ALBERT ASHWOOD
State Director

BRAD HENRY
Governor

STATE OF OKLAHOMA
DEPARTMENT OF EMERGENCY MANAGEMENT

November 22, 2010

Honorable Ray Bowen
Mayor of City of Bixby
P. O. Box 70
Bixby, Oklahoma 74008-0070

Reference: Approval of the City of Bixby, Oklahoma Multi-Jurisdictional Hazard Mitigation Plan.
Hazard Mitigation Grant Program FEMA-1677-DR-OK; Project # 9
Participating Jurisdictions: City of Bixby and Bixby Public Schools

Dear Mr. Bowen:

Congratulations! We just received the letter of approval from FEMA Region VI, dated November 15, 2010, acknowledging that the City of Bixby, Oklahoma Multi-Jurisdictional Hazard Mitigation Plan has successfully met the criteria established by Federal regulations. Based upon this approval, the participating jurisdictions retain eligibility for the Hazard Mitigation Grant Program and the Pre-Disaster Mitigation Grant Program for the next five (5) years from the date of the FEMA letter of approval.

This approval does not demonstrate eligibility or pre-approval of projects contained in this plan. FEMA has provided the enclosed Local Hazard Mitigation Plan Review Crosswalk, with Reviewer's Comments, to assist the communities in refining their plan further. Participating jurisdictions may begin the process of seeking eligibility and approval for mitigation project action items within the plan by preparing Notices of Intent (Enclosure B) with the Oklahoma Department of Emergency Management.

Because your plan has been approved, please contact Lori Calvert at lorriane.calvert@oem.ok.gov, or phone 405-521-3092 to schedule a time to close out your grant project.

If you have questions regarding this decision, you may contact Bill Penka, State Hazard Mitigation Officer, by telephone at 405-521-3072 or via email at bill.penka@oem.ok.gov .

Sincerely,

FRED W. LIEBE
Deputy Director

Enclosures

Copy: Ike Shirley, Emergency Management Director
✓Erik Enyart, Planning Director

EM
Oklahoma Emergency Management

U.S. Department of Homeland Security
Region VI
800 N. Loop 288
Denton, TX 76209-3698

FEMA

November 15, 2010

RECEIVED
NOV 19 2010
OKLAHOMA
EMERG. MGMT.

Mr. Bill Penka
Oklahoma Department of Emergency Management
P.O. Box 53365
Oklahoma City, OK 73152-3365

Re: Approval of the City of Bixby, Oklahoma Multi-Jurisdictional Hazard Mitigation Plan.
HMGP: FEMA-1677-DR-OK; #9

Dear Mr. Penka:

This office has concluded its review of the referenced plan, in conformance with the Final Rule on Mitigation Planning (44 CFR Part 201.6). This plan identifies the following participants on Enclosure A as being included within this plan.

Upon reviewing this plan using the guidance, "Multi-Hazard Mitigation Planning Guidance under the Disaster Mitigation Act of 2000", we are pleased to provide our approval of this plan in meeting the criteria set forth by this Agency. By receiving this approval, the City of Bixby, Oklahoma, and the additional listed jurisdictions, retains eligibility for the Hazard Mitigation Grant Program and Pre-Disaster Mitigation Grant Program for the next 5 years from the date of this letter, expiring on November 15, 2015.

This approval does not demonstrate eligibility or pre-approval of projects contained in this plan. This office has provided the enclosed Local Hazard Mitigation Plan Review Crosswalk, with Reviewer's Comments, to assist the communities in refining their plan further. Please advise the referenced entities of this approval.

If you have any questions, please contact Pat Schaffer, Community Planner, at (940) 898-5136.

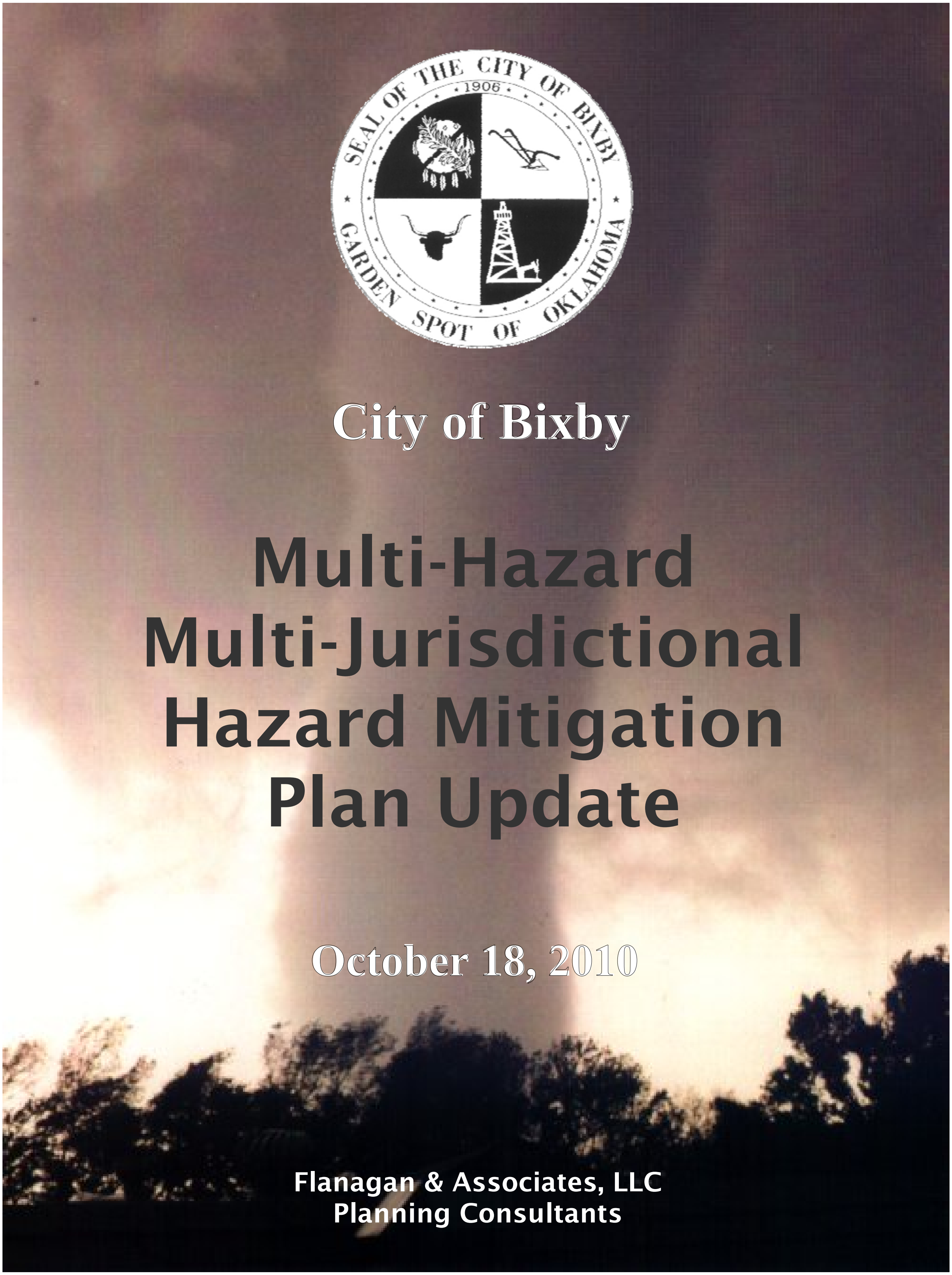
Sincerely,

Jack Quarles, P.E., Chief
Risk Analysis Branch

Dir	
Deputy	C
Admin	
Finance	
Purchasing	
PIO	
Response	
EM Coor	
Recovery	Penka
OPS Supp	
Training	
Haz/Mat	
Vol	

Enclosures

cc: Danielle Brown, R6-MT-HM



City of Bixby

Multi-Hazard Multi-Jurisdictional Hazard Mitigation Plan Update

October 18, 2010

Flanagan & Associates, LLC
Planning Consultants

CITY OF BIXBY
P.O. Box 70
116 W. Needles Ave.
Bixby, OK 74008
(918) 366-4430
(918) 366-6373 (fax)

Wednesday, January 13, 2010

Oklahoma Department of Emergency Management
Attn: Bill Penka, State Hazard Mitigation Officer
PO Box 53365
Oklahoma City, OK 73152

RE: City of Bixby and Bixby Public Schools Multi-Jurisdictional Multi-Hazard Mitigation Plan – 2010 Update

Dear Mr. Penka:

We are pleased to submit this *City of Bixby and Bixby Public Schools Multi-Jurisdictional Multi-Hazard Mitigation Plan-2010 Update*, as fulfillment of the requirements of the Hazard Mitigation Grant Program Grant (FEMA-1677-DR-OK #09).

This Multi-Hazard Mitigation Plan, prepared in accordance with State and Federal guidance, addresses floodplain management, dam and levee failures, tornadoes, high winds, hailstorms, lightning, winter storms, extreme heat, drought, expansive soils, wild fires, and earthquakes.

We look forward to implementing this plan to enhance protection of the lives and property of our citizens from natural hazards and hazard materials incidents. If we can answer any questions or be of further assistance, please do not hesitate to contact me at (918) 366-0427.

Sincerely,

Erik Enyart, AICP, CFM
City Planner / Floodplain Administrator

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List of Tables

List of Figures

Acknowledgements

The City of Bixby and Bixby Public Schools Multi-Jurisdictional Multi-Hazard Mitigation Plan was developed with assistance from a Hazard Mitigation Grant from the Oklahoma Department of Emergency Management, the Federal Emergency Management Agency, and local funding from the City of Bixby and Bixby Public Schools. The Bixby Multi-Hazard Mitigation Plan was prepared by the City of Bixby, Oklahoma, under the direction of the Bixby City Council. Numerous agencies, organizations and individuals participated in the study, including:

City of Bixby Elected Officials

Ray Bowen .... Mayor, Ward 4 Councilor
Denis Loudermilk .... Vice-Mayor, Ward 5 Councilor
John Easton .... Ward 1 Councilor
Stephen Sutton .... Ward 2 Councilor
Steve Todoroff .... Ward 3 Councilor
J. Blu Hulsey................................ City Manager

Bixby Hazard Mitigation Citizen Advisory Board

Thomas Holland.......................... Bixby Planning Commission
Tulsa Fire Department, District Chief, retired
Jim Powell................................... Bixby Planning Commission
Williams Company, retired
Steve Sutton. .... Bixby Planning Commission
Spirit Bank, Vice-President
Lance Whisman .... Bixby Planning Commission
Sr. Environmental Specialist
Larry Whiteley .... Bixby Planning Commission
Michael Wisner........................... Bixby Planning Commission
Muscogee Creek Nation, CEO

Bixby Technical Advisory Committee

Erik Enyart............................... Project Manager, Bixby City Planner
Bea Aamodt .... Director, Bixby Public Works
Steve Abel................................ Chief, Bixby Fire Department
Kaylin Coody........................... Assoc. Superintendent, Bixby Public Schools
Jared Cottle .... Bixby City Engineer
Gabe Hayes .... Safety Director, Bixby Public Schools
Duffy McAnallen..................... Director of Operations, EMSA
Ike Shirley................................ Chief, Bixby Police Dept., Bixby Emergency Manager
Jim Sweeden .... Fire Marshall, Bixby Fire Department
Mike Webster........................... Asst. City Manager, City of Bixby

Consultants

Flanagan & Associates, LLC
Planning Consultants
2745 E. Skelly Drive, Suite 100
Tulsa, Oklahoma 74105
(918) 749-2696
www.rdflanagan.com

Ronald D. Flanagan, CFM, Principal
David Wakefield, CFM
Bob Roberts
Graham Russell
Karen Hoyt
Nancy Mulcahy

Tulsa Partners, Inc.
PO Box 2131
Tulsa, Oklahoma 74101
(918) 632-0044
www.tulsapartners.org

Tim Lovell, Executive Director
Ann Patton
Penni Chandler
Lilliana Crossley

Executive Summary

In the 1970's and early 1980s Bixby was identified in a national study as being in one of the nation's most disaster-prone areas, having been declared a federal disaster area nine times in only fifteen years. 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 makes it subject to a wide variety of potentially violent weather and natural hazards.

This City of Bixby and Bixby Public Schools Multi-Jurisdictional Multi-Hazard Mitigation Plan 2010 Update of the original 2004 Mitigation Plan which adds Bixby Public Schools to the plan and 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 plan Update is developed in accordance with, and fulfills requirements for, the Pre-Disaster Mitigation Grant (PDM) and Hazard Mitigation Grant (HMGP). It also fulfills requirements for the Flood Mitigation Assistance Program (FMA), Severe Repetitive Loss Program (SRL), and the Community Rating System Plan (CRS) from the Federal Emergency Management Agency (FEMA).

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 the City of Bixby and Bixby Public Schools to apply for PDM funds, as well as 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

Virtually every area of the city is vulnerable to natural and man-made hazards. The Bixby Hazard Mitigation Citizen Advisory Committee (THMCAC) has identified 15 hazards potentially affecting the City of Bixby and Bixby Public Schools, including floods, tornadoes, high winds, lightning, hailstorms, severe winter storms, extreme heat, drought, expansive soils, wildfires, earthquakes, fixed site hazardous materials events, urban structure fire, transportation events, and dam failures.

Purpose

The purpose of this plan is to:

- Assess the progress on the previously identified mitigation measures;
- Assess the ongoing mitigation activities in the community;
- 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 the city, public schools, and other partners implement activities that are most effective and appropriate for mitigating natural hazards and hazardous materials incidents.

Bixby Hazard Mitigation 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 BCAC is comprised of the members of the City of Bixby Planning Commission. Members are listed in Chapter 3.

The Planning Process

Planning for the City of Bixby and Bixby Public Schools Multi-Jurisdictional 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 City of Bixby and Bixby Public Schools Multi-Jurisdictional Multi-Hazard Mitigation Plan provides guidance to help citizens protect life and property from natural 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 the City of Bixby and Bixby Public Schools. This chapter includes a community description including demographics, lifelines, and critical facilities.

Chapter 2- Existing Mitigation Strategies provides an overview and discussion of 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 documentation of the adoption resolutions, and the Plan maintenance process. 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 discussion of possible Mitigation Measures outlined in Chapter 6, organized by category.

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

Appendix D - 2004 Mitigation Measures provides a report on the current status of all Mitigation Measures included in the 2004 plan – whether complete, ongoing, in progress, not yet begun, modified, or dropped.

Appendix E - Plan Update Changes provides an overview of changes made in the plan update from the original City of Bixby Hazard Mitigation Plan of 2004.

Mitigation Measures

The following are the high priority mitigation measures defined by the Bixby Hazard Mitigation Technical Advisory and Citizens Advisory Committees:

Mitigation Measure Description	Hazards Addressed
1. Provide new/retrofit Facilities for the 911 Center and the Emergency Operations Center.	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
2. Install Saferooms in Schools.	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 regulatory ordinances.	Tornadoes, High Winds, Earthquakes
4. 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.	Floods, Tornadoes, High Winds, Severe Winter Storms, Extreme Heat, Drought, Urban Fires, Wildfires, Earthquakes, Fixed Site Hazardous Materials Events, Dam Failures, Transportation Events
5. Develop / Review / Update the debris management plan.	Floods, Tornadoes, High Winds, Hail, Severe Winter Storms, Earthquakes
6. Provide employee shelters/safe-rooms at critical facilities, such as 911 Center, fire stations and police stations to protect first responders.	Tornadoes, High Winds
7. Provide lightning warning systems for outdoor sports area, pools, golf courses, ball fields, and parks.	Lightning
8. Provide lightning warning systems for Bixby Public Schools outdoor sports areas and play grounds.	Lightning
9. Develop a Heat Emergency Action Plan/Heat Emergency Annex to the Emergency Operations Plan for the jurisdiction.	Extreme Heat
10. Establish an administrative procedure or change in City codes that require builders to check for expansive soils when applying for new residential construction permits, and to consider the use of foundations that mitigate expansive soil damages when in a moderate to high-risk area.	Expansive Soils
11. Prepare a comprehensive basin-wide Flood & Drainage Annex to the Hazard Mitigation Plan (FDAHMP) 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.	Floods
12. 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.	Floods

Mitigation Measure Description	Hazards Addressed
13. Continue Compliance with, and Participation in the National Flood Insurance Program (NFIP) and the Community Rating System (CRS).	Floods, Dam Failure
14. Evaluate, upgrade and maintain community-wide outdoor omni-directional voice/siren warning systems.	Tornadoes, High Winds, Flooding, Dam Failure, Hazardous Materials
15. Develop an Emergency Back-up Generator Hazard Mitigation Plan Annex (EBGHMP) for the community, assessing and prioritizing generator needs for critical facilities, both public and private. Assessment should include emergency generator needs, costs of installation for pads/transfer panels only, or for complete generator assembly installation.	Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat
16. Based on the results of the Emergency Back-up Generator Hazard Mitigation Plan Annex (EBGHMP), provide wiring and transfer switches to accommodate emergency generators during disaster power outages for critical facilities including Emergency Operations Centers, City Hall, Dispatch, Police, Fire, Community Centers used for emergency housing during disasters, critical facilities, lift stations, water treatment plants, and community medical facilities.	Floods, Tornadoes, High Winds, Lightning, Severe Winter Storms, Urban Fires, Wildfires, Earthquakes, Fixed Site Hazardous Materials Events
17. Obtain emergency generators for continuity of government/use during disaster power outages for critical facilities including Emergency Operations Centers, City Hall, Dispatch, Police, Fire, Community Centers used for emergency housing during disasters, critical facilities, lift stations, water treatment plants, and community medical facilities, as identified in the Emergency Back-up Generator Hazard Mitigation Plan Annex (EBGHMP).	Tornadoes, High Winds, Lightning, Severe Winter Storms
18. Obtain one generator for a booster pump.	Tornadoes, High Winds, Lightning, Severe Winter Storms
19. Obtain emergency generators for 23-26 lift stations.	Tornadoes, High Winds, Lightning, Severe Winter Storms
20. Provide routine trimming of trees to reduce power outages during storms.	Severe Winter Storms, Tornadoes, High Winds
21. Develop an All-Hazard Public Information, Education, and Awareness Program.	Floods, Tornadoes, High Winds Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Expansive Soils, Urban Fires, Wildfires, Earthquakes, Fixed Site Hazardous Materials Events, Transportation Events
22. 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.	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
23. Identify and encourage Private Critical Facilities (Financial Institutions, Elder 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.	Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat, Earthquakes

Mitigation Measure Description	Hazards Addressed
24. 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.	Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat, Earthquakes
25. When replaced, install Break/Shatter Resistant Glass in Schools.	Tornadoes, High Winds, Hail, Earthquakes
26. Provide surge and lightning protection for computer-reliant critical facilities (e.g. City Hall, 911 Center, EOC, Police and Fire stations, water/wastewater treatment plant and public works buildings).	Lightning
27. 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.	Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat, Earthquakes
28. Provide covered shelters for City First Response/government vehicles to protect against hail damage.	Hail

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.

For further information, contact:

Erik Enyart, CFM, AICP
City Planner, Floodplain Administrator
116 W. Needles
Bixby OK 74008-4410
(918) 366-0427
eenyart@bixby.com

Chapter 1: Introduction

1.1 About the Plan

This City of Bixby and Bixby Public Schools Multi-Jurisdictional Multi-Hazard Mitigation Plan 2010 Update 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.

This plan Update is developed in accordance with, and fulfills requirements for, the Pre-Disaster Mitigation Grant (PDM) and Hazard Mitigation Grant Program (HMGP). It also fulfills requirements for the Flood Mitigation Assistance Program (FMA), Severe Repetitive Loss Program (SRL), and the Community Rating System Plan (CRS) from the Federal Emergency Management Agency (FEMA). The plan addresses 15 natural and man-made or technological hazards.

Included in this Chapter:

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 the City of Bixby and Bixby Public Schools (Chapter 2).
- Describe the planning process used to develop the mitigation plan (Chapter 3).

- Identify and assess the hazards that pose a threat to residents, businesses, property, and schools (Chapter 4).
- Establish Goals and Objectives for community mitigation measures (Chapter 5)
- Evaluate Mitigation Measures that should be undertaken to protect residents, businesses, property, and schools (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 City of *Bixby Multi-Jurisdictional 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 reflect 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 mitigation activities for the next five years. It will ensure that the City of Bixby and Bixby Public Schools implement hazard mitigation activities that are most effective and appropriate for the natural hazards that threaten their communities.

1.1.2 Scope

The scope of the *City of Bixby Multi-Jurisdictional Multi-Hazard Mitigation Plan* is citywide. It addresses 15 natural hazards deemed a threat to the residents of Bixby and Bixby Public Schools. Both short-term and long-term hazard mitigation opportunities are addressed beyond existing federal, state, and local funding programs.

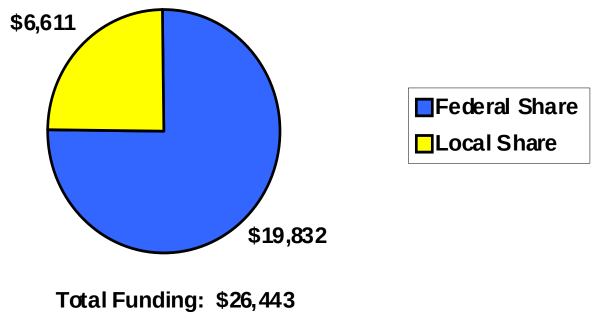
1.1.3 Authority

Section 322 of the Robert T. Stafford Disaster Assistance and Emergency Relief Act, 42 USC 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 *City of Bixby Multi-Jurisdictional Multi-Hazard Mitigation Plan Update* was provided by a $19,832 Hazard Mitigation Grant Program grant from the Federal Emergency Management Agency (FEMA) and the Oklahoma Department of Emergency Management (OEM), with a $6,611 local match.

Figure 1–1: Bixby Multi-Jurisdictional Multi-Hazard Mitigation Plan Funding



1.1.5 Goals

The Bixby Technical Advisory Committee (BTAC) and the Bixby Citizens' Advisory Committee, the Bixby Planning Commission, developed the updated goals for the *City of Bixby Multi-Jurisdictional Multi-Hazard Mitigation Plan*, with input from interested residents. 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 benefits 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 risk 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 an Enhanced Natural Hazards Mitigation Plan (updated 2008) to guide all levels of government, business, and the public to reduce or eliminate the effects of natural disasters. The primary goals of the plan are to:

- Protect public health and safety;
- Eliminate losses from severe repetitive loss properties;
- Eliminate losses from repetitive loss properties;
- Improve government recovery capability;
- Provide pre and post-disaster recovery guidance;
- Reduce losses/damage to property and infrastructure;
- Preserve natural and historic resources in vulnerable areas;
- Preserve the environment;
- Focus on those mitigation measures that are cost effective and provide the best benefit to communities.

The key measures to implement these goals include:

- Enhance communication between tribal, state, federal agencies and local governments to facilitate post-disaster recovery and pre/post-disaster mitigation;
- Coordinate federal, state, local, and private resources to enhance the preparedness and mitigation processes;
- Ensure consistency between federal and state regulations;
- Provide protection from hazards for critical facilities;
- Support legislation that protects hazardous areas from being developed.

Another important goal of the Oklahoma State Mitigation plan is to expand the focus of mitigation measures to include the major hazard threats to Oklahoma such as floods, tornado, severe weather, earthquakes, winter storms and wildfires.

Bixby's Goal

To improve the safety and well-being of the people residing and working in the City of Bixby and Bixby Public Schools by reducing the potential of deaths, injuries, property damage, environmental and other losses from natural hazards, and to do this 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 the mitigation of each of the hazards are presented in Chapter 5.

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, man-made, 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 Points of Contact

The primary points of contact for information regarding this plan are:

Primary City Contact
Erik Enyart, CFM, AICP
City Planner, Floodplain Administrator
116 W. Needles
Bixby OK 74008-4410
(918) 366-0427
eenyart@bixby.com

Secondary City Contact
Ike Shirley
Police Chief
PO Box 70
Bixby OK 74008-0070
(918) 336-0421
ishirley@bixby.com

Primary School Contact
Kaylin Coody, Ed.D.
Associate Superintendent
Bixby Public Schools
109 N. Armstrong
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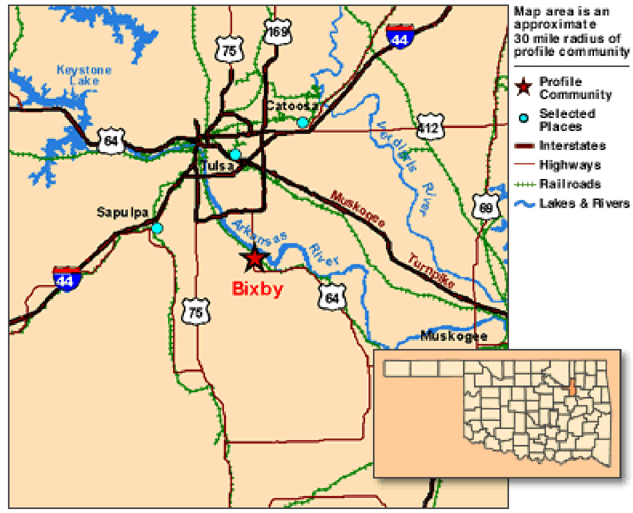
(918) 366-2241
kcoody@bixbyps.org

Secondary School Contact
Gabe Hayes
Safety Director
Bixby Public Schools
109 N. Armstrong
Bixby OK 74008
(918) 336-2279
gahayes@bixbyps.org

1.2 Community Description

The City of Bixby and Bixby Public Schools are faced with a variety of hazards, both natural and man-made. In recent history, winter storms, dam releases, lightning, floods, and tornadoes have made the national headlines but, in fact, any part of the city can also be impacted by high winds, drought, hail, fire, 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 the City of Bixby with its major features and highways are shown in Figure 1–4. Bixby's Public Schools and Parks are shown in Figure 1-5.

