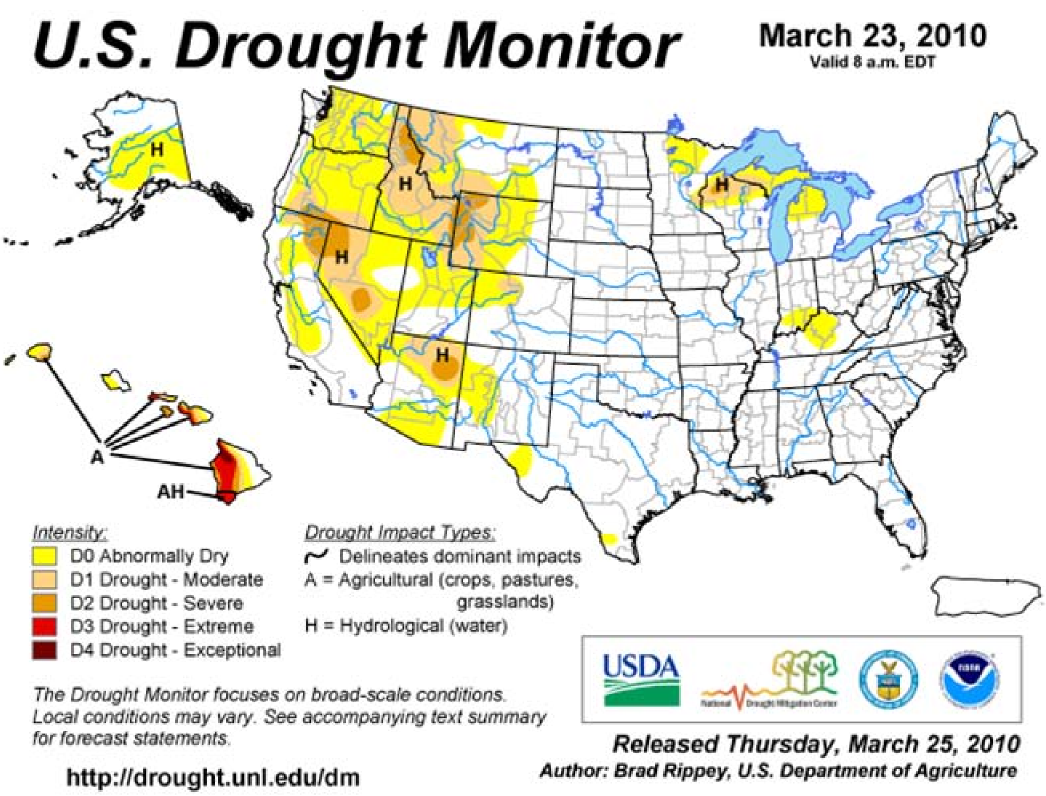
Major droughts in Oklahoma, as determined from stream flow records collected since the early 1920s, have predominately occurred during four periods: 1929-1941, 1951-1957, 1961-1972, and 1975-1982.

One of the greatest natural disasters in U.S. history and the most severe and devastating to Oklahoma was the decade-long drought in the 1930s that became known as the Dust Bowl. Reaching its peak from 1935 through 1938, high temperatures and low rainfall combined to destroy crops and livestock. High winds literally blew the land away, causing massive soil erosion. Hundreds of small rural communities were ruined and about 800,000 people were displaced. The total expenditure by the American Red Cross for drought relief in Oklahoma in 1930-1931 was the third largest ever in the nation.

August 2000. Oklahoma began the new century with drought conditions. In early August 2000, an extended period of unusually dry weather lasted for 2 months. Many parts of the state did not receive rain in August, and portions of southern and south central Oklahoma remained dry for almost 90 days, starting in June. Total agricultural losses were estimated between 600 million and 1 billion dollars statewide. Reservoir levels across southwest and south central Oklahoma averaged 50 percent of normal. Seven counties near the Texas border (not including Grady) were declared federal disaster areas.

July 2001 – A month of excessive heat and little rainfall brought drought to central Oklahoma and killed eight people from heat-related illnesses.

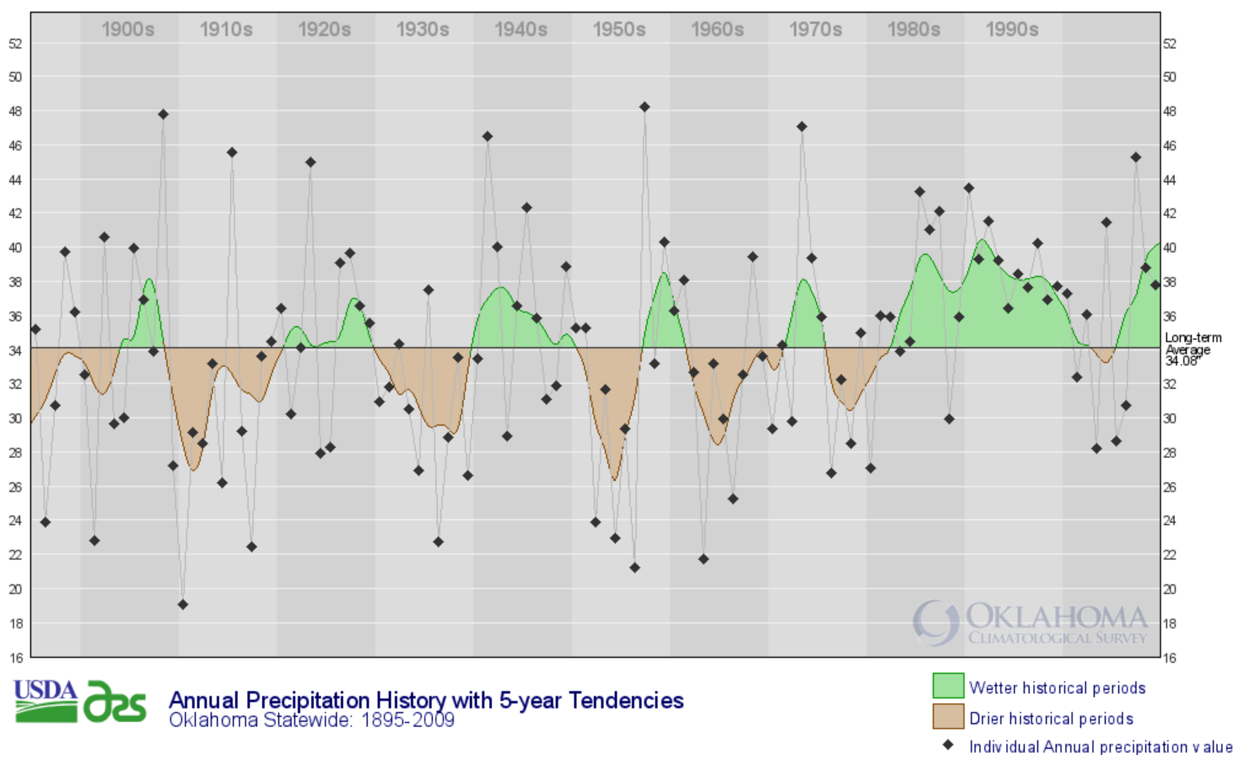
Figure 4–26: U.S. Drought Monitor (March 23, 2010)



March 2002- Lack of rainfall and an infestation of insects took a toll on western Oklahoma's wheat crop. State officials said 26 percent of the wheat crop was in very poor shape and conditions were so dry in the Panhandle that soil erosion was beginning to occur. The state's "wheat belt" region, the area around and west of U.S. 81, had received less than 50 percent of its normal rainfall since October of 2001, according to Derek Arndt of the Oklahoma Climatological Survey.**March 2005-April 2006 –** A sustained period of dry weather and high temperatures spread drought across much of Oklahoma, especially the east central and southeast portions of the state. The winter of 2005-2006 was the second driest since records began being kept in 1895. High winds, combined with dry soil conditions, helped spread the worst series of wildfire outbreaks in Oklahoma history. (See *4.11 Wildfire*) By April 2006, the severe drought had become "extreme drought" in some areas. Over 40 cities in Oklahoma had to impose some form of water rationing or restrictions on water use.

As illustrated in the following graph, Oklahoma has gone through six drought cycles, state-wide, since the early 1900s, with the latest being an almost 20-year period of wet weather lasting from about 1983 to 2003. If these trends continue, and the recent wet phase of the cycle is followed by a more or less equal number of dry years, then the State may well be facing a period of prolonged drought in the coming decades.

Figure 4–27: Annual Rainfall History from 1895-2009



Tulsa County Drought Events

Tulsa County has endured two extended periods of drought in the last two years. Beginning in November 2005, a three-month period of unusually dry weather affected all of Oklahoma, including Tulsa County. In January 2006, a period of below-normal rainfall affected all of northeastern Oklahoma, creating drought conditions. About 50 communities in Oklahoma were forced to restrict water usage, among them Ada, Holdenville, Newcastle, and Bartlesville. Communities in Tulsa County, however, because of their relative abundance of water sources, were not directly impacted. A secondary impact of drought is its contribution to wildfire. Tulsa County did experience wildfire outbreaks in November and December 2005, and January and March 2006. (See 4.11 Wildfires)

Probability/Future Events

As drought is a direct by-product of normal climatological activity, it is accepted that Tulsa County will continue to be hit by droughts of varying severity.

As stated above, based on history and previous occurrences, Tulsa County can expect drought conditions every 10-15 years. The region has gone through alternating wet and dry cycles since the early 1900s, and the region is just coming out of a 20-year period of wet weather, which lasted from about 1983 to 2003. If this wet cycle is followed by an equal number of dry years, then Tulsa County may well be facing a period of prolonged drought in the coming decades.

Drought, generally, will have a more devastating effect on the county's rural areas and agricultural and ranching communities than on its urban residents. Because of Tulsa County's relatively abundant water supplies, the most severe impact from drought could be from wildfire, indirectly, in the jurisdiction's expanding wildland/urban interface.

4.8.3 Vulnerability

Drought and Water Conditions in Tulsa County

As described in Section 1.2.5, *Lifelines*, Tulsa County does not supply water to any residences, businesses or jurisdictions. All utilities, except for highways, roads and drainage facilities, are provided by its communities and various commercial suppliers.

As Tulsa County's largest jurisdiction, the City of Tulsa draws its raw water from Spavinaw/Eucha and Oologah Lakes. Lake Hudson has provided water in the past and is available for future use. Spavinaw runs two major flowlines – a 54-60 inch and a 66-72 inch diameter line. Oologah also runs two flowlines – a 42-inch and a 54-72 inch line. Raw water is stored in Yahola Lake (2.0 billion gallon capacity) near the Mohawk Water Treatment Plant and the Lynn Lane Reservoir (1.1 billion gallon capacity) near the A.B. Jewell Water Treatment Plant. The two plans have the capacity to treat 220 Million Gallons per Day. Tulsa is currently operating at significantly below its water service capacity. Even in times of drought and extreme heat, as in the record-setting July of 1999, water usage can double, but has yet to exceed 190 MGD, well below the maximum capacity. The City of Tulsa has not had to impose any kind of rationing since the summer of 1981.

In all droughts, agriculture feels the impact, especially in non-irrigated areas. Other heavy water users such as landscapers are also negatively impacted, and residential users often have their water-related activities restricted. Droughts also cause power shortages in Oklahoma, since a good deal of the state's electric power comes from hydro plants. Heavy power users can be negatively affected by the results of electricity shortages due to drought, such as brownouts, blackouts, and spiking prices.

The primary impacts of drought in Tulsa County have been to farming and ranching. A secondary impact for both Tulsa County and the City of Tulsa, each of which has a good number of residential estates within their jurisdictions, is urban interface wildfire. Following upon a very wet spring in 2005, the drought conditions of 2005-2006, combined with unseasonably warm, windy weather from November to January, resulted in the worst wildfire season in state history. Over 1,500 acres in Tulsa County and Tulsa were burned by wildfire. This fire complex resulted in a Presidential Disaster Declaration.

Tulsa County's vulnerability to the impacts of drought is summarized below.

North Tulsa County

As described in *1.2.5 Lifelines*, northern Tulsa County water is provided by the City of Tulsa, Washington County Rural Water District #3, Tulsa County Water Improvement District #3, Skiatook Water Department, and Rogers County Rural Water District #3. The water supply and distribution systems of these providers are both adequate and in the process of being upgraded to meet future needs. North Tulsa County's vulnerability to water shortages due to drought is, therefore, low. However, due to rapid growth of rural estate housing in the prairie grasslands of north Tulsa, Owasso, Collinsville, Skiatook, Sperry and Turley, the entire area has moderate to high vulnerability to wildfire during periods of drought, as demonstrated by the grassfire outbreaks of 2005-2006.

West Tulsa County

Water for western Tulsa County is provided by City of Tulsa, Sand Springs, and the City of Sapulpa. Sand Springs water supply is adequate, as described in *1.2.5 Lifelines*. It does have some problems with low water pressure along the periphery of its service area during periods of peak use. Consequently, this extreme western portion of Tulsa County has moderate vulnerability to water shortages due to drought, and moderate to high vulnerability to wildfire in its rural estates developments during times of low water pressure due to drought and peak demand.

The City of Sapulpa, which supplies a 4-square-mile area south of 51st St., between 65th W. Ave. and 129th W. Ave., has adequate water supply and distribution facilities, and low vulnerability to water shortage due to drought. The remaining unincorporated areas of western Tulsa County, east of 65th W. Ave., are served by the City of Tulsa, and have low vulnerability water shortages from drought. However, due to rapid growth of rural estates housing in this part of Tulsa County, particularly in the prairie grasslands south of 51st St. and west of I-44, this portion of Tulsa County has moderate to high vulnerability to wildfire during periods of drought.

South Tulsa County

The southern portion of Tulsa County is served by the City of Tulsa, the Town of Glenpool, the City of Broken Arrow, the City of Bixby, Creek County Rural Water District #2, Wagoner County Rural Water District #8, and Okmulgee County Rural Water District #6.

Water for the City of Jenks and the Town of Glenpool is provided by the City of Tulsa. Broken Arrow gets its water from the Mid-America Industrial District south of Pryor, which is supplied by Grand Lake. Bixby's water comes from Lake Bixhoma and the City of Tulsa. Creek County RWD #2 draws its water from the City of Tulsa, the City of Sapulpa, and from the town of Kellyville. Wagoner County Rural Water District #8 receives its water from the Verdigris River, via Wagoner County RWD #4. The District supplies four houses in Tulsa County. All of these water service districts have adequate water supplies and distribution systems and, therefore, low vulnerability to water shortages due to drought.

Water for Okmulgee County Rural Water District #6 is provided by the City of Okmulgee, the City of Tulsa, and from the town of Glenpool. Due to existing difficulties meeting demand in some areas of Tulsa County because of line size and elevation, some of the District's service area, particularly south of Bixby Ranch Estates, has moderate to high vulnerability to water shortage from drought and peak usage.

Due to the rapid spread of rural estate developments in the grasslands of south Tulsa County, the entire area has moderate to high vulnerability to a secondary impact of drought—urban interface wildfire—as demonstrated by the rash of grassfires during the drought of 2005-2006. This is particularly true for the urban fringes of Tulsa, Glenpool, Broken Arrow, Bixby, Jenks and Mounds.

Electric Power

Electricity in Tulsa County is provided by AEP/PSO, Oklahoma Gas & Electric, Indian Electric, and East Central Electric Co-op. Virtually all electric power marketed by AEP/PSO and OG&E is generated by coal and gas. Electric power distributed by Indian Electric and East Central Electric Co-op is generated primarily from coal and gas, but both have a component of hydro generation that is subject to shortfalls during times of drought. Tulsa County has not experienced power shortages or brownouts due to drought from the power grid currently in place. However, with almost all electric power used in Tulsa County generated from Wyoming coal and gas, the cost of fuel, particularly during times of drought and low river flow, has made electric power prices vulnerable to sudden fuel increases and electricity price spikes. Altogether, Tulsa County has low vulnerability to electric power shortages due to drought.

Structures/Buildings

The primary threat to structures within the City of Tulsa lies in the effect of drought on Expansive Soils. More information on that hazard is available in Section 4.9.

Critical Facilities

See Critical Facilities listed in Table 1-8 and mapped in Figure 1-9.

Infrastructure

The effect on infrastructure is, for the most part, similar to the effect on structures, in that the primary danger is drought's effect on expansive soils.

In many communities, drought can have impacts on the community's ability for firefighting, with both wildland and structure fires. The City of Tulsa's water supply is significantly robust enough that the Tulsa Fire Department does not consider this an issue.

Water Treatment – Drought increases the demand for water and at the same time may impact the availability of raw water. The City of Tulsa monitors and regulates our lake levels to mitigate the impacts of drought and conserve water. In addition, the City's primary water supply lakes (Eucha, Spavinaw and Oolagah) are located in different water sheds. Due to differences in local weather patterns, one area may be impacted to a lesser degree than another. The City of Tulsa also has an emergency contract in place to purchase water from Lake Hudson.

Wastewater Treatment – No vulnerabilities outside those experienced by other City services/facilities.

Utilities - No vulnerabilities outside those experienced by other City services/facilities.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Roadways could potentially face secondary effects if located in areas situated in an expansive soil base.

Emergency Services- Fire services could potentially be affected if a severe drought reduces availability of water for fire suppression. Police and medical services would not face any vulnerabilities outside those experienced by other City services/facilities.

4.8.4 Drought Scenario

Since Tulsa County does not supply water to its jurisdiction, and the other primary impacts of drought are to agriculture and recreational activities, it is not considered necessary to include a fully developed Drought Scenario in this Hazard Mitigation Plan. The City of Tulsa's forward thinking water supply engineering in the 1970s and 1980s has rendered drought impact on local water supply minimal, and Tulsa County's economic climate is not as heavily dependent on agricultural and recreational activities as are many jurisdictions in the western and eastern parts of the state.

However, as stated above, West Tulsa County has moderate vulnerability to water shortages due to drought, and moderate to high vulnerability to wildfire in its rural estates developments during times of low water pressure due to drought and peak demand. In addition, there has been some difficulty meeting peak demand in South Tulsa County, due to line size and elevation.

The entire area of south Tulsa County has moderate to high vulnerability to a secondary impact of drought—wildfire in the wildland/urban interface—as demonstrated by the rash of grassfires during the drought of 2005-2006. This is particularly true for the urban fringes of Tulsa, Glenpool, Broken Arrow, Bixby, Jenks and Mounds.

A plausible drought scenario for South Tulsa County would be a wildfire in the rural/urban interface that occurs during a drought, fueled by a combination of high temperatures, high wind and peak water demand. Such a fire could have little to hinder it, if water pressure in the mains is low due to peak use and elevation.

4.8.5 Future Trends

For a map of Tulsa County's potential future growth areas, see Figure 1-8.

Population

As drought is primarily an agricultural threat, and Tulsa County is a largely urban jurisdiction, the population vulnerable to this threat would remain basically unchanged. However, should the drought become severe enough to impact local agricultural businesses, County businesses and residents dependent on agricultural labor could be impacted.

Structures/Buildings

The primary threat to structures in Tulsa County lies in the effect of drought on Expansive Soils. Any future development/renovations involving County structures/buildings should consider the Expansive Soil hazard. (See Section 4.9)

Critical Facilities

As with other structures/buildings within Tulsa County, the most severe threat to Critical Facilities is from Expansive Soils. Critical Facilities located on such soils should be monitored. (See Section 4.9)

Likewise, all critical facilities should plan for the possibility of water shortages during drought events, as these would have a severe impact not just on fire protection, but also on daycare, nursing home, and medical facilities.

Infrastructure

The vulnerability of future infrastructure would be to drought impacts on expansive soils.

As development continues within Tulsa County, the capacity, age and condition of the various water delivery systems should be reviewed to ensure these can meet the demand of increased and/or relocated populations. The siting and composition of roadways must be reviewed to ensure appropriate techniques and materials are utilized where roads cross expansive soils. The County should encourage communities to upgrade lines where delivery systems are inadequate.

4.8.6 Conclusion

There are signs that drought is becoming an increasing problem in the United States, including Oklahoma. However, it is difficult to predict drought probabilities for the near future due to the nature and complexity of the hazard. However, there are signs that the region may be entering a period of sustained low rainfall and drought, similar to that of the 1930s.

The severe droughts of the 1930s led to the construction of Oklahoma’s numerous hydroelectric dams and reservoirs, as well as the implementation of new farming practices and conservation policies. However, more recent drought response and recovery activities in Oklahoma, both on state and local levels, have not been as ambitious or successful. Planning for the state’s critical and emergency water resources needs should not be carried on only during and immediately after drought crises. There is clearly a “need to focus more on long-term water management and planning issues; to integrate the activities of numerous agencies with drought-related missions into a coherent national approach; and to achieve better coordination of mitigation, response, and planning efforts between State and Federal officials.”

Tulsa County is at low risk from the impacts of drought. The City’s water and electric supply is adequate to withstand drought conditions. However, like many jurisdictions that are experiencing growth on their urban fringes, Tulsa County is increasingly vulnerable to poor water supply in some outlying areas, and to one of the secondary impacts of drought—wildfire.

4.8.7 Sources

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4.9 Expansive Soils

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.

4.9.1 Hazard Profile

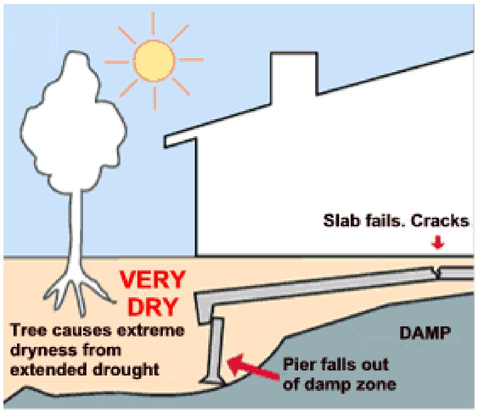
Changes in soil volume present a hazard primarily to structures built on top of expansive soils. Most often, these volume changes involve swelling clays beneath areas covered by buildings and slabs or layers of concrete and asphalt.

The total annual cost of expansive soil-related damage and preventative design of moderate to high-risk structures throughout the United States has been conservatively estimated at just under $2.5 billion. Recent estimates put the annual damage as high as $10 billion.

Because the hazard develops gradually and seldom presents a threat to life, expansive soils have received limited attention, despite their costly effects. Many problems are not recognized as being related to expansive soils or may be considered only nuisances and therefore never repaired.

The most extensive damage from expansive soils occurs to highways and streets. Damage to the built environment results from differential vertical movement that occurs as clay moisture content adjusts to the changed environment. In highway pavement, differential movement of 0.4 inches within a horizontal distance of 20 ft is enough to pose an engineering problem if high standards for fast travel are to be maintained.

Figure 4–28: Expansive Soil Diagram



Tulsa County is underlain by soils with shrink-swell potentials ranging from low to very high.

Houses and one-story commercial buildings are more apt to be damaged by the expansion of swelling clays than are multi-story buildings, which usually are heavy enough to counter swelling pressures. However, if constructed on wet clay, multi-story buildings may be damaged by shrinkage of the clay if moisture levels are substantially reduced, such as by evapotranspiration or by evaporation from beneath heated buildings.

The increase in soil volume also causes 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.

Location

The extent of damage from expansive soils can be reduced by mapping the soils in the jurisdiction and by informing property owners and prospective buyers and builders of potential soil hazards and the techniques that can be used to limit their impacts. The area extent of the Expansive Soils is shown on the maps in Figures 4-29a, 4-29b and 4-29c.

Measurements

The risk associated with expansive soil is related to shrink/swell potential in a qualitative manner: very high, high, moderate and low. Probability and frequency analyses have not been prepared because of the nature of this hazard, which is consistent with other geologic hazards that occur rarely or slowly over time.

The National Resource Conservation Service (NRCS), in its Soil Survey Geographic Database (SSURGO), identified expansive soils for Tulsa County, as shown in Figures 4–29a to 4–25c. SSURGO map units were classified from “low” to “very high” based on the weighted average of the Coefficient of Linear Extensibility (COLE) percent for the soils within the identified map units to depths between 0 inches and 60 inches, the depths at which damage to improvements from expansive soils is most likely to occur. Soil samples are dehydrated either through air-drying or oven drying for a predetermined length of time under a constant temperature. Bulk density, particle density, overall volume, and porosity are then plugged into a formula to obtain the above-mentioned COLE. In addition, the Oklahoma Department of Transportation has a program to evaluate the expansive tendencies of soils and shale formations in the state. Data on shrink-swell potential for each major soil type is kept for 77 counties.

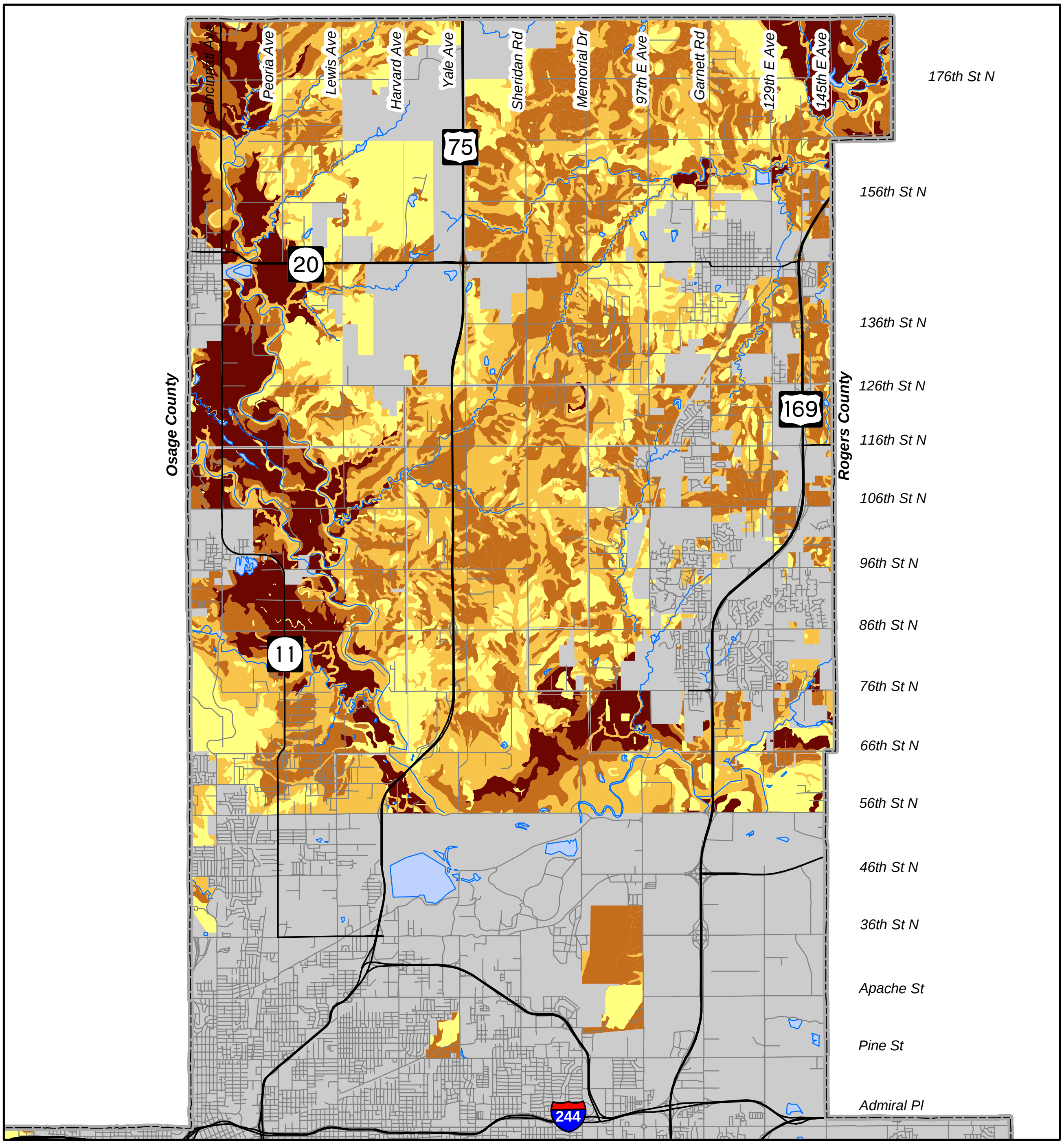
Extent

With 78% and 66% of the soils within North and South Tulsa County, respectively, having “moderate” to “very high” shrink/swell potential, these regions could suffer extensive damage from expansive soils. West Tulsa County is at low risk to expansive soils damage due to its high percentage of soils with low shrink/swell potential. This being said, the extent of expansive soils property damage can vary greatly across a jurisdiction, based on several factors: the long-term weather conditions, the type and quality of construction, materials used in construction, and, most importantly, the soils the structures are built upon. For example, aging gas and water pipelines, especially when originally constructed in wet soil, can rupture during periods of extended drought.

Cracks in a chimney caused by soil expansion

Frequency

Out of the 250,000 homes built each year on expansive soils, 10% sustain significant damage during their useful lives, some beyond repair, and 60% sustain minor damage. For all types of building construction, annual losses of $740 million are estimated.



LEGEND

0 1 2 Miles

- Highways
- Streets
- Streams
- Water Bodies
- Incorporated Areas

Shrink/Swell Properties

- Low
- Moderate
- High
- Very High

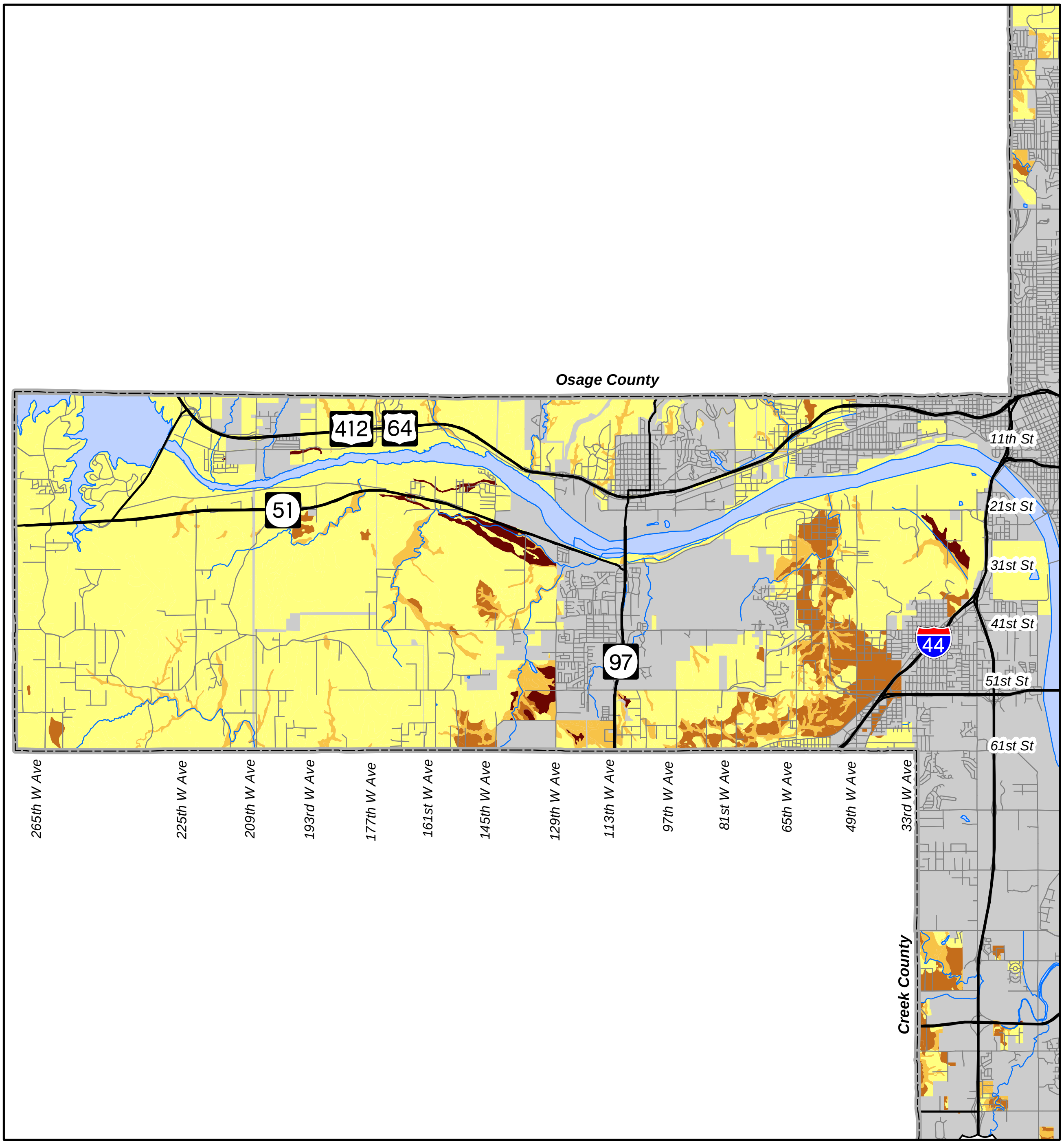
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-29a

Expansive Soils

Tulsa County - North



LEGEND

0 1 2 Miles

- Highways
- Streets
- Streams
- Water Bodies
- Incorporated Areas

Shrink/Swell Properties

- Low
- Moderate
- High
- Very High

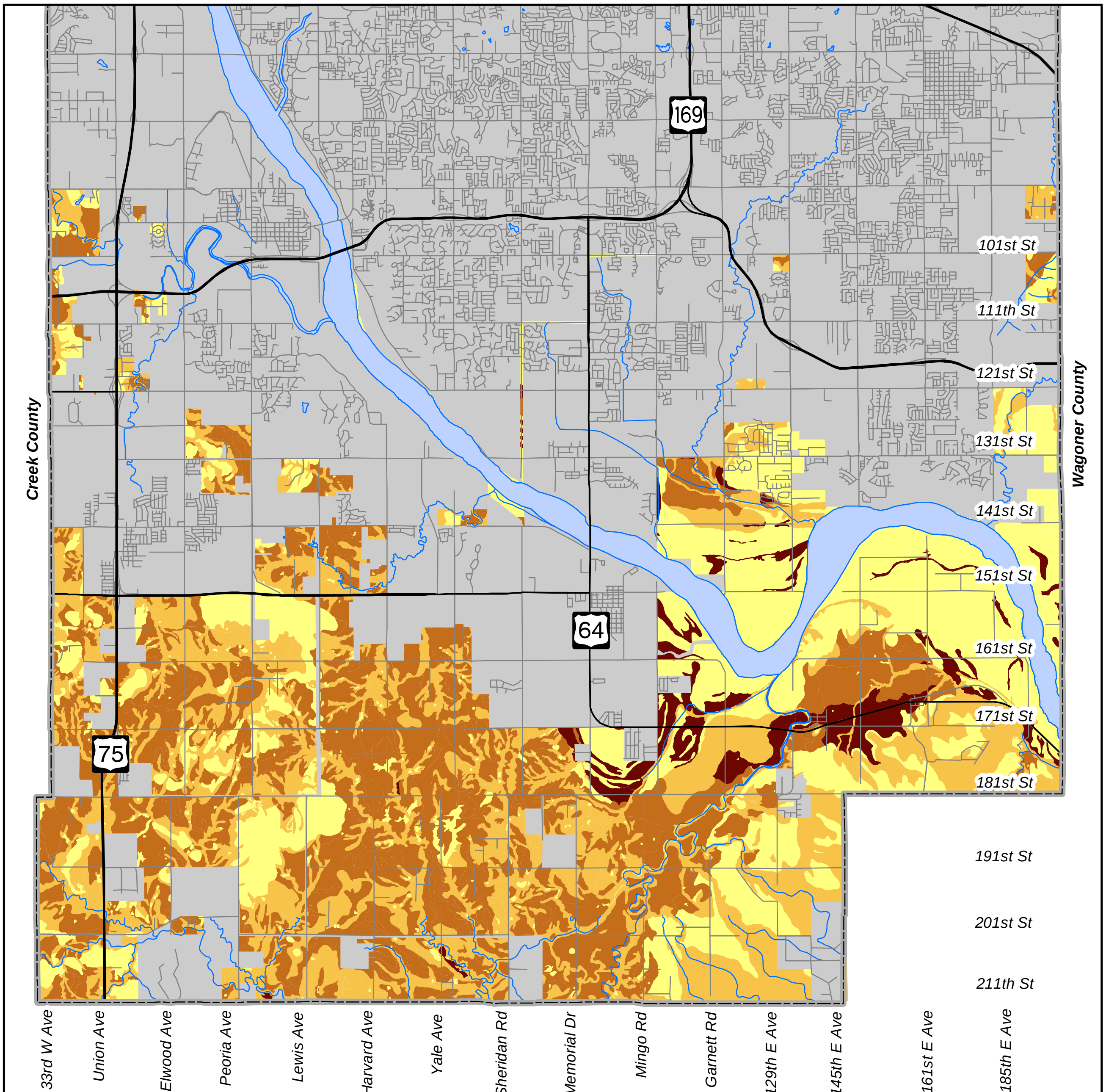
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-29b

Expansive Soils

Tulsa County - West



LEGEND

0 1 2 Miles

- Highways
- Streets
- Streams
- Water Bodies
- Incorporated Areas

Shrink/Swell Properties

- Low
- Moderate
- High
- Very High

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Planning Consultants

TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-29c

Expansive Soils

Tulsa County - South

Tulsa County considers a shrink-swell level of moderate and below to be a minor severity and a shrink-swell level of high and above to be a major severity.

Impact

The impact of this hazard occurs over time and affects structures and infrastructure. This can result in costly repairs and can reduce the value of structures affected.

4.9.2 History/Previous Occurrences

In Oklahoma, numerous foundation failures and pipeline breaks have resulted from soil shrinkage during the unusually hot and dry summers of 1998 and 2005-2006. During the drought of 2005-2006, soil shrinkage led to water main and sewer pipe breaks and leaks in many Oklahoma cities, including Holdenville, Okmulgee, Muskogee and Ada. For example, expansive soils are having a serious impact on Ada's aging water infrastructure, particularly during the drought and high temperature conditions of 2006. In July, 2006, Ada lost about 2.5 MGD from its water distribution system due to breaks, leaks and unmonitored (but authorized) use. Similar problems have plagued Okmulgee's water distribution system. Both cities have instituted aggressive pipeline maintenance programs to counter the effects of soil shrinkage during periods of prolonged drought.

The history of Tulsa County's expansive soil hazard is difficult to track, since the County does not specifically monitor damage to structures from expansive soils. The County treats all such damage as a maintenance issue. According to the County Engineer's office, the expansive soil hazard is routinely taken into account in engineering studies and construction practices. Furthermore, because the County does not provide utilities—other than roads, bridges and drainage structures—there is a less pressing need to identify and track pipeline damage due to expansive soils.

Long referred to as the "unknown hazard," expansive soils may be a hazard with more of a future than a past. As Oklahoma's infrastructures continues to age—particularly water and sewer lines built at the beginning of the last century with materials and techniques that would not meet today's codes—a prolonged period of drought could significantly speed and intensify infrastructure deterioration. The rehabilitation of roads and aging central business districts will likely include the replacement of much of the city's infrastructure that lies underground, especially if located in expansive soils. The use of the more flexible PVC piping could reduce the impact of expansive soils.

4.9.3 Vulnerability

The effects of expansive soils are most prevalent in regions of moderate to high precipitation, especially where prolonged periods of drought are followed by long periods of ground-saturating rainfall. The most problematic soil type for expansive soils is found in the semiarid west-central United States.

Houses and small buildings are impacted more by expansive soils than larger buildings. The greatest damage occurs when small buildings are constructed when clays are dry, such as during a drought, and then subsequent soaking rains swell the clay. Other cases of damage involve increases of moisture volume from broken or leaking water and sewer lines, over-watering of lawns and landscape, and surface modifications that produce ponding.

Expansive soils for Tulsa County, as identified by the National Resource Conservation Service (NRCS) in its Soil Survey Geographic Database (SSURGO), are shown for each study area in Figures 4-29a through 4-29c. SSURGO map units were classified from "low" to "very high" based on the weighted average of the linear elasticity percent for the soils within the identified map units to depths between 0" and 60", the depths at which damage to improvements from expansive soils is most likely to occur.

Table 4-38 outlines the percent coverage of each of the shrink/swell categories for the three areas of Unincorporated Tulsa County. Over 78% of the soils within North Tulsa County and nearly 66% of the soils within South Tulsa County are classified as having moderate to very high shrink/swell potential. West Tulsa County is the opposite of North and South Tulsa County, with over 78% of its soils having a low shrink/swell potential.

Table 4–38: Tulsa County Expansive Soils

Expansion Potential	*North (% Area)*	*West (% Area)*	*South (% Area)*
Very High	12.71	1.36	3.65
High	32.02	5.7	31.07
Moderate	33.44	6.94	31.11
Low	20.05	78.59	28.02
Water	1.79	7.42	6.15

Soils in the identified development areas of North Tulsa County are primarily classed as "very high," "high" and "moderate", but soils classed as "low" are also present, particularly near Skiatook east of Bird Creek to US Hwy 75, and between 126th and 156th St. North. Although future development areas in the central and east portion of North Tulsa County are underlain predominantly by soils with "high" and "moderate" ratings, there are some areas of "low" shrink-swell soils around both Owasso and Collinsville. Overall, North Tulsa County's future development areas are at high risk to the hazard of expansive soils.

The future development areas of West Tulsa County are primarily classed as "low," although "high" shrink-swell soils predominate between S. 21st and 61st St., and 49th and 65th W. Ave., and between 33rd and 49th W. Ave. from S. 41st to 61st St. Overall, West Tulsa County's development areas are at low risk to expansive soils.

The majority of soils in the development areas of South Tulsa County have "high" and "moderate" shrink-swell potential. Some soils classed as "low" are present northeast of Liberty, southeast of Glenpool, and east of Bixby and Broken Arrow. Some of the developable land near these latter two communities, however, lie within the Arkansas River floodplain, and are thus hazardous for other reasons (i.e., flooding). Overall, South Tulsa County's development areas are at high risk to the hazard of expansive soils.

Since Tulsa County does not operate water or sewer systems, it has no pipelines exposed to damage from expansive soils. However, people living in unincorporated Tulsa County who are served by lines from neighboring jurisdictions remain at risk to such damage.

Broken water mains serving areas with already marginal service could be impacted by breaks due to a combination of deteriorating infrastructure and expansive soils.

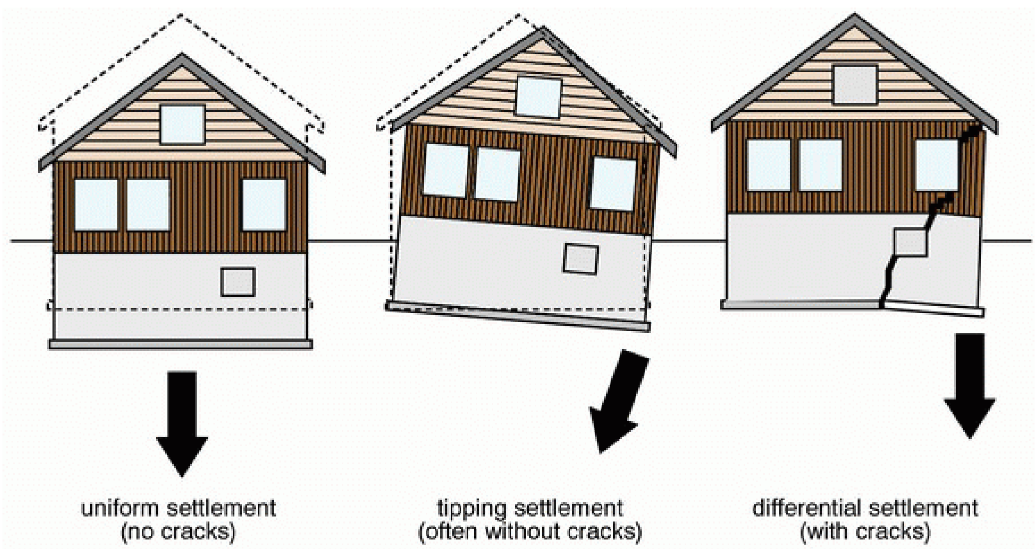
Population

Direct threats to life or personal injury have not generally been documented for expansive soils, due to the nature of the hazard.

Structures, Buildings

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.

Figure 4–30: Types of Expansive Soil Damage



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.

Houses and one-story commercial buildings are more apt to be damaged by the expansion of swelling clays than are multi-story buildings, which usually are heavy enough to counter swelling pressures. However, if constructed on wet clay, multi-story buildings may be damaged by shrinkage of the clay if moisture levels are substantially reduced, such as by evapotranspiration or by evaporation from beneath heated buildings.

The greatest damage occurs when small buildings are constructed when clays are dry, such as during a drought, and then subsequent soaking rains swell the clay. Other cases of damage involve increases of moisture volume from broken or leaking water and sewer lines, over-watering of lawns and landscape, and modifications of the surface that produce ponding.

Critical Facilities

Six of Tulsa County’s critical facilities, identified in Table 4–39 are built upon soils classified as having “high” or “very high” shrink/swell potential.

Table 4–39: Critical Facilities Vulnerable to Expansive Soils

ID	Name	Address
2	Cherokee Elementary School	6001 N. Peoria, Tulsa
3	Collinsville Rural Fire Protection	1018 S. 12th St., Collinsville
5	First Bank of Turley	6555 N. Peoria
8	Greeley Elementary School	105 E. 63rd St. North, Tulsa
16	Sand Springs Health Center	306 E. Broadway, Sand Springs
17	Liberty School	2727 E. 201st St. South, Mounds

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.

4.9.4 Expansive Soils Scenario

Since specific cost data is not available for the average damages per property incurred from Expansive Soils, it is not possible to include a realistic Expansive Soils Scenario. In future versions of this plan, it is possible that research data will have been developed and made available that allows such a scenario to be constructed.

4.9.5 Future Trends

Soils in Tulsa County's identified future-development areas are primarily classed as "Low" and "Moderate", but soils with a "High" and "Very High" are also present, primarily in the north part of the county. The irony of "future development" in unincorporated Tulsa County is that as areas develop along the fringes of existing cities, they are sooner or later incorporated into those communities and are no longer under County jurisdiction. Nevertheless, Tulsa County will continue to have moderate to high vulnerability to the damaging effects of expansive soils in the northern part of the jurisdiction, where soils with "High" and "Very High" shrink/swell properties are common. This is particularly true of soils in the Bird Creek and Caney Creek basins, and east of US Hwy 75.

Population

Direct threats to life or personal injury have not generally been documented or projected for expansive soils because of the nature of the hazard. The primary threat is economic.

Structures / Buildings

Damage to structures in Tulsa County can be expected during and following any period of extended drought. This is especially true of structures built during a period of a drought followed by soaking rains that cause swelling of clays.

Critical Facilities

Tulsa County has six critical facilities built on "High" or "Very High" shrink/swell soils. Three of these facilities are schools; one is a rural fire station and one a health center. While expansive soils will not impact the ability of these facilities to function or respond to emergencies, they could shorten the effective lifespan of the buildings, or require maintenance. Over time, long-term structural damage to schools, care facilities, and emergency response entities could place the residents and functions at risk if a building already weakened by wall and foundation cracks is exposed to a natural hazard event such as a tornado.

Infrastructure

Long referred to as the "unknown hazard," expansive soils may be a hazard with more of a future than a past. As Tulsa County's infrastructure continues to age, particularly those built at the beginning of the last century with materials and techniques that would not meet today's codes, a prolonged period of drought could significantly speed its deterioration. For example, aging gas and water pipelines, especially when originally constructed in wet soil, can rupture during periods of extended drought. The rehabilitation of roads and aging central business districts will likely include the replacement of much of the infrastructure that lies underground, especially if located in expansive soils. The use of the more flexible PVC or HDPE piping could reduce the impact of expansive soils.

4.9.6 Conclusion

With 78% and 66% of the soils within North and South Tulsa County being categorized as having "moderate" to "very high" shrink/swell potential, these regions have high vulnerability to the damaging effects of expansive soils. That being said, the damage resulting from expansive soils is often very slow in occurring and usually not "catastrophic" in nature. West Tulsa County is at low risk to expansive soils damage due to the high percentage of soils classified as having low shrink/swell potential.

Damage to structures in Tulsa County can be expected, during and following any period of drought. This is especially true of the structures built during a drought. Houses and one-story commercial buildings are more apt to be damaged by the expansion of swelling clays than are multi-story buildings, which usually are heavy enough to counter swelling pressures. However, if constructed on wet clay, multi-story buildings may be damaged by shrinkage of the clay if moisture levels are substantially reduced.

Tulsa County currently has six critical facilities located on "High" or "Very High" expansive soils, including two elementary schools, a fire station, and a health clinic. None of their structures or functions are at significant risk due to expansive soils. Since the County does not operate water or sewer systems, it has no pipelines exposed to damage from expansive soils. However, people living in unincorporated Tulsa County who are served by lines from neighboring jurisdictions remain at some slight risk to the hazard. Broken water mains serving areas with already marginal service, such as the area south of Bixby Ranch Estates, could be exposed to poor or no flow due to a combination of deteriorating infrastructure and expansive soils. Such an eventuality could hamper efforts to control structure fires and wildfire in these areas.

4.9.7 Sources

Landslides and Expansive Soils in Oklahoma, at Web address: www.ou.edu/special/ogs-pttc/earthsci/landsl.htm. Oklahoma Geological Survey, Earth Sciences, October, 1998.

Multi-Hazard Identification and Risk Assessment, p. 122–125. Federal Emergency Management Agency, 1997.

4.10 Urban Fires

Home fire is the fifth leading unintentional cause of injury and death in the United States, behind motor vehicle crashes, falls, poisoning by solids or liquids, and drowning. It also ranks as the first cause of death for children under the age of 15 at home. Roughly 80% of all fire deaths occur where people sleep, such as in homes, dormitories, barracks, or hotels. The majority of fatal fires occur when people are less likely to be alert, such as nighttime sleeping hours. Nearly all home and other building fires are preventable, even arsons.

4.10.1 Hazard Profile

Fires are an excellent example of how natural hazards interact in ways that can spiral out of control. Lightning, earthquakes, high winds, volcanoes, and floods can trigger or exacerbate fires. Lightning can trigger structural fires. For example, in 1994, a $1.5 million historic mansion in Pennsylvania was destroyed by a lightning-triggered fire. Buildings with rooftop storage tanks for flammable liquids are particularly susceptible.

Frame houses are particularly vulnerable to urban fire.

Cooking is the leading cause of home fires in the U.S. It is also the leading cause of home fire injuries. Cooking fires often result from unattended cooking and human error, rather than mechanical failure of ovens and stoves.

Careless smoking is the leading cause of fire deaths. Smoke alarms and smolder-resistant bedding and upholstered furniture are significant fire deterrents.

Heating is the second leading cause of residential fires and the second leading cause of fire deaths. However, heating fires are a larger problem in single-family homes than in apartments. Unlike apartments, the heating systems in family homes are often not professionally maintained.

Arson is both the third leading cause of residential fires and residential fire deaths. In commercial properties, arson is the major cause of deaths, injuries and dollar loss. *(Source: U.S. Fire Administration)*

The leading cause of death in a fire is asphyxiation by a three-to-one ratio over burns. Fire consumes the oxygen and increases the concentration of deadly carbon monoxide and other toxic gases in the air. Inhaling carbon monoxide can cause loss of consciousness or death within minutes. The heat from an urban fire exceeds anything to which a person is normally exposed. A fully developed room fire has temperatures over 1,100 degrees Fahrenheit. Building and house fires generate a black, impenetrable smoke that blocks vision and stings the eyes, making it often impossible to navigate and evacuate the structure.

Location

While the entire community is at risk from urban structure fires, there are some factors that can increase or decrease the risk of a fire occurring in a given location. Average age of structures, type of construction, and location relative to fire stations can all influence the likelihood or extent of damage of structure fires.

Measurement

Reports on fires are submitted by local fire departments to the State Fire Marshall's Office. This information is summarized to show community, county and state summaries. This allows the number of fires that a community has to be measured against state and national averages.

Extent

Tulsa County's 5,081 structural fires resulted in 318 casualties and $96,430,000 in fire damage to all structures, excluding critical facilities. Its 264 fires in critical facilities caused $6,460,000 damage. If these numbers are representative, the County can expect about $19,286,000 total damage per year in structural fires, or $19,000 damage per fire, and $1,292,000 damage per year in critical facilities (or $24,500 per fire). Various factors determine the extent of an urban fire's impact. The contents of a structure can influence the extent of an urban fire, as can local weather conditions. The impact can also be affected by notification techniques and procedures, fire department response speed, structure type and age, density of surrounding development, presence of flammable substances, water pressure and availability, and the use of smoke alarms. In recent years, the extent of urban fire has been greatly reduced because of advancements in fire protection, firefighting technology and training of local fire management officials. Improvements in building codes and technology have also enhanced Tulsa County's ability to contain and mitigate the damage caused by urban fire.

Frequency

From 1999 to 2003, Tulsa County experienced a total of 5,081 structural fires, and 264 fires in critical facilities. Given this data, the County can expect about 1,000 fires each year, and 53 fires per year in critical facilities.

Tulsa County Fire Departments

Tulsa County is served by 15 Fire Departments, listed in Table 4-40. The jurisdictional boundaries associated with these departments are depicted in Figure 2-2.

Tulsa County considers a minor severity to be $5,000 or less in damages and no loss of life or injury and a major severity to be more than $5,000 in damages or loss of life or injury.

Impact

The impact of this hazard can damage or destroy homes and businesses and can injure or kill people. This can be devastating to families who lose their home, job, or family member and can affect the economy.

Table 4–40: Tulsa County Fire Departments

Fire Department	Community	Fire Department	Community
Berryhill Fire Protection District	Tulsa	Keystone Volunteer Fire Department	Sand Springs
Bixby Fire Department	Bixby	Osage Hills Volunteer Fire Dept.	Tulsa
Broken Arrow Fire Department	Broken Arrow	Owasso Fire Dept	Owasso
City of Glenpool	Glenpool	Sand Springs Fire Department	Sand Springs
Collinsville Fire Department	Collinsville	Sperry Volunteer Fire Department	Sperry
Country Corner Fire District	Sperry	Tulsa Fire Department	Tulsa
Green Country VFD	Sand Springs	Turley Fire & Rescue	Tulsa
Jenks Fire Department	Jenks		

4.10.2 History/Previous Occurrences

In 1991, structural fires in the United States caused 4,465 civilian deaths, 21,850 injuries, and an estimated $8.3 billion in damage. In 1995, 3,640 people died in reported home fires – roughly 10 people per day. In addition, thousands of people were injured in home fires, many hospitalized, and some disfigured for life.

In Oklahoma, during the 12-year period from 1988 through 1999, there were 97,148 residential fires (average of 8095 per year), and fire losses of $858 million (average of $71 million per year).

Table 4-41 displays information supplied by the Oklahoma State Fire Marshal concerning fire-related damages, injuries and deaths for the State from 2004 through 2008.

Table 4–41: Oklahoma Urban Fire Damages and Injuries & Deaths 2004-2008
Source: Oklahoma State Fire Marshal
Damages in 1000's of Dollars

Type of Structure	2004		2005		2006		2007		2008		Total	
	#	Damage	#	Damage	#	Damage	#	Damage	#	Damage	#	Damage
Single Family	4,577	$77,789	4,081	$73,630	4,103	$77,104	3,526	$78,305	Unavailable		16,287	$306,828
Apartments	540	$6,309	587	$6,903	604	$6,271	585	$9,299			2,317	$28,782
Mobile Homes	639	$8,123	518	$7,187	459	$7,203	325	$4,464			30,726	$26,977
Commercial	208	$6,728	595	$12,002	200	$11,424	167	$9,709			1,170	$39,863
Warehouse	430	$5,841	411	$4,992	515	$8,111	3	$450			1,359	$19,394
Industrial	140	$8,450	97	$9,910	71	$1,474	49	$1,195			357	$21,029
Office	36	$756	32	$560	50	$1,038	25	$659			143	$1,137
Total	6,570	$114	6,321	$115,184	6,002	$112,625	4,680	$104,081	Unavailable		23,573	$444,010

Fire-Related Casualties

Casualty	2004	2005	2006	2007	2008	Total
Civilian Injuries	164	147	103	112	Unavailable	**526**
Civilian Deaths	69	87	55	55		**266**
Firefighter Injuries	139	106	68	119		**432**
Firefighter Deaths	0	0	1	1		**2**
Total Injuries	**303**	**253**	**171**	**231**	**Unavailable**	**958**
Total Deaths	**69**	**87**	**56**	**56**		**268**

Tulsa County information was compiled from data from the State Fire Marshall. Table 4-42 details the type and number of fires, along with damages and casualties related to these fires during this 5-year period.

Table 4–42: Tulsa County Urban Fire Damages and Injuries & Deaths 2004-2008
Source: Oklahoma State Fire Marshal
Damages in 1000's of Dollars

Type of Structure	2004		2005		2006		2007		2008		Total	
	#	Damage	#	Damage	#	Damage	#	Damage	#	Damage	#	Damage
Single Family	518	$9,894	570	$11,311	520	$10,938	Unavailable		396	$6,818	**2,004**	**$3,896**
Apartments	181	$1,897	171	$1,420	202	$3,113			190	$5,768	**744**	**$12,198**
Mobile Homes	15	$475	11	$90	14	$290			3	$51	**43**	**$906**
Other Residential	44	$1,524	36	$363	28	$528			32	$522	**140**	**$2,937**
Commercial	57	$652	68	$1,961	57	$3,308			53	$1,148	**235**	**$7,069**
Warehouse	28	$686	55	$950	37	$450			29	$529	**149**	**$2,615**
Industrial	16	$769	4	$23	2	$107			16	$2,980	**38**	**$3,879**
Total	**859**	**$15,897**	**915**	**$16,118**	**860**	**$18,734**			**719**	**$17,816**	**5,081**	**$96,430**

Fire-Related Casualties

Casualty	2004	2005	2006	2007	2008	Total
Civilian Injuries	24	26	22	Unavailable	19	**91**
Civilian Deaths	16	10	6		10	**42**
Firefighter Injuries	28	3	3		11	**45**
Firefighter Deaths	0	0	1		0	**1**
Total Injuries	**52**	**29**	**25**		**30**	**136**
Total Deaths	**16**	**10**	**7**		**10**	**43**

Critical Facilities are vulnerable to fire, and are of special importance because the impact that a fire may have. Critical facilities deserving special attention include nursing and retirement homes, hospitals and clinics, child care centers, correctional institutions, schools and colleges. Oklahoma fires in critical facilities, from 2004 through 2008 are shown in Table 4-43, and those specific to Tulsa County in Table 4-44.

Fire Fighters responding to a house fire, one of thousands that occur every year across the state

Table 4–43: Oklahoma Critical Facility Fires 2004-2008
Source: Oklahoma State Fire Marshal
Damages in 1000's of Dollars

Type of Structure	2004		2005		2006		2007		2008		Total	
	#	Damage	#	Damage	#	Damage	#	Damage	#	Damage	#	Damage
School, University	56	$391	54	$295	52	$198.1	Unavailable		44	$335.0	206	**$1,219.1**
Public Assembly	149	$2,603	165	$6,359	168	$7,739			142	$4,136	624	**$20,837**
Hospital	24	$99	31	$380	13	$2.4			14	159	82	**$640.4**
Correctional Facilities	11	$23	9	$3.2	49	$49.8			7	$2.7	76	**$78.7**
Child Care	5	$11	9	$62.7	7	$2.3			4	$1.1	25	**$77.1**
Nursing/ Retirement	62	$81	37	$230	48	$102.8			30	$81.9	177	**$495.7**
Total	**307**	**$3,209**	**305**	**$7,329**	**337**	**$8,094**			**241**	**$4,715**	**1,190**	**$23,348**

Table 4–44: Tulsa County Critical Facility Fires, 2004-2008
Source: Oklahoma State Fire Marshal
Damages in 1000's of Dollars

Type of Structure	2004		2005		2006		2007		2008		Total	
	#	Damage	#	Damage	#	Damage	#	Damage	#	Damage	#	Damage
School, University	11	$30	12	$4.6	7	$4	Unavailable		6	$140	36	**$179**
Public Assembly	29	$1,349	26	$760	16	$2,057			16	$843	87	**$5,009**
Hospital	1	$2	0	$0	3	$155			2	$4.5	6	**$162**
Correctional Facilities	0	$0	0	$0	1	$0			0	$0	1	**$0**
Child Care	1	$0.1	2	$2	1	$1			1	$65	5	**$68**
Nursing/ Retirement	4	$204	6	$28	3	$5			2	$8	15	**$245**
Other Institutional	0	$0	1	$14	1	$1			0	$0	2	**$15**
Total	**46**	**$1,585**	**47**	**$808**	**32**	**$2,223**			**27**	**$1,060**	**152**	**$5,678**

Real progress has been made nationally and locally in reducing the number of urban fires and fire-related fatalities. Nationally, in 1977 there were 3,264,500 fires, and 5,865 fatalities. By 2002, despite urban population growth, both figures have been reduced by almost half to 1,687,500 fires, and 2,670 fire-related deaths.

4.10.3 Vulnerability

In residences, the majority of fatal fires occur when people are less alert or sleeping. Victims are disproportionately children or elderly. Of the fires that kill children, two out of every five are started by children playing with fire.

States with the largest populations tend to have the greatest number of fire-related fatalities. The western United States is susceptible because of prolonged warm winds that can spread sparks and embers. Areas where seismic events are more likely to occur are also susceptible, particularly in areas where natural gas distribution systems can rupture. Floods can also trigger fires.

Some of the vulnerabilities peculiar to Oklahoma are related to flooding and lightning events, both of which can trigger urban fires. In many cases, communities with aging infrastructures may be more susceptible to urban fire due to the flammability of materials used in construction and number of structures built before current fire safety, plumbing and electrical codes were implemented. The National Association of Home Builders (NAHB) makes the statement in their *Housing Economics* publication:

> "An overarching cause of residential fire deaths is the age of the dwelling. Both known studies that have looked at this question have found that older structures burn much more frequently than newer ones."

Consequently, while any building is vulnerable to fire, particular attention needs to be paid to lower-income neighborhoods with older residences and aging commercial structures.

Population

The populations most at risk to structural fire are those living in aging and dilapidated structures with substandard heating and wiring, located in sections of the County where water lines are small and pressure low during hours of peak use.

Structures/Buildings

The primary fire threats to structures in Tulsa County are from alternative heating, lightning, faulty wiring, and cooking. Tulsa County has a high percentage of structures built prior to 1939, and some derelict structures. Derelict structures can pose a fire hazard to newer homes, particularly if embers are spread during times of high wind and drought. Almost 46% of Tulsa County's residential structures were built before 1970, with 8.2% constructed before 1939. In addition, some older homes have substandard heating systems, relying on kerosene, fuel oil and wood.

Critical Facilities

As with other structures/buildings within Tulsa County, the most severe threat to critical facilities is from water availability and distance from fire protection facilities. All critical facilities should plan for the possibility of water shortages, particularly during drought events, as these could have a severe impact on fire protection.

Infrastructure

The vulnerability of infrastructure is related to the age and condition of the various water delivery systems. The County should encourage communities to upgrade lines where delivery systems are inadequate.

All areas of Tulsa County are exposed to personal injury and property damage because of fires. This is also true of future development areas.

4.10.4 Urban Fire Scenario

As mentioned above, Tulsa County does not provide water service or fire protection, but depends for these upon its constituent communities. The fire departments that serve Tulsa County, which are listed in Table 4-40, have ISO ratings between 2 and 8. Water service is primarily supplied by the City of Tulsa, but also by 13 other suppliers, both public and private. Generally, water service is reliable and abundant. However, there two pockets on the outer peripheries of the county where service is poor due to small distribution lines and low pressure, as discussed in Section *1.2 Lifelines*, and in *4.8.3 Drought*, above. One of these low pressure areas is in West Tulsa County (served by the City of Sand Springs), and the other in the South (served by Okmulgee County Rural Water District #6).

A worst-case fire scenario for Tulsa County would be a structure fire in a business or dwelling located in one of these low water pressure areas. In the scenario, a fire caused by lightning from a dry thunderstorm during a period of peak water use would exceed the capacity of the tank trucks sent to the scene, and water pressure from local mains would be insufficient to quench the flames. The result could be complete destruction of the building, and perhaps the spread of the fire to other structures. If climatic conditions are those of drought, high temperatures and high wind, the fire could spread to trees and grasses and become a widely destructive wildland/urban interface fire.

4.10.5 Future Trends

For a map of Tulsa County’s potential future growth areas, see Figure 1-8.

Population

The populations most at risk to urban fire in the county’s future development areas are those located in sections where water lines are small and pressure low during hours of peak use—that is, along the extreme western periphery of West Tulsa County, and in the extreme southern part of South Tulsa County.

Structures/Buildings

The primary fire threat to structures in Tulsa County is from small water lines, low pressure during peak usage hours, and from slow response times due to distance from fire protection facilities. Unincorporated Tulsa County also has a high percentage of structures built prior to 1970, and some derelict structures. Derelict structures in the wildland/urban fringe, in particular, can pose a fire hazard to newer homes, particularly if embers from a derelict structure fire spread during times of high wind and drought to dry wildland grasses.

Critical Facilities

As with other structures/buildings within Tulsa County, the most severe threat to Critical Facilities is from small distribution lines and low pressure in some areas in the extreme west and south of the jurisdiction during periods of peak use. All critical facilities should plan for the possibility of water shortages, particularly during drought events, as these could have a severe impact on fire protection.

Infrastructure

The vulnerability of future infrastructure would be related to the age and condition of the various water delivery systems. These should be reviewed to ensure they can meet the demand of increased and/or relocated populations. The County should encourage communities to upgrade lines where delivery systems are inadequate.

4.10.6 Conclusion

Fires occur year-round, but the rate of residential fires during the U.S. holiday season and in January is twice that of the summer months. Fatalities tend to be distributed according to population density. Public information and education on smoke alarms have proven successful in reducing residential fires and fire related deaths.

The following factors influence the relative vulnerability of Tulsa County:

- The percentage of older structures (built before 1970) is higher than the state average (60.0% vs. 45.9%).
- The history of casualties due to urban fires is significantly lower than the state average (1 casualty per 28 fires vs. state figures of 1 casualty per 16.8 structure fires).
- Tulsa County has strong public education programs in place that include fire safety.
- Tulsa County has ISO Fire Protection Ratings ranging from 2 to 8.
- Rural structure fires are typically more destructive than urban due to response times and limited water supplies.

These factors would classify Tulsa County as having a moderate vulnerability to structural fires.

4.10.7 Sources

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4.11 Wildfires

A worker tries to help Tulsa firefighters put out a grass fire at 56th St. North and U.S. 169 northeast of Tulsa International Airport.
(Source: Tulsa World, 10/25/06)

As more people make their homes in woodland settings in or near forests, rural areas, or remote mountain sites, they face the real danger of wildfire. Wildfires often begin unnoticed and spread quickly, igniting brush, trees, and homes.

Wildfires can move on three different levels. A *surface fire* is the most common type and burns along the surface of grasslands or forests, usually moving quickly through an area. A *ground fire* is usually started by lightning and burns on or below the forest floor in the humus layer down to the mineral soil, mostly by smoldering combustion. A *crown fire* has ascended from the ground into the forest canopy, spreads rapidly by wind and moves by jumping along the tops of trees.

4.11.1 Hazard Profile

Wildfire is a serious and growing hazard over much of the United States, posing a great threat to life and property, particularly when it moves from forest or rangeland into developed areas. However, periodic forest, grassland, and tundra fires are a natural process in the environment, as natural and as vital as rain, snow, or wind. Naturally occurring or non-native species of trees, brush, and grasses fuel wildfires.

Fire suppression is now recognized to have created a larger fire hazard, because live and dead vegetation accumulates in areas where fire has been excluded. In addition, the absence of fire has altered or disrupted the cycle of natural plant succession and wildlife habitat in many areas. Consequently, United States land management agencies are committed to finding ways of reintroducing fire into natural ecosystems (such as prescribed burning) while recognizing that fire fighting and some types of fire suppression are still important.

The four categories of wildfires experienced throughout the United States are:

- **Interface or intermix fires** are fires that are fueled by both wildland vegetation and the built-environment.
- **Firestorms** are events of such extreme intensity that effective suppression is virtually impossible. They occur during extremely dry weather and generally burn until conditions change or available fuel is exhausted.
- **Prescribed fires** are those that are intentionally set or selected natural fires that are allowed to burn for beneficial purposes.
- **Wildland fires** are fueled by natural vegetation and typically occur in national forests and parks.

Topography, fuel, and weather are the three principal factors that impact wildfire hazards and behavior. Other hazard events have the potential to cause wildfires, such as earthquakes, lightning, and high winds. For example, in 1991, winds gusting to 62 mph downed power lines, resulting in 92 separate wildfires in Washington. U.S. Forest Service (USFS) figures for 1990 indicate that 25.7% of wildfires reported were caused by arson, 24% were caused by debris burns, and 13.3% were caused by lightning.

Lightning can cause particularly difficult fires when dry thunderstorms move across an area that is suffering from seasonal drought. Multiple fires can be started simultaneously. In dry fuels, these fires can cause massive damage before containment.

Wildfires leave problems behind them, even when the last ember is extinguished. Post-fire effects can trigger additional consequences that cascade into other serious hazard events. The loss of ground-surface cover from a fire and the chemical transformation of burned soils make watersheds more susceptible to erosion from rainstorms. Subsequent unchecked debris flows can then carry mud, rock, chemicals, and other debris into water supplies, reducing water quality. (See the section, “Historical Events” for examples.)

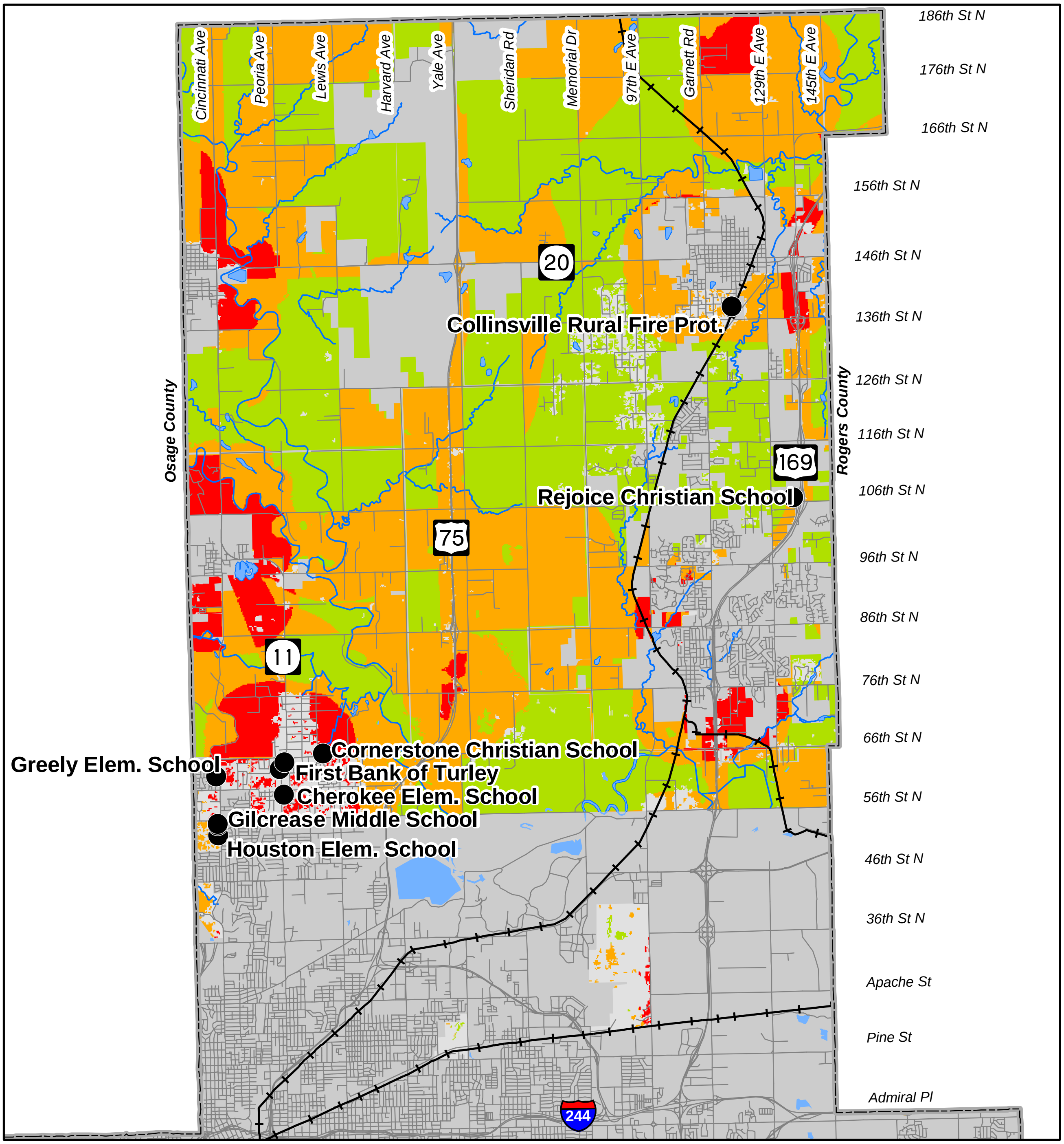
It is impossible to fully assess the economic impact of wildfires due to incomplete reporting. However, the U.S. Forest Service compiles statistics for wildfires on federal lands and is the primary federal source of information.

Location

Although all of unincorporated Tulsa County is at some risk of wildfire, the communities, structures and critical facilities located in the wildland/urban interface and surrounded by dry grass and trees are clearly the most vulnerable. Particularly at risk are South Tulsa County south and east of Glenpool, and North Tulsa County north of Turley and Owasso to the Washington County line. Since wildfire risk can be dramatically reduced by landscaping and debris clearance, a detailed wildfire risk assessment should be made of all critical facilities located in the wildland/urban fringe. Wildfire risk is shown in Figures 4-31a through 4-31c.

Measurement

Wildfire danger is measured using indexes that relate longer-term soil and vegetation conditions to shorter-term weather patterns. The most explosive conditions occur when dry, gusty winds blow across dry vegetation. 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**, Table 4-45, 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. A Zero rating would indicate no moisture deficiency, while 800 would indicate maximum drought conditions. The **Fire Danger Rating System**, Table 4-46, combines the combustibility of vegetation and weather conditions to derive the easily understood Green-Blue-Yellow-Orange-Red fire danger alerts. The **Burning Index**, Table 4-47, relates temperature, relative humidity, wind speed and solar radiation to the “relative greenness” of vegetation (taken from satellite measurements) and fuel models for native vegetation (assigned on a 1-kilometer grid across the State). These factors are used to derive four indices: Spread Component, Energy Release Component, Ignition Component, and Burning Index. The Burning Index is a synthesis of the Spread and Energy Release components, and is used to predict fire



LEGEND

● Critical Facilities

Wildfire Level of Concern

- No Impact
- Low
- Medium
- High

0 1 2 Miles

- Streets
- Railroads
- County Line
- Incorporated Areas

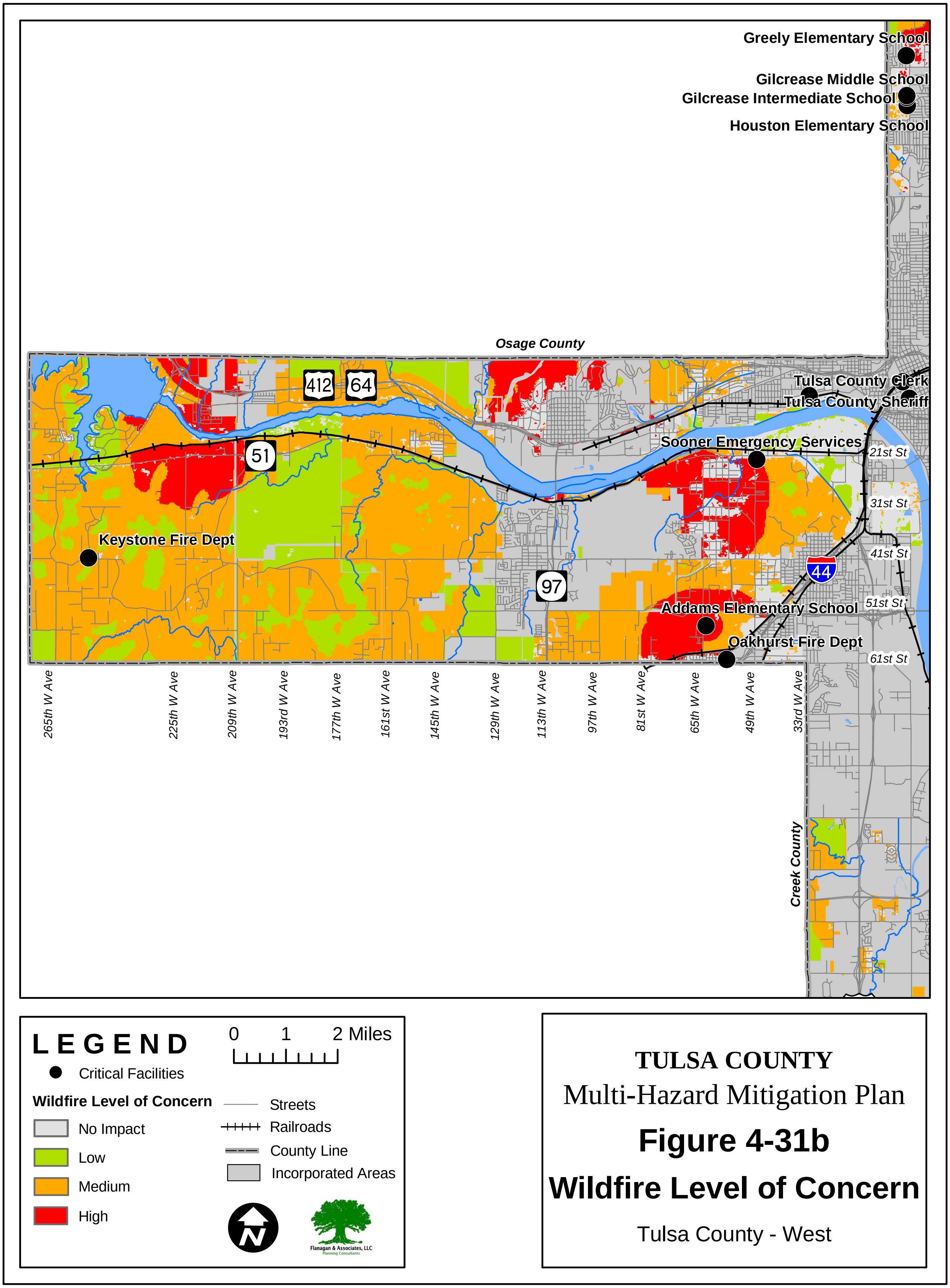
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-31a

Wildfire Level of Concern

Tulsa County - North



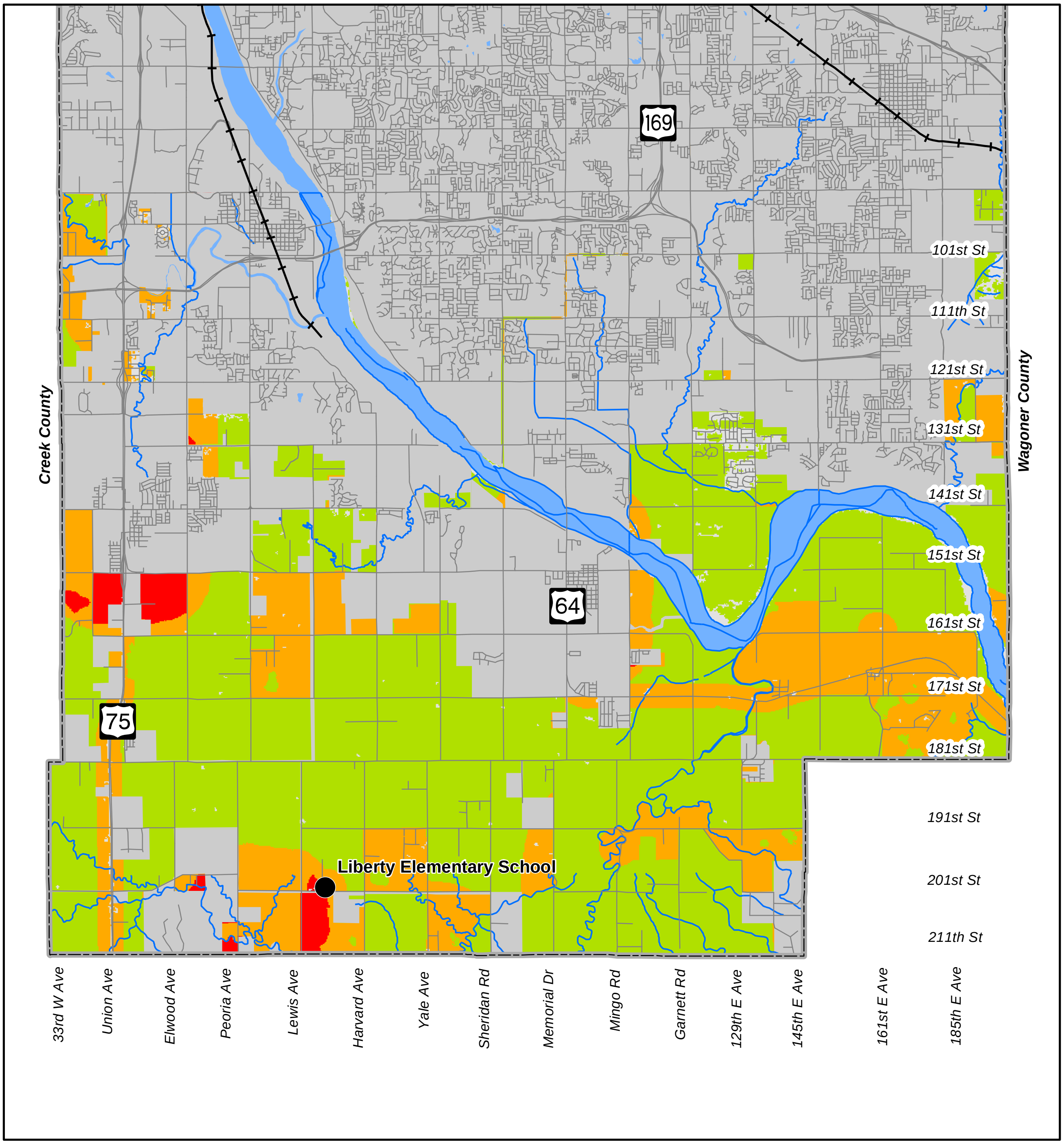
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-31b

Wildfire Level of Concern

Tulsa County - West



TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-31c

Wildfire Level of Concern

Tulsa County - South

line intensity and flame length. The higher the number, the more difficult the wildfire is to fight. These three wildfire measures are summarized in the following tables.

Table 4–45: The Keetch-Byram Drought Index (KBDI)
Source: Oklahoma Hazard Mitigation Plan

Rating	Description
0 - 200	Soil and fuel moisture are high. Most fuels will not readily ignite or burn. However, with sufficient sunlight and wind, cured grasses and some light surface fuels will burn in spots and patches.
200 – 400	Fires more readily burn and will carry across an area with no gaps. Heavier fuels will still not readily ignite and burn. Also, expect smoldering and the resulting smoke to carry into and possibly through the night.
400 – 600	Fire intensity begins to significantly increase. Fires will readily burn in all directions exposing mineral soils in some locations. Larger fuels may burn or smolder for several days creating possible smoke and control problems.
600 – 800	Fires will burn to mineral soil. Stumps will burn to the end of underground roots and spotting will be a major problem. Fires will burn through the night and heavier fuels will actively burn and contribute to fire intensity.

Table 4–46: Fire Danger Rating System
Source: Oklahoma Hazard Mitigation Plan

Color	Brief Description	Detailed Description
Low (L) (Green)	Fires not easily started	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 bum 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) (Blue)	Fires start easily and spread at moderate rate	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)	Fires start easily and spread at a rapid rate	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)	Fire start very easily and spread at a very fast rate	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)	Fire situation is explosive and can result in extensive property damage	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 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.

Table 4–47: Burning Index

Flame Length (ft)	Fire Line Intensity (Btu/(ft-s)	Interpretations
<4 (BI <40)	<100	Fires can generally be attacked at the head or flanks by persons using hand tools. Hand line should hold the fire.
4 – 8 (BI 40 – 80)	100 – 500	Fires are too intense for direct attack on the head by persons using hand tools. Hand line cannot be relied on to hold the fire. Equipment such as dozers, pumpers and retardant aircraft can be effective.
8 – 11 (BI 80 – 110)	500 – 1,000	Fires may present serious control problems, such as torching out, crowning and spotting. Control efforts at the fire head will probably be ineffective.
>11 (BI >110)	>1,000	Crowning, spotting and major fire runs are probable. Control efforts at head of fire are ineffective.

Extent

Wildfires have been increasing in number and causing a greater economic impact nation-wide, largely due to the rapid spread of rural estates on the peripheries of most American cities. Tulsa County is no exception. For example, in the winter of 2005-2006, drought and high winds combined to spread wildfire outbreaks across the state into wind-whipped firestorms. From November 27-30, 2005, wildfires raged in several central and eastern Oklahoma counties, including Tulsa County, burning a total of 35,000 acres. Wildfire struck Tulsa County again on January 1, 2006, and again on March 26. While this wildfire outbreak cannot be considered a "normal" year, it does illustrate the growing impact of the wildfire hazard.

From 2004 through 2008, Tulsa County fire departments made over 3,859 wildfire runs that burned over 33,944 acres, and did $1,834,419 in damage. The area most at risk is the urban/rural interface surrounding the county's major cities.

Dry conditions, high temperatures, low humidity and high winds can increase the potential and severity of a wildfire. In such conditions, wildfires can spread quickly, affecting large areas in a short amount of time. A worst-case scenario would be multiple wildfires started simultaneously by lightning during dry thunderstorms that move across an area that is experiencing drought conditions. The extent of the hazard for Tulsa County varies with landscape and weather conditions, with the relatively more open, grassy land being the most vulnerable. A higher likelihood of ignition exists in the wildland/urban interface, particularly around certain commercial structures, railroad tracks, stands of dry trees, and fields of Conservation Reserve Program (CRP) grass. Generally speaking, wildfires will range from a very small flame to flames of six or seven feet in height (Burning Index of 4-8). Most of these wildland fires can be extinguished with hand tools and pumper trucks.

Fine fuels, such as small twigs and vegetation litter, respond quickly to changing weather conditions and can dry quickly following a rain. Locations with higher average Burning Indexes most likely have experienced repeated periods of high fire danger (Orange and

Red Fire Danger), although individual events can cause the Burning Index to peak at locations that are not normally prone to high fire danger. Although North and South Tulsa County are clearly more at risk from wildfire, due to their more open, grassy landscapes, the entirety of Tulsa County is vulnerable to wildfire, as shown by the devastating events of 2005-2006 (see below). Under windy, dry conditions, wildfires can be intense anywhere in the county.

Tulsa County considers a reading of Moderate and below on the Fire Danger Rating system to be a minor severity and a rating of High and above to be a major severity

Frequency

According to the National Interagency Fire Center statistics for fires on federal lands from 1985 to 1994, an average of nearly 73,000 fires occur each year, resulting in over 3 million acres burned, 900 homes lost, and more than $411.5 million expended in suppression costs.

The rural/urban interface is the most vulnerable area to wildfire.

The Tulsa area has three wildland fire seasons. The worst is February through April, when grass fuels are dead, the humidity low, temperatures elevated, and winds as high as 50-70 mph. A moderate wildfire season occurs in July or August, when some grasses are dormant or dead from the mid-summer heat. The third wildfire season, also moderate, is in the fall, after frost has killed the annual grasses. It was in this fall wildfire season of 2005 when Oklahoma and Tulsa County were hit by one of the worst outbreaks of wildfire in recent history.

The State of Oklahoma had an average of 15,861 wildfire runs per year from 2004 through 2008, burning over two million acres and doing over $61 million in damage. Tulsa County had an average of 965 wildfire runs that burned 8,486 acres per year and did approximately $458,000 in damages over the same time period. Tables 4-48 and 4-49 detail the wildfire activity and damages for the State of Oklahoma and Tulsa County.

Table 4–48: Oklahoma Grass and Crop Fires, 2004 - 2008
Source: Oklahoma State Fire Marshal

Year	Runs	Acres Burned	Damages
2004	13,075	148,786	$4,268,591
2005	16,200	286,991	$8,551,634
2006	12,880	248,325	$6,062,907
2007	18,584	918,128	$20,818,700
2008	18,566	659,622	$21,447,445
Total	**79,305**	**2,261,852**	**61,149,277**
Average	**15,861**	**452,370**	**12,229,855**

The wildfire fire runs for Tulsa County are summarized in the following table.

Table 4–49: Tulsa County Grass and Crop Fires, 2004 - 2008
Source: Oklahoma State Fire Marshal

Year	***Runs***	***Acres Burned***	***Damages***
2004	796	17,716	$552,692
2005	1,167	8,210	$762,891
2006	1,335	7,829	$486,549
2007	Unavailable		
2008	561	189	$32,287
Total	**3,859**	**33,944**	**$1,834,419**
Average	**965**	**8,486**	**$458,604**

Impact

The impact of this hazard can be increased during times of drought or extreme heat. This hazard can cause loss of life, loss of homes, loss of business, and can cause devastating economic effects.

4.11.2 History/Previous Occurrences

The single worst wildfire event in terms of deaths in United States history occurred in Wisconsin in 1871, killing 1,182 people.

In 1994, one of the worst years since the early 1900s, 79,107 fires burned over four million acres and cost $934 million for suppression. Tragically, 34 firefighters lost their lives. On July 6, 1994, 14 firefighters died in one terrible incident during the South Canyon Fire just west of Glenwood Springs, Colorado.

Oklahoma Wildfires

Fall 2000 Wildfires

In 2000, an unseasonably wet late spring was followed by several months of dry weather during which the state averaged about 19% of normal rainfall. By mid-September, the soil across much of the state was dry to a depth of eight inches. In late July 2000, a wildfire near Oklahoma City burned 80 acres and injured two firefighters. On August 20, a fire near Binger, in Caddo County, burned 3,200 acres, destroying three homes and part of a Girl Scout lodge.

Arbuckle Mountains Wildfire - Between September 8-19, 2000, there was a rash of wildfires in Central Oklahoma. One fire that began near the Carter/Murray County line on September 8 spread north into the Arbuckle Mountains, burning for two weeks and consuming 11,500 acres in Carter, Murray and Garvin Counties. In all, six homes and one business were destroyed, totaling $1 million in damage.

Guthrie Wildfire – On September 19, 2000, a large wildfire began 9 miles south of Guthrie and burned for 6 miles, consuming 35 homes and causing $750,000 in damage.

Late November 2005-March 2006: Oklahoma's Worst Outbreak of Wildfires

In the late summer and autumn of 2005, drought conditions throughout the state set the stage for the worst outbreak of wildfires in recent Oklahoma history.

The winter of 2005 was the driest on record in Oklahoma. The drought, combined with high winds, unleashed a series of devastating wildfires. Between November 2005 and March 2006, Oklahoma had 120 consecutive days without moisture. The result was 2,800 fires and over 560,000 burned acres. By April 2006, 869 structures had been damaged by wildfires, and 300 were destroyed. A Federal disaster declaration was made on January 10, 2006, and Individual Assistance funds were made available to 26 Oklahoma counties. Public Assistance funds were made available to all 77 Oklahoma counties.

Between November 2005 and March 2006, wildfires burned over 560,000 acres in Oklahoma.

The wildfire outbreaks clustered around three time periods: late November to early December 2005, late December 2005 to early January 2006, and March, 2006.

Late November to Early December 2005 Wildfires – Strong surface low pressure in the southern and central plains caused sustained wind speeds of 20-35 mph, with gusts up to 45-65 mph. Combined with the drought-like soil and grass conditions, Oklahoma was like a tinderbox waiting for the spark.

Two areas in the state were hit by large wildfires on November 27-30, 2005. In the northeast part of the state, wildfires were reported in Cherokee, Mayes, McIntosh, Muskogee, Okfuskee, Okmulgee, Osage, Pittsburg, Tulsa and Wagoner Counties, burning 35,000 acres, killing one person, injuring 11, and destroying 35 homes and many outbuildings and automobiles.

In south central Oklahoma, several large wildfires burned in Cotton, Garvin and Stephens Counties. A 15-mile area near Velma in Stephens County caught fire on November 27 and continued to burn into early December, forcing the evacuation of the town. Twenty fire departments responded to the blaze. Altogether, the Stephens County fire destroyed 16 homes, two barns and many outbuildings, leaving $1 million in damage. In Cotton County, a wildfire near Walters destroyed six homes and several barns, causing $650,000 damage. In Garvin County, two wildfires burned 6,000 acres. Fourteen fire departments and 100 firefighters responded. Three homes and several outbuildings were destroyed. Losses were $350,000. Near Pauls Valley 500 acres burned, doing $50,000 in damage. On November 29, a fire near Wilson in Carter County killed one woman.

Late December 2005 to Early January 2006 Wildfires - Another rash of wildfires began on December 25, 2005, and continued, more or less without interruption through the first week of 2006. A string of wildfires began on Christmas Day in Choctaw, Creek and Sequoyah Counties, but others were soon raging throughout the state. On January 8, 2006, the Oklahoma Department of Emergency Management set up an Incident

Command Post at Shawnee to coordinate firefighters who were coming in from Alabama, Tennessee, Florida and North Carolina. On January 10, Oklahoma was declared a wildfire disaster area. Among the many fires were the following:

Tulsa County wildfire during the catastrophic 2005-2006 wildfire season

- December 27, 2005 – 10,000 acres burned in Hughes County, killing one person and destroying 8 homes, 14 barns and 20 outbuildings.
- A wildfire in Choctaw County burned 1,000 acres, destroyed four homes and injured two people.
- In Tulsa County a wildfire burned three homes, three structures and left $300,000 in damage.
- In Muskogee County, 2,000 acres west of Muskogee burned, destroying one house, one mobile home, two barns and an automobile, and leaving $225,000 in damage. Grassfires were also reported in Rogers, Okmulgee and McIntosh Counties.
- January 1, 2006 – In Oklahoma County, northeast of Oklahoma City, several homes were destroyed by wildfire and two neighborhoods evacuated. In Muskogee County, 16,000 acres caught fire southwest of Muskogee, destroying four homes, several barns and much hay. Damage was estimated at $500,000. In Creek County, 10,000 acres burned near Bristow, leaving $200,000 in damage. There were also wildfires in Pittsburg, Okfuskee, Haskell and Tulsa Counties.
- January 3, 2006 – In Beaver County, two fires burned 14,000 acres, while in Creek County, near Shamrock, a wildfire destroyed an abandoned school and vacant house and damaged two homes.
- January 8, 2006 – In McIntosh County, 7,000 acres burned, doing $50,000 in damage. In Payne County, seven miles northwest of Perkins, a grassfire ignited red cedar trees. Fires were reported at Davis, Welty, Bristow, Okemah, Slick, Stroud, Guthrie, Sapulpa, Sparks, Bethel, Skiatook, Wainright, Prague, Stigler, Prue, and Mayesville. The State established an ICP at Shawnee.
- February 4, 2006 – In Okmulgee County, a wildfire killed one person.
- February 27, 2006 – In Muskogee County, 750 acres burned and dozens of homes were threatened.

March 2006 Wildfires - On March 1, 2006, high winds, drought conditions, and temperatures in the 90s caused another rash of wildfires across the state. In Stephens County, a wildfire eight miles long injured several firefighters and killed one. In all, 10,000 acres were burned, 65 homes destroyed, 21 houses badly damaged, and numerous outbuildings, farm equipment and vehicles lost. Damage was estimated at $15 million. In Lincoln County, three firefighters were injured when blazing grass caused a propane tank to explode. In Creek County, southwest of Mannford, a wildfire burned hundreds of acres, destroying 4 homes and causing $250,000 in damage. Wildfires were also reported in Wagoner and Sequoyah Counties. Fires continued to plague the state throughout the month.

- March 7, 2006 – Wildfires were reported in Muskogee, Wagoner and Nowata Counties.
- March 8, 2006 – In Osage County, 1,000 acres burned near Burbank.
- March 10, 2006 – In Texas County, 7,000 acres burned east of Guymon, while in Tulsa County, wildfire destroyed two mobile homes, a tractor trailer, fire trucks and storage buildings, causing $150,000 damage.
- March 15, 2006 – Wildfires broke out in Osage, Rogers, Creek, Wagoner and Cherokee Counties.
- March 26, 2006 – Despite recent rains, warm and windy conditions led to wildfire outbreaks near Bristow, and at Scipio in Pittsburg County, as well as in Muskogee, Okfuskee, Okmulgee and Wagoner Counties.
- April 2, 2006 – A Texas County wildfire burned 600 acres.

Tulsa County Wildfires

As stated above, from 2004 through 2008 Tulsa County fire departments fought 3,859 wildfires that burned 33,944 acres and did $1,834,419 in damage. One of the worst wildfire seasons, however, occurred during the winter of 2005-2006, when fires destroyed five homes and 10 outbuildings and did over $550,000 in damage.

Sand Springs fireman battles a wildfire on March 6, 2006

- **December 27, 2005-** a wildfire burned three homes and three other structures in western Tulsa County, near the intersection of 65th W. Ave. and S. 51st St.
- **January 1, 2006-** a large grass fire occurred west of Jenks, near S. 111th St. and U.S. Hwy 75. One neighborhood was evacuated.
- **January 15, 2006-** two grassfires broke out in northern Tulsa County, one near Owasso at 116th St. North between Sheridan and Memorial, and the other near Sperry.
- **March 10, 2006-** a wildfire in the northeast part of the County burned two mobile homes, a tractor-trailer, fire trucks, and storage buildings.

Probability/Future Events

The continuing alarming spread of Eastern Red cedar in open grassland and the abundant fuel load in place from heavy rains and other naturally occurring events (2 ice storms within 12 months) – combined with the historical data available demonstrates that the threat of wildland/grass fires will continue to be a regularly occurring event in Tulsa County. In addition, suburban growth in the wildland interface will be a significant factor in the potential increase in number of wildfires occurring.

4.11.3 Existing Vulnerability

Wildfires occur in virtually all of the United States. The western states, with their more arid climate and prevalent conifer and brush fuel types, are subject to more frequent wildfires. Nonetheless, wildfires have become an increasingly frequent phenomenon nationwide. People are becoming more vulnerable to wildfires by choosing to live in wildland settings, and the value of exposed property is increasing at a faster rate than the population.

While Tulsa County does not appear to have a long history of damaging wildfires, it was hit five times by wildfire in the fall and winter of 2005-2006. This dramatic increase is largely due to changing settlement patterns in the Tulsa metropolitan area. Not only are the outlying towns growing rapidly past their own boundaries—like Broken Arrow, Bixby, Jenks, Owasso and Collinsville—but rural estates have become increasingly the residence of choice for those who can afford to build on 2- to 10-acre parcels. Almost all of these homes are located in what is called the wildland/urban interface (WUI). If precautions are not taken to keep grassy and woody fuels away from structures, particularly highly combustible plants like eastern red cedar, these trophy homes can become victims of wildfires during times of drought, hot temperatures and high winds. Wildfires can also have devastating economic effects on farmers and ranchers living in the Tulsa County area.

While most grasslands of the U.S. have a fuel load of 1,000 to 2,000 lb. per acre, around Tulsa County it is between 6,000 and 10,000 lbs. per acre.

Vulnerable wildland/urban interface areas are shown on the maps in Figure 4-31a-c.

Population

As evidenced by the 2005-2006 wildfire outbreaks, all rural and urban/wildland interface areas of Tulsa County are vulnerable to the wildfire hazard. Deaths and injuries with wildfires have been very low in the state, and largely confined to firefighters.

Structures/Buildings

Any structures/buildings constructed within the wildland/urban interface area or on ranches/farms situated in grassy/wooded areas should be considered at risk to the effects of a wildfire event.

Critical Facilities

Critical facilities such as medical care facilities, resident care homes, daycare facilities, and utility out-stations located in these high-risk areas should be considered vulnerable to the effects of wildfires. Critical facilities at risk are shown on Figures 4-31a-c and listed in the table 4-50.

Infrastructure

Water Treatment – Most significant effect during most major events would be from loss of electrical power. Additional threat from wildfire is not currently documented for facilities of this nature.

Table 4–50: Critical Facilities with Medium to High Vulnerability to Wildfire
(SFRAS – Level of Concern Calculations)

ID	Name	Threat
4	Cornerstone Christian Academy	High
7	Gilcrease Middle School	Medium
8	Greeley Elementary School	High
9	Houston Elementary School	Medium
10	Keystone Fire Dept.	Medium
15	Rejoice Christian School	Medium
17	Liberty School	High
31	Adams Elementary	High
32	Sooner Emergency Services	High

Wastewater Treatment – Most significant effect during most major events would be from loss of electrical power. Additional threat from wildfire is not currently documented for facilities of this nature.

Utilities- The primary utility providers for Tulsa's jurisdiction are AEP/PSO (electricity) and ONG (natural gas). **Electricity**: The largest threat to the delivery of electrical service would be the destruction/damage of power poles/lines.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Roadway inaccessibility would be the largest vulnerability posed to the transportation system during a Wildfire event. During a wildfire located near a major highway, it may become necessary to close a section of highway or divert traffic along that route. Roads and bridges in unincorporated Tulsa County would be at greater risk during a widespread event as they are located in closer proximity to fields/grasslands that could become involved in a wildfire.

Emergency Services- Fire, Police and Medical Services would all be similarly at risk to effects of a Wildfire event. During a severe outbreak of wildfire, roads may become impassable, potentially isolating portions of the community to vital services and/or supplies. Residential developments in unincorporated Tulsa County, along with any businesses/utilities supporting them in the immediate area, are especially at risk in the event of a large wildfire event.

4.11.4 Wildfire Scenario

A worst-case wildfire scenario for Tulsa County would be an outbreak of grassfires caused by lightning from a dry thunderstorm during a period of drought, high temperatures, gusting winds, and peak water use, in an area of rural estates. A rash of wildfires could stretch fire fighting resources thin, particularly in areas where tanker trucks would have to be used to protect homes and outbuildings. According to the City of Tulsa Fire Department, a worst-case scenario would involve the injury of one civilian and one firefighter, and damage to 4 to 5 structures, with no more than one or two receiving major damage before the event was brought under control. Most of Tulsa's "grass rigs" are in the wildland/urban interface areas, and during the height of wildfire season resources are relocated to augment protection of vulnerable areas based on identifiable risk.

4.11.5 Future Trends

Population

With many rural estate developments planned or underway in the rural/urban interface of West and South Tulsa County, the populations of these two geographical areas will continue to be at high risk to wildfire.

Structures/Buildings

As development in areas identified as “at risk” in the wildland/urban interface continues, any structures and/or buildings in these areas will be at risk of a wildfire event.

Critical Facilities

Special care should be exercised to ensure the appropriate location of any new critical facilities, such as medical care facilities, day care centers, utility outstations etc., and that such facilities are constructed/retrofitted using proper fire resistant building and landscaping practices.

Infrastructure

As sections of unincorporated Tulsa County develop, roadways, utility access, emergency services and other support businesses will also be at risk for a wildfire event and should be planned for appropriately.

4.11.6 Conclusion

Wildfires are a serious and growing hazard because people continue to build in open grassland and woodland areas. The value of these properties are increasing in value, with million dollar homes dotting the hillsides of what was once open ranchland.

As shown during the rash of wildfires in the winter of 2005-2006, all three areas of Tulsa County are at moderate to high risk of wildfire, particularly in the wildland/urban interface, and at severe risk during times of high wind and drought.

Data Limitations

Data to the State Fire Marshall’s office is frequently turned in well after the events occurred—often as much as a year later. Consequently, complete data is frequently 1 to 2 years old by the time it is published. In addition, the Fire Marshall’s office does not list the actual number of wildfires, but number of “fire department runs.” The Tulsa Fire Department, for example, may send a unit for a small grassfire in a center median, which does not show up as a grassfire in the NCDC database. Also, for a larger wildfire complex, many runs may be made for the event to separate locations over a period of days. Hence, the NCDC database contains 6 wildfire “events” for the 1998-2007 period, but the State Fire Marshall’s office shows 3,589 “runs” during the most 2004-2008 period for which the state’s office has data.

4.11.7 Sources

Multi-Hazard Identification and Risk Assessment, p. 234, 236, 239. Federal Emergency Management Agency, 1997.

Oklahoma State Fire Marshal, "Fire Statistics 1997-2000," at web address: www.state.ok.us/~firemar/index.htm. Office of the Oklahoma State Fire Marshal

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4.12 Earthquakes

An earthquake is a sudden, rapid shaking of the ground caused by the fracture and movement of rock beneath the Earth's surface. Most severe earthquakes take place where the huge 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 multitude of fault and fracture lines within the plates themselves.

The faults most likely to affect Oklahoma are the New Madrid Fault, centered in the Missouri Bootheel region, and the Meers Fault, located in southwestern Oklahoma near Lawton.

4.12.1 Hazard Profile

Although located in the relatively quiet Central Plains Province, nearness to the New Madrid, Missouri, fault exposes Tulsa County to VI intensity tremors.

As the Earth's crust moves and bends, stresses are built up, sometimes for hundreds of years, before suddenly breaking or slipping. This abrupt release of accumulated tension can be devastating to human communities on the surface.

The destructiveness of an earthquake depends upon a number of factors, including the magnitude of the tremor, direction of the fault, distance from the epicenter, regional geology, local soils, and the design characteristics of buildings and infrastructure, such as roads, bridges, and pipelines.

Earthquake intensity can be significantly affected by the stability of underlying soils. For example, during the Northridge, California earthquake, three times as much damage was done to single-family homes and buried utilities in ground failure zones than in nearby areas where the footing was more solid. In addition, the intensity of West Coast tremors is dissipated by the relative "warmth" of the region's geology. By contrast, the thick Pennsylvanian sandstone and limestone strata of the central United States are much more efficient conductors of tremors. Consequently, a 6.8-magnitude earthquake in the New Madrid Fault would have a much wider impact than a comparable event on the California coast.

Urbanization is probably the most important factor in translating earthquake magnitude into human impacts. In the continental United States, Alaska has the greatest number of large earthquakes—over a dozen above 7.3 magnitude between 1899 and 1999. However, these severe quakes resulted in relatively little loss of life or damage, since all but one occurred in uninhabited areas.

Location

The most likely major earthquake event that could impact the entire jurisdiction of Tulsa County would probably originate in the New Madrid Fault Zone, which has been relatively quiet for 150 years. Seismologists estimate a 90% or greater probability of a 6 to 7 magnitude earthquake in the New Madrid area in the next 50 years.

Measurement

Modern seismological technology has greatly enhanced the capability of scientists to sense earthquakes. Before the development of today's delicate sensors, only "felt" earthquakes were captured in the historical record.

Two standard measures are used to classify an earthquake's extent: *magnitude* and *intensity*. These are sometimes referred to as the Richter Scale (magnitude) and the Modified Mercalli (intensity). They are described below and compared in Table 4-51.

Table 4–51: Comparison of Mercalli and Richter Scales

Mercalli	*Richter*	*Description*
I	0-4.3	Vibrations are recorded by instruments. People do not feel any Earth movement.
II		A few people might notice movement if they are at rest and/or on upper floors of tall buildings.
III		Shaking felt indoors; hanging objects swing. People outdoors might not realize that an earthquake is occurring.
IV	4.3-4.8	Dishes rattle; standing cars rock; trees might shake. Most people indoors feel movement. Hanging objects swing. Dishes, windows, and doors rattle. A few people outdoors may feel movement.
V		Doors swing; liquid spills from glasses; sleepers awake. Almost everyone feels movement. Dishes are broken. Pictures on the wall move. Small objects move or are turned over. Trees shake.
VI	4.8-6.2	People walk unsteadily; windows break; pictures fall off walls. Everyone feels movement. Objects fall off shelves. Furniture moves. Plaster in walls may crack. Trees and bushes shake. Damage is slight in poorly built buildings. No structural damage.
VII		Difficult to stand; plaster, bricks, and tiles fall; large bells ring. Drivers feel their cars shaking. Some furniture breaks. Loose bricks fall from buildings. Damage is slight to moderate in well-built buildings; considerable in poorly built buildings.
VIII	6.2-7.3	Chimneys fall; branches break; cracks in wet ground. Drivers have trouble steering. Houses that are not bolted down might shift on their foundations. Tall structures such as towers and chimneys might twist and fall. Well-built buildings suffer slight damage. Poorly built structures suffer severe damage. Water levels in wells might change.
IX		General panic; damage to foundations; sand and mud bubble from ground. Well-built buildings suffer considerable damage. Houses that are not bolted down move off their foundations. Some underground pipes are broken. The ground cracks. Reservoirs suffer serious damage.
X		Most buildings destroyed; large landslides; water thrown out of rivers and lakes. Some bridges are destroyed. Dams are seriously damaged. The ground cracks in large areas. Railroad tracks are bent slightly.
XI	7.3-8.9	Roads break up; large cracks appear in ground; rocks fall. Most buildings collapse. Some bridges destroyed. Underground pipelines destroyed. Railroad tracks badly bent.
XII		Total destruction; "waves" seen on ground surface; river courses altered; vision distorted. Almost everything is destroyed. Objects are thrown into the air. Large amounts of rock may move.

Magnitude is an Arabic number representing the total amount of energy released by the earthquake source. It is based on the amplitude of the earthquake waves recorded on seismographs that have a common calibration. The magnitude of an earthquake is thus represented by a single, instrumentally determined value.

Intensity, expressed as a Roman numeral, is based on the earthquake's observed effects on people, buildings and natural features. It varies depending on the location of the observer with respect to the earthquake's epicenter. In general, the intensity decreases with distance from the fault, but other factors such as rupture direction and soil type also influence the amount of shaking and damage.

Extent

Tulsa County has recorded 5 earthquakes between 1978 and 2006. One had an epicenter in Sand Springs—a 1.5 magnitude event in south Sand Springs. Given this rate of occurrence, Tulsa County can expect a low-intensity earthquake every 5.6 years that does little to no damage and can only occasionally be felt.

FEMA's HAZUS software application provides a methodology to estimate earthquake losses at a regional scale. Building and population statistics from the U.S. Census are combined with estimated replacement values for local infrastructure to calculate an estimate on potential damages and losses to be expected from a specified earthquake event. The historic 5.7 magnitude El Reno earthquake event of April 9, 1952, was used as the input event in the HAZUS model run for Tulsa County. This event is shown as a 5.5 magnitude earthquake in the USGS data. HAZUS estimated that there would be 17 structures within Tulsa County damaged by an El Reno-size quake, 14 with slight damage and 3 with moderate damage, causing $30,000 in damages. It is also estimated that no injuries at any time of the day would result from this quake and only one leak each for potable water, waste water, and natural gas pipelines out of 13,000 kilometers of pipes. (For a fuller discussion, see Section 4.12.3, *Vulnerable Population*, below.)

Tulsa County considers a reading of 4.8 and below on the Richter Scale a minor severity and a reading of 4.9 and above to be a major severity.

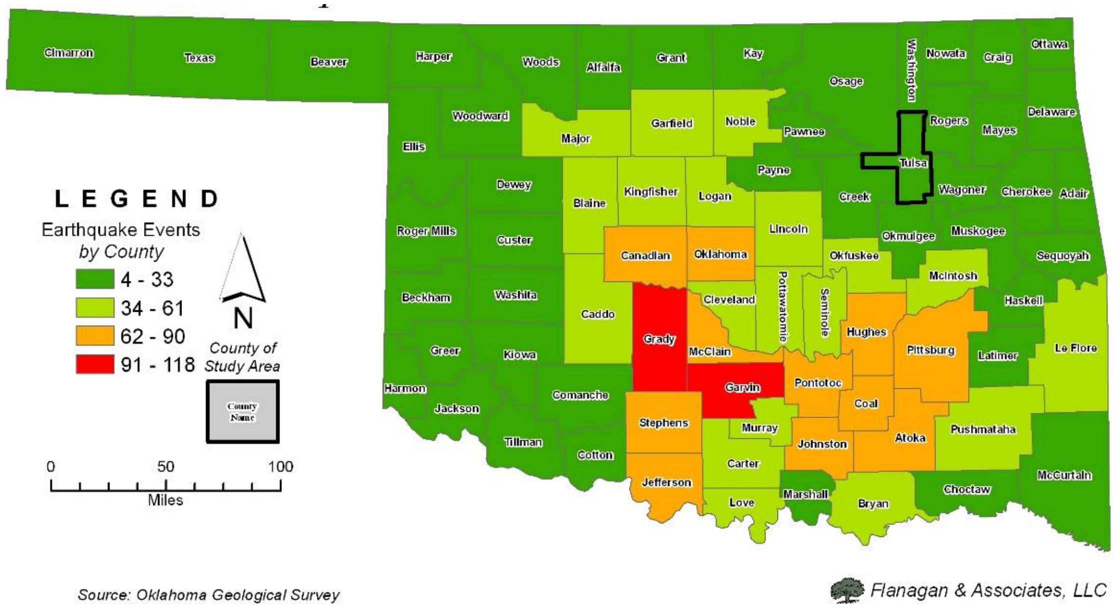
Frequency

In the United States, California experiences the most frequent damaging earthquakes, and Alaska has the greatest number of large earthquakes.

Oklahoma has experienced an average of 50 earthquakes each year since the Oklahoma Geological Survey began keeping records. Most of the earthquakes have been so small that they were not felt by people. Only about two or three per year have been large enough to be felt and the vast majority of these have caused no damage. As shown in the figure below, the majority of Oklahoma earthquakes are concentrated in Garvin, Grady, and McClain counties in south central Oklahoma where the Ouachita, Arbuckle and Wichita mountains converge.

The Meers Fault has had two major ruptures in the last 3,000 years, the last one about 1,600 years ago.

Figure 4–32: Earthquakes in Oklahoma from 1989-2009



Impact

The impact of this hazard depends on the intensity of the earthquake. Hazus projected earthquakes for Tulsa County indicate that the County would sustain $50,000 in damages and lost revenue and that moderate damage would be the most likely maximum damage

Earthquakes can cause poorly compacted, clay-free soils to temporarily lose strength and behave like viscous fluids rather than solids. This “liquefaction” can result in ground failure and damage to structures and buried utilities.

4.12.2 History/Previous Occurrences

In the United States, California and Alaska have earthquakes the most frequently, but the largest earthquake felt in the United States in historical times occurred in Missouri, along the New Madrid Fault. There, in 1811 and 1812, three earthquakes larger than a magnitude 8 totally destroyed the town of New Madrid, caused the land to roll in visible waves, raised and sank land as much as 20 feet, and formed and emptied lakes. The tremors rang church bells as far away as Boston, Massachusetts. These earthquakes were probably the first ones felt by residents in Oklahoma in historical times. Intensity VII earthquakes hit the New Madrid area again in January 1852 and June 1862.

Oklahoma Earthquakes

The earliest documented quake in what is now Oklahoma occurred on October 22, 1882, near Ft. Gibson, Indian Territory. The *Cherokee Advocate* reported that “the trembling and vibrating were so severe as to cause doors and window shutters to open and shut, hogs to squeal, poultry to run and hide, and cattle to low.” Other felt quakes occurred near Cushing, in Payne County, in December 1900, and in Rogers County on November 8, 1915. Other Oklahoma earthquakes include the following:

June 20, 1926- A 4.3 magnitude earthquake just west of Marble City in Sequoyah County.

December 28, 1929- A 4.0 magnitude, VI intensity quake struck El Reno in Canadian County.

June 1, 1939- A 4.4 magnitude, IV intensity quake occurred at Spaulding in Hughes County.

April 9, 1952- The largest earthquake on record in the state—a VII-intensity event that registered 5.7 on the Richter Scale—happened near El Reno. It was apparently caused by slippage along the Nemaha Fault. The tremor toppled chimneys and smokestacks, cracked bricks on buildings, broke windows and dishes, and was felt as far away as Austin, Texas, and Des Moines, Iowa.

October 30, 1956- A 4.1-magnitude, VII-intensity earthquake struck Catoosa, causing minor damage in Tulsa and Beggs.

June 17, 1959- A 4.2 magnitude, VI intensity quake occurred at Faxon in Comanche County.

April 27, 1961- A 4.1 magnitude, V intensity quake hit Wilburton in Latimer County.

May 2, 1969- A 4.6 magnitude, V intensity quake occurred at Wewoka, in Seminole County, causing cracks in plaster walls.

November 15, 1990- A 4.0 magnitude, VI intensity quake struck Lindsey in Garvin County.

January 18, 1995- A 4.2 magnitude, VI intensity quake shook Antioch in Garvin County.

September 6, 1997- A 4.4 earthquake shook Ada, in Pontotoc County, and rattled dishes as far away as Holdenville. The epicenter was 10 miles southeast of Ada, near Stonewall, at a depth of 15 km.

April 28, 1998- One of the largest earthquakes recorded in Oklahoma, measuring 4.2 on the Richter Scale, occurred near Lawton, at Richard's Spur, in Comanche County. The quake rattled dishes and caused a 14-foot crack to appear in the second floor of the Comanche County courthouse building.

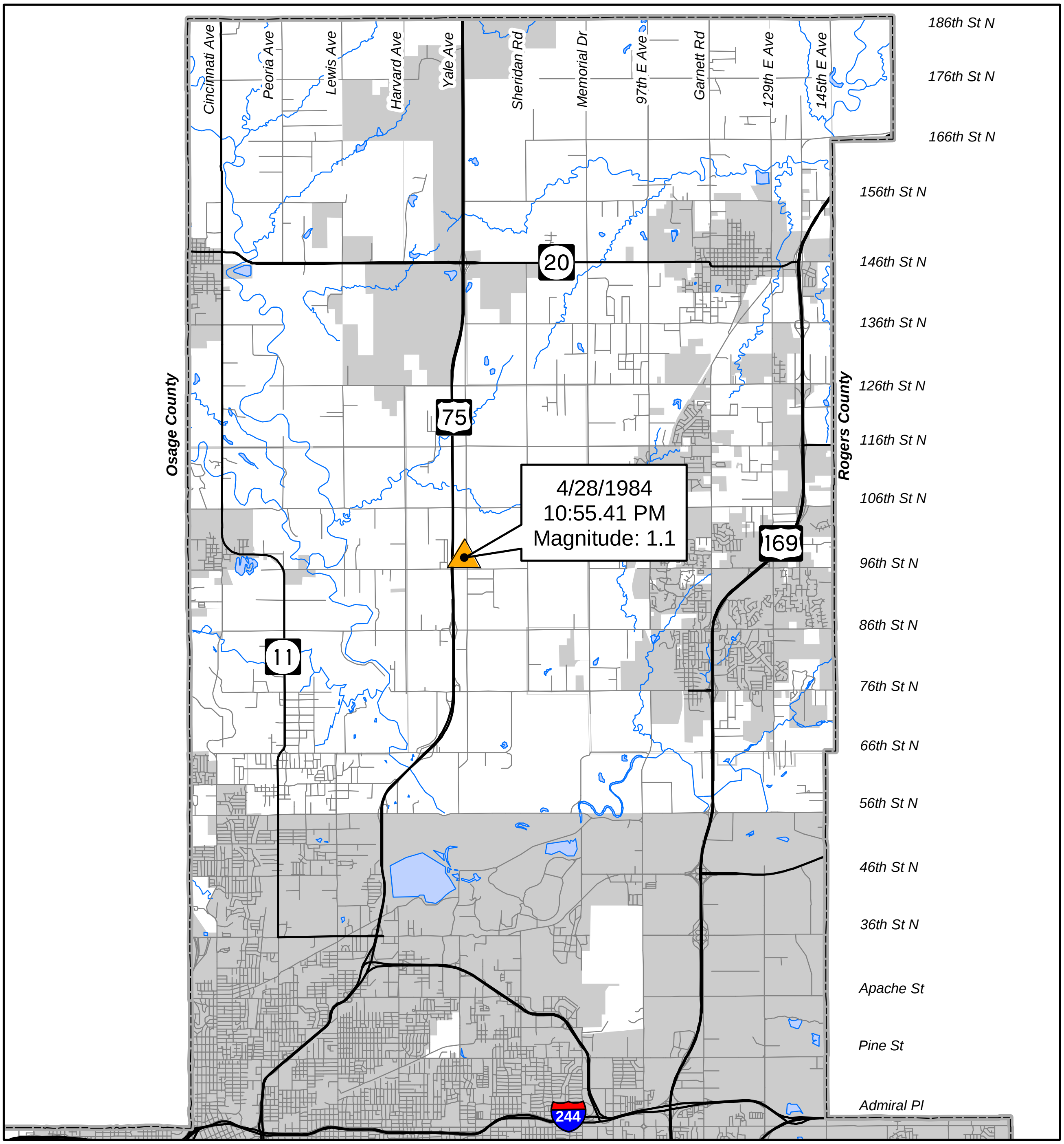
October 30, 1998- A 3.5 earthquake located 25 miles northwest of Ponca City was felt in Grant, Garfield and Kay Counties.

February 8, 2002- A 3.8 magnitude earthquake was detected 5.6 miles north of Lawton. The quake passed from northeast to southwest with a rolling motion that lasted about 1.5 seconds. The tremor was described as moderate that shook houses with a kind of rolling sensation rather than hard shaking. Pictures were knocked over on dressers.

Tulsa County Earthquakes

Tulsa County experienced five earthquakes between 1980 and 2004, or 0.2 per year. None of the quakes were "felt" (i.e., all were below 2.1 on the Richter scale), so a "low" probability score was awarded in the hazard analysis. See Figure 4-33a and 4-33b for a map of the earthquake epicenters within Tulsa County.

August 3, 1983- A 1.4-magnitude event occurred near the community of Liberty, southeast of the intersection of US Hwy 75 and S. 191st Ave.



LEGEND

0 1 2 Miles

Earthquakes
Highways
Streets
Streams
Water Bodies
Incorporated Areas

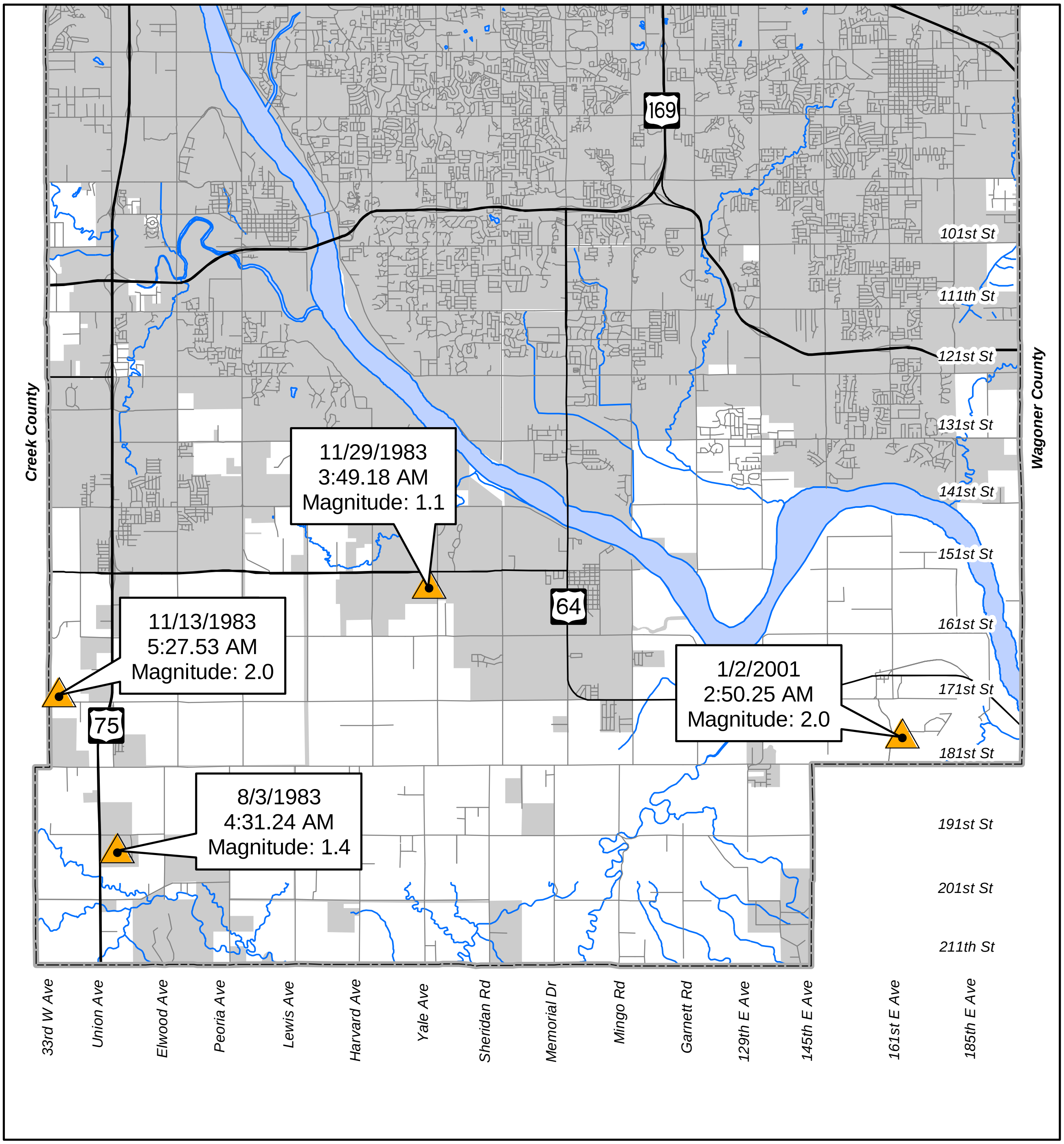
TULSA COUNTY

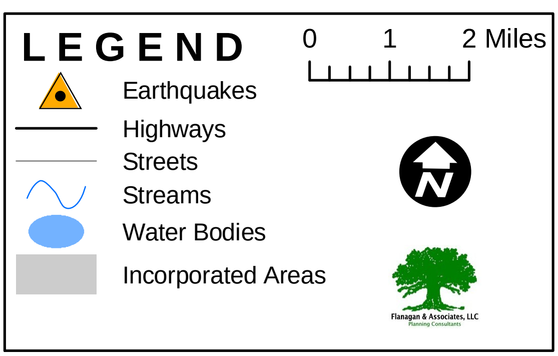
Multi-Hazard Mitigation Plan

Figure 4-33a

Historic Earthquakes

Tulsa County - North





TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-33b

Historic Earthquakes

Tulsa County - South

November 13, 1983- A 2.0-magnitude quake was reported near Kiefer, 1 mile west of US Hwy 75 and S. 171st St.

November 29, 1983- A 1.1-magnitude event occurred two miles west of Bixby just southwest of the intersection of S. 151st St. and Yale Ave.

April 28, 1984- A 1.1-magnitude quake occurred near Sperry just northeast of the intersection of US Hwy 75 and 96th St. North.

January 2, 2001- A 2.0-magnitude earthquake was reported near Leonard, just northeast of the intersection of S. 181st St. and 161 E. Ave.

Probability/Future Events

Tulsa County and its future development areas are at low risk from earthquakes. Any earthquake risk would most likely come from proximity to the New Madrid and Meers faults. The potential impact would be on Tulsa County as a whole, and would do little or no damage. According to Dr. James Lawson, chief geophysicist of the Oklahoma Geological Survey's Seismic Observatory at Leonard, the risk of an earthquake in the New Madrid Fault Zone should not be over emphasized. He believes a major seismic event there would have no greater impact on Tulsa than a locally generated earthquake. An 8-magnitude event in New Madrid would likely produce only VI-intensity tremors in Oklahoma, and would not be as severe as the Ft. Gibson quake of 1882.

4.12.3 Vulnerability

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. Buildings constructed to earlier seismic standards (or to no standard) can pose major threats to life and the continued functioning of key public services during an earthquake disaster. Un-reinforced masonry structures are the most vulnerable, while wood frame structures typically perform well. Of special 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.

Based on results from the HAZUS-MH scenario run for Tulsa County, the county has a low vulnerability to Earthquakes.

4.12.4 Earthquake Scenario

HAZUS, a software application developed by the Federal Emergency Management Agency and the National Institute of Building Sciences, provides a methodology for estimating earthquake losses at a regional scale. Building and population statistics from the U.S. Census are combined with estimated replacement values for local infrastructure to derive an estimate of potential damages from a specified earthquake event.

The historic, 5.7 magnitude, El Reno earthquake event of April 9, 1952 was used as the input event in the HAZUS model run for Tulsa County. Affecting most of the State and parts of Arkansas, Iowa, Kansas, Missouri, Nebraska, and Texas, historically, this is Oklahoma's largest earthquake event. Due to the structuring of data in HAZUS, the scenario was run for the entirety of Tulsa County, including all incorporated areas.

HAZUS estimated that there would be 17 structures out of 216,374 within Tulsa County damaged by the El Reno quake, 14 with slight damage and 3 with moderate damage, causing $40,000 in damages, and $10,000 in lost revenue. It is also estimated that no injuries at any time of the day would result from this quake and only one leak each for potable water, waste water, and natural gas pipelines out of 13,000 kilometers of pipes.

In summary, although this scenario was computed for the entirety of Tulsa County, it can be seen that the unincorporated areas of the county are at very low risk from a quake of this magnitude, especially when considering the low population and structural densities of the unincorporated areas. The very low risk of earthquake damage would also apply for areas of future development.

Future Trends

Based on a HAZUS analysis that a worst-case scenario creates very little damage and no injuries, there is safe to assume that any future development in Tulsa County will be impacted only very slightly, if at all, by an El Reno-size earthquake event.

4.12.5 Conclusion

In the period from 1980-2004, five earthquakes were recorded in Tulsa County, all below 2.1 in magnitude. Tulsa County is classified at low risk from earthquakes because most Oklahoma earthquakes are small in magnitude and cause little to no noticeable impacts. As calculated using HAZUS software, an earthquake similar to the 1952 El Reno quake would cause an estimated $30,000 in damage within all of Tulsa County, causing no injuries and limited damage to pipelines.

Data Limitations

While the HAZUS software is very comprehensive, structural integrity and Code requirements for a jurisdiction can greatly affect the actual damage to structures. Earthquake-resistant construction is not something routinely considered in Oklahoma, so damage prediction is not likely to be as accurate as in a California community, where earthquake resistant construction and analysis are routine and closely studied.

4.12.6 Sources

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4.13 Fixed Site Hazardous Material Events

Hazardous materials are chemical substances that, if released or misused, can pose a threat to the environment or human health. These chemicals are used in industry, agriculture, medicine, research, and consumer goods. Hazardous materials come in the form of explosives, flammable and combustible substances, poisons, and radioactive materials. These substances are often released as a result of chemical accidents at plant sites or transportation accidents.

In recent years, the increased usage of chemically dependent products and the introduction of new chemicals, materials and substances into commerce have resulted in a corresponding increase in the number of accidents and spills involving toxic and hazardous materials.

With 96 Tier II sites located within its fenceline, Tulsa County is vulnerable to hazardous materials events.

4.13.1 Hazard Profile

Hazardous materials, for regulatory purposes, are divided into two general categories: fixed sites, and transportation facilities.

Fixed sites (Tier II) include buildings or property where hazardous materials are manufactured or stored, and are regulated nationally under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) by the U.S. Environmental Protection Agency (EPA), and in Oklahoma by the Department of Environmental Quality. The federal government has established detailed systems for keeping track of Tier II hazardous materials sites. The Emergency Planning and Community Right to Know Act of 1986 defines a Tier II site as any location that has, for any 24 hour period, either 1) specified threshold amounts of defined Extremely Hazardous Substances, or 2) any other substance requiring a Material Safety Data Sheet (MSDS) for amounts greater than 10,000 pounds. In Oklahoma in 2001, there were 28,000 Tier II sites reported to the Oklahoma Department of Environmental Quality. Tulsa County accounted for 82 of those sites.

Transportation of hazardous materials is regulated by the U.S. Department of Transportation (DOT), under the Hazardous Materials Transportation Act, 49 CFR 119 for natural and other gases transported by pipeline, and 49 CFR 195 for liquids transported by pipeline. For intrastate commerce, the transportation of hazardous materials is regulated by the Oklahoma Corporation Commission.

The responsibility for receiving reports on hazardous materials and toxic waste events was given to the National Response Center (NRC), www.nrc.uscg.mil/nrcback.html, staffed by the U.S. Coast Guard. The NRC serves as the sole national point of contact for reporting all oil, chemical, radiological, biological, and etiological discharges into the environment anywhere in the United States or its territories. The NRC also acts as a 24-hour contact point to receive earthquake, flood, hurricane, and evacuation reports.

Many products containing hazardous chemicals are used and stored routinely in residential, commercial, and industrial applications. These products are also shipped daily on the nation's highways, railroads, waterways, and pipelines. In most cases, disasters involving hazardous materials are confined to a localized area, whether an accidental release occurs at a fixed facility or in association with a transportation incident. Transportation related events are addressed in Section 4.15: *Transportation Hazards*.

Gas and oil pipeline spills can be considered as either fixed-site events occurring in an extended industrial plant, or as transportation hazards (see 4.15.1 Hazard Profile, Transportation Hazards). Between 1990 and 2005, there were nearly 2,300 major natural oil and gas pipeline accidents in the United States resulting in over 200 deaths. Most of the accidents were at the local distribution company level. A major cause of pipeline failure, especially in Oklahoma's aging petroleum industry infrastructure, is corrosion. Of the 19 oil pipeline spills in Oklahoma between 2001-2006 that were reported to the National Response Center, at least 9 (and possibly as many as 11) were due to pipeline corrosion. (http://www.nrc.uscg.mil/nrchp.html) During the same timeframe, Oklahoma reported 4 spills from oil storage tanks, primarily due to lightning strikes and aging or faulty facilities.

As many as 500,000 products pose physical or health hazards and can be defined as hazardous chemicals. Each year, over 1,000 new synthetic chemicals are introduced. In an average city of 100,000 residents, 23.5 tons of toilet bowl cleaner, 13.5 tons of liquid household cleaners, and 3.5 tons of motor oil are discharged into city drains each month.

The United States Environmental Protection Agency sorts hazardous materials into six categories:

1. Toxic Agents (irritants, asphyxiates, narcotics)
2. Other Toxic Agents (hepatoxic, nephratoxic)
3. Hazardous Wastes
4. Hazardous Substances
5. Toxic Pollutants
6. Extremely Hazardous Substances

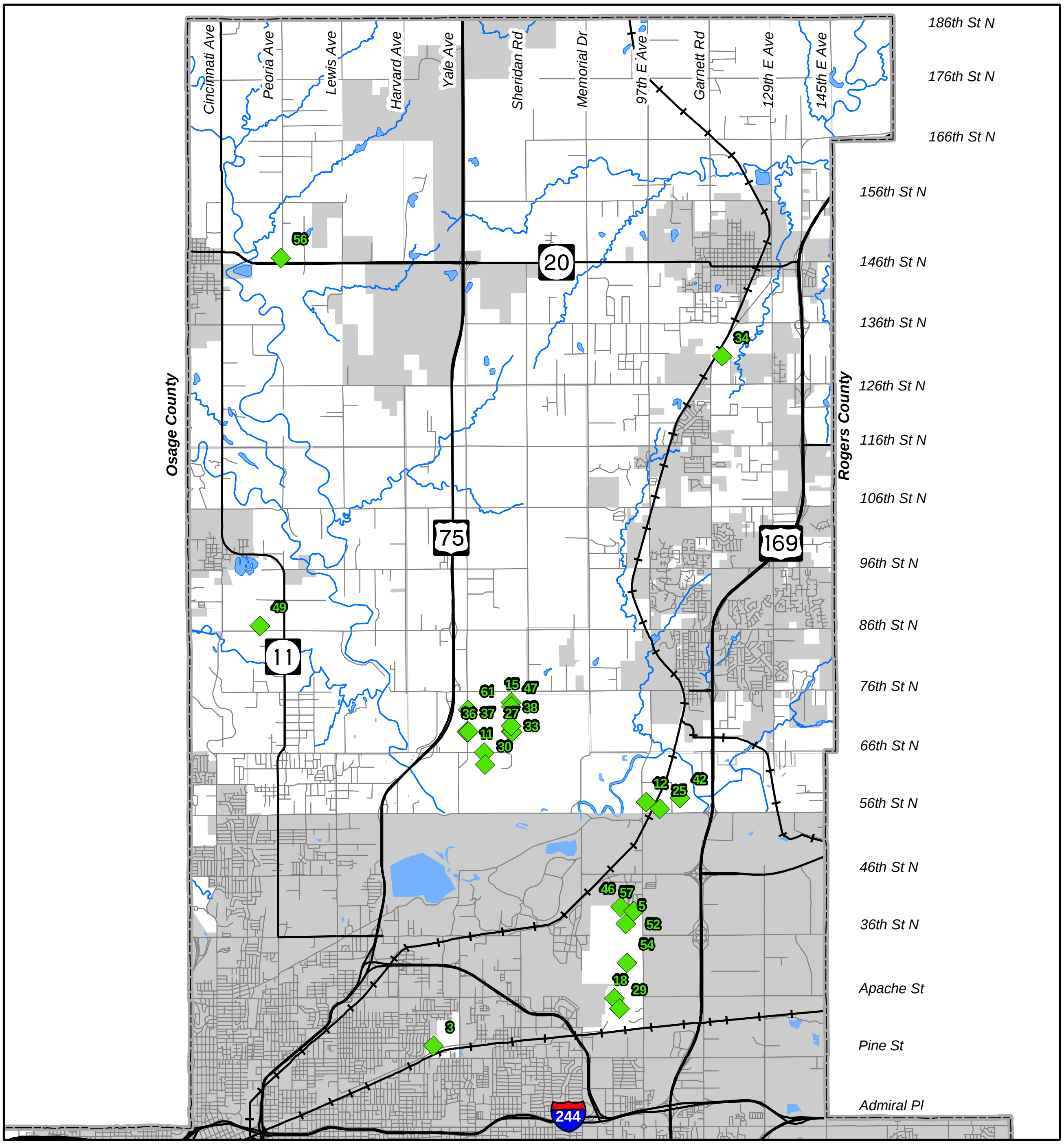
Hazardous materials affect people through inhalation, ingestion, or direct contact with skin. They can cause death, serious injury, long-lasting health problems, and damage to buildings, homes and other property.