Figure 1–2: Bixby Location Map

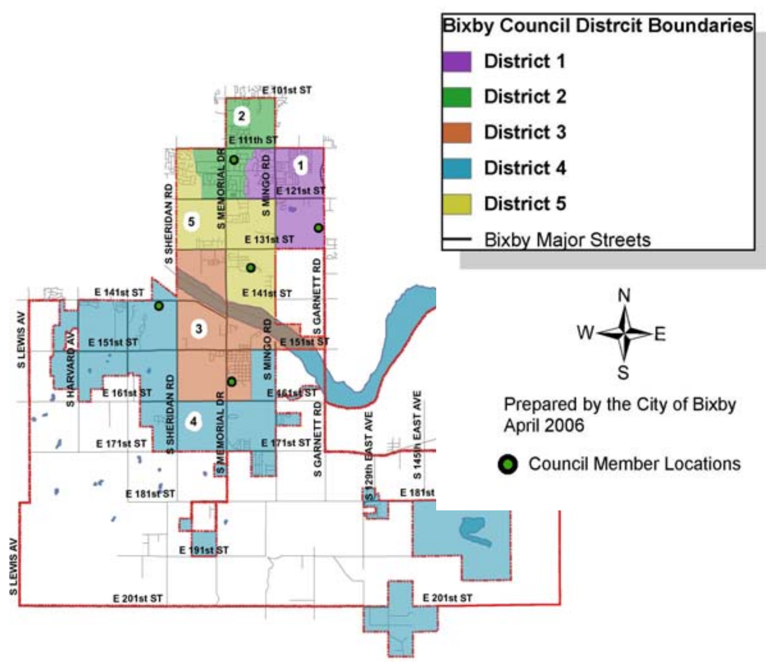


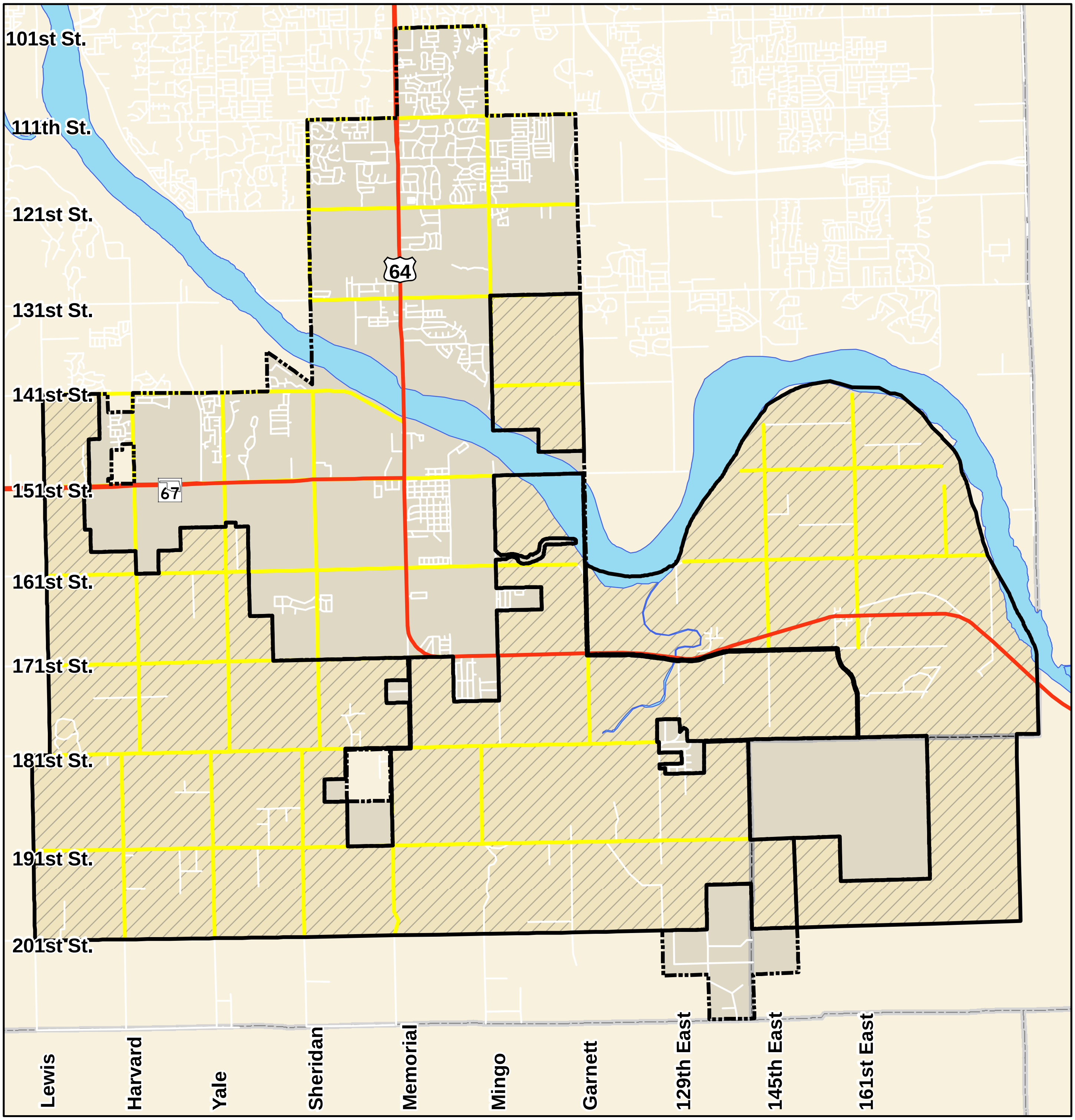
The City of Bixby is situated in the Creek Nation along the Arkansas River, just 25 minutes south of downtown Tulsa. Bixby has a Census 2000 population of 13,336, comprising 2.34% of Tulsa County's population and is located at the intersection of State Highway 67 and US 64. Bixby is located in the growth trend-line for the Tulsa Metropolitan Area, and experienced a rapid population growth rate of 40.35% since 1990, with an annual average of 4.04%.

1.2.1 Governance

The City is governed by a progressive City Council-Manager form of government. The City Manager is the Chief Administrative Officer of the City. All legislative powers of the City of Bixby, except for the rights of initiative and referendum reserved to the people of the City of Bixby by the Constitution of Oklahoma, are exercised by a Council composed of five Councilors elected by Ward. The Mayor is chosen from among the Councilors.

Figure 1–3: Bixby District Map





LEGEND

- Major Streets
- City Limits
- Highways
- Fenceline

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Planning Consultants

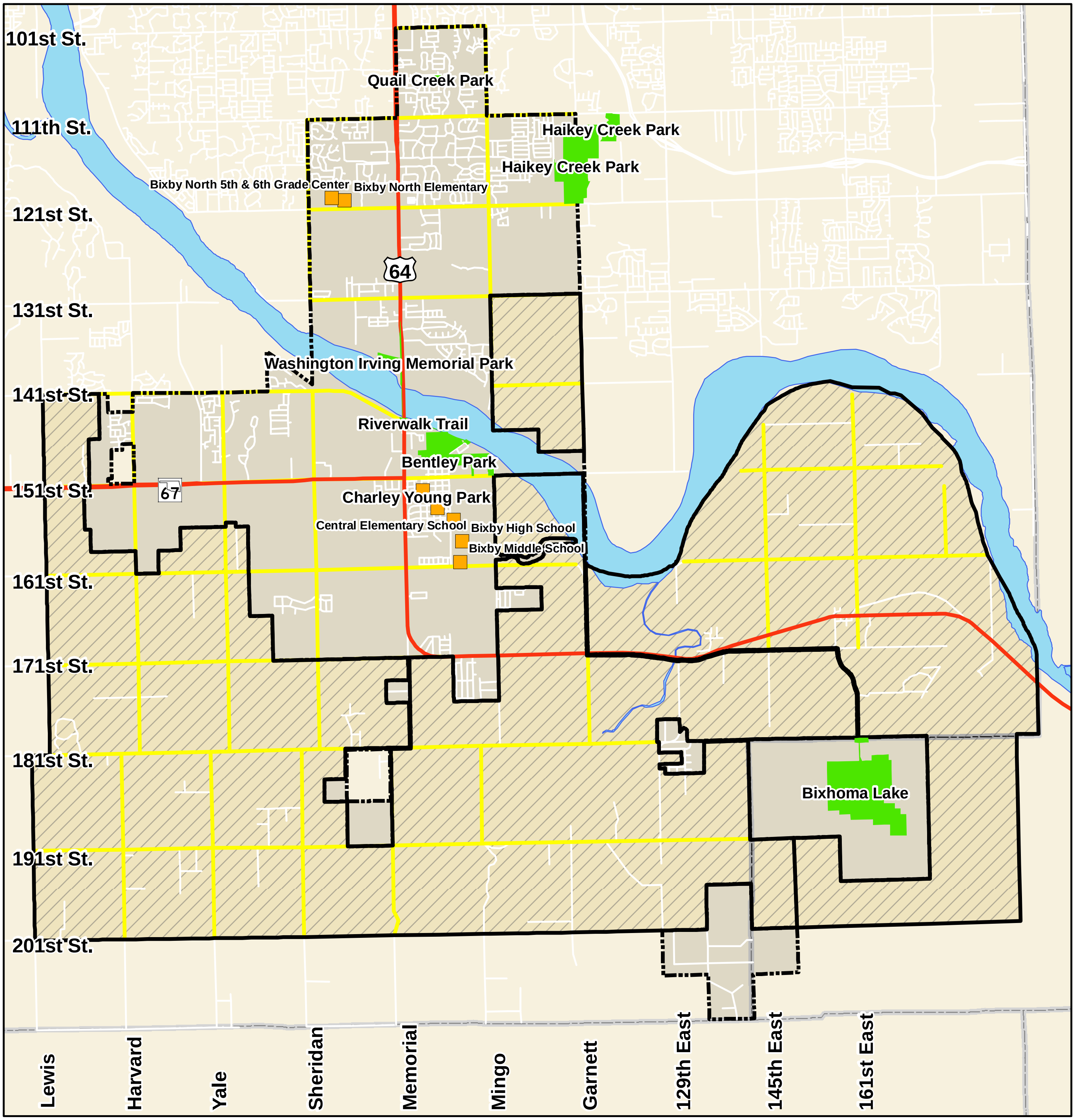
1 inch equals 8,375 feet

SEAL OF THE CITY OF BIXBY 1906 GARDEN SPOT OF OKLAHOMA

Figure 1-4

City of Bixby

Basemap



LEGEND

Schools
Major Streets
Parks
City Limits
Highways
Fenceline

1 inch equals 8,375 feet

Figure 1-5

City of Bixby

Parks & Schools

1.2.2 Geography

Latitude: 35.9449 N **FIPS Code:** 40143
Longitude: 95.8779 W

The City of Bixby is located directly south of Tulsa on the banks of the Arkansas River. Several associated drainage basins containing tributaries enter the Arkansas River within Bixby's vicinity creating a large floodplain and a frequent source for flooding. Large tracts of undeveloped land remain as well as several accessible routes linking the town and metropolitan area together. The City of Bixby's Land Use is shown in Figure 1-6.

The topography consists of hills, bluffs, and open prairie lands that mark the dividing line between the ridges of the Ozarks in the East and the broad plains of the West. Cattle and horse ranches combined with rich farmland distinguish the rural land uses in this area with the City of Tulsa just to the north. Oil and natural gas wells are common throughout the area. As a suburban city, 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.

1.2.3 Climate

Bixby lies at an elevation of approximately 700 feet above sea level. It is far enough south to miss the extreme cold of winter, with the climate being essentially continental, characterized by rapid changes in temperature. The winter months are usually mild. Temperatures occasionally fall below zero, but only last a very short time. Temperatures of 100°F or higher are often experienced from late July to early September. January's average temperature is 37.4° F and July's average is 81.9° F. The autumn season is usually short, consisting of pleasant, sunny days followed by cool nights. Winter temperatures, while generally mild, occasionally experience extremes below 0° while annual snowfall averages about 9 inches.

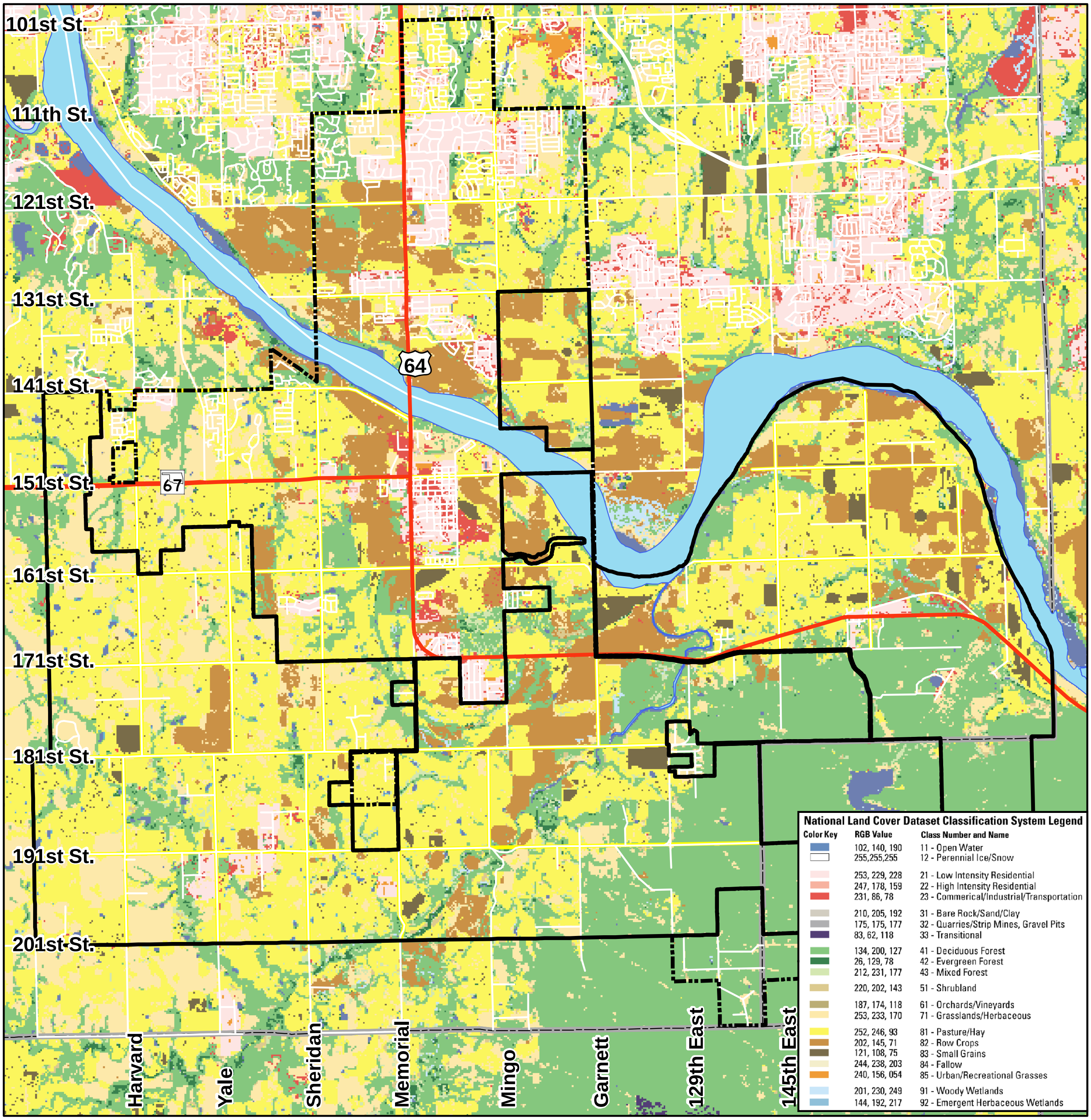
Bixby will receive a wide variety of precipitation in any given year. It averages 45.1 inches of rainfall and 9 inches of snow each year. Most of this precipitation comes in the form of convective thunderstorms that produce heavy amounts of rain in a short duration. Heavy winds, flash floods, and hail 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 the months of March and July. June is the most active month of the year for hail, wind, floods, and tornadoes. Severe weather is not limited, though, to this season, and tornadoes are possible in any month of the year.

Table 1–1: Weather averages for Bixby, Oklahoma

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Avg hi °F	46	52	61	72	79	88	93	93	84	74	60	50	71
Avg low °F	26	30	39	50	59	68	72	70	62	51	38	30	50
Precip (inches)	1.5	1.9	3.1	3.8	5.7	4.5	3.4	2.9	4.2)	3.4	2.6	2.0	39.2

Source: Weatherbase April 2007



LEGEND

- Highways
- Major Streets
- Water
- City Limits
- Fenceline

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1 inch equals 8,375 feet

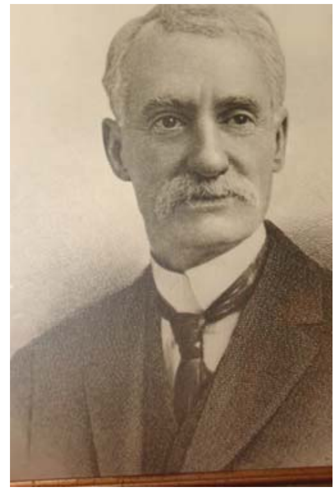
SEAL OF THE CITY OF BIXBY 1906 GARDEN SPOT OF OKLAHOMA

Figure 1-6

City of Bixby

Landuse

1.2.4 History


Tams Bixby

Bixby has a past ingrained historically with the Creek Nation within which it resides. The town is named after Tams Bixby, an appointed commissioner of the Dawes Commission, which listed members of the Five Civilized Tribes who were relocated to Oklahoma in the latter half of the 19th century. Bixby became a government town site with a post office in 1899. Located in the Muscogee (Creek) Nation, Indian Territory, The original 80-acre town site was approved in 1902. Many settlers were attracted to the area by the rich, though sometimes swampy river bottom land. In 1904 the Midland Valley Railroad laid tracks and built a depot in Bixby. This created factions that briefly split Bixby into two towns. The new part of town was deliberately surveyed so that the new streets did not align with the existing ones.

Bixby incorporated as an independent, self-governing town in 1906. The first mayor, recorder and five aldermen were elected in February, 1907. In 1911, a two-story brick schoolhouse was built on Main Street. Bixby Central Elementary is now near the original site. A traffic bridge was built over the Arkansas River in 1911, and for a time was said to be the longest bridge west of the Mississippi River. By statehood in 1907, the town of Bixby had a post office and several churches. Soon thereafter, a schoolhouse and a wagon bridge crossing the Arkansas River were established. Following WWI, several new school buildings and banks were constructed, public schools saw enrollment increases, and the town continued in population growth.

Bixby was impacted and enriched by the discovery of nearby oil fields in 1913, but farming remained the backbone of the community well into the 20th Century. Early farmers focused on production of cotton, wheat and alfalfa in the rich river bottom. During the 1930s, truck farming of vegetables slowly replaced those crops. In 1941 Bixby became an important regional center for shipping produce by railroad. It was at that time that Bixby was christened with it nick-name "The Garden Spot of Oklahoma," a designation still carried on the town seal and public vehicles. In time, the majority of the truck farms were converted to the production of sod, typically Bermuda grass, or developed for residential and other purposes. Only a small percentage of Bixby residents now work in agriculture, but the town continues to celebrate its earthy roots with the yearly "Green Corn Festival" in June.

Today, downtown Bixby retains its historic atmosphere, which has seen several significant historical events including a record high Christmas tree, construction of modern variety stores, and bank robberies by famous outlaw gangs. The bridge on highway 64 crossing the Arkansas River collapsed in the late 30’s, and fires in the 40’s and 60’s destroyed several public school buildings.

1.2.5 Cultural and Historical Properties

Bixby has no buildings currently on the National Register of Historic Places as of May, 2008.

It is home to **Washington Irving Memorial Park and Arboretum**, a public park and arboretum located just north of the Arkansas River Bridge at 13700 S. Memorial.

The park is named in honor of American writer Washington Irving, who camped in the area in October 1832 while participating in a federal expedition to the American West. The expedition included a 31-day, 350-mile circular tour of central Oklahoma.

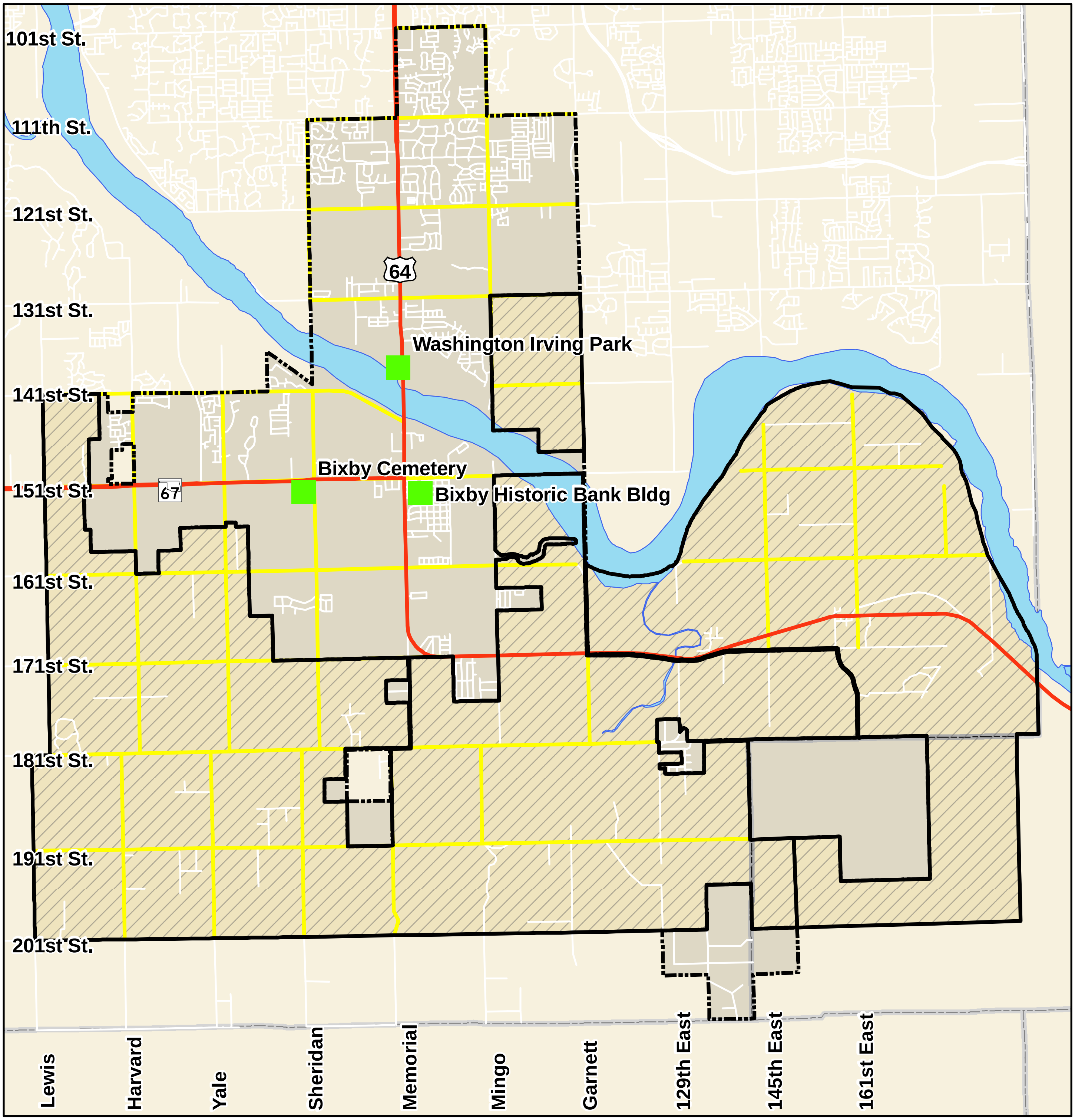
The park contains a wooded walking trail, the Laci Dawn Griffin Hill butterfly garden, and memorials to the children of the Alfred P. Murrah Federal Building bombing and to the September 11, 2001 attacks. It also contains a statue of Irving seated on an amphitheatre stage modeled after the facade of his home in Tarrytown, New York.

The **Bixby City Cemetery** is located on the southwest corner of 151^{st} St. South (Hwy. 67) and Sheridan Road.

One of the oldest buildings still standing in Bixby is at 1 West Dawes. It is about 100 years old, and was originally the home of **The Bank of Bixby**, an institution which failed during the great depression. It was most recently renovated and used as the "Goodies Community Coffee House." Between the time of the bank and the coffee house, the building provided space for doctors, dentists, jewelry stores, chiropractors, and other businesses.

Table 1–2: Cultural & Historic Places - Bixby, Oklahoma

	Name	Address
1	Historic Bank of Bixby Building	1 West Dawes
2	Bixby City Cemetery	151^{st} St. South and Sheridan Rd.
3	Washington Irving Park & Arboretum	13700 S. Memorial Dr.



LEGEND

Historic Sites

City Limits

Major Streets

Highways

Fenceline

Flanagan & Associates, LLC
Planning Consultants

1 inch equals 8,375 feet

SEAL OF THE CITY OF BIXBY 1906 GARDEN SPOT OF OKLAHOMA

Figure 1-7

City of Bixby

Historic / Cultural Sites

1.2.6 Demographics

Demography 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 was clearly demonstrated in 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 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 the community's vulnerability.

Bixby has a 2000 Census population of 13,336 and a 2007 population estimate of 17,233, which accounted, in 2000, for 1.65 percent of the population in the Tulsa Metropolitan Statistical Area (MSA). Over the last 8 years, the population of Bixby has been increasing for an average of 4.2 percent per year, while the population of the City of Tulsa itself has been declining for the first time since the Great Depression in the 1930s. All other things being equal, this change is anticipated to continue for the next few years. A great deal of this is due to population movement to the Tulsa suburbs, including Bixby. During the 1990's, the growth rate for Tulsa County was twice that of the City of Tulsa and the movement to the communities of Bixby, Broken Arrow, Jenks, and other suburbs is continuing to the present day. One factor to consider is that while residential living is moving to the suburbs, many of these suburban residents continue to work in the City of Tulsa. (*Source: Community Service Council Census Information Center*.)

Figure 1–8: Population of Selected Cities in Tulsa County

1970, 1980, 1990, 2000, and 2006 Estimates

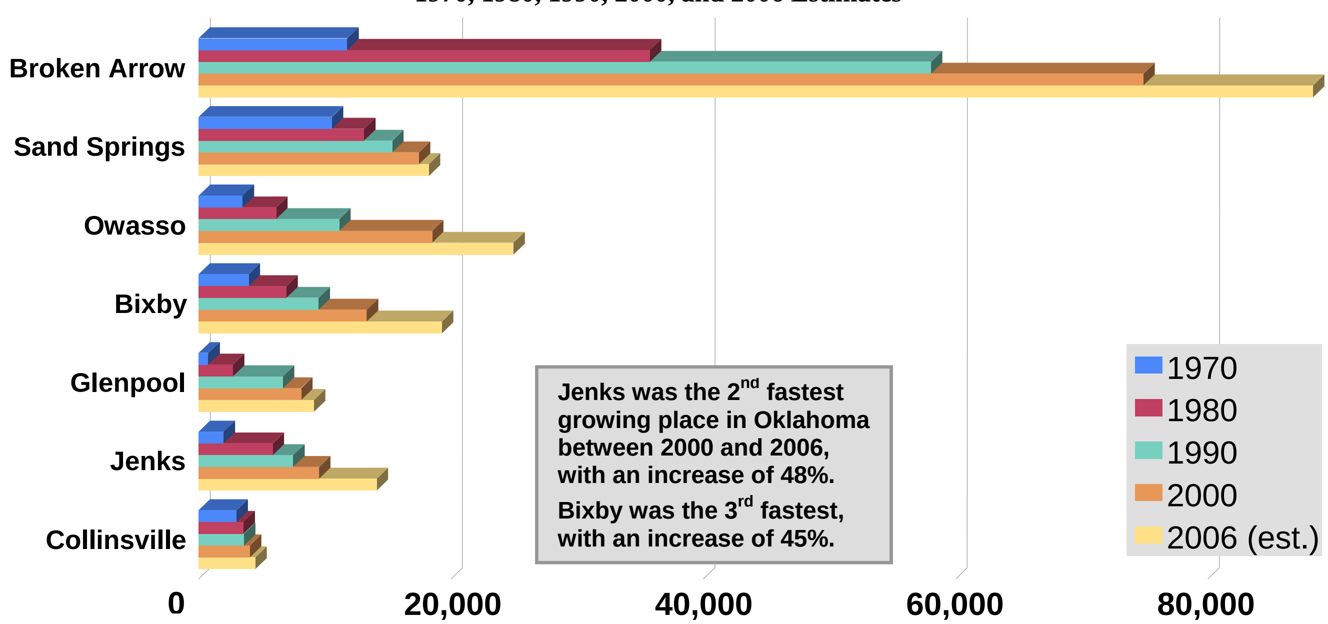


Table 1–3: Select Cities in Tulsa County Population Data

Source: US Census Bureau, 1970, 1980, 1990 & 2000 Censuses; Population Estimates Program, 2006.

Prepared by the Community Service Council of Greater Tulsa

	Broken Arrow	Sand Springs	Owasso	Bixby	Glenpool	Jenks	Collinsville
1970	11,787	10,565	3,491	3,973	770	1,997	3,009
1980	35,761	13,121	6,149	6,969	2,706	5,876	3,556
1990	58,043	15,346	11,151	9,502	6,688	7,493	3,612
2000	74,859	17,451	18,502	13,336	8,123	9,557	4,077
2006 (est.)	88,310	18,250	24,940	19,290	9,140	14,120	

The density of Bixby in 2000 was 663 people per square mile, compared with the population density of Tulsa County at 882.6 persons per square mile. Of Bixby's population, 25.8% are under 18 years of age (2007 estimated) and 10.7% are over 65. About 65.8 percent of Bixby's population is in the labor force (16 years of age and older). A map depicting the percentage of population aged 65 and above by Census block is shown in Figure 1-9; and a map depicting the percentage of population below poverty level by Census block is shown in Figure 1-10. Bixby's demographic data is summarized in Table 1-4.