Location

Tulsa County has inventoried local businesses and industry to identify dangerous chemicals that are being manufactured and/or stored in the community. Known hazardous materials sites for Tulsa County are shown on the maps in Figures 4–34a-c.

Measurement

Reports on hazardous materials events are submitted by the responsible party to the County LEPC, the Oklahoma Department of Environmental Quality, and the National Response Center. This information is summarized to show community, county and state



LEGEND

0 1 2 Miles

Tier 2 Sites

Streets

Railroads

County Line

Incorporated Areas

Flanagan & Associates, LLC
Planning Consultants

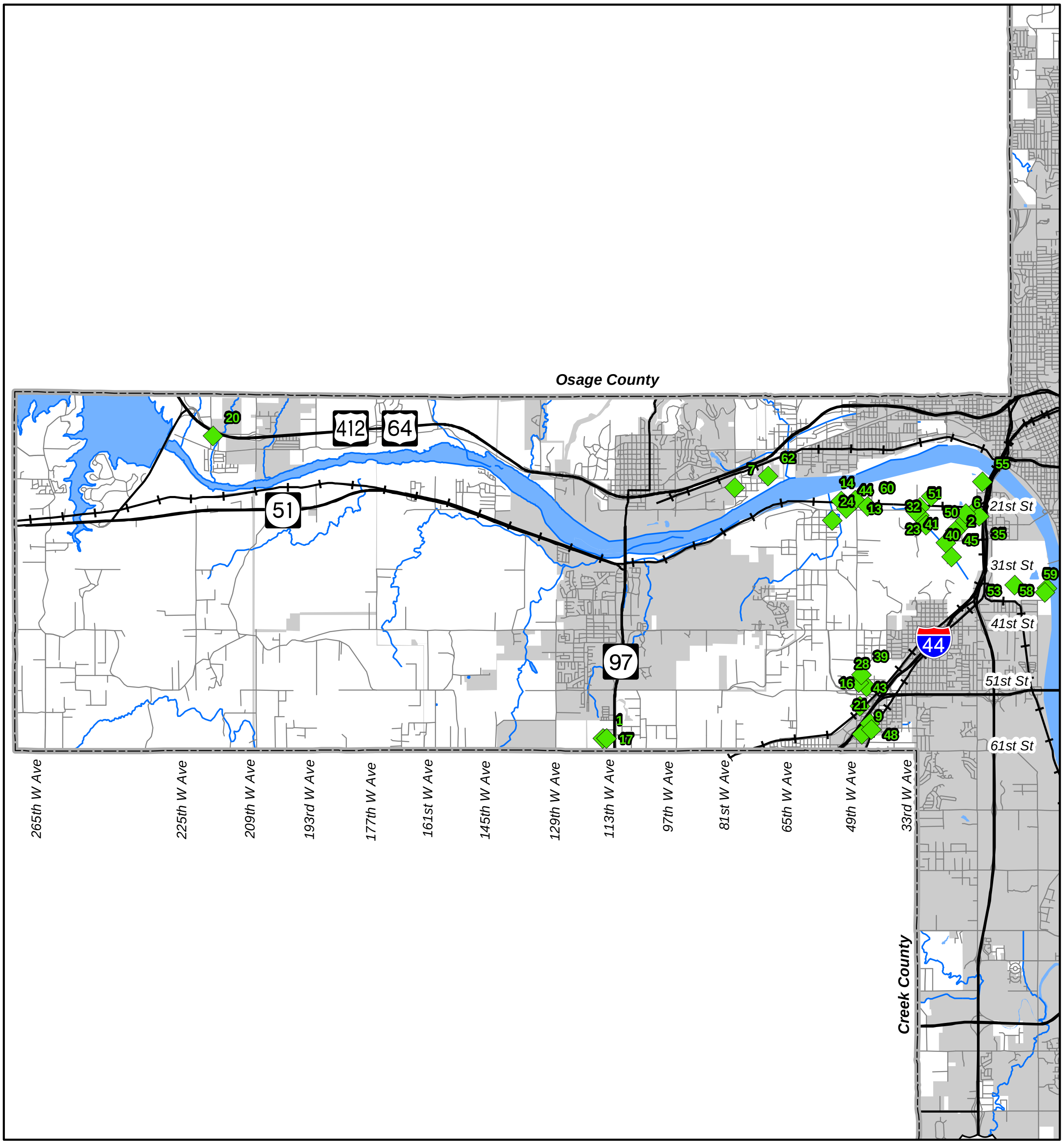
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-34a

Tier II Sites

Tulsa County - North



LEGEND

0 1 2 Miles

- Tier 2 Sites
- Streets
- Railroads
- County Line
- Incorporated Areas

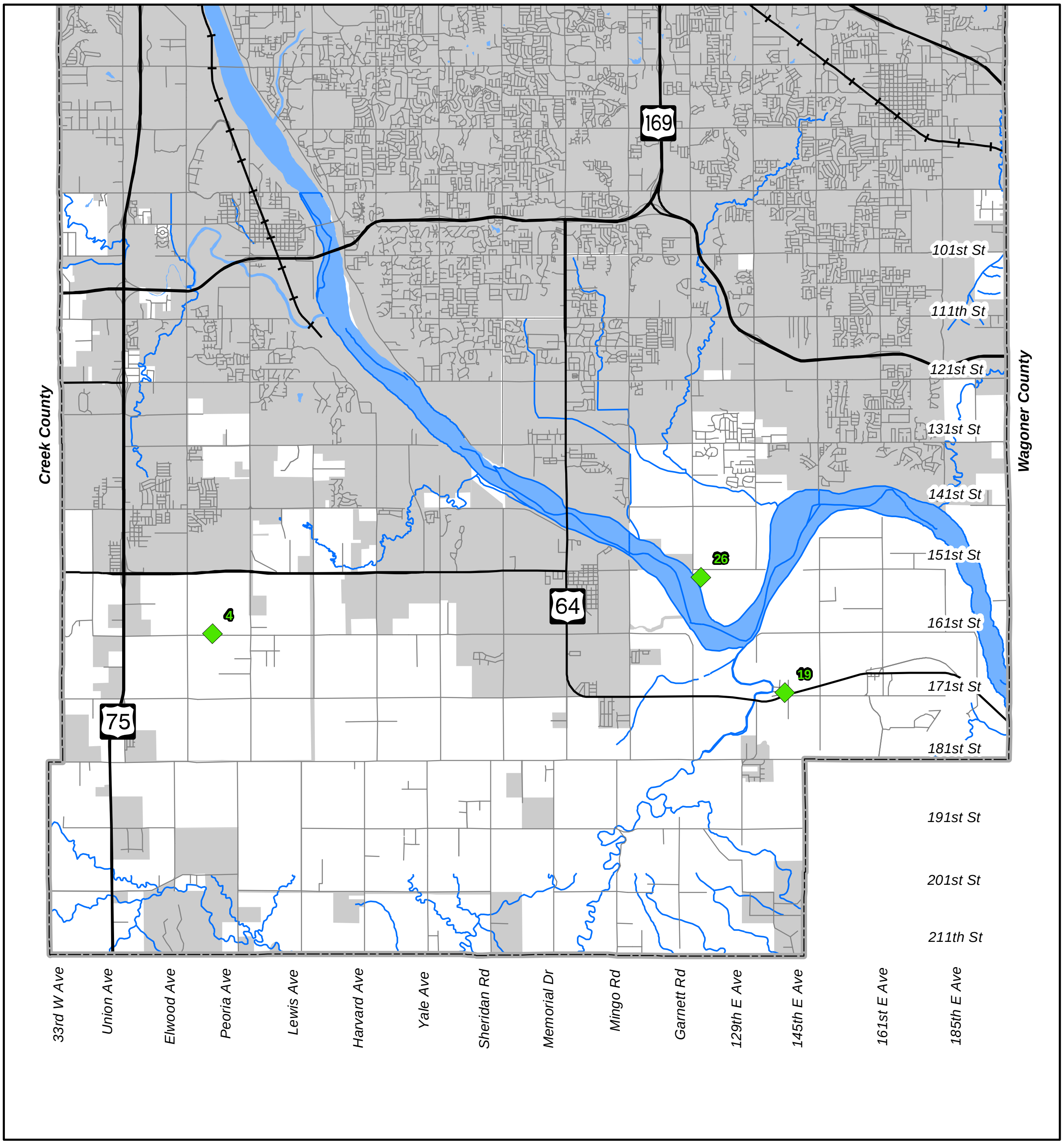
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-34b

Tier II Sites

Tulsa County - West



LEGEND

- Tier 2 Sites
- Streets
- Railroads
- County Line
- Incorporated Areas

0 1 2 Miles

TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-34c

Tier II Sites

Tulsa County - South

summaries. This allows the number of hazardous materials events that a community has to be measured against state and national averages.

Frequency

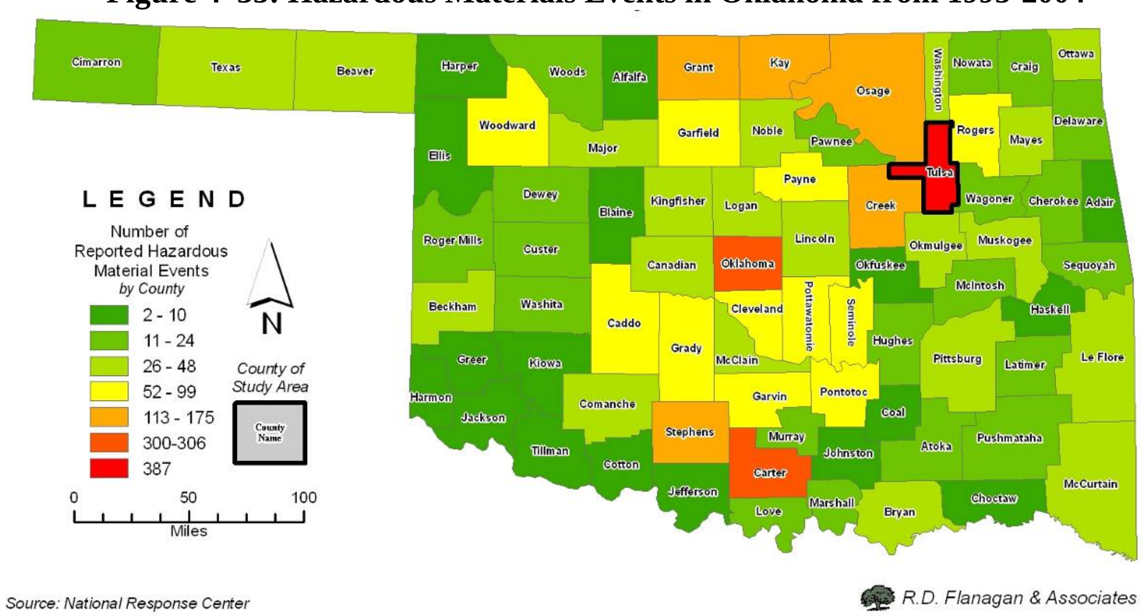
The National Response Center reports an average of approximately 32,185 hazardous materials events occur each year in the United States as shown in Table 4-52. Annually, on the average, about 12,000 are from fixed site locations, the largest number of any of the defined incident types.

The United States Fire Administration reports that in 2000, the nation's 26,354 fire departments responded to 319,000 hazardous materials incidents, up 7.2% from 1999.

Table 4–52: U.S. Hazardous Materials Incidents 1995-2004
Source: National Response Center

Incident Type	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Fixed	15,080	12,067	10,388	10,961	11,230	11,813	12,441	11,917	11,972	12,972
Unknown Sheen	5,147	4,433	4,228	4,809	4,802	4,016	4,147	3,426	3,733	3,411
Vessel	3,967	4,091	3,778	3,886	3,877	3,945	4,378	3,919	3,961	4,385
Mobile	3,133	2,511	2,490	2,718	2,835	3,597	3,216	2,942	2,946	3,192
Pipeline	1,530	1,737	1,740	1,657	1,404	1,618	1,841	1,621	1,643	1,574
Platform	1,770	2,106	1,943	1,570	1,465	1,428	1,355	1,233	1,343	1,198
Railroad	1,578	1,645	1,883	2,266	2,252	1,332	1,241	1,200	1,074	1,276
Aircraft	225	173	207	181	241	248	297	278	262	277
Drill/Exercise	228	349	349	503	532	669	789	908	809	1,073
Storage Tank	0	0	0	0	0	1,379	3,140	3,044	2,809	2,838
Total	32,658	29,112	27,006	28,551	28,638	30,045	32,845	30,488	30,552	32,196

Figure 4–35: Hazardous Materials Events in Oklahoma from 1995-2004



Extent

Tulsa County has 62 Tier II sites, in the unincorporated areas, with three critical facilities (including one school facility) within the maximum protective action distance of at least one of the sites. In addition, over 12,283 people, or 2.2% of the population of Tulsa County live within a half-mile of at least one Tier II site.

From January 1, 1998 to December 31, 2007, there were 219 Fixed Site incidents in all of Tulsa County reported to the National Response Center, almost ¾ of which were releases of toxic materials, like hydrogen sulfide and sulfur dioxide, into the air. About ¼ of the reported incidents were various kinds of oil and fuel releases onto the land. Based on this record, the County can expect about 22 limited-impact fixed hazmat events every year, almost 90% of which involve oil refining and pipeline operations.

The extent of a fixed site hazardous material event can range from relatively harmless to catastrophic with numerous long-term health and environmental effects. The extent of this hazard is predominately influenced by the amount of the chemical involved, local weather conditions, response team training and equipment, enforcement of community regulations and codes, identification of hazardous material storage sites and pipelines, and advanced warning systems (e.g., warning sirens with voice capability, Reverse 911, etc.).

Tulsa County considers a minor severity to be a chemical spill that is unlikely to cause severe casualties, or which meets the Emergency Response Guidebook definition of a "small spill" and a major severity to be the release of a toxic chemical which has the likelihood of producing serious injury or death or a release that meets the definition of a “large spill” for a particular chemical as stated in the most current edition of the Emergency Response Guidebook.

Impact

The impact of this hazard can interrupt business, affect transportation systems, disable emergency response capability, and cause injury, or loss of life

4.13.2 History/Previous Occurrences

In 1984, a deadly cloud of methyl isocyanate killed thousands of people in Bhopal, India. Shortly thereafter, there was a serious chemical release at a sister plant in West Virginia. These incidents underscored demands by industrial workers and communities in several states for information on hazardous materials. Public interest and environmental organizations around the country accelerated demands for information on toxic chemicals being released “beyond the fence line” – outside the facility.

On March 26, 1997, an explosion at Chief Supply Chemical Company, 5 miles northwest of Haskell on U.S. 64, sent up a column of smoke that could be seen for 50 miles. The fire continued to burn through the night of March 28. One employee was critically burned and later died. Chief Supply closed down.

On January 22, 2001, Carbon Monoxide was released from a piece of gas equipment into a Chickasha residence causing two fatalities. Reliant Energy Arkla Gas Company was the owner of the faulty equipment.

On October 17, 2006, a toxic chemical release occurred at Muskogee's water treatment plant when sodium chlorite was inadvertently emptied from a tanker truck into a tank of fluorosillic acid. The mixture produced a potentially lethal cloud of chlorine dioxide and forced the evacuation of the Port of Muskogee and the closure of several highways. The toxic cloud was dissipated by strong southeasterly winds.

Tulsa County Fixed Site Incidents

From January 1, 1998 to December 31, 2007, there were 184 Fixed Site incidents in Tulsa County reported to the National Response Center, the single point of contact for all pollution and hazardous material incident reporting. Of those 184 events, 155 were at sites that had multiple incidents. Those companies are listed in Table 4-53.

Table 4–53: Tulsa County Companies with Multiple Fixed-site Incidents

Company	Address	Events
Sinclair Oil	902 W. 25th St.	77
Sun Refinery	1700 S. Union Ave.	50
Williams Pipeline	2120 S. 33rd West Ave.	6
Baker Petrolite	9100 W. 21st St.	5
Bama Pie	2745 E. 11th St.	4
PSO	2128 E. 26th St., 3600 S. Elwood Ave.	4
American Airlines	3800 N. Mingo Rd.	3
Electronic Chemicals	5201 W. 21st St.	2
Koch Industries	11920 E. Apache	2
HCI Advanced Chemical	06 E. Morrow Rd.	2
	Total	**155**

The 184 hazardous materials incidents from fixed site locations that occurred in Tulsa County between 1998 and 2007 are listed in Table 4-54. The great majority of these incidents were harmless (but reportable) releases of materials used in manufacturing, such as nitrogen oxide, hydrogen sulfide, anhydrous ammonia, sulfur dioxide and sulfuric acid.

Table 4–54: Tulsa County Fixed Site Hazardous Materials Incidents 1998 - 2007
Source: National Response Center

Date	Location	Suspected Responsible Company	Medium Affected	Material Name
01/25/98	902 W 25th St	Sinclair Oil	Land	Gasoline
01/28/98	902 W 25th St	Sinclair Oil	Land	Kerosene
02/12/98	3800 N. Mingo Rd	American Airlines	Water	Jet fuel: JP-8
04/20/98	1602 S Madison Ave	Public Service Co.	Land	Polychlorinated Biphenyls
04/24/98	3800 N. Mingo Rd	American Airlines	Water	Rinse water, waste water, condensate
05/06/98	1700 S Union St	SUNOCO, Inc	Water	Misc motor oil
06/28/98	3300 W 21st St	Williams Pipeline	Land	Jet fuel: JP-8
07/12/98	Arkansas R / 21st St	Hillcrest Med Center	Water	Fuel oil: No. 2-D
07/23/98	06 E Morrow Rd	HEI Advanced	Air	Chlorine

Date	Location	Suspected Responsible Company	Medium Affected	Material Name
		Chemical		
08/06/98	1700 S Union St	SUNOCO, Inc	Land	Hazardous waste (Containing: FO37/KO48/KO49/KO51)
07/30/98	9100 W 21st St	Baker Petrolite	Air	Xylene (O-, M-, P-, & mixtures)
09/02/98	1700 S Union St	SUNOCO, Inc	Air	Benzene
10/05/98	1700 S Union St	SUNOCO, Inc	Water	Other oil (Slop oils/ transmission fluid)
10/05/98	3300 W 21st St	Williams Pipeline	Land	Fuel oil and gasoline mix
10/20/98	1700 S Union St	SUNOCO, Inc	Air	Various sulphur byproducts, Toluene, Benzene
11/03/98	902 W 25th St	Sinclair Oil	Land	Crude oil
12/31/98	3300 W 21st St	Williams Pipeline	Water	Unleaded gasoline
01/19/99	1700 S Union St	SUNOCO, Inc	Unknown	Benzene, gasoline stock
02/23/99	5201 W 21st St	Electronic Chemicals	Air	Sulfur trioxide
04/26/99	1700 S Union St	SUNOCO, Inc	Water	Unknown oil
04/15/99	5201 W 21st St	Electronic Chemicals	Air	Sulfur dioxide
05/21/99	06 E Morrow Rd	HCI Advanced Chemical	Land	Ammonium hydroxide
07/02/99	Tulsa Int'l Airport	Evergreen Airlines	Land	Hydraulic oil
09/15/99	3600 S Elwood	Public Service Co	Land	Sulfuric acid
09/16/99	9100 W 21st St	Baker Petrolite	Land	MD 3306
11/21/99	9100 W 21st St	Baker Petrolite	Land	Ethylene oxide
12/06/99	3800 N. Mingo Rd	American Airlines	Water	Chromic acid
02/17/00	16319 E Marshal	Safety Clean	Land	Waste chromic acid
03/07/00	North of Hwy 51	Sand Springs	Land	Unknown oil
03/20/00	8091 N US 169	Jim Brown Assoc	Land	Misc motor oil
05/06/00	1700 S Union St	SUNOCO, Inc	Water	Oil, misc lubricating
06/24/00	Hwy 75 / 66th St N	Williams Pipeline	Air	Ammonia, anhydrous
08/01/00	21440 E. 104th St	Warner Transportation	Land	Concrete, gasket remover, lubricator, WD 40, rust inhibitor, lacquer thinner, starting fluid, propane, and other materials
12/13/00	4727 W 21st St	KOCH Truck Terminal	Air	Ethyl mercaptan
01/03/01	1906 N Kingston	S&K Industries	Unknown	Unknown material
01/04/01	1700 S Union St	SUNOCO, Inc	Air	Unknown material
02/20/01	14023 Casper	Air Pigeon	Air	Refrigerant gases
03/25/01	8888 W 21st St	Cost-O-Fab	Water	Waste oil and water
04/15/01	1 mile west of 1st St & Hwy 75	Explorer Pipeline Co	Land	Gasoline, unleaded
05/30/01	North bank, Hwy 97 Arkansas R bridge	BP/ARCO Environmental Remediation	Water	Contaminated soil
07/20/01	Sand Creek Lagoon	City of Sand Springs	Water	Sewage
08/02/01	2745 E 11th St	Bama Pie	Air	Ammonia, anhydrous
10/10/01	5201 W 21st St	Koch Sulfur Products Co LLC	Soil	Low Ph water
10/22/01	5201 W 21st St	Koch Sulfur Products Co LLC	Land	Low Ph water (PH=1)
11/02/01	902 W 25th St	Sinclair Oil	Land	Sulfuric acid

Date	Location	Suspected Responsible Company	Medium Affected	Material Name
11/16/01	Hwy 75 / 126 St. S Glenpool Station	Williams Pipeline	Water	Jet fuel: JP-8
01/02/02	2435 N Lewis Ave	Bama Frozen Dough	Air	Ammonia, anhydrous
01/05/02	902 W 25th St	Sinclair Oil	Air	Catalytic reforming refromate (hydro carbons)
04/11/02	116th St N & Harvard Ave	Rock Oil Co	Water	Salt water, crude oil
05/08/02	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide
05/09/02	3300 W 21st St	Williams Pipeline	Water	Oil, diesel
05/21/02	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide
06/27/02	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide
07/22/02	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide, slufur dioxide
07/23/02	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
07/31/02	9100 W 21st St	Baker Petrolite	Air	Mixture of 83% Isopentane, 10% Dodecene, 4.5% hexene
08/05/02	W 69th St S	Patriot Energy	Land	Unknown oil
08/05/02	902 W 25th St	Sinclair Oil	Air	Unknown material
09/11/02	Sand Springs, S Adams Rd	Atlantic Richfield	Water	Oil, crude
11/09/02	Behind Industrial Area	Broken Arrow	Land	Unknown oil
11/12/02	902 W 25th St	Sinclair Oil	Air	Unknown
02/27/03	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide, Refinery fuel gas
03/22/03	2435 N Lewis Ave	Bama Frozen Dough	Air	Ammonia, anhydrous
08/18/03	31 N Peoria	Airgas MidSouth	Air	Ammonia, anhydrous
08/31/03	902 W 25th St	Sinclair Oil	Soil	Sulfuric acid (CAS 7664939)
10/15/03	9100 W 21st St	Baker Petrolite	Air	Xylene (O-, M-, P-, & mixtures)
09/01/03	5259 W 49th Ave	OK Forge	Water	Hydraulic oil
12/09/03	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
01/25/04	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide, Sulfur dioxide
02/09/04	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxide
03/14/04	1700 S Union St	SUNOCO, Inc	Air	Hydrogen sulfide
04/20/04	902 W 25th St	Sinclair Oil	Air	Ammonia, anhydrous, Hydrogen sulfide
04/20/04	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide
06/11/04	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
06/11/04	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide, Sulfur dioxide
06/11/04	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
06/11/04	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
06/11/04	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide, Sulfur dioxide
06/11/04	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
06/18/04	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
06/19/04	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide, Sulfur dioxide
06/20/04	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
06/21/04	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
06/22/04	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
06/22/04	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxide

Date	Location	Suspected Responsible Company	Medium Affected	Material Name
06/24/04	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
06/24/04	220 S Elm St	Ashers	Air	Ethylene glycol
06/25/04	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
06/26/04	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
06/27/04	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
06/28/04	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
07/02/04	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide
07/02/04	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides
07/02/04	902 W 25th St	Sinclair Oil	Water	UNISOL liquid red dye
07/21/04	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxide
08/06/04	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide
10/06/04	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxide
10/30/04	Unknown	Conoco Phillips	Land	Water and gasoline mixture
11/12/04	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides
11/09/04	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxide
11/24/04	1700 S Union St	SUNOCO, Inc	Air	Nitric oxide
12/06/04	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide
12/07/04	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides
12/20/04	13802 E Apache	Budget Used Auto Parts	Land	Unknown oil
12/21/04	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxide
12/23/04	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxide
12/28/04	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxide
12/28/04	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide
12/31/04	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide
01/07/05	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxide
01/07/05	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxide
01/13/05	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides
01/16/05	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides
01/19/05	902 W 25th St	Sinclair Oil	Land	Sulfuric acid
02/02/05	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide
03/14/05	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxide
03/19/05	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxide
03/23/05	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide, Sulfur dioxide
03/23/05	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide
04/17/05	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides
04/20/05	1700 S Union St	SUNOCO, Inc	Air	Nitrogen tetroxide
05/01/05	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide
05/22/05	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides
05/23/05	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides
07/12/05	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxide
08/08/05	2001 N 170th E Ave	Commercial Metal Co	Air	Chlorine
08/16/05	902 W 25th St	Sinclair Oil	Land	K050 (Heat exchanger bundle sludge)
08/19/05	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides

Date	Location	Suspected Responsible Company	Medium Affected	Material Name
09/15/05	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides
09/16/05	1700 S Union St	SUNOCO, Inc	Air	Sulfur dioxide
09/18/05	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides
10/17/05	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide, Sulfur dioxide
10/17/05	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide, Sulfur dioxide
10/20/05	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides
10/20/05	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxide
11/18/05	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides
12/30/05	902 W 25th St	Sinclair Oil	Land	Sulfuric acid
01/14/06	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide
03/09/06	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides
03/22/06	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide, Sulfur dioxide
04/06/06	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides
04/19/06	Tulsa Int'l Airport,	Southwest Airlines	Land	Human waste
04/30/06	2727 E 11TH ST	Bama Pie	Air	Ammonia, anhydrous
05/06/06	902 W 25th St	Sinclair Oil	Land	Benzene
05/01/06	126th St N	Collinsville	Land	Unknown material
05/31/06	902 W 25th St	Sinclair Oil	Air	Toluene, Xylene, Ethyl benzene, Naphthalene, Benzene
05/31/06	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides
06/13/06	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxide
06/15/06	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxide
06/20/06	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide
06/20/06	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide
06/20/06	902 W 25th St	Sinclair Oil	Land	Gas and oil catalyst mixture
07/05/06	63rd St N & 105th E Ave	City of Tulsa	Water	Asbestos, Nitrogen fertilizer
07/13/06	902 W 25th St	Sinclair Oil	Soil	Sulfuric acid
07/16/06	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
07/18/06	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides
08/09/06	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
08/10/06	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides
08/20/06	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxide
09/09/06	1700 S Union St	SUNOCO, Inc	Air	Nitrogen oxides
10/09/06	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide, Sulfur dioxide
11/17/06	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide
12/18/06	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
12/28/06	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide, Sulfur dioxide
01/11/07	Tulsa Int'l Airport	Aircraft Fueling Systems	Land	Oil: Diesel
01/12/07	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
01/23/07	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide
02/06/07	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide
02/06/07	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide
05/07/07	1700 S Union St	SUNOCO, Inc	Water	Unknown oil

Date	Location	Suspected Responsible Company	Medium Affected	Material Name
05/15/07	17085 N 13th St	Public Service Co	Land	Oil, misc transformer
05/20/07	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
05/21/07	902 W 25th St	Sinclair Oil	Soil	Fresh caustic
06/11/07	2700 S 25th W Ave	Permafix	Water	Sulfuric acid
07/12/07	902 W 25th St	Sinclair Oil	Land	Other oil (Hazardous waste)
08/13/07	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide, sulfur dioxide
09/13/07	7777 E Apache	Tulsa Int'l Airport	Other	Grease trap contents
10/11/07	902 W 25th St	Sinclair Oil	Air	Sulfur dioxide, Hydrogen sulfide
10/12/07	902 W 25th St	Sinclair Oil	Land	Benzene, Hydrogen sulfide
11/09/07	902 W 25th St	Sinclair Oil	Air	Hydrogen sulfide
11/13/07	902 W 25th St	Sinclair Oil	Land	Sulfuric acid
11/19/07	902 W 25th St	Sinclair Oil	Soil	Sulfuric acid
12/12/07	902 W 33rd St N	Public Service Co	Water	Oil, misc mineral
12/12/07	902 W 25th St	Sinclair Oil	Air	Benzene

4.13.3 Vulnerability

A hazardous material event can occur anywhere due to the widespread use of hazardous chemicals. However, the population at most risk to a fixed-site incident is the population that works or lives nearest to the machinery, refineries, or manufacturing plants that use or produce the hazardous materials. A recent study by the Department of Homeland Security (2004) estimated that a worst-case chlorine tank explosion at an industrial site in a major population center could result in thousands of deaths, severe injuries and hospitalizations, as well as the evacuation of thousands of downwind workers and residents. Therefore, Tulsa County has examined the Tier II list, and has inventoried local businesses and industry facilities to identify dangerous chemicals that are being manufactured and/or stored in the community. Known hazardous materials sites for Tulsa County are shown on the map in Figures 4–34a-c and are listed in Table 4-55.

Assessment of the vulnerability to a hazardous material release can be meticulous due to the relationship between the toxicity of the material, the amount of material released, the type of release, and the climate conditions at the time of the release. However, for the purposes of this report, general community vulnerability is assessed based on the type of material present at any one of the community's Tier II sites and the greatest necessary protective action distance as defined by the DOT "Emergency Response Guidebook 2004" for the materials housed at the specified location. When available, RMP*Comp, a computer program for risk management planning, was used to calculate the worst-case protective action distance based on the physical characteristics of the material and the specified amount of material housed at the site. The number of people within standard protective action distances are displayed in Table 4-55.

Population

Since approximately 75-80% of all hazardous materials releases occur at fixed-site facilities, the greatest danger is to the populations working at or living near the facilities where the material is released. Over 12,283 people, or 2.2% of the population of Tulsa County, live within a half-mile of at least one Tier II site.

People at heightened risk in the release area are 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.

Most Tier II sites that pose a risk to Tulsa County populations are in the jurisdiction of cities within the county, like Tulsa or Sand Springs. Likewise, hazardous materials releases in unincorporated Tulsa County will endanger populations in other jurisdictions. In all cases, the population most at risk, other than employees at the facility where the spill occurs, will be those living or working close by and downwind from the release.

Table 4–55: Tulsa County Tier II Sites

ID	Name	Contains EHS	Pop w/ in 500 ft. Buffer Zone	Pop. w/ in 1000 ft. Buffer Zone	Pop. w/ in 2640 ft. Buffer Zone
1	A&D Foundry Group	N	0	3	281
2	Aaon, Inc.	N	0	0	0
3	Acme Brick Company – Tulsa Plant	N	0	88	2321
4	Alpha Tank Cleaning Inc.	Y (2)	*0*	*0*	*22*
5	American Airlines Tulsa M&E Center	Y (7)	0	0	0
6	Ameron Pole Products Division	N	0	0	0
7	Ashland Distribution – Sand Springs	Y (2)	0	169	595
8	AT&T Telephone	Y (1)	0	0	0
9	B&M Oil Company – Tulsa		2	29	329
10	Baker Petrolite – Tulsa, OK	Y (3)	0	0	790
11	Bama Foods	Y (2)	0	0	0
12	Bluelinx – Tulsa Distribution Center	N	0	0	28
13	Builders Steel Co. Inc.	N	0	0	91
14	ChemTrade Refinery Services, Inc.	Y (4)	0	0	255
15	Cherokee Data Center	Y (1)	0	0	40
16	D-A Lubricant Company, Inc.	N	0	0	55
17	Dryvit Systems	Y(1)	0	3	281
18	FedEx Express – TULR	N	0	0	0
19	Ferrellgas – Bixby	N	2	2	6
20	Ferrellgas – Keystone	N	0	4	167
21	Frontier Plastic Fabricators	N	48	87	656
22	Fuel Marketing Corporation Terminal	N	0	0	7
23	Global Manufacturing Co, Inc.	N	0	0	0
24	Groendyke Transport, Inc.	N	78	142	594
25	H&L Tooth Company	N	0	0	0
26	Haikey Creek Wastewater Treatment Plant	Y (2)	0	0	0
27	Honeywell International	N	0	0	0
28	Hydrotex Partners	Y (2)	0	8	68
29	IC of Oklahoma, Inc.	Y (1)	0	0	0
30	Joseph T. Ryerson & Sons, Inc.	N	0	0	0

ID	Name	Contains EHS	Pop w/ in 500 ft. Buffer Zone	Pop. w/ in 1000 ft. Buffer Zone	Pop. w/ in 2640 ft. Buffer Zone
31	Keck Construction Inc. Shop	N	0	0	0
32	Magellan Pipeline Company – Tulsa Terminal	N	0	0	0
33	MCI – TUCBOK	Y (1)	0	0	0
34	Mid-Continent Concrete Company	N	0	267	295
35	Midwestern Manufacturing Company	N	0	0	1122
36	Nordam Manufacturing Division	Y (1)	0	7	36
37	Nordam Nacelle Thrust Reversers System	N	0	0	7
38	Nordam Transparency Division	N	0	0	0
39	Norris	Y (1)	0	0	200
40	North American Galvanizing Co. – Tulsa Plant 1	N	0	0	114
41	North American Galvanizing Co. – Tulsa Plant 2	N	0	0	0
42	Northside Wastewater Treatment Plant	Y (2)	0	0	0
43	Oklahoma Forge	N	0	12	168
44	Ozark Flourine Sepcialities Inc.	Y (1)	0	0	256
45	Perma-Fix Treatment Services, Inc.	Y (1)	0	0	0
46	PSO – American Airlines Substation	Y (1)	0	0	0
47	PSO – Cherokee Industrial Park Substation	Y (1)	0	0	0
48	PSO – Oak 138kV Substation	Y (1)	9	77	709
49	PSO – Tulsa North 138kV Substation	Y (1)	0	0	38
50	PSO – Tulsa Sunray Refinery Substation	Y (1)	0	0	0
51	PSO – Tulsa Williams Pipeline Substation	Y (1)	0	0	7
52	Secure Computer Center	Y (1)	0	0	0
53	Sinclair Tulsa Refining Company – Tulsa Refinery	Y (13)	0	0	407
54	Spirit AeroSystems	N	0	0	0
55	Sunoco Tulsa Refinery	Y (17)	0	0	1110
56	Synergy	N	0	0	23
57	Tulsa Computer Center	Y (1)	0	0	0
58	Tulsa Power Station (High Pressure Yard)	N	0	0	708
59	Tulsa Power Station (Low Pressure Yard)	N	0	0	117
60	Tulsa Propane Terminal	N	0	0	7
61	Whirlpool Corporation, Tulsa Division	Y (1)	0	0	36
62	Yaffe Metals	N	0	24	437

Critical Facilities

There are three critical facilities in West Tulsa County at risk of hazardous materials releases. These are the Oakhurst Fire Department, Addams Elementary School, and Sooner Emergency Services, all located between 49th and 65th West Avenue, and between the river and the Creek County line. (See Appendix D for detailed information regarding specific chemicals, evacuation distances, and contact information for each Tier II Hazardous Material site.)

These facilities are listed in the table below.

Table 4–56: Tulsa County Critical Facilities within .5 mi. of Tier II Sites

ID	*Name*	*Address*
29	Oakhurst Fire Department	5716 W. 6th St.
31	Addams Elementary School	5325 S. 65th W. Ave.
32	Sooner Emergency Services	2131 S. 49th St. West

Structures/Buildings

Structures and buildings are, as a rule, not vulnerable to hazardous material spills, except in the case of flammable and explosive materials, like natural gas and some petroleum products. No Tulsa County critical facilities are located close to facilities utilizing or transporting such materials.

Infrastructure

Water Treatment – 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 – Wastewater treatment plants not only process 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.

Utilities: The primary utility providers for Tulsa's jurisdiction are AEP/PSO (electricity) and ONG (natural gas).

Electricity – There are no immediate vulnerabilities to the supply of electricity because of a hazardous materials spill. Although electrical substations contain hazardous materials, such as acids, these do not pose a danger to local citizens, as substations are usually fenced.

Gas – No significant vulnerabilities in the delivery of natural gas supply during a fixed-site event. Natural gas is, itself, a hazardous material, and leaks from ruptured pipes could result in the temporary shut off of gas delivery through the affected lines.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Evacuation of contaminated areas can clog roadways or block traffic until the event has dissipated.

Emergency Services- Fire, Police and Medical Services could be impacted by having to evacuate facilities. In West Tulsa County, Oakhurst Fire Department is within the evacuation distance of a Tier II facility. Fire, Police and Medical Services would have a surge of demand for services. While not an immediate threat to delivery of these services, the demand for additional personnel to affect an effective response could potentially increase the cost for these resources.

4.13.4 Fixed-Site Event Scenario

On October 17, 2006, a toxic chemical release occurred at Muskogee's water treatment plant when sodium chlorite was inadvertently emptied from a tanker truck into a tank of fluorosillic acid. The mixture produced a potentially lethal cloud of chlorine dioxide and forced the evacuation of the Port of Muskogee and the closure of several highways. The toxic cloud was dissipated by strong southeasterly winds.

Since approximately 75-80% of all hazardous materials releases occur at fixed-site facilities, the greatest danger is to the populations working at or living near the facility where the material is released. About 90% of toxic material releases are of a single chemical or substance. Two of the most common toxic substances released are chlorine and ammonia, chemicals commonly used in manufacturing. Chlorine, which is used in water purification, is one of the most widespread and frequently used chemicals in Tulsa County. About 90% of toxic releases at fixed site facilities are a result of operator errors and equipment failure.

This scenario involves the accidental release of chlorine gas at the A.B. Jewell Water Treatment Plant in North Tulsa County, due either to operator error or equipment failure. Prevailing winds in Tulsa County are predominantly out of the north or south—with southerly winds blowing 15% of the time and northerly winds 10% of the time. Overall average wind speed is 6.9 mph. The population most at risk will be employees working at the water plant and those living downwind from the facility when the release occurs.

The plume from the Muskogee event was modeled in GIS software after interviewing Muskogee County and the City of Muskogee emergency management personnel that witnessed the event. The plume generated from the event extends north-northeast of the facility.

Using GIS software and laying this plume area over aerial photography of Unincorporated Tulsa County with it's apex at the Northside Wastewater Treatment Plant, there are only 5 habitable structures that would be affected. Therefore, the exposure of the population of Unincorporated Tulsa County surrounding the treatment plant is considered minimal.

4.13.5 Future Trends

For a map of Tulsa's potential future growth areas, see Figure 1-8.

Population

Development in Tulsa County will continue to expose the population to hazardous material spills.

Structures/Buildings

Structures and buildings will remain vulnerable to releases of flammable and explosive materials, like natural gas and some petroleum products. No developments are planned near facilities utilizing or transporting flammable and explosive materials.

Critical Facilities

There are no plans to site critical facilities in close proximity to hazardous materials sites.

Infrastructure

Infrastructure vulnerabilities to hazardous materials will continue to exist. Care should be given in future planning to ensure that both infrastructure and workers are not exposed to hazardous materials releases.

4.13.6 Conclusion

Varying quantities of hazardous materials are manufactured, used, or stored at an estimated 4.5 million facilities in the United States, from major industrial plants and water treatment facilities to local dry cleaning establishments and gardening supply stores.

The estimated annual damage from hazardous materials events in the United States is $22.4 million. Most victims of chemical accidents are injured at home. These incidents usually result from ignorance or carelessness in using flammable or combustible materials.

Based on Tulsa County's hazardous materials information, including percentage of the population at risk and other factors, the jurisdiction is at high risk from hazardous materials incidents. However, the number of critical facilities at risk should be a factor included in mitigation plans.

4.13.7 Sources

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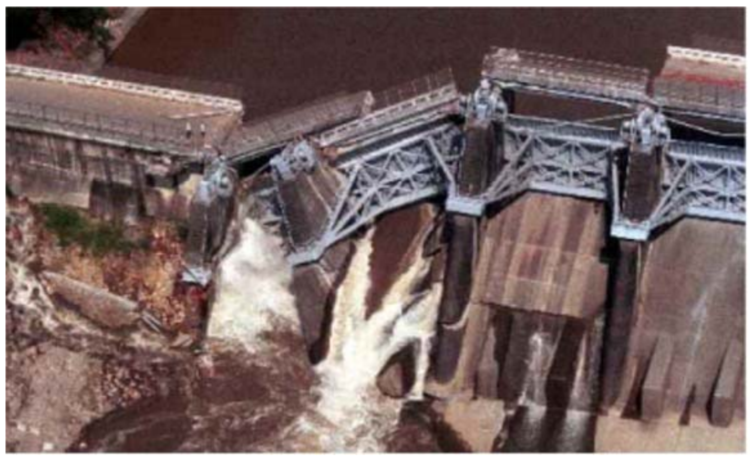
4.14 Dam Failures

Dams. The Federal Emergency Management Agency (FEMA) defines a dam as "a barrier constructed across a watercourse for the purpose of storage, control, or diversion of water." Dams typically are constructed of earth, rock, concrete, or mine tailings. A dam failure is the collapse, breach, or other failure resulting in downstream flooding.

Levees. A levee is an embankment or barrier of compacted soil designed to keep floodwaters away from buildings or other investments. Levees are considered "structural" flood control projects, and are generally constructed to protect floodplain development. Until the late 1960s, structural measures such as levees were the dominant approach to riverine floodplain management. Currently, however, under the National Flood Insurance Program (NFIP) regulations, levees are not recognized as acceptable measures for protecting new, substantially improved, or substantially damaged structures.

4.14.1 Hazard Profile



The overtopping or forced release of a dam due to heavy rain or abnormal river flows is a threat to downstream properties.

A break in a dam or levee produces an extremely dangerous flood situation because of the high velocities and large volumes of water. In the event of a dam or levee failure, the potential energy of the water stored behind even a small dam or levee can cause great property damage, as well as loss of life if there are people downstream from the dam or behind the levee.

The extent of this inundation may be minimal to uninhabited farmland or catastrophic in nature in an urban environment.

Dams. Dam failures are primarily caused by hydrologic or structural deficiencies. A hydrologic deficiency is inadequate spillway capacity caused by excessive runoff from heavy precipitation. Structural deficiencies include seepage, erosion, cracking, sliding, and overturning, mainly caused by the age of a dam and lack of maintenance. The operation of a reservoir can also influence the safety of the structure.

There can be varying levels of dam failure. Partial dam failures include inadequate spillway capacity that causes excess flow to overtop the dam; and internal erosion through the dam or foundation.

Complete failure occurs if internal erosion or overtopping results in a total structural breach, releasing a high-velocity wall of debris-laden water rushing downstream, damaging or destroying everything in its path.

Flooding can occur downstream from a dam without the structure being breached. Sometimes, to prevent overtopping and catastrophic failure, dams are forced to make emergency releases of large amounts of water, which can cause downstream flooding.

Levees. Levee failures or damages behind levees can be caused by several occurrences:

- overtopping due to flood heights exceeding the levee design-protection elevation;
- flooding from upstream sources internal to the levee;
- erosion caused by embankment leaking or “piping” or excessive saturation of a sand levee. “Piping” is internal erosion caused by seepage, and can occur around pipes, through animal burrows, around roots of trees, and other weaknesses.
- improper operation and maintenance, including failure to inspect and repair seepage problems or manage vegetation.

The failures of levees along the Mississippi River in 1993 and in New Orleans after Hurricane Katrina in 2005 have focused new attention on the inherent hazards of levees.

Levee failures can cause catastrophic floods, releasing sudden walls of water that can sweep across lands thought to be protected by the structure. Thus, levees and dams may create a false sense of security, increasing the amount of property at risk of flooding as people and businesses locate behind levees and floodwalls, believing they are totally safe. In addition, levees, dams, and other structural measures are extremely costly and can disrupt or destroy the natural environment.

A break in a dam produces an extremely dangerous flood situation because of the high velocities and large volumes of water. The severity of impact on areas downstream and the height to which waters will rise are largely functions of valley topography and the volume of water released.

Besides dam failures, there are hazardous actions that have to be taken to prevent dam failures, such as sudden releases of water when the dam is threatened with overtopping. In this case, a dam may have failed in its purpose to protect downstream people and property, without having literally or physically failed.

Location

The location of the areas affected by a dam or levee break is shown in the maps used in the scenario section of this hazard.

Measurement

The amount of water impounded in the reservoir behind a dam is measured in acre-feet. An acre-foot is the volume of water that covers an acre of land to a depth of one foot, or approximately 325,000 gallons. As a function of upstream topography, even a very small dam may impound or detain many acre-feet or millions of gallons of water.

Any artificial water barrier structure that has a height of 25 feet or more from the natural streambed and 50 acre feet or more of storage capacity qualifies as a dam and is under the jurisdiction of the Oklahoma Water Resources Board (OWRB).

There are 4,524 dams in Oklahoma (including private structures), with approximately half (2,300) operated by the National Resources Conservation Service (NRCS). Emergency Action Plans have been filed for 160 of the most important dams in the state.

The OWRB classifies dams as high-hazard, significant-hazard, and low-hazard, depending on the amount of water stored and downstream populations. The state has 165 high-hazard dams, which must be inspected every year. There are 88 dams having significant hazard potential, which are inspected every three years. The rest are classified as low hazard, and are inspected every five years.

Dams are classified based on the potential damages to downstream development. If a high-hazard dam fails, there likely will be loss of life and extensive damage to development – communal, industrial, or agricultural. Failure of a dam classified as significant would cause no loss of life and appreciable agricultural, industrial, or structural damage. Failure of a low hazard dam would cause no loss of life and minimal economic loss. The classification scheme in no way suggests that a dam is in need of repair – it could be in excellent condition or in poor condition. It simply reflects a dam's potential for doing damage downstream if it were to fail.

Areas likely to be impacted by a dam break are delineated using dam breach analyses that consider both "sunny day" failures and failures under flood conditions.

Extent

The extent of a dam failure can be influenced by several factors: the amount of water behind the dam; the height of the dam itself; and way in which a dam fails. The extent of a dam failure can be assessed before the event itself occurs. Using a GIS environment, a water body's volume can be measured with a high degree of accuracy. The inundation area of a dam and depth of flooding can be determined using readily available DEM or topographic maps. The extent of this inundation can be minimal to uninhabited farmland or can be catastrophic in nature in an urban environment.

Tulsa County has one high-hazard dam within the county and one outside that will significantly impact the county if failures were to occur: Keystone Lake Dam and Skiatook Lake Dam. In addition, there are three smaller high hazard dams that deserve visual analysis, although it appears that their failure would cause little or no damage or loss of life to downstream structures and populations: Shell Lake Dam in Osage County, and Yahola Lake Dam and Sand Springs Lake Dam in Tulsa County.

The economic impacts resulting from a breach of, or major emergency release from, Keystone Dam would impact a total of 2,085 properties in West and South Tulsa County, and do a total of $80,233,810 damage.

A breach of, or major emergency release from, Skiatook Lake Dam in Osage County would do a total of almost $97 million in damage to agricultural, residential, commercial, industrial and tax-exempt properties.

Arkansas River Corridor

Of particular concern for Tulsa County are Keystone Dam and three levees, all built by the Corps of Engineers on the Arkansas River upstream from and west of downtown Tulsa. These structures have prevented millions of dollars in flood damages since they were built, but they present inherent hazards for catastrophic disaster. Because of the unique hazard presented by these structures, this plan focuses on those structures and the Arkansas River valley corridor through Tulsa County.

The Arkansas River is one of the longest tributaries of the Mississippi River. The river rises at elevation 11,500 feet in the Rocky Mountains near Leadville, Colorado, and flows 1,450 miles through Kansas, Oklahoma and Arkansas. Altogether, the river drains 160,500 square miles. At Keystone Dam just above Tulsa, the Arkansas joins with a major tributary, the Cimarron River, which drains portions of New Mexico, Texas, and Oklahoma. Over the years, the Corps of Engineers has estimated bank-full channel capacity to be between 90,000 and 110,000 cubic feet per second.

A release of 40,000 cubic feet per second (cfs) from Keystone Dam, upstream of the City of Tulsa

Keystone Dam. The Corps of Engineers completed Keystone Dam in 1964 about 10 miles west of Tulsa. Authorized purposes include flood control, hydropower, water supply, water quality, navigation, irrigation, recreation, and fish and wildlife management. Keystone Dam is 4,600 feet long, 121 feet wide, and composed of masonry and earth fill.

It is also relevant for Tulsa County that, in 1976, the Corps completed Kaw Dam 115 river miles upstream (northwest) of Keystone. The Kaw flood pool contains 919,400 acre-feet of water, according to the Corps. The Corps estimates that, together, Keystone and Kaw dams provide an estimated 15-year level of flood control storage.

Arkansas River Levees at Tulsa. The levees of most concern for the City of Tulsa and Tulsa County are west of downtown on the north, south, and west sides of the Arkansas River, protecting the refineries and some adjacent neighborhoods.

After disastrous floods in 1941 and 1943, residents of Tulsa County appealed to the County Commission and the U.S. Department of War (now Corps of Engineers) to build levees to protect floodplain development and vital war industries, such as the refineries in West Tulsa. The levees were finished in 1945.

Garden City, an area of low-income homes, was left unprotected downstream from the Corps' refinery levee. Garden City residents subsequently built their own non-engineered private dirt levee on the west side of the Arkansas River between 21st and 51st streets to protect their homes.

Together, the three Corps earthen, grass-covered levees are about 20 miles long. The average height is 8 feet, with an average crest width of 8 feet.

The Corps designates these levees as:

- Levee A, the upstream left bank levee (the western levee, located north of the river in Sand Springs and Tulsa County);

- Levee B, the downstream left bank levee (the eastern levee, located north of the river, primarily within the jurisdiction of the City of Tulsa);
- Levee C, the right bank levee (the West Tulsa levee, within the Tulsa city limits, but also containing large unincorporated areas of Tulsa County. These unincorporated areas contain oil refineries, oil tank storage farms, and railroad switching yards.).

The three levees are not connected, although the left bank levees tie into a floodway structure and operate as a system. The levee project also includes 7 pumping stations, 4 stop-log structures, wing levees, diversion channels, and a floodway structure to pass flows from three tributaries north of the river.

The Corps of Engineers designed the levees to contain a Keystone dam release of 350,000 cfs, with a minimum of 3 feet of freeboard.

By agreement between the Corps and Tulsa County, the levees are maintained by Tulsa County Drainage District 12, a legal entity that is funded by assessments on properties behind the levees. A 2008 Corps of Engineers inspection report was critical of current maintenance.

Arkansas River Regulation. It is important to note that the City of Tulsa regulates land use within the Arkansas River corridor only to the standard of the National Flood Insurance Program – a 100-year floodplain based on existing watershed development. It is arguable that this standard is justified because of the size of the Arkansas watershed but is less stringent than the City regulation over floodplains in the balance of Tulsa. On the other hand, the Arkansas River offers far greater potential for catastrophic flooding than other Tulsa floodplains. City staff has proposed adjusting the regulatory standard so the Arkansas River regulations in Tulsa would be based on the 1986 flood, the flood of record since the construction of Keystone Dam.

Tulsa County considers seepage or a small failure that would release no more than one foot of water and be contained in the downstream river bed to be a minor severity. Tulsa County considers a dam failure creating a flow higher than one foot that would exceed the capacity of the downstream riverbed and rising above the 100 and 500 year flood zones to be a major severity.

Frequency

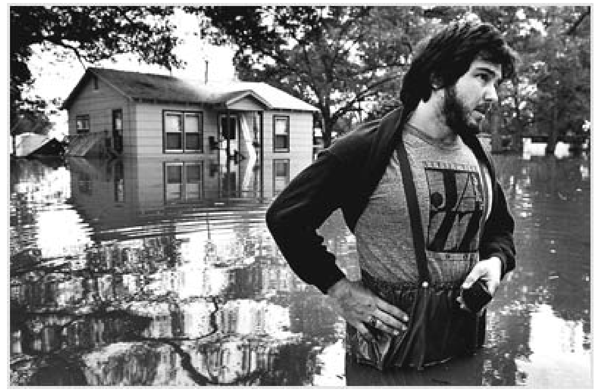
In the Arkansas River corridor, the frequency of flooding has been dramatically reduced by Keystone dam. Only one significant flood event (1986) has occurred along the Arkansas since the dam at Keystone Lake was completed.

Impact

The impact of this hazard can affect homes, business, agriculture, and infrastructure that is located downstream from the dam. Dam Failure can occur over prolonged periods of time where people have time to prepare for the imminent failure, or can be sudden with little to no warning time.

4.14.2 Historical Events

In Oklahoma, there have been only three significant, documented dam failures. On October 3, 1923, heavy rain caused a dam failure at Lake Overholser, which displaced 15,000 residents. Cleveland, in Pawnee County, suffered losses in the half-million dollar range when the town was inundated by the Cleveland Dam break on September 4, 1940. Both events resulted from sudden and heavy rainfall. After 14.6 inches of rain fell in the Wewoka area on the night of April 13-14, 1945, heavy flows on Coon Creek overtopped and breached the earth-filled Wewoka Dam, sending a wall of water into Wewoka Creek. Eight people in the path of the deluge were killed and the town of Wewoka was under 4 feet of water near the train depot. Eighty people were forced from their homes.



Bixby home during flood of October 1986, when Keystone Dam was forced to release 310,000 cfs

Dams can "fail" in ways other than being breached. Sometimes, in order to prevent overtopping and catastrophic failure, dams are forced to make emergency releases of huge amounts of water. In late September and early October, 1986, nearly 2 feet of rain fell northwest of Tulsa, causing the Arkansas, Caney, and Neosho Rivers to flood. To prevent the Arkansas River from overtopping the Keystone Dam, the Corps of Engineers had to open the floodgates and release 310,000 cfs of water down through Sand Springs, Tulsa, Jenks and Bixby. No one knew if the World War II era sand levees would hold, and a catastrophic failure of the levee system was widely feared. In fact, the Sand Springs levee was breached, but volunteers plugged it with sandbags. On the west bank, the river swamped Garden City up to the rooftops. More than 1,800 Tulsa-area homes and businesses went under water. Tulsa County damages were estimated at $63.5 million (in '86 dollars), Sand Springs' at $32.5 million, and Bixby's at $13.4 million.

A similar emergency release from Copan and Hulah Lakes during the same storm resulted in the worst flood in Bartlesville's history. The Caney River rose to 30 feet above normal, which was 17 feet above flood stage, flooding half of the city, including the downtown area. Damage was so extensive that the region was declared a Presidential Disaster Area.

4.14.3 Vulnerability

The number of fatalities resulting from dam failures is highly influenced by the number of people occupying the predicted dam failure floodplain and the amount of warning they are provided. Most dams in the United States are privately owned, located on private property, and not directly in the visual path. This factor contributes to the challenge of raising the issue of dam safety in the public consciousness and getting the information on dam safety to those who need it.

There are five dams inside Tulsa County that could impact the County if a dam failure were to occur.

Tulsa County High Hazard Dams

Keystone Lake Dam

General Location:	8 miles west of Sand Springs
Source:	Arkansas River
Owner/Operator:	United States Army Corps of Engineers
Year Completed:	1964
Length:	4,600 feet
Height:	121 feet
Maximum Storage:	1,348,000 acre feet of water
Land Area:	26,020 surface acres of water

Skiatook Lake Dam

General Location:	6 miles northwest of Sperry
Source:	Hominy Creek
Owner/Operator:	United States Army Corps of Engineers
Year Completed:	1984
Length:	3,590 feet
Height:	143 feet
Maximum Storage:	893,000 acre feet of water
Land Area:	10,540 surface acres of water

Sand Springs Dam

General Location:	Sand Springs City Limits
Source:	Bigheart Creek
Owner/Operator:	City of Sand Springs
Year Completed:	1960
Length:	680 feet
Height:	36 feet
Maximum Storage:	240 acre feet of water
Land Area:	14 surface acres of water

Shell Lake Dam

General Location:	5 miles northwest of Sand Springs in Osage County
Source:	Shell Creek
Owner/Operator:	City of Sand Springs
Year Completed:	1922
Length:	757 feet
Height:	65 feet
Maximum Storage:	12,700 acre feet of water
Land Area:	573 surface acres of water

Yahola Lake Dam

General Location:	Tulsa city limits in Mohawk Park
Source:	Bird Creek
Owner/Operator:	City of Tulsa
Year Completed:	1948
Length:	17,500 feet
Height:	35 feet
Maximum Storage:	7,514 acre feet of water
Land Area:	431 surface acres of water

A dam break or major forced release of any one of the high hazard dams would inundate much of the downstream floodplains, damaging many of the structures within them. It is required that the County's Emergency Operation Procedures include an identification of the vulnerable population downstream from the dam and include a plan as to how this population would be notified in case of a dam failure.

It is not within the scope of this study to identify the inundation areas associated with a failure of these four lesser dams, nor the properties likely to be affected by such an event.

Studies have been made of the likely consequences of forced releases from Keystone Dam of 250,000 cfs, 350,000 cfs (close to the size of the 1986 release), 450,000 cfs, Maximum Discharge, and the release that would result from dam failure. These consequences are summarized in Tables 4-57a-d. The critical facilities that would be impacted by these releases are listed in Table 4-58.

Table 4–57a: Keystone Dam Release of 250,000 cfs

Type	Number of Parcels	Improvement Value	Contents Value	Total Value
Residential	365	$25,323,960	$12,661,980	$37,985,940
Agricultural	154	$708,000	$354,000	$1,062,000
Commercial	34	$167,300	$83,650	$250,950
Industrial	7	$1,801,600	$900,800	$2,702,400
Special Needs / Tax Exempt Parcels	29	-	-	-
Vacant	92	-	-	-
Total	**681**	**$28,000,860**	**$14,000,430**	**$42,001,290**

Table 4–57b: Keystone Dam Release of 350,000 cfs

Type	Number of Parcels	Improvement Value	Contents Value	Total Value
Residential	678	$48,437,920	$24,218,960	$72,656,880
Agricultural	174	$768,300	$384,150	$1,152,450
Commercial	41	$318,600	$159,300	$477,900
Industrial	15	$2,359,400	$1,179,700	$3,539,100
Special Needs / Tax Exempt Parcels	44	-	-	-
Vacant	186	-	-	-
Total	**1,138**	**$51,784,220**	**$25,892,110**	**$77,676,330**

Table 4–57c: Keystone Dam Release of 450,000 cfs

Type	Number of Parcels	Improvement Value	Contents Value	Total Value
Residential	1,191	$63,686,820	$31,843,410	$95,530,230
Agricultural	187	$788,400	$394,200	$1,182,600
Commercial	77	$ 2,525,700	$1,262,850	$3,788,550
Industrial	81	$ 18,847,200	$9,423,600	$28,270,800
Special Needs / Tax Exempt Parcels	78	-	-	-
Vacant	339	-	-	-
Total	**1,953**	**$85,848,120**	**$42,924,060**	**$128,772,180**

Table 4–57d: Keystone Dam Release Dam Failure

Type	Number of Parcels	Improvement Value	Contents Value	Total Value
Residential	1,507	$80,838,360	$40,419,180	$121,257,540
Agricultural	260	$967,140	$483,570	$1,450,710
Commercial	90	$2,848,400	$1,424,200	$4,272,600
Industrial	87	$19,331,200	$9,665,600	$28,996,800
Special Needs / Tax Exempt Parcels	105	-	-	-
Vacant	461	-	-	-
Total	**2,510**	**$103,985,100**	**$51,992,550**	**$155,977,650**

Of the five high hazard dams that would impact Tulsa County if they were to fail, only Keystone Lake Dam and Skiatook Lake Dam are large enough to impact a significant number of structures and population downstream. The other three dams and lakes are not only much smaller, but also have very little development downstream. Consequently, Skiatook Lake Dam and Keystone Lake Dam will receive more substantial analysis in the Scenarios below than Sand Springs Lake Dam, Shell Lake Dam or Yahola Dam.

4.14.4 Dam/Levee Failure Scenario

Keystone Dam Failure

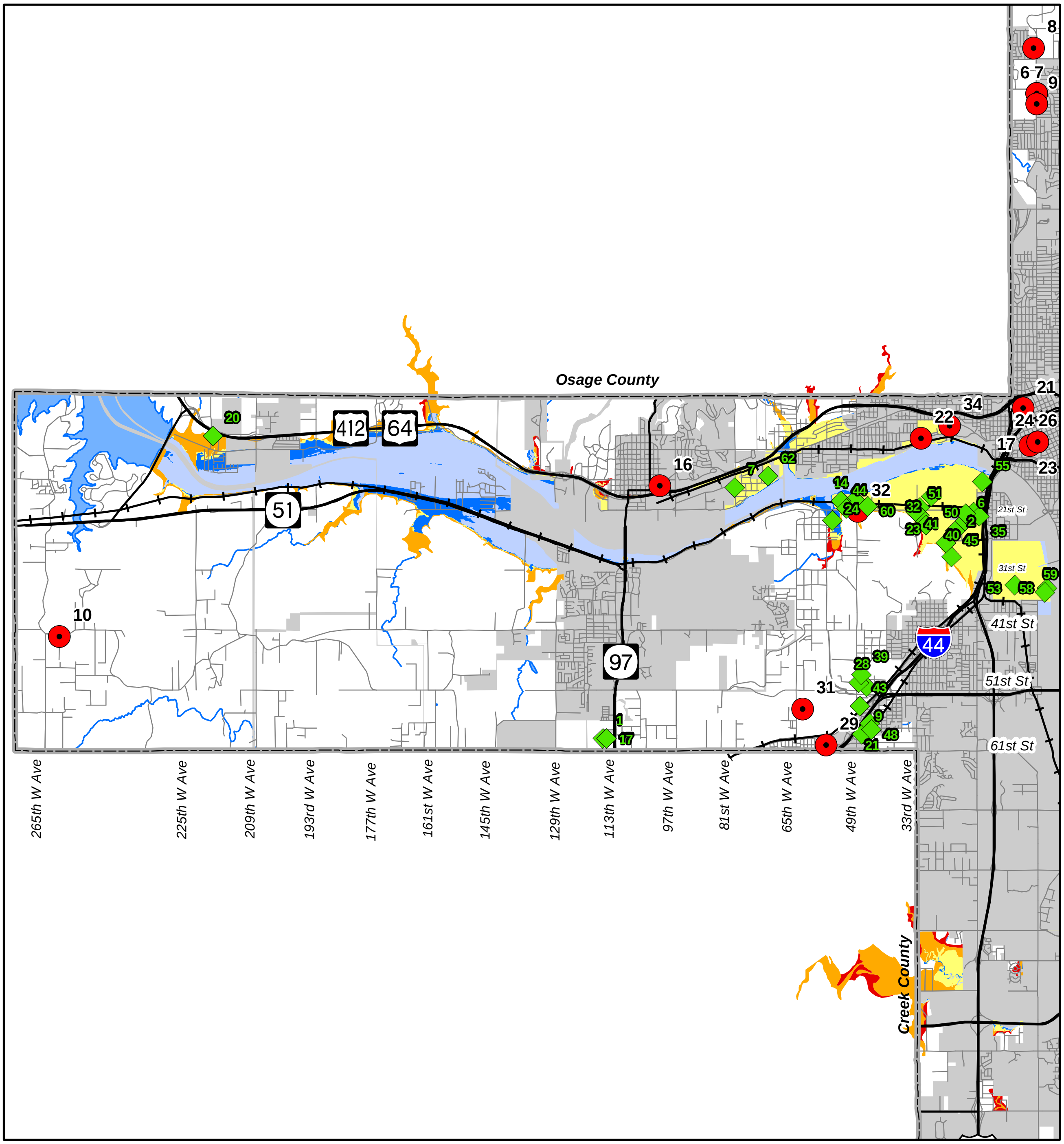
The 1,450-mile-long Arkansas River begins in the Rocky Mountains of Colorado and drains an area of 74,500 square miles above Keystone Dam. Average and peak flows on the river are generally 5,000 cfs during winter months and 15,000 cfs during May and June. The river runs from west to southeast through 25 miles of Tulsa County. The unregulated drainage area between Keystone Dam and the Wagoner County line is approximately 650 square miles. The river has a long history of catastrophic flooding, but the completion of Keystone Dam in 1964 and Kaw Reservoir in 1976 have reduced, but not eliminated, this hazard—as evidenced by the widespread flooding that occurred as a result of the 1986 emergency releases from Keystone Dam that impacted Tulsa County, Sand Springs, Tulsa, Jenks, Bixby and Broken Arrow.

Completed in 1964, Keystone Lake Dam is 131 feet high, 4,600 feet long, and impounds 1,348,000 acre feet of water covering 26,020 acres on the Arkansas and Cimarron Rivers. The purpose of the dam is flood control, power generation and recreation. Its success in flood control has encouraged development in the Arkansas River floodplain downriver from the dam in the communities of Sand Springs, Tulsa, Jenks, Bixby and Broken Arrow. However, the heavy rains of 1986 that forced emergency releases of 310,000 cfs from Keystone Dam, demonstrated the limitations of the facility for guaranteeing the safety of downstream structures and populations that have been built "in harm's way."

In Tulsa County there are 12 critical facilities and 25 Tier II sites within the inundation area associated with a major release from Keystone Dam. Table 4-58 lists the critical facilities at risk from a major release in Tulsa County, and Table 4-59 lists the at-risk Tier II sites in Tulsa County, and Table 4-60 shows the total number of properties in the county that would be affected. Figure 4-36a shows the West Tulsa County inundation areas and impacted critical facilities and Tier II sites for a Keystone Dam failure or emergency release, and Figure 4-36b shows such impacts in South Tulsa County. Such an event could produce widespread power outages, and the release of hazardous chemicals from industries along the river in West Tulsa County and the cities of Tulsa and Sand Springs.

Table 4–58: Critical Facilities Vulnerable a Keystone Dam Maximum Release

ID	Name	Address
1	Bixby Health Center	12 W. Dawes, Bixby
2	Cherokee Elementary School	6001 N. Peoria
3	Collinsville Rural Fire Protection	1018 S. 12th St., Collinsville
5	First Bank of Turley	6555 N Peoria
15	Rejoice Christian School	13413 E. 106th St. North
16	Sand Springs Health Center	306 E. Broadway, Sand Springs
32	Sooner Emergency Services	2131 S. 49th St. West
20	Tulsa City-County Health Dept.	315 S. Utica
21	Tulsa County Correctional Facility	300 N. Denver
22	Tulsa County Deputy Sheriff	3420 W. Charles Page Blvd.
27	Tulsa County Sheriff Office	303 W. 1st St.
30	Turley Fire & Rescue Co.	6404 N. Peoria



LEGEND

- 250,000 CFS
- 350,000 CFS
- 450,000 CFS
- Maximum Discharge
- Dam Break

0 1 2 Miles

- Streets
- Railroads
- County Line
- Incorporated Areas

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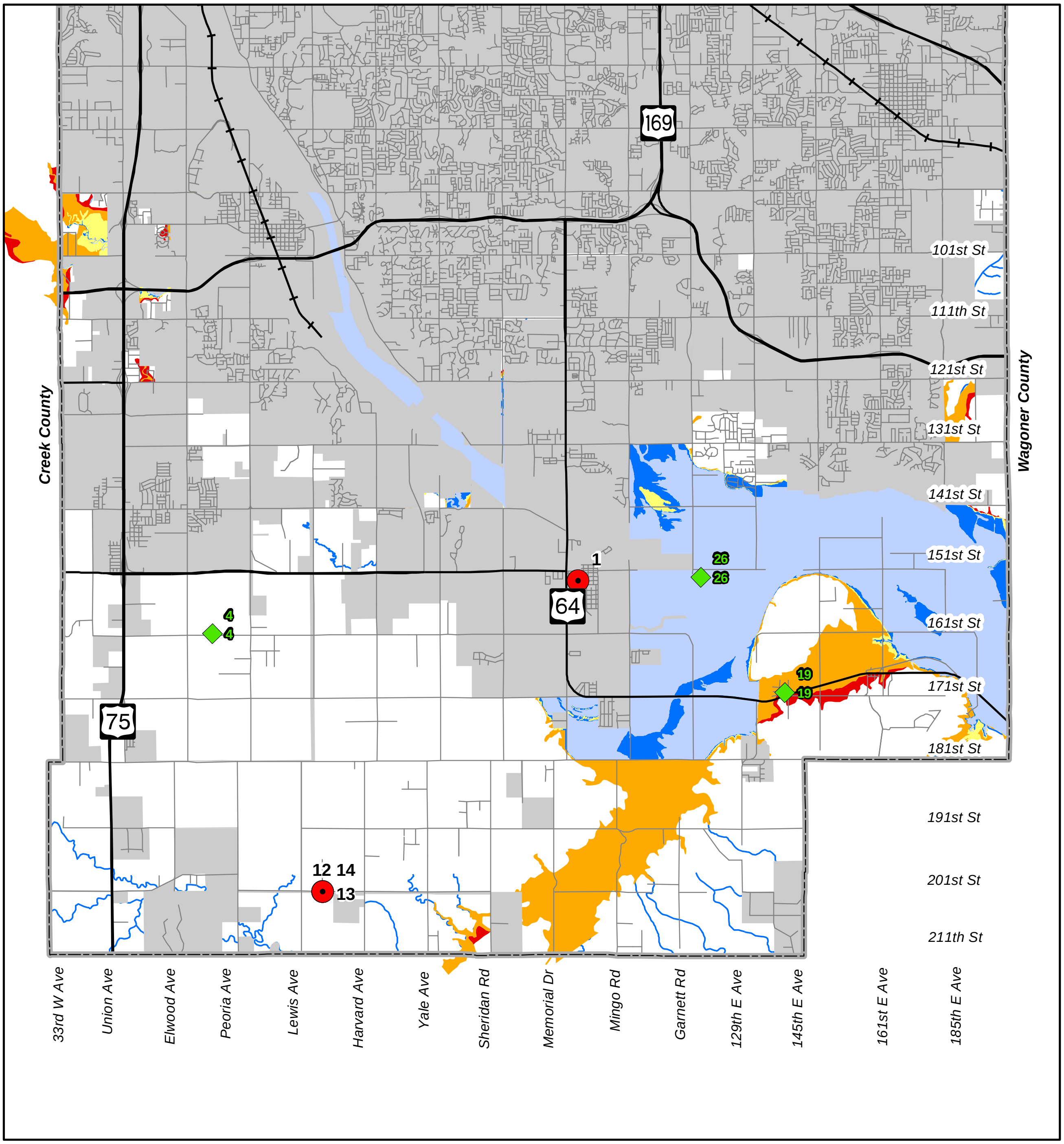
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-36a

Keystone Dam Failure

Tulsa County - West



LEGEND

- 250,000 CFS
- 350,000 CFS
- 450,000 CFS
- Maximum Discharge
- Dam Break

0 1 2 Miles

- Streets
- Railroads
- County Line
- Incorporated Areas

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TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-36b

Keystone Dam Failure

Tulsa County - South

Table 4–59: Tier II Sites Impacted by a Keystone Dam Maximum Release

ID	Name
2	Aaon, Inc.
6	Ameron Pole Products Division
7	Ashland Distribution – Sand Springs
10	Baker Petrolite – Tulsa, OK
13	Builders Steel Co. Inc.
19	Ferrellgas – Bixby
22	Fuel Marketing Corporation Terminal
23	Global Manufacturing Co., Inc.
24	Groendyke Transport, Inc.
	Haikey Creek Wastewater Treatment Plant
	Magellan Pipeline Company – Tulsa Terminal
	Midwestern Manufacturing Company
	North American Galvanizing Company – Tulsa Plant 1
	North American Galvanizing Company – Tulsa Plant 2
	Ozark Fluorine Specialities, Inc.
	Perma-Fix Treatment Services, Inc.
	PSO – Tulsa Sunray Refinery Substation
	PSO – Tulsa Williams Pipeline Substation
	Sinclair Tulsa Refining Company – Tulsa Refinery
	Sunoco Tulsa Refinery
	Tulsa Power Station – High Pressure Yard
	Tulsa Power Station – Low Pressure Yard
	Tulsa Propane Terminal
	Yaffe Metals

Table 4–60: Properties Impacted by Keystone Dam Maximum Release

Type	Number of Parcels	Improvement Value	Contents Value	Total Value
Residential	1,384	$74,703,160	$37,351,580	$112,054,740
Agricultural	253	$953,340	$476,670	$1,430,010
Commercial	80	$2,710,200	$1,355,100	$4,065,300
Industrial	85	$19,278,200	$9,639,100	$28,917,300
Special Needs / Tax Exempt Parcels	89	-	-	-
Vacant	419	-	-	-
Total	**2,310**	**$97,644,900**	**$48,822,450**	**$146,467,350**

Skiatook Lake Dam Failure

Skiatook Lake is located on Hominy Creek, a tributary of Bird Creek, about 6 miles upstream from Sperry and the Tulsa County line. Hominy Creek flows generally southeast through Skiatook Lake, and joins Bird Creek about 2 miles east of Sperry. Hominy Creek has a drainage area of 415 square miles. Average and peak flows on the creek are about 40 cfs in winter and 500 cfs in May and June. Bird Creek originates in Osage County and flows 149 miles generally southeast past Sperry and Owasso to join the Verdigris River near Catoosa, in Rogers County. Stream mile 9 through 43 are in Tulsa County. The Bird Creek drainage basin above Owasso is 1,023 square miles. Bird Creek's major tributaries in Tulsa County are Hominy Creek, Delaware Creek, Flat Rock Creek, Coal Creek and Mingo Creek. The flood of record for Bird Creek was 32.03 feet on March 11, 1974. The creek's flood stage is 17 feet in Tulsa County.

Skiatook Lake is 10,540 acres in size, and has a storage capacity of 500,700 acre-feet. The 3,590-ft long, 143-ft-high dam was completed in 1984. The purpose of the dam is water supply, flood control, and recreation. A Skiatook Dam failure or breach would send a wall of water into the Hominy Creek and Bird Creek floodplains, which in many reaches are 2 miles wide. The resulting property damage in North Tulsa County would be $47,442,910 to residential parcels, $47,527,400 to commercial, $13,332,500 to industrial, $161,600 to agricultural, totaling an estimated $163 million damage.

Table 4–61: Skiatook Dam Failure Property Exposure

Type	Number of Parcels	Improvement Value	Contents Value	Total Value
Residential	1,294	$47,442,910	$23,721,455	$71,164,365
Agricultural	314	$161,600	$80,800	$242,400
Commercial	92	$47,527,400	$23,763,700	$71,291,100
Industrial	21	$13,332,500	$6,666,250	$19,998,750
Special Needs / Tax Exempt Parcels	109	-	-	-
Vacant	321	-	-	-
Total	**2,151**	**$108,464,410**	**$54,232,205**	**$162,696,615**

In North Tulsa County there are 6 critical facilities, and 4 Tier II sites within the inundation area associated with a major release from, or failure of, Skiatook Lake Dam. Table 4-62 lists the critical facilities and Table 4-63 the Tier II sites at risk from a major release. Figure 4-37 shows the North Tulsa County inundation areas and impacted critical facilities and Tier II sites for a Skiatook Lake Dam failure or emergency release.

Table 4–62: Critical Facilities Impacted by a Skiatook Dam Failure

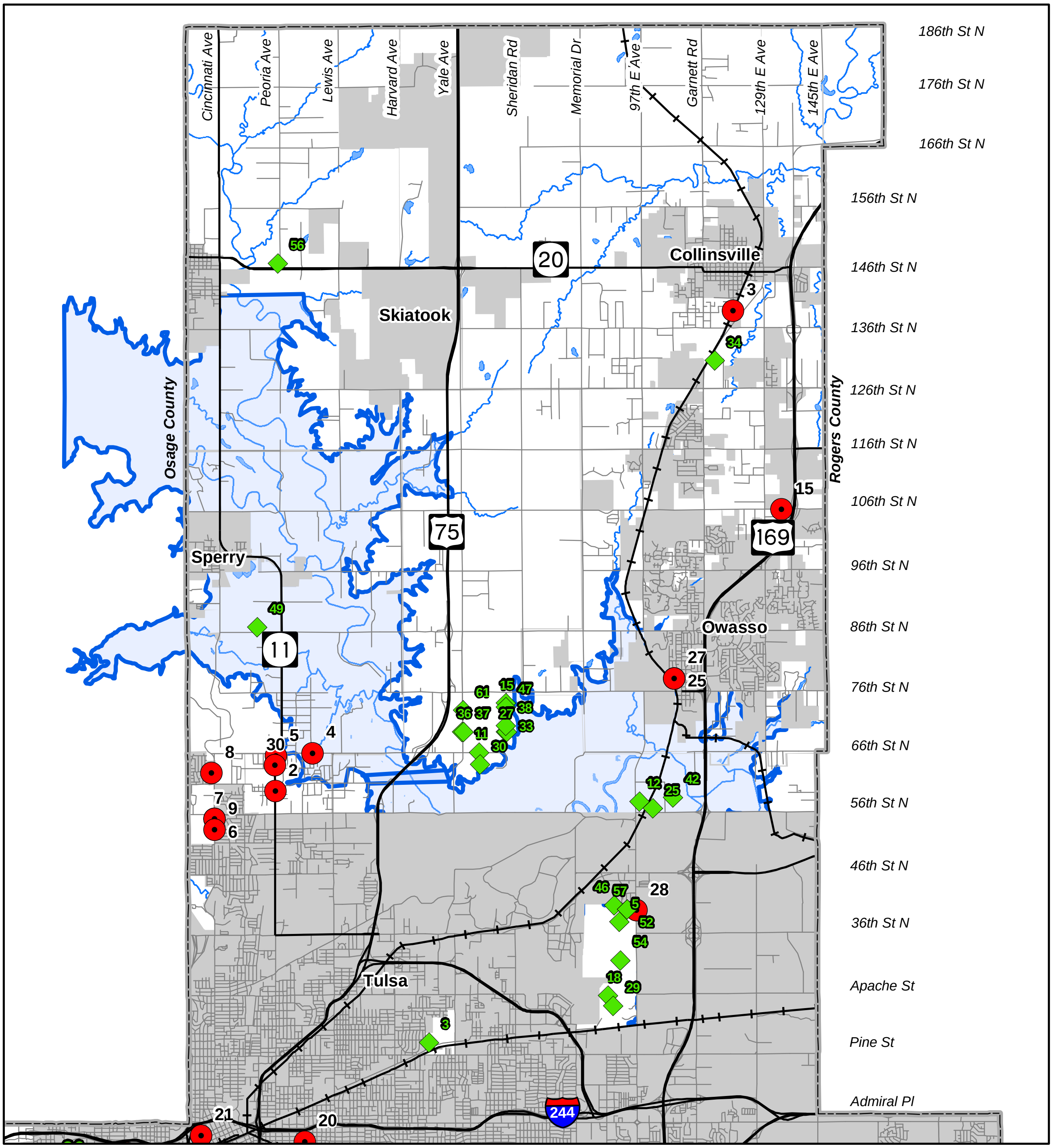
ID	Name	Address
10	Cherokee Elementary School	6001 N. Peoria
1	Collinsville Health Center	1201 W. Center, Collinsville
2	Collinsville Rural Fire Protection	1018 S. 12th St., Collinsville
5	First Bank of Turley	6555 N Peoria
7	Rejoice Christian School	13413 E. 106th St. North
4	Turley Fire & Rescue Co.	6404 N. Peoria

Table 4–63: Tier II Sites Impacted by a Skiatook Dam Failure

ID	Name	Address
12	Bluelinx – Tulsa Distribution Center	5717 N Mingo Rd
25	H&L Tooth Company	10055 E 56th St N
42	Northside Wastewater Treatment Plant	105th E. Ave. & 56th St. N.
49	PSO – Tulsa North 138kV Substation	727 E. 86th St. N.

Yahola Lake Dam Failure

Yahola Lake Dam is located in the Bird Creek drainage, at the northern rim of the City of Tulsa, and the west side of Mohawk Park Golf Course. The lake is an artificial, pumped storage reservoir that serves as water supply for the City's AB Jewell Water Plant,



Legend

- Tier 2 Sites
- Crit. Facs.
- Dam Break Area
- Dam Break Outline
- Streets
- Railroads
- County Line
- Incorporated Areas

0 1 2 Miles

TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-37

Skiatook Inundation Area

Tulsa County - North

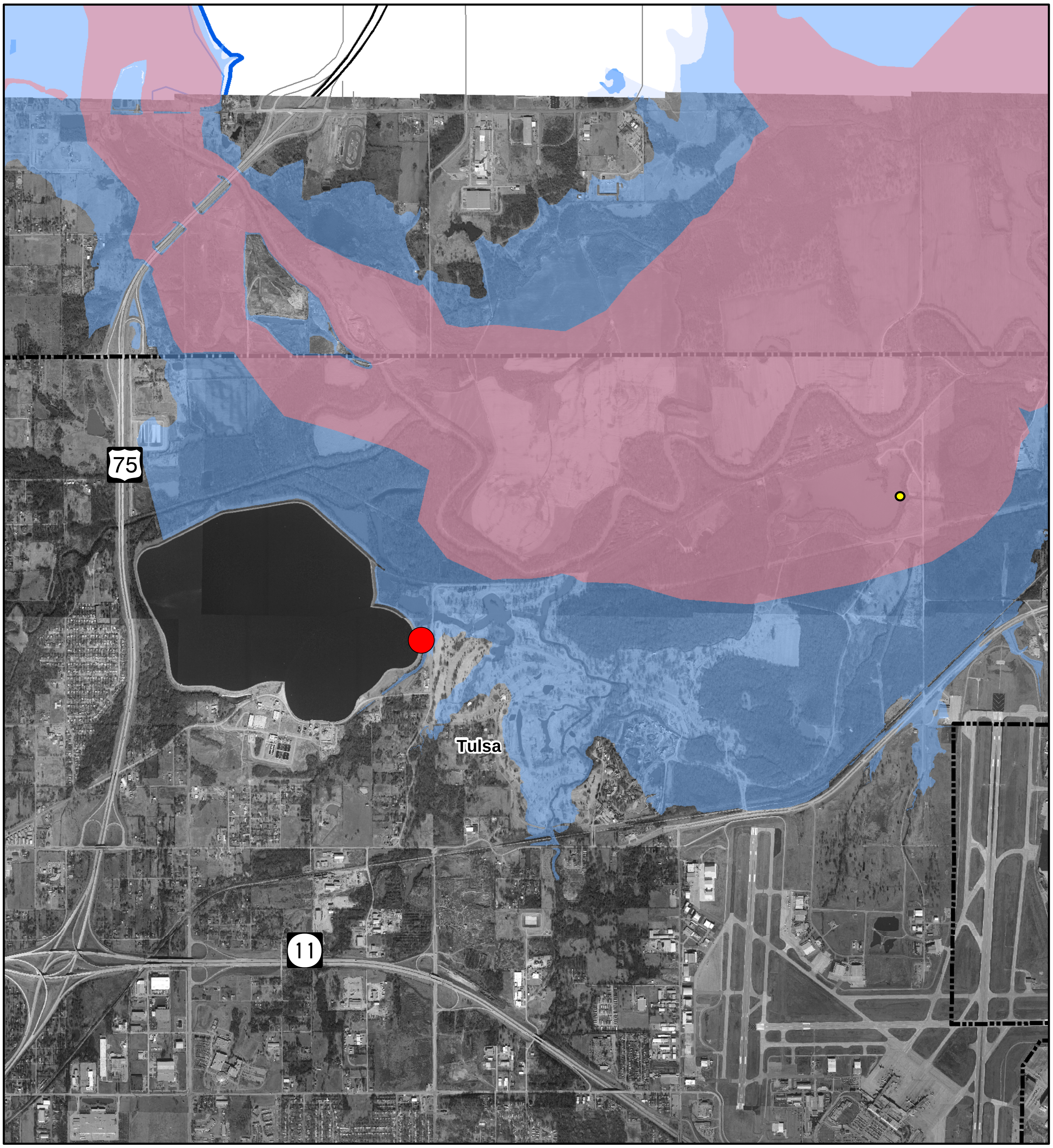
located on the lake's southern edge. The 431-acre lake has a 35-ft.-high, 17,500 ft.-long dam that impounds 7,514 acre feet of water. The outlet of the lake flows into Mohawk Park Golf Course for about 1 mile before joining Bird Creek. The inundation areas for a break or failure of Yahola Lake Dam have been mapped using visual and GIS analytical techniques and vulnerable structures identified. This analysis is shown in Figures 4-38a and 4-38b. There are no Tulsa County structures beneath the dam that would likely be impacted by a failure. The methodology used in this visual GIS analysis is, by its nature, somewhat cursory and provisional. A more exact analysis of probable inundation depths and vulnerable structures and populations should be made by either hydrological studies or field surveys.

Shell Creek Lake Dam Failure

Shell Creek Lake Dam is located on Shell Creek, about 2 miles west of Sand Springs' Pogue Municipal Airport, and about 3 miles above the creek's juncture with the Arkansas River. The lake is 573 acres in size, has a 65-ft. high dam, and impounds 12,700 acre-feet of water. The inundation areas for a break at Shell Lake Dam have been mapped using visual and GIS analytical techniques and vulnerable structures identified. This analysis is shown in Figures 4-39a and 4-39b. There are no Tulsa County structures below the dam that would likely be impacted by a failure. The methodology used in this visual GIS analysis is, by its nature, somewhat cursory and provisional. A more exact analysis of probable inundation depths and vulnerable structures and populations should be made by either hydrological studies or field surveys.

Sand Springs Lake Dam Failure

Sand Springs Lake Creek is a 3-mile-long tributary to West Bigheart Creek about 1.5 miles east of OK Hwy 97, on the north side of US Hwy 64/214. The lake is 14 acres in size, has a 36-ft. high dam, and impounds 240 acre-feet of water. The inundation areas for a break at Sand Springs Lake Dam have been mapped using visual and GIS analytical techniques and vulnerable structures identified. This analysis is shown in Figures 4-40a and 4-40b. There are no structures downstream from the dam that would likely be impacted by a failure. As with Shell Creek Dam break analysis, the methodology used in the analysis is somewhat cursory and provisional. A more exact analysis of probable inundation depths and vulnerable structures and populations should be made by either hydrological studies or field surveys.



LEGEND

- Floodways
- 100 yr. Floodplains
- City Limits
- Streets
- Railroads
- County Line
- Incorporated Areas

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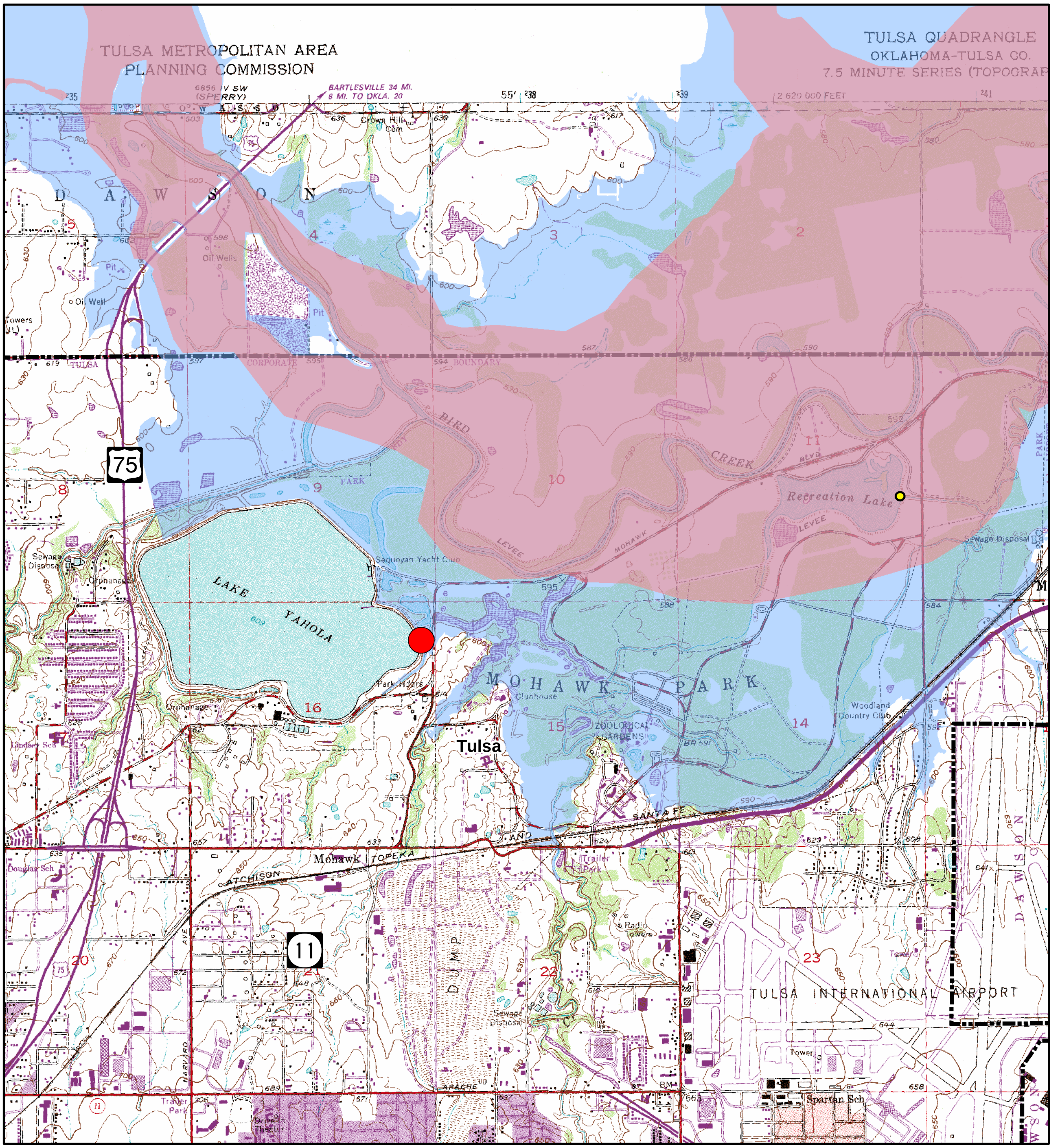
0 1,600 3,200 Feet

TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-38a
Yahola Dam
(Aerial)

Tulsa County - North



LEGEND

- Floodways
- 100 yr. Floodplains
- City Limits
- Streets
- Railroads
- County Line
- Incorporated Areas

0 1,600 3,200 Feet

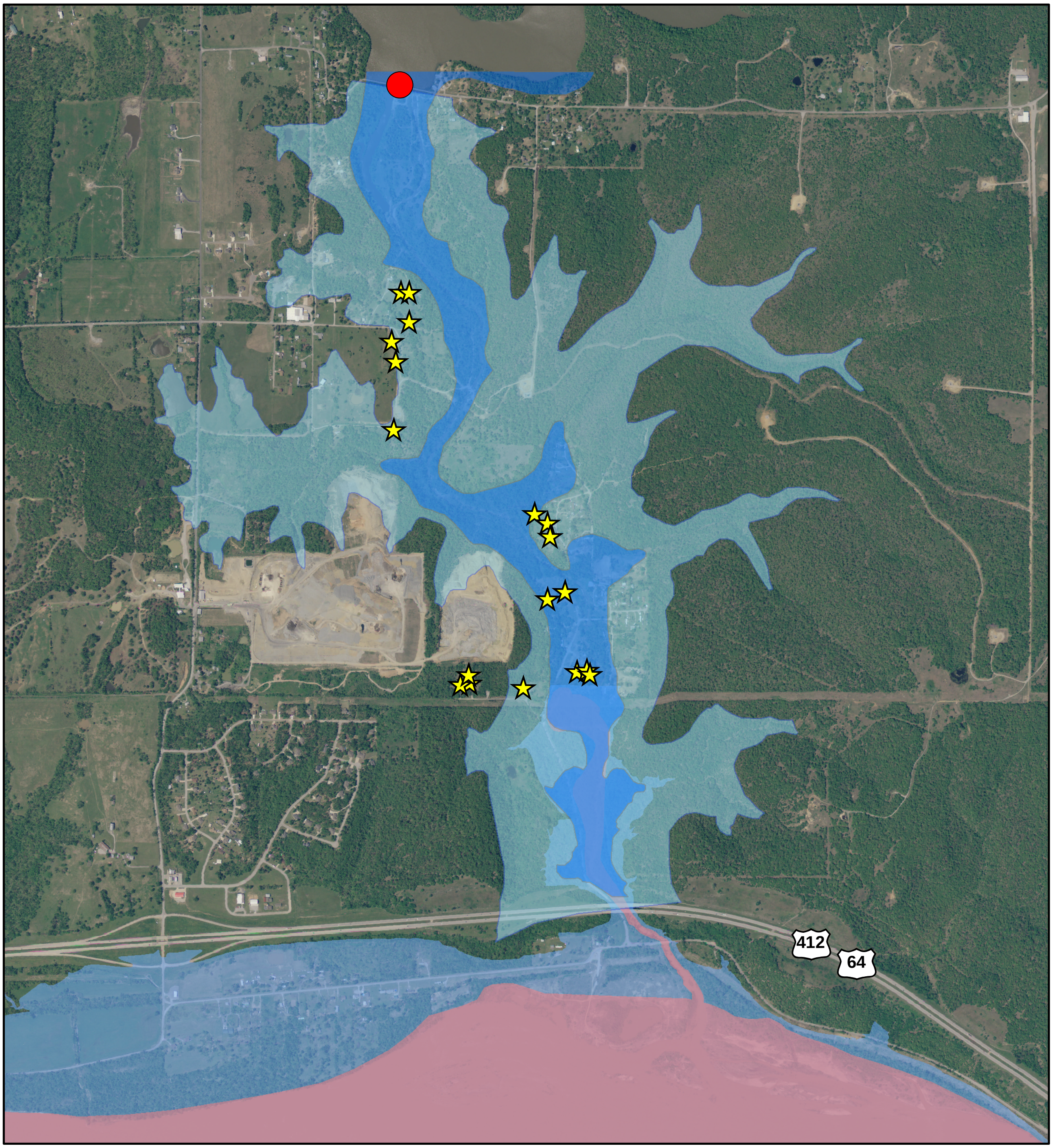
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-38b

Yahola Dam (DRG)

Tulsa County - North



LEGEND

- ★ Potential Vulnerable Structures
- Floodways
- 100 yr. Floodplains
- City Limits
- Streets
- Railroads
- County Line
- Incorporated Areas

0 850 1,700 Feet

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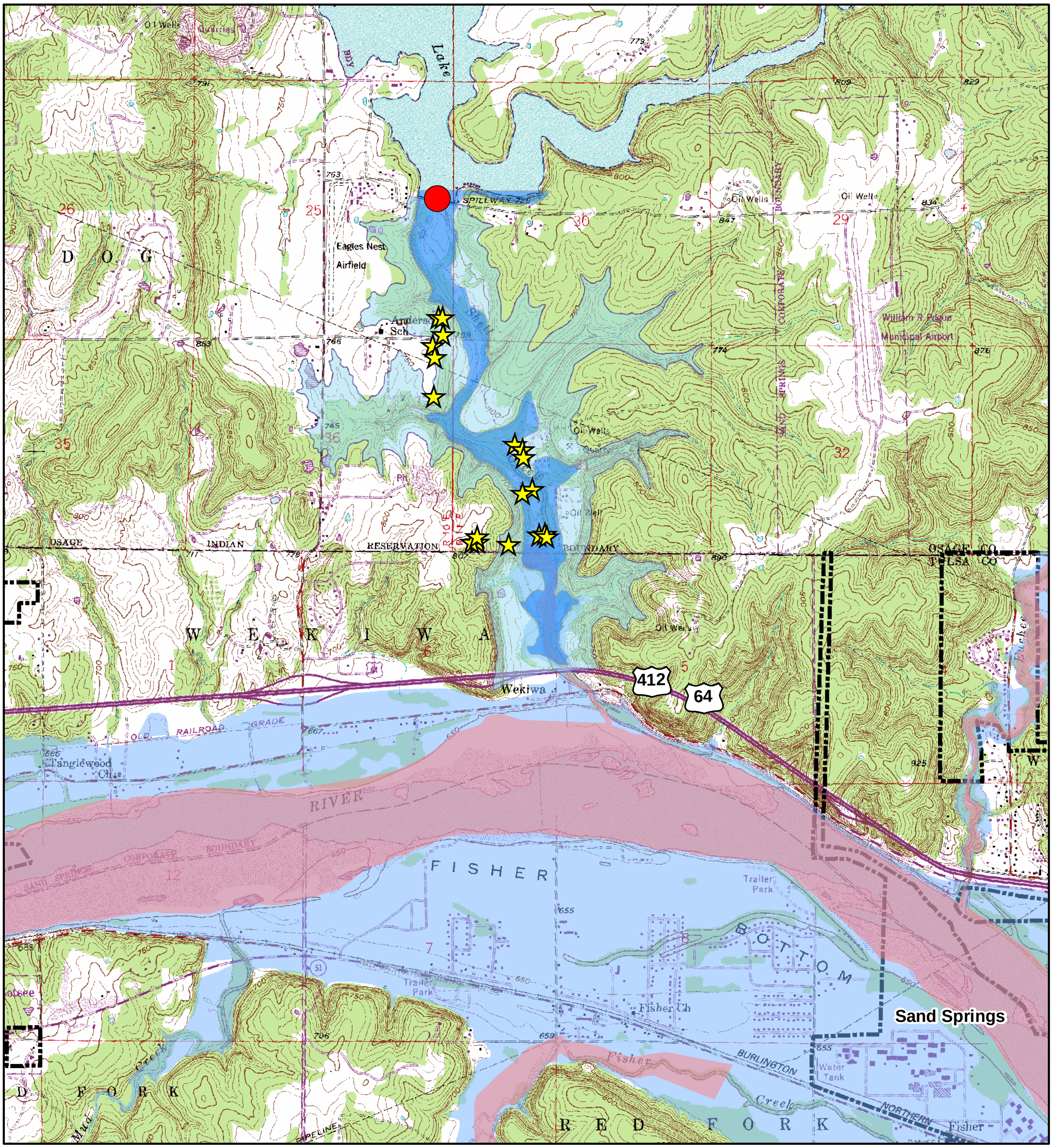
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-39a

Shell Lake Dam (Aerial)



LEGEND

- Potential Vulnerable Structures
- Floodways
- 100 yr. Floodplains
- City Limits
- Streets
- Railroads
- County Line
- Incorporated Areas

0 1,450 2,900 Feet

TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-39b

Shell Lake Dam (DRG)

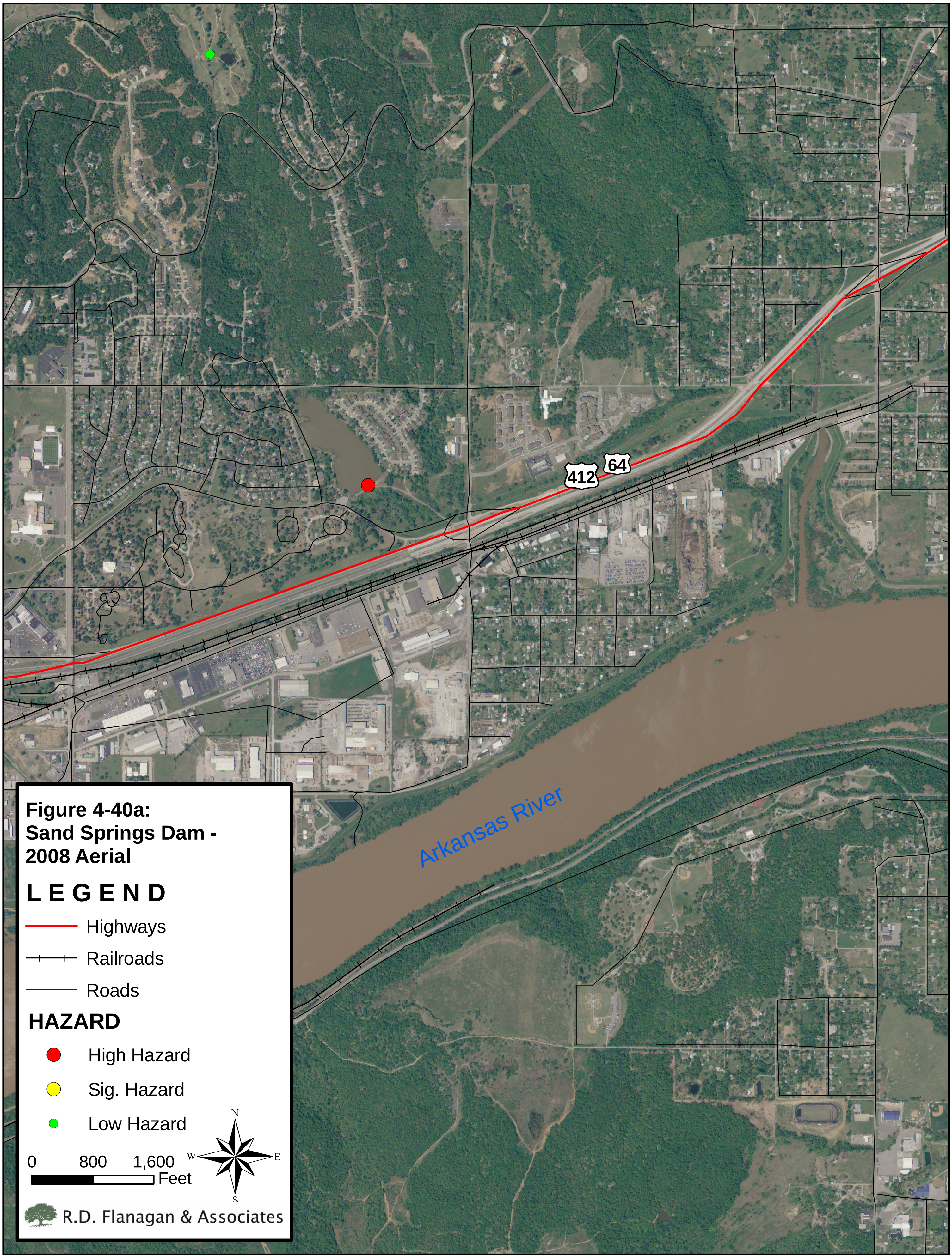


Figure 4-40a:
Sand Springs Dam -
2008 Aerial

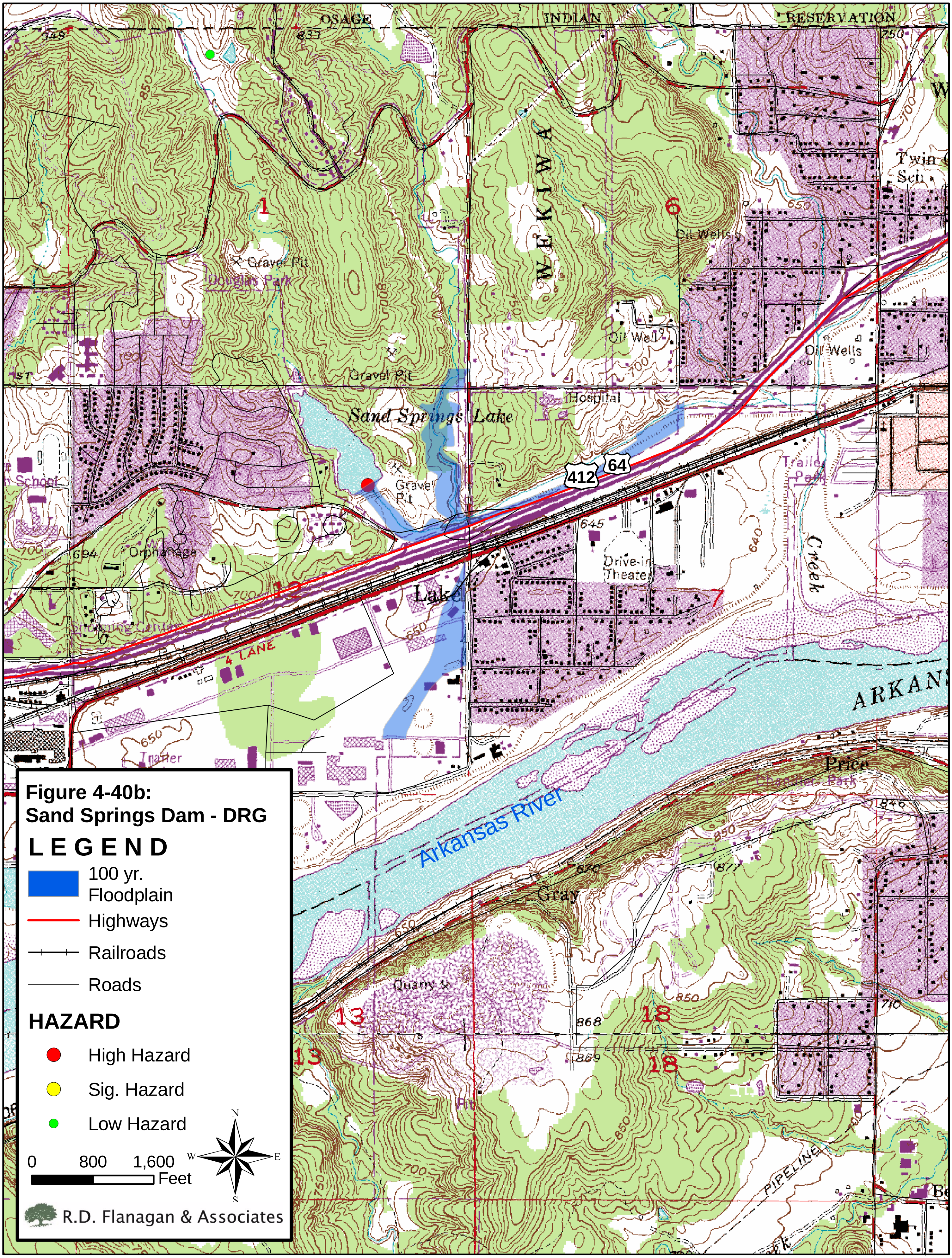


Figure 4-40b:
Sand Springs Dam - DRG
LEGEND
100 yr. Floodplain
Highways
Railroads
Roads
HAZARD
High Hazard
Sig. Hazard
Low Hazard
0
800
1,600
Feet
N
S
E
W
R.D. Flanagan & Associates
OSAGE
INDIAN
RESERVATION
Sand Springs Lake
Gravel Pit
Hospital
Oil Wells
Oil Well
Orphanage
Drive-in Theater
Trailer Park
Creek
Arkansas River
ARKANS
4 LANE
412
64
Quarry
Gray
Price
PIPELINE
WEKIWA

4.14.5 Future Trends

Many in Tulsa County have said the riverbanks and even the river itself should be developed to provide an economic base in Central Tulsa and spur development to the west and southeast. Others have said they want to retain the existing and evolving River Parks to provide a beautiful band of green that is used by thousands of Tulsans and generally prized as one of the city’s best features. Others see the river as a treasure-trove of natural resources that should be preserved at all costs.

Given the inherent dangers along a river that drains nearly 75,000 square miles of land area, the future hazards along the Arkansas River will be determined by the balance of development and management that the communities along the river choose. Various planning exercises offer possibilities for redefining local commitment to economic development, resource preservation, and hazard management.

This analysis of future trends rests on several development plans:

- The Arkansas River Corridor Plan developed by the Indian Nations Council of Governments;
- The Comprehensive Plan (currently being updated by the City of Tulsa);
- Adopted Master Drainage Plans (currently proposed for major updates);
- Tulsa County Vision 2025 plans and proposals (which include river-development projects such as low-water dams);
- Infrastructure plans and projects, including the Gilcrease Expressway and a proposal for light rail in central Tulsa.

The riverfront future may hinge on how Tulsa City and County define the term “development” along the river. The future may be very different if “development” is defined as building parks and recreation areas, rather than homes and businesses along the river’s banks and in its floodplains.

No additional control structures are currently planned that would improve the river’s flood potential and recent Corps’ analyses have concluded that no significant control structures (such as raising the height of the levees) would be feasible for the river. Therefore, the future depends in large measure on how the communities decide to manage and use the floodplains throughout Tulsa County’s segment of the Arkansas Valley.

Figure 1-8 shows future growth areas in Tulsa County.

Population

Virtually all of the current proposals would be expected to increase the number of people at risk in the Arkansas River lowlands. For this plan, it is assumed that management decisions will be based on FEMA’s 100-year floodplain standard. Therefore, the numbers of people in all categories – living, working, going to school, traveling through, with special needs, etc. – will increase, exposing more people to risk from larger events (such as the 1986 flood).

Buildings

Similarly, all of the current proposals would be expected to increase the number of buildings at risk in the Arkansas River lowlands. For this plan, it is assumed that building decisions will be based on the FEMA 100-year floodplain standard. Therefore, the numbers of buildings will increase, exposing more buildings to risk from larger events such as the 1986 flood. If the 100-year floodplain standard were to be revised, the number of new structures at risk could be substantially reduced.

Critical Facilities

Current riverfront development proposals do not focus on critical facilities, so it is anticipated that the number of critical facilities would not increase in the river lowlands in the future. The future may hinge on whether leaders consider hazard management in siting decisions for schools, detention facilities, social service agencies, health clinics, and other critical facilities. Again, it is anticipated that these decisions will be based on only the FEMA 100-year floodplain standard.

Infrastructure

Generally, all the current plans would increase the investment in infrastructure in the river lowlands. For example, proposals all include new roads, new low-water dams and bridges, utilities, parks and walking trails. If higher standards than the FEMA 100-year floodplain are used, and if infrastructure impacts on the floodplain are carefully considered, infrastructure decisions might decrease future risks to valley properties and populations.

4.14.6 Conclusion

People, property, and infrastructure downstream of dams could be subject to devastating damage in the event of a failure of either Keystone or Skiatook dams. The areas impacted are delineated using dam breach analyses that consider both “sunny day” failures and failures under flood conditions. The downstream extent of impact areas and the height to which waters will rise are largely functions of valley topography and the volume of water released during failure.

The most important factor for public safety is the timeliness and effectiveness of warning given to vulnerable downstream populations. Dams are often not visible from the neighborhoods of most Americans and therefore dam safety is not in the public consciousness.

The building of the two upriver flood control dams, Keystone Dam and Kaw Reservoir, have significantly reduced the vulnerability of Tulsa County to Arkansas River flooding. Likewise, Skiatook Dam has reduced flooding along Bird Creek.

Sand Springs during the October 1986 flood, when Keystone Dam was forced to release 300,000 cfs

However, as demonstrated in the forced-release flooding of 1986, these dams have not eliminated floods on the Arkansas River or Bird Creek, and in fact may have made a truly catastrophic flood more likely, by both encouraging development in floodplains and then storing up water that later has to be released when the dams are in danger of being overtopped by runoff from torrential rains, usually when other rivers and streams in the county are already in flood.

A related threat to Tulsa County is posed by the Arkansas River levees, built in 1945 and protecting residences, commercial properties and industrial parcels ($147,453,020 in property in the City of Tulsa, alone). Failure of the levees along the Arkansas River would have a devastating impact upon the City of Tulsa and Tulsa County.

Tulsa County has a high vulnerability to low probability dam breaks, and a high vulnerability to medium probability emergency water releases from Keystone and Skiatook Lakes. The existing levees cannot be expected to protect City or County properties or populations during a flood of record combined with emergency releases from Keystone Dam. Such an event could produce widespread power outages, and the release of hazardous chemicals from industries along the river in West Tulsa County and the cities of Tulsa and Sand Springs.

Data Limitations

Census figures are insufficient to identify the number of people with disabilities, or with limited knowledge of English, who would be extremely vulnerable in an event with a short warning time.

The City of Tulsa is in the process of developing a new Comprehensive Plan. The current plan is approximately 30 years old, so new development data for the city as it impacts Tulsa County is necessarily incomplete or highly speculative.

4.14.7 Sources

Kuhnert, Nathan (Hydrologist Oklahoma Water Resources Board). Telephone interview by Michael Flanagan, January 10, 22, 2002, March 18, 19, 2002.

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National Inventory of Dams, at Web address: http://crunch.tec.army.mil/nid/webpages/nid.cfm.

4.15 Transportation Hazards

Transportation is defined as the physical movement of an object through components of a system and its subsystems. Transportation includes the use of aviation, highway, railroad, pipeline, and marine systems to convey movement of objects and people. In 1967, the Department of Transportation (DOT) was created in order to administer and protect the nation's transportation systems. The National Transportation Safety Board (NTSB) was established within the DOT as an independent agency responsible for investigating transportation incidents and promoting transportation safety.

4.15.1 Hazard Profile

Location

Oklahoma alone consists of over 111,000 miles of highways including Interstates 35, 40 and 44, over 180 navigable river miles allowing barge traffic to navigate from the Mississippi River up the Arkansas and Verdigris Rivers, approximately 6,000 miles of rail track and an un-disclaimed quantity of pipelines. Each mode of transportation is used in the transport of hazardous materials. When in transport, hazardous materials are characterized by nine separate classes of hazards. They are as follows: 1) explosives, 2) gases, 3) flammable liquids, 4) flammable solids, 5) oxidizers and organic peroxides, 6) toxics, 7) radioactive materials, 8) corrosive materials, and 9) miscellaneous dangerous goods. By far the greatest percentage of any hazard shipment (72%) falls under the flammable liquids category. Gases and corrosive materials are next with 8.8% and 8.7% respectively. Radioactive materials are shipped the least and account for only 0.6% of all hazardous material shipments. More specifically, 40.9% of hazardous material shipments are comprised of gasoline (UN# 1203).

In 1997, a joint commodity flow survey was undertaken with collective participation from the Bureau of the Census, U.S. Department of Commerce, the Bureau of Transportation Statistics and the U.S. Department of Transportation. In the results of the five major modes of hazardous material transport, truck carriers represented 63.9% of all hazardous material transports, pipelines accounted for 18.4%, rails accounted for 7.1%, water accounted for 5.8%, and air accounted for 1.8%.

Roads: The national highway system is made up of 46,677 miles of Interstate Highways, 114,511 miles of other National Highways and is used by 505,900 active interstate motor carriers. There were over 3.95 million miles of public roads in the United States in 2000, of which 3.09 million miles were in rural communities (rural communities are defined as those places with fewer than 5,000 residents and urban communities are defined as those areas with 5,000 or more people). Local governments controlled over 77 percent of total highway miles in 2000; States controlled about 20 percent; and the Federal Government owned about 3 percent. Hence, the Nation's highway system is overwhelmingly rural and local. Truck shipments represent the greatest mode of transport for hazardous materials accounting for 63.9% of all shipments and totaling nearly 870,000 tons of hazardous materials in 1997.

Oklahoma has 930 miles of interstate highways, or 2% of the nation's total interstates. The state also contains 22,708 bridges as of August of 2001. The principal north-south arterials traveled in Oklahoma are Interstate 35 crossing the middle of the state from border to border connecting Oklahoma City to major thoroughfares in Kansas and Texas and Interstate 75 crossing the eastern third of the state through Tulsa. Interstate 44 crosses the state from the southwest to the northeast and connects the two main metropolitan areas of Tulsa and Oklahoma City to locations in Missouri and Texas. Interstate 40, running east and west, is the modern day thoroughfare replacing the nation's first trans-continental highway, Route 66. It crosses through Oklahoma City and is a major national transportation route of interstate travel.

In Tulsa County, major highways include:

- Interstate 44—running SW-NE through the center of the County. I-44 is a heavily traveled highway, including tourist, business, and commercial truck traffic. I-44 carries a high volume of hazardous material traffic, including chemical and petroleum products, and in some cases, radiological materials.
- US 75—running out of Kansas and passing through Bartlesville and Tulsa, then heading south to I-40. Due to the Wal-Mart Distribution Center in Bartlesville (approximately 40 miles to the north of Tulsa), and the highway's intersection with both I-44 and I-40, it is a particularly heavily traveled 4-lane highway.
- US 412—running E-W and connecting Arkansas with New Mexico. US 412 is four lanes through Tulsa County, and since it is one of the primary roads into northwestern Oklahoma, carries a substantial amount of traffic, both passenger and commercial.
- US 51—traveling the same stretch as US 412 to the west, and running southeast towards Muskogee. It becomes the Muskogee Turnpike immediately outside of Tulsa, and therefore carries a great deal of commuter and commercial traffic.
- Creek County Turnpike—connecting the Muskogee Turnpike (US 51) to the east of Tulsa County with the Turner Turnpike (I-44) to the west. It is heavily traveled by commercial traffic and commuter traffic who wish to loop around the more heavily trafficked portions of those highways that travel through the major urban areas.

Air: There are 8,228 certified air carrier aircrafts in the United States operated by 75 carriers of international, national and regional level. Airports are defined into hub classes based on the number of enplaned passengers using airline services. Hubs are classified by large, medium, small, and non-hub where large hubs see over 6.3 million passengers and non-hubs receive less than 319,451 passengers over a 12-month period. There are 72 airports in the nation considered as large hubs. These 72 airports see almost 75% of all the airline passenger traffic in the nation.

Oklahoma airports, in the year 2000, performed 61,512 departures enplaning over 3.4 million passengers. The two largest airports, Will Rogers World Airport in Oklahoma City and Tulsa International saw 1.73 and 1.66 million passengers respectively classifying them both as Medium Air Traffic Hubs for the year 2000. Oklahoma also has several Air Force bases including Tinker AFB in Oklahoma City, Altus AFB in Altus, and Vance AFB in Enid.

Union Pacific coal train on its way through Oklahoma to power plants on the Gulf Coast

Rail: North American railroads operate over 173,000 miles of track, and earn $42 billion in annual revenues. U.S. freight railroads alone are the world's busiest, moving 70% of all automobiles produced in the U.S. by train, 30% of the nation's grain harvest, 65% of the nations coal and operating on over 143,000 miles of track. In the U.S., railroads account for more than 40% of all freight transportation. Railroad companies are categorized into four classes. Class I railroads are the U.S. line haul freight railroads with operating revenues in excess of $266.7 million. The seven Class I railroads in 2002 are as follows: The Burlington Northern and Santa Fe Railway, CSX Transportation, Grand Trunk Corporation, Kansas City Southern Railway, Norfolk Southern Combined Railroad Subsidiaries, Soo Line Railroad, and Union Pacific Railroad. Combined, these companies have 477,751 freight cars in service and operate on 123,070 miles of tracks when trackage rights are included. Non-Class I railroads include the three sub-classes: Regional, Local Linehaul and Switching & Terminal. In 2001, there were 563 Non-Class I railroad companies operating on 45,000 miles of track.

In Oklahoma, Class I rail carriers include Burlington Northern Santa Fe (BNSF), Union Pacific, and Kansas City Southern for freight. Amtrak connects Oklahoma City to an Amtrak hub in Fort Worth, Texas for passenger travel. Regional rails include the South Kansas & Oklahoma Railroad. Local rails include the Arkansas & Oklahoma Railroad, Inc., AT&L Railroad, De Queen & Eastern Railroad, Grainbelt Corp., Hollis & Eastern Railroad, Kiamichi Railroad Co., Sand Springs Railway Company, Stillwater Central Railroad, Inc., and Tulsa-Sapulpa Union Railway Co.

In Tulsa County, the BNSF carries most goods, including coal, agricultural and forest products, chemicals, metals, and consumer goods. UP cargoes through Oklahoma include grain bound for export, coal, cement and aggregates.

Water: Inland waterways carry an estimated 15% of the nation's bulk freight by volume. A fully loaded barge with 1,500 tons is the equivalent to the load of 58 trucks on the highway. Of the bulk freight, 59.1% of bulk weight waterborne transports are comprised of crude petroleum followed by an 11.6% bulk weight of food and farm products. Of the 50 states, Oklahoma is ranked 39th according to total tons of domestic and foreign loads of waterborne traffic. Louisiana, Texas and California respectively were the top three states for domestic and foreign shipments in U.S. waterborne traffic for the year 2001. Oklahoma waterborne commerce in 2001 was responsible for 4.1 tons of domestic products and received no measurable amount of foreign products.

The navigation channel along the Arkansas River known as the McClellan-Kerr Navigation System is made up of 15 lock chambers between the Mississippi River to the final lock at Webbers Falls, Oklahoma. The Oklahoma portion of the channel spans 173 miles and terminates at the Port of Catoosa east of Tulsa. Tonnage shipped on the system was 12,896,887 in 2004. Primary cargoes are chemical fertilizer, farm products, sand/gravel and rock, coke, iron and steel, fly ash, petroleum products, pipe, zinc, liquid asphalt, floor tile, wheat and soybeans.

Pipelines: The pipeline network supporting energy transportation in the United States includes approximately 1.9 million miles of natural gas and hazardous liquid pipelines and has more than 3,000 companies operating in all 50 states. Pipelines represent 18.4% of all hazardous material transportation in the U.S. Natural gas distribution, with over 1.8 million miles of pipelines, represents the greatest commodity transported through pipelines. Over 305,000 miles of pipelines are used in the transport of natural gas transmission and almost 160,000 miles of pipelines are used in the transport of hazardous liquids including petroleum products. Most pipelines are installed in underground right-of-ways (ROW), which are maintained for access and marked with above ground markers and warning signs.

Figure 4–41: Pipeline Markers

There were nearly 2,300 major natural gas pipeline accidents in the United States between 1990 and 2005, resulting in over 200 deaths. Most of these accidents were at the local distribution company level (affecting smaller pipelines carrying gas within a metropolitan area), due to "outside forces" such as damage by the pipeline owner, third-party damage (as by contractor dig-ins), and natural disasters such as landslides and fires. (Clarke, Beers et. al., *Forgotten Homeland*, p. 106). Another principal cause of pipeline failure, especially in Oklahoma's aging infrastructure, is pipe corrosion, which leads to a rupture and fuel spill, in the case of oil, or explosion, in the case of gas. Of the 19 oil pipeline spills in Oklahoma reported to the National Response Center between 2001-2006, at least 9 (and possibly as many as 11) were due to pipeline corrosion, 2 to third-party damage, and one to earthquake. (http://www.nrc.uscg.mil/nrchp.html) During the same timeframe, Oklahoma reported 4 spills from oil storage tanks (primarily from lightning strikes and aging or faulty facilities), two from railroad tank cars, and 1 from truck transport.

According to the National Pipeline Mapping System, there are four pipeline operators within Tulsa County. They include Enogex Inc (out of Oklahoma City). Specific routes of pipelines and their operators within Tulsa County are not identified.

Human casualties and releases of hazardous materials are the typical results from a transportation incident. Because of the difficulties that hazardous chemicals and their reactions present, responses to accidents of this nature become very sensitive.

Additionally, mass casualty incidents are often too large in scale for emergency responders and supporting organizations such as local blood banks and hospitals to handle. In general, mutual aid agreements, like those used by local fire departments, can compensate for the over extended response capabilities in events such as this. Transportation accidents also tend to interact with other forms of transportation. Often railroad bridges and highway overpasses are near each other, if not structurally connected, and navigable rivers often meander under the two. Municipal airports' flight paths can overlap due to the direction of associated runways if they are not planned accordingly.

The interaction of transportation hazards does not end there. Natural disasters, particularly earthquakes, can cause hazardous material releases at fixed sites and complicate spill response activities. Tornadoes, floods, and winter storms have also been known to damage intact transportation systems, whether they are pipelines, railroads, water, airlines or highways. Meteorological impacts compromising vehicle safety on roads include slick bridges and overpasses from ice and rains and heavy fog cover affecting visibility. Earthquakes, floods, severe thunderstorms, expansive soils, wildfires, and hazardous material incidents can also impact the integrity of the highway system. Factors listed, combined with heavy traffic and high speeds facilitate accidents and even multi-vehicle pileups that result in injuries and fatalities.

Roads: The primary highway incidents of concern involve hazardous materials. While large transporters are the obvious hazard, there are many commercial and private vehicles on the road carrying hazardous substances, both chemical and radiological, in quantities that could be considered an immediate danger to life and health if released.

Air: Accidents involving aircraft can range from human error to meteorological explanations. Fog, ice, thunderstorms and windshear are conditions that can lead to difficulties in properly controlling aircraft. Weather delays are common in air transportation and are respected to help prevent accidents. Airport runway pavement is also a concern. When deteriorated, runway pavement can cause damage to aircraft turbines, propellers, landing gear and may result in runway closure.

Rail: Millions of passengers are transported annually on the nation's heavy and light rail public systems and over 1.52 million carloads of hazardous material move by rail each year. Collisions and derailments are the most common accidents for rail travel.

Water: In order for ports to function effectively, intermodal rail and truck services must be available. Inadequate control of truck traffic into and out of port terminals combined with the lack of adequate on-dock or near-dock rail access, affects the productivity of ports and waterborne trade.

Pipeline: Incidents that involve a loss of product during pipeline transmission have been correlated through several studies with the age of the affected pipeline. Besides corrosion, failures are caused by external impacts, structural failures, mechanical

Pipeline break in Jackson County

defects, and natural hazards including earthquakes, land subsidence, avalanches, floods, lightning, fires and severe winter storms.

Measurement

The National Transportation Safety Board (NTSB) investigates significant accidents in all forms of transportation including all civil aviation accidents, selected highway accidents, railroad accidents, major marine accidents, pipeline accidents, hazardous material releases from any form of transportation, and other transportation problems that have a recurring nature. Accident reports, safety studies, numerous databases, and historical archives are all available at the NTSB through the Freedom of Information Act.

Miscellaneous dangerous goods, a hazardous materials shipment hazard class has the highest accident and incident rate of all shipments. The gases class, more specifically, the non-flammable gases sub-class, has the lowest accident and incident rates during shipment. The largest possible economic impact associated with hazardous material transport incidents comes from flammable and combustible liquids. In terms of incident cost, release-causing enroute accidents have the highest average cost, followed by enroute accidents in which a release does not occur. Of those enroute accidents resulting in a release, explosions have the highest per incident cost, followed by fires and then releases where neither a fire nor explosions ensues. Explosions result in an average cost of over $2.1 million per accident, followed by $1.2 million per accident involving fire, and accidents involving releases with no fire or explosions average slightly over $400,000. The greatest economic impact though, is associated with accidents enroute where a release does not occur, due to the higher frequency of these events.

Roads: The Federal Motor Carrier Safety Administration conducted a sample survey of 62% of the nation’s active interstate motor carriers. Of the total active interstate motor carriers, 62% received a “satisfactory” safety score while 8% received an unsatisfactory score. The same survey was conducted using 55% of all the hazardous materials carriers. Of those carriers surveyed, 78% received a “satisfactory” score for safety and only 2% received an “unsatisfactory” safety score.

According to the Federal Motor Carrier Safety Administration, 440,000 large trucks were involved in accidents in 1997. This translates into 232 crashes per every 100,000,000 miles driven by trucks. Of the estimated crashes per 100 million miles, 2.6 of those will involve a fatality. Hazardous materials make up between four and eight percent of all truck shipments. Trucks carrying hazardous materials have an accident rate of 0.32 per million vehicle miles as compared to 0.73 accidents per million vehicle miles of non-hazardous material shipments. Due to the volume of transport activity, non-hazardous material truck accidents rates are more than twice the hazardous material accident rates.

Hazardous materials placards are required when shipping hazardous materials on United States, Canada and Mexico highways. The U.S. Department of Transportation (DOT) regulates transportation of materials classified as hazardous, with regulations covering packaging, labeling marking and descriptions on shipping papers. Hazardous materials are classified into the nine numbering system classes in Table 4-64.

Table 4–64: Hazardous Material Transport Placards

Class	*Name*	*Description*	*Symbol*
1 Orange	**Explosives**	Materials that explode or detonate such as dynamite and military rockets; burn rapidly and give off sparks, such as gunpowder; and pop, such as blasting caps and fireworks.	
2 Red	**Compressed Gasses**	Pressurized gas ignitable when exposed to air.	
2 Green		Includes compressed gas, liquefied gas, pressurized cryogenic gas, compressed gas in solution, asphyxiat gas and oxidizing gas.	
2 Yellow		Oxygen is considered non-flammable because it does not burn. It is, however, required for combustion to take place. High concentrations of oxygen greatly increase the rate and intensity of combustion.	
2 White		Gas poisonous by inhalation is known or presumed to be so toxic to humans as to pose a hazard to health.	
3 Red	**Flammable Liquids**	Cargo is easily ignitable. Explosion is possible and vapors may cause dizziness or suffocation. Vapors could ignite.	
4 Red/White Stripes	**Flammable Solids**	Materials that may cause a fire through friction, metal powders that can ignite or thermally unstable materials.	
4 Red & White		A liquid or solid material that, even without an external ignition source, can ignite or self-heat after coming in contact with air.	
4 Blue		Material when contacted with water is liable to become spontaneously flammable or to give off flammable or toxic gas	
5 Yellow	**Oxidizers**	Oxidizer means a material that may, generally by yielding oxygen, cause or enhance the combustion of other materials.	
6 White	**Poisons**	Indicates a severe or presumed severe health hazard. The substance may be poison gas, insecticide, fungicide, hydrochloric acid, chlorine, hydrogen cyanide or other injurious substance.	 
7 Yellow & White	**Radioactive Materials**	Any material or combination of materials that spontaneously emits ionizing radiation.	
8 Black & White	**Corrosive Liquids**	A liquid or solid that causes destruction of human skin at the site of contact or a liquid that has a severe corrosion rate on steel or aluminum.	

9	**Miscellaneous**	A material which presents a hazard during transportation but which does not meet the definition of any other hazard class.	

Air: According to a 1997 commodity flow study of hazardous materials; airlines represent 1.8% of hazardous material shipments in the United States.

Rail: Coal was the dominant freight carried by rail and comprises 43% of all commodity types. Nonmetallic minerals, farm products and chemicals round out the top four 2001 commodities shipped by rail. Chemicals and allied products total approximately 7.9% of all freights while petroleum and coke only account for 2.7%.

Water: In December, 1999, Webbers Falls lock, located on river mile 366, passed 1,113 vessels carrying 4,007 kilotons of cargo for the month. The main commodity originating in Oklahoma and shipped out through water transports are petroleum products. In 2000, a total of 98,797 tons of petroleum products were delivered to other states through waterborne commerce. In 2001, the total petroleum waterborne commerce originating in Oklahoma and delivered to other states increased to 132,843 tons.

Pipeline: In 2002, pipelines carrying hazardous liquids experienced 140 accidents resulting in over $31 million in property damage. This is less than the 17-year annual average of $47.7 million occurring between the years 1986-2002 on hazardous material accidents involving pipelines.

Crude and petroleum products represent over 40% of all hazardous material transports. Pipelines represent the greatest transportation system for petroleum and petroleum by-products. In 2001, pipelines accounted for 66.24% of all U.S. domestic petroleum products transportation. Water carriers accounted for 28.05%, followed by 3.54% by motor carriers and 2.17% by railroads.

Extent

Unincorporated Tulsa County contains nearly 86 miles of highways and 100 miles of railroad. The County is crossed by I-44, US Hwy 64/OK Hwy 51/Broken Arrow/Keystone Expressway, US Hwy 169/Mingo Valley Expressway, US Hwy 75/Okmulgee Beeline, Creek Turnpike, OK Hwy 97, OK Hwy 11, OK Hwy 21, and OK Hwy 51—all of which carry volatile and toxic chemical products through the jurisdiction. Tulsa County also is home to two small airports: Richard Lloyd Jones Airport in southwest Tulsa and Harvey Young Airport in east Tulsa. The transportation corridor covers over 53 square miles within Unincorporated Tulsa County, which is 18.8% of the total land area. Nearly 7,000 residents, or 20% of the population of the unincorporated areas of the County, live within the transportation corridor. In addition, 12 of Tulsa County's 34 critical facilities are within the corridor. Tulsa County had 12 railroad accidents, 57 aviation accidents (all involving small private aircraft), and 40 reported mobile hazardous materials events in the 10 years between 1995 and 2004. In light of this experience, Tulsa County can expect 1.2 railroad and 5.7 aviation accidents per year, and 4 mobile hazardous materials events. However, with the amount of traffic on US Hwy 64/Keystone/Broken Arrow Expressway, I-44, US Hwy 75, and US 64/169/Mingo Valley Expressway, plus the heavy railroad traffic through the county, more significant incidents are quite possible. For example, a worst-case railroad chlorine tank explosion could result in hundreds of deaths, severe injuries, and hospitalizations. The extent of a transportation event can be lessened by, among other measures, well-trained and equipped Hazmat Teams, Reverse 9-1-1 notifications of people in the impact area, planned and practiced notification and evacuation procedures, and by relocating hazardous material transportation routes away from populated areas and critical facilities.

Tulsa County considers a minor severity to be an incident where detours are less than half a mile, traffic disruption of less than half an hour, Hazardous Materials are contained within a quarter mile, and there is no loss of life or major injuries. A major severity incident would include detours exceeding half an hour, traffic disruption of more than half an hour, Hazardous Materials that exceed a quarter mile, or loss of life and/or major injuries.

Impact

The impact of this hazard occurs more frequently during Storms. Storms cause streets to become slick, which increases the risk of transportation hazards. Excessive speed, exhaustion and other causes increase the risk also. Revenue is lost, injuries occur and sometimes even loss of life are the results of Transportation Hazards.

4.15.2 History/Previous Occurrences

Webbers Falls / I-40 Bridge Collapse

On May 27, 2002, three piers connected to an Interstate 40 bridge crossing the Arkansas River near Webbers Falls Oklahoma were struck by a tugboat at 7:43 a.m. collapsing sections of the bridge and killing 14 motorists. The navigation channel and the highway were both subsequently closed for 35 days. Detours were up to 60 miles long for eastbound traffic. Approximately 20,000 vehicles per day use that portion of I-40, and a barge on the navigation system can carry the equivalent load of 15 railcars or 80 semis. On June 4, 2002, the Federal Highway Administration committed an initial $3 million in emergency relief funds to aid in reconstruction.

I-40 Bridge collapse at Webbers Falls on the McClellan-Kerr Navigation System of the Arkansas River

U.S. 75 HazMat Spill near Ramona

In May of 2001, a tanker carrying 10 cylinders of hydrogen gas was pushed off the road when a vehicle traveling along side lost control and forced both vehicles into a ditch. The collision broke a seal on one of the cylinders causing an initial explosion and subsequent fire. The tanker ended upside down in the ditch and the accident claimed the life of the tanker driver. In response to the accident, several area fire departments assisted with the fire that, due to high winds, cascaded into a grass fire. Emergency management remained on the scene until all ten leaking cylinders were emptied with necessary precautions taken to keep those leaks from exploding. Because of the crews continuously extinguishing the hydrogen leaks and grass fires, residents were kept to a limited supply of water during the response and rural water districts in the area were contacted to help maintain a consistent and necessary supply of water for the fire fighters.

Koch Industries Oil Spills in Midwest

In January 2000, Koch Industries of Wichita, KS was fined $30 million by the EPA for allowing some 3 million gallons of crude oil and related products to spill from its Midwest pipelines into ponds, lakes, rivers, streams and shorelines between 1990 and 1997. Most of the spills were caused by pipeline corrosion in rural areas—something the EPA believed Koch could have prevented by proper operation and maintenance. Koch owns and operates extensive underground and above ground pipelines in Oklahoma, Texas and Kansas. In one Texas case, almost 100,000 gallons of spilled oil caused a 12-mile oil slick on Nueces Bay and Corpus Christi Bay.

Tulsa County Transportation Events

The Federal Railroad Administration lists twelve rail events in the Tulsa County area in the last 10 years. Three involved fatalities with a pedestrian, three were non-injury train-vehicle collisions, one was an injury (minor) school bus-train collision, and the remainder of the incidents were low-speed derailments or rail yard collisions, none reported to involve casualties. The majority took place within the city limits of Tulsa. A list of the incidents is in Table 4-65. Two key events, both petroleum tank fires, are described below.

ConocoPhillips Tank Fire, Glenpool, Oklahoma

On the evening of April 8, 2003, around 9:00 P.M., a ConocoPhillips holding tank exploded at a tank farm located east of Interstate 75 near 131st Street and Elwood Ave. north of Glenpool. The tank, which contained diesel fuel, ignited after receiving a delivery of 8,400 barrels of diesel from a pipeline branched off Explorer Pipeline Company's 1,400-mile main pipeline connecting the Gulf Coast to the upper Midwest. The explosion was reportedly felt over 1½-miles away.

The ConocoPhillips tank fire forced the evacuation of over 400 people.

Responders were concerned with the possibility of the fire spreading to adjacent tanks that contained highly volatile unleaded fuel. Work to contain the fire was effective. The next morning, however, live power lines melted by the flames fell onto spilled fuel in the containment basin and reignited the blaze. Strong northerly winds pushed the blaze into a second tank containing naphtha, which subsequently did not explode. Environmental contamination of Coal Creek, which drains directly through the tank farm, was minimal due to a pre-existing containment levee around the tank. Had the levee been compromised, areas along Polecat Creek and the Arkansas River could have been adversely impacted. The fire forced the evacuation of homes and businesses within a 1½-mile radius of the tank farm and closed down U.S. 75 in both directions. Glenpool Schools were also closed as a precautionary measure.

Firefighters from Glenpool, Jenks and Tulsa responded to the event and were supported with a foam truck from Sun Refinery. Equipment from ConocoPhillips headquarters in Houston was also shipped to the scene. The National Transportation Safety Board concluded that static electricity triggered the fire.