Table 1–4: City of Bixby Population Data

Source: 2000 Census and 2007 Population Estimates (http://factfinder.census.gov)

Subject	***Number (2000)***	***City % (2000)***	***Estimate (2007)***	***City % (2007)***
Total Population	13,336	100	17,233 ↑	100
Under 5 years old	1,025	7.7	1,423 ↑	7.9 ↑
Between 5-18 years old	3,566	11.3	4,216 ↑	17.9 ↑
65 years and older	1,306	9.8	1,846 ↑	10.7 ↑
White	11,590	86.9	15,755 ↓	91.4 ↑
African-American	125	0.9	128 ↑	0.7 ↓
Native American	767	5.7	509 ↓	3.0 ↓
Hispanic	530	4.0	774 ↑	4.5 ↑
Language other than English spoken at home (5 years and over)	523	4.3	--	--
Poverty Status in 1999 * (Families)	163	4.3	--	3.8 ↓
Poverty Status in 1999 * (Individuals)	706	5.4	--	4.7 ↓

* The Census Bureau uses a set of money income thresholds that vary by family size and composition to determine who is in poverty. For more information on the thresholds and what qualifies as eligible vs. non-eligible income, go to www.census.gov/hhes/www/poverty/povdef.html

Vulnerable Populations

In any community, there are residents who may have greater vulnerability to the effects of disasters than does the general population. These groups may have little or nothing in common, and their needs may be very different. There is no "one size fits all" solution for handling populations with greater vulnerability. Some may need special consideration in warning, communication or evacuation, some may have special sheltering needs, whether

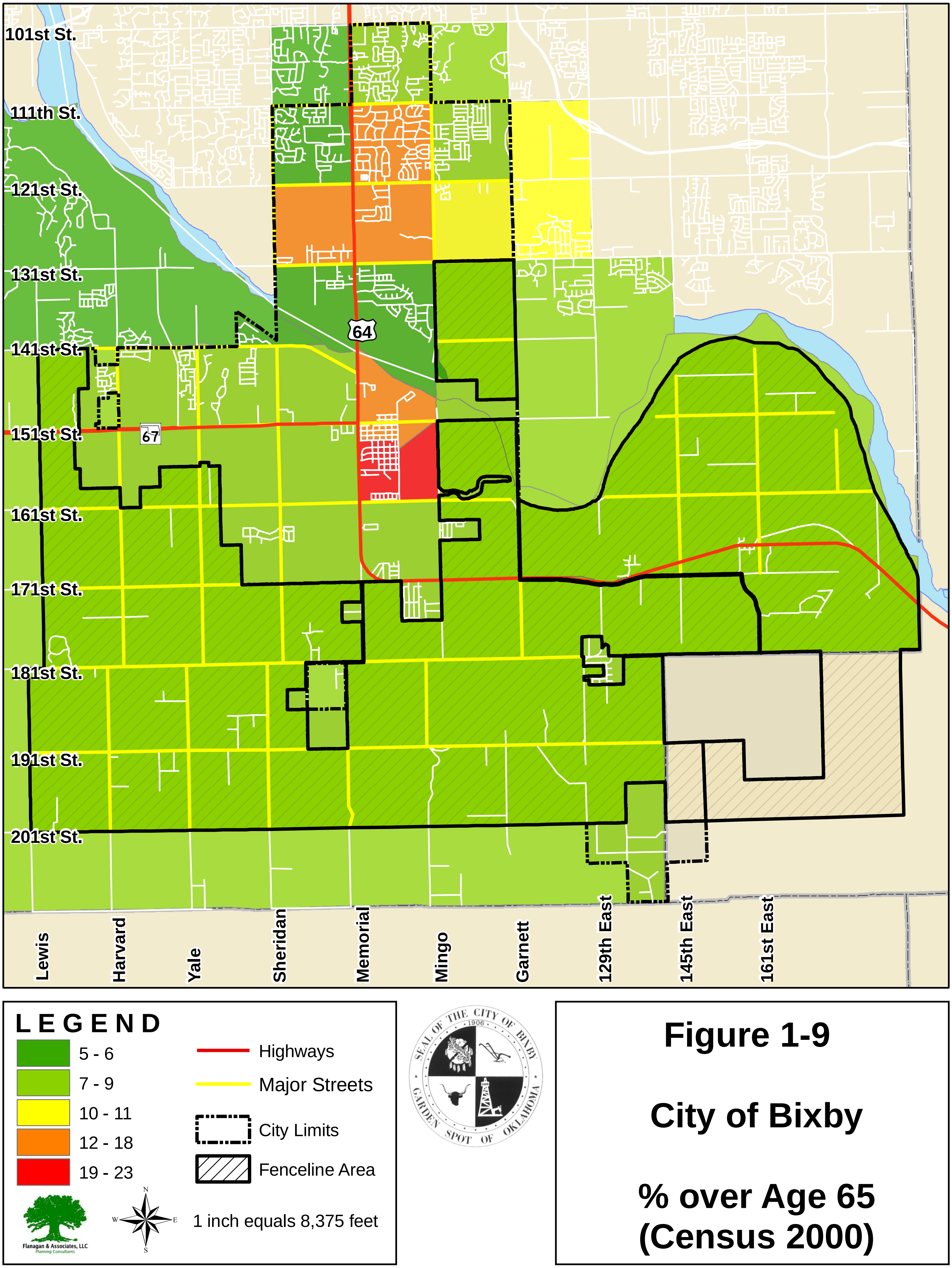
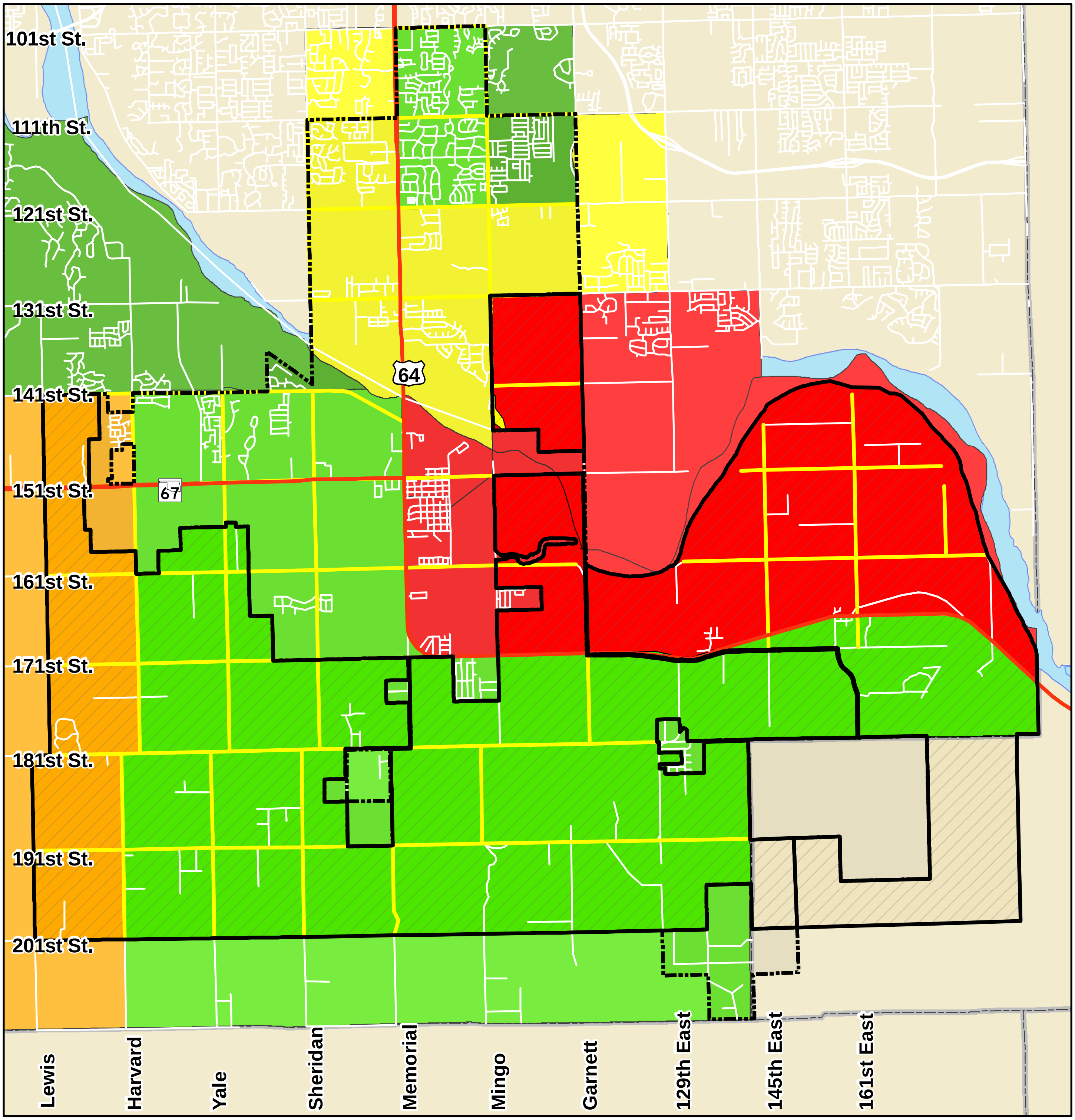


Figure 1-9

City of Bixby

% over Age 65 (Census 2000)



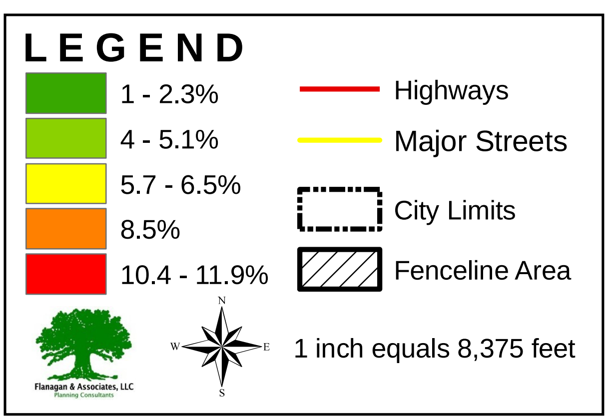


Figure 1-10

City of Bixby

% Living in Poverty (Census 2000)

medical or non-medical, and some may require other considerations in emergency planning and mitigation. Almost all have the ability to participate in a meaningful and active way in the planning, response, and mitigation activities of the community.

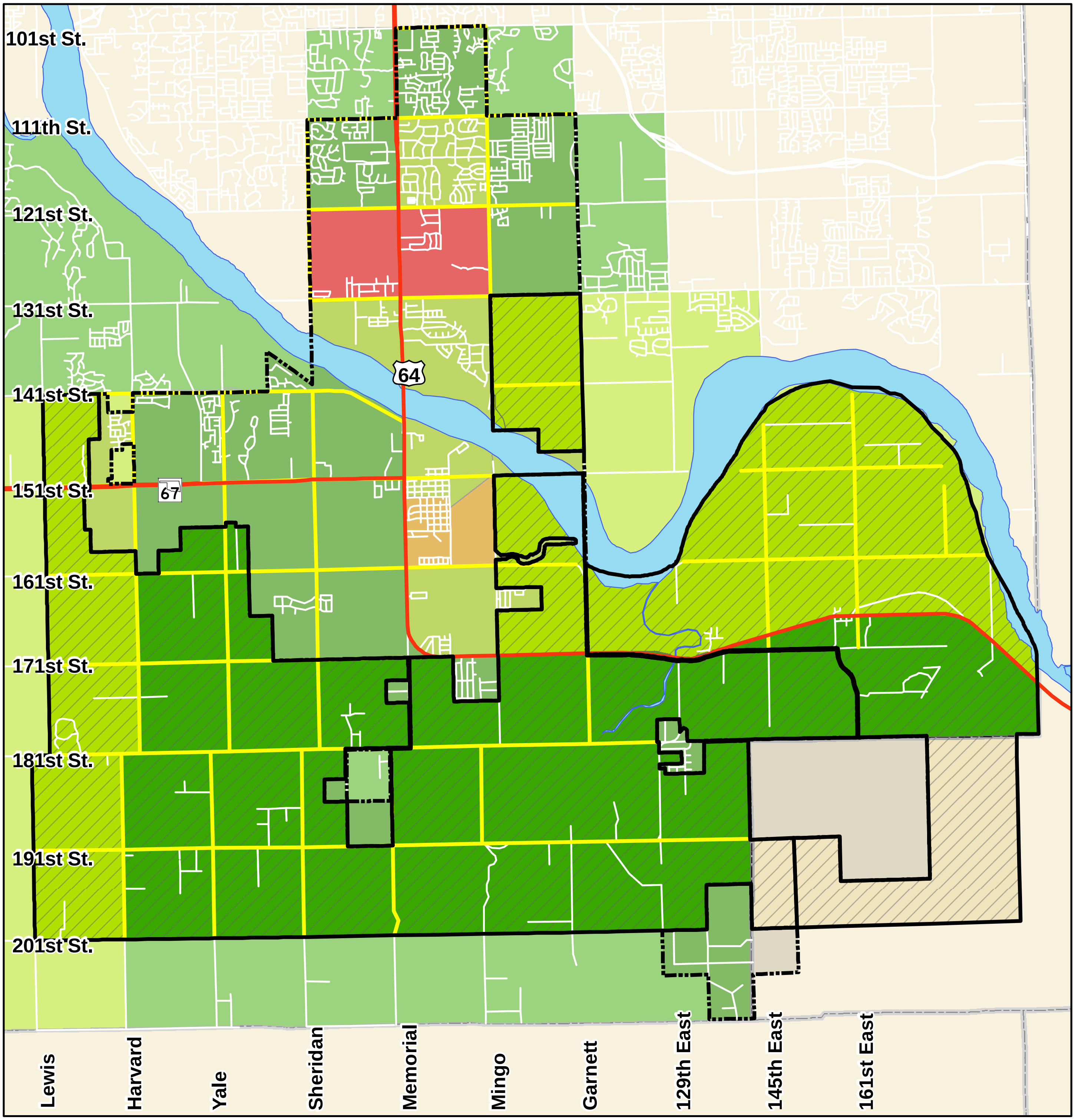
> *"The term "special needs" is widely used within the emergency management world. It generally refers to an extremely broad and heterogeneous population, including people with disabilities, minority groups, people who do not speak English, children and the elderly. Given this lack of specificity, it is conceivable that "special needs" could cover over 50 percent of the nation's population, rendering the term meaningless. These groups represent a large and complex variety of concerns and challenges. Many of these groups have little in common beyond the fact that they are often left out of emergency planning."*
>
> (June Isaacson Kailes, Disability Policy Consultant. From the International Association of Emergency Managers Bulletin, Vol. 22, No. 4, April 2005.)

These vulnerable populations may include:

- The elderly;
- People in poverty;
- People who speak a language other than English;
- People with mobility, hearing, visual or other physical disabilities;
- People with developmental or other cognitive disabilities;
- People with no access to private transportation;
- People with medical needs or medical/life support devices;
- People with pets.

The following map identifies some of the more vulnerable populations for the purposes of planning and to help ensure that these groups are meaningfully included in the planning process. The map is based on information from the 2000 U.S. Census Bureau.

- Figure 1-11: People with disabilities (as defined by the U.S. Census Report)



LEGEND

- 7.16 - 24.13%
- 24.14 - 41.10%
- 41.11 - 58.06%
- 58.07 - 75.03%
- Highways
- Major Streets
- City Limits
- Fenceline

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Planning Consultants

1 inch equals 8,375 feet

SEAL OF THE CITY OF BIXBY 1906 GARDEN SPOT OF OKLAHOMA

Figure 1-11

City of Bixby

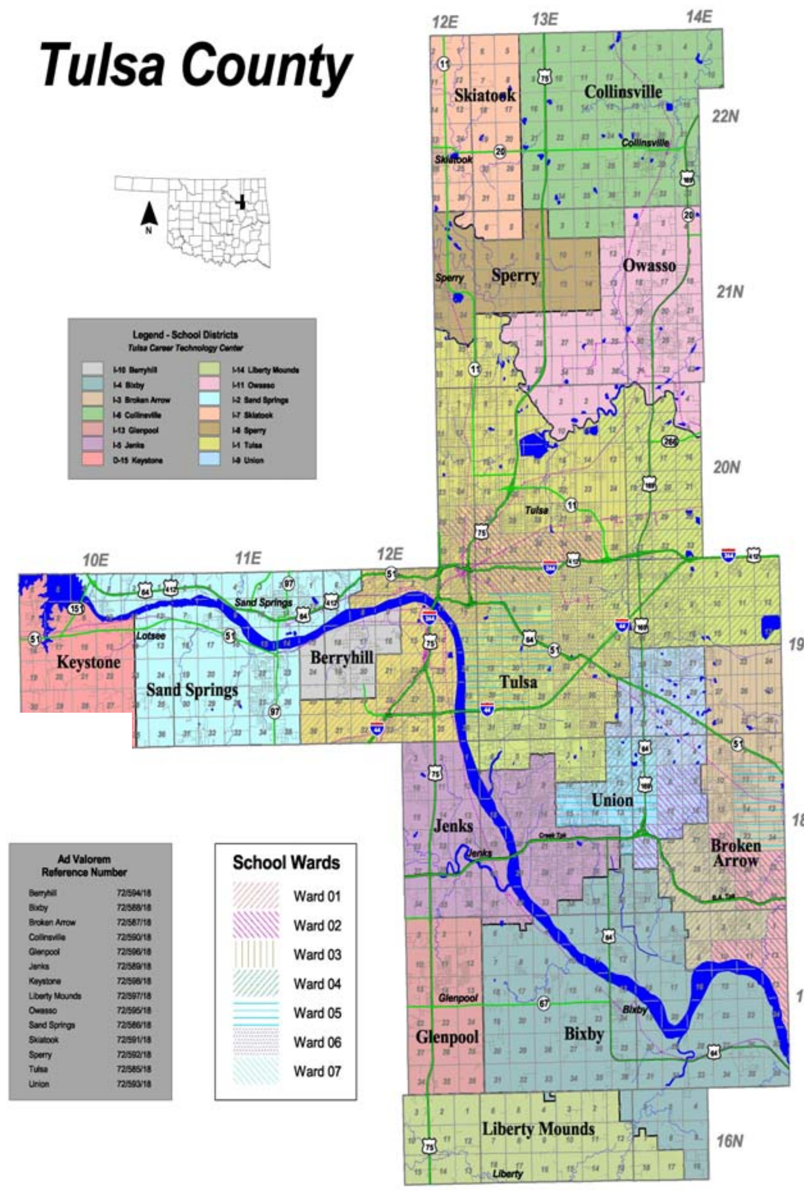
% of Population w. Disability

1.2.7 Bixby Public Schools

The Bixby School District serves nearly 4,400 students within the 70 square miles of the school boundaries. A map of Tulsa County School Districts and Bixby's relation to other Districts is included in Figure 1-12. A map of the Bixby School District is in Figure 1-13.

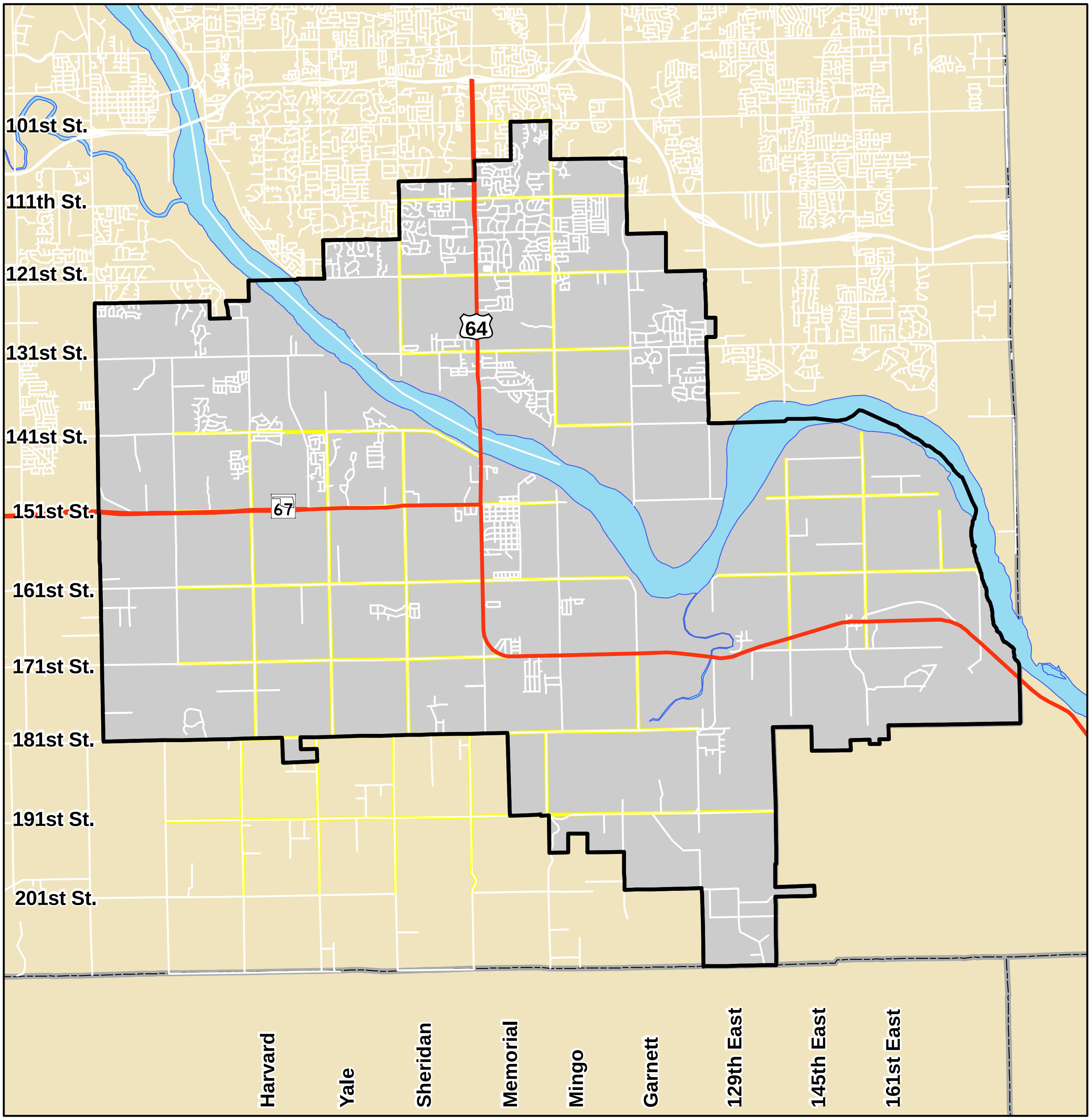
The schools are organized into four separate grade groupings. In this structure, students in grades kindergarten through fourth grade attend Central Elementary and Bixby North Elementary. Both elementary sites also offer a four year old program. Beginning in the fall of 2008, fifth and sixth grade students will attend Brassfield and North 5th & 6th Grade Centers. For the 2007-2008 school year, North will serve fifth grade students only. Middle School serves grades seven and eight. Bixby High School includes grades nine, ten, eleven and twelve. All schools are fully accredited by the State of Oklahoma. Bixby High School is also accredited by the North Central Association.

Figure 1–12: Tulsa County School Districts



1.2.8 Lifelines

Lifelines are defined as systems that are 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,



LEGEND

- Highways
- Major Streets
- Water
- School District

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1 inch equals 10,000 feet

SEAL OF THE CITY OF BIXBY 1906 GARDEN SPOT OF OKLAHOMA

Figure 1-13

City of Bixby

School District

telecommunications, water, and wastewater. Emergency service facilities include Emergency Alert System (EAS) communication facilities, hospitals, and the police and fire departments. Emergency service facilities are dealt with in detail in Section 2.6.

Utility Systems

Water Service

Bixby's water supply is brought from the City of Tulsa and is regulated by the Bixby Public Works Authority. Tulsa's water supply comes from Spavinaw/Eucha and Oologah Lakes. Lake Hudson, located approximately 40 miles to the east of the city, has provided water in the past and remains available for future use.

The first Spavinaw flowline is 54 inches to 60 inches in diameter and is 53.9 miles long. The second flowline from Spavinaw ranges from 66 inches to 72 inches in diameter and is 52.2 miles long.

The first Oologah flowline is 42 inches in diameter and runs 16.7 miles to the 66-inch Bird Creek to Lynn Lane pipeline that is 7.9 miles long. The second Oologah flowline is 54 inches-72 inches in diameter and is 22.87 miles long.

Raw water is stored in Yahola Lake (2.0 billion gallon capacity) near Mohawk Water Treatment Plant and Lynn Lane Reservoir (1.1 billion gallon capacity) near A.B. Jewell Water Treatment Plant.

The two plants treat between 90 and 190 million gallons of drinking water a day. Due to the foresight of area officials and the support of ratepayers, Tulsa has not been forced to restrict water use, either to residents or to communities dependent upon its supply, since the summer of 1981.

Bixby's Distribution system includes 94.03 miles of 2" to 12" pipe. It depends upon an electric pumping system that maintains an average 110 PSI of pressure. Bixby has a storage capacity of 2,350,000 gallons at ground level.

Planned expansions of the system include upgrade of controls and valves and upgrading of both wastewater lagoons.

Wastewater Treatment

Sewage Treatment is provided by Bixby Public Works Authority with the type of treatment being Secondary/Lagoons. Bixby has two wastewater sewage lagoons. The System capacity is 1,300,000 GPD with present usage at 500,000 GPD.

Information on each of the stations is in the following table.

Table 1–5: City of Bixby Wastewater Treatment

Name	Built	Upgraded	Design flow
North Lagoon	1982	2006	0.853 MGD
South Lagoon	1971	2002	0.45 MGD
TOTAL			**1.303 MGD**

The lagoons are served by 25 sanitary sewer lift stations, identified in Table 1-6 below. The table also includes information on which stations have generator backup power and which lagoon they serve.

Table 1–6: City of Bixby Sanitary Sewer Lift Stations

No.	Lift Station	Generator	No.	Lift Station	Generator
1	South Main	N	14	Carmichaels	N
2	Ellard	N	15	Blue Ridge	N
~~3~~	~~Pecan Park~~	Eliminated	16	Southbridge	Y
4	Southtown	N	17	Sunburst	N
5	Saker	Y	18	Heritage Park	N
6	Atkinson Acres	N	19	Shannondale	N
7	Eagle Rock 1	N	20	126 Center Main	Y
8	Eagle Rock 2	N	21	131 Street Main	Y
9	Whitehawk	Y	22	Riverbend	N
10	Springtree	Y	23	Baseball Field	N
11	Shadow Valley	N	24	Maintenance Garage	N
12	Pecan Valley	N	25	Water Garage	N
13	John's Park	N	26	Soccer Field	N

Proposed			Legend
	Lantern Hill	Y	South Lagoon
			North Lagoon

Electrical Service

Bixby's electric power is provided by three separate companies: AEP/Public Service Company of Oklahoma (PSO), East Central Oklahoma Electric, and Oklahoma Gas & Electric (OG&E).

PSO serves the majority of residential and business clients in Bixby, primarily north of the Arkansas River. PSO's headquarters is in Tulsa, with regulatory and external affairs offices in Oklahoma City. PSO serves 514,000 customers in Oklahoma. PSO recently became part of the American Electric Power system (AEP), which serves more than 5 million customers across 11 states.

East Central Electric Cooperative and OG&E divide the smaller portion of the community south of the River.

OG&E, with its headquarters in Oklahoma City, serves more than 765,000 retail customers in Oklahoma and western Arkansas, along with a number of wholesale customers throughout the region.

Electrical System Outages

The electrical grid infrastructure is vulnerable to a number of the natural disasters that will be addressed in this plan, primarily high winds, tornadoes, and severe winter storms.

The following table displays the number of power outages over the last 5 years from the primary provider of electrical power in the City of Bixby.

Table 1–7: PSO Outages with Greater Than 20,000 Customers Affected Jan 2003 – Dec 2008

Interruption Start Date	Number of Interruptions	Total Accounts Affected	Total Customer Hours Interrupted	Average Customer Hours (Days) Interrupted	Cause
08/01/2003	349	45,572	332,004	7.29 (0.30)	High Winds
05/13/2004	204	23,443	98,218	4.19 (0.17)	T'storms/High Winds
06/02/2004	508	63,255	1,226,376	19.40 (0.81)	T'storms/High Winds
06/04/2005	296	35,945	340,162	9.46 (0.39)	High Winds
06/16/2005	384	36,729	227,710	6.2 (0.26)	High Winds
11/27/2005	245	34,765	244,247	7.03 (0.29)	High Winds
10/17/2007	324	29,404	182,168	6.2 (0.26)	High Winds
12/09/2007	241	106,837	8,697,662	81.41 (3.39)	Ice Storm
12/10/2007	579	219,646	16,444,032	74.87 (3.12)	Ice Storm
12/11/2007	138	25,419	904,240	35.57 (1.48)	Ice Storm
06/01/2008	622	71,788	1,022,533	14.2 (0.59)	T'storms/High Winds

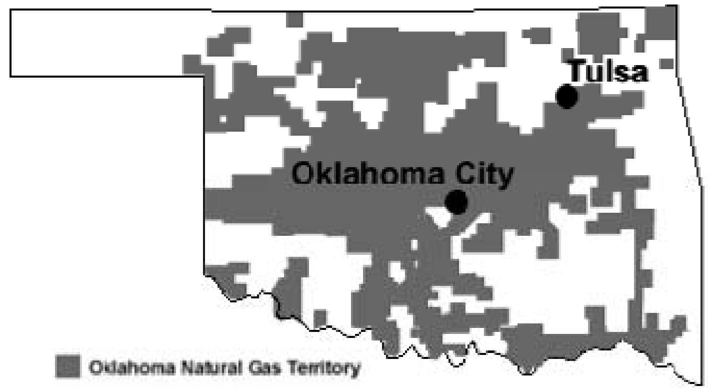
It is apparent that, while the majority of these outages are caused by high winds and thunderstorms, the most severe are those from ice storms. This is primarily due to the extensive and widespread physical damage to lines and poles during a heavy ice storm.