Explorer Pipeline Tank Fire, Glenpool Oklahoma

On June 18, 2006, just after 9 A.M., a fuel storage tank at the Explorer Pipeline tank farm caught fire when lightning struck a tank containing over 5 million gallons of unleaded gasoline. Explorer Pipeline is located near 131st & Elwood, east of Highway 75 and southwest of the City of Tulsa. The nearby area was evacuated due to smoke and fumes which, over the course of the next 11 hours, continued to change direction with the shifting wind. Over 800,000 gallons of fuel was lost, but the company was able to salvage over 4.3 million gallons by pumping it out from under the area of the burning tank. The firefighters were able to keep adjacent tanks from being affected, which reduced the catastrophic effect of the blaze. Five families in the area evacuated as a precautionary measure. Responders from Glenpool, Jenks, Bixby and Tulsa battled the blaze, as well as responders from Sun Refinery and Williams Fire Control of Beaumont, TX.

2006 Explorer Pipeline tank fire near Glenpool

Table 4–65: Tulsa County Railroad incidents (non-HazMat)
Source: National Response Center

Date	Location	City	Suspected Responsible Party	Notes
10/09/98	East Pine Street, DOT 663776t	Tulsa		Train struck pedestrian on tracks.
12/21/98	Fisher Subdivision		BNSF Railroad	15-20 cars derailed. Some went into Fisher Creek.
07/20/99	DOT: 413396 across St: Ft Worth	Broken Arrow		Auto struck train at Crossing
09/27/99	Broken Arrow Expressway	Tulsa		School bus vs. train. Four minor injuries
01/01/00	DOT: 663800 across Street: Elwood St.	Tulsa	BNSF Railroad	Train struck pedestrian on tracks.
05/31/01	Tulsa Railyard	Tulsa		Four car derailment. No injuries
07/12/02	Railyard 1631, West 33rd Pl.	Tulsa	BNSF Railroad	Five car derailment. No injuries
08/30/04	Mile 433.42	Shirk		Train struck tractor-trailer. No injuries.
11/01/05	Tulsa Subdivision mile Marker 278.25	Tulsa	Union Pacific RR	Fifteen car derailment. No injuries
02/12/06	Cherokee Rail Yard	Tulsa		Two trains collided inside rail yard. No injuries.
02/12/06	Sheridan St.	Tulsa		Collision with vehicle at crossing. No injuries.
07/15/06	Mile Post 424.7	Tulsa		Train struck trespasser.

The National Transportation Safety Board (NTSB) reports 57 aviation accidents in Tulsa County between 1995 and 2005, all involving small private aircraft. There have been a total of 37 injuries and 8 deaths, all involving the occupants of the aircraft.

According to the National Response Center, within the period from 1995 to 2004 there were 40 reported mobile hazardous materials events within Tulsa County. Of these events, 31 were related to the release of a petroleum product such as oil, gasoline, diesel, or kiln fuel. The remainder of the events included releases of materials such as sulfuric acid, anhydrous ammonia, and sodium hydroxide, and resulted in at least six injuries, but no deaths. The non-petroleum incidents are listed in Table 4-66.

Table 4–66: Tulsa County Mobile Hazardous Materials Incidents 1995 - 2005
Source: National Response Center

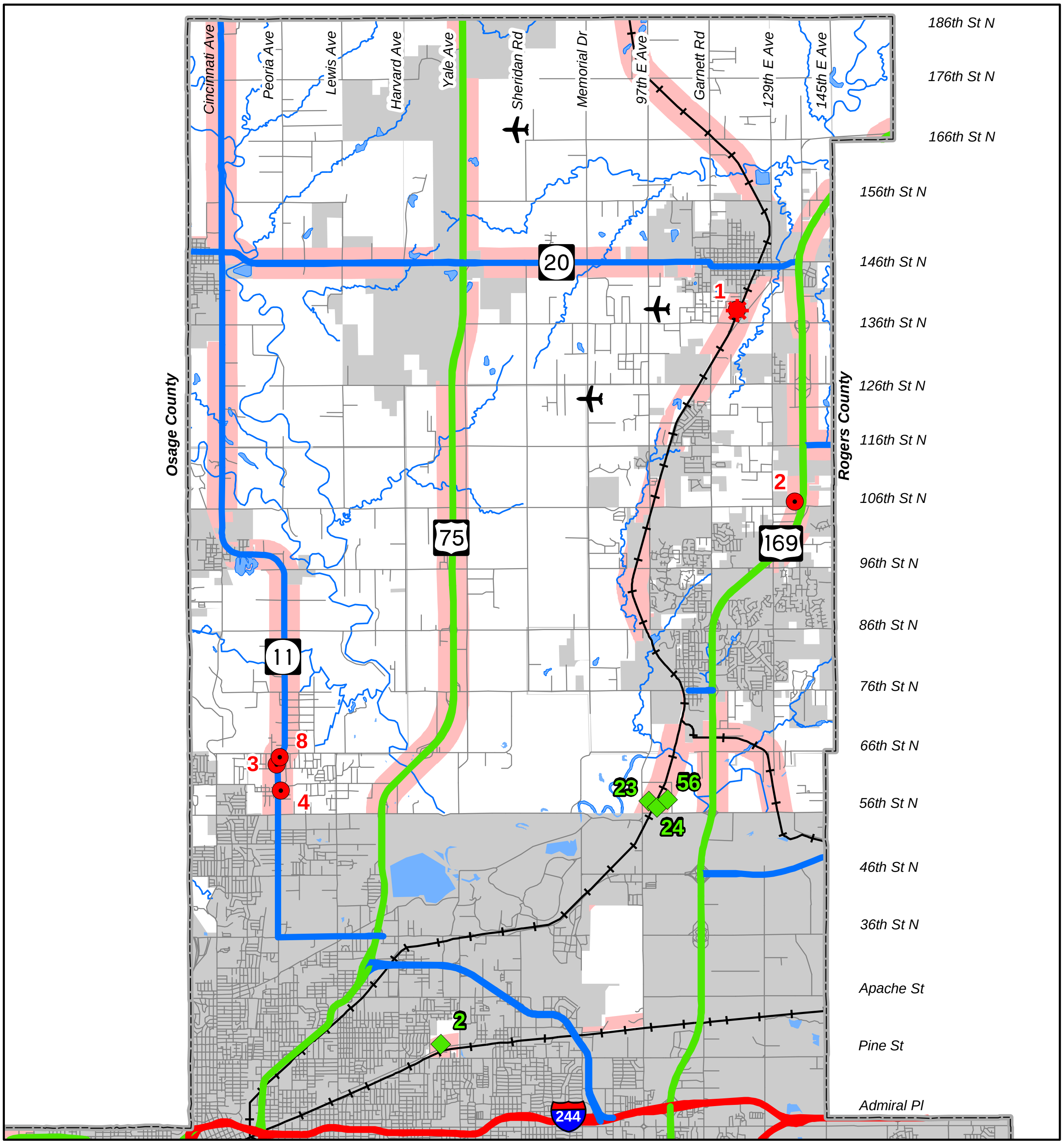
Date	Location	Suspected Responsible Party	Injuries/ Deaths	Medium Affected	Material Name
10/2/1996	2857 Dawson Rd	Crosby & McKissick	0/0	Water	Sulfuric acid 15% solution
1/23/1997	2700 South 25th West Ave	Perma-Fix Treatment Serv	0/0	Land	Hazardous Waste (DO-39)
8/11/1997	I-244 Northbound and US 75	GLS Corp	0/1	Land	Flammable Resin (1866)
8/4/1998	1700 South Union	SUN Co Inc	0/0	Land	Hazardous Waste (FO37/KO48/KO49/KO51)
1/6/1999	51st Street and Garnet Ave	Conway Southern Express	0/0	Land	Sodium Hydroxide
12/14/2000	I-44	US Bulk Transport	0/2	Land	Flue Dust
1/26/2001	On HWY 412 near the junction of 65th West Ave.	Advanced Chemical Co	0/0	Land	Perchloroethylene
5/3/2001	I-44 Westbound / Lewis Ave	Emily's Trucking Inc	0/0	Land	Liquid Potassium Lactate
6/15/2001	12900 West Hwy 64	(null)	0/3	Other	Ammonia, Anhydrous

4.15.3 Vulnerability

Communities close to highways, railroads, pipelines, and air and water transportation systems are at risk from transportation accidents and hazardous materials events. Trucks and railcars carrying toxic and flammable materials pass through almost every major U.S. town and city, including Tulsa County, which is a crossroads of major highways and rail lines. A worst-case truck or railcar chlorine tank explosion in a major population center like Tulsa could result in deaths, severe injuries, and many hospitalizations. Although Tulsa County itself is not a major population center, the jurisdiction is crisscrossed by several major highways and rail lines that carry volatile and toxic chemical products, exposing populations and critical facilities within one-quarter mile of such transportation hazards.

Unincorporated Tulsa County contains nearly 86 miles of highways – including stretches of I-44, US-75, and US-169 – and 100 miles of railroad. Tulsa County also is home to two small airports: Richard Lloyd Jones Airport in southwest Tulsa and Harvey Young Airport in east Tulsa. A ¼ mile buffer was placed around these transportation features in North, West and South Tulsa County, as shown in Figure 4-42a, 4-42b and 4-42c, respectively, to identify vulnerable populations and critical facilities.

The transportation corridor covers over 53 square miles within Unincorporated Tulsa County, which is 18.8% of the total land area. Nearly 7,000 residents, or 20% of the population of the unincorporated areas of the County, live within the transportation corridor. In addition, twelve of Tulsa County's 23 critical facilities, which are listed in Table 4-67, are located within the corridor. Therefore, Tulsa County has moderate vulnerability to the impacts of transportation hazards.



LEGEND

- 1/4 Mile Buffer
- State Highways
- US Highways
- Interstates
- Turnpikes
- Streets
- Railroads
- Airports
- Heliports
- Tier 2 Sites
- Critical Facilities
- County Line
- Incorporated Areas

0 1 2 Miles

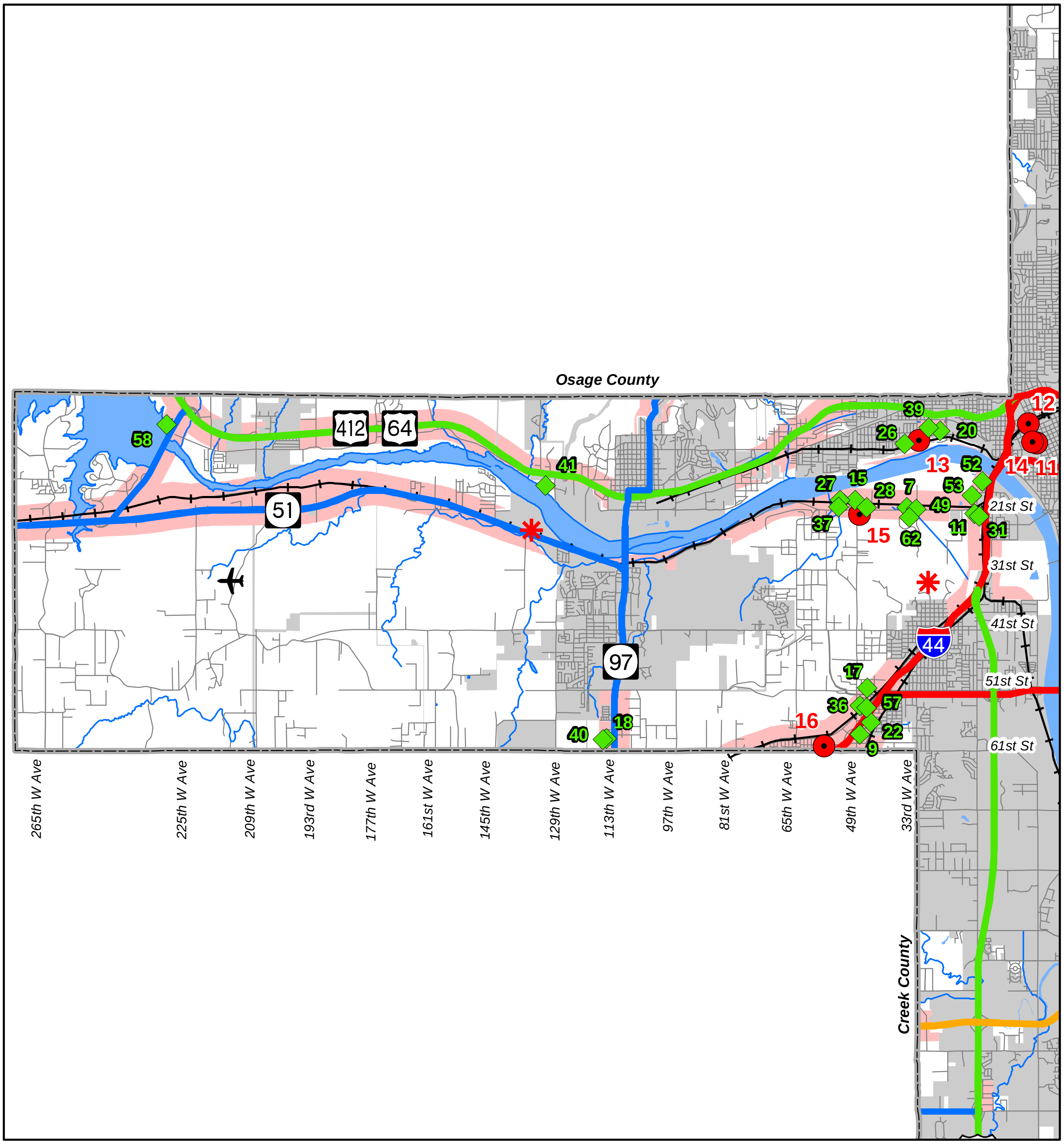
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-42a

Transportation Corridors

Tulsa County - North



LEGEND

- 1/4 Mile Buffer
- State Highways
- US Highways
- Interstates
- Turnpikes
- Streets
- Railroads
- Airports
- Heliports
- Tier 2 Sites
- Critical Facilities
- County Line
- Incorporated Areas

0 1 2 Miles

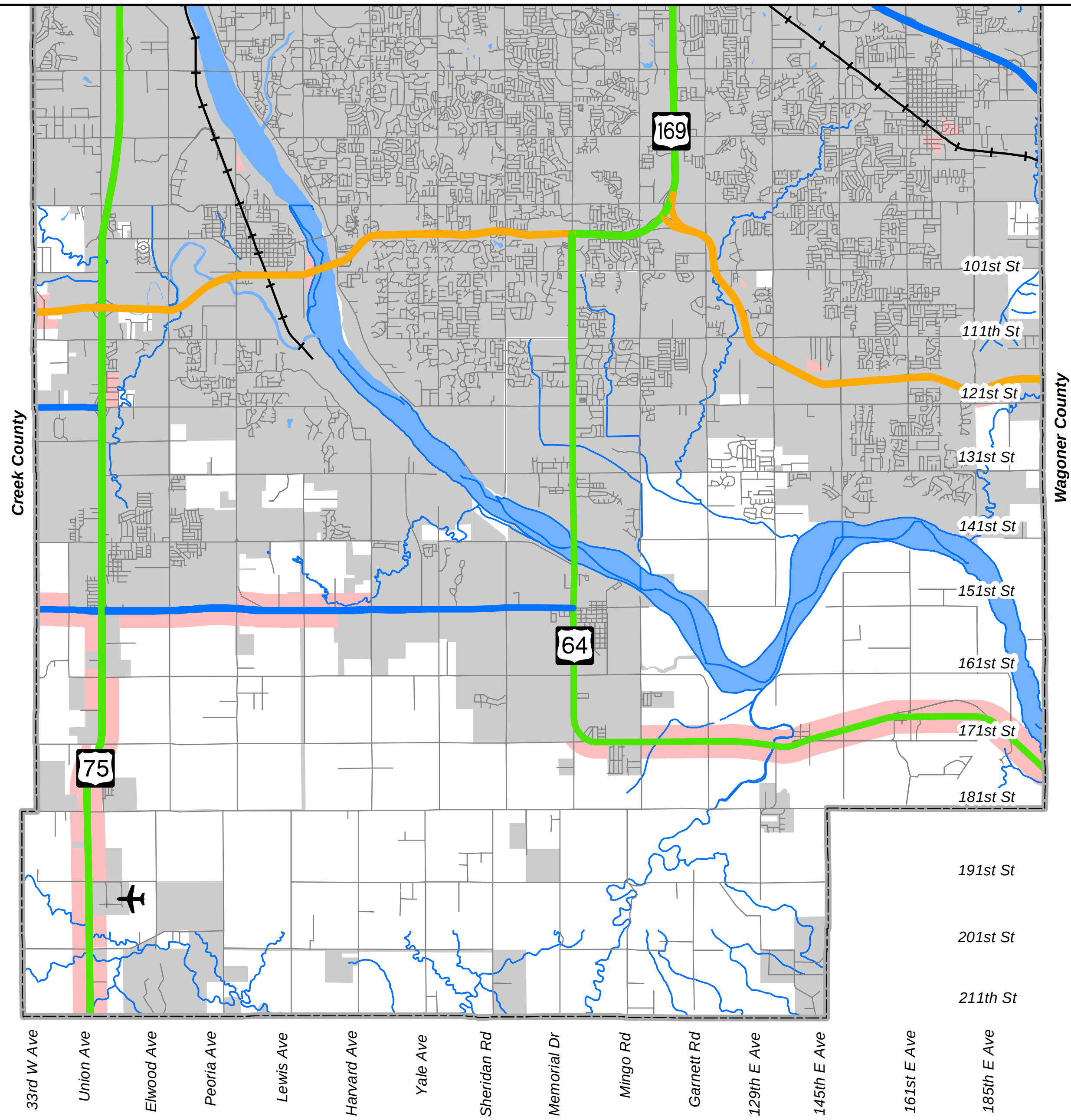
TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-42b

Transportation Corridors

Tulsa County - West



LEGEND

- 1/4 Mile Buffer
- State Highways
- US Highways
- Interstates
- Turnpikes
- Streets
- Railroads
- Airports
- Heliports
- Tier 2 Sites
- Critical Facilities
- County Line
- Incorporated Areas

0 1 2 Miles

TULSA COUNTY

Multi-Hazard Mitigation Plan

Figure 4-42c

Transportation Corridors

Tulsa County - South

Table 4–67: Tulsa County Critical Facilities in Transportation Corridor

ID	Name	Address
1	Bixby Health Center	12 W. Dawes, Bixby
2	Cherokee Elementary School	6001 N. Peoria
3	Collinsville Rural Fire Protection	1018 S. 12th St., Collinsville
5	First Bank of Turley	6555 N Peoria
15	Rejoice Christian School	13413 E. 106th St. North
16	Sand Springs Health Center	306 E. Broadway, Sand Springs
32	Sooner Emergency Services	2131 S. 49th St. West
20	Tulsa City-County Health Dept.	315 S. Utica
21	Tulsa County Correctional Facility	300 N. Denver
22	Tulsa County Deputy Sheriff	3420 W. Charles Page Blvd.
25	Tulsa County Sheriff Office	303 W. 1st St.
30	Turley Fire & Rescue Co.	6404 N. Peoria

Population

Tulsa County is a transportation hub, for air, highway and railroad transportation and is at high risk to the transportation hazard. All populations living and working within ¼ mile of major highways and railroads are exposed to transportation accidents involving hazardous materials.

Buildings

Structures alongside the major traffic ways are at high risk from the transport of explosive or highly flammable products by highway or rail. Most vulnerable are structures where loading and unloading of hazardous materials occurs, including pipelines.

Critical Facilities

Critical facilities located next to major traffic corridors are at high risk to the transportation hazard, including the 12 critical facilities listed in Table 4-67.

Infrastructure

Tulsa County roads, bridges, railways and pipelines can themselves become hazardous due to deterioration and insufficient maintenance. Although Tulsa County transportation facilities are in good condition, private rail and pipeline networks require oversight to ensure that these do not become hazardous to surrounding populations.

4.15.4 Transportation Scenario

The worst-case scenario for a catastrophic transportation event would be a Burlington Northern train accident south of the Cherokee Yard that resulted in the release of liquid chlorine within the county. In this scenario, a tank car carrying 100,000 gallons of liquid chlorine is derailed and ruptures near W. 45th St. and S. 36th W. Ave., with calm to very light wind coming out of the south east.

4.15.5 Future Trends

Population

As a transportation hub, for air, highway and railroad transportation, Tulsa County will continue to be at high risk to the transportation hazard. The exposure to risk could be reduced by new transport technologies. For example, Burlington Northern Railroad has instituted rate reductions for shippers of chlorine, anhydrous ammonia, and other poisons, if improved tank cars, which meet new Department of Transportation specifications, are used for the transport.

Buildings

Structures alongside the major traffic ways will continue to be at high risk from the transport of explosive or highly flammable products by highway or rail. Most vulnerable are structures where loading and unloading of hazardous materials occurs. In addition, pipelines carrying highly flammable petroleum products, such as gasoline, are exposed to lightning-caused fires, as in the Explorer Pipeline tank fire of June 18, 2006.

Critical Facilities

Critical facilities located next to major traffic corridors will continue to be at high risk to the transportation hazard. This includes all 12 of the critical facilities listed in Table 4-67. Future siting and construction of critical facilities along major traffic ways should be analyzed for this hazard, and minimum offsets from the corridor considered.

Infrastructure

The highway, rail and pipeline transportation infrastructure, itself, is subject to wear and deterioration from the traffic it carries, and if not maintained, can increase the likelihood of catastrophic accidents. Many, if not most, pipeline toxic spills are due to deteriorated facilities, as are many railroad accidents. In a period of economic downturn, maintenance of roads, bridges, railroads and pipelines may be reduced to meet fiscal requirements of both the public and private transportation networks.

4.15.6 Conclusion

The United States has the most productive transportation systems in the world. These operating systems include roads, air, rail, water, and pipelines. These systems make possible a high level of personal mobility and freight activity for the nation's residents and business establishments. Although the source and location of transportation accidents can vary, the effects are typically the same. Accidents often involve human injury or death and/or the release of hazardous materials. Responses to transportation incidents also follow a similar course. Determinations are first made concluding the presence or absence of hazardous material. This is followed by the assistance of injured people involved in the incident.

Unincorporated Tulsa County contains nearly 86 miles of highways and 100 miles of railroad, an international airport and two small airports, all of which carry volatile and toxic chemical products through the jurisdiction. The transportation corridor covers over 53 square miles within Unincorporated Tulsa County, which is 18.8% of the total land area. Nearly 7,000 residents, or 20% of the population of the unincorporated areas of the County, live within the transportation corridor. In addition, 12 of Tulsa County's 34 critical facilities are within the corridor. Based on historical data, Tulsa County can expect 1.2 railroad and 5.7 aviation accidents per year, and 4 mobile hazardous materials events. Based on the information and analysis presented above, Tulsa County has a high vulnerability to transportation hazards.

4.15.7 Sources

"Airport Activity Statistics of Certified Air Carriers" at Web address: http://www.bts.gov, Bureau of Transportation Statistics.

Comparative Risks of Hazardous Materials and Non-Hazardous Materials Truck Shipment Accidents/Incidents – Final Report, "Hazardous Materials," pgs. 1.2, 10.2, Federal Motor Carrier Safety Administration, March 2001.

National Pipeline Mapping System, at Web address: http://199.107.71.24/publicsearch/

The National Transportation Safety Board, *Annual Report to Congress 2000-2001* http://www.ntsb.gov/publictn/2002/SPC0201.pdf

"Railroad Statistics," at Web address: http://www.aar.org/PubCommon/Documents/AboutTheIndustry/Statistics.pdf, Association of American Railroads, 2002.

"Safety Fact Sheet," at web address: http://www.fmcsa.dot.gov/factsfigs/dashome.htm, Federal Motor Carrier Safety Administration, October1, 1999.

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Transportation Statistics Annual Report 2001, pg. 36. Bureau of Transportation Statistics, U.S. Department of Transportation, 2001.

"The U.S. Waterway System Facts," U.S. Army Corps of Engineers, at Web address: http://www.iwr.usace.army.mil/ndc/factcard/fc02/factcard.htm

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Clarke, Richard and Rand Beers et. al., Forgotten Homeland: A Century Foundation Task Force Report, June 29, 2006: http://www.tcf.org/list.asp?type=PB&pubid=569

Chapter 5:
Mitigation Goals and Objectives

Included in this Chapter:

This chapter identifies the hazard mitigation goals set by Tulsa County and discusses the mitigation projects, or measures, to be taken to achieve those goals.

The Research, Review, and Prioritization Process

The Hazard Mitigation Planning Committee (HMPC) and supporting staff identified and prioritized the measures that will help protect the lives and property of the citizens of Tulsa County.

National literature and sources were researched to identify best practices mitigation measures for each hazard. These measures were documented, and staff screened several hundred recommended mitigation actions and selected those that were most appropriate for the County.

The HMPC reviewed the measures recommended by staff and revised, added, deleted, and approved measures for each hazard. The HMPC and staff prioritized the measures through a prioritization exercise using STAPLEE criteria recommended by FEMA. Table 5-1 lists these criteria. The results were tabulated and the individual measures were ranked by priority. The measures were then grouped into categories.

Table 5–1: STAPLEE Prioritization and Review Criteria

Evaluation Category	Sources of Information
Social	Members of Local, County and State Government were members of the Hazard Mitigation Planning Committee and had input throughout the planning process. It must be noted that many small town political leaders are also business or professional persons. Existing county and community plans were used wherever possible. Members of the Media were contacted and invited to attend all HMPC meetings.
Technical	The following Persons/Agencies were consulted as to the technical feasibility of the various projects: Tulsa County Commission, the Tulsa County Engineering Office, Oklahoma State University Extension Service, Soil Conservation Service, County and State Health Departments, and Oklahoma Forestry Service. All of these had their comments and suggestions incorporated.

Evaluation Category	Sources of Information
Administrative	Staffing for proper implementation of the plan currently will rely on existing members of the various agencies involved. It is the opinion of the HMPC that insufficient staff is available currently due to budget constrains as staff has been cut to a minimum and many agencies have staff members who are overloaded now. Technical assistance is available from contractors and various State Agencies. The Local Emergency Planning Committee and the County Emergency Management Director have agreed to an annual review and assessment of the Plan and its progress. Operations Costs are under discussion by the relevant department heads.
Political	Representatives of the Tulsa County Commission attended the HMPC meetings and were consulted on all aspects of the Plan.
Legal	Members of the HMPC discussed legal issues with the County Commission, and it was their opinion that no significant legal issues were involved in the projects that were selected by the HMPC.
Economic	Economic issues were the predominant issues discussed by all concerned, with an emphasis on cost/benefit review. Each entity felt that the projects selected would have a positive effect in that the projects would attract business and recreation to the area as well as help the community be better prepared for a disaster. Funding for the various projects was the major concern, as local budgets were not capable of fulfilling the needs due to the economic down turn. Outside grants will be relied upon heavily for completion of projects.
Environmental	Oklahoma Department of Environmental Quality, Oklahoma Forestry Service, and the Oklahoma Water Resources Board were all consulted as to the environmental impact of the various projects. It was felt that there would be no negative impact. Local governments are currently considering zoning of environmentally sensitive areas.

Mitigation Categories

The measures that communities and individuals can use to protect themselves from, or mitigate the impacts of, natural and man-made hazards fall into six categories:

- Public Information and Education
- Preventive Measures
- Structural Projects
- Property Protection
- Emergency Services, and
- Natural Resources Protection

This chapter is organized by mitigation category, with the HMPC mitigation mission statement and goals listed first in section 5.1.

Tulsa County's natural hazard mitigation planning process involves citizens in every phase.

5.1 Tulsa County Hazard Mitigation Goals

5.1.1 Mission Statement

To create a disaster-resistant community and improve Tulsa County's safety and well-being 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 more livable, viable, and sustainable communities.

5.1.2 Mitigation Goal

To identify county 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 county.

5.1.3 Goals for All Natural 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 Hazard-Specific Goals and Objectives

Flood	
GOAL: ***To reduce the incidence of injuries, loss of life, and damage to property, equipment and infrastructure due to Floods and Flash Floods.***	
Objective 1.	Improve public awareness of Flood and Flash Flood hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	Identify and protect populations, structures, and critical infrastructure that are vulnerable to Flood and Flash Flood hazards.
Objective 3.	Ensure that Flood and Flash Flood prevention and mitigation policies have no negative impacts and, whenever possible, provide positive protection and enhancements to natural resources.

Tornado	
GOAL: ***To reduce the incidence of injuries, loss of life, and damage to property, equipment and infrastructure due to Tornadoes.***	
Objective 1.	Improve public awareness of Tornado hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	Identify and protect populations, structures, and critical infrastructure that are vulnerable to Tornado hazards.

High Wind	
GOAL: ***To reduce the incidence of injuries, loss of life, and damage to property, equipment and infrastructure due to High Winds.***	
Objective 1.	Improve public awareness of High Wind hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	Identify and protect populations, structures, and critical infrastructure that are vulnerable to High Winds.

Lightning	
GOAL: ***To reduce the incidence of injuries, loss of life, and damage to property, equipment and infrastructure due to Lightning strikes.***	
Objective 1.	Improve public awareness of Lightning hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	Identify and protect populations, structures, and critical infrastructure that are vulnerable to Lightning strikes.

Hail	
GOAL: ***To reduce the high costs of property and infrastructure damage caused by Hailstorms.***	
Objective 1.	Improve public awareness of Hailstorm hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	Identify and protect structures and critical infrastructure that are vulnerable to Hail damage.

Winter Storms	
GOAL: ***To reduce the incidence of injuries, loss of life, loss of critical utilities, and damage to property, equipment and infrastructure due to Winter Storms.***	
Objective 1.	Improve public awareness of Winter Storm and ice hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	Identify and protect people and critical infrastructure that are vulnerable to Winter Storms and ice storms.
Objective 3.	Ensure that Winter Storm mitigation policies have no negative impacts on the environment.

Heat	
GOAL: ***To reduce the incidence of heat-related illnesses, loss of life, and exacerbation of other hazards such as drought and expansive soils due to extreme Heat conditions.***	
Objective 1.	Improve public awareness of extreme Heat hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	Identify and protect people and critical infrastructure that are vulnerable to extreme Heat conditions.
Objective 3.	Ensure that extreme Heat mitigation policies have no negative impacts and, whenever possible, provide positive enhancements to the environment.

Drought	
GOAL: ***To reduce the impact of Drought on property, infrastructure, natural resources and local government response functions.***	
Objective 1.	Improve public awareness of Drought and measures by which people can protect themselves, their property, and their community.
Objective 2.	Identify and protect resources and critical infrastructure that are vulnerable to Drought.
Objective 3.	Ensure that Drought mitigation policies have no negative impacts and, whenever possible, provide positive enhancements to the environment.

Expansive Soil	
GOAL: ***To reduce the damage caused by Expansive Soils on property and local infrastructure.***	
Objective 1.	Improve public awareness of Expansive Soil hazards and measures by which people can protect their property and their community.
Objective 2.	Identify and protect resources and critical infrastructure that are vulnerable to Expansive Soils.
Objective 3.	Ensure that Expansive Soil mitigation policies have no negative impacts and, whenever possible, provide positive enhancements to the environment.

Urban Fire	
GOAL: ***To reduce the incidence of injuries, loss of life, and damage to property, equipment and infrastructure due to Urban Fires.***	
Objective 1.	Improve public awareness of Urban Fire hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	Identify and protect populations, structures, and critical infrastructure that are vulnerable to Urban Fires.

Wildfire	
GOAL: ***To reduce the incidence of injuries, loss of life, and damage to property, equipment and infrastructure due to Wildfires.***	
Objective 1.	Improve public awareness of Wildfire hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	Identify and protect populations, structures, and critical infrastructure that are vulnerable to Wildfires.
Objective 3.	Ensure that Wildfire mitigation policies have no negative impacts and, whenever possible, provide positive enhancements to the environment.

Earthquake	
GOAL: ***To reduce the likelihood of injury, loss of life, and damage to property, equipment and infrastructure due to Earthquakes.***	
Objective 1.	Improve public awareness of Earthquake hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	Identify and protect populations, structures, and critical infrastructure that are vulnerable to Earthquakes.

Hazardous Materials, Fixed Site	
GOAL: ***To reduce the incidence of injuries and loss of life and the negative impact on the community and the environment due to Fixed Site Hazardous Material incidents.***	
Objective 1.	Improve public awareness of Fixed Site Hazardous Material incidents and measures by which people can protect themselves and their community.
Objective 2.	Identify and protect populations and critical infrastructure that are vulnerable to Fixed Site Hazardous Material incidents.
Objective 3.	Identify and limit the damage that Fixed Site Hazardous Material incidents have on the environment.

Dam Break	
GOAL: ***To reduce the incidence of injuries, loss of life, and damage to property, equipment and infrastructure due to partial or total Dam failures.***	
Objective 1.	Improve public awareness of Dam Break hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	Identify and protect populations, structures, and critical infrastructure that are vulnerable to Dam Break hazards.
Objective 3.	Ensure that Dam Break prevention and mitigation policies have no negative impacts and, whenever possible, provide positive protection and enhancements to natural resources.

Transportation	
GOAL: ***To reduce the incidence of injuries and loss of life and the negative impact on public infrastructure and the environment due to Transportation-related hazardous material incidents and other Transportation incidents with the potential for causing mass casualties.***	
Objective 1.	Improve public awareness of Transportation incidents and measures by which people can protect themselves and their community.
Objective 2.	Identify and protect populations and critical infrastructure that are vulnerable to Transportation incidents.
Objective 3.	Identify and limit the damage that Transportation incidents have on the environment.

Chapter 6: Action Plan & Mitigation Measures

Tulsa County has reviewed and analyzed the risk assessment studies for the natural hazards events that may impact the County. The Tulsa County Hazard Mitigation Technical and Citizens' Advisory Committees prioritized and developed an Action Plan for those mitigation measures considered most effective for the County. This chapter identifies specific high priority actions to achieve the County's mitigation goals, the lead agency responsible for implementation of each action item, an anticipated time schedule, estimated cost opinion, and identification of possible funding sources.

Included in this Chapter:

Table 6–1: Mitigation Measures per Hazard

Hazard	*Measures Addressing*	*Hazard*	*Measures Addressing*
Flood	16	Expansive Soil	6
Tornado	21	Urban Fire	7
High Wind	21	Wildfire	9
Lightning	14	Earthquake	17
Hail	8	Fixed Site Hazmat	7
Winter Storm	16	Dam Failure	11
Extreme Heat	11	Transportation	6
Drought	6		

6.1 Action Plan

Flood, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Urban Fires, Wildfires Earthquakes, Fixed Site Hazardous Materials Events, Dam Failures, Transportation Events

1. **Provide new/retrofit Facilities for the 911 Center and the Emergency Operations Center.**

Lead: County Engineer/Emergency Management

Time Schedule: 2010-ongoing

Estimated Cost: $291,600

Facility	Staff	Size x 6 sq. ft.	Cost x $200/ sq. ft.
Emerg. Opns. Cntr.	233	1,398	279,600
Maintenance Facility	10	60	12,000
Totals	**243**	**1,458**	**$291,600**

Source of Funding: Local/General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: Government Emergency Operations that can withstand natural and man-made disasters, and be able to respond to the needs of the community in the event of a disaster.

Tornadoes, High Winds, Earthquakes

2. **Provide employee shelters/safe-rooms at County Critical Facilities, such as Sheriff's Office, to protect first responders.**

Lead: County Engineer

Time Schedule: June 1, 2012

Estimated Cost: $725,000

Source of Funding: General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: Construction of shelters or safe rooms with the intent of protecting first responders from tornadoes and high winds.

Tornadoes, High Winds, Earthquakes

3. **Educate residents, building professionals, and safe room vendors on the International Codes Council/National Storm Shelter Association's "Standard for the Design and Construction of Storm Shelters" and consider incorporating this Standard into current information and practices.**

Lead: Building Inspections Official

Time Schedule: 2010- On Going

Estimated Cost: Undetermined

Source of Funding: Local/General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: An educated citizenry and professional building and design community as to the advantages and requirements of the ICC/NSSA "Standard for the Design and Construction of Storm Shelters," and the adoption of practices and procedures recommending that all safe rooms comply with the ICC/NSSA standard.

Floods, Dam Failure

4. Prepare a comprehensive basin-wide Flood & Drainage Annex to the Hazard Mitigation Plan for all watersheds within the jurisdiction. The plan will identify all flooding problems within the county, and recommend the most cost-effective and politically acceptable solutions to the flooding problems

Lead: County Engineer

Time Schedule: June 1, 2010

Estimated Cost: 570 sq. mi. @ $15,000 per sq. mi. = $8,550,000

Source of Funding: General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP, Flood Mitigation Assistance (FMA).

Work Product/Expected Outcome: A comprehensive, basin-wide Flood & Drainage Annex to the Hazard Mitigation Plan for the unincorporated areas of the County that identifies the existing and potential future drainage and flooding problems to public facilities and private property, and recommends the most cost-effective and politically acceptable structural and non-structural solutions to the flooding problems, and provides guidance for future development. The basin plans will take into account those parts of the basins within incorporated communities, and their Master Drainage Plans and recommendations.

Floods, Dam Failure

5. Acquire and remove floodplain and repetitive loss properties where the county's repetitive loss plan and Flood & Drainage Annex to the Hazard Mitigation Plan identifies acquisition as the most cost-effective and desirable mitigation measure.

Lead: County Engineer/Floodplain Manager

Time Schedule: On going

Estimated Cost: To be determined as a result of the Flood & Drainage Annex to the Hazard Mitigation Plan

Source of Funding: General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP, ICC, and FMA.

Work Product/Expected Outcome: Acquisition of the community's most severely vulnerable flood-risk properties, and relocation of flood victim families to safe homes out of the floodplain and harm's way, in accordance with the recommendations of the County's Flood & Drainage Annex to the Hazard Mitigation Plan.

Floods, Dam Failure

6. Continue Compliance with, and Participation in the National Flood Insurance Program (NFIP) and the Community Rating System (CRS).

Lead: County Engineer/Floodplain Manager

Time Schedule: 2010- On Going

Estimated Cost: Undetermined

Source of Funding: Local/General budget.

Work Product/Expected Outcome: Compliance with, and enforcement of local storm drainage and floodplain management ordinances and regulations, and requirements of the National Flood Insurance Program and the Community Rating System (CRS).

Tornadoes, High Winds, Floods

7. Evaluate, upgrade, and maintain community-wide outdoor omni-directional voice/warning system.

Lead:	Tulsa Area Emergency Management Agency (TAEMA)
Time Schedule:	2010- On Going
Estimated Cost:	$153,000
Source of Funding:	Local/General budget, FEMA HMGP/PDM.

Work Product/Expected Outcome: Updated, modern outdoor omni-directional outdoor warning system to warn and notify the public in the event of eminent disaster event.

Wildfires

8. Develop a Wildfire Susceptibility Analysis and Wildfire Mitigation Plan for the vulnerable Rural/Urban Interface areas of the County.

Lead:	Emergency Management
Time Schedule:	2011
Estimated Cost:	$28,500
Source of Funding:	General budget, FEMA HMGP, OK Dept. of Forestry

Work Product/Expected Outcome: Identification of structures vulnerable to wildfires in the Rural/Urban Interface areas of the County, and the development of a Wildfire Mitigation Plan.

Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat

9. Develop an Emergency Back-up Generator Hazard Mitigation Plan Annex (EBGHMP) for the county, assessing and prioritizing generator needs for critical facilities, both public and private. Assessment should include generator needs, costs of installation for pads/transfer panels only, or for complete generator assembly installation.

Lead:	County Engineer/Emergency Management
Time Schedule:	October 1, 2010
Estimated Cost:	$35,000
Source of Funding:	General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: Develop a plan for identifying, prioritizing and implementing generator needs for critical and first response facilities. The plan would include performing a power audit for facilities identifying the power requirements for critical functions. In addition, the plan would outline needs and potential costs for generator pads, automatic transfer switches, and sources for generators. It would identify existing generator capabilities and whether those were adequate for response needs. It would also identify funding sources and lead personnel responsible.

Floods, Tornadoes, High Winds, Lightning, Severe Winter Storms, Urban Fires, Wildfires, Earthquakes

10. **Provide wiring and transfer switches to accommodate emergency generators during disaster power outages for critical facilities including Emergency Operations Centers, County Court House, Dispatch, Sheriff's Offices, Community Centers used for emergency housing during disasters, critical facilities, lift stations, and community medical facilities**

Lead: County Engineer/Emergency Management

Time Schedule: October 1, 2011

Estimated Cost: To be determined as a result of the Emergency Back-up Generator Hazard Mitigation Plan Annex.

Source of Funding: General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: Adequate pre-installed wiring and required transfer switches that will accommodate emergency generators during power outages in a disaster. This allows for the continued operation of facilities to provide critical services for the community.

Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat

11. **Obtain or Identify source of generators that are required as identified in the Emergency Back-up Generator Hazard Mitigation Plan Annex.**

Lead: County Engineer/Emergency Management

Time Schedule: June 1, 2010

Estimated Cost: To be determined

Source of Funding: General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: Will provide generators on-site for critical facilities that require constant electrical power, and identify sources of generators for facilities that can function without electricity for a period of time.

Floods, Tornadoes, High Winds, Severe Winter Storms, Earthquakes, Dam Failures

12. **Adopt and Implement a plan for continuity and restoration of power to the county and critical facilities as a result of power outages due to natural and manmade hazards, such as the McGuire plan.**

Lead: County Engineer/Emergency Management

Time Schedule: October 1, 2010

Estimated Cost: $25,000

Source of Funding: General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: A plan and procedure to coordinate the restoration of power to the County after a power outage. The Plan would prioritize and coordinate, in an orderly manner, the restoration activities of the electric power providers restoring transmission and feeder lines, and electricians restoring weather-heads and service lines to individual homes and businesses in a manner that maximizes restoration of electric service to the County.

Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat, Earthquakes

13. **Identify and encourage Private Critical Facilities (Financial Institutions, Long-term Care Facilities, Designated/Potential Community Emergency Shelters, etc.) to have generator pad, wiring/transfer switches and Emergency Back-Up Generators, or Reliable Contracts to provide Back-Up Generators.**

Lead: County Engineer

Time Schedule: 2010-2014

Estimated Cost: Undetermined

Source of Funding: Local/General budget.

Work Product/Expected Outcome: Private critical facilities (financial institutions, elder care facilities, designated/potential community emergency shelters, etc.) have generator pads, wiring and transfer switches, and emergency back-up generators, or reliable contracts for the provision of back-up generators, in the event of power failure.

Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat, Earthquakes

14. **Identify and/or encourage key important private service facilities (gas stations, convenience stores, etc.) to have wiring/transfer switches and emergency back-up generators installed, or reliable contracts for the provision of back-up generators, in the event of disasters or power outages.**

Lead: County Engineer

Time Schedule: 2010-2014

Estimated Cost: Undetermined

Source of Funding: Local/General budget.

Work Product/Expected Outcome: Key important private service facilities (gas stations, convenience stores, etc.) have wiring, transfer switches and emergency back-up generators, or reliable contracts for the provision of back-up generators, to ensure continued operation of essential services in times of emergency, disaster, or power outage.

Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat, Earthquakes

15. Develop Memorandums of Understanding (MOUs) with private sector gasoline service facilities to provide priority fuel to emergency/critical vehicles (government, Police, Fire, ambulance, etc.) in times of emergency or power outage.

Lead:	County Engineer
Time Schedule:	2010
Estimated Cost:	None anticipated
Source of Funding:	None anticipated

Work Product/Expected Outcome: Memorandums of understanding (MOUs) with private sector gasoline service facilities to provide priority fuel to emergency/critical vehicles (government, Police, Fire, ambulance, etc.) in times of emergency or power outage, so that emergency and First Responder personnel can meet the needs of the community.

Lightning

16. Provide lightning warning systems for outdoor sports areas, pools, golf courses, ball fields, parks, and Fairgrounds.

Lead:	County Parks & Recreation Department
Time Schedule:	October 1, 2011
Estimated Cost:	$68,000
Source of Funding:	General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: Lightning sensing and warning systems for Tulsa County's parks, golf courses, outdoor recreation areas, Fair Grounds, etc., where citizens are likely to assemble, and be vulnerable to lightning strikes. This project could be developed and coordinated in conjunction with the City of Tulsa and Tulsa Public Schools' ThorGuard lightning sensing and warning systems.

Floods, Dam Failure

17. Develop and distribute flood and flash flood safety tips to inform citizens of the dangers of flood waters

Lead:	Safety Development Department
Time Schedule:	June 1, 2010
Estimated Cost:	$56,000
Source of Funding:	General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: Provides information regarding the dangers of floods and flash floods to residents.

Expansive Soils

18. Establish administrative procedures, and provide maps and information to inform builders about Expansive Soils when they apply for development and building permits.

Lead:	County Inspections
Time Schedule:	June 1, 2010
Estimated Cost:	$12,000
Source of Funding:	General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: In conjunction with the NRCS and County Extension Office, prepare and distribute Expansive Soils maps and information on appropriate foundation design to developers and builders.

Expansive Soils

19. Educate builders on appropriate foundation types for soils with different degrees of shrink-swell potential. For example, using "post-tensioned slab-on-grade" or "drilled pier" vs. standard "slab-on-grade" or "wall-on-grade" foundations.

Lead:	Safety Development Department
Time Schedule:	June 1, 2010
Estimated Cost:	$5,000
Source of Funding:	General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: Provide information to builders allowing construction of structures with foundations appropriate for, and able to withstand the hazards of expansive soils.

Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Expansive Soils, Urban Fires, Wildfires, Earthquakes, Fixed Site Hazardous Materials Events, Dam Failures, Transportation Hazards

20. Develop an all-hazard public information, education, and awareness strategy and program

Lead:	Emergency Management
Time Schedule:	On going
Estimated Cost:	$65,000
Source of Funding:	General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: A program for the distribution of hazard preparedness and mitigation literature as well as promoting demonstrations on prevention issues that seek to lessen the vulnerability of populations to natural and man-made hazards. Materials to include Family Preparedness Guide; translations into Spanish; programs for the Special Needs populations; focus on Business Continuity, etc. Other resources may include public broadcast, brochures, radio commercials, and newspaper articles to reach broad audiences and otherwise unknown but potentially impacted citizens. Programs should coincide with the months that the hazards are likely to occur.

Floods, Tornadoes, High Winds, Expansive Soils, Earthquakes, Fixed Site Hazardous Materials, Transportation Hazards, Dam Failures

21. Modify/Adopt the County Land Use Plan to:
1) Guide development away from hazardous areas, including Hazardous Materials sites.
2) Reduce population density in hazardous areas
3) Implement stronger development restrictions
4) Encourage Natural Resource Protection.

Lead:	County Engineer/County Inspections
Time Schedule:	On going
Estimated Cost:	Undetermined
Source of Funding:	General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: An updated Land-Use Plan and policy that will assist the County in reducing the risk to development of future areas by identifying, planning for, and regulating development in potentially risky or hazardous areas.

Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Urban Fires, Wildfires, Earthquakes, Fixed Site Hazardous Materials Events, Dam Failures, Transportation Hazards

22. Develop and distribute a Family Emergency Preparedness Guide to all families.

Lead:	Emergency Management
Time Schedule:	October 1, 2010
Estimated Cost:	To be determined
Source of Funding:	General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: Obtain and distribute a Family Preparedness Guide of information about hazard preparedness and mitigation as well as prevention issues that seek to lessen the vulnerability of populations to natural and man-made hazards.

Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Urban Fires, Wildfires, Earthquakes, Fixed Site Hazardous Materials Events

23. Educate the public on the importance of a Family Disaster Plan and Supply Kit

Lead:	Emergency Management
Time Schedule:	October 1, 2010
Estimated Cost:	To be determined

Source of Funding: General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: A three-year public information and education program to educate County families on the importance of having a Family Disaster Preparedness Plan and Emergency Supply Kit for preparing for, and responding to disasters.

Tornadoes, High Winds, Hail

24. When replaced, install break resistant glass in government offices, and critical facilities.

Lead: County Engineer

Time Schedule: June 1, 2010

Estimated Cost: To be determined

Source of Funding: General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: Shatter-resistant exterior windows in Critical Facilities that prevent injuries from broken and flying glass resulting from tornadoes, high winds, hail, and man-made hazards.

Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Expansive Soils, Urban Fires, Wildfires, Earthquakes, Fixed Site Hazardous Materials Events, Dam Failures, Transportation Events

25. Obtain funding for development and distribution of public information and education plans for responding to all-hazards to at-risk and vulnerable populations and contact agencies that distribute information to at-risk populations

Lead: Emergency Management

Time Schedule: June 1, 2010

Estimated Cost: $725,000

Source of Funding: General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: Development and distribution of informational brochures specifically aimed at target vulnerable populations for each natural and man-made hazard.

Floods, Tornadoes, High Winds, Severe Winter Storms, Extreme Heat, Drought, Urban Fires, Wildfires, Earthquakes, Fixed Site Hazardous Materials Events, Dam Failures, Transportation Events

26. Install a Mass Emergency Telephone Communication system, such as Reverse 911 or Black Board Connect, for mass call-outs to targeted areas of the community for emergency notification and/or information.

Lead: 911 Trust Authority/Emergency Management

Time Schedule: 2010-2012

Estimated Cost: 13,685 addresses X $1.91 per address per year = $26,140, (1 Year Start-up + 1 year operation = $52,280.

Source of Funding: Local/General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: An Emergency Mass Communications System (Reverse 911) capable of simultaneously calling targeted areas of the County, and delivering specific emergency/hazard messages to the occupants.

Tornados, High Winds, Lightning, Severe Winter Storms, Earthquakes

27. Provide surge and lightning protection for computer-reliant critical facilities (e.g. County Offices, EOC, and Sheriff's Offices).

Lead: County Engineer

Time Schedule: 2010- On Going

Estimated Cost: To be determined

Source of Funding: Local/General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: Computer-reliant systems in government and public critical facilities are protected from lightning and power surges.

Floods, Tornadoes, High Winds, Lightning, Hail, Winter Storms, Extreme Heat, Drought, Expansive Soil, Wildfires, Earthquakes

28. Train/Educate builders, developers, architects and engineers in techniques of disaster-resistant homebuilding, such as the Fortified Home standards developed by the Institute for Business & Home Safety (IBHS), the Blueprint for Safety guidelines developed by the Federal Alliance for Safe Homes (FLASH).

Lead: County Engineer/Inspections-Building Official

Time Schedule: 2010- On Going

Estimated Cost: Undetermined

Source of Funding: Local/General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: Enhanced construction practices for residences that will result in homes that will withstand most tornadoes, high winds and earthquakes.

Floods, Tornadoes, High Winds, Hail, Severe Winter Storms, Earthquakes

29. Develop/Review/Update the Debris Management Plan.

Lead: County Engineer/Emergency Management

Time Schedule: June 1, 2010

Estimated Cost: $8,280

Source of Funding: General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: An updated Debris Management Plan that identifies procedures for the collection, removal and disposal of debris resulting from natural hazards in a method that reduces danger to workers and residents of the county, and enhances recovery efforts.

Prioritized Mitigation Measure List for Tulsa County

Rank	Hazard	Mitigation Category	Mitigation Measure
1	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Structural Projects	Provide new/retrofit facilities for the 911 Center and the Emergency Operations Center.
2	Tornadoes, High Winds, Earthquakes	Preventive Measures	Provide employee shelters/safe-rooms at critical facilities, such as 911 Center, fire stations and Sheriff's stations to protect first responders.
3	Tornadoes, High Winds, Earthquakes	Public Information and Education	Educate residents, building professionals, and safe room vendors on the International Codes Council/National Storm Shelter Association's "Standard for the Design and Construction of Storm Shelters" and consider incorporating this Standard into current information and practices.
4	Floods	Preventive Measures	Prepare a comprehensive basin-wide Flood & Drainage Annex to the Hazard Mitigation Plan for all watersheds within the jurisdiction. The plan should identify all flooding problems within the jurisdiction, and recommend the most cost-effective and politically acceptable solutions.
5	Floods	Property Protection	Acquire and remove floodplain and repetitive loss properties where the community’s Repetitive Loss Plan and Flood & Drainage Annex to the Hazard Mitigation Plan identify acquisition as the most cost-effective and desirable mitigation measure.
6	Floods, Dam Failures	Property Protection	Continue Compliance with, and Participation in the National Flood Insurance Program (NFIP) and the Community Rating System (CRS)
7	Tornadoes, High Winds, Lightning, Hail	Emergency Services	Evaluate, upgrade and maintain community-wide outdoor omni-directional voice/siren warning systems
8	Wildfires	Preventive Measures	Develop a Wildfire Susceptibility Analysis and Wildfire Mitigation Plan for the vulnerable Rural/Urban Interface area of the County.
9	Tornadoes, High Winds, Lightning, Severe Winter Storms	Emergency Services	Develop an Emergency Back-up Generator Hazard Mitigation Plan Annex for the community, assessing and prioritizing generator needs for critical facilities, both public and private. Assessment should include generator needs, costs of installation for pads/transfer panels only, or for complete generator assembly installation.
10	Floods, Tornadoes, High Winds, Lightning, Severe Winter Storms, Urban Fires, Wildfires, Earthquakes	Preventive Measures	Provide wiring and transfer switches to accommodate emergency generators during disaster power outages for critical facilities including Emergency Operations Centers, County Court House, Dispatch, Sheriff's Offices, Community Centers used for emergency housing during disasters, critical facilities, lift stations, and community medical facilities

Rank	Hazard	Mitigation Category	Mitigation Measure
11	Tornadoes, High Winds, Lightning, Severe Winter Storms	Emergency Services	Obtain or Identify source of generators that are required as identified in the Emergency Back-up Generator Hazard Mitigation Plan Annex
12	Floods, Tornadoes, High Winds, Severe Winter Storms, Earthquakes, Dam Failures	Preventive Measures	Adopt and Implement a plan for continuity and restoration of power to the county and critical facilities as a result of power outages due to natural and man-made hazards, such as the McGuire plan.
13	Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat, Earthquakes	Preventive Measures	Identify and encourage Private Critical Facilities (Financial Institutions, Long Term Care Facilities, Designated/Potential Community Emergency Shelters, etc.) to have generator pad, wiring/transfer switches and Emergency Back-Up Generators, or Reliable Contracts to provide Back-Up Generators
14	Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat, Earthquakes	Preventive Measures	Identify and/or encourage key important private service facilities (gas stations, convenience stores, etc.) to have wiring/transfer switches and emergency back-up generators installed, or reliable contracts for the provision of back-up generators, in the event of disasters or power outages.
15	Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat, Earthquakes	Emergency Services	Develop Memorandums of Understanding (MOUs) with private sector gasoline service facilities to provide priority fuel to emergency/critical vehicles (government, Police, Fire, ambulance, etc.) in times of emergency or power outage
16	Lightning	Preventive Measures	Provide lightning warning systems for outdoor sports areas, pools, golf courses, ball fields, parks, and Fairgrounds.
17	Floods	Public Information and Education	Develop and distribute flood and flash flood safety tips to inform citizens of the dangers of flood waters
18	Expansive Soils	Preventive Measures	Establish administrative procedures, and provide maps and information to inform builders about Expansive Soils when they apply for development and building permits.
19	Expansive Soils	Preventive Measures	Educate builders on appropriate foundation types for soils with different degrees of shrink-swell potential. For example, using "post-tensioned slab-on-grade" or "drilled pier" vs. standard "slab-on-grade" or "wall-on-grade" foundations.
20	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Expansive Soils, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Public Information and Education	Develop an all-hazard public information, education, and awareness strategy and program.
21	Floods, Tornadoes, High Winds, Expansive Soils, Earthquakes, Fixed Site Haz Mat Events, Dam Failures	Preventive Measures	Modify/Adopt a Land Use Plan to: 1) Guide development away from hazardous areas 2) Reduce population density in hazardous areas 3) Implement stronger development restrictions 4) Encourage Natural Resource Protection

Rank	Hazard	Mitigation Category	Mitigation Measure
22	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Public Information and Education	Develop and distribute a Family Emergency Preparedness Guide to all families.
23	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events	Public Information and Education	Educate the public on the importance of a family disaster plan and supply kit
24	Tornadoes, High Winds, Hail, Earthquakes	Property Protection	When replaced, install break resistant glass in government offices, and critical facilities.
25	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Expansive Soils, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Public Information and Education	Obtain funding for development and distribution of public information and education plans for responding to all-hazards to at-risk and vulnerable populations and contact agencies that distribute information to at-risk populations
26	Floods, Tornadoes, High Winds, Severe Winter Storms, Extreme Heat, Drought, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Emergency Services	Install a Mass Emergency Telephone Communication system, such as Reverse 911 or Black Board Connect, for mass call-outs to targeted areas of the community for emergency notification and/or information.
27	Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat, Earthquakes	Preventive Measures	Provide surge and lightning protection for computer-reliant critical facilities (e.g. County Offices, EOC, and Sheriff's Offices)
28	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Expansive Soils, Wildfires, Earthquakes	Public Information and Education	Train/Educate builders, developers, architects and engineers in techniques of disaster-resistant homebuilding, such as the Fortified Home standards developed by the Institute for Business & Home Safety (IBHS), the Blueprint for Safety guidelines developed by the Federal Alliance for Safe Homes (FLASH)
29	Floods, Tornadoes, High Winds, Hail, Severe Winter Storms, Earthquakes	Preventive Measures	Develop / Review / Update the debris management plan.
30	Floods	Public Information and Education	Inform residents who refuse to vacate the floodplain of floodproofing and flood mitigation alternatives, such as elevation of structure or utilities, diking, etc.

Rank	Hazard	Mitigation Category	Mitigation Measure
31	Wildfires	Preventive Measures	Develop a Wildfire Susceptibility Analysis and Wildfire Mitigation Plan for the vulnerable Rural/Urban Interface area of the community.
32	Floods, Tornadoes, High Winds, Severe Winter Storms, Expansive Soils, Earthquakes, Fixed Site Haz Mat Events, Transportation Events	Preventive Measures	Develop and Implement a Capital Improvements Plan that includes hazard mitigation considerations for flooding, expansive soils, earthquakes, severe winter storms, high winds, tornados, and hazardous materials events.
33	Fixed Site Haz Mat Events	Public Information and Education	Identify populations around potential fixed-site hazmat hazards, and distribute information and materials to support "Shelter-in-Place" actions among home and business owners
34	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Expansive Soils, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Public Information and Education	Develop distribution centers in local libraries, government facilities, and other public buildings where information and safety guidance on natural and man-made hazards can be provided to citizens.
35	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Preventive Measures	Develop a plan to identify and respond to vulnerable populations within the jurisdiction and the agencies that work with those jurisdictions in the event of a disaster.
36	Wildfires	Public Information and Education	Provide public information on controlled burns and use of fire-retardant vegetation.
37	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Expansive Soils, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Preventive Measures	Build or enhance partnerships involving local government officials, civic, business and volunteer groups to work together to mitigate all-hazards.
38	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Emergency Services	Develop an inventory of Special Needs populations requiring special assistance during disasters.

Rank	Hazard	Mitigation Category	Mitigation Measure
39	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Emergency Services	Provide backup facilities for the 911 Center and the Emergency Operations Center.
40	Tornadoes, High Winds	Structural Projects	Provide manufactured home parks with community shelters/safe rooms.
41	Tornadoes, High Winds, Lightning, Hail	Preventive Measures	Designate individuals at jurisdiction recreation facilities and schools that are educated in storm spotting and safety, who have the authority to take proper action. Equip individuals with NOAA radios.
42	Tornadoes, High Winds, Earthquakes	Structural Projects	Install safe-rooms in licensed childcare centers.
43	Tornadoes, High Winds, Earthquakes	Structural Projects	Provide group safe rooms at jurisdiction recreation centers
44	Floods, Dam Failures	Natural Resources Protection	Maintain natural and beneficial functions of streams and floodplains
45	Severe Winter Storms	Preventive Measures	Devise and implement an 'aggressive snow and ice removal plan'
46	Floods	Structural Projects	Construct regional detention ponds to compensate for future urban development
47	Drought	Natural Resources Protection	Prescribed burns of Eastern Red Cedar can mitigate the effects the trees have on groundwater recharge and loss of water table resources. Red Cedars can reduce by up to 40% the amount of moisture reaching the water table.
48	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Expansive Soils, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Public Information and Education	Educate businesses on the availability of Business Interruption Insurance, in the event their business is impacted for a period of time by an unforeseen event.
49	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Expansive Soils, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Public Information and Education	Investigate making educational materials for all hazards standardized, readily available off the shelf, and economical.

Rank	Hazard	Mitigation Category	Mitigation Measure
50	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Expansive Soils, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Preventive Measures	Acquire and utilize GIS and GPS technologies to record and maintain information on private safe rooms and private water wells.
51	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Public Information and Education	Develop a process for updating appropriate disaster safety information for the non-emergency 211 system, such as cooling shelters in extreme heat, and heating shelters in severe winter storms.
52	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Preventive Measures	Train emergency management staff at National Emergency Management Institute.
53	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Emergency Services	Continue educational programs for jurisdiction employees to recognize and render assistance for symptoms of life-threatening emergencies.
54	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Emergency Services	Provide Certified Disaster Training for jurisdiction employees, and coordinate efforts with local CERT Teams.
55	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Preventive Measures	Develop and test site emergency plans for correctional facilities

Rank	Hazard	Mitigation Category	Mitigation Measure
56	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Emergency Services	Develop use of HAM operators as communications source during hazardous events.
57	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Emergency Services	Install street addresses on all buildings and curbs.
58	Floods, Tornadoes, High Winds, Lightning, Hail, Severe Winter Storms, Extreme Heat, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Emergency Services	Teach jurisdiction employees the symptoms of common, life-threatening emergencies and how to administer CPR and first aid.
59	Floods, Tornadoes, High Winds, Severe Winter Storms, Extreme Heat, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Public Information and Education	Develop/continue a program to inform the public on proper evacuation plans for government buildings, businesses, offices, and residences.
60	Floods, Tornadoes, High Winds, Severe Winter Storms, Extreme Heat, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events, Dam Failures, Transportation Events	Emergency Services	Provide emergency equipment for community emergency response teams (CERT)
61	Tornadoes, High Winds, Earthquakes	Public Information and Education	Develop public information and education programs and provide materials about construction methods and mitigation measures that protect a building's roof, outside openings, and the building envelope for overall structural resistance to tornadoes, high winds and earthquakes.
62	Tornadoes, High Winds, Earthquakes	Public Information and Education	Educate local builders on the low cost of adding Roof-to-Wall connectors in new construction which minimizes the impact of Tornadoes, High Winds, and Earthquakes.
63	Tornadoes, High Winds, Hail	Preventive Measures	Record GPS locations of private water wells and underground storm shelters (to rescue potentially trapped storm victims).

Rank	Hazard	Mitigation Category	Mitigation Measure
64	Tornadoes, High Winds, Earthquakes	Property Protection	Cover all exposed fluorescent lighting tubes in county and school facilities with impact resistant plastic coverings
65	Tornadoes, High Winds, Hail	Property Protection	Provide damage-resistant glass replacements for jurisdiction facilities.
66	Urban Fires, Wildfires	Public Information and Education	Investigate and raise public awareness of fire-resistant materials for buildings.
67	High Winds, Severe Winter Storms	Preventive Measures	Encourage utility company tree trimming program to keep trees off power lines during high wind and severe winter storms.
68	Lightning, Urban Fires	Preventive Measures	Ensure that fire extinguishers are strategically placed and properly maintained in all community facilities.
69	Drought, Wildfires	Preventive Measures	Develop a warning plan based on drought conditions and moisture measurements to alert officials of increased risk of drought and wildfire.
70	Drought, Wildfires	Emergency Services	Pre-identify and inventory "water-moving" equipment, including pumps, pipeline, tanker trucks, "water buffaloes" and other resources.
71	Urban Fires, Wildfires	Emergency Services	Review and evaluate the community fire alarm system.
72	Fixed Site Haz Mat Events, Transportation Events	Emergency Services	Train dispatchers in the use of Cameo or other response programs
73	Floods, Dam Failures	Natural Resources Protection	Develop and incorporate warning and evacuation plans and systems for areas at risk from dam failure or large release flooding
74	Floods, Dam Failures	Preventive Measures	Ensure that critical facilities are elevated or flood-proofed to the 500-year flood elevation, be provided access above the 500-year flood elevation, and that new critical facilities are not located within the 500-year floodplain.
75	Floods	Public Information and Education	Inform floodplain residents of the availability of flood insurance to eligible National Flood Insurance Program communities
76	Lightning	Public Information and Education	Educate the community about lightning safety through public service announcements and other media outlets.
77	Lightning	Public Information and Education	Encourage utilities to provide lightning damage prevention information materials and programs to their customers.
78	Lightning	Public Information and Education	Provide lightning injury and damage prevention materials and programs to vulnerable public.
79	Hail	Public Information and Education	Work with insurance companies to provide a public information program that communicates the advantages and costs of hail-resistant roofing.
80	Severe Winter Storms	Public Information and Education	Educate the public on the dangers of carbon monoxide pollution and the use of appropriate heating systems.
81	Severe Winter Storms	Public Information and Education	Provide public education on effective ways to monitor and avoid ice damage, frozen pipes, and damage to roofs due to snow load.

Rank	Hazard	Mitigation Category	Mitigation Measure
82	Extreme Heat	Public Information and Education	Arrange for extra staffing and extended hours when appropriate at designated community facilities.
83	Extreme Heat	Public Information and Education	Educate jurisdiction employees on the symptoms of heat disorders and how to administer first aid.
84	Extreme Heat	Public Information and Education	Encourage residents to get relief during the hottest part of the day at malls, community centers, libraries, recreation centers, and other air-conditioned facilities.
85	Extreme Heat	Public Information and Education	Establish a community hotline for residents to obtain extreme heat-related information.
86	Drought	Public Information and Education	Develop a public information program designed to communicate the potential severity of a drought and the appropriate responses of the local population, including voluntary water conservation measures the public can take.
87	Drought	Public Information and Education	Develop education programs on cross-contamination. Most communities do not require back-flow preventers/valves on residential structures. Low pressure in community drinking water lines can lead to back-flow from residential gray water into primary lines. This can lead to illness throughout the community. Conditions that can lead to cross connections include garden hoses left lying in pools of water, shower hoses in bath tubs, kitchen sink spray nozzles left lying in dirty dish water, and other situations.
88	Drought	Public Information and Education	Organize drought information meetings for the public and the media
89	Expansive Soils	Public Information and Education	Develop and implement a public information strategy that informs citizens and developers of the dangers and costs related to expansive soils.
90	Urban Fires	Public Information and Education	Develop a public education project addressing the advantages of individual fire suppression in residences, including fire extinguishers.
91	Fixed Site Haz Mat Events	Public Information and Education	Distribute information identifying hazardous materials to at risk citizens, such as the elderly, infirm, poor, and outside laborers.
92	Fixed Site Haz Mat Events	Public Information and Education	Institute a countywide public awareness and collection program for household pollutants, illustrating their dangers and identifying disposal information through media, schools, public offices, sheriff's offices, and fire stations.
93	Dam Failures	Public Information and Education	Prepare and distribute a public information document letting people know that they reside or work in a dam failure inundation area.
94	Floods	Preventive Measures	Inventory inadequate bridges.
95	Floods	Preventive Measures	Investigate the feasibility of a stormwater utility fee to fund maintenance of creeks and streams
96	Floods	Preventive Measures	Measure first finished floor above ground surface elevations of all buildings located in the floodplain (SFHA). Reconcile addresses, take pictures, determine depth of flooding, create and enter data into a database

Rank	Hazard	Mitigation Category	Mitigation Measure
97	Floods	Preventive Measures	Obtain elevation certificates for pre-FIRM homes located in the floodplain.
98	Floods	Preventive Measures	Perform the FEMA Full Riverine Module for Benefit/Cost Analysis for Acquisition of 100-Year floodplain buildings with first finished floor below the Base Flood Elevation (BFE), to confirm potential candidates for acquisition and removal from the floodplain.
99	Floods	Preventive Measures	Prepare elevation certificates for floodplain candidate properties for acquisition with positive benefit/cost ratios greater than 1.0
100	Tornadoes	Preventive Measures	Provide technical assistance in obtaining grants for storm shelters/safe rooms in mobile home parks
101	Extreme Heat	Preventive Measures	Develop and promote actions to reduce the effects of community "heat islands," such as increasing the reflectivity of urban surfaces. (eetd.lbl.gov/HeatIsland/) (www.epa.gov/heatisland/)
102	Extreme Heat	Preventive Measures	Establish protocols with local utility providers to suspend utility shutoffs during extreme heat conditions.
103	Extreme Heat	Preventive Measures	Identify and develop a plan to assist with installing window air conditioners for the vulnerable population.
104	Extreme Heat	Preventive Measures	Identify public events scheduled during the hotter times of the year and include a plan to delay, suspend, or move to a cooler part of the day when possible.
105	Extreme Heat	Preventive Measures	Identify the vulnerable population and individuals at risk from extreme heat
106	Drought	Preventive Measures	Develop a replacement program for aging and defective water meters.
107	Drought	Preventive Measures	Develop contacts with the Oklahoma Water Resources Board and the Corps of Engineers to assist in identifying opportunities for future water conservation.
108	Drought	Preventive Measures	Develop information on "water miser" appliances, shower heads, toilets, etc.
109	Drought	Preventive Measures	Examine statutes governing water rights for possible modification during water shortages
110	Drought	Preventive Measures	Identify major "water-dependent" entities in the community, including large water usage employers, hospitals, food services, and so on. Work with those entities to (a) prioritize the most critical facilities, and (b) develop drought contingency plans in the event of water shortages or rationing.
111	Drought	Preventive Measures	Implement water conservation policies, such as low flow plumbing devices, inverted block water rate structure, moisture sensors & the use of grey water for irrigation.
112	Drought	Preventive Measures	Include "water shortage criteria" in all community projects to mitigate drought-related slow-downs during drought years.

Rank	Hazard	Mitigation Category	Mitigation Measure
113	Drought	Preventive Measures	Pre-identify "drought planning teams" comprised of stakeholders in the community, including public works and utility representatives, members of the agricultural and ranching communities, county extension offices, city/county officials and others.
114	Drought	Preventive Measures	Review the use of non-potable water sources to meet community requirements, for example, irrigation and watering of golf courses and city parks.
115	Drought	Preventive Measures	Using water main leak detection survey teams followed by repair and replacement as necessary to reduce water system losses.
116	Drought	Preventive Measures	Work with County Extension Offices and others to develop information on drought tolerant grass varieties and xeriscapes.
117	Drought	Preventive Measures	Work with the Fire Department to develop contingency plans for firefighting during periods when drought conditions may produce decreased water pressure and supply.
118	Expansive Soils	Preventive Measures	Establish an administrative procedure to inform builders when they apply for permits to check for expansive soils.
119	Wildfires	Preventive Measures	Develop a contingency plan for evacuating population endangered by a wildfire.
120	Earthquakes	Preventive Measures	Adopt residential building codes that require earthquake-resistant construction, such as using foundation piers.
121	Earthquakes	Preventive Measures	Provide public and builder awareness that construction techniques for mitigating tornado damage also mitigates damage from minor earthquakes.
122	Fixed Site Haz Mat Events	Preventive Measures	Label sanitary sewer drains to warn citizens against dumping chemicals and automotive fluids into the sanitary sewer drain.
123	Dam Failures	Preventive Measures	Annual inspection of all identified dams: shape of spillway, proper opening and closing of gates, etc.
124	Dam Failures	Preventive Measures	Annually inspect and update municipal dams and keep Emergency Action Plan up to date and on file at OWRB
125	Dam Failures	Preventive Measures	Develop GIS modeling program for mapping appropriate cubic feet per second (CFS) dam release rates
126	Dam Failures	Preventive Measures	Prepare contingency plans for terrorist attacks on local dams.
127	Dam Failures	Preventive Measures	Update US Army Corps of Engineers hydrology and hydraulics for dams.
128	Transportation Events	Preventive Measures	Study routing of hazardous materials through the jurisdiction.
129	Floods	Structural Projects	Apply for mitigation funding for backflow valves for commercial, industrial and multi-family buildings
130	Floods	Structural Projects	Construct all new bridges to pass 100-year regulatory flood without overtopping
131	Floods	Structural Projects	Eliminate storm-water infiltration and inflow (I&I) into the sanitary sewer system.

Rank	Hazard	Mitigation Category	Mitigation Measure
132	Floods	Structural Projects	Maintain culverts to adequately allow stormwater drainage
133	Tornadoes	Structural Projects	Investigate a voluntary pilot program for mobile home communities to provide a storm shelter / safe-room for residents.
134	Tornadoes	Structural Projects	Investigate community tornado shelter programs implemented in other cities or states
135	Hail	Structural Projects	Provide hail-resistant measures/materials to protect existing public infrastructure improvements.
136	Severe Winter Storms	Structural Projects	Review the possible critical structural "snow load" thresholds on flat-roofed community or critical facilities
137	Drought	Structural Projects	Implement minor structural measures to obtain temporary water supplies from inactive or dead storage or from ground water sources
138	Expansive Soils	Structural Projects	Provide information on landscaping techniques that can mitigate foundation damage due to expansive soils, such as xeriscaping, increased drainage, and providing sloping areas next to a structure.
139	Wildfires	Structural Projects	Create fire breaks along fence rows to thwart road jumping.
140	Earthquakes	Structural Projects	Provide information to local builders encouraging building reinforcements against wind and tornado damage will also protect against the minor earthquakes projected for the area.
141	Floods	Property Protection	Compensate for the impacts of new bridges and channel improvements.
142	Lightning	Property Protection	Construct lightning rods for protection of critical facilities.
143	Lightning	Property Protection	Install surge protection in existing critical facilities and provide where necessary
144	Lightning	Property Protection	Provide educational demonstrations and information in whole-house surge protection technology.
145	Hail	Property Protection	Provide covered shelter for local government vehicles (e.g., Sheriff's Vehicles)
146	Drought	Emergency Services	In drought plans, include measures to minimize fish and wildlife impacts
147	Wildfires	Emergency Services	Develop protocols for support by non-profit agencies during wildfire situations where mobile vehicles and canteen operations could find themselves in harm's way during the incident.
148	Fixed Site Haz Mat Events	Emergency Services	Develop a "Quick Response Guide to Local Hazardous Material Sites" with evacuation maps and chemical details of local Tier 2 facilities for emergency responders
149	Fixed Site Haz Mat Events	Emergency Services	Develop and reinforce hazardous materials emergency equipment and response teams.
150	Dam Failures	Emergency Services	Develop profile of who lives or works in the floodway below a high hazard dam.

Rank	Hazard	Mitigation Category	Mitigation Measure
151	Transportation Events	Emergency Services	Improve awareness of pipeline routes and materials transported through the Pipeline Group information available to city emergency management officials (www.pipelinegroup.com)
152	Floods	Natural Resources Protection	Control erosion during development with vegetation or sediment capture, reducing sedimentation which may fill in channels and lakes, reducing their ability to carry or store floodwaters.
153	Floods	Natural Resources Protection	Include appropriate native vegetation along stream and river banks that resist erosion, possibly "retrofitting" the shoreline with willow cuttings, wetland plants, or rolls of landscape material until the bank can be stabilized by plant roots.
154	Floods	Natural Resources Protection	Include recreation opportunities, off-street hiking and biking trails, and other enhancements in floodwater control and retention projects.
155	Floods	Natural Resources Protection	Look for opportunities to maintain habitat for flora and fauna in flood control projects. Maintaining or developing wetlands may be an effective area to receive or reduce floodwaters.
156	Extreme Heat	Natural Resources Protection	Increase urban vegetation and improve landscaping to reduce the effects of "urban heat islands."
157	Drought	Natural Resources Protection	Enact a policy to increase and protect instream flows and wetlands
158	Dam Failures	Natural Resources Protection	Include measures to promote effective use of regulated downstream areas from dams to facilitate beneficial uses of the property for Park, Recreation, and Wildlife Management

Chapter 7: Plan Maintenance and Adoption

This chapter includes a discussion of the plan maintenance process and documentation of the adoption of the plan by the Tulsa County Citizens Advisory Committee, and the Tulsa County Commissioners.

Included in this Chapter:

7.1 Monitoring, Evaluating, and Updating the Plan

Tulsa County will ensure that a regular review and update of the Multi-Hazard Mitigation Plan occurs. The Hazard Mitigation Citizens' Advisory Committee (HMCAC) will continue to meet on a semi-annual basis, or as conditions warrant, to oversee and review updates and revisions to the plan. The County Engineer will continue to head the Technical Advisory Committee, which will monitor and oversee the day-to-day implementation of the plan. The plan will be updated and resubmitted to the State and FEMA for approval every five years, as per FEMA requirements.

Monitoring the Plan- Monitoring of the Plan, the Action Plan, and Mitigation Measures is the responsibility of the Emergency Manager, County Commissioners, 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 HMCAC on progress and/or impediments to progress of the mitigation measures.

Evaluating the Plan- The Tulsa County Multi-Hazard Mitigation Plan will be continually evaluated by the Project Manager, and a report will be made to the HMCAC twice each year. 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 County's Capital Improvements Plan process. These programs will continue to be monitored and updated on an annual basis, if not more often.

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

1. Revise and Update- the County will incorporate revisions to the plan document identified during the monitoring and evaluation period, as well as items identified in the previous Crosswalk.
2. Submit for Review- the revised plan will be submitted to ODEM and FEMA through the State Hazard Mitigation Officer for review and approval, and to FEMA no later than six (6) months prior to the end of the original performance period.
3. Final Revision and Adoption- if necessary, the plan will be revised per ODEM and FEMA remarks, adopted by the Tulsa County Commission, and the updated plan sent to FEMA prior to the expiration of the 5-year approval period.

7.2 Public Involvement

Tulsa County 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 Tulsa City-County Public Library, and the plan will be placed on the Tulsa County Website.

A public meeting will be held prior to submission of the update of the Tulsa County Multi-Hazard Mitigation Plan. This meeting will be advertised to the general citizenry, and will 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.

7.3 Incorporating the Multi-Hazard Mitigation Plan

Tulsa County's local planning mechanisms available for incorporating the recommendations and requirements of the Hazard Mitigation Measures are listed below. The Tulsa County Multi-Hazard Mitigation Plan will be adopted by the Tulsa County Commission as an amendment to the County's Comprehensive Plan. The Tulsa County Commissioners will adopt the plan as a guide to county 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
- Tulsa County Building Code
- Tulsa County Emergency Operations Plan
- Tulsa County Water and Sewer Plan

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 to the HMCAC on a semi-annual basis as to the progress made on each measure, identifying successes and impediments to their implementation.

To be included on the following pages of this chapter are Resolutions of Adoption of the Tulsa County Multi-Hazard Mitigation Plan:

1. Tulsa County Commissioners

APPROVED
JUL 19 2010

RESOLUTION

ADOPTING THE TULSA COUNTY MULTI-HAZARD MITIGATION PLAN

WHEREAS, Tulsa County and its environs are subject to danger and damage from flooding, tornadoes, high winds, lightning, wildfire and other natural hazards; and

WHEREAS, several different agencies, organizations and business have programs that can address these hazards or their impact, but there is an overriding need for a comprehensive, coordinated plan to assess the problems faced by the County and measures that are and can be brought to bear on them; and

WHEREAS, Tulsa County would benefit from the development and adoption of a multi-hazard mitigation plan; and

WHEREAS, the 2000 Stafford Act mandates that jurisdictions must have a multi-hazard mitigation plan before they can apply for funds from the Hazard Mitigation Grant Program and Pre-Disaster Mitigation Grant Program; and

WHEREAS, Tulsa County was awarded a Hazard Mitigation Grant Program planning grant in the amount of $60,000 and Tulsa County provided local funds and in-kind services to prepare a hazard mitigation plan for the County; and

WHEREAS, the Tulsa County Commission, after due and proper notice and hearing, has considered said Multi-Hazard Mitigation Plan and has determined that it is in the best interest of the citizens of Tulsa County to approve such a plan.

NOW, THEREFORE, BE IT RESOLVED BY THE COUNTY COMMISSION OF TULSA COUNTY, OKLAHOMA:

Section 1. That the *Tulsa County Multi-Hazard Mitigation Plan*, made a part of this resolution, together with any and all graphic representations referenced in this *Multi-Hazard Mitigation Plan*, are hereby approved;

Section 2: That upon its adoption, this plan should be considered as an amendment to the *Tulsa County Comprehensive Plan* and County Ordinances;

Section 3: That copies of the *Multi-Hazard Mitigation Plan* will be maintained in the County Courthouse and Tulsa City-County Public Library.

PASSED BY THE COUNTY COMMISSION OF TULSA COUNTY, OKLAHOMA, THIS 19 DAY OF July, 2010

John Smaligo., District #1

Karen Keith., District #2

Fred Perry., District #3

Attest:

County Clerk Earlene Wilson

Appendix A: Glossary of Terms

Anchoring: Special connections made to ensure that a building will not float off, blow off or be pushed off its foundation during a flood or storm.

Base Flood: Flood that has a 1 percent probability of being equaled or exceeded in any given year. Also known as the 100-year flood.

Base Flood Elevation (BFE): Elevation of the base flood in relation to a specified datum, such as the National Geodetic Vertical Datum of 1929. The Base Flood Elevation is used as the standard for the National Flood Insurance Program.

Basement: Any floor level below grade.

Bedrock: The solid rock that underlies loose material, such as soil, sand, clay, or gravel.

Building: A structure that is walled and roofed, principally above ground and permanently affixed to a site. The term includes a manufactured home on a permanent foundation on which the wheels and axles carry no weight.

Community Rating System (CRS): A National Flood Insurance Program (NFIP) that provides incentives for NFIP communities to complete activities that reduce flood hazard risk. When the community completes specified activities, the insurance premiums of policyholders in these communities are reduced.

Computer-Aided Design And Drafting (CADD): A computerized system enabling quick and accurate electronic 2-D and 3-D drawings, topographic mapping, site plans, and profile/cross-section drawings.

Consequences: The damages, injuries, and loss of life, property, environment, and business that can be quantified by some unit of measure, often in economic or financial terms.

Contour: A line of equal ground elevation on a topographic (contour) map.

Critical Facility: Facilities that are critical to the health and welfare of the population and that are especially important during and following hazard events. Critical facilities include shelters, police and fire stations, schools, childcare centers, senior citizen centers, hospitals, disability centers, vehicle and equipment storage facilities, emergency operations centers, and city hall. The term also includes buildings or locations that, if damaged, would create secondary disasters, such as hazardous materials facilities, vulnerable facilities, day care centers, nursing homes, and housing likely to contain occupants who are not very mobile. Other critical city infrastructure such as telephone exchanges and water treatment plants are referred to as lifelines. See Lifelines.

Dam Breach Inundation Area**:** The area flooded by a dam failure or programmed release.

Debris**:** The scattered remains of assets broken or destroyed in a hazard event. Debris caused by a wind or water hazard event can cause additional damage to other assets.

Development**:** Any man-made change to real estate.

Digitize: To convert electronically points, lines, and area boundaries shown on maps into x, y coordinates (e.g., latitude and longitude, universal transverse mercator (UTM), or table coordinates) for use in computer applications.

Duration**:** How long a hazard event lasts.

Earthquake**:** A sudden motion or trembling that is caused by a release of strain accumulated within or along the edge of earth's tectonic plates.

Emergency**:** Any hurricane, tornado, storm, flood, high water, wind-driven water, tidal wave, tsunami, earthquake, volcanic eruption, landslide, mudslide, snowstorm, drought, fire, explosion, or other catastrophe in any part of the United States which requires federal emergency assistance to supplement State and local efforts to save lives and protect property, public health and safety, or to avert or lessen the threat of a disaster. Defined in Title V of Public Law 93-288, Section 102(1).

Emergency Operations Center (EOC)**:** A facility that houses communications equipment that is used to coordinate the response to a disaster or emergency.

Emergency Operations Plan (EOP)**:** Sets forth actions to be taken by State or local governments for response to emergencies or major disasters.

Emergency Response Plan**:** A document that contains information on the actions that may be taken by a governmental jurisdiction to protect people and property before, during, and after a disaster.

Extent**:** The size of an area affected by a hazard or hazard event.

Fault**:** A fracture in the continuity of a rock formation caused by a shifting or dislodging of the earth's crust, in which adjacent surfaces are differentially displaced parallel to the plane of fracture.

Federal Emergency Management Agency (FEMA)**:** The independent agency created in 1978 to provide a single point of accountability for all Federal activities related to disaster mitigation and emergency preparedness, response and recovery.

***FIPS*:** Stands for Federal Information Processing Standards. Under the Information Technology Management Reform Act (Public Law 104-106), the Secretary of Commerce approves standards and guidelines that are developed by the National Institute of Standards and Technology (NIST) for Federal computer systems. These standards and guidelines are issued by NIST as Federal Information Processing Standards (FIPS) for use government-wide. NIST develops FIPS when there are compelling Federal government requirements such as for security and interoperability and there are no acceptable industry standards or solutions.

***Fire Potential Index (FPI)*:** Developed by United States Geological Survey (USGS) and United States Forest Service (USFS) to assess and map fire hazard potential over broad areas. Based on such geographic information, national policy makers and on-the-ground fire managers established priorities for prevention activities in the defined area to reduce the risk of managed and wildfire ignition and spread. Prediction of fire hazard shortens the time between fire ignition and initial attack by enabling fire managers to pre-allocate and stage suppression forces to high fire risk areas.

***Flash Flood*:** A flood event occurring with little or no warning where water levels rise at an extremely fast rate.

***Flood*:** A general and temporary condition of partial or complete inundation of normally dry land areas from (1) the overflow of inland or tidal waters, (2) the unusual and rapid accumulation or runoff of surface waters from any source, or (3) mudflows or the sudden collapse of shoreline land.

***Flood Depth*:** Height of the flood water surface above the ground surface.

***Flood Elevation*:** Elevation of the water surface above an established datum, e.g. National Geodetic Vertical Datum of 1929, North American Vertical Datum of 1988, or Mean Sea Level.

***Flood Hazard Area*:** The area shown to be inundated by a flood of a given magnitude on a map.

***Flood Insurance Rate Map (FIRM)*:** Map of a community, prepared by the Federal Emergency Management Agency, which shows both the special flood hazard areas and the risk premium zones applicable to the community.

***Flood Insurance Study (FIS)*:** A study that provides an examination, evaluation, and determination of flood hazards and, if appropriate, corresponding water surface elevations in a community or communities.

***Flood Mitigation Assistance Program (FMA)*:** A planning and project implementation grant program funded by the National Flood Insurance Program. Provides pre-disaster grants to State and local governments for both planning and implementation of mitigation strategies. Grant funds are made available from NFIP insurance premiums, and therefore are only available to communities participating in the NFIP.

Flood of Record**:** The highest known flood level for the area, as recorded in historical documents.

Floodplain**:** Any land area, including watercourse, susceptible to partial or complete inundation by water from any source.

Floodproofing**:** Protective measures added to or incorporated in a building to prevent or minimize flood damage. "Dry floodproofing" measures are designed to keep water from entering a building. "Wet floodproofing" measures minimize damage to a structure and its contents from water that is allowed into a building.

Floodway**:** The stream channel and that portion of the adjacent floodplain which must remain open to permit conveyance of the base flood. Floodwaters are generally the swiftest and deepest in the floodway. The floodway should remain clear of buildings and impediments to the flow of water.

Freeboard**:** A margin of safety added to a protection measure to account for waves, debris, miscalculations, lack of scientific data, floodplain fill, or upstream development.

Frequency**:** A measure of how often events of a particular magnitude are expected to occur. Frequency describes how often a hazard of a specific magnitude, duration, and/or extent typically occurs, on average. Statistically, a hazard with a 100-year recurrence interval is expected to occur once every 100 years on average, and would have a 1 percent chance – its probability – of happening in any given year. The reliability of this information varies depending on the kind of hazard being considered.

Fujita Scale of Tornado Intensity**:** Rates tornadoes with numeric values from F0 to F5 based on tornado wind speed and damage sustained. An F0 indicates minimal damage such as broken tree limbs or signs, while an F5 indicates severe damage sustained.

Functional Downtime**:** The average time (in days) during which a function (business or service) is unable to provide its services due to a hazard event.

Geographic Area Impacted**:** The physical area in which the effects of the hazard are experienced.

Geographic Information System (GIS)**:** A computer software application that relates physical features on the earth to a database to be used for mapping and analysis.

Ground Motion**:** The vibration or shaking of the ground during an earthquake. When a fault ruptures, seismic waves radiate, causing the ground to vibrate. The severity of the vibration increases with the amount of energy released and decreases with distance from the causative fault or epicenter, but soft soils can further amplify ground motions.

***Hazard*:** A source of potential danger or adverse condition. An event or physical condition that has the potential to cause fatalities, injuries, property and infrastructure damage, agriculture loss, damage to the environment, interruption of business, or other types of harm or loss. Hazards, as defined in this study, will include naturally occurring events such as floods, dam failures, levee failures, tornadoes, high winds, hailstorms, lightning, winter storms, extreme heat, drought, expansive soils, urban fires, wildfires that strike populated areas, and earthquakes. A natural event is a hazard when it has the potential to harm people or property. For purposes of this study, hazardous materials events are also included.

***Hazard Event*:** A specific occurrence of a particular type of hazard.

***Hazard Identification*:** The process of defining and describing a hazard, including its physical characteristics, magnitude and severity, probability and frequency, causative factors, and locations or areas affected.

***Hazard Mitigation*:** Sustained actions taken to reduce or eliminate long-term risk to human life and property from natural and technological hazards and their effects. Note that this emphasis on long-term risk distinguishes mitigation from actions geared primarily to emergency preparedness and short-term recovery.

***Hazard Mitigation Grant Program (HMGP)*:** Authorized under Section 404 of the Stafford Act; a FEMA disaster assistance grant program that funds mitigation projects in conformance with post-disaster mitigation plans required under Section 409 of the Stafford Act. The program is available only after a Presidential disaster declaration.

***Hazard Mitigation Plan*:** The plan resulting from a systematic evaluation of the nature and extent of vulnerability to the effects of natural hazards present in society that includes the actions needed to minimize future vulnerability to hazards. Section 409 of the Stafford Act requires the identification and evaluation of mitigation opportunities, and that all repairs be made to applicable codes and standards, as condition for receiving Federal disaster assistance. Enacted to encourage identification and mitigation of hazards at all levels of government.

***Hazard Profile*:** A description of the physical characteristics of hazards and a determination of various descriptors including magnitude, duration, frequency, probability, and extent. In most cases, a community can most easily use these descriptors when they are recorded and displayed as maps.

***HAZUS (Hazards U.S.)*:** A GIS-based nationally standardized earthquake loss estimation tool developed by FEMA.

***Hydrology*:** The science of dealing with the waters of the earth. A flood discharge is developed by a hydrologic study.

***Infrastructure*:** The public services of a community that have a direct impact on the quality of life. Infrastructure includes communication technology such as phone lines or Internet access, vital services such as public water supplies and sewer treatment facilities, and includes an area's transportation system such as airports, heliports; highways, bridges, tunnels, roadbeds, overpasses, railways, bridges, rail yards, depots, and waterways, canals, locks, and regional dams.

Insurance Service Office, Inc. (ISO)**:** An insurance organization that administers several programs that rate a community's hazard mitigation activities.

Intensity**:** A measure of the effects of a hazard event at a particular place.

Landslide**:** Downward movement of a slope and materials under the force of gravity.

Lifelines**:** Systems necessary for human life and urban function, especially during emergencies. Transportation and utility systems, as well as emergency service facilities are considered the lifelines of a community. Transportation systems include interstate, US, and state highways, roadways, railways, waterways, ports, harbors, and airports. Utility systems consist of electric power, gas and liquid fuels, telecommunications, water, and wastewater. Emergency service facilities include Emergency Alert System communication facilities, hospitals, and the police and fire departments.

Liquefaction**:** The phenomenon that occurs when ground shaking causes loose soils to lose strength and act like viscous fluid. Liquefaction causes two types of ground failure: lateral spread and loss of bearing strength.

Lowest Floor**:** Under the NFIP, the lowest floor of the lowest enclosed area (including basement) of a structure.

Magnitude**:** A measure of the strength of a hazard event. The magnitude (also referred to as severity) of a given hazard event is usually determined using technical measures specific to the hazard.

Mitigation**:** Sustained action taken to reduce or eliminate the long-term risk to human life and property from natural and technological hazards and their effects. Note that this emphasis on long-term risk distinguishes mitigation from actions geared primarily to emergency preparedness and short-term recovery (Burby, 1998).

National Flood Insurance Program (NFIP)**:** A federal program created by Congress in 1968 that provides the availability of flood insurance to communities in exchange for the adoption and enforcement of a minimum floodplain management ordinance specified in 44 CFR §60.3. The ordinance regulates new and substantially damaged or improved development in identified flood hazard areas.

National Geodetic Vertical Datum of 1929 (NGVD)**:** Datum established in 1929 and used in the NFIP as a basis for measuring flood, ground, and structural elevations, previously referred to as Sea Level Datum or Mean Sea Level. The Base Flood Elevations shown on most of the Flood Insurance Rate Maps issued by the Federal Emergency Management Agency are referenced to NGVD.

National Weather Service (NWS)**:** Prepares and issues flood, severe weather, and coastal storm warnings and can provide technical assistance to Federal and state entities in preparing weather and flood warning plans.

Oklahoma Department of Civil Emergency Management (ODCEM)**:** The State department responsible for hazard mitigation, community preparedness, emergency response, and disaster recovery.

Oklahoma Water Resources Board (OWRB)**:** The State agency responsible for administration of the National Flood Insurance Program, and the dam safety program.

Planimetric**:** Describes maps that indicate only man-made features like buildings.

Planning**:** The act or process of making or carrying out plans; the establishment of goals, policies and procedures for a social or economic unit.

Planning for Post-Disaster Reconstruction**:** The process of planning (preferably prior to an actual disaster) those steps the community will take to implement long-term reconstruction with one of the primary goals being to reduce or minimize its vulnerability to future disasters. These measures can include a wide variety of land-use planning tools, such as acquisition, design review, zoning, and subdivision review procedures. It can also involve coordination with other types of plans and agencies but is distinct from planning for emergency operations, such as restoration of utility services and basic infrastructure.

Preparedness**:** Activities to ensure that people are ready for a disaster and respond to it effectively. Preparedness requires figuring out what will be done if essential services break down, developing a plan for contingencies, and practicing the plan.

Probability**:** A statistical measure of the likelihood that a hazard event will occur.

Project Impact**:** A program that encourages business, government agencies and the public to work together to build disaster-resistant communities.

Reconstruction**:** The long-term process of rebuilding the community's destroyed or damaged buildings, public facilities, or other structures.

Recovery**:** The process of restoring normal public or utility services following a disaster, perhaps starting during but extending beyond the emergency period to that point when the vast majority of such services, including electricity, water, communications, and public transportation have resumed normal operations. Recovery activities necessary to rebuild after a disaster include rebuilding homes, businesses and public facilities, clearing debris, repairing roads and bridges, and restoring water, sewer and other essential services. Short-term recovery does not include the reconstruction of the built environment, although reconstruction may commence during this period.

Recurrence Interval**:** The time between hazard events of similar size in a given location. It is based on the probability that the given event will be equaled or exceeded in any given year.

Repetitive Loss Property**:** A property that is currently insured for which two or more National Flood Insurance Program losses (occurring more than ten days apart) of at least $1000 each have been paid within any 10-year period since 1978. While Repetitive Loss Properties constitute only 2% of insured properties, they account for 40% of flood damage claims against the NFIP.

Replacement Value**:** The cost of rebuilding a structure. This is usually expressed in terms of cost per square foot, and reflects the present-day cost of labor and materials to construct a building of a particular size, type and quality.

Retrofitting**:** Modifications to a building or other structure to reduce its susceptibility to damage by a hazard.

Richter Scale**:** A numerical scale of earthquake magnitude devised by seismologist C.F. Richter in 1935.

Risk**:** The estimated impact that a hazard would have on people, services, facilities, and structures in a community; the likelihood of a hazard event resulting in an adverse condition that causes injury or damage. Risk is often expressed in relative terms such as a high, moderate or low likelihood of sustaining damage above a particular threshold due to a specific type of hazard event. It also can be expressed in terms of potential monetary losses associated with the intensity of the hazard.

Risk Assessment**:** A process or method for evaluating risk associated with a specific hazard and defined in terms of probability and frequency of occurrence, magnitude and severity, exposure and consequences. Also defined as: "The process of measuring the potential loss of life, personal property, housing, public facilities, equipment, and infrastructure; lost jobs, business earnings, and lost revenues, as well as indirect losses caused by interruption of business and production; and the public cost of planning, preparedness, mitigation, response, and recovery. (Burby, 1998).

Riverine**:** Of or produced by a river.

Scale*:* A proportion used in determining a dimensional relationship; the ratio of the distance between two points on a map and the actual distance between the two points on the earth's surface.

Scarp**:** A steep slope.

Scour**:** Removal of soil or fill material by the flow of flood waters. The term is frequently used to describe storm-induced, localized conical erosion around pilings and other foundation supports where the obstruction of flow increases turbulence.

Seismicity**:** Describes the likelihood of an area being subject to earthquakes.

Special Flood Hazard Area (SFHA)**:** An area within a floodplain having a 1 percent or greater chance of flood occurrence in any given year (100-year floodplain); represented on Flood Insurance Rate Maps by darkly shaded areas with zone designations that include the letter A or V.

Stafford Act**:** The Robert T. Stafford Disaster Relief and Emergency Assistance Act, PL 100-107 was signed into law November 23, 1988 and amended the Disaster Relief Act of 1974, PL 93-288. The Stafford Act is the statutory authority for most Federal disaster response activities, especially as they pertain to FEMA and its programs.

State Hazard Mitigation Team**:** Composed of key State agency representatives, the team evaluates hazards, identifies strategies, coordinates resources, and implements measures that will reduce the vulnerability of people and property to damage from hazards. The Oklahoma State Hazard Mitigation Team is convened by the Oklahoma Department of Civil Emergency Management (ODCEM), and includes the State departments of Agriculture, Climatological Survey, Commerce, Environmental Quality, Health, Human Services, Insurance, Transportation, Wildlife Conservation, Conservation Commission, Corporation Commission, Historical Society, Insurance Commission, Water Resources Board, Association of County Commissioners (AACCO), Oklahoma Municipal League (OML), Department of Housing and Urban Development (HUD), and the U.S. Army Corps of Engineers (USACE).

State Hazard Mitigation Officer (SHMO)**:** The representative of state government who is the primary point of contact with FEMA, other state and Federal agencies, and local units of government in the planning and implementation of pre- and post-disaster mitigation activities.

Stormwater Management**:** Efforts to reduce the impact of stormwater or snowmelt runoff on flooding and water quality.

Stormwater Detention**:** The storing of stormwater runoff for release at a restricted rate after the storm subsides, or the flood crest passes.

Substantial Damage**:** Damage of any origin sustained by a structure in a Special Flood Hazard Area whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage.

Surface Faulting**:** The differential movement of two sides of a fracture – in other words, the location where the ground breaks apart. The length, width, and displacement of the ground characterize surface faults.

Tectonic Plate**:** Torsionally rigid, thin segments of the earth's lithosphere that may be assumed to move horizontally and adjoin other plates. It is the friction between plate boundaries that cause seismic activity.

Topographic**:** Characterizes maps that show natural features and indicate the physical shape of the land using contour lines. These maps may also include man-made features.

***Tornado*:** A violently rotating column of air extending from a thunderstorm to the ground.

***Vulnerability*:** Describes how exposed or susceptible to damage an asset is. Vulnerability depends on an asset's construction, contents, and the economic value of its functions. Like indirect damages, the vulnerability of one element of the community is often related to the vulnerability of another. For example, many businesses depend on uninterrupted electrical power – if an electric substation is flooded, it will affect not only the substation itself, but a number of businesses as well. Often, indirect effects can be much more widespread and damaging than direct ones.

***Vulnerability Assessment*:** The extent of injury and damage that may result from a hazard event of a given intensity in a given area. The vulnerability assessment should address impacts of hazard events on the existing and future built environment.

***Wildfire*:** An uncontrolled fire spreading through vegetative fuels, exposing and possibly consuming structures.

***Zone*:** A geographical area shown on a Flood Insurance Rate Map (FIRM) that reflects the severity or type of flooding in the area.

Appendix B: Mitigation Strategies

The following items illustrate many of the broad mitigation strategies that communities, tribes, counties, and other entities can implement to help protect lives, property and the environment in their jurisdictions. The following grid lists the six basic mitigation categories outlined by FEMA (introduced in Chapter 2), the strategies that fall in those categories, and the hazards those strategies may be effective for.

Many of the strategies, while listed in one category, may have elements that include other categories as well. For example, almost all strategies have a Public Information & Education component, where homeowners and business owners are educated about possible measures they may take on their own.

Table B–1: List of Mitigation Strategies

Category	Mitigation Strategy		Hazards Impacted
Public Information & Education	B.1.1	Public Information Program Strategy	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Extreme Heat, Drought, Expansive Soils, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.1.2	Educational Programs	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Extreme Heat, Drought, Expansive Soils, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.1.3	Outreach Projects	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Extreme Heat, Drought, Expansive Soils, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.1.4	Technical Assistance	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Extreme Heat, Drought, Expansive Soils, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.1.5	Map Information	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Extreme Heat, Drought, Expansive Soils, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.1.6	Library	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Extreme Heat, Drought, Expansive Soils, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation

Category	Mitigation Strategy		Hazards Impacted
	B.1.7	Websites	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Extreme Heat, Drought, Expansive Soils, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.1.8	Real Estate Disclosure	Flood, Expansive Soils
	B.1.9	FireWise Communities	Wildfire
	B.1.10	Business Continuity Planning & Mitigation	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Extreme Heat, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
Preventive Measures	B.2.1	Planning	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Extreme Heat, Drought, Expansive Soils, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.2.2	Zoning	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Extreme Heat, Drought, Expansive Soils, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.2.3	Floodplain Development Regulations	Flood, Dam Failure
	B.2.4	Stormwater Management	Flood, Dam Failure
	B.2.5	Building Codes	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Expansive Soil, Urban Fire, Wildfire, Earthquake
	B.2.6	IBHS Fortified Home Program	Flood, Tornado, High Wind, Lightning, Hail, Urban Fire, Wildfire, Earthquake
	B.2.7	Smoke Detectors	Urban Fire
	B.2.8	Hurricane Fasteners	Tornado, High Wind, Earthquake
	B.2.9	Mobile Home Tie-Downs	Tornado, High Wind
	B.2.10	Lightning Warning Systems	Lightning
	B.2.11	Power Outages from Winter Storms	Winter Storm, Lightning
	B.2.12	Standby Electric Generators	Tornado, High Wind, Lightning, Winter Storm
	B.2.13	Critical Facility Protection	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Extreme Heat, Drought, Expansive Soils, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.2.14	Extreme Heat Protection	Extreme Heat
	B.2.15	Proper Storage & Disposal of Hazardous Materials	Hazardous Material
	B.2.16	Water Conservation	Drought
	B.2.17	Open Space Preservation	Flood, Drought, Dam Failure
Structural Projects	B.3.1	Safe Rooms	Tornado, High Wind
	B.3.2	School Safe Rooms	Tornado, High Wind
	B.3.3	Reservoirs and Detention	Flood

Category	Mitigation Strategy		Hazards Impacted
	B.3.4	Levees & Floodwalls	Flood, Dam Failure
	B.3.5	Channel Improvements	Flood, Dam Failure
	B.3.6	Crossings and Roadways	Flood, Dam Failure
	B.3.7	Drainage and Storm Sewer Improvements	Flood, Dam Failure
	B.3.8	Drainage System Maintenance	Flood, Dam Failure
Property Protection	B.4.1	The Community's Role	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Extreme Heat, Drought, Expansive Soils, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.4.2	Insurance	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Urban Fire, Wildfire, Earthquake, Dam Failure, Transportation
	B.4.3	Acquisition and Relocation	Flood
	B.4.4	Building Elevation	Flood, Dam Failure
	B.4.5	Barriers	Flood, Dam Failure
	B.4.6	Retrofitting	Flood, Tornado, High Wind, Lightning, Hail, Expansive Soil, Wildfire, Earthquake
	B.4.7	Impact Resistant Windows & Doors	Tornado, High Wind, Hail
	B.4.8	Impact Resistant Roofing	Tornado, High Wind, Hail
	B.4.9	Lightning Protection Systems	Lightning
	B.4.10	Surge and Spike Protection	Lightning
	B.4.11	Landscaping for Wildfire Prevention	Wildfire
Emergency Services	B.5.1	Threat Recognition	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Extreme Heat, Drought, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.5.2	Warning	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Extreme Heat, Drought, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.5.3	9-1-1 and 2-1-1	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Extreme Heat, Drought, Expansive Soils, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.5.4	Emergency Telephone Notification Systems (ETNS)	Flood, Winter Storm, Extreme Heat, Urban Fire, Wildfire, Hazardous Material
	B.5.5	Response	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Extreme Heat, Drought, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.5.6	Emergency Operations Plan (EOP)	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation

Category	Mitigation Strategy		Hazards Impacted
	B.5.7	Incident Command System (ICS)	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.5.8	Mutual Aid / Interagency Agreements	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.5.9	CERT (Community Emergency Response Teams)	Flood, Tornado, High Wind, Winter Storm, Extreme Heat, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.5.10	Debris Management	Flood, Tornado, High Wind, Winter Storm, Wildfire, Earthquake
	B.5.11	Critical Facilities Protection	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.5.12	Site Emergency Plans	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.5.13	Post-Disaster Recovery & Mitigation	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Urban Fire, Wildfire, Earthquake, Hazardous Material, Dam Failure, Transportation
	B.5.14	StormReady Communities	Flood, Tornado, High Wind, Hail, Winter Storm
Natural Resource Protection	B.6.1	Wetland Protection	Flood, Wildfire
	B.6.2	Erosion and Sedimentation Control	Flood, Wildfire
	B.6.3	River Restoration	Flood, Wildfire, Hazardous Material
	B.6.4	Best Management Practices	Flood, Hazardous Material
	B.6.5	Dumping Regulations	Flood, Tornado, High Winds, Winter Storm, Hazardous Material

B.1 Public Information and Education

A successful public information and education program involves both the public and private sectors. Public information and education activities advise and educate residents, property owners, renters, businesses, and local officials about hazards and ways to protect people and property from them. Public information activities are among the least expensive mitigation measures, and at the same time are often the most effective thing a community can do to save lives and property. All mitigation activities – preventive, structural, property protection, emergency services, and natural resource protection – begin with public information and education.

B.1.1 Public Information Program Strategy

Getting Your Message Out
Professional advertising agencies may be willing to help get the message out regarding disaster preparedness and mitigation at little or no cost. They have a vested interest in their community and want to keep it safe. The same holds true for the media. The local newspaper, radio or television will contribute to keeping a safe and prepared community. Invite them to, and let them participate in special events, meetings, practice exercises, etc.

Education alliance partners, such as restaurants, convenience stores or the library, can put preparedness tips on tray liners or sacks, distribute brochures or allow you to erect a display with disaster information of local interest.

Many other options are available such as including brochures with utility bills, presentations at local gatherings, billboards, direct mailing and websites. See an example of a sample Flood Safety flyer at the end of this section, Figure B-1.

Summer camps, and other educational programs for children, can teach a new generation about nature, natural hazards, and preservation.

General
Numerous publications on tornadoes, thunderstorms, lightning, winter storms and flooding are available through NOAA. Up to 300 copies of most publications can be ordered from your local National Weather Service, NOAA Outreach Unit or American Red Cross. Many of the brochures can be downloaded from www.nws.noaa.gov/om/brochures.shtml.

For a nominal fee the American Red Cross offers videos on general preparedness, winter storms, chemical emergencies, hurricanes and earthquakes.

The National Weather Service issues watches and warnings for tornadoes, severe thunderstorms, floods, winter storms and extreme heat that may include “Call to Action” statements. The messages appear on the NWS telephone line, the local weather service office website and on television stations carrying Emergency Alert System messages.

Communities can encourage residents to prepare themselves by stocking up with necessary items and planning for how family members should respond if any of a number of possible emergency or disaster events strike.

Hazard Brochures

Area agencies or the American Red Cross have available the book *Repairing Your Flooded Home* and fliers *Are You Ready for a Flood?* and *Avoiding Flood Damage.* For a summary of what to do after a tornado see www.redcross.org/services/disaster/0,1082,0_502_,00.html. The brochure *Taking Shelter From the Storm: Building a Safe Room for your Home or Small Business* is available from FEMA. A copy of the brochure can be requested from the FEMA website www.fema.gov/library/viewRecord.do?id=1536. *Are You Ready for a Tornado?* is available from the American Red Cross, FEMA and the National Oceanic and Atmospheric Administration. Area agencies or the American Red Cross have available the fliers *Are You Ready For a Heat Wave? Are You Ready For a Winter Storm?* and *Are You Ready For a Thunderstorm?*

After reviewing possible and locally implemented public information activities covered in the previous sections, a community may develop a strategy based on the Community Rating System format, including the following components:

a. The local hazards, discussed in Chapter 4 of this plan

b. The safety and property protection measures appropriate for the hazards, discussed in Chapter 5 and this Appendix.

c. Hazard-related public information activities currently being implemented in the community or Tribe, including those by non-government agencies (discussed in Chapter 2)

d. Goals and Objectives for the community's public information program (covered in Chapter 5)

e. Outreach projects that will reach the goals (see Chapter 6, Action Items and Table 6-2.)

f. A process for monitoring and evaluating the projects (see Chapter 7)

B.1.2 Educational Programs

A community's most important natural resource is its children. They will inherit the resources, infrastructure and development built by earlier generations at great cost and effort. They will also face the same natural forces that bring floods, tornadoes, storms and other hazards.

Environmental education programs can teach children about natural hazards, the forces that cause them, and the importance of protecting people, property and nature, such as watersheds and floodplains. Educational programs can be undertaken by schools, park and recreation departments, conservation associations, and youth organizations, such as the Boy Scouts, Campfire Girls and summer camps. An activity can be complex enough as to require course curriculum development, or as simple as an explanatory sign near a river.

Educational programs designed for children often reach adults as well. Parents often learn innovative concepts or new ideas from their children. If a child comes home from school with an assignment in natural hazard safety, the parents will normally become interested in finding out about it as well.

There are many programs that provide information and curriculum materials on nature and natural hazards. On FEMA website www.fema.gov/kids/ children can learn about having a family disaster plan, what they might feel in and following a disaster, what the different disasters are, what to do during a disaster, take quizzes and play games. There is also information on how to get a free video, brochures and other fun stuff.

Another site, for students and educators on water resources, is the USGS "Water Science for Schools" http://ga.usgs.gov/edu/. The American Red Cross has a 24-page *Disaster Preparedness Coloring Book* for kids age 3-10. The coloring book is available online and can be printed from www.redcross.org/pubs/dspubs/genprep.html.

Youth programs and activities often include posters, coloring books, games, and references. Hands-on models that allow students to see the effects of different land use practices are also available through local natural resources conservation districts.

B.1.3 Outreach Projects

Mapping and library activities are of little use if no one knows they exist. An outreach project can remedy this. Sending notices to property owners can help introduce the idea of property protection and identify sources of assistance.

Outreach projects are the first step in the process of orienting property owners to property protection and assisting them in designing and implementing a project. They are designed to encourage people to seek out more information in order to take steps to protect themselves and their properties.

The most effective types of outreach projects are mailed or otherwise distributed to flood-prone property owners or to everyone in the community. Other approaches may include the following:

- articles and special sections in newspapers;
- radio and TV news releases and interview shows;
- hazard protection video for cable TV programs or to loan to organizations;
- presentations at meetings of neighborhood, civic or business/professional groups;
- displays in public buildings or shopping malls;

- open houses about floodproofing.

Research has proven that outreach projects work. However, awareness of the hazard is not enough. People need to be told what they can do about the hazard, so projects should include information on safety, health, and property protection measures. Research has also shown that a properly run local information program is more effective than national advertising or publicity campaigns.

B.1.4 Technical Assistance

While general information helps, most property owners do not feel ready to take major steps, like retrofitting their buildings, without help or guidance. Check with your local community government, Tribal resource or Chamber of Commerce to see what expert guidance, such as a Home Builders Association or Remodelers Council, may be available in your area. Experienced construction specialists can provide advice, not necessarily to design a protection measure, but to steer the owner onto the right track.

Local building, public works, or engineering staff members may be available to visit properties and offer suggestions. Most can recommend or identify qualified or licensed companies, an important resource for owners who are unsure of the project or the contractor.

Other new construction or retrofitting guidance and resources, such as the National Storm Shelter Association or the Institute for Business and Home Safety's *Fortified…for Safer Living* program, are available on the websites listed in Table B-2.

B.1.5 Map Information

Many benefits stem from providing map information to inquirers. Residents and businesses that are aware of the potential hazards can take steps to avoid problems and reduce their exposure to flooding, dam failure or releases, expansive soils, hazardous materials events, and other hazards that have a geographical distribution. Real estate agents and house hunters can find out if a property is flood-prone and whether flood insurance may be required.

Maps provide a wealth of information about past and potential hazards. Geographic Information Systems, sometimes called smart maps, provide efficiency and add to capabilities of many government services. Assessors, public works, parks and recreation, and 911 services are all typical departments capable of applying GIS applications to improve their services. GIS allows trained users to complete comprehensive queries, extract statistical information, and completely manage all relevant spatial information and the associated attribute information that pertain to those departments.

Flood maps

Several legal requirements are tied to FEMA's Flood Insurance Rate Maps (FIRMs) and Flood Insurance Study Maps. These include building regulations and the mandatory purchase of flood insurance. FEMA provides floodplain and FIRM information as a mitigation service. Local government can help residents submit requests for map amendments and revisions when these are needed to show that a building is outside the mapped floodplain.

Although FEMA maps are accurate, users and inquirers must remember that maps are not perfect. They display only the larger flood-prone areas that have been studied. In some areas, watershed developments make even recent maps outdated. Those inquiring about flood maps must be reminded that being outside the mapped floodplain is no guarantee that a property will never flood. In fact, many properties that flood are not located in a designated floodplain.

By taking the initiative locally to accurately map problem areas with information not already on FEMA maps, a community can warn residents about potential risks that may not have been anticipated. Upgrading maps provides a truer measure of risks to a community.

Other Hazard Data

Other data that can be shown on maps include those hazards that are distributed geographically. These include:

- dam breach inundation areas;
- levee failure inundation areas;
- expansive soils;
- wildfire risk zones;
- earthquake risk zones;
- hazardous materials sites;
- wetlands.

General location maps for many of these natural and man-made hazards have been developed by U. S. Army Corps of Engineers, Association of South Central Governments (ASCOG), Oklahoma Geological Survey, and Flanagan & Associates, LLC, several of which are included in this Multi-Hazard Disaster Mitigation Plan study.

Flood zone determinations are usually available, possibly free of charge, to any resident through a local Floodplain Administrator or other local government office. If the determination is for a building permit, local ordinances must be followed.

B.1.6 Library

The local Public Library is a place for residents to seek information on hazards, hazard protection, and protecting natural resources. Historically, libraries have been the first place people turn to when they want to research a topic. Interested property owners can read or check out handbooks or other publications that cover their situation. The libraries also have their own public information campaigns with displays, lectures, and other projects, which can augment the activities of the local government.

The local public library System may maintain flood related documents, available to library patrons, required under the NFIP and CRS.

B.1.7 Websites

Today, Websites are becoming more popular as research tools. They provide quick access to a wealth of public and private sites and sources of information. Through links to other Websites, there is almost no limit to the amount of up to date information that can be accessed by the user.

Most communities, counties or Tribes have a local website where safety information can be made available to local residents. FEMA's Mapping Website is at http://msc.fema.gov. Additional websites related to specific hazards are listed in the following table.

Websites have become one of the more popular research tools

Table B–2: Disaster Safety and Mitigation Websites

Agency	***Web Address***
	General
American Red Cross	www.redcross.org/services/prepare/0,1082,0_239_,00.html
Federal Alliance for Safe Homes (FLASH)	www.flash.org
Federal Emergency Management Agency	www.fema.gov
Oklahoma Dept. of Emergency Management	www.odcem.state.ok.us
Institute for Business and Home Safety (IBHS)	www.ibhs.org/
National Clearinghouse for Educational Facilities	www.edfacilities.org
USGS - Hazards Page	www.usgs.gov/themes/hazard.html
	Floods
CDC – Floods	http://emergency.cdc.gov/disasters/floods/
FLASH – Floods	www.flash.org/activity.cfm?currentPeril=2
Oklahoma Water Resources Board	www.owrb.state.ok.us/
Oklahoma Floodplain Managers Association	www.okflood.org/
U.S. Army Corps of Engineers	www.usace.army.mil/
National Flood Insurance Program	www.fema.gov/nfip/whonfip.shtm
Stormwater Manager's Resource Center	www.stormwatercenter.net/
USGS – Floods	www.usgs.gov/hazards/
	High Winds / Tornadoes
CDC – Tornadoes	http://emergency.cdc.gov/disasters/tornadoes/
FLASH – Tornadoes	www.flash.org/activity.cfm?currentPeril=3
National Climatic Data Center	www.ncdc.noaa.gov/oa/ncdc.html
The Tornado Project Online	www.tornadoproject.com/
	Lightning
FLASH – Lightning	www.flash.org/activity.cfm?currentPeril=4
National Lightning Safety Institute	www.lightningsafety.com/nlsi_lls.html
	Hailstorms
FLASH – Hail	www.flash.org/activity.cfm?currentPeril=5
	Winter Storms

Agency	Web Address
American Red Cross – Power Outage	www.redcross.org/services/prepare/0,1082
American Red Cross – Winter Storms	www.redcross.org/services/prepare/0,1082,0_252_,00.html
CDC – Winter Weather	http://emergency.cdc.gov/disasters/winter/
FLASH – Power Outages	www.flash.org/activity.cfm?currentPeril=13
FLASH – Winter Storms	www.flash.org/activity.cfm?currentPeril=15
Extreme Heat	
American Red Cross – Heatwaves	www.redcross.org/services/prepare/0,1082,0_243_,00.html
Centers for Disease Control & Prevention (CDC)	http://emergency.cdc.gov/disasters/extremeheat/
National Weather Service – Heat Index	www.hpc.ncep.noaa.gov/heat_index.shtml
Drought	
American Red Cross – Drought	www.redcross.org/services/prepare/0,1082,0_95_,00.html
OWRB - Drought Monitoring Page	www.owrb.state.ok.us/supply/drought/drought_index.php
Expansive Soils	
US Department of Agriculture	www.usda.gov/
Natural Resource Conservation Service	www.nrcs.usda.gov/
Urban Fires	
Oklahoma State Fire Marshal's Office	www.oklaosf.state.ok.us/~firemar/
National Fire protection Association	www.nfpa.org
Wildfires	
CDC – Wildfires	http://www.bt.cdc.gov/disasters/wildfires/
FireWise Communities	www.firewise.org
FLASH – Wildfire	www.flash.org/activity.cfm?currentPeril=8
USGS Wildfires	www.usgs.gov/themes/wildfire.html
Earthquakes	
CDC – Earthquakes	http://emergency.cdc.gov/disasters/earthquakes/
FLASH – Earthquake	www.flash.org/activity.cfm?currentPeril=7
U.S. Geological Survey	www.usgs.gov/hazards/earthquakes/
Oklahoma Geological Survey	www.okgeosurvey1.gov/home.html
National Geophysical Data Center	www.ngdc.noaa.gov/
Hazardous Materials Events	
National Response Center	www.nrc.uscg.mil
National Transportation Safety Board	www.ntsb.gov/
Oklahoma Department of Environmental Quality	www.deq.state.ok.us/
Environmental Protection Agency	www.epa.gov
Dam Failures	
Oklahoma Water Resources Board	www.owrb.state.ok.us/
US Army Corps of Engineers	www.usace.army.mil/
Grand River Dam Authority	www.grda.com/

B.1.8 Real Estate Disclosure

After a flood or other natural disaster, people often say they would have taken steps to protect themselves if they had known their property was exposed to a hazard.

Flooding and other hazards are sometimes not disclosed until it is too late. Hazard maps can help homebuyers avoid surprises like this.

Flood insurance is required for buildings located within the base floodplain if the mortgage or loan is federally insured. However, because this requirement has to be met only ten days before closing, applicants are often already committed to purchasing a property when they first learn of the flood hazard.

The "Residential Property Condition Disclosure Act" requires sellers to provide potential buyers with a completed, signed and dated "Residential Property Condition Disclosure Statement". Included in the statement are disclosures regarding flooding and flood insurance. For a copy of the "Residential Property Condition Disclosure Statement" see www.orec.state.ok.us/pdf/disclose3.pdf.

B.1.9 Firewise Communities

While incorporating components from several of the different mitigation strategies, The Firewise program primarily depends on homeowners taking actions to protect their own property. Therefore Public Education and Information is a key factor to its success. While it is not possible, or in many cases even desirable, to prevent wildfires, it is certainly possible, by interrupting the natural flow of the fire, to assure that wildfires will not produce catastrophic home or crop losses. In the words of Judith Cook, Project Manager for Firewise Communities/USA, "We can modify our home ignition zones. We're basically saying to the fire, 'there's nothing for you here!'"

Firewise Community USA is a project of the National Wildfire Coordinating Group. It recognizes communities that have gone through a process to reduce the dangers of wildfires along what is referred to as the Wildland-Urban Interface (WUI). Additional information on the Firewise Community program can be found at www.firewise.org/usa.

In order to become a Firewise Community, a community will:

1. Contact a Firewise Specialist. In Oklahoma, the Firewise Specialist may be reached through the Oklahoma Department of Agriculture, Forestry Services, at (405) 521-3864. The Specialist will coordinate with local fire officials to schedule a site visit and assess the community.

2. The community will create a Firewise Board that includes homeowners, fire professionals, and other stakeholders.
3. The Firewise Specialist will schedule a meeting with the Board to present the assessment report for review and acceptance.
4. The Board will use the report to create agreed-upon, area-specific solutions to the fire issues, which the Specialist will review and, if acceptable, will work with the community to seek project implementation funds, if necessary.

A home in the WUI surrounded by a “defensible” zone that helped protect it from damage during a wildfire outbreak.

5. Local solutions will be implemented following a schedule designed by the local Board and the Specialist, A permanent Firewise task force or committee is created that will maintain the program into the future.
6. A completed plan and registration form will be submitted to Firewise Communities/USA for formal recognition of the Community.
7. An important consideration to remember is that if a community or Tribe covers a larger jurisdiction, it may be appropriate to identify smaller areas, such as a homeowner’s addition, that can be developed independently of the community at large. The smaller project can then serve as a model program for other homeowner’s associations or planning groups to develop programs in their at-risk area.

B.1.10 Business Continuity Planning and Mitigation

While Business Continuity Planning (BCP) can include portions from many of the categories listed in this chapter, an integrated program for small and medium businesses and non-profits is a frequently neglected component in a community’s mitigation strategy. It has been demonstrated repeatedly that many businesses and non-profits that close their doors following a disaster either fail to re-open, or struggle to remain open following the event. This is especially true of smaller businesses that may rely on a limited number of locations and a

Insurance is a start, but won’t cover the cost of lost sales, lost jobs and lost customers if a business is affected.

narrow customer base, or may not have the economic reserves to recover from financial losses. The lack of ability to recover may be for several reasons:

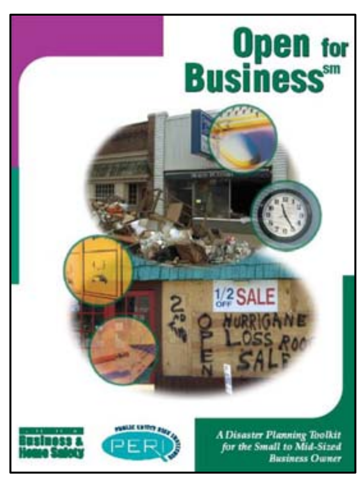
- absenteeism from employees who are affected or who have affected family members;
- psychological trauma from losing co-workers;
- loss of an irreplaceable executive or manager;
- economic stress on the business from having to make repairs and replenish stock over and above what may be covered by insurance;
- loss of revenue from having the doors closed for even a short period of time;
- loss of the customer base, either from people who are forced to evacuate the area or who may not have immediate disposable income for the company's products;
- loss of a critical customer or the vendor of a critical inventory item ("upstream" and "downstream" issues);
- loss of critical data, either paper or electronic records;
- an interruption in community or Tribal infrastructure (utilities, road access, media losses, etc.).

In addition, the loss of a business, even for a short period of time, may adversely affect the community or Tribe in many ways, some of which may include:

- loss of tax revenue for community services;
- loss of jobs for community residents;
- loss of access to the company's products (especially significant if the company supplies an essential service or product, such as construction equipment, medications, transportation, or groceries);

Effective Business Continuity Planning (BCP) may include such activities as:

- making regular back-ups of critical data and keeping it in an off-site location;
- maintaining accurate contact information (phone, e-mail, pager, etc.) on critical employees;
- identifying potential off-site locations that can be used in case the primary location of the company is damaged or inaccessible;
- reviewing all activities of a company and identifying which activities are critical and must resume right away, which are less critical and may not need to resume for a short period of time, and which activities can be put on hold for a longer period of time;
- developing "canned" PR pieces that can be quickly disseminated in the event of an incident at the company;
- having an honest conversation with insurers to determine that policies are sufficiently inclusive and appropriate for the business;
- communicating with suppliers and critical customers on



what their emergency response and business resumption plans include.

Business continuity planning can be facilitated by the community in a number of ways, primarily in the area of Public Information.

- The Chamber of Commerce may sponsor programs such as the Institute for Business & Home Safety's (IBHS) *Open For Business* presentation. For more information, see www.ibhs.org/business_protection.
- The American Red Cross has also teamed with the Federal Emergency Management Agency to produce the *Emergency Management Guide for Business and Industry*. More information is available at www.redcross.org/services/disaster/0,1082,0_606_,00.html.

Several professional groups such as the Association of Contingency Planners (www.acp-international.com/okla/) or ARMA, a professional organization of Records & Information Management professionals (www.arma.org) may be available in your area to assist with developing disaster preparedness and mitigation plans or exploring ways to safeguard critical records and information.

In addition, if a community, Tribe or other entity (such as a University) is promoting Community Emergency Response Teams (CERT), business CERTs can be developed to respond to a disaster, not only within a neighborhood, but also within a business establishment. CERTs are trained in disaster organization, immediate disaster evaluation, immediate disaster first aid, light search and rescue, and light fire suppression. For more information on CERT, see www.citizencorps.gov/cert.

B.1.11 Conclusions

1. There are many ways public information programs can be used so people and businesses will be more aware of hazards they face and how they can protect themselves.
2. Most public information activities can be used to advise people about all hazards, not just floods.
3. Other public information activities require coordination with other organizations, such as schools and real estate agents.
4. There are several area organizations that can provide support for public information and educational programs.
5. Developing effective strategies for small businesses and non-profits is as critical as for other elements of the communities.

B.1.12 Recommendations

Refer to *Chapter 6: Action Plan and Mitigation Measures,* Table 6–2, for a complete listing of all recommended mitigation measures by hazard and priority.

Figure B–1: A Sample Public Service Notice for Flooding

Flood Safety

- Do not walk through flowing water. Drowning is the number one cause of flood deaths. Currents can be deceptive; six inches of moving water can knock you off your feet. Use a pole or stick to ensure that the ground is still there before you go through an area where the water is not flowing.
- Do not drive through a flooded area. More people drown in their cars than anywhere else. Don't drive around road barriers; the road or bridge may be washed out.
- Stay away from power lines and electrical wires. The number two flood killer after drowning is electrocution. Electrical current can travel through water. Immediately report downed power lines to your local fire department.
- Look out for animals that have been flooded out of their homes and who may seek shelter in yours. Use a pole or stick to poke and turn things over and scare away small animals.
- Look before you step. After a flood, the ground and floors are covered with debris including broken bottles and nails. Floors and stairs that have been covered with mud can be very slippery.
- Be alert for gas leaks. Use a flashlight to inspect for damage. Don't smoke or use candles, lanterns, or an open flame unless you know the gas has been turned off and the area has been ventilated.
- Carbon monoxide exhaust kills. Use a generator or other gasoline-powered machine outdoors. The same goes for camping stoves. Charcoal fumes are especially deadly -- cook with charcoal outdoors.
- Clean everything that got wet. Floodwaters have picked up sewage and chemicals from roads, farms, factories, and storage buildings. Spoiled food, flooded cosmetics, and medicine can be health hazards. When in doubt, throw them out.
- Take good care of yourself. Recovering from a flood is a big job. It is tough on both the body and the spirit and the effects a disaster has on you and your family may last a long time.

B.2 Preventive Measures

Preventive activities are designed to keep matters from occurring or getting worse. Their objective is to ensure that future development does not increase damages or loss of life, and that new or remodeled construction is protected from those hazards. Preventive measures are often administered by building, zoning, planning, and code enforcement offices. They typically include planning, zoning, open space preservation, building codes, drainage criteria, Flood & Drainage Annex to the Hazard Mitigation plan and floodplain development regulations, and stormwater management. In addition, there are a number of other ways to make homes and commercial structures stronger and less vulnerable to the effects of disasters.

The first three measures (planning, zoning, and open space preservation) work to keep damage-prone development *out* of hazardous or sensitive areas.

The next two measures (building codes and floodplain development regulations) impose standards on what is allowed to be built *in* the floodplain. These protect buildings, roads, and other facilities from flood damage and prevent the new development from making any existing flood problem worse. Building codes are also critical to mitigating the impact of non-flood hazards on new buildings.

Stormwater management addresses the runoff of stormwater from new developments onto other properties and into floodplains.

The mitigation planning process involves meetings with civic groups and local residents, as well as with decision-making councils and commissions

B.2.1 Planning

While plans generally have limited authority, they reflect what the community would like to see happen in the future. Plans guide other local measures such as capital improvements and the development of ordinances. Planning can include, but is not limited to:

• Capital Improvement Plans	Infrastructure planning decisions can affect flood hazard mitigation. For example, decisions to extend roads or utilities to an area may increase exposure. Communities may consider structural flood protections such as levees or floodwalls.
• Flood & Drainage Annex to the Hazard Mitigation Plan	A Flood & Drainage Annex to the Hazard Mitigation Plan (FDAHMP) addresses the current and future drainage needs of a given community. The boundary of the plan usually follows regional watershed limits. The proposed facilities may include channels, storm drains, levees, basins, dams, wetlands or any other conveyance capable of economically relieving flooding

	problems within the plan area. The plan includes an estimate of facility capacity, sizes and costs. FDAHMP's are prepared for a variety of purposes. First, the plans provide a guide for the orderly development of the community. Second, they provide an estimate of costs to resolve flooding issues within a community. Community or Tribal officials will use FDAHMP's to determine Capital expenditures for each budget year. Finally, the plans can be used to establish Area Drainage Plan fees for a given community, which prevent existing taxpayers from having to shoulder the burden of land development costs.
• Zoning Ordinance Adoption or Amendments	Examples of zoning methods that affect flood hazard mitigation include: 1. adopting ordinances that limit development in the floodplain; 2. limiting the density of developments in the floodplain; 3. requiring floodplains be kept as open space.
• Subdivision Ordinances or Amendments	Subdivision design standards can require elevation data collection during the platting process. Lots may be required to have buildable space above the base flood elevation.
• Building Code Adoption or Amendments	Requirements for building design standards and enforcement include that: 1. a residential structure be elevated; 2. a non-residential structure be elevated or floodproofed.
• Conservation Easements	Conservation easements may be used to protect environmentally significant portions of parcels from development. They do not restrict all use of the land. Rather, they direct development to areas of land not environmentally significant.
• Transfer of Development Rights	In return for keeping floodplain areas in open space, a community may agree to allow a developer to increase densities on another parcel that is not at risk. This allows a developer to recoup losses from non-use of a floodplain site with gains from development of a non-floodplain site.
• Purchase of Easement / Development Rights	Compensating an owner for partial rights, such as easement or development rights, can prevent a property from being developed contrary to a community’s plan to maintain open space. This may apply to undeveloped land generally or to farmland in particular.
• Stormwater Management Ordinances or Amendments	Stormwater ordinances may regulate development in upland areas in order to reduce stormwater run-off. Examples of erosion control techniques that may be employed within a watershed include proper bank stabilization with sloping or grading techniques, planting vegetation on slopes, terracing hillsides, or installing riprap boulders or geotextile fabric.

- **Multi-Jurisdiction Cooperation Within Watershed** — Forming a regional watershed council helps bring together resources for comprehensive analysis, planning, decision-making, and cooperation.
- **Comprehensive Watershed Tax** — A tax can be used as a mitigation action in several ways:
  1. Tax funds may be used to finance maintenance of drainage systems or to construct reservoirs.
  2. Tax assessments may discourage builders from constructing in a given area.
  3. Taxes may be used to support a regulatory system.
- **Post-Disaster Recovery Ordinance** — A post-disaster recovery ordinance regulates repair activity, generally depending on property location. It prepares a community to respond to a disaster event in an orderly fashion by requiring homeowners to:
  1. obtain permits for repairs;
  2. refrain from making repairs;
  3. make repairs using standard methods.

  While many communities will attempt to build back rapidly just as they were before, it is far preferable to build back stronger and more disaster resistant.

B.2.2 Zoning

A community's zoning ordinances should regulate development by dividing the community into zones or districts and setting development criteria for each zone or district. Zoning ordinances are considered the primary tool to implement a comprehensive plan's guidelines for how land should be developed.

B.2.3 Floodplain Development Regulations

Most communities with a flood problem participate in the National Flood Insurance Program (NFIP). The NFIP sets minimum requirements for subdivision regulations and building codes. These are usually spelled out in a separate ordinance.

Experience shows that the National Flood Insurance Program's minimum standard is insufficient for developing urban communities. A community's regulations may exceed the NFIP's minimum national standards in several significant ways.

The Community Rating System (CRS) is a companion program to the NFIP. It rewards a community for taking actions over and above minimum NFIP requirements with the goal of further reducing flood damages in the jurisdiction. The more actions a community or Tribe takes, the lower the premiums for flood insurance within that community.

Subdivision regulations govern how land will be subdivided into individual lots, and set the construction and location standards for the infrastructure the developer builds to serve those lots, including roads, sidewalks, utility lines, storm sewers, and drainageways. They provide an additional vehicle for floodplain development rules. For example, some communities require that every subdivision in a floodplain provide a building site above the flood level for every lot and/or require streets to be at or no more than one foot below the base flood elevation.

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. The development of a comprehensive, basin-wide Flood & Drainage Annex to the Hazard Mitigation Plan that identifies existing and potential future drainage and flooding problems to public facilities and private property can be a vital tool in disaster mitigation planning.

Minimum National Flood Insurance Program Regulatory Requirements

The National Flood Insurance Program (NFIP) is administered by the Federal Emergency Management Agency (FEMA). As a condition of making flood insurance available for their residents, communities that participate in the NFIP agree to regulate new construction in the area subject to inundation by the 100-year (base) flood.

There are four major floodplain regulatory requirements. State and local law may set additional floodplain regulatory requirements.

1. All development in the 100-year floodplain must have a permit from the community. The NFIP regulations define “development” as any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operations or storage of equipment or materials.
2. Development should not be allowed in the floodway. The NFIP regulations define the floodway as the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot. The floodway is usually the most hazardous area of a riverine floodplain and the most sensitive to development. At a minimum, no development in the floodway may cause an obstruction to flood flows. Generally an engineering study must be performed to determine whether an obstruction will be created.
3. New buildings may be built in the floodplain, but they must be protected from damage by the base flood. In riverine floodplains, the lowest floor of residential buildings must be elevated to or above the base flood elevation (BFE). Nonresidential buildings must be either elevated or floodproofed.
4. Under the NFIP, a “substantially improved” building is treated as a new building. The NFIP regulations define “substantial improvement” as any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the start of construction of the improvement. This requirement also applies to buildings that are substantially damaged.

Communities are encouraged to adopt local ordinances that are more comprehensive or provide more protection than the state or Federal criteria. This is especially important in areas with older Flood Insurance Rate Maps that may not reflect the current hazard. Such ordinances could include prohibiting certain types of highly damage-prone uses from the floodway or requiring that structures be elevated 1 or more feet above the BFE. The NFIP’s Community Rating System provides insurance premium credits to recognize the additional flood protection benefit of higher regulatory standards.

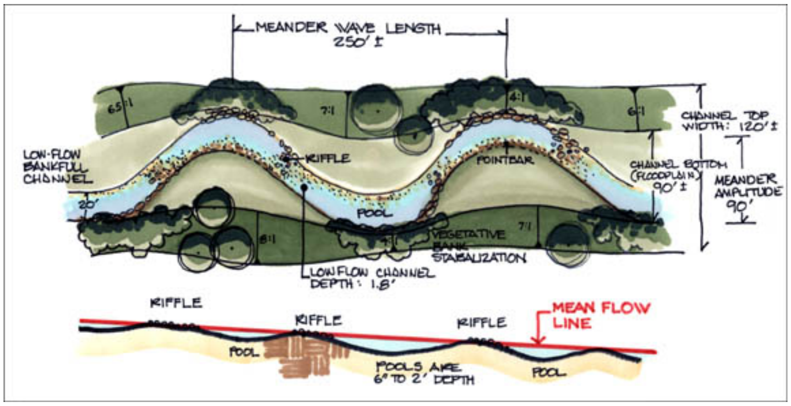
B.2.4 Stormwater Management

Development outside a floodplain can contribute significantly to flooding problems. Runoff is increased when natural ground cover is replaced by urban development. To prevent stormwater from flooding roads and buildings, developers construct storm sewers and improve ditches to carry the water away more efficiently.

As watersheds develop, runoff usually becomes deeper and faster and floods become more frequent. 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 that NFIP floodplain maps must be based on existing watershed development, but unless plans and regulations are based on future watershed urbanization, development permitted today may flood tomorrow as uphill urbanization increases runoff.

This combination of increased runoff and more efficient stormwater channels leads to increases in downstream storm peaks and changes in the timing when storm peaks move downstream. Unconstrained watershed development often will overload a community's drainage system and aggravate downstream flooding.