Loss of electrical power is perhaps more critical than the loss of other infrastructure services due to the dependence on power to support the other services – including water treatment plants, telecom services, fuel delivery, and so on. In addition, many people depend on electrically-driven life-assistive devices such as breathing machines or dialysis equipment.

Power outages also create additional threats to life and health. Traffic signals may be disrupted, creating the potential for vehicle accidents. In the most recent major power outages in the Tulsa Metro area, a number of people were treated for carbon monoxide poisoning due to inappropriate use of alternative heating or generating devices. At least 40 were transported to local hospitals with CO related symptoms. Residential fires increased dramatically due to both electric lines coming into the home being damaged, and unsafe alternate sources of heat – charcoal grills, gas stoves and ovens, or combustion heaters. Unsafe use of home generators can also put electric service personnel at risk due to "backfeeding" into service lines. For additional information on power outages and emergency generators, see Appendix B, Section B.2.11 and B.2.12.

Natural Gas Service

Figure 1–14: Oklahoma Natural Gas Territory



Bixby's gas service is provided by Oklahoma Natural Gas (ONG), a subsidiary of its parent company, ONEOK, founded in 1906. Oklahoma Natural Gas serves approximately 800,047 residential, commercial and industrial customers in Oklahoma. The company has affiliates that operate transmission and gathering operations in Oklahoma that include 2,348 miles of pipeline and five strategically-located underground storage facilities, also located in Oklahoma.

Transportation Systems

Major Highways and Roads

The City of Bixby has two major highways, including:

US Highway 64—U.S. 64 is the longest U.S. highway in the state of Oklahoma. At just less than 600 miles, it is the second longest highway in Oklahoma, behind only OK 3. From a nationwide perspective, U.S. 64 runs from the northeast corner of Arizona to the Atlantic Ocean near Nags Head, North Carolina. Approaching Tulsa, U.S. 64 heads due south along Memorial Drive to serve south Tulsa and the suburb of Bixby. The highway is two lanes at that point. Just south of OK 67 and Bixby, U.S. 64 curves to the east, but continues heading mostly to the south all the way to the U.S. 62/OK 16 intersection several miles west of Muskogee.

State Highway 67—OK 67 connects OK 75A in Kiefer to U.S. 64 in Bixby. It is a crucial east-west connection on the southern edges of the Tulsa metropolitan area. OK 67 has already been widened to a 4-lane divided highway east of U.S. 75, and construction during late 2002 and most of 2003 widened the highway between Kiefer and U.S. 75.

Traffic counts on these highways plus Bixby's major streets are presented in Table 1-8. The major street data is from January 2004.

Table 1–8: Highway Traffic Counts
(Source: Oklahoma Department of Transportation, 2006, and Bixby Chamber of Commerce)

Highway	*Daily Traffic Counts*	*Highway*	*Daily Traffic Counts*
OK-67, west of US-64	11,700	South of 161st & Memorial	10,781
US-64, north of OK-67	26,100	North of 111th & Memorial	15,454
US-64, south of OK-67	12,200	Memorial & 124th St.	21,244
US-64, E-W, south side of Bixby	4,900	West of 151st & Memorial	11,454
South of 111th & Memorial	21,537		

Future transportation for the Tulsa Metro Area, including the Bixby area, 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 INCOG, ODOT and the Metropolitan Tulsa Transit Authority. For Bixby's major highways, the Plan includes:

- Expansion of US Hwy 64 as an arterial 6-lane road north into the City of Tulsa and as a 4-lane south and east of Bixby.
- Expansion of OK-67 as an arterial 4-lane to the east of Bixby.

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.

Bus Lines and Taxi Service

The only metropolitan bus service provider for the Bixby area is the Metro Tulsa Transit Authority (MTTA), a public trust of the City of Tulsa, established in 1968. In addition to regular bus service, MTTA operates the Lift Program, a curb-to-curb paratransit service for persons with disabilities who have been determined ADA Paratransit Eligible. The Lift Program offers service utilizing lift-equipped vans and taxis operating within the Tulsa City Limits.

MTTA services a route that touches Bixby's northernmost border on 101st Street. At this time, service does not extend into the City.

The community is also serviced by over 20 taxicab, airport shuttle, and limousine companies that operate throughout the Tulsa metropolitan area, although none, at this time, are based in Bixby.

An MTTA's lift-equipped paratransit bus, part of the Lift Program

Railway

The City of Tulsa is reviewing the feasibility of a light-rail transit system to support commuter traffic to nearby communities, which may include Bixby, but no action is anticipated for several years, and studies, at this point, do not indicate the major locations of potential routes. Currently Bixby has no rail lines in the city limits.

Airports

The City of Bixby is served by two airports, including:

- Tulsa International Airport – Average of 167 aircraft based at field with an average of 79 operations/day. This is the Tulsa area's primary commercial airport. TIA also houses the 138th Fighter Wing of the Air National Guard and is the global maintenance headquarters for American Airlines.
- Richard Lloyd Jones Airport (Riverside) – Average of 543 aircraft based at field with 926 operations/day. Riverside is primarily an airport for business-owned private aircraft. It is located 8.5 miles to the northwest of Bixby.

1.2.9 Economy

The City of Bixby is a Tulsa County community and its economy are part of the Tulsa Metropolitan Statistical Area (MSA). Bixby is known for its convenient proximity to Tulsa while maintaining a quaint, small town atmosphere.

Of Bixby's population over the age of 16 years, 71.2% are in the labor force and only 2.3% are unemployed. Of the people employed, about 84.1% are private wage and salary workers, 7.9% are government workers, and 7.5% are self-employed in unincorporated businesses. The median household income in 1999 was $50,854, and the median family income was $58,104.

Bixby has four industrial areas:

- Area 1 is between 141st and 151st Street and west of Memorial. The area is known as Morris Bright Industrial Park, and is located in the 500-year floodplain. The area has City water and sewer, and its businesses include American Foundry, S & S Molding, Steel Fab, Bixby Wrecker, and others.
- Area 2 is Bixby Industrial Park located south of 151st Street on 76th & 77th East Avenue. It was developed some years ago and much of the area is floodplain. Businesses include a trucking firm, a decorative concrete casting company, a photographic business, contractors, and others. The area has both city water and sewer. The Corps of Engineer Bixby Creek Project will lower the flood level in this area. It remains to be seen how much of the site will be removed from the flood hazard zone.
- Area 3 is not developed and consists of about 21.5 acres west of Bixby off Highway 67 in the Southwest Quarter of Section 16, Township 17 North, Range 13 East. Almost the entire area is outside a floodplain. Water and Sewer are available to the site. The City hopes to attract new business to this site.
- The Chognard Business Park is located between 141st and 151st St. So., and between and Harvard and Yale Avenues. The business park, which is presently undeveloped, has 235 acres set aside for corporate and business development. The site has important urban services readily available, including 12–inch water mains along 151st St. So. and Yale Place (Industrial Road), and an 8-inch main along 141st St. So.

Employment and income data for Bixby are presented in Table 1-9.

Table 1–9: City of Bixby Employment and Income Data

Source: 2000 Census and 2005-7 Population Estimates, Department of Commerce

Subject	Number (2000)	%	Number (2006)	%
Population 16 Years and Older	10,030	76.1%	13,024	64.8%
Population in Labor Force	7,047	71.2%	8,864	44.1%
Employed	6,812	68.8%	-	-
Total Households	4,903	-	6,438	-
Individuals Below Poverty Level	706	5.4%	1,085	5.4%

Major Employers

Bixby's major employers are listed in Table 1-10.

Table 1–10: Major Employers
Oklahoma Department of Commerce, 2007

Company	Employees (Approx)	Sector
Regal Plaza (Including Hampton Inns and Suites)	650	Hospitality
Bixby Public Schools	460	Education
Kimberly Clark	400	Manufacturing
City of Bixby	100	Government
Lowes	100	Retail
Citizens Security Bank	90	Financial
BTC Broadband	65	Telecommunications

1.2.10 Development

According to the Tulsa County Assessor's Office, there are 9,355 properties within the City of Bixby, with an assessed value of $1,076,488,792. Numbers of properties with improvements (buildings, garages, pools, storage, and so forth) and improvement values, by type, are shown in the table below. No land values are included. Due to their vulnerability to natural hazards, the locations of mobile homes have been identified on the map in Figure 1–15.

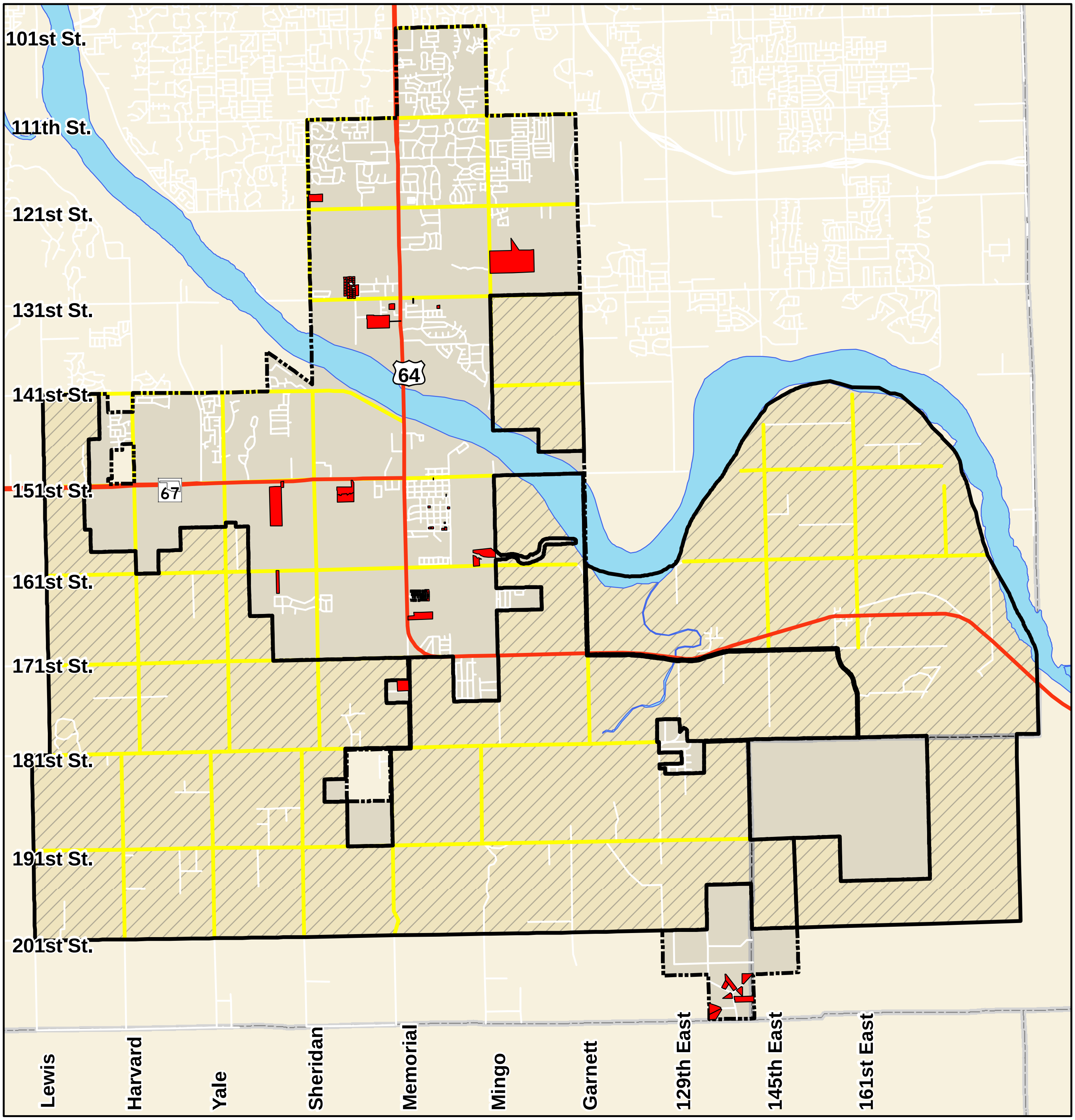
Table 1–11: City of Bixby 2008 Housing Units, Value and Type
Source: Tulsa County Assessor's Office

Improvement Type	*Number*	*Total Value*
Agricultural	127	$420,600
Residential Single Family	6,399	$953,649,796
Residential Multi-Family	55	$21,975,161
Residential Single/Mobile Home	151	$959,277
Commercial	221	$75,257,392
Industrial	86	$22,170,537
Other	2,346	$2,056,029
Total	**9,355**	**$1,076,488,792**

Future Development

The Tulsa Metropolitan Area is growing at 1.3% annually, the same as the national growth rate. Comparatively, the State of Oklahoma is growing at 1% annually. Bixby is experiencing an annual growth rate of 4.04%.

Regional coordination is a key to future development, as emphasized 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 Tulsa is inextricably connected. These jurisdictions include the City of Bixby.



LEGEND

- Mobile Homes
- Highways
- Major Streets
- Water
- City Limits
- Fenceline

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1 inch equals 8,375 feet

Figure 1-15

City of Bixby

Mobile Homes & Mobile Home Parks

Growth Trends

Over the past 15 years, growth has primarily taken place north of the Arkansas River because of the large floodplain area south of the Arkansas. Floodplain Regulations have restricted growth in the floodplain. Much of the developed area south of the river pre-dates FEMA FIRM (Flood Insurance Rate Maps) maps.

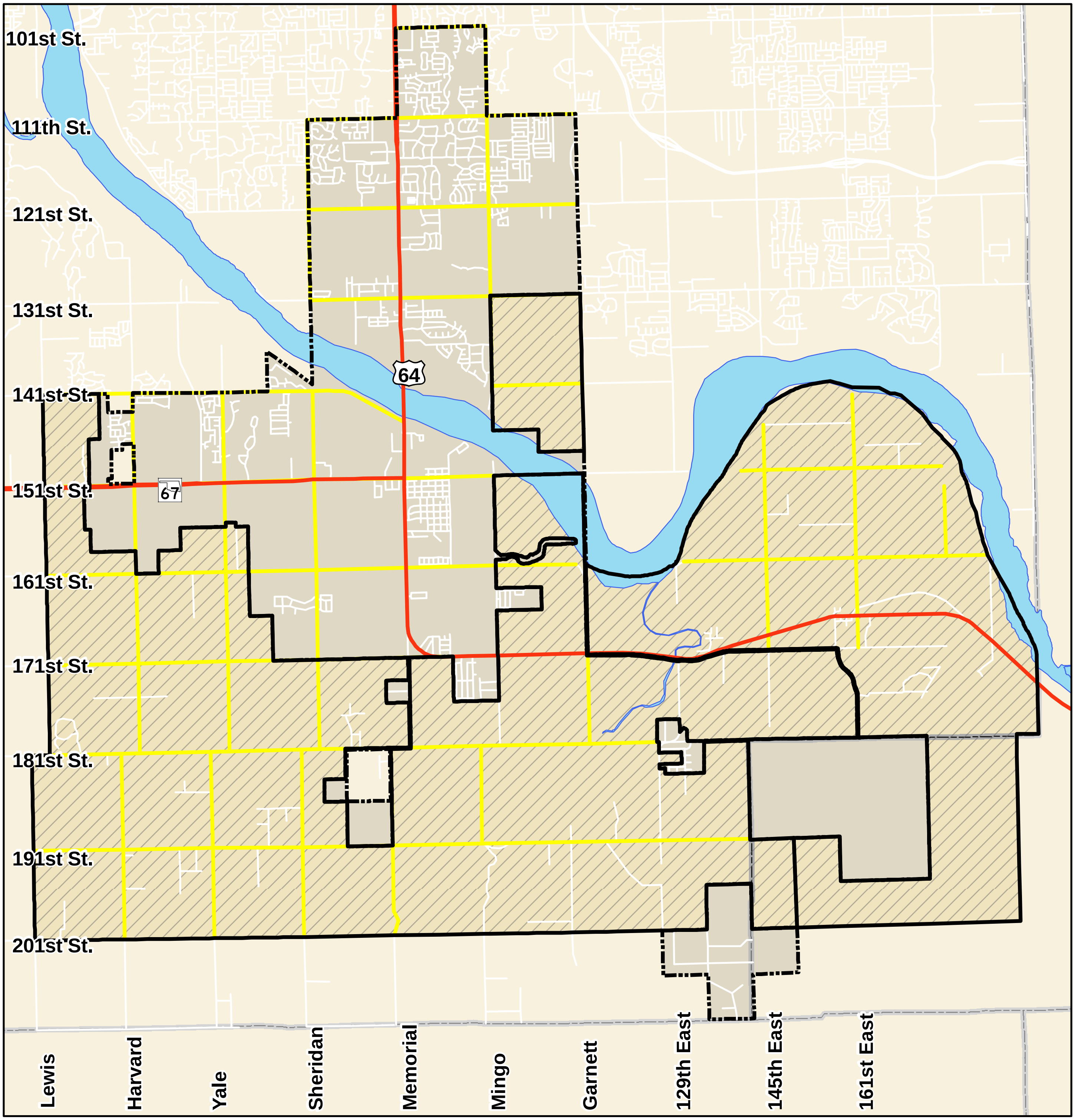
The area from 101st Street S. to 111th Street S. between Memorial Dr. and Mingo Rd. has experienced prime residential and commercial development. The area between 111th St. S. and 121st Street S. – between Sheridan Rd. and Garnett Rd. – has also been a prime development area, with commercial focused along Memorial Dr. and residential development in other areas. The area from 121st St. S. to the Arkansas River has historically been limited, in terms of development, due to restrictions on development in the floodplain. However, development has proceeded in this area since the completion of the Fry Ditch Corps of Engineer Project, which took large parts of this area out of the 100- and 500-year floodplains.

The land available for development north of the Arkansas River is greatly diminished and some development is now happening south of the River. This development is centered to the west away from the low-lying areas of "Old Town Bixby" and out of the reach of floodwaters. While this area between Yale Ave. and Sandusky Ave., and between 141st and 151st St. So., was first conceived as Commercial and Industrial in the Comprehensive Plan, over the past few years residential development has predominated.

The Comprehensive Plan adopted in October of 2002 discourages additional development in flood areas. This policy is supported by the Bixby Floodplain Regulations (City Code Title 13). Development outside of the floodplain is encouraged, but development anywhere in the City is constrained by very strict drainage standards and stormwater control measures. The Zoning Code also establishes a Detailed Site Plan review requirement for development in the Corridor Appearance Districts, which ranges between 300 and 600 feet in width on both sides of Highway 64 (Memorial Dr.), Highway 67 (151st Street S.), and certain other primary corridors.

Figure 1-16 shows the City of Bixby's Fenceline area which reserves area for the city to grow into. Figure 1-17 shows the growth of Bixby since 2004 highlighted in red. The future growth areas are shown based on projected type of growth and are detailed below.

- Single-Family Residential: There are 542 acres that are projected to house four residences per acre, valued at $165,000 per residence. This results in $357,720,000 in future growth in areas shown in light blue.
- Multi-Family Residential: There are 48 acres that are projected to house twenty units per acre, valued at $60,000 per unit. This results in $57,600,000 in future growth in areas shown in light green.
- Commercial/Industrial: There are 408 acres of which half is expected to be used for development. This provides 204 acres that are projected to provide 43,560 square feet of development, valued at $120 per square foot. This results in $1,066,348,800 in future growth in areas shown in light purple.
- Other (Churches, Schools, Civic): There are 68 acres that are projected to be used for facilities that are generally classified as tax-exempt properties. Due to



LEGEND

- Highways
- Major Streets
- Water
- City Limits
- Fenceline

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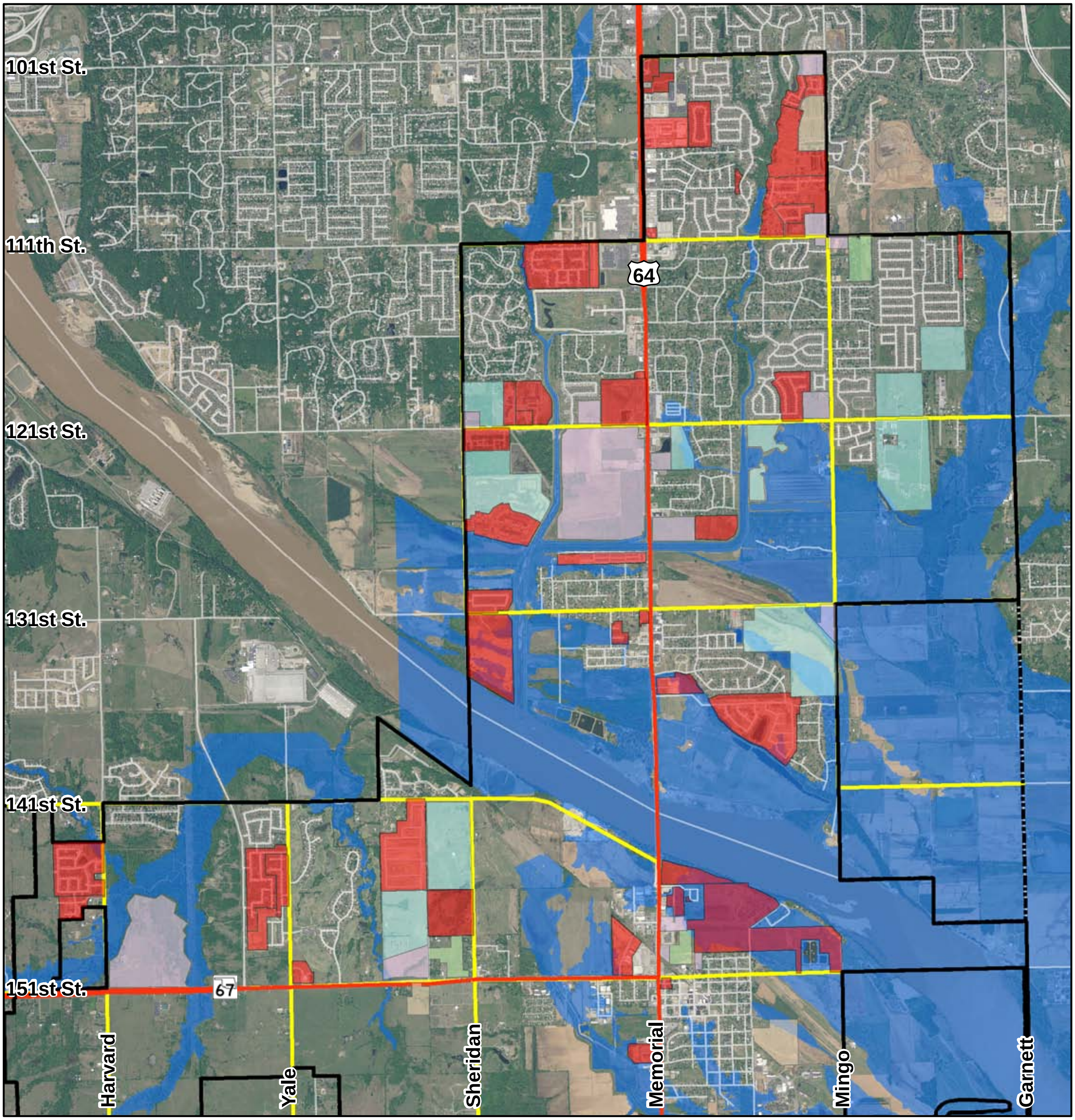
1 inch equals 8,375 feet

SEAL OF THE CITY OF BIXBY 1906 GARDEN SPOT OF OKLAHOMA

Figure 1-16

City of Bixby

Fenceline



LEGEND

Development Since 2004

Future Growth Areas

Type

- Commercial/Industrial
- Multifamily Residential
- Single Family Residential
- Other (Church, School, Civic)

100 yr. Floodplains

City Limits

Fenceline

Highways

Major Streets

0 1,450 2,900 5,800 Feet

N W E S

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SEAL OF THE CITY OF BIXBY 1906 GARDEN SPOT OF OKLAHOMA

Figure 1-17

City of Bixby

Growth Areas

the wide variety of types of uses for these properties and their associated values, it is not realistic to assess values for future growth potential. Most of the value for structures built in these areas is based on the value of their services, not on the structure built.

Transportation

In addition to the roadwork detailed in the comprehensive planning document, *Destination 2030,* detailed in the Major Highways and Roads Section above, a proposed bicycle trail expansion along both sides of the Arkansas River is being reviewed.

1.2.11 Critical Facilities

Critical facilities are defined differently by different organizations and agencies, but are usually considered to be those facilities vital to the health, safety, and welfare of the population and that are especially important following hazard events, or 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:

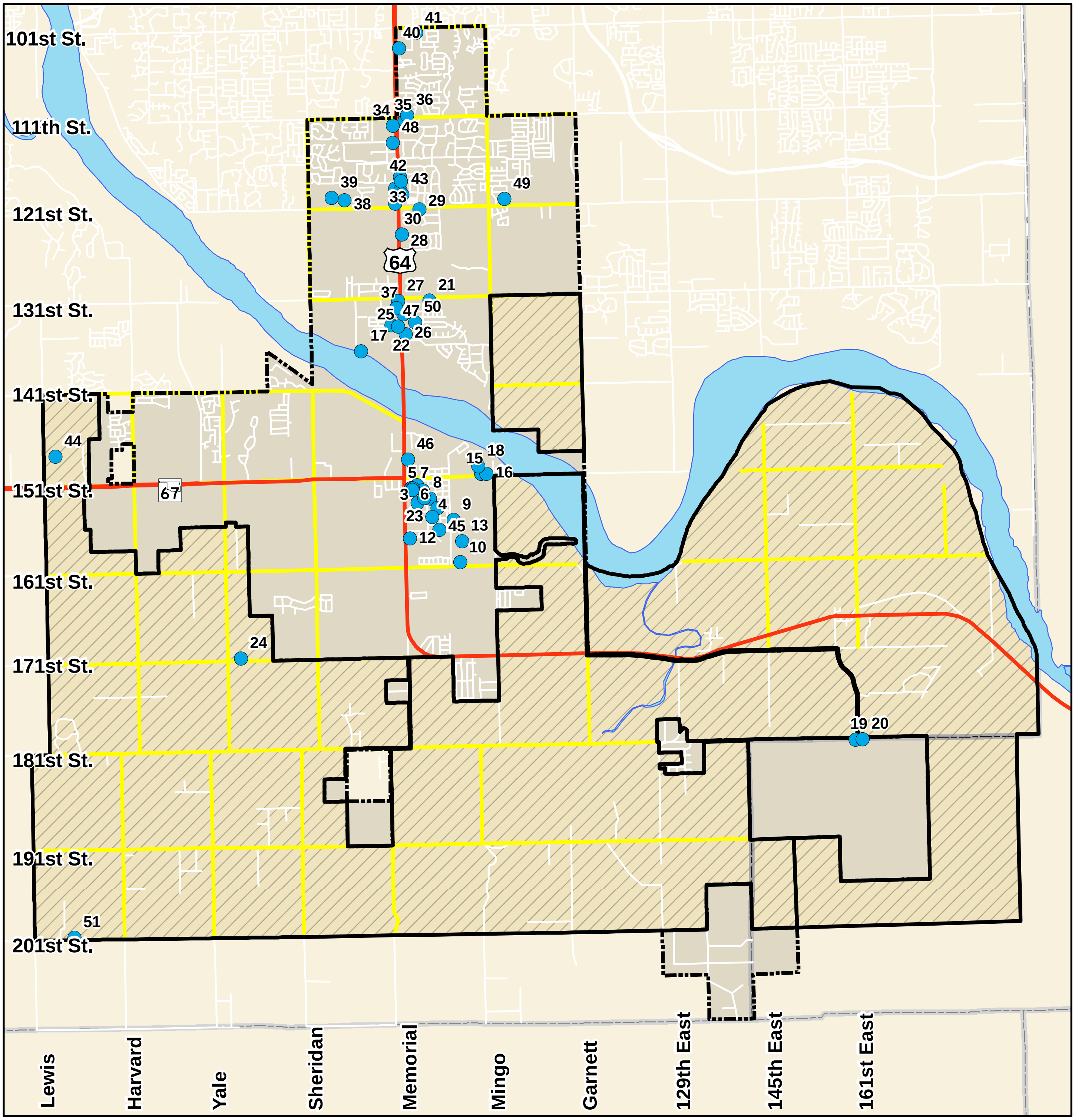
- Structures or facilities that produce, use or store highly volatile, flammable, explosive, toxic and/or water-reactive materials;
- Hospitals, nursing homes, and housing likely to contain occupants who may not be sufficiently mobile to avoid death or injury during a disaster;
- Police stations, fire stations, vehicle and equipment storage facilities, and emergency operations centers that are needed for disaster response activities before, during, and after an event;
- 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 9/11/2001, FEMA has also added banks and other major financial institutions to their critical facilities list. The City of Bixby's critical facilities are listed in Table 1-12 and mapped in Figure 1–18.