In addition to detention facilities, stormwater management plans can include restoring some channelized streams with meanders and native vegetation to slow runoff and prevent flash flooding.

A second problem with stormwater is its impact on water quality. Runoff from developed areas picks up pollutants on the ground, such as road oil and lawn chemicals, and carries them to the receiving streams.

Oklahoma communities that participate in the NFIP are listed at www.fema.gov/cis/OK.pdf.

Retention / Detention

Some communities with stormwater management regulations require developers to build retention or detention basins to minimize the increases in the runoff rate caused by impervious surfaces and new drainage systems. Generally, each development must not let stormwater leave at a higher rate than under pre-development conditions. It is recommended that communities require a drainage plan from new developments.

The Community Rating System (CRS) uses three factors to measure the impact of stormwater management regulations on downstream flooding:

1. What developments have to account for their runoff? If only larger subdivisions have to detain the increased runoff, the cumulative effect of many small projects can still produce greater flows to downstream properties.

2. How much water is managed? Historically, local stormwater management programs address smaller storms, such as the 2- or 10-year storms. The CRS reflects the growing realization nationally that the runoff from larger storms must be managed. It provides full credit only for programs that address all storms up to the 100-year storm.

3. Who is responsible to ensure that the facility works over time? Roads and sewers are located on dedicated public rights-of-way and the community assumes the job of maintaining them in the future. Stormwater management detention basins have traditionally stayed on private property and maintenance has been left up to the owner. Often homeowners associations do not know how and do not have the capability to properly maintain these facilities. The community receives up to 110 points if the community assumes responsibility to ensure that the facilities are maintained.

Stormwater Detention Ponds manage the increased runoff from new developments, temporarily store flood waters, and can be used for community parks, recreation, and open-space.

Watershed Approaches

The standard regulatory approach of requiring each development to manage stormwater to the same criteria has several shortcomings:

1. It does not account for differences in stream and watershed conditions (although the standards can be revised to reflect findings from watershed studies).

2. Municipalities within the same watershed may require different levels of control of stormwater.

3. There is no review of the downstream impacts from runoff or any determination of whether the usual standards compound existing flooding problems.

4. It results in many small basins on private property that may or may not be properly maintained.

The way to correct these deficiencies is to conduct a master study of the watershed to determine the appropriate standards for different areas and, sometimes, to identify where a larger central basin would be more effective and efficient than many smaller ones. The CRS program provides up to 225 points if communities adopt such master plans.

B.2.5 Building Codes

Hazard protection standards for all new and improved or repaired buildings can be incorporated into the local building code. These standards should include criteria to ensure that the foundation will withstand flood forces and that all portions of the building subject to damage are above, or otherwise protected from, flooding.

Building codes are also a prime mitigation measure for other natural hazards, especially earthquakes, tornadoes, windstorms and heat and cold. When properly designed and constructed according to code, the average building can withstand the impacts of most of these forces. The code could include provisions such as:

- requiring sprinkler systems for fire protection in larger or public buildings;
- regulating overhanging masonry elements that can fall during an earthquake;
- ensuring that foundations are strong enough for earth movement and that all structural elements are properly connected to the foundation;
- making sure roofing systems will handle high winds and expected snow loads.

Ideally, current codes should include elements from the most recent International Building Codes (IBC), which includes the International Residential Code, the Plumbing Code, Mechanical Code, Fire Code, and Residential and Fuel Gas Codes. For additional information on International Building Codes, see www.iccsafe.org.

B.2.6 IBHS Fortified Home Program

What is a Fortified Home

The *Fortified…for Safer Living* home program gives builders and homeowners a set of criteria for upgrades that help reduce the risk of damage from natural disasters. The program raises a homes' overall safety above building code minimum requirements. During construction and upon completion a home is inspected and certified as a "Fortified…for Safer Living" home.

The combination of materials and techniques produces residences equipped to better resist hurricanes, tornadoes, fire and floods. The fortified home construction method produces homes that are comfortable while being resistant to natural disasters.

The following are features of a "Fortified…for Safer Living" home:

- The home and critical utilities are elevated by reinforced continuous piles a minimum of two feet above ground-level walls, stairs and Base Flood Elevation (BFE).
- The home is connected from the peak of the roof to the foot of the reinforced piles to form a continuous load path capable of withstanding 130 mph winds.
- Windows, doors and other openings are properly flashed and protected to withstand the impact of windborne debris without penetration of wind and water.

- The roof truss system has a 110 mph wind rated covering, a secondary moisture barrier, twice the required underlayment, thicker plywood deck sheathing and a stronger holding nail and nailing pattern.
- Other features include non-combustible roof materials, reinforced entry garage doors and landscaping techniques reducing wildfire and flooding vulnerability.
- A certified inspector verifies all required Fortified home products and materials are installed correctly in accordance with manufacturer's specifications for "Fortified…for Safer Living" program specifications.
- The home and property are also verified to be a low risk hazard for exposure to wildfire.

More information about Fortified Home guidelines is available at www.disastersafety.org/text.asp?id=fortified.

Economics of a Fortified Home

Cost (new home)

Depending on the quality of the material the buyer chooses, the cost to add fortified features could be as low as five percent of the total cost of a new home. See the following table, from the Institute of Business and Home Safety (IBHS) for a typical upgrade.

Table B–3: Cost Differentials for Fortified Home vs. standard Construction

As-built base home price: $151,500 (including lot and options, before "Fortified" upgrade).

	Standard Home	"Fortified" Home	Incremental Cost to "Fortify"
Windows and doors	5,450*	$15,500** ($7,700)	$10,050 ($2,250)
Garage doors	$650	$1,250	$600
Roof decking	$650	$1,750	$1,100
Sealing roof joints	$0	$650	$650
Roof covering	$2,350	$3,350	$1,000
Concrete/steel down pours	$0	$500	$500
Fortified inspection costs	$0	$1,000	$1,000
		Total increment cost:	$14,900 ($7,100)
		Percentage of base cost:	9.8% (4.7%***)

* Based on selection of PGT® window & door products.
** Fortified with PGT® WinGuard™ impact-resistant windows & doors.
*** Cost of panel shutters instead of impact-resistant windows.

Cost (existing home)

Many of the fortification techniques used to build new homes are too expensive as retrofits. Fortifying is much more expensive when a home is already built. However, there are creative ways to reduce costs and still fortify an existing home. Improving roof decking on an existing structure would cost about $5,000. For $50 a certain type of glue gun available in most hardware stores can retrofit a roof as effectively as if a new roof had been put on with wood screws.

Savings

In Florida, a fortified home can save homeowners over 20% in insurance premiums. A standard brick, stone, or masonry house in a coastal area, with a deductible of $500 and a 2% hurricane deductible, would generate an annual premium of $2,240. In contrast, the same home with the additional fortified construction features would pay an annual premium of $1,746, a savings of $504, or 22.5%. Also, underwriting guidelines may be relaxed for fortified homes. Insurers may make exceptions for fortified homes in areas where they wouldn't normally write policies.

Lower deductibles may be available. In Florida, policies covering wind damage typically have a deductible of 2% of the covered amount. On a $150,000 home the deductible would be $3,000. Fortified homeowners may be eligible for a flat deductible of $500.

As for intangible savings, personal photographs, important family documents and computer data are just a few of the items a fortified home may protect. Additionally there is the inconvenience and cost of other living arrangements while a home is being rebuilt.

For more information about one insurer's guidelines on insuring fortified homes see www.roughnotes.com/rnmagazine/search/general_articles/01_08p52.htm.

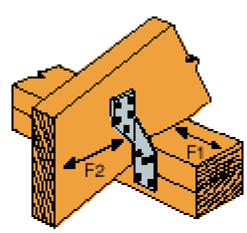
B.2.7 Smoke Detectors

Smoke detectors save lives. Approximately two-thirds of fatal fires occur in the 10% of homes not protected with smoke detectors. You are twice as likely to die in a fire if you do not have a properly operating smoke detector.

There are two basic types of smoke detectors - photoelectric and ionization. Photoelectric smoke alarms generally are more effective at detecting slow-smoldering fires, fires that might smolder for hours before bursting into flames. Ionization smoke alarms are more effective at detecting fast-flaming fires, fires that consume materials rapidly and spread quickly.

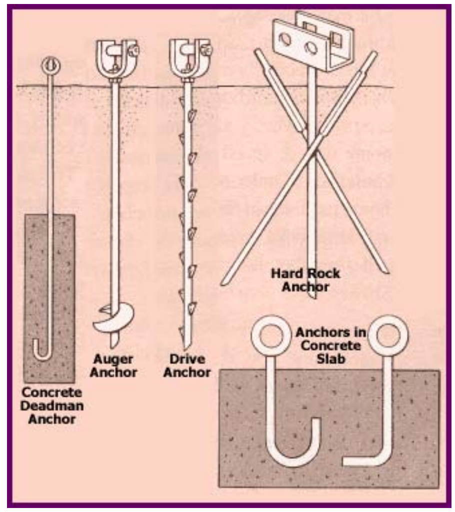
Test smoke detectors every month, change the batteries twice per year, clean detectors at least once per year and replace smoke detectors every 10 years. For more facts about smoke detectors see www.firemar.state.ok.us/forms/lg-alarm.pdf.

B.2.8 Hurricane Fasteners



A home's roof system is its most vulnerable and expensive component. Hurricane roof-to-wall and additional straps are metal connectors designed to hold a roof to its walls in high winds. They make a home's roof-to-wall connection five-to-15 times stronger than traditional construction and can prevent damage in winds at least 75 mph. In many coastal communities, reinforcing connections are enforced as a code restriction for new homes. Although designed to protect roofs during the extended and violent winds of hurricanes, these fasteners have proven effective in preventing roof removal in tornado events. For more information on hurricane fasteners and straps and protecting your roof, go to www.nhc.noaa.gov/HAW2/pdf/hurricane_retrofit.pdf.

B.2.9 Mobile Home Tie-Downs



Tie-downs are devices that anchor or otherwise secure a mobile home to the ground in order to protect the mobile home and its surroundings from damage caused by wind and/or other natural forces. All tie-downs must comply with the specifications of the home manufacturer and, if applicable, with standards set by local government officials. Anchoring and tie-down systems vary greatly. It's important for a homeowner to contact the local building inspector for regulations regarding anchoring and blocking installation in each community. Regulations may vary considerably from one community to the next.

Anchors are available for different types of soil conditions, including concrete slab. Auger anchors have been designed for both hard soil and soft soil. Rock anchors or drive anchors allow attachment to a rock or coral base. This type of anchor is also pinned to the ground with crossing steel stakes.

To resist wind forces, a home may need two different types of tie-downs. In older homes, a vertical or over-the-top tie-down is needed to compensate for the uplift force. A diagonal or frame tie-down is needed to compensate for both lateral and uplift forces. Singlewide manufactured homes need both types of tie-downs. Doublewide homes only need the diagonal ties.

To be tied down safely, find out from a local manufactured home association or building inspector how many tie-downs and anchors are needed for local wind and soil conditions. The cost of installing additional tie-downs and anchors is small compared to the potential cost of wind damage to a manufactured home that was not properly tied down.

B.2.10 Lightning Warning Systems

There are two basic types of warning systems:

Strike Location and Identification Systems sense the electromagnetic pulse or the electrostatic pulse that accompanies a lightning discharge. Sensors and processing equipment work from those pulses or transients. These systems are most useful for tracking storms, locating a lightning strike and producing density plots of lightning activity by geographical area. They do not provide early warning of an impending storm.

Pre-storm Warning Systems sense the conditions that precede a storm. All severe storms create a related electrostatic field. This field provides a reliable storm signature that is peculiar to severe storms and can be related to the severity of the storm. That signature is present prior to lightning activity and provides a measurable parameter for pre-storm warning. The electrostatic field strength is directly related to the state of the storm and/or its proximity to the site. Therefore, an increase in the electrostatic field is an indicator of a storm moving into or building up over the area. The warning time is determined by the rate of buildup or the rate of movement of the storm.

Table B–4: Lightning Detection Options
From the National Lightning Safety Institute

Lightning Detection Options - Accuracy vs. Cost vs. Complexity			
Source of Information	**Accuracy**	**Cost**	**Complexity**
Hearing thunder	Danger is near	None	Simple
TV weather channel	General info.	None	Simple
Weather radios	General info.	Up to $40	Simple
Handheld detectors	50-60% accurate	Up to $500	Somewhat
Boltek system (www.boltek.com)	70-80% accurate	Up to $1,500	Somewhat
ThorGuard system (www.thorguard.com)	85-90%	$1,000 - $6,500	Somewhat
WXLine system (www.WXLine.com)	90-95% accurate	Up to $7,000	Somewhat
Subscription service	95%+ accurate	Monthly fee	Simple

Essential companions to any type of lightning warning system include:

- a written Lightning Safety Policy;
- designation of Primary Safety Person;
- determination of when to suspend activities;
- determination of Safe/Not Safe Shelters;
- notification to Persons at Risk;
- education – at a minimum consider posting information about lightning and the organization’s safety program;
- determination of when to resume activities.

The above options can be developed with many variations, up to and including all-in-one units that include a lightning threat detector, strobe light and 360° warning horn, and fully-automated programmable computer to pre-set various options for different types of facilities, such as times of operation, degrees of sensitivity, and appropriate sounding of an “all clear” signal.

B.2.11 Power Outages from Winter Storms

Power outages from winter storms can lead to an abundance of problems. Homeowners without power will resort to candles or open flames for heat and light. Generators are noisy, produce potentially deadly exhaust and can cause power spikes damaging equipment. Kerosene heaters burn oxygen and increase the potential of asphyxiation and production of carbon monoxide. With fuel burning equipment there is a constant danger of fire or explosion, burns and breathing poisonous exhaust. In addition, the inability to heat a home increases the risk of pipes freezing.

Power lines can be protected and power outages prevented by:

- Replacing existing power lines with heavier T-2 line, shorter spans, and heavier poles and crossbars. It is estimated this will increase the overall strength of power distribution lines by 66%.
- Burying utility lines. This removes the risk of power outages due to ice accumulation or tree limbs bringing down power lines.
- Pruning trees away from power lines and enforcing policies regarding tree limb clearances.
- Designed-failure allowing for lines to fall or fail in small sections rather than as a complete system.

For a success story on wind storm power outage mitigation, see www.fema.gov/regions/v/ss/r5_n09.shtm. Options for alternate power sources are described at www.currentsolutionspc.com/doc/distributed.pdf.

When power outages occur, the first imperative in emergency power planning is to equip essential facilities with permanent backup power, and to make sure existing backup sources are properly sized and maintained. Essential post-disaster services include:

- medical care;
- drinking water supply;
- police and fire protection;
- refrigeration;
- communications;
- pollution control (especially wastewater treatment);
- transportation (especially airports and seaports);
- weather forecasting;
- temporary relief shelters;
- emergency response command and control.

Ice can add up to 500# of weight per line between power poles. (Picture from the Oklahoma 12/2007 ice storms)

Backup systems should be sized

to meet the requirements of a facility's necessary public services. Some facilities, such as wastewater treatment plants and hospitals, are so important that backup systems should be sized to carry full loads. A complete and consistent planned maintenance program that includes regular inspection and operational testing should cover all backup power systems.

B.2.12 Standby Electric Generators

Standby electric generators can provide an extra sense of security during unpredictable weather and resulting power outages. But even small, portable electric generators – if used improperly – can threaten resident safety and the safety of power company linemen working on the electrical system. For information on safely purchasing and using a residential generator, see www.redcross.org/services/disaster/0,1082,0_565_,00.html.

Before purchasing a generator, consider how it will be used. That will help ensure buying a generator that is correctly sized for the application in mind. Portable, gasoline-driven generators are designed to be used for appliances with cords connected to them. Typically, they are not designed to be connected to a home or building wiring. Residents should not attempt to install these devices to an electrical panel.

Fixed Generators

Large, fixed generators generally are directly connected to building wiring to provide standby power during emergencies or power outages. However, the wiring needs to be properly installed by a qualified electrical contractor. Properly installing a “permanent” generator is extremely dangerous, and usually requires an electrical permit from the local electrical or building inspector's office. Picking an appropriate fixed-site emergency generator involves a number of issues including:

- Type of fuel – Usually a choice between propane, natural gas or diesel, depending on the availability of either fuel in an emergency, and any possible regulations concerning on-site storage. Other considerations:
    - Natural gas or propane emit far fewer exhaust emissions, which may be a factor.
    - Natural gas generators usually have to be larger, since natural gas does not have the BTU output of gasoline or diesel, and NG generators tend to be more expensive.
    - Natural gas is frequently shut off in the event of a fire or some other disasters. This may not be an issue during winter storms or following lightning strikes (the two most common causes of major power outages), but should be considered during other events.
    - Diesel will require an onsite storage tank and a reliable source for refills during an extended outage. This is frequently an issue since so many commercial sources are dependent on electric pumps to deliver fuel. Also, diesel is seasonally-rated, since extreme cold can have a detrimental effect on standard diesel.
    - Propane will also require onsite storage, which could be a safety concern since propane tanks are traditionally above ground. But getting commercial propane tanks refilled may be easier during a power outage than getting diesel refills.

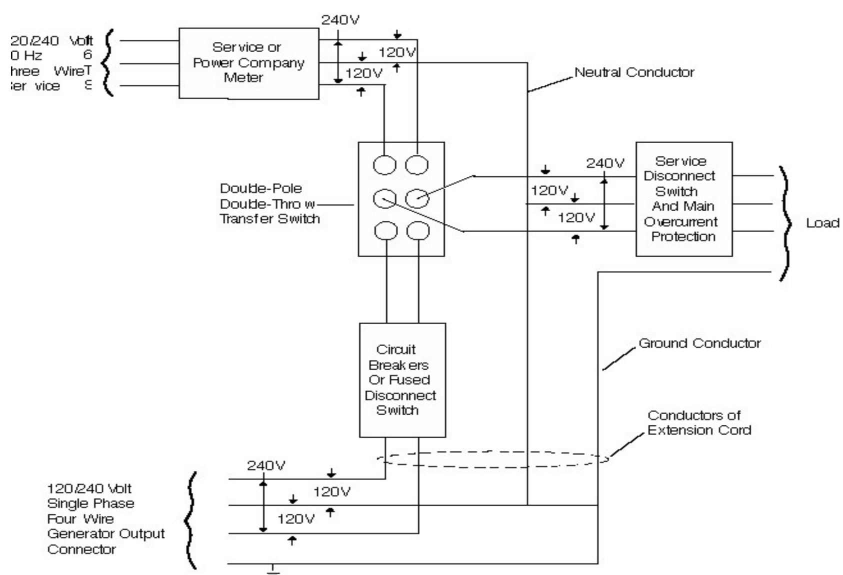
- Proper voltage – It's usually best for an emergency generator to match your standard incoming voltage, whether it's single-phase 120/240 or three-phase 277/480, which is the more common commercial application.
- Power requirements – this will entail (a) identifying your critical functions, and (b) having an electrical professional rate the running/start-up kilowatt (kW) requirements for those functions. (See Table B-5 for some basic power ratings for typical applications.)
- Cost – even a small (30-45 kW, 277/480 volt) natural gas standby generator can cost $10,000, plus expenses for installation and automatic transfer switches. Most emergency operations centers, 911 dispatch centers, and other critical facilities will need a generator with higher requirements.

"Back feeding" - a dangerous condition

Improperly connecting a portable generator to electric wiring can produce "back feed" – a dangerous current that can electrocute or critically injure residents or others. Back feed into power lines from a generator could create "hot" power lines during an outage. Linemen who expected lines to be de-energized have been injured or killed.

One good way to avoid back feeding is to install a double-pole, double throw transfer-switch gear. A qualified electrical contractor can install this transfer switch so that dangerous back feed can be prevented. "In accordance with the National Electrical Code, paragraph 700-6; Transfer equipment shall be designed and installed to prevent the inadvertent interconnection of normal and emergency sources of supply in any operation of the transfer equipment. Automatic transfer switches shall be electrically operated and mechanically held." The transfer switch must be a break-before-make switch, which will "break" the electrical connection with commercial power lines before it "makes" the connection between the generator and wiring. The switch also will prevent utility power from damaging the generator when regular service is restored. An electrical diagram of an installation using a transfer switch appears in Figure B-2.

Figure B–2: Standby power equipment and connections



Since transfer switches can be expensive, another way to install a generator is to have a sub-panel with main breakers and power from the main panel or generator. Main panel breaker and generator breaker in sub-panel would have handles interlocked to prevent both from being opened and closed at the same time. This prevents back feed to commercial power when the generator is in use.

For commercial emergency installations, it is also critical that an electrical professional review what the standard and max loads will be on the system. An evaluation needs to be made as to what critical functions need to be operational – HVAC, communications, lighting, security, cooking capabilities, and so on. In health care facilities, assistive devices and water supply equipment can pull large quantities of power, which will need to be taken into account.

Typical wattage requirements are described in the following table:

Table B–5: Typical Wattage Requirements for Generator Usage

Item	Running Watts	Item	Running Watts
Air conditioner (12,000 BTU)	1,700	Furnace Fan (1/3 HP)	1,200
Battery Charger (20 A)	500	Light Bulb	100
Chain Saw	1,200	Microwave Oven	1,000
Circular Saw	1,000	Oil Burner on Furnace	300
Coffee Maker	1,000	Radio	50
Compressor (1 HP)	2,000	Refrigerator	600
Deep Freeze	500	Submersible Pump (1 HP)	2,000
Electric heater (small)	1,500	Sump Pump	600
Electric Range (1 element)	1,500	Television	300

Source: Above information adapted from American Electric Power, *A Word About Portable Electric Generators*, and Flathead Electric Cooperative, *Safely Installing Your Electric Generator, 2007.*

B.2.13 Critical Facility Protection

Critical facilities require a higher level of protection because they are vital public facilities, pose a higher risk of pollution of floodwaters from hazardous materials, or are critical to the response and recovery effort during and after a disaster. The Community Rating System (CRS) provides credit for regulations protecting critical facilities from the 500-year flood.

Sample regulatory language can be found at the FEMA training website at http://training.fema.gov/EMIWeb/CRS/m6s4main.htm.

B.2.14 Extreme Heat Protection

Outdoor workers or people who engage in strenuous yard work or recreational activities are extremely vulnerable to heat-related illness.

Elderly, children, low-income individuals and people with compromised immune systems are more vulnerable to health risks due to intense climate changes, especially extreme heat. Aging is often accompanied by chronic illnesses that may increase susceptibility to extreme environmental conditions. Poverty among elderly increases the risk.

Children are vulnerable due to their size, behavior and fact that they are growing and developing. Children living in poverty or without access to proper medical care are especially vulnerable.

Low-income individuals are less likely to be able to afford air-conditioning and have less access to health care.

Cancer, AIDS and diabetes compromise individual's immune systems. Afflicted individuals are more susceptible to physical stresses such as those during extreme heat.

Steps individuals and families can take to protect themselves from the heat include:

- install window air-conditioners snugly and insulate spaces for a tighter fit;
- hang shades, draperies, awnings or louvers on windows receiving morning or afternoon sun. Awnings or louvers can reduce heat entering the house by up to 80%.
- stay indoors as much as possible. If air conditioning is not available stay on the lowest floor out of the sunshine.
- drink plenty of water and limit alcoholic beverages;
- dress in light-colored, loose fitting clothes that cover as much skin as possible;
- take a cool bath.

Suggestions for a community heat emergency intervention plan include:

- Standardizing guidelines for providing warnings to the public, including not only the National Weather Service, but also Emergency Medical Services, the Health Department, Emergency Management, Tribal Community Health Representatives and other recognized agencies.
- The public must have access to steps to take to lessen the likelihood of heat problems, such as staying in air-conditioning, if possible, and drinking plenty of fluids.
- A room air conditioner loan program for bed-ridden/chair-ridden individuals can assist those individuals who cannot physically leave their homes to visit an air-conditioned location each day.
- "Buddy systems" can be established where an individual is assigned to check on people at risk. The "buddy" should be trained to deal with heat related emergencies.
- Utility companies should not be allowed to terminate service during a heat emergency, even if individuals have not paid their bill.

For more information on extreme heat, mitigation and protection from the heat see www.fema.gov/hazards/extremeheat/heatf.shtm.

B.2.15 Proper Storage and Disposal of Hazardous Materials

Household chemicals and motor oil dumped down drains or directly onto the ground can work their way into the waterways and ground waters. Oil from a single oil change can ruin one million gallons of fresh water. Used crankcase oil has been reported to account for more than 40% of the oil pollution in waterways.

Most public and private vehicle maintenance facilities have well-developed systems to store their waste oil for recycling. However, "do-it-yourselfers" account for a large percentage of the oil changes in any community. Therefore, it is important for community recycling and solid waste management programs to include a system for waste oil collection and provide ways to collect and dispose of household chemicals.

Many counties and communities offer household pollutant collection events. Among the pollutants collected are oil-based paints, paint thinners, pesticides, fertilizers, cleansers, acids, ammunition, batteries, motor oil, and antifreeze. Residents are not charged for items collected. Events are typically funded by participating communities.

Containers of hazardous materials should not be located in a flood hazard area. If such a location is necessary hazardous material containers need to be anchored. Contents can contaminate water and multiply the damaging effects of flooding by causing fires or explosions, or by otherwise making structures unusable. Buoyant materials should be anchored. If they float downstream they may cause additional damage to buildings or bridges or may plug a stream resulting in higher flood heights.

The link www.earth911.org/zip.asp provides a list of hazardous waste recycling centers and used oil collection facilities based on zip code.

B.2.16 Water Conservation

97% of the earth's water is in the oceans and 2% is trapped in icecaps and glaciers. Only about 1% of the earth's water is available for human consumption. The water supply is taxed to supply all the competing interests: residential – including drinking and sanitation, manufacturing, environmental, agricultural, and recreational.

Conserving water conserves energy – gas, electric or both – reduces monthly water/ sewer bills and postpones the construction of or eliminates the need to build expensive capital projects such as wastewater or water treatment plants that need future maintenance.

Plumbing codes implemented in Phoenix Arizona in 1990 required low-flow faucets, shower heads, and toilets. Since then water consumption per capita has decreased 27 percent. Other cities, such as Wilsonville, Oregon, have implemented an inverted block water rate structure charging customers higher rates as water consumption increases.

Public education can have a significant impact. Household conservation tips include:

- updating plumbing fixtures with low-flow devices;
- keeping a pitcher of water in the refrigerator instead of running the tap;
- watering the yard and gardens in the morning or evening when temperatures are cooler to minimize evaporation;
- collecting water used for rinsing and reusing it to water plants;
- landscaping with drought-resistant, low water use plants;
- using a hose nozzle and turning off the water while washing cars.

B.2.17 Open Space Preservation

Keeping the floodplain open and free from development is the best approach to preventing flood damage. Preserving open space is beneficial to the public in several ways. Preserving floodplains, wetlands, and natural water storage areas maintains the existing stormwater storage capacities of an area. These sites can also serve as recreational areas, greenway corridors and provide habitat for local flora and fauna. In addition to being preserved in its natural landscape, open space may also be maintained as a park, golf course, or in agricultural use.

B.2.18 Conclusions

1. Planning and zoning will help the community or Tribe develop proactively so that the resulting infrastructure is laid out in a coherent and safe manner.
2. Building codes for foundations, sprinkler systems, masonry, and structural elements such as roofs are prime mitigation measures for occurrences of floods, tornadoes, high winds, extreme heat and cold, lightning strikes, and earthquakes.
3. Public education (see Section B.1) can demonstrate preventive measures individuals and businesses can use to protect their own lives and facilities.
4. Communities should participate in the NFIP and use subdivision regulations to control the direction of floodplain development.
5. Deficiencies in stormwater management can be identified by conducting a Flood & Drainage Annex to the Hazard Mitigation plan for watersheds to determine appropriate standards for different areas.

B.2.19 Recommendations

Refer to *Chapter 6: Action Plan and Mitigation Measures*, Table 6–2, for a complete listing of all recommended mitigation measures by hazard and priority.

B.3 Structural Projects

Structural projects are usually designed by engineers or architects, constructed by the public sector, and maintained and managed by governmental entities. Structural projects traditionally include stormwater detention reservoirs, levees and floodwalls, channel modifications, drainage and storm sewer improvements, and community tornado safe-rooms.

B.3.1 Safe Rooms

Safe rooms are specially constructed shelters intended to protect occupants from tornados and high winds. Constructed of concrete and steel, properly built safe rooms can provide protection against wind speeds of 250mph and airborne debris traveling as fast as 100mph.

A safe room can be incorporated into the construction of a new home, or can be retrofitted above or below ground into an existing home. The cost of constructing a safe room is between $2500 and $6000, depending on the room size, location and type of foundation on which the home is built. Safe rooms can function year-round as a usable area, such as a bathroom, closet or utility room.

Dr. Ernst Kiesling, Civil Engineering Professor at Texas Tech University, inspects a safe room in the aftermath of the May 8, 2003 tornadoes in Moore, Oklahoma.

The State of Oklahoma, FEMA and communities may offer reimbursement grants for construction of certain categories of Safe Rooms through the Hazard Mitigation Grant Program (HMPG).

FEMA 320, *Taking Shelter From the Storm: Building a Safe Room for Your Home or Small Business* has specific designs for tornado and hurricane safe rooms. To obtain a copy of FEMA 320 refer to www.fema.gov/plan/prevent/saferoom/fema320.shtm.

National Storm Shelter Association

The National Storm Shelter Association (NSSA) is an industry organization developed to ensure the highest quality of manufactured and constructed storm shelters. The NSSA has developed a program to verify that design, construction, and installation of storm shelters are in compliance with the most comprehensive and extensive safety standards available. Without full compliance with the standard, vulnerabilities may exist and safety may be compromised. Shelter-producing members of the NSSA submit shelter designs to the

scrutiny of an independent third-party engineering company and have their shelters tested for debris impact resistance (FEMA 320 designs have been tested). In addition they will file a certificate of installation with NSSA for each shelter.

Upon building or installing a storm shelter, the member applies a seal to the shelter certifying that it is designed, built, and installed to meet the NSSA standard. Only the shelter producer or an agency that carefully inspects the shelter design, construction, and installation may certify compliance with an applicable standard. Claims of "FEMA Certified" or "Texas Tech Certified" are misleading since neither FEMA nor the Texas Tech Wind Science and Engineering Research Center (contributors to the FEMA standards for individual and community SafeRooms) certifies shelter quality. This program not only provides assurance to the user of a storm shelter that it has been built to a certain performance standard, but it shifts some responsibility from the community to provide verification from building inspectors for compliance and reduces building inspectors' training requirements. Additional information on the NSSA certification program can be obtained at www.nssa.cc.

B.3.2 School Safe Rooms

In the past, a school's interior areas, especially hallways, have been designated as the best place to seek refuge from violent storms. However, in 1999 the hallways of two schools in Sedgwick County, Kansas received significant damage which could have resulted in student casualties had school been in session.

The FEMA 361 publication, *Design and Construction Guidance for Community Shelters*, provides guidelines for constructing school safe rooms. A community shelter strong enough to survive a violent storm can also be used as a

Before and after photos of hallways in Wichita Kansas schools damaged by a tornado

cafeteria, gymnasium or other common area.

Schools, administration buildings and institutions of higher learning are required to have written plans and procedures in place for protecting students, faculty, administrators and visitors from natural and man-made disasters and emergencies. The requirement, directed by Oklahoma House Bill HB1512, was enacted May 29, 2003.

For more information about Sedgwick County's new school safe rooms go to www.fema.gov/mit/saferoom/casestudies.shtm. To receive a copy of FEMA 361, see www.fema.gov/pdf/hazards/nhp_fema361.pdf. For more information on HB1512, see www.lsb.state.ok.us/2003-04HB/HB1512_int.rtf.

B.3.3 Reservoirs and Detention

Reservoirs control flooding by holding high flows behind dams or in storage basins. After a flood peaks, water is released or pumped out slowly at a rate that the river can accommodate downstream. The lake created may provide recreational benefits or water supply (which could help mitigate a drought).

Reservoirs are suitable for protecting existing development downstream from the project site. Unlike levees and channel modifications, they do not have to be built close to or disrupt the area to be protected. Reservoirs are most efficient in deeper valleys where there is more room to store water, or on smaller rivers where there is less water to store. Building a reservoir in flat areas and on large rivers may not be cost-effective, because large areas of land have to be purchased.

Reservoirs provide storage of rainwater without the hazards of maintaining a dam.

In urban areas, some reservoirs are simply man-made holes dug to store floodwaters. When built in the ground, there is no dam for these retention and detention basins and no dam failure hazard. Wet or dry basins can also serve multiple uses by doubling as parks or other open space uses.

B.3.4 Levees and Floodwalls

Probably the best-known flood control measure is a barrier of earth (levee) or concrete (floodwall) erected between the watercourse and the property to be protected. Levees and floodwalls confine water to the stream channel by raising its banks. They must be well designed to account for large floods, underground seepage, pumping of internal drainage, and erosion and scour.

Failure to maintain levees can lead to significant loss of life and property if they are stressed and broken or breached during a flood event. An inspection, maintenance and enforcement program helps ensure structural integrity.

Levees placed along the river or stream edge degrade the aquatic habitat and water quality of the stream. They also are more likely to push floodwater onto other properties upstream or downstream. To reduce environmental impacts and provide multiple use benefits, a setback levee (set back from the floodway) is the best project design. The area inside a setback levee can provide open space for recreational purposes and provide access sites to the river or stream.

B.3.5 Channel Improvements

By improving channel conveyance, more water is carried away at a faster rate. Improvements generally include making a channel wider, deeper, smoother or straighter. Some smaller channels in urban areas have been lined with concrete or put in underground pipes.

B.3.6 Crossings and Roadways

In some cases buildings may be elevated above floodwaters, but access to the building is lost when floodwaters overtop local roadways, driveways, and culverts or ditches. Depending on the recurrence interval between floods, the availability of alternative access, and the level of need for access, it may be economically justifiable to elevate some roadways and improve crossing points.

Culverts like this one can constrict flow and cause backwater flooding.

For example, if there is sufficient downstream channel capacity, a small culvert that constricts flows and causes localized backwater flooding may be replaced with a larger culvert to eliminate flooding at the waterway crossing point. The potential for worsening adjacent or downstream flooding should be considered before implementing any crossing or roadway drainage improvements.

B.3.7 Drainage and Storm Sewer Improvements

Man-made ditches and storm sewers help drain areas where the surface drainage system is inadequate, or where underground drainageways may be safer or more practical. Storm sewer improvements include installing new sewers, enlarging small pipes, and preventing back flows. Particularly appropriate for depressions and low spots that will not drain naturally, drainage and storm sewer improvements usually are designed to carry the runoff from smaller, more frequent storms.

Drainageways should be inspected regularly for blockage from debris

Because drainage ditches and storm sewers convey water faster to other locations, improvements are only recommended for small local problems where the receiving stream or river has sufficient capacity to handle the additional volume and flow of water. To reduce the cumulative downstream flood impacts of numerous small drainage projects, additional detention or run-off reduction practices should be provided in conjunction with the drainage system improvements.

B.3.8 Drainage System Maintenance

The drainage system may include detention ponds, stream channels, swales, ditches and culverts. Drainage system maintenance is an ongoing program to clean out blockages caused by an accumulation of sediment or overgrowth of weedy, non-native vegetation or debris, and remediation of stream bank erosion sites.

"Debris" refers to a wide range of blockage materials that may include tree limbs and branches that accumulate naturally, or large items of trash or lawn waste accidentally or intentionally dumped into channels, drainage swales or detention basins. Maintenance of detention ponds may also require revegetation or repairs of a restrictor pipe, berms or overflow structure.

Maintenance activities normally do not alter the shape of a channel or pond, but they do affect how well a drainage system can do its job. Sometimes it is a very fine line that separates debris that should be removed from natural material that helps form habitat.

B.3.9 Conclusions

1. Reservoirs can hold high flows of water that can later be released slowly or retained for recreational purposes or drought mitigation.
2. Levees and floodwalls are not as effective overall because of possible underground seepage, erosion, degradation of aquatic habitat and water quality, and ineffectiveness in large floods.
3. Channel improvements allow more water to be carried away faster.
4. The effectiveness of elevating buildings depends on the availability of alternative access when flooding occurs.
5. Crossing and roadway drainage improvements must take into account additional detention or run-off reduction.
6. Drainage and storm sewer improvements carry runoff from smaller, more frequent storms.
7. Drainage system maintenance is an ongoing project of removing debris that decreases the effectiveness of detention ponds, channels, ditches, and culverts.

B.3.10 Recommendations

Refer to *Chapter 6: Action Plan and Mitigation Measures*, Table 6–2, for a complete listing of all recommended mitigation measures by hazard and priority.

B.4 Property Protection

Property protection measures are used to modify buildings or property subject to damage from various hazardous events. The property owner normally implements property protection measures. However, in many cases technical and financial assistance can be provided by a governmental agency. Property protection measures typically include acquisition and relocation, flood-proofing, building elevation, barriers, retrofitting, safe rooms, hail resistant roofing, insurance, and the like.

B.4.1 The Community's Role

Property protection measures are usually considered the responsibility of the property owner. However, local government should be involved in all strategies that can reduce losses from natural hazards, especially acquisition. There are various roles the community can play in encouraging and supporting implementation of these measures.

Providing basic information to property owners is the first step in supporting property protection measures. Owners need general information on what can be done. They need to see examples, preferably from nearby neighborhoods or communities.

Financial Assistance

Communities can help owners by helping to pay for a retrofitting project, just like they pay for flood control projects. Financial assistance can range from full funding of a project to helping residents find money from other programs. Some communities assume responsibility for sewer backups and other flood problems that arise from an inadequate public sewer or drain system.

Less expensive community programs include low interest loans, forgivable low interest loans and rebates. A forgivable loan is one that does not need to be repaid if the owner does not sell the house for a specified period, such as five years. These approaches do not fully fund the project but they cost the community treasury less and they increase the owner's commitment to the flood protection project.

Often, small amounts of money act as a catalyst to pique the owner's interest to get a self-protection project moving. Several Chicago suburbs have active rebate programs that fund only 20% or 25% of the total cost of a retrofitting project. These programs have helped install hundreds of projects that protect buildings from low flood hazards.

Acquisition Agent

Local Government can be a focal point for many acquisition projects. In most cases, when acquisition of a property is feasible, the local government is the ultimate owner of the property, but in other cases, the school district or other public agencies can assume ownership and the attendant maintenance responsibilities.

Other Incentives: "Non-financial Incentives"

Sometimes government actions can provide a financial incentive from another source, or other incentive options are available. A flood insurance premium reduction will result if a building is elevated above the flood level. This reduction is not enough to take much of a bite out of the cost of the project, but it reassures the owner that he or she is doing the right thing. Other forms of floodproofing are not reflected in the flood insurance rates for residential properties, but they may help with the Community Rating System, which provides a premium reduction for all policies in the community.

Other incentives to consider are programs to help owners calculate the benefits and costs of a project and a "seal of approval" for retrofitted buildings. The latter would be given following an inspection that confirms that the building meets certain standards. There are many other personal but non-economic incentives to protect a property from flood damage, such as peace of mind and increased value at property resale.

B.4.2 Insurance

Insurance has the advantage that, as long as the policy is in force, the property is protected and no human intervention is needed for the measure to work. There are three types of insurance coverage:

NFIP Coordinator Dianna Herrera presenting a class on flood insurance requirements

1. The standard homeowner's, dwelling, and commercial insurance policies cover against the perils of wildfire and the effects of severe weather, such as frozen water pipes.
2. Many companies sell earthquake insurance as an additional peril rider on homeowner's policies. Individual policies can be written for large commercial properties. Rates and deductibles vary depending on the potential risk and the nature of the insured properties.
3. Flood insurance is provided under the National Flood Insurance Program.

Flood Insurance

Although most homeowner's insurance policies do not cover a property for flood damage, an owner can insure a building for damage by surface flooding through the National Flood Insurance Program (NFIP). Flood insurance coverage is provided for buildings and their contents damaged by a "general condition of surface flooding" in the area.

Building coverage is for the structure. Contents coverage is for the removable items inside an insurable building. A renter can take out a policy with contents coverage, even if there is no structural coverage.

Some people have purchased flood insurance because the bank required it when they got a mortgage or home improvement loan. Usually these policies just cover the building's structure and not the contents.

In most cases, a 30-day waiting period follows the purchase of a flood insurance policy before it goes into effect. The objective of this waiting period is to encourage people to keep a policy at all times. People cannot wait for the river to rise before they buy their coverage.

B.4.3 Acquisition and Relocation

Moving out of harm's way is the surest and safest way to protect a building from damage. Acquiring buildings and removing them is also a way to convert a problem area into a community asset and obtain environmental benefits.

The major difference between the two approaches is that acquisition is undertaken by a government agency, so the cost is not borne by the property owner, and the land is converted to public use, such as a park. Relocation can be either government or owner-financed.

Moving a home out of the floodplain is sometimes the only way to protect it from flooding

While almost any building can be moved, the cost goes up for heavier structures, such as those with exterior brick and stone walls, and large or irregularly shaped buildings. However, experienced building movers know how to handle any job.

Cost

An acquisition budget should be based on the median price of similar properties in the community, plus $10,000 to $20,000 for appraisals, abstracts, title opinions, relocation benefits, and demolition. Costs may be lower after a flood or other disaster. For example, the community may have to pay only the difference between the full price of a property and the amount of the flood insurance claim received by the owner.

One problem that sometimes results from an acquisition project is a "checkerboard" pattern in which nonadjacent properties are acquired. This can occur when some owners, especially those who have and prefer a waterfront location, prove reluctant to leave. Creating such an acquisition pattern in a community simply adds to the maintenance costs that taxpayers must support.

Relocation can be expensive, with costs ranging from $30,000 for a small wood frame building to over $60,000 for masonry and slab on grade buildings. Two story houses are more expensive to move because of the need to relocate wires and avoid overpasses. Additional costs may be necessary for acquiring a new lot on which to place the relocated building and for restoring the old site. Larger buildings may have to be cut and the parts moved separately. Because of all these complications, there are cases where acquisition is less expensive than relocation.

Where Appropriate

Acquisition and relocation are appropriate in areas subject to:

- flash flooding;
- deep waters;
- dam break flooding;

- landslides;
- potential hazardous materials spills;
- other high hazard that affects a specific area.

Acquisition and relocation are not appropriate for hazards like tornadoes or winter storms because there are no areas safe from the hazard. Relocation is also preferred for large lots that include buildable areas outside the hazardous area or where the owner has a new lot in a safer area.

Acquisition (followed by demolition) is preferred over relocation for buildings that are difficult to move, such as larger, slab foundation, or masonry structures, and for dilapidated structures that are not worth protecting.

B.4.4 Building Elevation

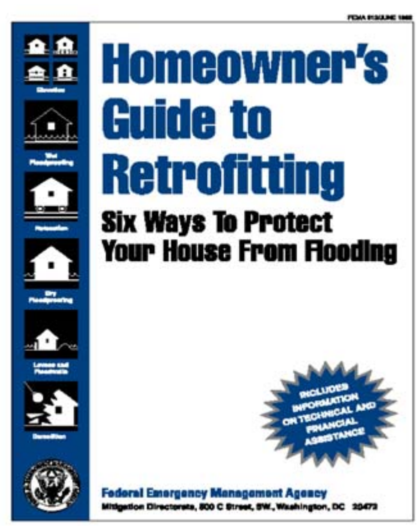
Raising a building above the flood level is the best on-site property protection method for flooding. Water flows under the building, causing little or no damage to the structure or its contents. Alternatives are to elevate on continuous foundation walls (creating an enclosed space below the building) or elevation on compacted earthen fill.

B.4.5 Barriers

Barriers keep surface waters from reaching a building. A barrier can be built of dirt or soil (“berm”) or concrete or steel (“floodwall”). In cases of shallow flooding, regrading a yard can provide the same protection as a separate barrier.

B.4.6 Retrofitting

This term covers a variety of techniques for modifying a building to reduce its susceptibility to damage by one or more hazards.



FEMA guides are available to help homeowners retrofit their flood-prone properties

Where Appropriate

Some of the more common approaches are:

Floods and dam failures:

- Dry floodproofing keeps the water out by strengthening walls, sealing openings, or using waterproof compounds or plastic sheeting on walls. Dry floodproofing is not recommended for residential construction.
- Wet floodproofing, using water resistant paints and elevating anything that could be damaged by a flood, allows for easy cleanup after floodwaters recede. Accessory structures or garages below the residential structure are potential candidates for wet floodproofing.
- Installing drain plugs, standpipes or backflow valves to stop sewer backup.

Tornado:

- Constructing an underground shelter or in-building "safe room"
- Securing roofs, walls and foundations with adequate fasteners or tie downs
- Strengthening garage doors and other large openings

High winds:

- Installing storm shutters and storm windows
- Burying utility lines
- Using special roofing shingles designed to interlock and resist uplift forces
- Installing/incorporating backup power supplies

Hailstorms:

- Installing hail resistant roofing materials

Lightning:

- Installing lightning rods and lightning surge interrupters
- Burying utility lines
- Installing/incorporating backup power supplies

Winter storms:

- Adding insulation
- Relocating water lines from outside walls to interior spaces
- Sealing windows
- Burying utility lines
- Installing/incorporating backup power supplies

Extreme heat and drought:

- Adding insulation
- Installing water saver appliances, such as shower heads and toilets

Urban and wild fires:

- Replacing wood shingles with fire resistant roofing
- Adding spark arrestors on chimneys
- Landscaping to keep bushes and trees away from structures
- Installing sprinkler systems
- Installing smoke alarms

Earthquake:

- Retrofitting structures to better withstand shaking.

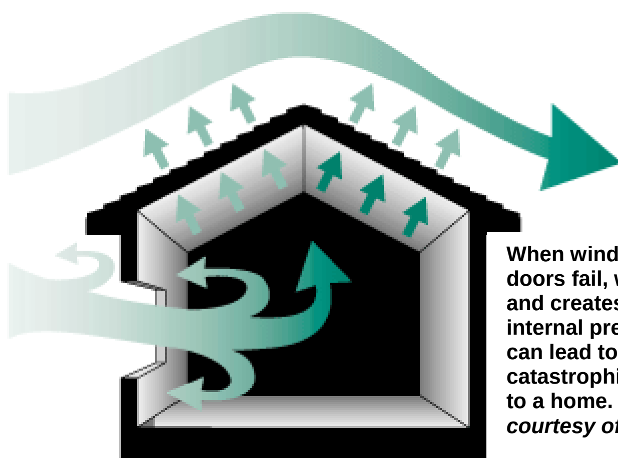
- Tying down appliances, water heaters, bookcases and fragile furniture so they won't fall over during a quake.

Common Measures

From the above lists, it can be seen that certain approaches can help protect from more than one hazard. These include:

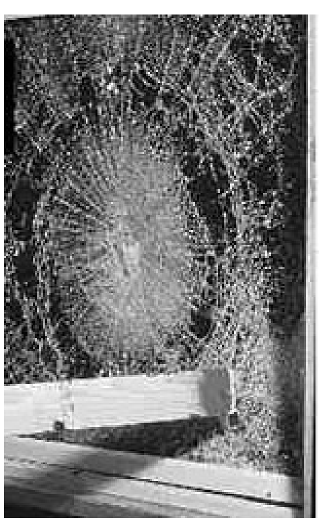
- strengthening roofs and walls to protect from wind and earthquake forces;
- bolting or tying walls to the foundation protect from wind and earthquake forces and the effects of buoyancy during a flood;
- adding insulation to protect for extreme heat and cold;
- anchoring water heaters and tanks to protect from ground shaking and flotation;
- burying utility lines to protect from wind, ice and snow;
- installing backup power systems for power losses during storms;
- installing roofing that is hail resistant and fireproof.

B.4.7 Impact Resistant Windows and Doors



When windows and doors fail, wind enters and creates an internal pressure that can lead to catastrophic damage to a home. (*Drawing courtesy of Flash.org*)

Doors and windows can be the most vulnerable components of your home. During high wind events, such as thunderstorms or tornadoes, wind-driven debris can easily penetrate unprotected or unreinforced windows and doors, breaching the secure envelope of the structure. The debris and rain may cause damage to interior furnishings or harm to residents, but the wind itself can create extreme pressures on the walls and ceiling, leading to catastrophic structural failure. This danger can be mitigated by the installation of impact-resistant windows and doors.



Windows

Today's impact-resistant glass sandwiches a laminated inner layer made of polyvinyl butyral, a plastic, between two sheets of glass. Stronger than a car windshield, the glass might shatter if a heavy object crashes into it, but it won't break to bits. That makes wind less likely to penetrate the envelope of a home and create interior pressure severe enough to blow a roof off. Impact-resistant windows are only as strong, though, as the frame in which they rest. "An impact resistant window is tested as a unit that includes the glass, the frame as well as the attachment hardware and the installation method." (*Federal Alliance for Safe Homes – FLASH*)

The second type of impact-resistant glass uses a film applied to the surface. Impact-resistant film is placed over the glass to keep windows from shattering into sharp particles if broken. Since these films are added to the glass, they may not be as effective as a standard impact-resistant system. Their durability depends on how well the glass and protective laminate stay in the frame and window assembly. They will be effective against smaller objects, but larger pieces of debris may still take the window out of the frame. For more information on protective window films and other technologies, visit the Protecting People First Initiative (www.protectingpeople.org/arenspage.shtm) or the International Window Film Association (www.iwfa.com/iwfa/Consumer_Info/safety.html).

While costs for replacing window glass or using impact-resistant glass in new construction can be expensive, there are additional benefits that may be gained. Impact-resistant glass has been used successfully to reduce burglaries, vandalism and break-ins with both homes and businesses. In addition, using an impact-resistant glazing that is also more energy efficient can produce substantial energy savings. According to the Partnership for Advancing Housing Technology (PATH), a public-private partnership between leaders in the homebuilding, product manufacturing, and insurance industries and several Federal agencies:

> Special glass "…can be used to both make windows impact resistant and more energy efficient. Low-E and solar control low-E (also called spectrally selective) coatings can be used to boost the energy efficiency of windows. Low-E double pane windows, most common in cold and moderate climates, are more energy efficient than clear windows because the low-E coating reduces heat loss through the window.
>
> Solar control glass, also called Low E2, is a good glass for hot climates because, in addition to improving the insulating ability of windows, it also limits solar heat gain by blocking passage of infrared and some ultraviolet rays. Solar control glass allows a higher level of visible light to pass through a window with less solar heat gain reduction than tinted window coatings."

PATH gives a tentative cost estimate for using impact resistant glass systems in a model 2,250 sq. ft. home at $14,850. (www.pathnet.org/sp.asp?id=18692). In addition, residential users may view a window and door protection cost estimate tool at the Federal Alliance for Safe Homes (FLASH) website www.blueprintforsafety.org/tools/shuttertoolhome.aspx.

One manufacturer provides the following pricing table for commercial applications:

Table B–6: Impact Resistant Windows Cost Estimate Table

The following pricing table is for estimating purposes only. Changes in dimensions, glass types, finishes, hardware selection, volume discounts, and other variables could raise or lower prices.
(Provided by CGI Windows, www.cgiwindows.com.)

APPROXIMATE IMPACT RESISTANT PRICING 2007 - COMMERCIAL GRADE ALUMINUM PRODUCTS

Product	W	x	H	Max. Design Pressure (PSF)	COST*
Series 238 - Casement Window	24"	x	48	+110 / -120	$400.12
Series 238 - Casement Window	30"	x	60	+110 / -120	$526.63
Series 238 - Casement Window	36"	x	60	+110 / -120	$593.31
Series 238 - Casement Window	32"	x	72	+85 / -85	$625.18
Series 360 - Single Hung Window	36"	x	72	+100 / -167.2	$593.80
Series 360 - Single Hung Window	54"	x	96"	+100 / -120	$1,274.27
Series 450 - Pair of Door	74 1/2"	x	96 3/4	+100 / -110	$2,425.69

Aluminum Finish: White, Bronze, or Driftwood ESP
Glass Type: 7/16" Laminated Glass Typical (Ann/Ann) / 5/16" Lami Glass at Single Hungs (Ann/Ann)
Glass Color: Clear, Gray, Bronze, Dark Gray (Turtle Code)

** Note: Cost excludes special items, colonial muntins, HS/HS Glass, Temp/Temp Glass, aluminum tube mullions, shipping, shop drawings, installation, permits, special engineering, windload calculations, etc.*

Garage Doors

Illustrating the dangers of unreinforced garage doors, in all but the house at upper left, these doors have been breached, leading to substantial roof damage – in some cases, completely removing a second floor. But in the home with an intact garage door, the roof is almost entirely undamaged.

Garage doors are particularly vulnerable, especially doublewide garage doors because of their long span and, frequently, lightweight materials. Reinforced garage door and track systems are available to help avoid that problem. Retrofit kits are also available to reinforce existing garage doors, but the retrofit kits do not provide the same level of protection as systems designed to be wind and impact-resistant. (*Source: Federal Alliance for Safe Homes – FLASH. www.flash.org.)*

B.4.8 Impact Resistant Roofing

Hail is a hazard that threatens most states, but it doesn't strike all areas equally. Since 1980, the country has averaged 3,000 hailstorms per year, with four states accounting for 42% of the total: Texas, 500 per year; Oklahoma, 400; Kansas, 225; Nebraska, 135. In these high risk states, hail strikes may occur up to 6 times a year, putting houses in repeated danger. (Source: State Farm Insurance)

In 1996, the Institute for Business & Home Safety (IBHS) and Underwriters Laboratory (UL) developed a protocol for testing and rating roofing systems against impact damage. The test uses four sizes of steel balls, ranging from 1¼ -2 inches in diameter, to replicate different sizes of hailstones. The balls are dropped from different heights to simulate various impact speeds. The materials are rated on a scale of 1 (least resistant) to 4 (most resistant).

New impact-resistant roofing will cost more, even in mass production. New shingles may also require more labor at installation. However, some impact-resistive, asphalt-based products will add as little as 10-15% up to 50% to the cost. Class 4 products made of aluminum, copper, plastic and resin shingles have been available for years, but they cost considerably more than standard roofing materials. With the introduction of modified asphalt materials, many more homeowners are able to achieve greater wind and hail resistance than ever before.

LET IT HAIL, LET IT HAIL!

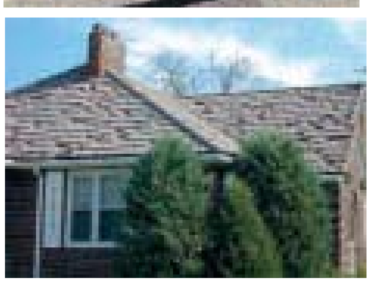
The March thunderstorm blew in without much warning during the Ft. Worth early evening rush hour. When softball-size hail smashed through the roof of a downtown restaurant, customer Mario Valverde headed for safety to escape falling debris and glass shards from exploding windows.

Valverde, a National Weather Service (NWS) veteran, knew this storm would make headlines.

"The hail punched right through the ceiling," Valverde said. "The hailstones knocked ceiling tiles loose and rainwater cascaded down from the electrical fixtures. I hid out in the restaurant's freezer room along with the other customers and employees. I found out later the storm killed two people." An experienced weatherman, Valverde knew that the fierce storm had passed directly over his home in Saginaw. "I called my insurer and the claim adjuster told me the roof had to be replaced. Afterwards, property insurance premiums went up ten percent in my area."

Fortunately, most storms aren't as violent as the one Valverde experienced, and hail larger than baseball size is rare. "Ninety percent of hail is golf ball size or less," said contractor Scott Hamilton, of Lon Smith Roofing in Fort Worth. However, while smaller hailstones may not fracture standard roof shingles, damage still remains.

(Source: Insurance Journal – TX)



Photos courtesy of State Farm Insurance

However, in areas where storms and high winds can damage many roofs, these shingles offer additional protection to the structure and occupants. Depending on location and frequency of storms, the costs for this type of roofing could be less than the costs of replacing roofing due to impact or wind. With a 6-nail vs. 3-nail installation, Class 4 shingles frequently come with a limited warranty against 120-130 mph winds. (Source: National Association of Home Builders). Additionally, insurance companies may offer a discount to homeowners on their homeowner's insurance policy for shingles meeting Class 4 rating from UL 2218. Also, Class 4 shingles frequently have a 30-50 year guarantee, vs. a 15-20 year guarantee for conventional Class 1 material, thus greatly extending the period between roof replacements.

Class 4 Roofing materials Cost Effectiveness

If the insurance carrier offers a premium discount, the total impact to the homeowner is reduced. Assuming an average annual premium for our sample home of $800, and further assuming our hail-resistant product qualifies for the maximum discount offered by the insurance carrier (25 percent), then our homeowner will be saving $200 per year in premiums, or $6,000 over 30 years. The total impact to the homeowner of $2,100 now becomes a savings of $3,900 or approximately $130 per year.

The selection of a hail-resistant shingle, in conjunction with an incentive from the insurance carrier, is a cost effective alternative for both the homeowner and the insurance company. To make this program a reality, however, the insurance company must educate the homeowner on the potential long-term cost savings that are associated with the installation of the preferred roofing system.

Article originally published by: Professional Investigative Engineers, Inc.

B.4.9 Lightning Protection Systems

The purpose of a lightning protection system is to intercept lightning and safely direct its current to ground. If the system is properly designed, installed and maintained it can provide almost 100% protection to buildings.

The system for an ordinary structure includes at least air terminals (lightning rods), down conductors, and ground terminals. These three elements of the system must form a continuous conductive path for lightning current. Many systems of air terminals now may not even be connected to the building. They may be comprised of freestanding cables or towers above or next to the building. This is especially needed where the structure may house explosives or delicate electronics, since even with a lightning rod, some energy may be transferred to the structure through induction.

National Fire Protection Association document NFPA 780, *Standard for the Installation of Lightning Protection Systems* describes lightning protection system installation requirements. NFPA 780 is available through www.nfpa.org/Codes/NFPA_Codes_and_Standards/List_of_NFPA_documents/NFPA_780.asp. Additional information on design and construction of lightning protection systems is available on www.montana.edu/wwwpb/pubs/mt8529ag.pdf.

B.4.10 Surge and Spike Protection

The average home has 2,200 or more power surges annually, 60% of which are generated within the home. Most surges are caused by motors starting in air conditioners, garage doors, refrigerators and other major appliances. Electronic appliances can be damaged or destroyed by over-voltage surges or spikes.

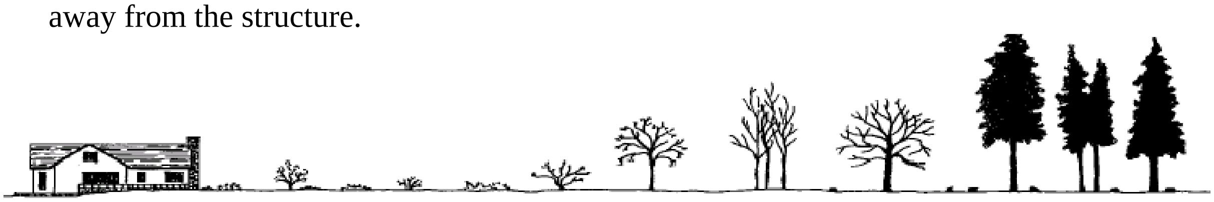
Whole house surge protectors offer the first line of defense against high-energy, high-voltage surges. These devices thwart the energy of the initial surge and reduce it before it reaches electrical appliances. In many cases this level of protection is enough to protect the home. Surge protectors should be sufficient to also provide "spike protection," which can defend against the extremely high spiking voltage created by lightning strikes. Many surge protectors, while effective against routine voltage fluctuations, may not defend against high level spikes.

Surge protection devices connected directly to appliances offer the second line of defense. They are the only defense against surges within the home as when, for example, a large appliance kicks in. The combination of whole house and point-of-use surge protection provides the best possible protection.

For more information on whole house and point-of-use surge protectors, refer to www.howstuffworks.com/surge-protector.htm.

B.4.11 Landscaping for Wildfire Prevention

The chance of losing property due to wildfire can be reduced using fire prevention landscaping techniques. The amount of cleared space around a home improves its ability to survive a wildfire. A structure is more likely to survive when grasses, trees and other common fuels are removed, reduced or modified to reduce a fire's intensity and keep it away from the structure.



Zone 1: Moist and trim. Turf, perennials, groundcovers and annuals form a greenbelt that is regularly watered and maintained. Shrubs and trees are located at least 10 feet from the house.

Zone 2: Low and sparse. Slow growing, drought-tolerant shrubs and groundcovers keep fire near ground level. Native vegetation can be retained if it is low growing, does not accumulate dry, flammable material and is irrigated.

Zone 3: High and clean. Native trees and shrubs are thinned and dry debris on the ground is removed. Overgrowth is removed and trees are pruned every 3-5 years.

Zone 4: Natural area. Native plants are selectively thinned. Highly flammable vegetation is replaced with less fire-prone species.

For comprehensive lists of steps to protect your home before, during and after a wildfire, see www.fema.gov/pdf/library/98surst_wf.pdf or www.cnr.uidaho.edu/extforest/F3.pdf.

B.4.12 Conclusions

1. Acquisition and relocation of property is the most effective for property protection in the case of hazards that are expected to occur repeatedly in the same locations. Acquisition followed by demolition is preferable.

2. Other methods of property protection for flooding include raising building elevations and building berms and floodwalls.
3. Building modifications are also appropriate for some hazards.
4. Property insurance has the advantage of protecting the property without human intervention.
5. Local government can help in reducing losses from natural hazards by providing financial assistance, having an acquisition program, and other incentives.

B.4.13 Recommendations

Refer to *Chapter 6: Action Plan and Mitigation Measures*, Table 6–2, for a complete listing of all recommended mitigation measures by hazard and priority.

B.5 Emergency Services

Emergency services measures protect people during and after a hazard event. Measures include preparedness, threat recognition, warning, response, critical facilities protection, and post-disaster recovery and mitigation.

B.5.1 Threat Recognition

Threat recognition is the key. The first step in responding to a flood, tornado, storm or other natural hazard is being aware that one is coming. Without a proper and timely threat recognition system, adequate warnings cannot be disseminated.

Emergency Alert System (EAS)

Using digital technology to distribute messages to radio, television and cable systems, the EAS provides state and local officials with the ability to send out emergency information targeted to a specific area. The information can be sent electronically through broadcast stations and cable systems even if those facilities are unattended.

Floods

A flood threat recognition system provides early warning to emergency managers. A good system will predict the time and height of the flood crest. This can be done by measuring rainfall, soil moisture, and stream flows upstream of the community and calculating the subsequent flood levels.

Areas subject to flooding should be clearly posted

On larger rivers, including the Washita, the National Weather Service does the measuring and calculating, which is in the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA). Flood threat predictions are disseminated on the NOAA Weather Wire or NOAA Weather Radio. NOAA Weather Radio is considered by the federal government to be the official source for weather information.

The National Weather Service issues notices to the public, using two levels of notification:

Flood watch: conditions are right for flooding;

Flood warning: a flood has started or is expected to occur.

On smaller rivers, local rainfall and river gages are needed to establish a flood threat recognition system. The National Weather Service may issue a "flash flood watch." This means the amount of rain expected will cause ponding and other flooding on small streams and depressions. These events are sometimes so localized and rapid that a "flash flood warning" may not be issued, especially if no gauges or other remote threat recognition equipment is available.

Meteorological Hazards

The National Weather Service is the primary agency for detecting meteorological threats, such as tornadoes, thunderstorms, and winter storms. As with floods, the Federal agency can only look at the large scale, e.g., whether conditions are appropriate for formation of a tornado. For tornadoes and thunderstorms, the local government can provide more site-specific and timely recognition by sending out spotters to watch the skies when the Weather Service issues a watch or warning.

NOAA Weather (All-Hazard) Radios

The National Oceanographic and Atmospheric Administration (the parent agency for the National Weather Service) maintains a nationwide network of radio stations broadcasting continuous weather information direct from regional National Weather Service offices. The NWS broadcasts warnings, watches, and forecasts 24 hours a day. Post-event information is also broadcast for natural hazards (such as tornados and earthquakes) and environmental hazards (such as chemical releases or oil spills). In addition, many emergency management agencies have access to these radios to broadcast Amber Alerts and other hazard and safety information.

These broadcasts can be received by any radio capable of receiving the Weather Service frequency. NOAA All Hazard Radios have the additional advantage of being activated by a pre-broadcast signal transmitted by the NWS, coming off standby and sounding an alert tone loud enough to wake sleeping individuals before transmitting the warning message. NOAA Weather Radio receivers can be purchased at many retail stores that sell electronic merchandise. Typical cost of a residential grade NOAA Weather Radio is between $20 and $80.

For more information on NOAA Weather Radios, see www.nws.noaa.gov/nwr/.

B.5.2 Warning

After the threat recognition system tells the Emergency Manager or other local government official that a flood or other hazard is coming, the next step is to notify the public and staff of other agencies and critical facilities. The earlier and the more specific the warning is given, the greater the number of people who can implement protection measures. The following are some of the more common warning methods:

Broadcast announcements & EAS	Good tools for delivering an alert to a wide coverage area but not well suited for delivering "actionable" information to specific population segments. For an EAS to be effective, it is essential for the target audience to be tuned in to a regional station. Actual practice shows this is not always the case, particularly late at night when the general population is asleep.

Door-to-door Notification	Door-to-door notification would be an ideal way to communicate with specific individuals or neighborhoods. However, efficiency is impacted by the number of addresses to be contacted, the number of personnel available to "walk the streets", and the amount of time available prior to the event (i.e., evacuation). It is highly unlikely that sufficient public safety personnel would be available to effectively provide such door-to-door notification services. Door-to-door also has the potential of putting first responders in harm's way.
Other Communications Devices	There are many communication devices available that may be able to receive emergency notifications – faxes, pagers, PDAs and cell phones. However, as with Weather Alert Radio, their level of penetration throughout the population is too low to ensure effective delivery. Selecting distinct population segments based on geography with such devices is also a problem.
Outdoor warning sirens	Sirens can be effective in their ability to alert people within hearing distance that a crisis or emergency situation may exist. Outdoor warning sirens and public address systems are commonly located in densely populated urban settings, but are not as useful in rural areas. Sirens are intended to alert the public to implement some pre-determined action (i.e., tune to radio and television for specific information on a hazard). However the public generally has no awareness of the need to do so and often will ignore sirens thinking they are a "test" unless they see the hazard approaching, which is often then too late to take appropriate action. In addition, in many areas, sirens are used only for specific emergencies, such as floods or tornadoes, and are of little use in helping public safety personnel alert residents to other events/crises.
NOAA Weather Radio	Weather Alert Radio, while an invaluable tool, has limited applicability. Lacking proper feedback, public safety and emergency management officials have no way of being sure that everyone in their jurisdiction can be reached with such announcements because, similar to broadcast announcements, the audience must have a NOAA radio, and be tuned in.
Sirens on public safety vehicles	These have many of the same drawbacks as both door-to-door notification and outdoor warning sirens. Emergency vehicle sirens do not provide "actionable" information on how to respond. In addition, crucial emergency service personnel may be tied up when their services are more urgently needed for response.

Adapted from *NENA Minimum Standards for Emergency Telephone Notification Systems, NENA 56-003, June 12, 2004*

Multiple or redundant systems are the most effective, since people do not hear one warning, they may still get the message from another part of the system. Each has advantages and disadvantages. Outdoor warning sirens can reach the most people quickly (except those around loud noise, such as at a factory or during a thunderstorm), but they do not explain what hazard is coming and cannot be sounded unless a timely means of threat recognition exists. Radio and TV provide a lot of information, but people have to know to turn them on. Telephone trees are fast, but can be expensive, do not work when phones lines are down, and can break down if some people in the chain are directly affected.

Just as important as issuing a warning is telling people what to do. A warning program should have a public information aspect. People need to know the difference between a tornado warning (when they should seek shelter in a basement) and a flood warning (when they should stay out of basements).

B.5.3 9-1-1 and 2-1-1

Some communities have expanded their basic 9-1-1 location identification telephone service to include features such as "enhanced 9-1-1" registering name, address, and a description of the building/site. Additionally, non-emergency 2-1-1 service can be used to have people call to get information, such as locations of cooling shelters during a heat wave. For information on coverage areas and contact information for area 2-1-1 systems, see www.211oklahoma.org.

B.5.4 Emergency Telephone Notification Systems (ETNS)

It has become more common to use an "Emergency Telephone Notification System" (frequently referred to as "reverse 9-1-1") with which a community or Tribe can send out a mass telephone announcement to targeted numbers in the 9-1-1 system, effectively supplementing a community's other warning systems. An effective ETNS can offer certain advantages over other systems:

- ETNS systems provide the ability to precisely target populations in specific geographic locations better than existing alternatives, particularly when ETNS systems are integrated with geographic information systems (GIS) maps commonly used by 9-1-1 systems;
- The telephone, more than any other communications medium, allows officials to deliver specific actionable information that lets those in harm's way know exactly what to do, what to expect, or what to look for;
- The telephone is always on, providing the opportunity to reach nearly everyone in a target area either live or through voicemail.
- Many systems also offer the option of allowing people to call in and retrieve the same message or an updated one. This can reduce the subsequent number of calls to 9-1-1 from people who did not fully understand the message the first time. (*Source: NENA Minimum Standards for Emergency Telephone Notification Systems, NENA 56-003, June 12, 2004*).

B.5.5 Response

The protection of life and property is the foremost important task of emergency responders. Concurrent with threat recognition and issuing warnings, government officials should respond with actions that can prevent or reduce damage and injuries. Typical actions and responding parties include the following:

- activating the emergency operations room (emergency management);
- closing streets or bridges (police or public works);

- shutting off power to threatened areas (utility company);
- holding children at school/releasing children from school (school district);
- passing out sand and sandbags (public works);
- ordering an evacuation (mayor);
- opening evacuation shelters (Red Cross);
- monitoring water levels (engineering);
- providing security and other protection measures (police).

In the event of an emergency, responders must make an organized effort to minimize the impacts of the incident.

An emergency action plan ensures that all bases are covered and that the response activities are appropriate for the expected threat. These plans are developed in coordination with the agencies or offices that are given various responsibilities.

Emergency response plans should be updated annually to keep contact names and telephone numbers current and to make sure that supplies and equipment that will be needed are still available. They should be critiqued and revised after disasters and exercises to take advantage of the lessons learned and changing conditions. The end result is a coordinated effort implemented by people who have experience working together so that available resources will be used in the most efficient manner.

B.5.6 Emergency Operations Plan (EOP)

An EOP develops a comprehensive (multi-use) emergency management program which seeks to mitigate the effects of a hazard, to prepare for measures to be taken which will preserve life and minimize damage, to respond during emergencies and provide necessary assistance and to establish a recovery system in order to return communities to their normal state of affairs. The plan defines who does what, when, where and how in order to mitigate, prepare for, respond to and recover from the effects of war, natural disasters, technological accidents and other major incidents / hazards.

Funding for creating or updating an EOP is available from FEMA. For information on how to obtain funding contact the Oklahoma Office of Homeland Security or go to www.dhs.gov/xopnbiz/grants/.

The State of Oklahoma’s Emergency Operations Plan is published on www.ok.gov/OEM/Programs_&_Services/Planning/State_Emergency_Operations_Plan_(EOP)/.

Communities and Public School Districts should coordinate the local emergency response plans with the local school district's emergency operations plan.

B.5.7 Incident Command System (ICS)

The Incident Command System is the model tool for the command, control and coordination of resources at the scene of an emergency. It is a management tool of procedures for organizing personnel, facilities, equipment and communications. ICS is based upon basic management skills managers and leaders already know: planning, directing, organizing, coordinating, communicating, delegating and evaluating.

Continuity of Operations (COOP) planning should be addressed in the EOP. COOP ensures the essential functions of an organization, including government, can continue to operate during and after an emergency incident. An incident may prevent access to normally operating systems, such as physical plant, data or communication networks, or transportation. Government, business, other organizations, and families should be encouraged to prepare by regularly backing up computer hard drives, copying essential files, and storing these items in a separate location.

ICS is not a means to wrestle control or authority away from agencies or departments, a way to subvert the normal chain of command within a department or agency, nor is it always managed by the fire department, too big for small everyday events or restricted to use by government agencies and departments. ICS is an adaptable methodology suitable for emergency management as well as many other categories. If leadership is essential for the success of an event or a response, ICS is the supporting foundation for successfully managing that event.

The Incident Command System is built around five major management activities. These activities are:

- Command – sets objectives and priorities and has overall responsibility at the incident or event.
- Operations – conducts tactical operations to carry out the plan and directs resources.
- Planning – develops the action plan to accomplish objectives and collects and evaluates information.
- Logistics – provides resources and services to support incident needs.
- Finance / Administration – monitors costs, provides accounting, reports time and cost analysis.

The system can grow or shrink to meet changing needs. This makes it very cost-effective and efficient. The system can be applied to a wide variety of situations such as fires, multi-jurisdiction and multi-agency disasters, hazardous material spills and recovery incidents, pest eradication programs and state or local natural hazards management.

For a detailed description of ICS, a diagram of ICS organization, or checklists of duties for each management activity and links to other resources see http://www.911dispatch.com/ics/ics_main.html.

B.5.8 Mutual Aid / Interagency Agreements

Local governments should establish mutual aid agreements for utility and communications systems, including 9-1-1. Mutual aid or interagency agreements have value for preventing or responding to other hazard or emergency situations, as fire and police departments often do.

B.5.9 CERT (Community Emergency Response Team)

After a major disaster, local emergency teams quickly become overwhelmed. CERT is designed to have trained groups of people in every neighborhood and business ready to assist first responders (police, firefighters and EMS) during an emergency.

CERT programs train and equip residents in neighborhoods and businesses enabling them to "self-activate" immediately after a disaster. CERT teams are trained in:

- disaster preparedness;
- light fire suppression;
- Incident Command System;
- light search and rescue;
- basic disaster medical care;
- basic disaster psychology.

FEMA grants have been given to states for funding CERT programs or expanding existing teams. For information about the Oklahoma grant see www.fema.gov/news/newsrelease.fema?id=3155.

For more information on the CERT program talk to your local emergency management official or visit training.fema.gov/emiweb/CERT/.

B.5.10 Debris Management

The tornados of May 3, 1999 left an estimated 500,000 cubic yards of debris. Debris in the aftermath of a disaster poses significant health and safety risks. Debris can include fuel containers, chemicals, appliances and explosives.

Two key considerations regarding debris management are the need for rapid removal and protection of the public health and environment. Before a disaster strikes, communities should set up staging area(s) where residents and cleanup crews can take debris prior to final disposal.

Community members can participate in debris control by securing debris, yard items, or stored objects that may otherwise be swept away, damaged, or pose a hazard if floodwaters would pick them up and carry them away. Additionally, a community can pass and enforce an ordinance regulating dumping.

For the Oklahoma Department of Environmental Quality's *Guidelines for Debris Management* see document: http://www.deq.state.ok.us/factsheets/local/debris.pdf.

B.5.11 Critical Facilities Protection

"Critical facilities" were previously discussed in Section 2.3.5. Generally, they fall into three categories:

- buildings or locations vital to the response and recovery effort, such as police and fire stations and telephone exchanges;
- buildings or locations that, if damaged, would create secondary disasters, such as hazardous materials or utility facilities, or water treatment plants;
- locations that would require extraordinary response or preparedness measures, such as hospitals, retirement homes, or childcare facilities.

In addition, since September 11th, FEMA has included financial institutions as possible critical facilities, because of the potential devastating effect on the community infrastructure upon their loss.

Protecting privately-owned critical facilities during a disaster is the responsibility of the facility owner or operator. However, if they are not prepared for an emergency, the rest of the Tribe or community could be impacted. If a critical facility is damaged, workers and resources may be unnecessarily drawn away from other disaster response efforts. If the owner or operator adequately prepares such a facility, it will be better able to support the community's emergency response efforts.

Many critical facilities have full-time professional managers or staff who are responsible for the facility during a disaster. These people often have their own emergency response plans. Many facilities would benefit from early disaster warning, disaster response planning, and coordination with community disaster response efforts.

Schools are critical facilities not only because of the special population they accommodate, but because they are often identified as shelter sites for residents. Processes and procedures can be developed to determine mitigation priorities incorporated into capital improvement plans that will ensure these buildings function after an event.

Protocols should be in place to ensure there are adequate backup facilities for the Emergency Operations Centers and 9-1-1 Centers, both of which are critical facilities.

B.5.12 Site Emergency Plans

Communities can encourage development and testing of internal emergency plans and procedures, including continuity planning, by businesses and other organizations.

Communities should develop and test site emergency plans for schools, factories, office buildings, shopping malls, Tribal casinos, hospitals, correctional facilities, stadiums, recreation areas, and other similar facilities.

B.5.13 Post-Disaster Recovery and Mitigation

After a disaster, communities should undertake activities to protect public health and safety, facilitate recovery, and help people and property for the next disaster. Throughout the recovery phase, everyone wants to get “back to normal.” The problem is, “normal” means the way they were before the disaster. Measures needed include the following:

Recovery Actions

- patrolling evacuated areas to prevent looting;
- providing safe drinking water;

- monitoring for diseases;
- vaccinating residents for tetanus;
- clearing streets;
- cleaning up debris and garbage;
- regulating reconstruction to ensure that it meets all code requirements, including the NFIP's substantial damage regulations.

A firefighter searches through the remains of a hotel in Midwest City.
Oklahoman Staff Photo by Paul Hellstern

Mitigation Actions

- conducting a public information effort to advise residents about mitigation measures they can incorporate into their reconstruction work;
- evaluating damaged public facilities to identify mitigation measures that can be included during repairs;
- acquiring substantially or repeatedly damaged properties from willing sellers;
- planning for long term mitigation activities;
- applying for post-disaster mitigation funds.

Requiring permits, conducting inspections, and enforcing the NFIP substantial improvement/substantial damage regulations can be very difficult for local, understaffed overworked offices after a disaster. If these activities are not carried out properly, not only does the municipality miss a tremendous opportunity to redevelop or clear out a hazardous area, it may be violating its obligations under the NFIP.

B.5.14 StormReady Communities

StormReady, a program started by the National Weather Service in Oklahoma in 1999, helps arm America's communities with the communication and safety skills needed to save lives and property before and during an event. *StormReady* communities are better prepared to save lives from the onslaught of severe weather through better planning, education, and awareness.

StormReady has different guidelines for different sized communities. To be StormReady a community must:

- establish a 24-hour warning point and emergency operations center;
- have more than one way to receive severe weather warnings and forecasts and to alert the public;
- create a system that monitors weather conditions locally;
- promote the importance of public readiness through community seminars;
- develop a formal hazardous weather plan, which includes training severe weather spotters and holding emergency exercises.

The economic investment in *StormReady* will depend on current assets. There is currently no grant funding for becoming *StormReady*. However, the Insurance Services Organization (ISO) provides CRS credit to *StormReady* communities. This credit is used to determine the CRS rating, which can lower flood insurance rates.

For details on how to become *StormReady* and the requirements based on community size see http://www.stormready.noaa.gov/. For a list of currently certified Stormready communities and counties, see www.stormready.noaa.gov/com-maps/ok-com.htm.

B.5.15 Conclusions

1. Using solid, dependable threat recognition systems is first and foremost in emergency services.
2. Following a threat recognition, multiple or redundant warning systems and instructions for action are most effective in protecting residents.
3. Good emergency response plans that are updated yearly ensure that well-trained and experienced people can quickly take the appropriate measures to protect residents and property.
4. To ensure effective emergency response, critical facilities protection must be part of the plan.
5. Post-disaster recovery activities include providing neighborhood security, safe drinking water, appropriate vaccinations, and cleanup and regulated reconstruction.

B.5.16 Recommendations

Refer to *Chapter 6: Action Plan and Mitigation Measures,* Table 6–2, for a complete listing of all recommended mitigation measures by hazard and priority.

B.6 Natural Resource Protection

Natural resource protection activities are generally aimed at preserving and restoring the natural and beneficial uses of natural areas. In doing so, these activities enable the beneficial functions of floodplains and drainageways to be better realized. These natural functions include:

- storage of floodwaters;
- absorption of flood energy;
- reduction of flood scour;
- infiltration and aquifer/groundwater recharge;
- removal/filtration of excess nutrients, pollutants, and sediments from floodwaters;
- habitat for flora and fauna;
- recreation and aesthetic opportunities;
- opportunities for off-street hiking and biking trails.

Wetlands are a valued resource to ecosystems and should be protected.

This Section reviews natural resource protection activities that protect natural areas and mitigate damage from other hazards. Integrating these activities into the hazard mitigation program will not only reduce the community's susceptibility to flood damage, but will also improve the overall environment.

B.6.1 Wetland Protection

Wetlands are often found in floodplains and depressional areas of a watershed. Many wetlands receive and store floodwaters, thus slowing and reducing downstream flows. They also serve as a natural filter, which helps to improve water quality, and provide habitat for many species of fish, wildlife, and plants.

Wetlands are regulated by the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency under Section 404 of the Clean Water Act. Before a "404" permit is issued, the plans are reviewed by several agencies, including the Corps and the U.S. Fish and Wildlife Service. Each of these agencies must sign off on individual permits. There are also nationwide permits that allow small projects that meet certain criteria to proceed without individual permits.

Wetlands

- Store large amounts of floodwaters.
- Reduce flood velocities and erosion.
- Filter water, making it cleaner for those downstream.
- Provide habitat for species that cannot live or breed elsewhere.

B.6.2 Erosion and Sedimentation Control

Farmlands and construction sites typically contain large areas of bare exposed soil. Surface water runoff can erode soil from these sites, sending sediment into downstream waterways. Sediment tends to settle where the river slows down and loses power, such as when it enters a lake or a wetland.

Construction projects, which can expose large areas to erosion, should be closely monitored.

Sedimentation will gradually fill in channels and lakes, reducing their ability to carry or store floodwaters. When channels are constricted and flooding cannot deposit sediment in the bottomlands, even more is left in the channels. The result is either clogged streams or increased dredging costs.

Not only are the drainage channels less able to do their job, but also the sediment in the water reduces light, oxygen, and water quality and often brings chemicals, heavy metals and other pollutants. Sediment has been identified as the nation's number one nonpoint source pollutant for aquatic life.

Practices to reduce erosion and sedimentation have two principal components:

1. minimize erosion with vegetation;
2. capture sediment before it leaves the site.

Lack of vegetation along drainage channels promotes erosion.

Slowing surface water runoff on the way to a drainage channel increases infiltration into the soil and reduces the volume of topsoil eroded from the site. Runoff can be slowed down by measures such as terraces, contour strip farming, no-till farm practices, sediment fences, hay or straw bales (as illustrated), constructed wetlands, and impoundments (e.g., sediment basins and farm ponds).

Erosion and sedimentation control regulations mandate that these types of practices be incorporated into construction plans. They are usually oriented toward construction sites rather than farms. The most common approach is to require applicants for permits to submit an erosion and sediment control plan for the construction project. This allows the applicant to determine the best practices for the site.

One tried and true approach is to have the contractor design the detention basins with extra capacity. They are built first, so they detain runoff during construction and act as sediment catch basins. The extra capacity collects the sediment that comes with the runoff until the site is planted and erosion is reduced.

B.6.3 River Restoration

There is a growing movement that has several names, such as "stream conservation," "bioengineering" or "riparian corridor restoration." The objective of these approaches is to return streams, stream banks and adjacent land to a more natural condition, including the natural meanders. Another term is "ecological restoration" which restores native indigenous plants and animals to an area.

A key component of these efforts is using appropriate native plantings along the banks that resist erosion. This may involve "retrofitting" the shoreline with willow cuttings, wetland plants, and/or rolls of landscape material covered with a natural fabric that decomposes after the banks are stabilized with plant roots.

Retrofitting streambanks with willow cuttings and geotextiles can be more cost effective than riprap or concrete-lined floodways.

Studies have shown that after establishing the right vegetation, long-term maintenance costs are lower than if the banks were concrete. The Natural Resources Conservation Service estimates that over a ten-year period, the combined costs of installation and maintenance of a natural landscape may be one-fifth of the cost for conventional landscape maintenance, e.g., mowing turf grass.

B.6.4 Best Management Practices

Point source pollutants come from pipes such as the outfall of a municipal wastewater treatment plant. State and federal water quality laws have reduced the pollutants that come from these facilities.

Non-point source pollutants come from non-specific locations and are harder to regulate. Examples are lawn fertilizers, pesticides, and other farm chemicals, animal wastes, oils from street surfaces and industrial areas, and sediment from agriculture, construction, mining and forestry. These pollutants are washed off the ground's surface by stormwater and flushed into receiving storm sewers, ditches and streams.

Best management practices (BMPs) are measures that reduce nonpoint source pollutants that enter the waterways. BMPs can be implemented during construction and as part of a project's design to permanently address nonpoint source pollutants.

There are three general categories of BMPs:

1. **Avoidance—**Setting construction projects back from the stream;
2. **Reduction—**Preventing runoff that conveys sediment and other water-borne pollutants, such as planting proper vegetation and conservation tillage;
3. **Cleansing—**Stopping pollutants after they are en route to a stream, such as using grass drainageways that filter the water and retention and detention basins that let pollutants settle to the bottom before they are drained.

In addition to improving water quality, BMPs can have flood related benefits. By managing runoff, they can attenuate flows and reduce the peaks after a storm. Combining water quality and water quantity measures can result in more efficient multi-purpose stormwater facilities.

Because of the need to clean up our rivers and lakes, there are several laws mandating the use of best management practices for new developments and various land uses. The furthest reaching one is the U.S. Environmental Protection Agency's National Pollutant Discharge Elimination System (NPDES) requirements.

B.6.5 Dumping Regulations

NPDES addresses liquid pollutants. Dumping regulations address solid matter, such as shopping carts, appliances and landscape waste that can be accidentally or intentionally thrown into channels or wetlands. Such materials may not pollute the water, but they can obstruct even low flows and reduce the channels' and wetlands' ability to convey or clean stormwater.

Many cities have nuisance ordinances that prohibit dumping garbage or other "objectionable waste" on public or private property. Waterway dumping regulations need to also apply to "non-objectionable" materials, such as grass clippings or tree branches, which can kill ground cover or cause obstructions in channels.

Many people do not realize the consequences of their actions. They may, for example, fill in the ditch in their front yard not realizing that it is needed to drain street runoff. They may not understand how regrading their yard, filling a wetland, or discarding leaves or branches in a watercourse can cause a problem to themselves and others. Therefore, a dumping enforcement program should include public information materials that explain the reasons for the rules as well as the penalties.

Regular inspections to catch violations also should be scheduled. Finding dumped materials is easy; locating the source of the refuse is hard. Usually the owner of a property adjacent to a stream is responsible for keeping the stream clean. This may not be fair for sites near bridges and other public access points.

B.6.6 Conclusions

1. Wetlands play an important role in the natural course of flood control, preservation of water quality, and wildlife habitation, making a strong case for their protection.
2. Erosion can be reduced by use of vegetation. Sedimentation should be captured before it leaves its original location with oversized detention basins.
3. Vegetation used along riverbanks works more effectively in river maintenance than using banks made of concrete.
4. Nonpoint source pollutants are best managed by keeping construction projects away from streams, reducing sediment runoff, and using grass drainageways and detention basins for filtration.
5. Dumping regulations need to be communicated to the public and enforced.

6. The establishment and maintenance of wildlife habitat and natural ecosystems should be an important aspect of any drainage system program the community may implement in regards to floodplain management. This can be developed in cooperation with the Oklahoma Department of Wildlife Conservation, allowing aquatic plants and wildlife to be established in stormwater detention ponds and floodways.

B.6.7 Recommendations

Refer to *Chapter 6: Action Plan and Mitigation Measures,* Table 6–2, for a complete listing of all recommended mitigation measures by hazard and priority.

TULSA COUNTY LEPC MEETING AGENDA – 3/24/06

Call to Order

Review of last Meeting's Minutes (January 20, 2006) – Discussion/Acceptance

Officer's/Project Chairperson's Reports
1. Treasurer
2. Others

Old Business:
1. Review of activities related to reformulation and re-staffing of the LEPC by the current and present chairman
2. Update on Technical Developments, Equipment Acquisition, Training Activities, Governmental Activities relating to Emergency Planning – R. Brasfield (if available), TEMA representative, others as appropriate

New Business
1. Discussion of Chairman's Proposal that the LEPC's first priority shall be Organization/Updating/Availability of data on chemical inventories, their size and location so that such information can be readily provided to parties with a legitimate need for such information.
   A. Authorization for employment of a temporary employee to work with the LEPC Chairman to physically review, organize and codify available records and request updated materials as necessary. Current Temporary Employment-5/10 working Days
2. Chairman/Past Chairman Meeting with Tulsa Fire Chief-Before Next LEPC Meeting
3. Creation of a Public Relations Sub-Committee-Contact with Media Sources
4. Presentation by a representative of R. J. Flannigan & Associates on a City of Tulsa commissioned project to qualify for Federal Emergency Management Funds (FEMA) for financial assistance in the event of a catastrophic occurrence.

Tentative Schedule for Next Meeting

Adjournment

6/12/06

Tulsa County LEPC
Interested in TAC/CAC

Name	Tech Ad.	Citizens Adv.	Contact
Henry Townsend	✓	✓	628-0651
Don Karecki (K&M)		✓	499-3959
Jeff Schippers	✓		560-4096
Barbara Bailey	✓	✓	918-261-9447
Gay Campbell	✓	✓	918-494-2497
John Campbell TAEMA possi	✓		596-9897
Johnnie Munn	✓	✓	596-3669
Tim Hoss (TRMC)	✓	✓	599-5610 (c) 340-0436
Joe Bennett (Sunoco)		✓	594-6492

Meeting Sign in Sheet

R.D. FLANAGAN & ASSOCIATES
Planning Consultants
www.rdflanagan.com

Project:	**TULSA COUNTY MULTI-HAZARD MITIGATION PLAN**
Purpose of Meeting:	TAC/CAC (1st CAC mtg.)
Date of Meeting: 6/15/06	**Time Begin:** 1500 **Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	Flanagan, Ron	Consultant		918-749-2696	Rdflanagan@rdflanagan.com
	Roberts, Bob	Consultant		918-749-2696	broberts@rdflanagan.com
BB	1. Bailey, Barbara	City of Tulsa	C	918-591-4384	barbailey@ci.tulsa.ok.us
agc	2. Campbell, Gay	St. Francis ~~Med Center~~ Health System	C	918-494-2497	agcampbell@saintfrancis.com
	3. Campbell, John	TAEMA	T	918-596-9899	jcampbell@cityoftulsa.org
[illegible]	4. Downing, Dennis		C	918-366-3041	gdowning@tulsarealtor.com
	5. Fox, Patrick	City of Tulsa	T	918-596-2600	pfox@cityoftulsa.org
	6. Goodson, Marsha, MPH	Disaster Coord, St. John Medical Ctr	C	918-744-3157	Mgoodson@SJMC.org
[illegible]	7. Gund, Steve	Consultant	C	918-366-8711 918-629-6533	stevegund@olp.net
TH	8. Hoss, Tim	TRMC	C	918-599-5610	thoss@hillcrest.com
	9. Jordan, Ray	Tulsa County Engineer	T	918-596-5730	engineers@tulsacounty.org
	10. Karecki, Don	K&M Publishing	C	918-499-3959	dkarecki@cox.net

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
CMM	11. McCool, Mike	Director TAEMA	T	918-596-9890	mmccool@ci.tulsa.ok.us
	12. Munn, Johnnie	EMSA MERC Coordinator	C/T	918-596-3669	munnj@emsa.net
[illegible]	13. ~~Painter~~ Tosh, ~~Theresa~~ Teresa	County Inspections	T	918-596-5290	tpainter@tulsacounty.org
	14. Schippers, Jeff	Chemtrade	T	918-560-4096	jschippers@chemtradelogistics.com
H.T.	15. Townsend, Henry	Chair LEPC	C	918-628-0651	hdytownsend@peoplepc.com
[illegible]	16. West, Terry	County Inspections	T	918-596-5296	twest@tulsacounty.org
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Project:	**TULSA COUNTY MULTI-HAZARD MITIGATION PLAN**		
Purpose of Meeting:	**TAC / CAC**		
Date of Meeting: July 20/2006		**Time Begin:** 11:00	**Time End:** 12:30

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	Flanagan, Ron	Consultant		918-749-2696	Rdflanagan@rdflanagan.com
	Roberts, Bob	Consultant		918-749-2696	broberts@rdflanagan.com
BB	1. Bailey, Barbara	Envir. Compliance City of Tulsa	C	918-591-4384	barbailey@ci.tulsa.ok.us
	2. Campbell, Gay	Envir. Safety, St. Francis Health System	C	918-494-2497	agcampbell@saintfrancis.com
	3. Campbell, John	TAEMA	T	918-596-9899	jcampbell@cityoftulsa.org
[signature]	4. Downing, Dennis	Retired	C	918-366-3041	gdowning@tulsarealtor.com
	5. Fox, Patrick	Historic Preservation City of Tulsa	T	918-596-2600	pfox@cityoftulsa.org
	6. Goodson, Marsha, MPH	Disaster Coord, St. John Medical Ctr	C	918-744-3157	Mgoodson@SJMC.org
[signature]	7. Gund, Steve	Consultant	C	918-366-8711 918-629-6533	stevegund@olp.net
TH	8. Hoss, Tim	Safety Officer Tulsa Reg'l Med Ctr.	C	918-599-5610	thoss@hillcrest.com
R.J	9. Jordan, Ray	Tulsa County Engineer	T	918-596-5730	engineers@tulsacounty.org
	10. Karecki, Don	President K&M Publishers	C	918-499-3959	dkarecki@cox.net

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
[illegible]	11. McCool, Mike	Director TAEMA	T	918-596-9890	mmccool@ci.tulsa.ok.us
[illegible]	12. Munn, Johnnie	EMSA MERC Coordinator	C/T	918-596-3669	munnj@emsa.net
[illegible]	13. Tosh, Theresa	Plans Examiner, CFM County Inspections	T	918-	Tpainter@tulsacounty.org
[illegible]	14. Schippers, Jeff	Chemtrade	T	918-560-4096	jschippers@chemtradelogistics.com
HT	15. Townsend, Henry	Chair, LEPC Consultant	C	918-628-0651	hdytownsend@peoplepc.com
[illegible]	16. West, Terry	Zoning Officer County Inspections	T	918-596-5296	twest@tulsacounty.org
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Meeting Sign in Sheet

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Project:	**TULSA COUNTY MULTI-HAZARD MITIGATION PLAN**		
Purpose of Meeting:	**TAC / CAC**		
Date of Meeting:	**August 23, 2006**	**Time Begin: 11:00 a.m.**	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	Flanagan, Ron	Consultant		918-749-2696	Rdflanagan@rdflanagan.com
	1. Bailey, Barbara	Envir. Compliance City of Tulsa	C	918-591-4384	barbailey@ci.tulsa.ok.us
	2. Campbell, Gay	Envir. Safety, St. Francis Health System	C	918-494-2497	agcampbell@saintfrancis.com
	3. Campbell, John	TAEMA	T	918-596-9899	jcampbell@cityoftulsa.org
✓	4. Downing, Dennis	Retired	C	918-366-3041	gdowning@tulsarealtors.com
	5. Fox, Patrick	Historic Preservation City of Tulsa	T	918-596-2600	pfox@cityoftulsa.org
	6. Goodson, Marsha, MPH	Disaster Coord, St. John Medical Ctr	C	918-744-3157	Mgoodson@SJMC.org
✓	7. Gund, Steve	Consultant	C	918-366-8711 918-629-6533	stevegund@olp.net
TH	8. Hoss, Tim	Safety Officer Tulsa Reg'l Med Ctr.	C	918-599-5610	thoss@hillcrest.com
	9. Jordan, Ray	Tulsa County Engineer	T	918-596-5730	engineers@tulsacounty.org
	10. Karecki, Don	President K&M Publishers	C	918-499-3959	dkarecki@cox.net

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
Z.M.M.	11. McCool, Mike	Director TAEMA	T	918-596-9890	mmccool@ci.tulsa.ok.us
	12. Munn, Johnnie	EMSA MERC Coordinator	C/T	918-596-3669	munnj@emsa.net
	13. Tosh, Theresa	Plans Examiner, CFM County Inspections	T	918-	Tpainter@tulsacounty.org
	14. Schippers, Jeff	Chemtrade	T	918-560-4096	jschippers@chemtradelogistics.com
HT	15. Townsend, Henry	Chair, LEPC Consultant	C	918-628-0651	hdytownsend@peoplepc.com
[illegible]	16. West, Terry	Zoning Officer County Inspections	T	918-596-5296	twest@tulsacounty.org
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Project:	**TULSA COUNTY MULTI-HAZARD MITIGATION PLAN**		
Purpose of Meeting:	**TAC / CAC**		
Date of Meeting:	**September 21, 2006**	**Time Begin: 11:00 a.m.**	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	Flanagan, Ron	Consultant		918-749-2696	Rdflanagan@rdflanagan.com
BB	1. Bailey, Barbara	Envir. Compliance City of Tulsa	C	918-591-4384	barbailey@ci.tulsa.ok.us
	2. Campbell, Gay	Envir. Safety, St. Francis Health System	C	918-494-2497	agcampbell@saintfrancis.com
	3. Campbell, John	TAEMA	T	918-596-9899	jcampbell@cityoftulsa.org
[illegible]	4. Downing, Dennis	Retired	C	918-366-3041	gdowning@tulsarealtors.com
	5. Goodson, Marsha, MPH	Disaster Coord, St. John Medical Ctr	C	918-744-3157	Mgoodson@SJMC.org
[illegible]	6. Gund, Steve	Consultant	C	918-366-8711 918-629-6533	stevegund@olp.net
[illegible]	7. Hoss, Tim	Safety Officer Tulsa Reg'l Med Ctr.	C	918-599-5610	thoss@hillcrest.com
	8. Jordan, Ray	Tulsa County Engineer	T	918-596-5730	engineers@tulsacounty.org
	9. Karecki, Don	President K&M Publishers	C	918-499-3959	dkarecki@cox.net
	10. McCool, Mike	Director TAEMA	T	918-596-9890	mmccool@ci.tulsa.ok.us

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	11. Munn, Johnnie	EMSA MERC Coordinator	C/T	918-596-3669	munnj@emsa.net
[illegible]	12. Tosh, Theresa	Plans Examiner, CFM County Inspections	T	918-	Tpainter@tulsacounty.org
[illegible]	13. Schippers, Jeff	Chemtrade	T	918-560-4096	jschippers@chemtradelogistics.com
	14. Townsend, Henry	Chair, LEPC Consultant	C	918-628-0651	hdytownsend@peoplepc.com
[illegible]	15. West, Terry	Zoning Officer County Inspections	T	918-596-5296	twest@tulsacounty.org
[illegible]	16. Sager, Nelson	Fire Chief Turley Fire Rescue		4250716 918 284057	lightitup7@cox.net
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Planning Consultants
www.rdflanagan.com

Project:	**TULSA COUNTY MULTI-HAZARD MITIGATION PLAN**		
Purpose of Meeting:	**TAC / CAC**		
Date of Meeting: 10-19-06		**Time Begin:** 11:00 a.m.	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	Flanagan, Ron	Consultant		918-749-2696	Rdflanagan@rdflanagan.com
	1. Bailey, Barbara	Envir. Compliance City of Tulsa	C	918-591-4384	barbailey@ci.tulsa.ok.us
[illegible]	2. Campbell, Gay	Envir. Safety, St. Francis Health System	C	918-494-2497	agcampbell@saintfrancis.com
	3. Campbell, John	TAEMA	T	918-596-9899	jcampbell@cityoftulsa.org
	4. Downing, Dennis	Retired	C	918-366-3041	gdowning@tulsarealtors.com
	5. Goodson, Marsha, MPH	Disaster Coord, St. John Medical Ctr	C	918-744-3157	Mgoodson@SJMC.org
[illegible]	6. Gund, Steve	Consultant	C	918-366-8711 918-629-6533	stevegund@olp.net
	7. Hoss, Tim	Safety Officer Tulsa Reg'l Med Ctr.	C	918-599-5610	thoss@hillcrest.com
	8. Jordan, Ray	Tulsa County Engineer	T	918-596-5730	engineers@tulsacounty.org
	9. Karecki, Don	President K&M Publishers	C	918-499-3959	dkarecki@cox.net
	10. McCool, Mike	Director TAEMA	T	918-596-9890	mmccool@ci.tulsa.ok.us

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	11. Munn, Johnnie	EMSA MERC Coordinator	C/T	918-596-3669	munnj@emsa.net
	12. Sager, Nelson	Fire Chief City of Turley	T	918-425-0716 918-284-1057	Lightitup7@cox.net
[signature]	13. Tosh, ~~Theresa~~ Teresa	Plans Examiner, CFM County Inspections	T	918-596 5290 918 272 0093	tpainter@tulsacounty.org
[signature]	14. Schippers, Jeff	Chemtrade	T	918-560-4096	jschippers@chemtradelogistics.com
HDYT.	15. Townsend, Henry	Chair, LEPC Consultant	C	918-628-0651	hdytownsend@peoplepc.com
[signature]	16. West, Terry	Zoning Officer County Inspections	T	918-596-5296	twest@tulsacounty.org
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Meeting Sign in Sheet

R.D. FLANAGAN & ASSOCIATES
Planning Consultants
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Project:	**TULSA COUNTY MULTI-HAZARD MITIGATION PLAN**		
Purpose of Meeting:	**TAC / CAC**		
Date of Meeting:	**November 16, 2006**	**Time Begin: 11:00 a.m.**	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	Flanagan, Ron	Consultant		918-749-2696	Rdflanagan@rdflanagan.com
	1. Bailey, Barbara	Envir. Compliance City of Tulsa	C	918-591-4384	barbailey@ci.tulsa.ok.us
	2. Campbell, Gay	Envir. Safety, St. Francis Health System	C	918-494-2497	agcampbell@saintfrancis.com
	3. Campbell, John	TAEMA	T	918-596-9899	jcampbell@cityoftulsa.org
	4. Downing, Dennis	Retired	C	918-366-3041	gdowning@tulsarealtors.com
	5. Goodson, Marsha, MPH	Disaster Coord, St. John Medical Ctr	C	918-744-3157	Mgoodson@SJMC.org
	6. Gund, Steve	Consultant	C	918-366-8711 918-629-6533	stevegund@olp.net
	7. Hoss, Tim	Safety Officer Tulsa Reg'l Med Ctr.	C	918-599-5610	thoss@hillcrest.com
	8. Jordan, Ray	Tulsa County Engineer	T	918-596-5730	engineers@tulsacounty.org
	9. Karecki, Don	President K&M Publishers	C	918-499-3959	dkarecki@cox.net

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	10. McCool, Mike	Director TAEMA	T	918-596-9890	mmccool@ci.tulsa.ok.us
	11. Munn, Johnnie	EMSA MERC Coordinator	C/T	918-596-3669	munnj@emsa.net
	12. Sager, Nelson	Fire Chief City of Turley	T	918-425-0716 918-284-1057	Lightitup7@cox.net
	13. Tosh, Teresa	Plans Examiner, CFM County Inspections	T	918-596-5290 918-272-0093	tpainter@tulsacounty.org
	14. Schippers, Jeff	Chemtrade	T	918-560-4096	jschippers@chemtradelogistics.com
	15. Townsend, Henry	Chair, LEPC Consultant	C	918-628-0651	hdytownsend@peoplepc.com
	16. West, Terry	Zoning Officer County Inspections	T	918-596-5296	twest@tulsacounty.org
	17. JOLLIFF, ROGER	DEPUTY DIRECTOR TAEMA		918 596 9848	RJOLLIFF@CITYOFTULSA.ORG
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Tulsa County LEPC
Minutes – Meeting of 11/15/06

The meeting was called to order at 9:10 am by Chairman Henry Townsend.

John gave a handout and brief report of the financial status.

1. We are currently using the 2000 census to calculate funding from the contributing cities.
2. Each company participating in the LEPC should submit a list of expenditures that would be beneficial.

Old Business

1. Meet with the Tulsa County Health Department
   Matt Sharp from the Heath Department presented a Powerpoint presentation on disaster planning

2. Status
   a. LEPC responsibilities were reviewed.
   b. Several of the LEPC responsibilities have been taken over by the TFD & TEMA.

3. LEPC at the Broken Arrow community activity (10/28/06)
   a. Handed out information but information was out of date and led callers to the Library.

New Business

a. Election of subcommittee chairpersons
   1. Finance – John
   2. Hazard Analysis – Joe Chaback
   3. Education Advisory – Gay Campbell & Henry Townsend
   4. Public Relations/ Awareness – R.D. Flanagan & Assoc.

b. Get more involvement
   1. Suggested to invite appropriate businesses to a social gathering.
   2. Website creation. (further review at next meeting)

Please submit recommendations for Webmasters & Caterers.
Meeting adjourned at 10:30 am.

Next Meeting Scheduled for 1/25/2007 location to be emailed by 1/11/2007.

Meeting Sign in Sheet

R.D. FLANAGAN & ASSOCIATES
Planning Consultants
www.rdflanagan.com

Project:	**TULSA COUNTY MULTI-HAZARD MITIGATION PLAN**		
Purpose of Meeting:	**TAC / CAC**		
Date of Meeting:	**January 4, 2006**	**Time Begin: 11:00 a.m.**	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	Flanagan, Ron	Consultant		918-749-2696	Rdflanagan@rdflanagan.com
BB	1. Bailey, Barbara	Envir. Compliance City of Tulsa	C	918-591-4384	barbailey@ci.tulsa.ok.us
	2. Campbell, Gay	Envir. Safety, St. Francis Health System	C	918-494-2497	agcampbell@saintfrancis.com
	3. Campbell, John	TAEMA	T	918-596-9899	jcampbell@cityoftulsa.org
	4. Downing, Dennis	Retired	C	918-366-3041	gdowning@tulsarealtors.com
	5. Goodson, Marsha, MPH	Disaster Coord, St. John Medical Ctr	C	918-744-3157	Mgoodson@SJMC.org
	6. Gund, Steve	Consultant	C	918-366-8711 918-629-6533	stevegund@olp.net
TH	7. Hoss, Tim	Safety Officer Tulsa Reg'l Med Ctr.	C	918-599-5610	thoss@hillcrest.com
	8. Jordan, Ray	Tulsa County Engineer	T	918-596-5730	engineers@tulsacounty.org
ADK	9. Karecki, Don	President K&M Publishers	C	918-499-3959	dkarecki@cox.net

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
C.M.M.	10. McCool, Mike	Director TAEMA	T	918-596-9890	mmccool@ci.tulsa.ok.us
	11. Munn, Johnnie	EMSA MERC Coordinator	C/T	918-596-3669	munnj@emsa.net
	12. Sager, Nelson	Fire Chief City of Turley	T	918-425-0716 918-284-1057	Lightitup7@cox.net
[illegible]	13. Tosh, Teresa	Plans Examiner, CFM County Inspections	T	918-596-5290 918-272-0093	tpainter@tulsacounty.org
	14. Schippers, Jeff	Chemtrade	T	918-560-4096	jschippers@chemtradelogistics.com
HDYT	15. Townsend, Henry	Chair, LEPC Consultant	C	918-628-0651	hdytownsend@peoplepc.com
	16. West, Terry	Zoning Officer County Inspections	T	918-596-5296	twest@tulsacounty.org
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Meeting Sign in Sheet

R.D. FLANAGAN & ASSOCIATES
Planning Consultants
www.rdflanagan.com

Project:	TULSA COUNTY MULTI-HAZARD MITIGATION PLAN		
Purpose of Meeting:	TAC / CAC		
Date of Meeting: 2/15/2007		**Time Begin:** ~~11:00~~ 10:00 ~~a.m.~~	**Time End:** 12:00

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	Flanagan, Ron	Consultant		918-749-2696	Rdflanagan@rdflanagan.com
GR	Russell, Graham	Consultant			grussell@rdflanagan.com
BB	1. Bailey, Barbara	Envir. Compliance City of Tulsa	C	918-591-4384	barbailey@ci.tulsa.ok.us
AGC	2. Campbell, Gay	Envir. Safety, St. Francis Health System	C	918-494-2497	agcampbell@saintfrancis.com
JC	3. Campbell, John	TAEMA	T	918-596-~~9899~~ 9897	jcampbell@cityoftulsa.org
[illegible]	4. Downing, Dennis	Retired Attorney	C	918-366-3041	gdowning@tulsarealtors.com
	5. Goodson, Marsha, MPH	Disaster Coord, St. John Medical Ctr	C	918-744-3157	Mgoodson@SJMC.org
	6. Gund, Steve	Consultant	C	918-366-8711 918-629-6533	stevegund@olp.net
TH	7. Hoss, Tim	Safety Officer Tulsa Reg'l Med Ctr.	C	918-599-5610	thoss@hillcrest.com
	8. Jordan, Ray	Tulsa County Engineer	T	918-596-5730	engineers@tulsacounty.org
ADK	9. Karecki, Don	President K&M Publishers	C	918-499-3959	dkarecki@cox.net

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
MM	10. McCool, Mike	Director TAEMA	T	918-596-9890	mmccool@ci.tulsa.ok.us
	11. Munn, Johnnie	EMSA MERC Coordinator	C/T	918-596-3669	munnj@emsa.net
	12. Sager, Nelson	Fire Chief City of Turley	T	918-425-0716 918-284-1057	Lightitup7@cox.net
[illegible]	13. Tosh, Teresa	Plans Examiner, CFM County Inspections	T	918-596-5290 918-272-0093	tpainter@tulsacounty.org
	14. Schippers, Jeff	Chemtrade	T	918-560-4096	jschippers@chemtradelogistics.com
HT	15. Townsend, Henry	Chair, LEPC Consultant	C	918-628-0651	hdytownsend@peoplepc.com
[illegible]	16. West, Terry	Zoning Officer County Inspections	T	918-596-5296	twest@tulsacounty.org
	17. Lind, Bill	Hazmat Coordinator T.F.D.		918-591-4405	blind@cityoftulsa.org
[illegible]	18. Roberts, Bob				
	19. LOVELL, TIM	CITY OF TULSA CITIZEN CORPS		918-596-7808	tlovell@cityoftulsa.ORG
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TULSA COUNTY LEPC

FEBRUARY 15,2007

AGENDA

OLD BUSINESS

TREASURER'S REPORT

NEW BUSINESS

1. Discussion and listing of member's suggestions for Website Creator – Bid Solicitation
2. Discussion of New Member Involvement through "Get Acquainted" Luncheon-
   Members Input on Restaurants to Bid on On-Site and Catered Meals
3. Discussion of Possible Host Sites for Catered Luncheon
4. Presentation/Discussion of TCLEPC in Project to Prepare & Provide Tier II Data to
   Tulsa Fire Dept. for $1,000.00 fee
5. Summary Report by Citizen's Disaster & Catastrophe Planning Committee
6. Determination of Next Meeting Date & Time-Adjournment

MEETING-CITIZENS' DISASTER & CATASTROPHE PLANNING COMMITTEE

1. Review of Data-Dam Failure-Flooding Issues
2. Discussion of Related or Member Generated Concerns
3. Determination of Next Meeting Date & Time - Adjournment

Meeting Sign in Sheet

R.D. FLANAGAN & ASSOCIATES
Planning Consultants
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Project:	**TULSA COUNTY MULTI-HAZARD MITIGATION PLAN**		
Purpose of Meeting:	**TAC / CAC**		
Date of Meeting:	**March 15, 2007**	**Time Begin: 11:00 a.m.**	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	Flanagan, Ron	Consultant		918-749-2696	Rdflanagan@rdflanagan.com
BB	1. Bailey, Barbara	Envir. Compliance City of Tulsa	C	918-591-4384	barbailey@ci.tulsa.ok.us
	2. Campbell, Gay	Envir. Safety, St. Francis Health System	C	918-494-2497	agcampbell@saintfrancis.com
JC	3. Campbell, John	TAEMA	T	918-596-9897	jcampbell@cityoftulsa.org
	4. Downing, Dennis	Retired	C	918-366-3041	gdowning@tulsarealtors.com
	5. Goodson, Marsha, MPH	Disaster Coord, St. John Medical Ctr	C	918-744-3157	Mgoodson@SJMC.org
	6. Gund, Steve	Consultant	C	918-366-8711 918-629-6533	stevegund@olp.net
	7. Hoss, Tim	Safety Officer Tulsa Reg'l Med Ctr.	C	918-599-5610	thoss@hillcrest.com
	8. Jordan, Ray	Tulsa County Engineer	T	918-596-5730	engineers@tulsacounty.org
	9. Karecki, Don	President K&M Publishers	C	918-499-3959	dkarecki@cox.net

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	10. McCool, Mike	Director TAEMA	T	918-596-9890	mmccool@ci.tulsa.ok.us
	11. Munn, Johnnie	EMSA MERC Coordinator	C/T	918-596-3669	munnj@emsa.net
	12. Sager, Nelson	Fire Chief City of Turley	T	918-425-0716 918-284-1057	Lightitup7@cox.net
[illegible]	13. Tosh, Teresa	Plans Examiner, CFM County Inspections	T	918-596-5290 918-272-0093	tpainter@tulsacounty.org
[illegible]	14. Schippers, Jeff	Chemtrade	T	918-560-4096	jschippers@chemtradelogistics.com
H.T.	15. Townsend, Henry	Chair, LEPC Consultant	C	918-628-0651	hdytownsend@peoplepc.com
[illegible]	16. West, Terry	Zoning Officer County Inspections	T	918-596-5296	twest@tulsacounty.org
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Meeting Sign in Sheet

R.D. FLANAGAN & ASSOCIATES
Planning Consultants
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Project:	**TULSA COUNTY MULTI-HAZARD MITIGATION PLAN**		
Purpose of Meeting:	**TAC / CAC**		
Date of Meeting:	04-26-07	**Time Begin: 11:00 a.m.**	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	Flanagan, Ron	Consultant		918-749-2696	Rdflanagan@rdflanagan.com
BB	1. Bailey, Barbara	Envir. Compliance City of Tulsa	C	918-591-4384	barbailey@ci.tulsa.ok.us
	2. Campbell, Gay	Envir. Safety, St. Francis Health System	C	918-494-2497	agcampbell@saintfrancis.com
JC	3. Campbell, John	TAEMA	T	918-596-9897	jcampbell@cityoftulsa.org
	4. Downing, Dennis	Retired	C	918-366-3041	gdowning@tulsarealtors.com
	5. Goodson, Marsha, MPH	Disaster Coord, St. John Medical Ctr	C	918-744-3157	Mgoodson@SJMC.org
SG	6. Gund, Steve	Consultant	C	918-366-8711 918-629-6533	stevegund@olp.net
TH	7. Hoss, Tim	Safety Officer Tulsa Reg'l Med Ctr.	C	918-599-5610	thoss@hillcrest.com
	8. Jordan, Ray	Tulsa County Engineer	T	918-596-5730	engineers@tulsacounty.org
	9. Karecki, Don	President K&M Publishers	C	918-499-3959	dkarecki@cox.net

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	10. McCool, Mike	Director TAEMA	T	918-596-9890	mmccool@ci.tulsa.ok.us
	11. Munn, Johnnie	EMSA MERC Coordinator	C/T	918-596-3669	munnj@emsa.net
	12. Sager, Nelson	Fire Chief City of Turley	T	918-425-0716 918-284-1057	Lightitup7@cox.net
	13. Tosh, Teresa	Plans Examiner, CFM County Inspections	T	918-596-5290 918-272-0093	tpainter@tulsacounty.org
	14. Schippers, Jeff	Chemtrade	T	918-560-4096	jschippers@chemtradelogistics.com
	15. Townsend, Henry	Chair, LEPC Consultant	C	918-628-0651	hdytownsend@peoplepc.com
	16. West, Terry	Zoning Officer County Inspections	T	918-596-5296	twest@tulsacounty.org
JC	17 Campbell, John	Fiscal officer TAEMA		918-596-9897	jcampbell@ci.tulsa.ok.us
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Meeting Sign in Sheet

R.D. FLANAGAN
& ASSOCIATES
Planning Consultants
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Project:	**TULSA COUNTY MULTI-HAZARD MITIGATION PLAN**		
Purpose of Meeting:	**TAC / CAC**		
Date of Meeting:	**May 24, 2007**	**Time Begin: 11:00 a.m.**	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
RDF	Flanagan, Ron	Consultant		918-749-2696	Rdflanagan@rdflanagan.com
	1. Bailey, Barbara	Envir. Compliance City of Tulsa	C	918-591-4384	barbailey@ci.tulsa.ok.us
[illegible]	2. Campbell, Gay	Envir. Safety, St. Francis Health System	C	918-494-2497	agcampbell@saintfrancis.com
	3. Campbell, John	TAEMA	T	918-596-9897	jcampbell@cityoftulsa.org
[illegible]	4. Downing, Dennis	Retired	C	918-366-3041	gdowning@tulsarealtors.com
	5. Goodson, Marsha, MPH	Disaster Coord, St. John Medical Ctr	C	918-744-3157	Mgoodson@SJMC.org
[illegible]	6. Gund, Steve	Consultant	C	918-366-8711 918-629-6533	stevegund@olp.net
TH	7. Hoss, Tim	Safety Officer Tulsa Reg'l Med Ctr.	C	918-599-5610	thoss@hillcrest.com
	8. Jordan, Ray	Tulsa County Engineer	T	918-596-5730	engineers@tulsacounty.org
	9. Karecki, Don	President K&M Publishers	C	918-499-3959	dkarecki@cox.net

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
C.M.M.	10. McCool, Mike	Director TAEMA	T	918-596-9890	mmccool@ci.tulsa.ok.us
	11. Munn, Johnnie	EMSA MERC Coordinator	C/T	918-596-3669	munnj@emsa.net
	12. Sager, Nelson	Fire Chief City of Turley	T	918-425-0716 918-284-1057	Lightitup7@cox.net
[signature]	13. Tosh, Teresa	Plans Examiner, CFM County Inspections	T	918-596-5290 918-272-0093	tpainter@tulsacounty.org
	14. Schippers, Jeff	Chemtrade	T	918-560-4096	jschippers@chemtradelogistics.com
HDT	15. Townsend, Henry	Chair, LEPC Consultant	C	918-628-0651	hdytownsend@peoplepc.com
[signature]	16. West, Terry	Zoning Officer County Inspections	T	918-596-5296	twest@tulsacounty.org
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Meeting Sign in Sheet

R.D. FLANAGAN & ASSOCIATES
Planning Consultants
www.rdflanagan.com

Project:	**TULSA COUNTY MULTI-HAZARD MITIGATION PLAN**		
Purpose of Meeting:	**TAC / CAC**		
Date of Meeting: June 28, 2007		**Time Begin:** 11:00 a.m.	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	Flanagan, Ron	Consultant		918-749-2696	Rdflanagan@rdflanagan.com
BB	1. Bailey, Barbara	Envir. Compliance City of Tulsa	C	918-591-4384	barbailey@ci.tulsa.ok.us
	2. Campbell, Gay	Envir. Safety, St. Francis Health System	C	918-494-2497	agcampbell@saintfrancis.com
	3. Campbell, John	TAEMA	T	918-596-9897	jcampbell@cityoftulsa.org
	4. Downing, Dennis	Retired	C	918-366-3041	gdowning@tulsarealtors.com
	5. Goodson, Marsha, MPH	Disaster Coord, St. John Medical Ctr	C	918-744-3157	Mgoodson@SJMC.org
SG	6. Gund, Steve	Consultant	C	918-366-8711 918-629-6533	stevegund@olp.net
TJ	7. Hoss, Tim	Safety Officer Tulsa Reg'l Med Ctr.	C	918-599-5610	thoss@hillcrest.com
	8. Jordan, Ray	Tulsa County Engineer	T	918-596-5730	engineers@tulsacounty.org
	9. Karecki, Don	President K&M Publishers	C	918-499-3959	dkarecki@cox.net

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	10. McCool, Mike	Director TAEMA	T	918-596-9890	mmccool@ci.tulsa.ok.us
	11. Munn, Johnnie	EMSA MERC Coordinator	C/T	918-596-3669	munnj@emsa.net
	12. Sager, Nelson	Fire Chief City of Turley	T	918-425-0716 918-284-1057	Lightitup7@cox.net
[illegible]	13. Tosh, Teresa	Plans Examiner, CFM County Inspections	T	918-596-5290 918-272-0093	tpainter@tulsacounty.org
	14. Schippers, Jeff	Chemtrade	T	918-560-4096	jschippers@chemtradelogistics.com
HDYT	15. Townsend, Henry	Chair, LEPC Consultant	C	918-628-0651	hdytownsend@peoplepc.com
	16. West, Terry	Zoning Officer County Inspections	T	918-596-5296	twest@tulsacounty.org
RJ	17. JOLLIFF, ROGER	DEPUTY DIRECTOR TAEMA	T	9185969898	RJOLLIFF@CITYOFTULSA.ORG
	18.				
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	22.				
	23.				

R.D. FLANAGAN
& ASSOCIATES
Planning Consultants
www.rdflanagan.com

Meeting Sign in Sheet

Project:	**TULSA COUNTY MULTI-HAZARD MITIGATION PLAN**		
Purpose of Meeting:	**TAC / CAC**		
Date of Meeting:	**July 19, 2007**	**Time Begin: 11:00 a.m.**	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	Flanagan, Ron	Consultant		918-749-2696	Rdflanagan@rdflanagan.com
BB	1. Bailey, Barbara	Envir. Compliance City of Tulsa	C	918-591-4384	barbailey@ci.tulsa.ok.us
	2. Campbell, Gay	Envir. Safety, St. Francis Health System	C	918-494-2497	agcampbell@saintfrancis.com
	3. Campbell, John	TAEMA	T	918-596-9897	jcampbell@cityoftulsa.org
	4. Downing, Dennis	Retired	C	918-366-3041	gdowning@tulsarealtors.com
	5. Goodson, Marsha, MPH	Disaster Coord, St. John Medical Ctr	C	918-744-3157	Mgoodson@SJMC.org
[illegible]	6. Gund, Steve	Consultant	C	918-366-8711 918-629-6533	stevegund@olp.net
[illegible]	7. Hoss, Tim	Safety Officer Tulsa Reg'l Med Ctr.	C	918-599-5610	thoss@hillcrest.com
	8. Jordan, Ray	Tulsa County Engineer	T	918-596-5730	engineers@tulsacounty.org
	9. Karecki, Don	President K&M Publishers	C	918-499-3959	dkarecki@cox.net

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	10. McCool, Mike	Director TAEMA	T	918-596-9890	mmccool@ci.tulsa.ok.us
	11. Munn, Johnnie	EMSA MERC Coordinator	C/T	918-596-3669	munnj@emsa.net
	12. Sager, Nelson	Fire Chief City of Turley	T	918-425-0716 918-284-1057	Lightitup7@cox.net
[illegible]	13. Tosh, Teresa	Plans Examiner, CFM County Inspections	T	918-596-5290 918-272-0093	tpainter@tulsacounty.org
	14. Schippers, Jeff	Chemtrade	T	918-560-4096	jschippers@chemtradelogistics.com
H.T.	15. Townsend, Henry	Chair, LEPC Consultant	C	918-628-0651	hdytownsend@peoplepc.com
[illegible]	16. West, Terry	Zoning Officer County Inspections	T	918-596-5296	twest@tulsacounty.org
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Meeting Sign in Sheet

R.D. FLANAGAN & ASSOCIATES
Planning Consultants
www.rdflanagan.com

Project:	**TULSA COUNTY MULTI-HAZARD MITIGATION PLAN**		
Purpose of Meeting:	**TAC / CAC**		
Date of Meeting:	**August 30, 2007**	**Time Begin: 11:00 a.m.**	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	Flanagan, Ron	Consultant		918-749-2696	Rdflanagan@rdflanagan.com
	1. Bailey, Barbara	Envir. Compliance City of Tulsa	C	918-591-4384	barbailey@ci.tulsa.ok.us
	2. Campbell, Gay	Envir. Safety, St. Francis Health System	C	918-494-2497	agcampbell@saintfrancis.com
	3. Campbell, John	TAEMA	T	918-596-9897	jcampbell@cityoftulsa.org
[signature]	4. Downing, Dennis	Retired	C	918-366-3041	gdowning@tulsarealtors.com
	5. Goodson, Marsha, MPH	Disaster Coord, St. John Medical Ctr	C	918-744-3157	Mgoodson@SJMC.org
[signature]	6. Gund, Steve	Consultant	C	918-366-8711 918-629-6533	stevegund@olp.net
TH	7. Hoss, Tim	Safety Officer Tulsa Reg'l Med Ctr.	C	918-599-5610	thoss@hillcrest.com
	8. Jordan, Ray	Tulsa County Engineer	T	918-596-5730	engineers@tulsacounty.org
	9. Karecki, Don	President K&M Publishers	C	918-499-3959	dkarecki@cox.net

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	10. McCool, Mike	Director TAEMA	T	918-596-9890	mmccool@ci.tulsa.ok.us
	11. Munn, Johnnie	EMSA MERC Coordinator	C/T	918-596-3669	munnj@emsa.net
	12. Sager, Nelson	Fire Chief City of Turley	T	918-425-0716 918-284-1057	Lightitup7@cox.net
	13. Tosh, Teresa	Plans Examiner, CFM County Inspections	T	918-596-5290 918-272-0093	tpainter@tulsacounty.org
	14. Schippers, Jeff	Chemtrade	T	918-560-4096	jschippers@chemtradelogistics.com
	15. Townsend, Henry	Chair, LEPC Consultant	C	918-628-0651	hdytownsend@peoplepc.com
	16. West, Terry	Zoning Officer County Inspections	T	918-596-5296	twest@tulsacounty.org
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	23.				

Meeting Sign in Sheet

R.D. FLANAGAN & ASSOCIATES
Planning Consultants
www.rdflanagan.com

Project:	**TULSA COUNTY MULTI-HAZARD MITIGATION PLAN**		
Purpose of Meeting:	**TAC / CAC**		
Date of Meeting: October 18, 2007		**Time Begin:** 11:00 a.m.	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
RDF	Flanagan, Ron	Consultant		918-749-2696	Rdflanagan@rdflanagan.com
BB	1. Bailey, Barbara	Envir. Compliance City of Tulsa	C	918-591-4384	barbailey@ci.tulsa.ok.us
	2. Campbell, Gay	Envir. Safety, St. Francis Health System	C	918-494-2497	agcampbell@saintfrancis.com
	3. Campbell, John	TAEMA	T	918-596-9897	jcampbell@cityoftulsa.org
[signature]	4. Downing, Dennis	Retired	C	918-366-3041	gdowning@tulsarealtors.com
	5. Goodson, Marsha, MPH	Disaster Coord, St. John Medical Ctr	C	918-744-3157	Mgoodson@SJMC.org
[signature]	6. Gund, Steve	Consultant	C	918-366-8711 918-629-6533	stevegund@olp.net
	7. Hoss, Tim	Safety Officer Tulsa Reg'l Med Ctr.	C	918-599-5610	thoss@hillcrest.com
	8. Jordan, Ray	Tulsa County Engineer	T	918-596-5730	engineers@tulsacounty.org
	9. Karecki, Don	President K&M Publishers	C	918-499-3959	dkarecki@cox.net

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	10. McCool, Mike	Director TAEMA	T	918-596-9890	mmccool@ci.tulsa.ok.us
	11. Munn, Johnnie	EMSA MERC Coordinator	C/T	918-596-3669	munnj@emsa.net
	12. Sager, Nelson	Fire Chief City of Turley	T	918-425-0716 918-284-1057	Lightitup7@cox.net
	13. Tosh, Teresa	Plans Examiner, CFM County Inspections	T	918-596-5290 918-272-0093	tpainter@tulsacounty.org
	14. Schippers, Jeff	Chemtrade	T	918-560-4096	jschippers@chemtradelogistics.com
	15. Townsend, Henry	Chair, LEPC Consultant	C	918-628-0651	hdytownsend@peoplepc.com
[illegible]	16. West, Terry	Zoning Officer County Inspections	T	918-596-5296	twest@tulsacounty.org
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AGENDA
BOARD OF COUNTY COMMISSIONERS
Monday, July 12, 2010
Tulsa County Administration Building
500 S. Denver, Tulsa, Oklahoma
Room 119, 9:30 A.M.

I. CALL TO ORDER

II. MINUTES
A. Board of County Commissioners Meeting of July 6, 2010

III. PRESENTATION - (State Historic Preservation Officer) - Citation of Merit Award to Tulsa County in Recognition of Outstanding Accomplishments Contributing to the Preservation of Oklahoma's Heritage

IV. REPORTS
A. Elected Official - County Clerk

B. County Department - Election Board

C. Summary of Consumable Items - IT

V. UNFINISHED BUSINESS
A. Bids/Proposal Openings
1. Administrative Services - Paperstock for Printing Voting Ballots
2. Highways - One (1) New or Used Power Broom
3. Parks - Sta-Rite & Gould Submersible Pumps, Parts, and Repair
4. Tulsa County CDBG Urban County - CDBG Urban County Request for Applications from Competitive Category Applicants

B. Bid/Proposal Awards/Recommendations:
1. Building Operations - Air Conditioning and Refrigeration Supplies
2. Sheriff - Dash-Mounted Traffic Radar
3. TC Departments - Agent of Record of Tulsa County Property and Content Insurance - ***DEFERRED***
4. TC Departments - Fire Protection Equipment, Maintenance and Repair - ***DEFERRED***
5. Tulsa County Employees Retirement System - International Equity Manager - ***DEFERRED***

C. Public Hearing - (Board of County Commissioners) - to Review the Tulsa County, Oklahoma Local Hazard Mitigation Plan

VI. NEW BUSINESS
A. Gasoline and Diesel Fuel Quotes

B. Requests:
1. Commissioner Keith - for Authorization of Board of County Commissioners Chairman to Issue a Letter of Intent to Participate as the Non-Federal Sponsor in a Feasibility Study on the Arkansas River in Tulsa County
2. Parks - to Accept Donation from Todd Rollins
3. Parks - to Donate a Foot Bridge to the City of Owasso

C. Resolutions:
1. Board of County Commissioners - to Serve as Applicant and Grantee for an Award of Financial Assistance from the Oklahoma Water Resource Board
2. CC Health - to Designate Replacement Requisitioning Officer
3. Engineers - to Appoint a Member to Serve on the Board of Circuit Engineering District #1
4. Engineers - to Renew Membership with ACCO Circuit Engineering District #1

D. Agreements:
   1. County Clerk - ACS/Erxchange
   2. County Clerk - First American Title and Abstract
   3. Highway Construction - BMI Systems Corporation - ***(4)***
   4. Human Resources - Tulsa Technology Center
   5. Human Resources - United Safety & Claims, Inc.
   6. IT - Century Bank of Oklahoma
   7. IT - Romania Cordova
   8. Juvenile Bureau - Office of Juvenile Affairs
   9. Parks - Mr. Pat Kinnison
   10. Parks - Journal Broad Cast Group
   11. Parks - Pure Fitness Corporation
   12. Sheriff - City of Tulsa
   13. Sheriff - Zaida Giovanna Kepford
   14. Sheriff - Union Public Schools
   15. Sheriff - Xenon, LLC
   16. Treasurer - Business Imaging Systems, Inc.
   17. Treasurer - Pitney Bowes
   18. Treasurer - Xerox - ***(6)***

E. Request to Advertise for Bids:
   1. Parks - Top Dressing Sand
   2. TC Central Garage - High Pursuit Tires
   Bids to open 7/26/10 at 9:30 a.m.

F. Sole Sources:
   1. Administrative Services - Business Imaging Systems
   2. CC Health - Channing Bete Company, Inc.
   3. Parks - Rex Playground Equipment-Playworld Systems
   4. Sheriff - BI 2 Technologies

G. Travel/Training - OSU Extension

H. Personnel Actions:
   1. Court Services
   2. Engineers
   3. Highways
   4. Parks

I. Juvenile Bureau Documents to Accept & File:
   1. Personnel Actions

J. CC Health Documents to Accept & File:
   1. Personnel Actions
   2. Travel/Training

K. Claims to be disallowed (payments cancelled as of 7/6-9/10)

L. Claims (payments for bills to be paid from 6/28/10-7/2/10)

M. Blanket Purchase Orders & Emergency Purchase Orders Submitted from 7/6-9/10

N. **<u>ANNOUNCEMENTS</u>**
   County Events and Status Updates for Comment and Discussion from: Administrative Services, Building Operations, Court Services, Election Board, Fiscal Officer, HR, IT, Parks, Purchasing, Social Services, Engineering, Inspections, Sheriff's Office, Assessor, County Clerk, Court Clerk, Treasurer, D.A., Presiding Judge, Expo Square, Juvenile Justice, Expo Square, INCOG, TAEMA, City-County Library, City-County Health, Board of County Commissioners Chief Deputies, Public Information Officer

VII. ADJOURN

AGENDA
BOARD OF COUNTY COMMISSIONERS
Monday, July 19, 2010
Tulsa County Administration Building
500 S. Denver, Tulsa, Oklahoma
Room 119, 9:30 A.M.

I. CALL TO ORDER

II. PROCLAMTION - (Board of County Commissioners) - Celebrating the 20th Anniversary of the Americans with Disabilities Act

III. MINUTES
   A. Board of County Commissioners Meeting of July 12, 2010

IV. REPORTS
   A. County Department - Election Board
      1. Social Services - Monthly Admission to Emergency Shelter
      2. Social Services - Summary of Emergency Housing & Meals

V. UNFINISHED BUSINESS
   A. Bid Openings
      1. TC Departments - Car Rentals

   B. Bid/Proposal Awards/Recommendations:
      1. Administrative Services - Paperstock for Printing Voting Ballots
      2. Highways - One (1) New or Used Power Broom
      3. Parks - Sta-Rite & Gould Submersible Pumps, Parts, and Repair
      4. Tulsa County CDBG Urban County - CDBG Urban County Request for Applications from Competitive Category Applicants - ***DEFERRED***
      5. TC Departments - Agent of Record of Tulsa County Property and Content Insurance
      6. TC Departments - Fire Protection Equipment, Maintenance and Repair - ***DEFERRED***
      7. Tulsa County Employees' Retirement System - International Equity Manager - ***DEFERRED***

   C. Amendment #2 - (Purchasing) - to Bid Award for Rental of Uniforms, Shop Towels and Misc. Items

VI. NEW BUSINESS
   A. Gasoline and Diesel Fuel Quotes

   B. Resolutions on Disposition of Funds/Cash Fund Estimate of Needs - ***(2)***

   C. Requests:
      1. PMg - for Acceptance of Right-of-Way Quit Claim Deeds from the City of Bixby, a 4 to Fix II Project
      2. Sheriff - Gary G. Glanz, to Retain Peace Officer Status and be Designated as a Peace Officer, Retired
      3. Social Services - to Accept Donations

   D. Resolution - (Tulsa Area Emergency Management Agency) - Adopting Tulsa County Multi-Hazard Mitigation Plan

   E. Resolutions:
      1. CC Health - to Designate Replacement Requesting Officer
      2. Law Library - to Designate Replacement Receiving Officer

   F. Tort Claim - (District Attorney) - TC-2010-23, Claimant: Terri Bridges

   G. Agreements:
      1. Administrative Services - Business Imaging Systems, Inc.
      2. Administrative Services - Neopost
      3. Administrative Services - Xerox Corporation - ***(7)***
      4. County Clerk - Ingeo Systems, Inc.

5. Court Services - Oklahoma Department of Corrections - ***(2)***
6. District Attorney - JD Young - ***(2)***
7. Highways - BMI Systems Corporation
8. IT - Hans Bashore
9. IT - Tate Law Firm
10. Parks - Christie Anderson
11. Parks - The David Dover Band
12. Parks - Brittany Friske
13. Parks - Christy Hays
14. Parks - Victoria Hickman
15. Parks - Ali Huffer - ***(2)***
16. Parks - Julie Potter/TSHA
17. Sheriff - Brewster & DeAngelis, P.L.L.C.
18. Sheriff - Oklahoma Communications Systems, Inc.
19. Sheriff - The Parent Child Center
20. Treasurer - JPMorgan Chase Bank, NA
21. TC Central Garage - River Parks Authority
22. TC Central Garage - Tulsa Area Emergency Management Agency (TAEMA)
23. Tulsa County Public Facilities Authority - American Kennel Club, Inc.

H. Request to Advertise for Bids:
1. Administrative Services - Paperstock for Printing Voting Ballots
2. Building Operations - Door and Cabinet Hardware
3. Parks - Granular Sodium Bentonite
4. TC Departments - Plumbing Installation, Maint., and Repair
5. TC Departments - Service Contract for Inspections of Alarm Systems and Sprinkler Systems
6. TC Departments - Window Washing

Bids to open 8/2/10 at 9:30 a.m.

I. Utility Permit - (Engineers) - ARCADIS, Inc.

J. Personnel Actions:
1. Building Operations
2. Election Board
3. Highways
4. Human Resources
5. Parks
6. Social Services

K. Juvenile Bureau Documents to Accept & File:
1. Personnel Actions

L. CC Health Documents to Accept & File:
1. Agreements
    a. Scott Adkins Consulting
    b. ChallengerSoft
    c. St. John Medical Center
    d. SPOT Consultants, Inc. - ***(2)***
    e. Roy D. Johnsen
2. Personnel Actions
3. Travel/Training

M. Claims to be disallowed (payments cancelled as of 7/12-16/10)

N. Claims (payments for bills to be paid from 7/6-9/10)

O. Blanket Purchase Orders & Emergency Purchase Orders Submitted from 7/12-16/10

P. **ANNOUNCEMENTS**
County Events and Status Updates for Comment and Discussion from: Administrative Services, Building Operations, Court Services, Election

Board, Fiscal Officer, HR, IT, Parks, Purchasing, Social Services, Engineering, Inspections, Sheriff's Office, Assessor, County Clerk, Court Clerk, Treasurer, D.A., Presiding Judge, Expo Square, Juvenile Justice, Expo Square, INCOG, TAEMA, City-County Library, City-County Health, Board of County Commissioners Chief Deputies, Public Information Officer

VII. ADJOURN