Table 1–12: Bixby Critical Facilities

ID	Name	Address	ID	Name	Address
Government Facilities			**Long Term Care Facilities / Medical**		
6	Bixby City Hall	116 W. Needles	50	Autumn Park Retirement	8401 E 134th St.
1	Bixby Community Center	211 N. Cabanis	42	ERgent Care of Green Country	11717 S. Memorial
7	Bixby Fire Station #1	116 W. Needles	49	Sand Plum Retirement	9999 E. 121st St.
29	Bixby Fire Station #2	8300 E. 121st St.	12	Southtown Nursing & Rehab.	76 W. Rachel St.
15	Bixby Maintenance Building	9501 E. 151st St.	41	Warren Clinic	8414 E. 101st St.

ID	Name	Address	ID	Name	Address
5	Bixby Police Dept.	116 W. Needles	43	Warren Clinic	11919 S. Memorial
8	Bixby Public Library	20 E. Breckenridge		**Educational Facilities**	
20	Bixhoma Lake Water Bldg.	181st & 161st East	13	Bixby High School	601 S. Riverview
19	Bixhoma Lake Water Tower	181st & 161st East	10	Bixby Middle School	9401 E. 161st St.
14	Dawes Bldg. City Offices	113 W. Dawes	39	Bixby North 5th & 6th Grade Center	6941 E. 121st St.
17	North Sewer Treatment	13700 S. Memorial	38	Bixby North Elementary	7101 E. 121st St.
18	South Sewer Treatment	9501 E. 151st St.	2	Bixby Public Schools	109 N. Armstrong
16	Water Dept. Maintenance Bldg.	9575 E. 151st St.	9	Brassfield 5th & 6th Grade Center	501 S. Riverview
3	Bixby USPS	16 S. A Ave.	11	Central Elementary School	201 S. Main
	Financial Institutions		51	Liberty Public Schools	2727 E. 201st St.
33	Arvest Bank	11709 S. Memorial		**Childcare Facilities**	
30	Bank of Oklahoma	12052 S. Memorial	22	YMCA	7910 E. 134th St.
32	Bank of the West	11845 S. Memorial	44	8 Acres Camp Daycare	14775 S. Lewis Ave.
46	Citizens Security Bank & Trust	14821 S. Memorial	45	A Child’s Dream Daycare	213 E. Stadium Rd.
48	Citizens Security Bank	11402 S. Memorial	25	After the Bell Student Center	13201 S. Memorial
28	Grand Bank	12345 S. Memorial	4	Bixby Early Education Daycare – FBC	114 E. Breckenridge
31	IBC Bank	11886 S. Memorial	37	Destiny Learning Academy	13164 S. Memorial
34	MidFirst Bank	11122 S. Memorial	24	Midwest Childcare	5161 E 171st St.
26	Tulsa Teacher’s Credit Union	13475 S. Memorial	21	Playland Daycare Center	8510 E. 131st St.
27	Valley National Bank	13112 S. Memorial	35	Primary Concepts Preschool	8180 E. 111th St.
36	Western Sun Federal Credit Union	8315 E. 111th St.	23	Storybrook Inn	210 S. Main
			47	YMCA Daycare – Wilson Bldg.	13406 S. Memorial



LEGEND

- Critical Facilities
- Major Streets
- Highways
- City Limits
- Fenceline

1 inch equals 8,375 feet

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SEAL OF THE CITY OF BIXBY 1906 GARDEN SPOT OF OKLAHOMA

Figure 1-18

City of Bixby

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 Emergency Operations Plans and Emergency Operations Centers, to purchasing fire trucks and ambulances and constructing large and small infrastructure projects like levees and safe rooms. Most communities have already made considerable investments in these critical areas. 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 Bixby'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 planning 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.

Bixby's location as a floodplain community on the Arkansas River makes it especially vulnerable to the threat of upstream dam failure, dam releases, and flooding. To counter these hazards, Bixby has a host of programs that range from informing people about protection measures, warning the public of impending threats, requiring protection measures to be incorporated in new buildings, and constructing flood control projects. Bixby has a large portion of its corporate boundaries in a floodplain. The people of Bixby have voted millions of dollars in taxes to turn the “Flood Capital of Oklahoma” into the “Garden Spot of Oklahoma.” All efforts to mitigate the impact of hazards have helped, but they have not eliminated all potential problems.

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 consider floods 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.

Bixby has participated in the National Flood Insurance Program since 1979. All residents of Bixby are eligible to purchase federal flood insurance. The City of Bixby continues to maintain full compliance with the NFIP. Current policy holder locations are shown in Figure 2-1, and Claims against the NFIP are shown in Figure 2-2.

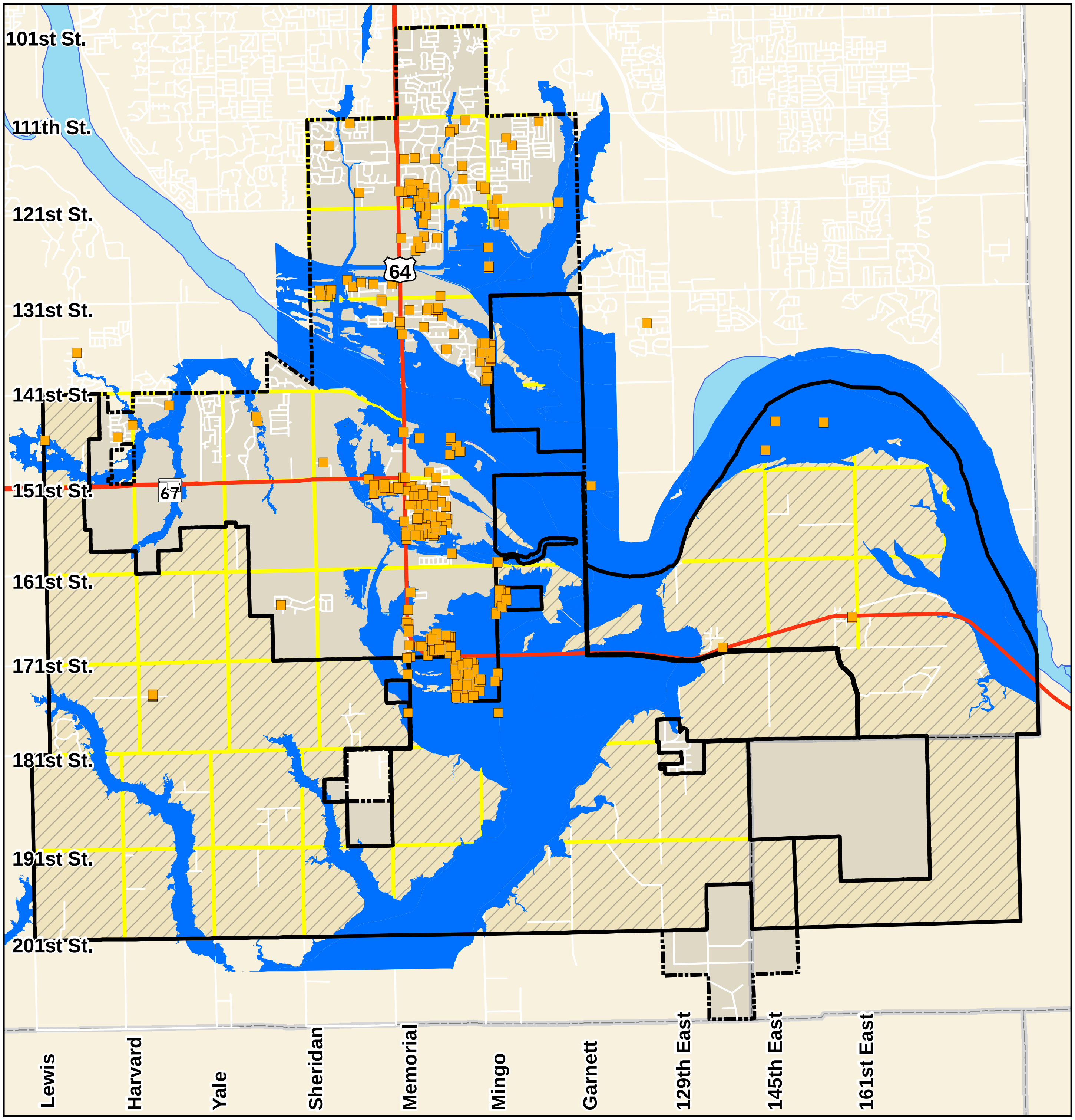
Table 2–1: City of Bixby Flood Insurance Policy Information as of 3/31/2010

Flood Insurance	Amount
Flood Insurance Policies in Force	452
Value of Insurance in Force	$67,987,800
Paid Premiums	$334,830
Number of Claims since 1978	238
Amount of Flood Losses Paid	$2,490,791

Community Rating System (CRS)

The CRS is a voluntary part of the National Flood Insurance Program that seeks to coordinate all flood-related activities, reduce flood losses, facilitate accurate insurance rating, and promote public 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 (from 10 to 1, with 1 being the best rating), with residents of the community who live within FEMA’s Special Flood Hazard Areas (SFHA) receiving a 5% reduction in flood insurance rates for every Class improvement in the community’s CRS rating. Bixby takes part in the following CRS activities:

- Public information activities;
- Mapping and regulatory activities;
- Flood damage reduction activities;
- Flood preparedness activities.



LEGEND

- NFIP Policies
- 100 yr. Floodplains
- Major Streets
- Highways
- City Limits
- Fenceline

1 inch equals 8,375 feet

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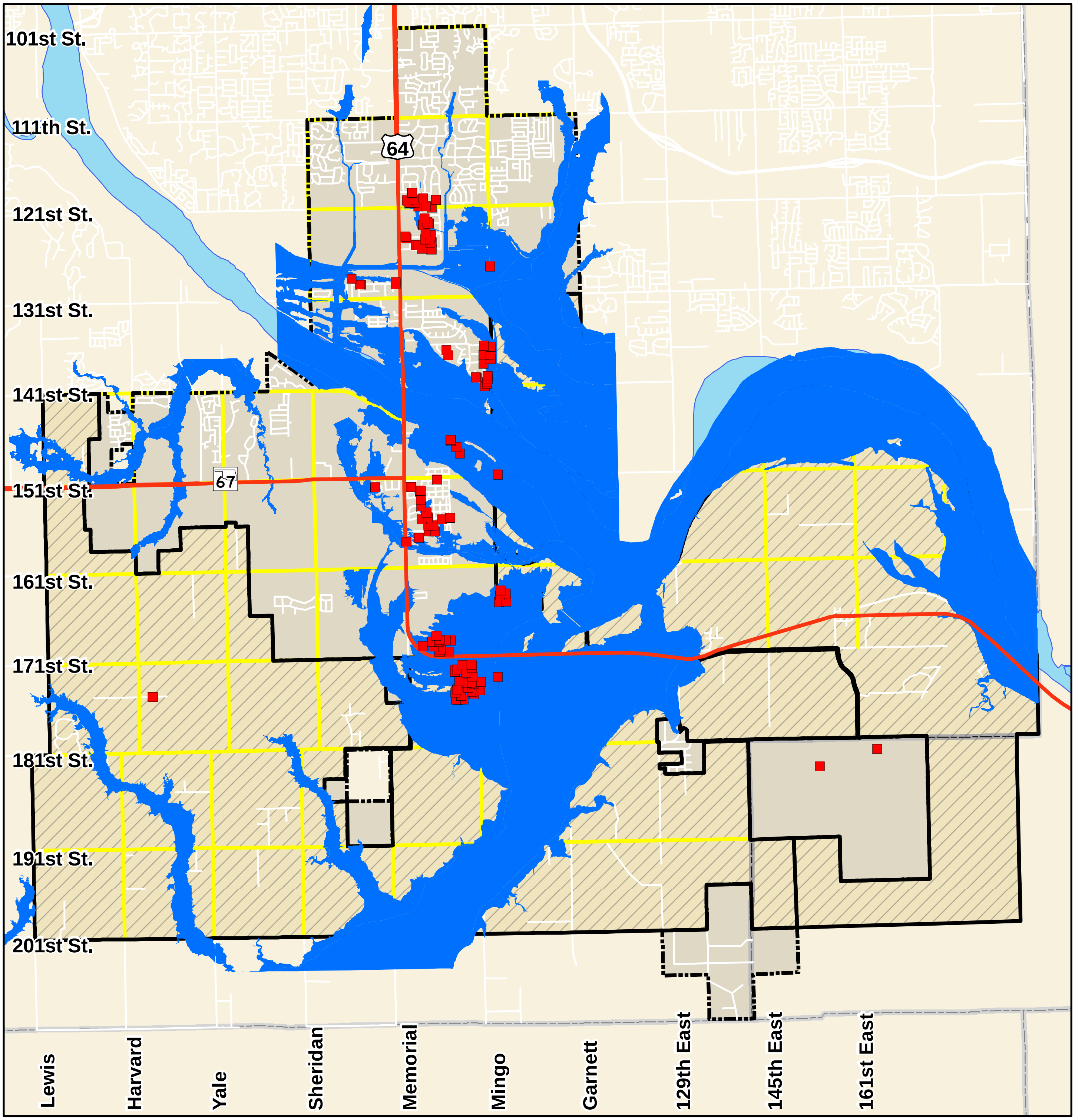
SEAL OF THE CITY OF BIXBY 1906 GARDEN SPOT OF OKLAHOMA

Figure 2-1

City of Bixby

NFIP Policies



LEGEND

- NFIP Claims
- 100 yr. Floodplains
- Major Streets
- Highways
- City Limits
- Fenceline

1 inch equals 8,375 feet

Figure 2-2

City of Bixby

NFIP Claims

Bixby entered the CRS program on October 1, 1993. As of October 1, 1998, Bixby's CRS Rating was a 10. The City's status in the program is listed as "rescinded" as of 12/31/2008. All rates are based on where the structure is located in FEMA's Flood Insurance Rate Maps (FIRMs). FIRMs from the previous plan were published April 2003, and new Digital Maps (DFIRMs) have been released and adopted by the City Council on July 27, 2009. The adoption was effective immediately and the new DFIRMs went into effect August 3, 2009 per FEMA and Ord. 2019.

Bixby has had 238 flood insurance policy claims totaling $2,490,790.54 (as of 3/31/2010) and 74 post-FIRM policy claims totaling $1,259,747 since 1978.

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. Under the program, a specialist from Firewise Communities USA works with the local community to assess wildfire dangers and create a plan that identifies agreed-upon, achievable solutions to be implemented. For additional information on Firewise Communities, see Chapter 5, Section 5.2.9 or visit www.firewise.org/usa/. Bixby does not participate in the Firewise Community program.

2.1.3 Fire Protection Rating

ISO's Public Protection Classification (PPC) program provides important information about municipal fire-protection services, which, in the past, has been used by insurance companies to establish fire insurance premiums. Currently most fire insurance rates are determined by actual loss figures and history within specific zip codes. The PPC program does help communities plan for, budget, and justify improvements in order to mitigate the effects of the fire hazard.

A uniform set of criteria 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. These criteria incorporate nationally-recognized standards developed by the National Fire Protection Association and the American Water Works Association. The evaluation inventories and analyzes the following 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.

City of Bixby Fire Protection Rating

Bixby has a fire insurance rating of 5.

2.1.4 StormReady Community

StormReady is a nationwide community preparedness program that began in Tulsa in 1999, and 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 http://www.stormready.noaa.gov/.

Bixby is currently evaluating their emergency management program and policies in order to receive this accreditation in the future.

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 city's tax base and revenue. In 1993, a tornado struck in the area of Catoosa, OK, destroying a number of residences and a major truck stop on Interstate 44. The truck stop, and associated traffic and personnel it attracted, supported restaurants, clothing stores, motels, and numerous 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 2002 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.

A great deal of the mitigation information in this document is applicable to residential, public, and commercial properties. When available, the plan will include business-specific information and strategies. For further discussion on business vulnerability and the importance of Business Continuity Planning (BCP), see Chapter 5, Section 5.2.9.

The City of Bixby is served by the Disaster Resistant Business Council (DRBC), a coalition of a number of groups, including the Tulsa Metro Chamber, Red Cross, Flanagan & Associates, LLC, Family & Children's Services, the Oklahoma Department of Insurance, the Tulsa Health Department, State Farm Insurance, and others. The DRBC is a program of Tulsa Partners Inc., and has worked since 2004 to promote and support business continuity planning with small businesses, long term care facilities, hospitals, and non-profit agencies. For more information, see www.tulsapartners.org/DRBC.

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 and around Bixby, and the programs and activities that the City currently has in place to serve this purpose. See Chapter 6 and Appendix B for discussions of potential activities and programs within this category.

2.2.1 Public Information Infrastructure

Television/Radio

Cable television is supplied by BTC Broadband. Bixby is served by the following TV stations:

Table 2–2: Bixby Area Television Stations

Channel	Call sign	Network	Owner
2	KJRH-TV	NBC	E.W. Scripps Company
6	KOTV-TV	CBS	Griffin Communications
8	KTUL-TV	ABC	Allbritton Communications Company
11	KOED-TV	PBS	Oklahoma Educational Television Authority
19	KQCW-TV	The CW	Griffin Communications
23	KOKI-TV	FOX	Clear Channel
35	KRSC-TV	Educational	Rogers State University
41	KMYT-TV	MyNetworkTV	Clear Channel
44	KTPX-TV	ION Television	ION Media Networks
47	KWHB-TV	Religious	LeSea Broadcasting
51	KXAP-TV	Hispanic	Perez Broadcasting
53	KGEB-TV	Religious	Oral Roberts University

Bixby is also served by 11 AM radio stations and 19 FM stations.**Telephone, Wireless and Cable Service**

Bixby has an advanced telecommunications infrastructure provided by BTC Broadband. In addition, there are a number of cellular and private telecom providers. BTC Broadband also provides VOIP telephone service in the area.

Newspapers

Daily area newspaper service is provided to Bixby by the *Tulsa World.* In addition, the *Bixby Bulletin* covers local news and is published once a week on Thursdays. Also providing area coverage is an African American community newspaper, *The Oklahoma Eagle,* a Hispanic community newspaper, *Hispano de Tulsa*, and an American Indian newspaper, *Native American Times.*

2.2.2 Outreach Programs

Outreach Programs, as the name implies, are designed to inform the community about natural hazards and measures that can be taken to protect against them. Bixby has outreach programs through the Bixby Fire Department, City of Bixby Public Works, American Red Cross, Tulsa Area Emergency Management and a number of other organizations. The City also maintains a comprehensive Internet web site that posts local ordinances, agency contact information, and meeting agendas.

Bixby City government has a close relationship with the area newspaper, the *Tulsa World,* which serves as a reliable outlet for municipal news releases on hazard related issues. The *Tulsa World* provides coverage of City Council and Planning Commission meetings, and makes itself available for in-depth presentations and discussions of matters of local importance. The *Tulsa World* makes their articles available to the public via the Internet, www.tulsaworld.com.

The City of Bixby has an outreach program for informing citizens about natural hazards, how to prevent or mitigate their impacts, and what resources the community has to assist in damage prevention, mitigation and recovery. For example, over the past five years the *Tulsa World* has carried articles on family preparedness, tornado mitigation, lightning safety, house and wildfire mitigation, flooding, storm drainage, floodplain regulations, dam safety, the City's EOC, storm sirens, the Red Cross, amateur radio operators, storm spotters, and hazard mitigation planning.

Other local outreach efforts include:

- The Emergency Operations Center (EOC) and the National Weather Service Tulsa Forecasting Office offers presentations to groups interested in storm preparedness.
- Bixby's Mayor issues a declaration supporting September as being National Preparedness Month.
- The National Weather Service and local ham radio groups offer classes for future storm spotters.
- Bixby Fire Department has an active Public Education component.
- The Governor declared April to be McReady Oklahoma Family Preparedness Month and Bixby participated in the state-wide "McReady" program, distributing disaster safety literature at kiosks in McDonald's restaurants and at City facilities.
- Tulsa Partners provides a number of outreach programs in the area including, but not limited to:
    - An annual conference on *Emergency Preparedness for Long Term Care Facilities*;
    - The Disaster Resistant Business Council provides opportunities for businesses to develop business continuity plans.

City of Bixby Radio/TV Programs/Communications

Tulsa County's and Bixby's Emergency Manager has direct access to the cable television system and local radio to alert citizens of emergencies.

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 the City of Bixby. See Chapter 6 and Appendix B for discussion of potential activities and programs within this category.

2.3.1 Planning and Zoning Ordinances

Bixby's Comprehensive Plan defines policies for providing guidance and direction of the city's physical development. It covers ordinances for land use, zoning and subdivision, and the development of standards for transportation and public facilities.

Private individuals who established the original town site did the earliest planning for Bixby. This pioneer settlement was followed with minimal development associated with the agricultural economy of the surrounding area and the development of the railroad. Formalized community planning efforts were initiated in the early 1970's in conjunction with growing development pressures. This resulted in the preparation and adoption of subdivision and zoning regulations in the mid-1970's and the *Comprehensive Plan* in the summer of 1976. Additional development and planned highway improvements resulted in the preparation and adoption of an amendment to the Plan for the Memorial Drive corridor (the area north of the Arkansas River on both sides of Memorial Drive) in the summer of 1980.

The City of Bixby continued its ongoing attention to development and planning with the addition of planning staff through a cooperative agreement with the Indian Nations Council of Governments. Revisions and updates to the City's development codes and design standards have been made by the Bixby Planning Commission and planning staff. Proposed highway improvements and new area development significantly impacting Bixby resulted in the update to the Plan in 1991. Continuing growth pressure resulted in an extended study process by the City of Bixby, which has included review of study findings and recommendations by Bixby citizens, Plan update study committees, municipal staff, Bixby Park Board, Bixby Planning Commission and Bixby City Council, and preparation of a 2001 update to the *Bixby Comprehensive Plan*.

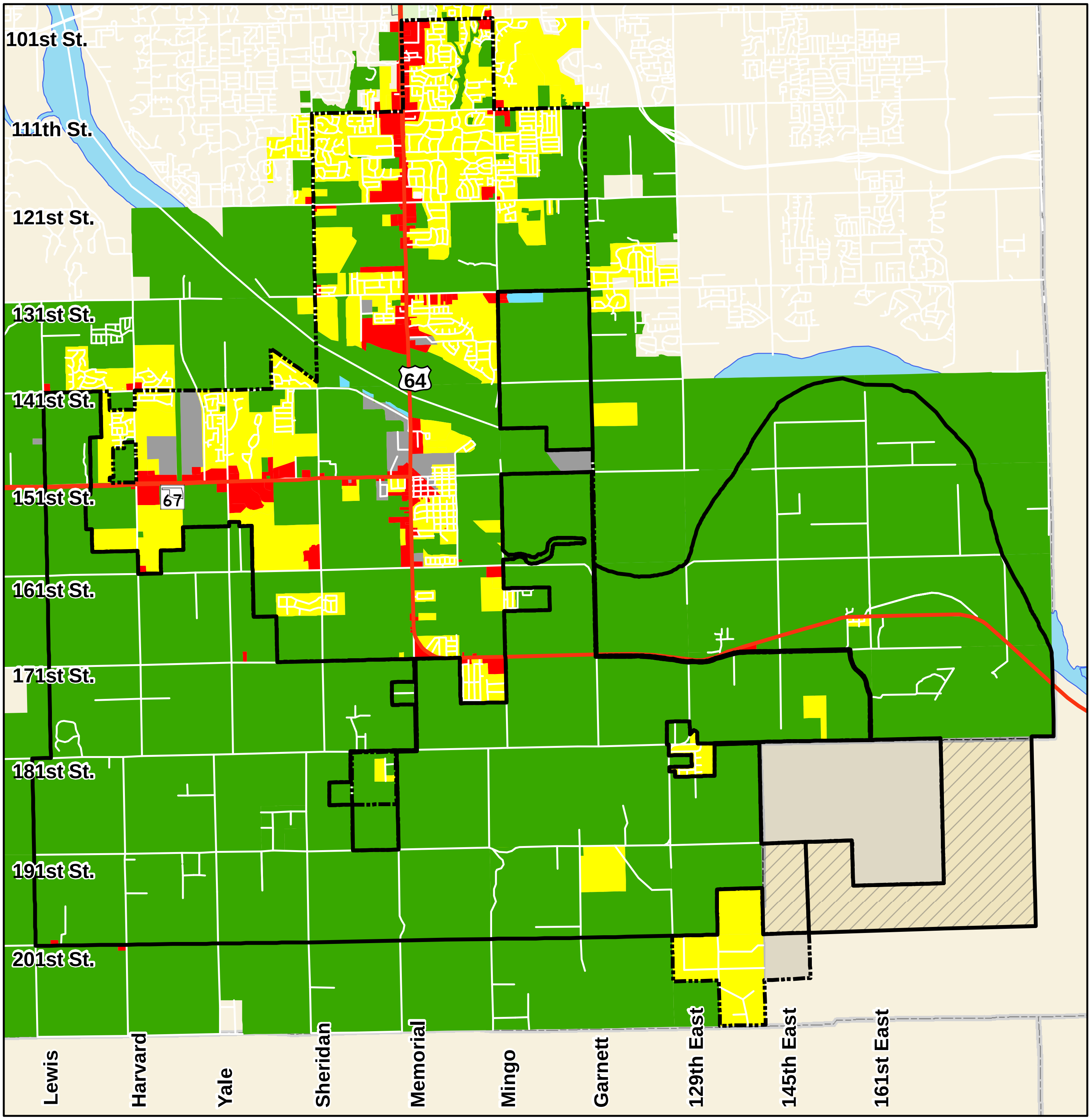


Figure 2-3

City of Bixby

Zoning

2.3.2 Flood and Stormwater Management

As a result of Bixby voters allocating monies for flood mitigation efforts, in 2001 the City allocated $42 Million in funds over two years for:

- Improvements to the Fry Creek Tributaries
- The Saker/Southtown Drainage Project
- The Bixby Creek Drainage Project
- The Downtown Drainage Project
- The 94th Street and 111th Street Project
- The Detention Facility at 111th
- The Fry Creek Corps of Engineers Drainage Project
- The Property Acquisition Previously-flooded Homes Project
- The Bentley Park and Drainage Property Acquisition Project
- Other miscellaneous water projects

A Bixby drainage ordinance requires a permit any time earth is moved in even limited amounts for landscaping. The earth change permits are reviewed by the City Engineer. The Sub Division Regulations will not allow a subdivision to be developed in the 1% floodplain and also requires an engineering design by a registered engineer to develop commercial or residential (more than one dwelling) properties in the city. The Flood Ordinance requires: 1) all new structures in the 1% floodplain to be elevated one foot above base flood elevation including electrical and mechanical, 2) elevation certificates for the lowest habitable floor, and 3) in most cases flow through foundations. Storm water discharges are reviewed in the light of adverse impact, and the design of systems requires evaluation of the entire drainage basin.

2.3.3 Building Codes

Bixby has adopted the following Building Codes (current as of 5/19/2010):

- International Building Code, 2003 Edition
- National Fire Prevention Code, 2003 Edition
- International Residential Code, 2003 Edition (excluding chapters 33-42)
- International Plumbing Code, 2003 Edition (excluding article 312.9)
- International Fuel and Gas Code, 2003 Edition
- International Mechanical Code, 2003 Edition
- International Property Maintenance Code, 2003 Edition
- International Private Sewage Disposal Code, 2003 Edition
- National Electrical Code, 2005 Edition

2.4 Structural Projects

Structural projects are usually designed by engineers and architects, constructed by the public sector, and maintained and managed by governmental entities. They typically 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 included in current planning. See Chapter 6 and Appendix B for discussion of potential activities and programs within this category.

2.4.1 City of Bixby Capital Improvements Plans

The City of Bixby's Capital Improvements Plan lists approved street, building, water, sewer, and stormwater capital improvement needs, their costs, priority, and 5-year funding schedule. Capital improvements projects identified for hazard mitigation purposes include projects for floods, tornadoes, high winds, and drought.

Some of the more significant projects either ongoing or planned are:

- FEMA Downtown Project and the Bixby Creek Project will channel water safely away lower-lying areas of the city. Part of a $4 million FEMA grant was used to buy about 30 residential properties near the downtown that will be removed and replaced with small detention ponds connected to the Bixby Creek drainage channel.

2.5 Property Protection

Property protection measures are used to modify buildings or property that are 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. The following section includes examples of property protection measures which have already been implemented within the City of Bixby or which are part of current projects. See Chapter 6 and Appendix B for discussion of potential activities and programs within this category.

2.5.1 City of Bixby Property Protection

Expansive Soils: Bixby typically runs a soils report before beginning any City construction. Building elevation and meeting current 2006 IBC codes that highlight safety concerns are two other areas that are considered part of the normal business process.

Expansive Soils/Extreme Heat: For the last 25 years, water and sewer lines have been bedded in sand or gravel to reduce the risk from line breakage due to expansive soils and increased water usage during extreme heat. This is more of a problem with older pipelines, and breaks from increased demand are more common than breaks from soil movement.

Hail: Providing hail resistant roofing is considered when the project budget can accommodate the added cost. Flood proofing, SafeRooms and lightning protection are typically considered on a site-by-site basis based on the critical nature of the facility.

Lightning: Critical facilities such as telecommunications and water treatment plants have lightning protection. All critical, individual City computers have surge protection, but not robust enough to protect against a significant lightning strike and lightning protection is not typically included in the design of new facilities unless there is considerable or sensitive electronics and computer equipment.

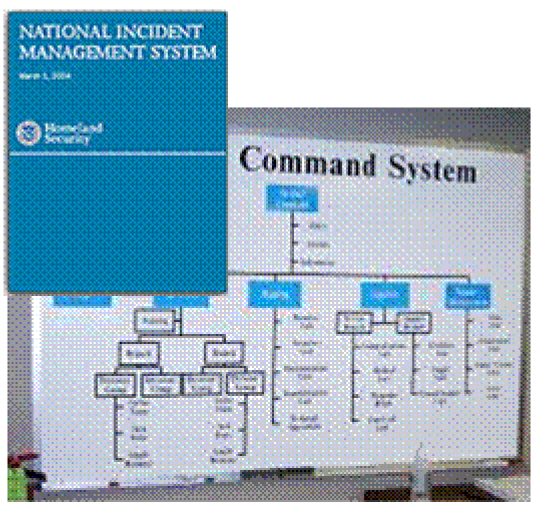
2.6 Emergency Response Procedures and Resources

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 Bixby's current emergency response procedures, notification and warning systems, critical facility protection and available emergency response resources. See Chapter 6 and Appendix B for discussion of potential activities and programs within this category.

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.

The NIMS incorporates a system currently used called Incident Command System (ICS), a management system developed by the fire service 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 to a major tornado event. ICS also allows for "unified command" for situations where multiple agencies may be in charge of various aspects of the operation



A typical Emergency Operations Center ICS Assignment Board

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

For further information on integrating NIMS/ICS into an Emergency Operations Plan, see the NIMS Integration Center at <u>www.fema.gov/emergency/nims/nims.shtm</u>. 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 <u>www.fema.gov/pdf/emergency/nims/eop-sop_local_online.pdf</u>.

For a jurisdiction to be "NIMS Compliant," the following conditions must be met:

1. NIMS must be incorporated into existing training programs and exercises. Training will include, but not be limited to, completing FEMA course IS 700, *National Incident Management System, an Introduction.* The course is available on the FEMA website at <u>training.fema.gov/EMIWeb/IS/is700.asp</u>.

2. The jurisdiction must formally recognize NIMS and adopt NIMS principles and policies. State, territorial, tribal, and local entities should establish legislation, executive orders, resolutions or ordinances to formally adopt NIMS.

3. A baseline must be established by determining which NIMS requirements the jurisdiction already meets. As gaps in compliance with NIMS are identified, entities should use existing initiatives such as the Office for Domestic Preparedness (ODP) Homeland Security grant programs to develop strategies for addressing those gaps.
4. The concepts of NIMS must be incorporated into the Emergency Operations Plan (EOP).
5. A timeframe for fully implementing NIMS must be established.
6. As of FY 2007, Federal preparedness assistance became dependent upon the entity being fully NIMS compliant.

The City of Bixby and Tulsa County have met all the preceding conditions and are both fully NIMS compliant.

2.6.2 Emergency Operation Plan

Bixby Emergency Management has established emergency operations and procedures. The Emergency Management Office participates in the National Weather Service accredited program *StormReady*. Requirements for the program include an established warning point and 24-hour functioning emergency operations center, 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. The Bixby Emergency Management Office has provided advanced training to 10 volunteer Storm Spotters who are capable of providing accurate warning information from the field as well as supporting damage assessments in the aftermath of an emergency. Live NexRad radar and measurements including rainfall, wind speed/direction and temperature are provided in real time in the Emergency Operations office by the Oklahoma's First-response Information Resource System using Telecommunications (OKFIRST). This system provides uninterrupted access to NexRad radar specifically for the Bixby area and is used in collaboration with storm spotters and community warning systems.

2.6.3 Emergency Operations Center

Bixby's Emergency Operations Center

The Emergency Operations Center (EOC), located in City Hall, may be activated by the Police Chief, Police Captain or the Supervisor on duty when it appears that any portion of Bixby is, or may be, threatened with loss of life or extensive property damage.

During major emergencies, Bixby's City government will be moved to the EOC. Bixby, at this time, has no backup EOC. The establishment and operation of the EOC is covered in detail in Bixby's *Emergency Operations Plan*.

The Emergency Management Director (EMD) is responsible for coordinating all phases of the emergency management program, including emergency planning and training, education and warning, and communications. The EMD makes routine decisions and advises the Policy Group on alternatives when major decisions are required of that body as per the current Policies and Procedures Manual. During emergencies, the EMD is responsible for the proper functioning of the EOC and its staff and acts as liaison with other local, county, state, and federal emergency management agencies.

The EOC has three stages of operation: Normal Peacetime Readiness, Increased Readiness, and Emergency Period.

- **Normal Peacetime Readiness.** Ensure the 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 officials and departments.
- **Increased Readiness.** Policy Group is advised of emergency measures; prepare EOC for activation; review EOC procedures and brief EOC staff; obtain necessary supplies; test internal and external communications; coordinate feeding of EOC staff.
- **Emergency Period.** Sound warning system; activate EOC; establish security; establish internal and external communications; move essential City functions to EOC.

The EOC is equipped with a communications center with all necessary communications equipment, including the 911 system, storm computer system, siren controls, outdoor warning systems, backup radio systems and Computer Aided Dispatch systems. An emergency generator with fuel for a substantial period is available. During an emergency, the EOC operates on a two-shift, around the clock basis. An incident command post may be set up to coordinate activities at the site of a disaster. When necessary, offices and equipment at City Hall are available to support emergency operations.

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

The City of Bixby and the EOC keep an index of citizen storm shelters, so that in the aftermath of a disaster that spreads debris over shelters, emergency rescue teams will know where to begin looking for survivors.

2.6.4 Emergency Notification and Warning Systems

Warning systems may be activated from any level of government by agencies having responsibility to notify the public of imminent danger. At the local level these warnings are channeled through the Emergency Management Director in order to assign responsibility and ensure control of the warning process.

Bixby 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.

Table 2–3: EAS stations in or near Bixby

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
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					
BTC Broadband (Local television override is available)					

Emergency warnings are received and disseminated through the National Warning System (NAWAS). NAWAS is a protected, full time, voice communication system interconnecting the National Warning Center and numerous warning points in each state. Oklahoma has one primary state warning point, 2 alternate state warning points, and 30 secondary warning points. The primary point is at Oklahoma Highway Patrol headquarters in Oklahoma City. Alternates are located in the Oklahoma Department of Emergency Management EOC and the National Guard EOC. The 30 secondary points are located in OHP district headquarters, sheriff/police departments, fire departments, and local EOCs throughout the state.

TAEMA is one of the in-state warning points for NAWAS. This system is answered in both the EOC and the Public Safety Response Center.

SkyWarn (Weather Spotters) is a national program designed to place personnel in the field to spot and track tornadoes. They are trained by NWS and instructed in what to report. Teams are made up of government employees and private citizens. During severe weather, storm spotters relay reports to their coordinator in the EOC. Confirmed tornado sightings are relayed to the NWS, which then disseminates appropriate warnings.

Notifications of severe weather or other serious hazards are relayed to the public through Bixby's siren warning system, mobile teams, and TV/Cable override, as authorized by the Mayor, Policy Group, Emergency Manager or Police or Fire Department personnel. Instructions to activate the warning system are channeled through the Emergency Management Director, if time permits, to fix a single point of responsibility for the warnings and ensure control.

Bixby's Emergency Management has installed NOAA weather radios at all public buildings and schools. The EOC has the capability of overriding local radio and television stations, including cable channels. The emergency warning messages are generic, alerting the public of the danger and advising what to do or where to get further information.

Members of Bixby's deaf and hard-of-hearing community are served by two state programs that can facilitate alerts and warnings:

- OK-WARN is the Oklahoma Weather Alert Remote Notification program for emergency weather/situation notification service via pagers and/or E-mail addresses. The hazardous weather pager program gives deaf and hard-of-hearing Oklahoman's better access to important severe weather information. The success of a pilot program in 2001 led to the creation of OK-WARN, which now provides life-saving messages about tornadoes, severe thunderstorms, winter storms, flash floods, river floods and high wind warnings from local National Weather Service offices to deaf and hard-of-hearing people who sign up for the service. There is no cost for qualified deaf and hard of hearing persons.
- The State Department of Rehabilitation Services can (a division of Oklahoma Department of Health) provide free NOAA weather radios specially adapted to the needs of the deaf and hard of hearing community with such accessories as strobes and bed shakers.

Flood Alert System

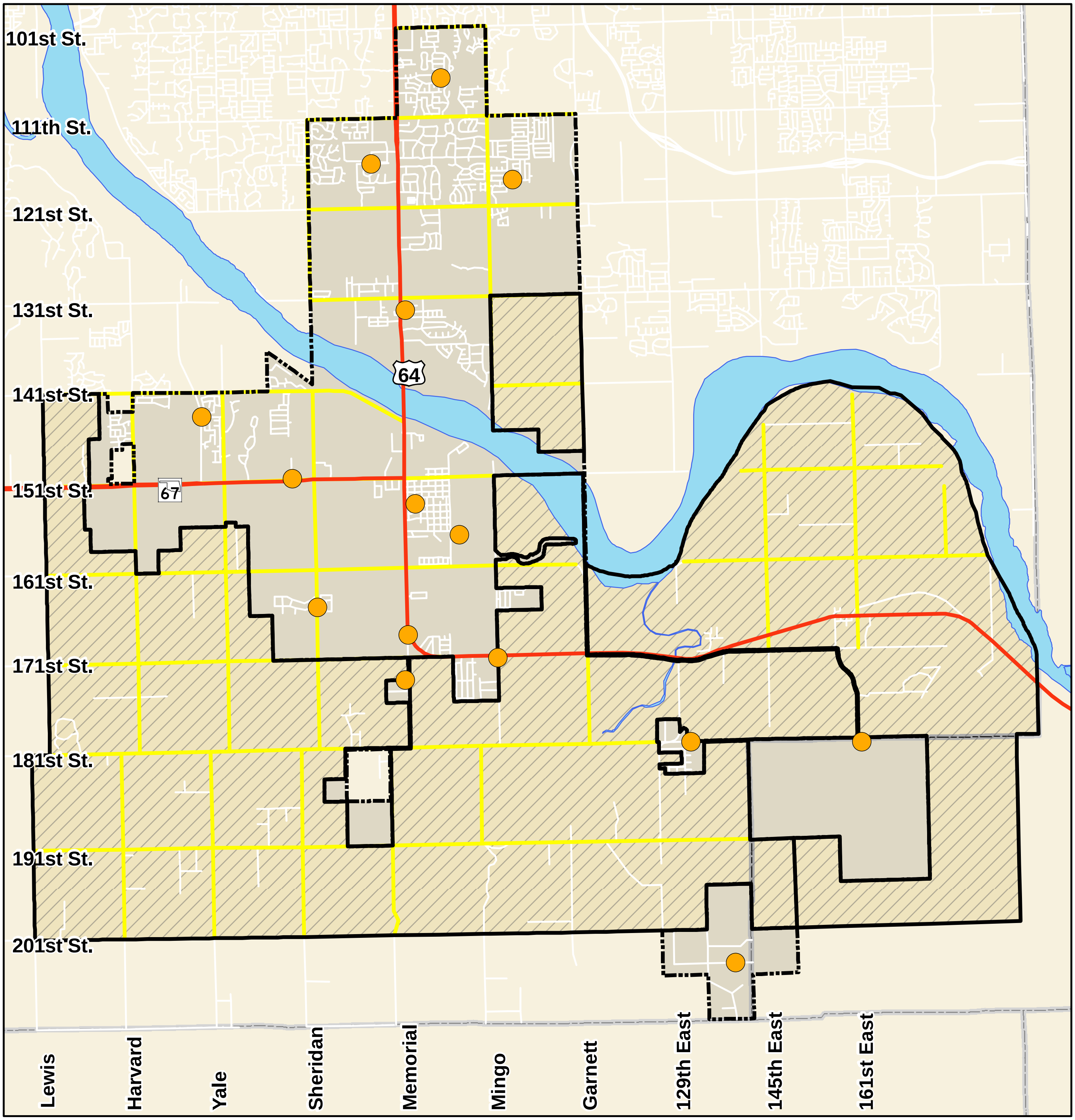
Bixby installed a flood alert system in 1984, with the help of FEMA and the National Weather Service. The system monitors rainfall and stream levels to provide advance warning of potential flooding. (SNP, 09-04-05)

Emergency Mass Notification Systems

Bixby is purchasing a Telephone-based Mass Notification System, commonly referred to as Reverse 911, in November, 2009.

Warning Sirens

The City of Bixby has 15 warning sirens strategically placed around the community. The sirens are computer controlled and radio activated with a battery backup system to ensure uninterrupted service in the event of a power failure. Silent tests are conducted weekly and a full-activated test is performed once a month on a regular scheduled basis. The system is capable of activating only select sirens or groups of sirens if only an isolated warning is needed. The City of Bixby's Warning Sirens are shown in Figure 2-4.



LEGEND

- Warning Sirens
- Highways
- Major Streets
- Water
- City Limits
- Fenceline

1 inch equals 8,375 feet

Flanagan & Associates, LLC
Planning Consultants

Figure 2-4

City of Bixby

Warning Sirens

The all clear is made over local radio stations and Cable Television and not over the warning sirens.

Table 2–4: Alert and Siren Signals

Type of Alert	Hazard	Siren Signal
Natural Disaster Alert	Tornado Warning	3-minute straight tone
Natural Disaster Alert	Flood Warning	3-minute slow high-low siren tone
Other Disaster Alerts	Nuclear Attack	3-minute wavering tone

2.6.5 Fire Safety Resources

Bixby Fire Department and Resources

The Fire Department, with headquarters located at 116 W. Needles, has two fire stations staffed by a minimum of 3 firefighters per shift per station, on a 24-hour basis. Several are trained at First Responder or Basic EMT level. Equipment includes five engines, a ladder truck, and three brush pumpers. The Department provides primary fire control and suppression for the City of Bixby.

The City of Bixby *Emergency Operations Plan* lists the emergency functions of the Fire Department as follows:

- Fire suppression
- Fire investigation
- Fire prevention and education
- Rescue operations
- Medical First Response
- Hazardous material operations
- Supporting the operation of the warning system
- Hazardous material decontamination
- Assisting in damage assessment
- Communication system support

Fire Department resources for fulfilling emergency functions are listed in Table 2-5.

Table 2–5: Fire Department Resources

Resource	Quantity	Resource	Quantity
Basic EMT	7	Staff Vehicle	3
Intermediate EMT	0	4-wheel-drive SUVs	3
Fire Stations	2	Squad Hazmat Truck	0
Pump Engine 1000+ GPM	5	Portable Generator	3
Brush Pumper	3	Portable Light System	3
Ladder Truck	1		

Bixby Fire Department has mutual aid agreements with all area Departments, and frequently assists with response in areas outside the Bixby City Limits.

The Bixby Fire Department (BFD) along with EMSA provides pre-hospital emergency medical service to the City of Bixby, with the number of emergency medical calls continuing to increase each year. All Department firefighters are cross-trained in rescue and emergency medical skills. The City's EMTs are licensed by the Oklahoma State Department of Health and certified by the National Registry of Emergency Medical Technicians.

2.6.6 Public Safety Resources

Bixby Police Department and Resources

The Police Department, located at City Hall, has over 40 employees, including 30 commissioned police officers.

The City of Bixby's *Emergency Operations Plan* lists the emergency functions of the Police Department as follows:

- Maintain law and order
- Traffic control
- Access control of restricted areas
- Security of vital facilities
- Operation of backup warning system
- Communication system support
- Liaison with other law enforcement agencies
- Search and rescue operation support

Bixby Police Department resources available for fulfilling emergency functions are listed in Table 2-6.

Table 2–6: Police Department Resources

Resource	*Quantity*	*Resource*	*Quantity*
Total Officers	25	Ford Expedition	1
Special Operations	5	Volunteers Reserve Officers	6
K-9 Units	1	In-car Radio	34
Squad Cars	33	In-car Computer	18
Portable Generators	1	Bull Horn	2

2.6.7 Public Works Department Resources

Bixby Public Works Department and Resources

Bixby's Public Works Department is located at various locations around the City. Under Bixby's *Emergency Operations Plan*, the Public Works Department has the following responsibilities:

- Debris clearance
- Maintaining roads and bridges
- Assisting with damage assessment of public property
- Assisting in decontamination operations

Bixby's Public Works Department resources available for fulfilling emergency functions are listed in Table 2-7.

Table 2–7: Public Works Department Resources

Resource	Quantity	Resource	Quantity
Total Employees	11	Pickup Trucks	8
Office Staff	1	4-Wheel Drive Vehicle	1
Total Field Personnel	11	Portable Light systems	2
Hand-held Radios	2	Portable generators	2
Frontend Loaders	3		

2.6.8 Tulsa County Sheriff's Department Resources

The Tulsa County Sheriff's Department is located at 303 W. 1st St. in Tulsa. Under Tulsa's *Emergency Operations Plan*, the Sheriff's Department has the following responsibilities:

- Coordinate all law enforcement in the County
- Disseminate warnings throughout the County
- Coordinate relocation traffic control
- Coordinate mutual aid agreements
- Support emergency public safety activities
- Provide for security, protection and relocation of inmates in the County Jail.

The Tulsa County Sheriff Department resources available for fulfilling emergency functions are listed in Table 2-8.

Table 2–8: Tulsa County Sheriff Department 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		

2.6.9 Other City, County, State and Federal Response

Bixby City Clerk is responsible for City administrative and fiscal duties.

Bixby City Attorney is responsible for legal and emergency information services and serves as a member of an advisory committee.

Superintendent of Bixby Schools is responsible for providing buses for transporting evacuees, and for MOUs with neighboring jurisdictions for use of buses for evacuation.

Tulsa Civil Air Patrol assists with search and rescue and crowd control.

Tulsa County office of the State Medical Examiner, when committed:

- Collects, identifies, and coordinates interment of deceased disaster victims
- Coordinates funeral home support activities

Tulsa Health Department, when committed:

- Investigates sanitation conditions and establishes 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

Tulsa County Office 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 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
- Provides chemical, biological, and radiological detection services

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 Health Care Facilities and Shelters

Bixby has four major medical centers and numerous specialty hospitals and clinics available in the Tulsa County area.

Hillcrest Medical Center, located in mid-town Tulsa, is a 493-licensed-bed tertiary medical center. In addition to the primary care facility, Hillcrest has facilities in Women's Healthcare, Exercise and Lifestyle, a Chest Pain Center, emergency department and trauma, cardiology unit, and a premier burn care unit.

Hillcrest Medical Center

St. Francis Medical System is a not-for-profit Catholic healthcare organization made of Saint Francis Hospital, Saint Francis Hospital at Broken Arrow, Laureate Psychiatric Clinic and Hospital, Warren Clinic, The Children's Hospital at Saint Francis, and Saint Francis Heart Hospital. It has a staff of nearly 7,000 full and part-time employees.

St. John Health System is a not-for-profit Catholic healthcare system operates hospitals in Tulsa, Owasso, Sapulpa, and Bartlesville. Other subsidiaries of St. John Health System include OMNI Medical Group primary care physicians, St. John Physicians, Inc. multi-specialty group practice, St. John Urgent Care Centers, St. John Villas Senior Living Centers and medical complexes in South Tulsa and Claremore.

OSU Medical Center, located in downtown Tulsa, is the largest osteopathic teaching facility in the country, with 15 postgraduate programs that train 126 residents each year in both primary care and sub-specialty areas. OSU Medical Center provides numerous highly specialized services, including a telemedicine program serving 35 regional hospital and clinic partners in rural Oklahoma through the OSU Center for Health Sciences. Among the other services offered are cardiology care, adolescent, geriatric and psychiatric care, and comprehensive wound care.

In addition, the Tulsa Health Department has a branch office, the **Bixby Community Health Center**, at 1820 E. 126th Street, that provides services such as WIC and immunizations.

For locations of healthcare facilities in the community, see Figure 1-18.

2.6.11 Medical Response and Coordination

EMSA EMERGENCY MEDICAL SERVICES AUTHORITY

In the event of a multi-jurisdictional response, the Tulsa County Medical Coordinator is one of the Emergency Medical Services Authority (EMSA) Directors. He will operate in accordance with the Tulsa Metropolitan Medical Response System (MMRS). For a Bixby response, the Medical Director will be the Bixby Fire Chief or his designee.

The City/County Health Director is responsible for:

- Inspects food and water to ensure safe supplies of both.
- Investigates sanitary conditions of emergency shelters and disaster relief operations to protect the health and safety of occupants and workers.
- Controls insects and rodents and employs other environmental health measures to prevent epidemics and the spread of disease.
- Provides core public health services, such as immunization programs and other related medical services.
- Disseminates public health information concerning safety issues and hazards.
- Monitors the community health status and reports identified public health problems to appropriate agencies.
- Provides limited hazardous materials emergency response capability.
- Enforces laws and regulations to protect public health and ensure safety.

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

TULSA HEALTH DEPARTMENT
Reggie Ivey, Interim 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.

As of July 2008, Bixby is home to three long-term care facilities:

- Bixby Manor, LLC, 76 W. Rachel St.
- Autumn Park Retirement, 8401 E. 134th St. South
- Sand Plum Assisted Living, 9999 E. 121st St. South

During an emergency or disaster, medical service providers are responsible for emergency medical care for victims, health care, and crisis counseling.

In the case of a disaster requiring shelters, the Superintendent of Bixby Public Schools will assist with providing buses for transportation during disaster relief operations. The Tulsa Area Chapter of the American Red Cross will assist with shelter operation and support activities, supported by the Salvation Army, the County office of the Department of Human Services, and the Tulsa Medical Reserve Corps. Emergency shelters will be drawn from a mixture of public and private resources and utilized according to the following priority: public schools first, followed by churches, government buildings, colleges/universities, and private buildings.

Ambulance service is provided by the Emergency Medical Services Authority, with support from Bixby Fire Department. EMSA operates 30 ambulance units in its Eastern division with one basic EMT and one paramedic each, operating 24 hours a day, seven days a week staffed as needed by on-duty or off-duty personnel.

2.6.12 Volunteer and Community Support Organizations

- The **Tulsa Area Chapter of the American Red Cross** provides reception, care, food, lodging, and welfare assistance throughout northeastern Oklahoma; coordinates relief and shelter activities; and provides first aid support and blood supply, counseling, and damage assessment of private property.
- **Salvation Army** helps people in need of food, clothing, utilities, cleaning supplies, and life sustaining prescriptions. It also assists in finding missing persons and offers disaster services.
- The **United Way** provides assistance to Tulsa area non-profits for such things as emergency food, clothing, shelter, utility bill assistance, counseling, literacy, advocacy and legal assistance.
- **Tulsa Community Action Program** (CAP) provides homeless services, including both emergency and transitional housing. Emergency shelter is offered to those with no resources who are in immediate need of shelter.
- **The Language & Culture Bank** is a group of people with identified proficiencies in cultural and language skills. The L&CB will support emergency response agencies during a disaster, whether single-family or catastrophic, in working with members of various cultural groups. It includes such groups as the Hispanic Chamber of Commerce, the YWCA Multi-Cultural Center, the TCC Language Center, Communication Services for the Deaf, the Jewish Federation, the Russian Golothic Church, the Islamic Foundation, and others.
- The Tulsa Red Cross maintains the **Community Emergency Response Team** (CERT) program. CERT volunteers are available to assist first responders (police, firefighters and EMS) during emergencies. CERT teams also assist in mitigation activities, including public awareness programs and other non-structural community mitigation measures. Additional information on CERT is included in Chapter 5, and is available on the Internet at www.citizencorps.gov/cert/.
- The **Tulsa Medical Reserve Corps** is a Citizen Corps program that provides licensed medical professionals (frequently retired) plus support staff for emergencies. The Tulsa group currently has over 1,000 volunteers, with 60% of them being licensed professionals. They are coordinated out of the Tulsa Health Department.
- The **Tulsa Human Response Coalition** is a collaboration of mental health and social service agencies, many of them faith based, culturally based, or otherwise "non-traditional" in the disaster realm, such as the National Guard Family Support

Group. THRC can call upon its partners for a coordinated response to support other agencies in the area of mental health, social services, and cultural and religious support.

- The **Tulsa Amateur Radio Club** and **Tulsa Repeater Organization** provide emergency communications, storm spotting and damage assessments.
- **Tulsa Partners Inc**. is a Tulsa-based 501(c)3 organization that coordinates multiple programs, including the Disaster Resistant Business Council (see Section 2.1.5) and programs to provide preparedness and business continuity support to childcare centers, long term care facilities, and hospitals. They also assisted Tulsa Area Emergency Management Agency with developing an Emergency Operations Plan Annex for childcare facilities.

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. This section reviews the natural resource protection activities that have already been implemented in the community or are already in the planning stages. See Chapter 6 and Appendix B for discussion of potential activities and programs within this category.

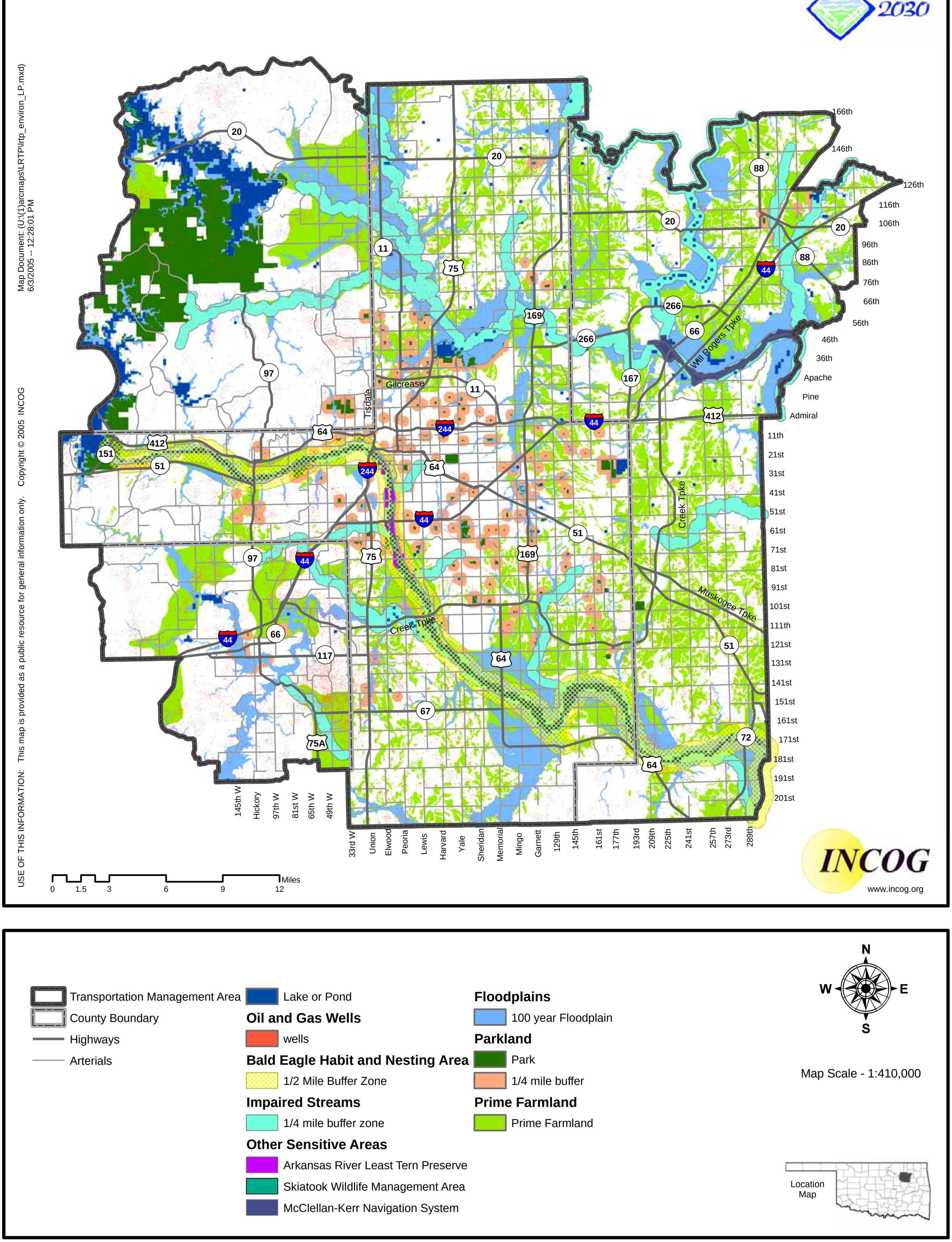
2.7.1 City of Bixby Resource Protection

Bixby maintains certain policies in place to address Natural Resource Protection. Erosion and Sediment Control are covered in City development regulations and as required by EPA and the Oklahoma Department of Environmental Quality. Floodplain Regulations and Earth Change Permit standards require adequate modeling and engineering of any regulated activities that would affect major and minor stream corridors.

2.7.2 Environmentally Sensitive Areas

The following map, Figure 2-5, by the Indian Nations Council of Governments, identifies areas such as wildlife preserve or nesting areas, parkland, prime farmland, and other areas that should be included in the planning for development of certain mitigation activities such as flood control projects or other structural projects.

Environmentally Sensitive Areas

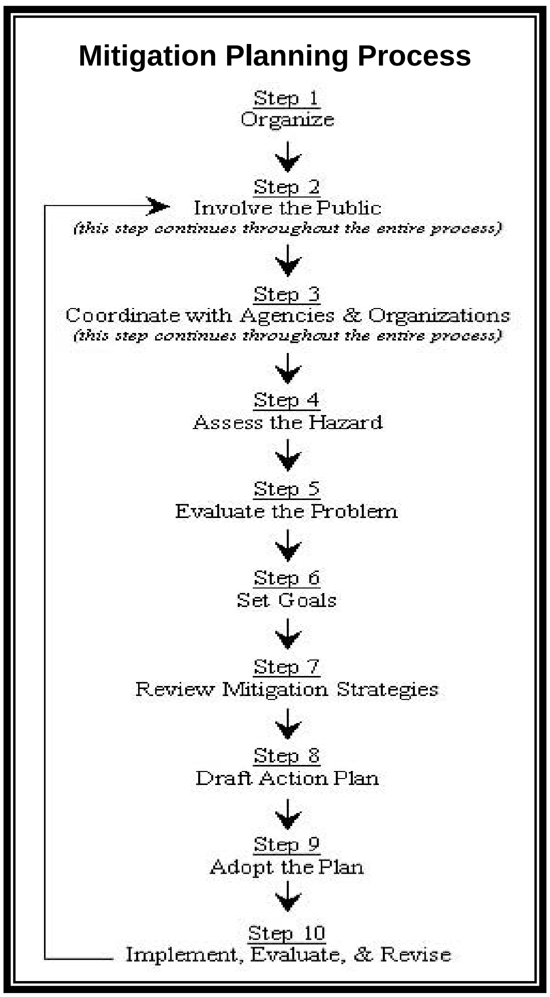


Chapter 3:
The Planning Process

Included in this Chapter:

The City of Bixby and Bixby Public Schools Multi-Jurisdictional Multi-Hazard Mitigation Plan is an effort to direct the multi-hazard planning, development, and mitigation activities of the City of Bixby and Bixby Public Schools. The City of Bixby is 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.



This plan addresses the following hazards:

- Floods
- Tornadoes
- High Winds
- Lightning
- Hailstorms
- Severe Winter Storms
- Transportation Incidents
- Extreme Heat
- Drought
- Expansive Soils
- Wildfires
- Earthquakes
- Dam/Levee Failures
- Fixed-Site Hazardous Materials Incidents
- Urban (Structure) Fires

The planning for this plan 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 are described on the following pages.

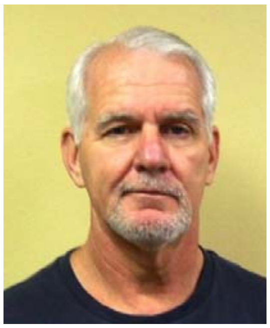
3.1 Step One: Organize to Prepare the Plan

(Oct. 2008 – Dec. 2008)
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 City Council of Bixby. The resolution designated the Bixby Planning Committee to serve as the Bixby Citizens' Advisory Committee (BCAC) to oversee the planning effort.

City of Bixby Citizens' Advisory Committee

The **BCAC** consists of the following members:



Thomas Holland
Bixby Planning Commission

Associates Degree in Fire Technology from Tulsa Community College;
Executive Fire Officer Graduate from the National Fire Academy;
Bixby Planning Commission, Chair;
Retired District Chief from the Tulsa Fire Department;
FEMA Hazard Mitigation.

Jim Powell
Bixby Planning Commission

Williams Companies – retired;
Bixby Planning Commission, Vice-Chair;
Board of Adjustments – Past Member

Steve Sutton
Bixby Planning Commission

BA in Communications from the University or Kentucky;
Vice President, Public Sector Advisory Services, Spirit Bank;
Bixby Planning Commission, Commissioner;
Bixby Fire Department, Volunteer Firefighter;
Bixby City PTA, Vice President;
Tulsa Sports Commission, Board Member; Bixby Rotary Club Member.

Lance Whisman
Bixby Planning Commission
Senior Environmental Specialist
BS in Environmental Health Science (Environmental Management)
Registration/Certification: OSHA/EPA;
HAZWOPER training – 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2004;
Department of Transportation training;
Oklahoma/AHERA Asbestos Managmenet Planner License – 2002, 2002;
Oklahoma/AHERA Asbestos Inspector License 1999, 2000, 2001, 2002.

Larry Whiteley
Bixby Planning Commission

Member, City Planning Commission.

Michael Wisner
Bixby Planning Commission

BS in Criminal Justice;
BS in Pre-Law;
BS in Political Science;
Muscogee Creek Nation – CEO;
SAME – Member;
USMC – Major, Egr Officer

Supporting the BCAC is the Bixby Technical Advisory Committee (BTAC), which includes representatives of departments that have roles in multi-hazard planning, response, protection, and mitigation. Most of the detail work was done by management teams consisting of the following:

City of Bixby Technical Advisory Committee

Erik Enyart, CFM, AICP
Bixby City Planner, Project Manager

BS in Community and Regional Planning from Missouri State University;
MS (pending, June 2010) in Architecture from the University of Oklahoma;
Certified Floodplain Manager, Accredited with the American Institute of Certified Planners

Bea Aamodt
Director, Bixby Public Works

BS in Civil Engineering from Clarkson University;
Rotary Club Member.

Steve Abel
Bixby Fire Department

Fire Chief.

Kaylin Coody
Assoc. Superintendent, Bixby Public Schools

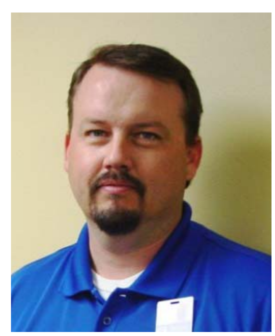
BA in Speech Pathology from the University of Oklahoma;
MA in Speech Pathology from Tulsa University;
EdD in Educational Leadership from Oklahoma State University;
Bixby Public Schools Crisis Response Team – Administrative Leader.

Jared Cottle
Bixby City Engineer

BS in Civil and Environmental Engineering from Cornell University;
ASCE – Tulsa Chapter;
ASCE HEC-RAS Training;
FEMA Funding for 2007 Ice Storm;
NRCS Funding for Erosion Projects.

Gabe Hayes
Safety Director, Bixby Public Schools

BS in Criminal Justice from Northeastern State University;
Oklahoma Association of Pupil Transportation, Past Board Member;
Emergency Preparedness for Schools Certification from Okla. Emergency Mgmt;
Hazard Assessment Training from Oklahoma Dept. of Homeland Security;
Developed Emergency Response Plans for Bixby Schools.



Duffy McAnallen
EMSA, Director of Operations

Associates degree – Paramedic;
Tulsa County Sheriff's Office, Reserve Deputy;
Oklahoma EMT Association, Board of Directors;
DHS Region 7, EMS Representative;
Certified All NIMS Levels 100-800.

Ike Shirley
Chief, Bixby Police Department
Bixby Emergency Manager

BS in Management from the University of Central Oklahoma;
MS in Criminal Justice from the University of Central Oklahoma;
FBINA, Member;
Oklahoma Association of Chiefs of Police, Member;
International Association of Chiefs of Police, Member.

Jim Sweeden
Fire Marshall, Bixby Fire Department

Fire Service from Oklahoma State University
Experience in Arson Investigation, Fire Service, Fire Marshal,
Building Inspection, Plan Reviews, Final Construction Inspection.

Mike Webster
City of Bixby

Assistant City Manager.

The BTAC met periodically during the year's planning process. BTAC members also attended all meetings of the BCAC and meetings with elected officials.

Consultant:

Ronald D. Flanagan, CFM
Principal Planner

Flanagan & Associates, LLC
Planning Consultants
2745 E. Skelly Dr., Suite. 100
Tulsa OK 74105

Other entities involved in the development of the Mitigation Plan included:

Tulsa Partners, Inc

TP is a Tulsa-based non-profit that has been working since 1998 to develop public / private / non-profit collaborations to help create a disaster-resistant and sustainable community and improve the Community's safety and well-being by reducing deaths, injuries, property damage, environmental and other losses from natural or technological hazards. Tulsa Partners provides expertise in the areas of community education and public involvement in the planning process.

The BCAC met monthly at City Hall and the BTAC met weekly or bi-weekly at Bixby City Hall during the planning process to review progress, identify issues, receive task assignments, and advise the consultants. A list of BCAC, BTAC, and public meetings and dates is shown in Table 3-1, below. Refer to Appendix C for meeting agendas.

Table 3–1: Bixby Hazard Mitigation Committee Meetings and Activities

Date	***Activity***
July 30, 2008	FEMA Obligation Date: City of Bixby and Bixby Public Schools Multi-Jurisdictional Multi-Hazard mitigation Plan Update.
Oct. 1, 2008	Project Start Date
Oct. 13, 2008	Initial meeting between Emergency Manager, Police Chief Shirley, Project Manager Erik Enyart, and Consultants; Discuss proposed Planning Process.
Oct. 27, 2008	Presentation of Hazard Mitigation Plan Proposal and Contract to Bixby City Council.
Oct. 28, 2008	Contract with Flanagan & Assoc., to assist in preparation of Bixby & Bixby Public Schools Multi-Hazard Mitigation Plan Update.
Nov. 7, 2008	Initial City of Bixby Multi-Hazard Mitigation Plan Update Technical Advisory Committee (TAC) and Citizens Advisory Committee (CAC) Introductory meeting.
Nov. 20, 2008	Meeting of TAC and CAC; Presentation, review, discussion of Urban Fires and Wildfires; Goals and Objectives; Existing Mitigation Measures, Potential additional Mitigation Measures, Hazard Priority Matrix.

Date	Activity
Dec. 18, 2008	Meeting of TAC and CAC; Presentation, review, discussion of Severe Winter Storms; Goals and Objectives; Existing Mitigation Measures, Potential additional Mitigation Measures, Hazard Priority Matrix.
Jan. 8, 2009	Meeting of TAC and CAC; Presentation, review, discussion of Hazardous Materials Events, and Transportation Hazards; Goals and Objectives; Existing Mitigation Measures, Potential additional Mitigation Measures, Hazard Priority Matrix.
Jan. 22, 2009	Meeting of TAC and CAC; Presentation, review, discussion of Earthquakes and Expansive Soils; Goals and Objectives; Existing Mitigation Measures, Potential additional Mitigation Measures, Hazard Priority Matrix.
Feb. 12, 2009	Meeting of TAC and CAC; Presentation, review, discussion of Thunder Storms, Lightning, and Hail; Goals and Objectives; Existing Mitigation Measures, Potential additional Mitigation Measures, Hazard Priority Matrix.
Feb. 26, 2009	Attend Oklahoma Water Resources Board Status Report Update meeting on City of Bixby NFIP Map Modernization.
March 5, 2009	Meeting of TAC and CAC; Presentation, review, discussion of High Winds and Tornadoes; Goals and Objectives; Existing Mitigation Measures, Potential additional Mitigation Measures, Hazard Priority Matrix.
March 12, 2009	Meeting of TAC and CAC; Presentation, review, discussion of Floods and Dam Failures; Goals and Objectives; Existing Mitigation Measures, Potential additional Mitigation Measures, Hazard Priority Matrix.
March 26, 2009	Meeting of TAC and CAC; Update and review, discussion of revised new D-FIRM FEMA NFIP maps; Goals and Objectives; Existing Mitigation Measures, Potential additional Mitigation Measures, Hazard Priority Matrix.
April 9, 2009	Meeting of TAC and CAC; Presentation, review, discussion of Extreme Heat and Drought; Goals and Objectives; Existing Mitigation Measures, Potential additional Mitigation Measures, Hazard Priority Matrix.
April 30, 2009	Meeting of TAC and CAC; Presentation, review, discussion of all Natural and Man-Made Hazards.
May 14, 2009	Meeting of TAC and CAC; Presentation, review, discussion of Goals and Objectives for each of the Hazards that could impact the City of Bixby.
May 28, 2009	Meeting of TAC and CAC; Presentation, review, discussion of Existing Mitigation Measures, Potential additional Mitigation Measures for each of the Hazards.
July 9, 2009	Meeting of TAC and CAC; Review and discussion of Mitigation Measures; Update information on measures done, in process and measures to be done.

3.2 Step Two: Involve the Public

(Oct. 2008 – Ongoing)
In addition to the BCAC, the management team of BTAC undertook projects to inform the public of this effort and to solicit their input. All meetings of the BCAC were publicly posted as required by ordinances and rules of the jurisdiction. Seventeen Committee

meetings were held in Bixby City Hall. These meetings were all open to the public. In addition, two City Council meetings were also public meetings. In all public meetings, surveys were made available to participants to review concerns and questions.

3.3 Step Three: Coordinate with Other Agencies and Organizations

(Oct. 2008 – Ongoing)
Many public agencies, private organizations, and businesses contend with natural hazards. Management team members contacted them to collect their data on the hazards and determine how their programs can best support the Bixby Multi-Hazard Mitigation planning program. A sample letter and a list of agencies contacted are included below.

A private website was created where the draft plan was maintained so participating agencies and organizations could review and provide feedback as the plan was developed.

The Emergency Operations Plan is administered under the Tulsa Area Emergency Management Agency and Bixby Emergency Management. The Public Works and Planning Departments play key roles during most emergencies.

Federal

Federal Emergency Management Agency, Region VI (FEMA)
National Weather Service (NWS)
Natural Resource Conservation Service (NRCS)
US Army Corps of Engineers – Dam Safety
US Army Corps of Engineers – Disaster Response
US Army Corps of Engineers – Floodplain Management
US Fish and Wildlife Service
US Geological Survey

National Non-Profit

American Red Cross, Tulsa Area Chapter
American Red Cross, Oklahoma City
Salvation Army, Tulsa
Tulsa Area United Way
Tulsa County ARES

State

Oklahoma Biological Survey
Oklahoma Climatological Survey
Oklahoma Conservation Commission
Oklahoma Department of Agriculture, Food & Forestry
Oklahoma Department of Commerce
Oklahoma Department of Education
Oklahoma Department of Emergency Management
Oklahoma Department of Environmental Quality
Oklahoma Department of Labor
Oklahoma Department of Transportation
Oklahoma Department of Wildlife Conservation
Oklahoma Fire Marshal
Oklahoma Geological Survey

Oklahoma Insurance Department
Oklahoma State Department of Health
Oklahoma Water Resources Board

- State Dam Safety Coordinator
- State National Flood Insurance Program (NFIP) Coordinator

Regional

Indian Nations Council of Governments (INCOG)
Muscogee (Creek) Nation

County

Tulsa County Assessor
Tulsa County Board of Commissioners
Tulsa County Emergency Management Agency
Tulsa County Sheriff's Office
Tulsa City/County Health Department
Tulsa County Local Emergency Planning Committee (LEPC)

City

Bixby City Manager
Bixby Emergency Manager
Bixby Fire Department
Bixby Police Department
Bixby Public School District
Department of Public Works
Director of Economic Development, Bixby
Office of the Mayor
Sustainable Tulsa

Businesses

Home Builders Association of Greater Tulsa
Bixby Chamber of Commerce
SouthCrest Hospital, Tulsa
OG&E, Sapulpa
ONG, Broken Arrow

Education

OSU Cooperative Extension Service, Tulsa

Neighboring Communities

City of Tulsa
City of Broken Arrow
City of Jenks
City of Glenpool

CITY OF BIXBY
P.O. Box 70
116 W. Needles Ave.
Bixby, OK 74008
(918) 366-4430
(918) 366-6373 (fax)

Mr. H Stephen Williamson
President, CEO
EMSA
111 Classen Drive
Oklahoma City, OK 73103

March 26, 2009

Subject: Bixby Multi-Hazard Mitigation Plan Update

Dear Mr. Williamson:

The Oklahoma Department of Emergency Management and the Federal Emergency Management Agency have awarded the City of Bixby with a Hazard Mitigation Grant Program (HMGP) grant to update a Multi-Hazard Mitigation Plan for the community.

The planning process began October 2008, and is expected to be completed by August 2009. A Hazard Mitigation Citizens Advisory Committee and a Staff Technical Advisory Committee have been appointed by the City 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, may 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, Erik Enyart at (918) 366-0427 or by e-mail at eenyart@bixby.com .

Sincerely,

Erik Enyart, AICP, CFM
City Planner / Floodplain Administrator

3.4 Step Four: Assess the Hazard

(Jan. 2008 – June 2009)

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/Levee Failures	Input from US Army Corps of Engineers (USACE) Input from Oklahoma Water Resources Board, (OWRB), Dam Safety Division Input from Bixby Department of Public Works	• Population and buildings below dam are very vulnerable in event of major release or dam failure • Dam break/release contingency plan needs updating • Warning systems need to be updated and refined • City considering redevelopment options for areas behind downstream of major dam
Drought	Historical vulnerability to drought, the "Dust Bowl" era Recent (2002) drought and water shortages in Bartlesville, just north of Tulsa Widespread Oklahoma drought of 2005-2007.	• 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 Bixby's metropolitan area population
Earthquakes	Historic records of area earthquakes Input from Oklahoma Geological Survey Input from USGS HAZUS Surveys of potential damages	• Bixby area has a history of mild earthquakes • Tulsa County has experienced earthquakes on the average of once every 5 years • Earthquake event at the New Madrid fault or at El Reno could have consequences for the City of Bixby and Tulsa County
Expansive Soils	Review of Natural Resource Conservation Service data Input from City Building Inspections Department Input from Oklahoma Department of Transportation	• Expansive soils are prevalent in the City of Bixby. • Damage to buildings and infrastructure from expansive soils can be mitigated with public information and building code provision
Extreme Heat	Review of number of heat-related deaths and injuries from EMSA and State/Local Health Departments Review of data from National Climatic Data Center and National Center for Disease Control & Prevention	• TAEMA and local community service organizations have made heat-related deaths a high priority • High percentage of outdoor workers at risk • High percentage of poor and elderly populations at risk • 91 heat-related deaths in Oklahoma in the last 15 years

Hazard	How Identified	Why Identified
Floods	Review of FEMA floodplain maps Buildings in the floodplains Historical floods and damages (detailed in Chapter 4)	• 14 Flood events resulting in $3.192 Mil in damage between 1995-2009 • Thunderstorms have dumped over 7 inches of rainfall in a single day causing devastating flash floods • Frequent floods have affected Bixby throughout its history
Hailstorms	Review of data from National Climatic Data Center	• 38 hail damage events in the Bixby area 1995-2009 • Over $75,000 in reported property damage
High Winds	National Weather Service data Loss information provided by national insurance companies	• 42 high wind-related events in the Bixby area in the last 15 years • Several events exceeded 70 miles per hour • $142,000 reported in structure damages
Lightning	National Climatic Data Center information and statistics National Lightning Safety Institute Statistics	• Oklahoma has had 374 incidents resulting in 11 deaths, 76 injuries, and $26.0 Mil over a 15-year period. • Tulsa County has had 10 lightning events since 1998 resulting in $2.3 Mil in damage, one death and two injuries. • Bixby has had1 event resulting in $25K in damages.
Severe Winter Storms	Review of past disaster declarations Input from Emergency Management Input from Bixby Department of Public Works Input from area utility companies	• Severe winter storms are an annual event in the Bixby area and can produce both wide-spread economic disruption and massive public utility outages. • Bixby has had 290 major winter storm events from 1995-2009 resulting in $50,154,000 in damages
Tornadoes	Review of recent disaster declarations Input from Emergency Management Review of data from the National Climatic Data Center	• Bixby is located in “Tornado Alley” • An average of 52 tornadoes per year strike Oklahoma • Recent disaster events and damage • Oklahoma City tornado of 1999 killed 42 people and destroyed 899 buildings • All citizens and buildings are at risk • There have been 9 tornadoes in Tulsa County in the last 10 years. Two of those struck the City of Bixby, causing $2,100,000 in reported damages.

Hazard	How Identified	Why Identified
Wildfires	Input from Bixby Fire Department Input from surrounding county & community fire departments Input from State Fire Marshal Input from Oklahoma State University Rangeland Conservation Southern Wildfire Assessment Model Analysis	• Fires of the urban/rural interface threaten Bixby properties • Several miles of Bixby's perimeter and a number of identified critical facilities are exposed and vulnerable to wildfires • 328 wildfires in Bixby area between 1999-2003 resulted in over $48,000 in damage • Six wildfires in 2005-2006 in Tulsa County caused 1 death, 11 injuries, and $2.05 Mil in reported damages.

3.5 Step Five: Assess the Problem

(Jan. 2008 – June 2009)
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 the Indian Nations Council of Governments. 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 *City of Bixby 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 the City of Bixby 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 are 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's office.
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.

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

(Jan. 2008 – June 2009)
Project and community hazard mitigation goals and objectives for Bixby were developed by the BCAC to guide the development of the plan. The hazard mitigation goals for the jurisdictions are listed in Chapter 5 and Appendix B.

3.7 Step Seven: Review Possible Activities

(Jan. 2008 – July 2009)
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 "Chapter 5: 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

The BTAC and the BCAC, after reviewing the potential mitigation activities, screened and selected the measures they felt were applicable, feasible, cost effective, and politically acceptable to their community. The measures specifically identified as potentially benefiting the community were combined into a new, more community-specific list for review.

To prioritize the list of possible mitigation measures, made up of over 140 identified mitigation measures, the BCAC members were given twenty votes each to select the individual measures they felt would best benefit the community'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. The Mitigation Measures selected and prioritized by this voting process best reflected the values and goals of the community, and the Mitigation priorities generally reflected the disaster and damage experience of the community.

The true challenge is to identify mitigation strategies and measures that represent the goals and political will of the community. 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 priority measures became the focus for the next phase of the plan, the "Action Plan".

3.8 Step Eight: Draft an Action Plan

(July 2009 – September 2009)
The high-priority Mitigation Measures that constitute the Action Plan are listed and detailed in Chapter 6:

- 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
- 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.

3.9 Step Nine: Adopt the Plan

(March 2010)
The Draft *City of Bixby Multi-Hazard Mitigation Plan Update 2009* was submitted to the Oklahoma Department of Emergency Management and FEMA Region VI for review and approval. The BCAC approved the final plan, adopted it as an amendment to the *Comprehensive Plan*, and submitted it to, and was approved and adopted by the Bixby City Council.

3.10 Step Ten: Implement, Evaluate, and Revise

(March 2010 – Ongoing)
Adoption of the *Multi-Hazard Mitigation Plan* is only the beginning of this effort. Community offices, other agencies, and private partners will proceed with

implementation. The BCAC will continue to meet on a regular basis to monitor progress, evaluate the activities, and periodically recommend revisions to the Plan and Action Items. The plan will be formally updated a minimum of every five years, as required by FEMA.

Chapter 4: Natural 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 defined as one of 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 a natural hazard occur, 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 hazard 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 the City of Bixby and Bixby Public Schools. 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. Dam Failures
14. Transportation
15. Hazardous Materials Events

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 and impact of the hazards; and the identification of any topographic or geological conditions that would make a particular area prone to the hazard.
- **History/Previous Occurrences –** 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.
- **Vulnerability –** 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. In addition, the potential effect on infrastructure, such as communications and utilities are reviewed.
- **Scenario –** When appropriate for the hazard, a "worst-case" scenario is presented and analyzed. This information can be used to further prioritize the risks for the community inherent in a particular hazard.
- **Future Trends –** Potential effects of the hazard in terms of future development areas of the community are reviewed in terms of population, structures, infrastructure, and critical facilities. When known, other factors such as emerging technological trends may be included in this analysis.
- **Conclusion –** The information provided on each of the hazards is condensed into a brief summary/conclusion statement.

Hazards Summary

Floods

A flood is the accumulation of water within a water body and the overflow of 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. According to the National Climatic Data Center (NCDC), from 1995-2009 Bixby experienced 14 flood events, causing nearly $3.2 million in reported damages. The City of Bixby is at High Risk from the effects of floods, with 1,015 buildings of all kinds located in the FEMA Special Flood Hazard Area (SFHA).

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. Due to the nature of Bixby's climate and the severe thunderstorms it frequently produces, tornadoes will remain a threat to this community. Although historically Bixby has a low historical frequency of tornadoes and damage, and the community has a number of mitigation measures in place, the community's overall Risk remains High. Improved building technologies, advances in public communication capabilities, and opportunities for collaboration among community agencies should, therefore, remain prominent in the planning and response communities' endeavors.

High Winds

Wind is the motion of air relative to the earth's surface. Extreme windstorm events are associated with cyclones, severe thunderstorms, and accompanying phenomena such as tornadoes and downbursts.

Due to the nature of Bixby's climate, severe thunderstorms and the winds they produce will remain a High Risk to this community. Recent events both in Bixby and in the surrounding areas serve as proof that while sporadic, high wind 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.

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.

Lightning is one of the most deadly and consistent hazards in the United States. In recent years, new technology has made it possible for communities and individuals to provide increased warning and alerts, increased surge protection, and increased building strike protection. The threat of injury, death, or property damage in the City of Bixby is high.

Of course, unreported damages from individuals and businesses would be expected to be higher. 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 1" (changed from ¾" in 2009) and accompanied by winds greater than 60 miles per hour.

The states in the middle of the Great Plains, and particularly Oklahoma, are the most likely to have severe thunderstorms and therefore have the most hail events. Oklahoma experiences an average of 401 hailstorms each year with hailstones measuring at least 1.0" in diameter. Between 1995-2009, Bixby was struck by 38 hail events, indicating a High Risk to hailstorms.

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 earth, plants, roads, homes and other structures.

Winter storms are a significant hazard to the City of Bixby, as they occur frequently and may affect the entire area. According to the NCDC, 29 winter storm events have affected Tulsa County and the Bixby area since 1995. 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. Extreme heat impacts the City of Bixby and can be expected every summer. The population most at risk to extreme heat is the 19.4% of the population aged 65 and above, the 17% of the population that is classified as low income, and those that work outdoors. Property damage is also possible, but damage due to extreme heat is minimal, except from wildfire, a secondary impact of drought and extreme heat, and power outages.

Drought

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

The severe droughts of the 1930s led to the construction of Oklahoma's numerous hydroelectric dams and reservoirs, as well as to the implementation of new farming and conservation policies. However, more recent drought response and recovery activities in Oklahoma, both at the state and local level, have not been as ambitious or successful. There is 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."

The City of Bixby has a Moderate Risk 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.

Expansive soils develop gradually and are seldom a threat to the population, but can cause severe damage to improvements built upon them.

With 30.2% of the soils within the city limits classified as having moderate to high shrink/swell potential, 53.3% in the low category, and 11.4% in the "very high" category, the City of Bixby is at High Risk to the damaging effects of expansive soils. Increased damage to structures could be expected during and following a period of extended drought, particularly for structures built during a drought.

Urban (Structure) Fires

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

Urban fires affect a very small area or group of the population, as opposed to hazards that occur over much larger geographical areas. The City of Bixby has a Moderate Risk of urban fire.

Wildfires

A wildfire is 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; or 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 rapidly, especially in the western states.

As shown during the rash of wildfires in the winter of 2005-2006, the areas of the City of Bixby that are in the wildland/urban interface are at Moderate Risk from wildfires, and at Severe Risk during times of high wind and drought. However, the vulnerable areas are a relatively low percentage of the total area of the community.

The City of Bixby's overall Risk would be considered Moderate.

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. Almost all Oklahoma earthquakes are too small to be felt and cause little to no visible damage.

Tulsa County experienced six earthquakes between 1977 (the year Oklahoma Geological Society began seismographic tracking of tremors) and 2008 or 0.21 per year, none of which were "felt" earthquakes. None of the earthquakes was centered in the City of Bixby, so Bixby has a Low Risk of Earthquakes. As calculated using HAZUS software, an earthquake similar to the 1952 El Reno event would cause no damage to the Bixby area.

Hazardous Materials 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, and radioactive materials.

No fixed site hazardous material events within the City of Bixby have been reported since 1989. However, there are seven hazardous materials sites within Bixby, two sites adjacent to Bixby and three sites in the future growth areas working with chemicals such as propane, chlorine and diesel fuels. The community is considered to have a Low Risk to a hazardous materials event.

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 the collapse, breach, or other failure of such a structure resulting in downstream flooding.

The dam posing the greatest threat to Bixby is Keystone. However, the Corps of Engineers believes that the potential for failure is low because Keystone is operated by the Corps and is inspected at least once each year.

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.

The worst-case event, failure of Keystone Dam and the Arkansas River levees could impact 3,014 parcels with improvements (including 36 critical facilities) within the city limits of Bixby and cause an estimated $271.5 million in damage. In addition, it could produce widespread power outages, and release of hazardous chemicals.

Although the likelihood of a major dam or levee failure is low, its potential impact would be devastating. Consequently, the community is considered to have a High Risk to Dam Failure.

Transportation

Transportation is 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 move objects and people.

Because of the low number of major highways through the city, and the relatively small amount of population and properties that would be impacted, Bixby has a Low Risk to a transportation event.

Annual Average Damages

Although available data is limited, information on total damage to property, injuries and loss of lives for the 20-year period from 1989 through 2008 has been summarized in Table 4-1 below. Sources for information include the National Climatic Data Center, the National Response Center, the Oklahoma Geological Survey, and the Oklahoma Fire Marshall’s Office, in addition to information obtained from local sources.

Table 4–1: Bixby Summary of Damages

Hazard	*Events*	*Events/ Year*	*Total Property Damage*	*Property Dmg/ Event*	*Property Dmg/ Year*	*Injuries*	*Injuries/ Event*	*Injuries/ Year*	*Deaths*	*Deaths/ Event*	*Deaths/ Year*
Floods	22	1.1	$3.74 Mil	$169,863	$186,850	0	0	0	2	0.1	0.1
Tornadoes	1	0.05	$2,000	$2,000	$20	0	0	0	0	0	0
High Winds	43	2.87	$142,000	$3,302	$9,467	0	0	0	0	0	0
Lightning	1	0.07	$25,000	$25,000	$1,667	0	0	0	0	0	0
Hail	38	2.53	$75,000	$1,974	$5,000	0	0	0	0	0	0
Winter Storms[1]	29	1.93	$50.15 Mil	$1.7 Mil	$3.34 Mil	0	0	0	0	0	0
Extreme Heat[1]	10	.67	$0	$0	$0	52	5.2	3.47	13	1.3	.87
Drought[1]	8	.53	$0	$0	$0	0	0	0	0	0	0
Expansive Soils	*Insufficient Data*										
Urban Fires[2]	70	14.0	$2.307Mil	$32,965	$461,510	1	0.01	0.2	4	0.06	0.8
Wildfires[2]	163	36.8	$7,610	$47	$1,520	*Insufficient Data*					
Earthquakes	0	0	$0	$0	$0	0	0	0	0	0	0
HazMat, Fixed	0	0	$0	$0	$0	0	0	0	0	0	0
Dam Failures	0	0	$0	$0	$0	0	0	0	0	0	0
Transportation	1	0.1	*Insufficient Data*			0	0	0	0	0	0

[1] Since these events cover such a wide region, figures are for the Metro Area.
[2] Figures are for 2004-2008, the most updated numbers from the State Fire Marshall's Office.

Hazards Risk Analysis: Probability and Vulnerability

A Hazard Risk Analysis provides a quantitative 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 risk analysis for the City of Bixby, which includes a quantification of the history, probability, vulnerability, and maximum threat for each event, along with mitigating conditions such as extent of existing mitigation activities and capabilities of local and area response agencies. Table 4-3 provides a summary of the ranking criteria and the scoring method.

Table 4–2: City of Bixby Hazard Risk Analysis

Type of Hazard	Occurrence		Vulnerability					Resources		Total
	Historical	Probability	Human	Property	Infrastructure	Business	Mitigation Activities	Internal	External	
Winter Storm / Ice Storm	5	5	3	5	5	4	2	3	3	6.2
Flooding	5	5	3	4	3	2	3	2	2	5.2
Dam / Levee Failure	3	3	3	4	4	4	1	2	1	4.9
Expansive Soils	5	5	1	3	2	2	1	1	3	4.6
High Wind Events	5	5	2	3	1	3	1	3	4	4.4
Hail	5	5	1	3	1	1	1	1	1	4.3
Tornadoes	1	1	4	5	5	4	2	2	2	4.0
Wildfires	5	5	1	1	1	1	1	2	4	3.4
Urban (Structure) Fires	5	5	1	1	1	1	2	2	4	3.3
Heat, Extreme	5	5	1	1	1	1	2	3	4	3.2
Lightning	3	3	2	2	2	2	2	2	2	3.1
Drought	1	3	2	2	2	3	1	3	3	2.8
Transportation Incidents	0	2	3	1	1	3	1	1	3	2.1
Hazardous Material, Fixed Site	0	1	3	1	1	3	1	1	3	1.7
Earthquake	0	1	1	1	1	1	1	2	2	0.8

Table 4–3: Summary of Hazard Risk Analysis Ranking Criteria

<table>
<tr><td colspan="3">Summary: This tool looks at an organization's or a community's vulnerability to the effects of various hazards. Using a scale of 0 to 5, the probability of occurrence and the impact potential are measured against mitigation activities and the resources available to respond to the hazard. The total is based on a formula that weighs risk heavily but provides credit for mitigation and response and recovery resources.

The highest score possible is 7.8.

The lower the total score, the lower the overall risk from the Hazard.</td></tr>
<tr><td colspan="3">Instructions: Score each hazard based on a scale of 0 to 5 with 5 being the highest.

Ratings values: 1 = Low : 2-3 = Moderate : 4-5 = High</td></tr>
<tr><td colspan="3">Historical Occurrence: Based on the number of occurrence in the last 20 years. Maximum is 5; if it is a new hazard or has no history, use 0.</td></tr>
<tr><td colspan="3">Probability: Score 0 if non-existent, 1 if less than 1%, 2 if less than 5%, 3 if less than 10%, 4 if less than 20%, and 5 if greater than 20%. Probability is the likelihood an event will occur. History and probability are similar, but hazards that are newly developing, hazards where the likelihood has increased or decreased based upon new developments or activities, or hazards that have a lack of historical information may need to be considered individually.</td></tr>
<tr><td colspan="3">Vulnerability: Based on a “worst-case scenario” – identify the greatest possible vulnerability, should a worst-case event occur. The vulnerability is expressed in terms of human casualties, property loss, infrastructure vulnerability, and business interruption/loss revenue issues. Secondary events need to be factored in where necessary. Assume maximum population when appropriate (for example, industrial park during peak work hours).</td></tr>
<tr><td colspan="3">Internal/External Resources: Based on the resources available to the community internally, or to Mutual Aid agreements or other understandings with neighboring jurisdictions. May also include private resources available, such as corporate firefighting/hazmat teams or medical resources.</td></tr>
<tr><td rowspan="2">Analysis Results:</td><td>Extreme Risk: Greater than 6.0</td><td>Moderate Risk: 2.5 to 4.0</td></tr>
<tr><td>High Risk: 4.0 to 6.0</td><td>Low Risk: Less than 2.5</td></tr>
</table>

Secondary Events

Although hazards may be individually identified and categorized, many are interrelated, and a disaster may involve multiple hazards. Severe thunderstorms, for example, may spawn high winds, lightning, hailstorms, tornadoes, and flooding. It is generally more useful to consider all secondary events as a part of the overall situation created by the primary event. These are frequently referred to as “Cascade Events.” Table 4-4 identifies secondary events that are related to each of the natural and technological hazards studied in this report.

Table 4–4: Secondary (Cascade) 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									●	
Wildfire					●	●	●	●		
Earthquake	●				●	●	●	●	●	
Dam Failure				●	●	●		●	●	

Vulnerability Assessment

The following table highlights assessed vulnerability to the hazards studied in this report for the City of Bixby and Bixby Public Schools. The assessment reveals that Bixby and Bixby Public Schools are vulnerable to all hazards studied in this document, with the exception of a significant Earthquake event for Bixby Public Schools.

Table 4–5: Hazard Vulnerability for the City of Bixby and Bixby Public Schools

Jurisdiction	Flood	Tornado	High Winds	Lightning	Hailstorm	Winter Storm	Extreme Heat	Drought	Expansive Soils	Urban Fire	Wildfire	Earthquake	Fixed Site HazMat	Dam Failure	Transportation Event
City of Bixby	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Bixby Public Schools	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

4.1 Floods

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

Floods can lead to "cascading" events increasing the damage – including power outages, health issues, and hazardous materials releases, as illustrated in the above photo of a community where the flood breached a nearby oil refinery.

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.

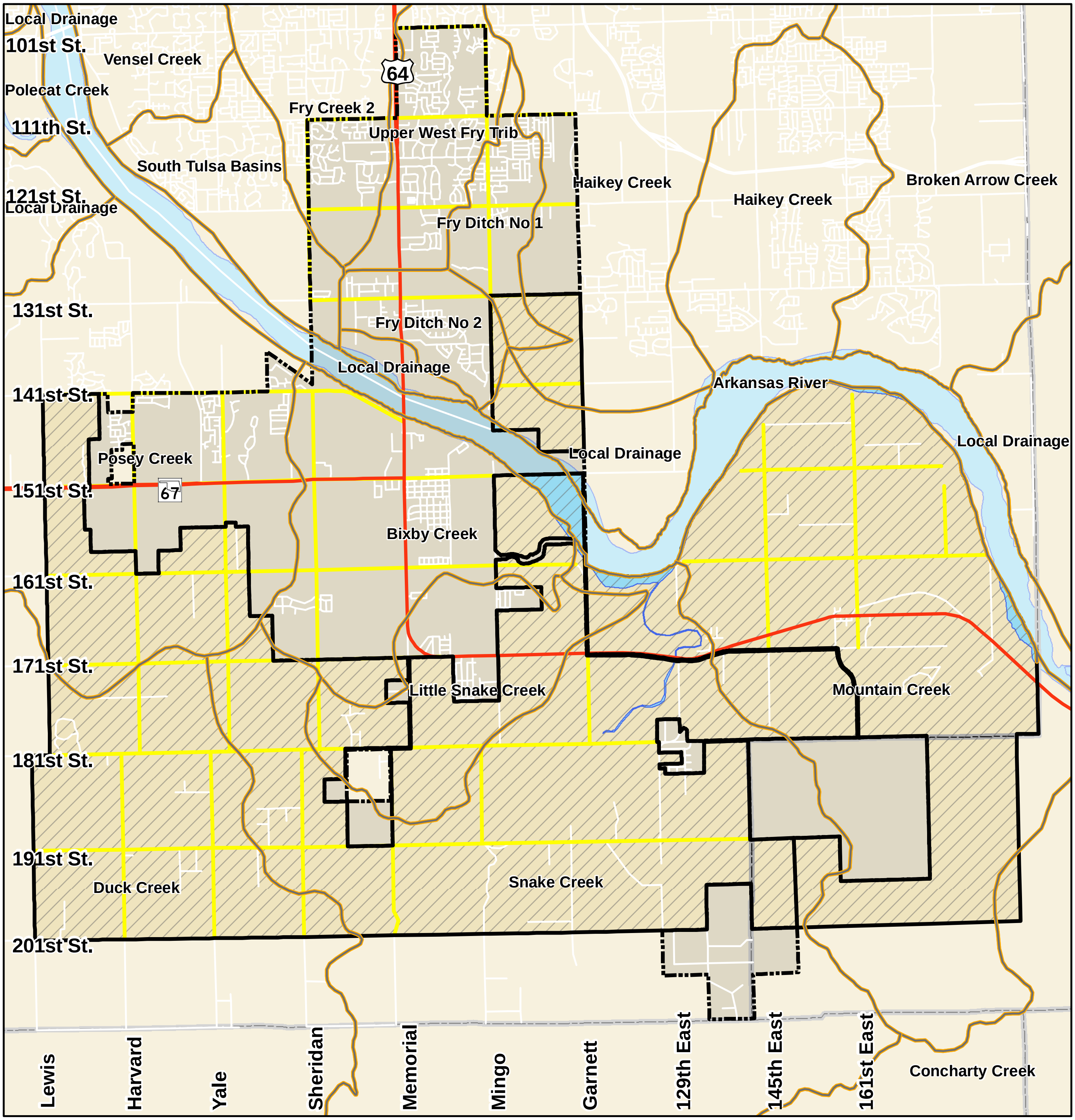
Location

This section contains summary information about the locations of Bixby's creeks and floodplains. Locations of lakes and impoundments, as well as more detailed information about the Arkansas River, are contained in the section on dams and levees.

The map below shows the state of Oklahoma, with Tulsa County highlighted, and includes summary data on flood occurrences throughout the state, by county.

The drainage basins affecting the City of Bixby and Bixby Public Schools are listed in Table 4-6 and are shown on Figure 4-1.Within the City of Bixby's 25.3 square miles, several significant tributaries converge on the wide Arkansas River floodplain, including Fry Creek, Haikey Creek, Posey Creek, Bixby Creek, and Snake and Little Snake Creeks.

FEMA and Bixby have identified those areas within the watersheds of the streams of Bixby that have a one-percent chance of flooding in any given year. Figure 4-2 is a generalized map showing floodplains that have been identified along the major



LEGEND

	Drainage Basins		Water
	Highways		City Limits
	Major Streets		Fenceline

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Planning Consultants

N W E S

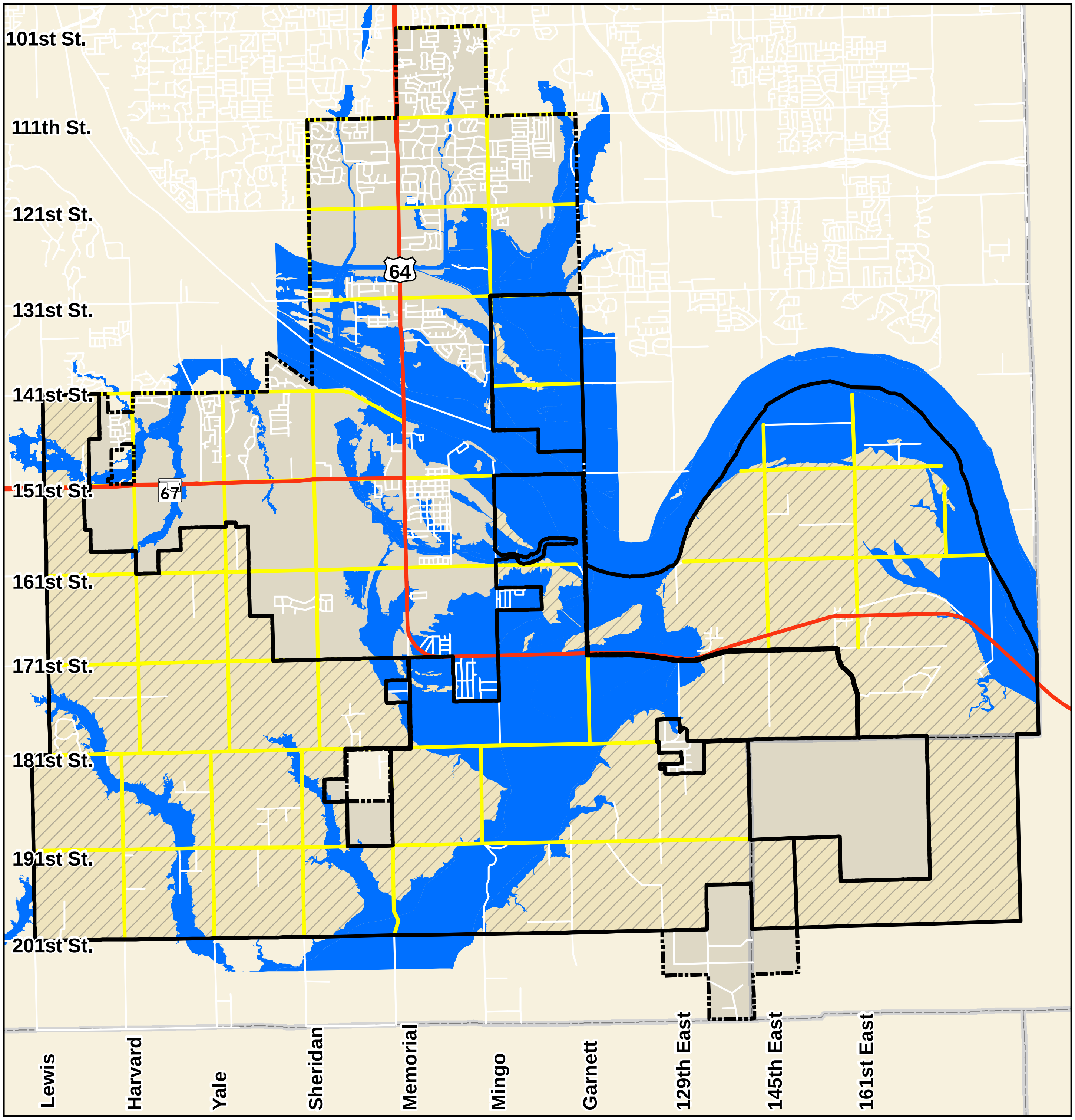
1 inch equals 8,375 feet

SEAL OF THE CITY OF BIXBY 1906 GARDEN SPOT OF OKLAHOMA

Figure 4-1

City of Bixby

Drainage Basins



LEGEND

- 100 yr. Floodplains
- Highways
- Major Streets
- City Limits
- Fenceline

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1 inch equals 8,375 feet

Figure 4-2

City of Bixby

100 yr. Floodplains (2007)

waterways and rivers. The combined floodplains of the Arkansas River and these tributaries comprise more than 7.9 square miles, or 31% of the land within the City limits.

Figure 4–3: Flood Events in Oklahoma from 1989-2008

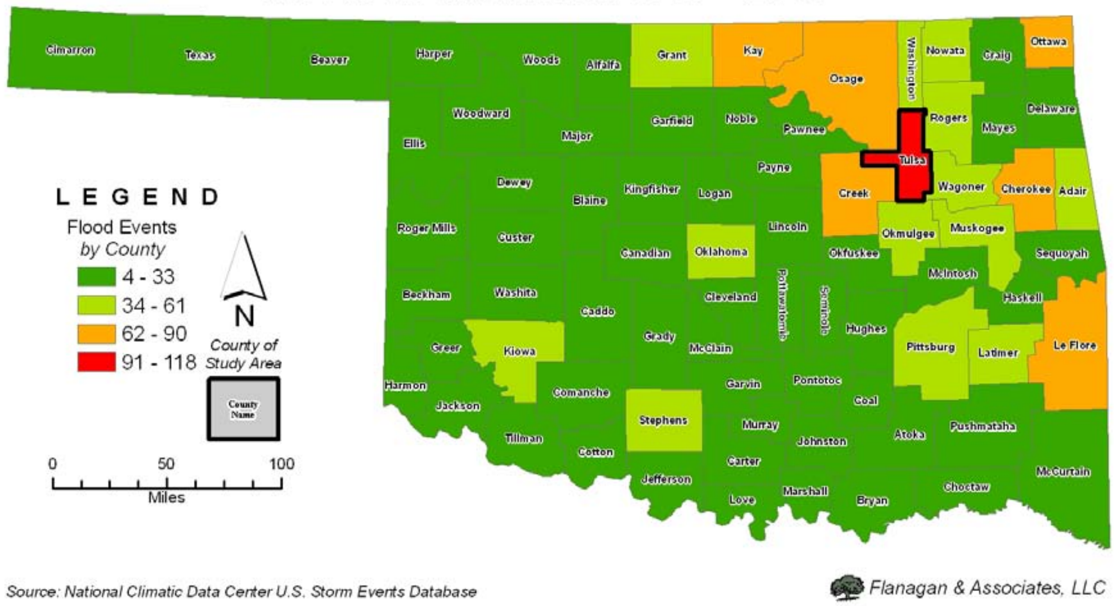


Table 4–6: City of Bixby Streams and Drainage Areas

Stream	Total Drainage Area at Bixby (sq. mi.)
Bixby Creek	4.5
Fry Creek	11.6
Fry Ditch No. 1 (below Fry Creek Project)	2.3
Fry Ditch No. 2 (below Fry Creek Project)	1.1
Haikey Creek	36.7
Little Snake Creek	5.9
Posey Creek	17.0
Snake Creek	185.0

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-MH was used to estimate damages within the City of Bixby from a 100-year flood event. Hazard rankings for floodplain lands are typically based on the frequency, depth, duration, and velocity of anticipated floods.

The following table 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. For information on Bixby's existing floodplain management program, see Section 2.3.2.

Table 4–7: FEMA Flood Zones

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		

Extent

Bixby rainfall averages almost 41 inches per year, but thunderstorms can, and have, dumped over 7 inches on the city in a single day, causing widespread flooding and devastating flash floods.

Bixby flood problems are widely dispersed and could be divided into several categories:

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

Bixby Old Town located south of the Arkansas River and east of Memorial has been the location of many floods over the last 80 years. The flooding problems are two-fold: First, storm water flows south across Old Town, Privit, Midland, River Terrace, Ramsey Terrace, and Pecan Valley Sub-divisions to Bixby Creek during the less intense storms. This presents a safety hazard with street flooding and in the past water has entered some residences with low-lying first floors. Second, water backs up from the Arkansas River into Bixby Creek during the more intense storms and during a 100-year event. The south side of the Arkansas River is shielded by dykes and floodwaters enter this area only through inlets into the river or backwater flow into creeks.

The area below Bixby Creek to the south of 161st Street South collects water that flows south and east toward Little Snake Creek. Johns Park, Saker, Southtown, and Woodland Acres subdivisions are affected in the low intensity storms. These are areas of shallow flooding of three feet or less. Little Snake Creek flows north and northeast to the Arkansas River with a larger watershed to the south that reaches Okmulgee. Direct flow from the Little Snake can flood Woodland Acres, Southtown, Saker, and Johns Park. A 100-year event flooding in this area is complicated by backwater through the mouth of Bixby Creek, Snake Creek, and Little Snake Creek, as well as the direct flow of the creeks to the Arkansas River.

The areas north of the river flood as the water within the watershed makes its way south to the Arkansas River. Fry Creek and Haikey Creek have overflowed their banks and inundated the land with stormwater run off.

The Corps of Engineers' Fry Creek channelization project has controlled the flow of stormwater in the Fry Creek Basin and removed properties from flood hazards through the 100-year event. Haikey Creek remains a major problem.

The area to the west and south of the Arkansas River contains the Posey Creek Basin. This basin has had some flooding, but not with the destructiveness of the other Bixby creeks since most of the area is agricultural land.

Additional information about the Arkansas River dams is contained in Section 4.14.

Frequency

Bixby has recorded 100-year event storms in 1923 (when over four feet of water entered the downtown area); 1940, 1957, and 1959. In each of these events, many properties were damaged. The construction of Keystone Dam on the Arkansas River above Tulsa in 1966 has reduced flooding considerably. However, the city experienced extensive flooding in 1986, when abnormally heavy rainfall forced the Corps of Engineers to make an emergency release from Keystone Dam, the volume of which exceeded a 100-year event and caused widespread damage. Although Bixby's flooding problems remain, much has been done in recent years to limit property damage from stormwater runoff.

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. For more details on the impact of flooding, see section 4.1.3.

Bixby 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.

4.1.2 History/Previous Occurrences

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

Table 4–8: Floods in Oklahoma and Bixby for 1995 through 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 Damage
Bixby*	14	0	0	7	$3,192,000
Tulsa County	119	2	0	24	$3,760,000
Oklahoma	1,971	25	25	355	$79,668,000

*** Information in NCDC does not allow for damages to a community to be separated from the county report. The dollar damages for the events that affected Bixby were for all areas affected by those events.**

Floods have accounted for many of the most frequent and costly weather disasters in Oklahoma and Bixby. In the 15 years between 1970 and 1985, Tulsa County experienced nine major floods serious enough to be declared federal disasters – the most of any community in the nation at that time.

Historic Floods

The following paragraphs summarize some of the major floods recorded since 1900, including those that have impacted Bixby and Tulsa County. *(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, until the flood of 1986.
- **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.
- **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. This flood is considered by many to be the trigger for the ensuing flood control programs instituted in the Tulsa area.

The 1986 Arkansas River Flood

The 1986 Arkansas River Flood served as a reminder of the finite protection of Keystone Dam. Between September and October 1986, Keystone Reservoir filled to capacity, forcing the U.S. Army Corps of Engineers to release water at the rate of 310,000 cubic feet per second. Downstream flooding was inevitable. At Tulsa, a private west bank levee failed, causing $1.3 million in damages to 64 buildings.

Citizens sandbagging to save their homes from flooding of the Arkansas River

A photo from the flood indicates Bixby was flooded with several feet of water in the Old Town, Midland, Privet, Riverview Terrace, Saker/Southtown, Johns Park, Woodland Acres Sub Divisions to the South of the River; and Houser, Blue Ridge, Sunburst, Grey Mac Acres, Miller Poe Lacasa, Riverview Park, and Southern Memorial Acres Sub Divisions North of the River. As a result of the flooding over $28,000,000.00 has been spent in the Bixby Area to control stormwater run off.

- **October 1986.**. 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 was plugged with sandbags before serious damage occurred. Total damages in the Tulsa region were more than $63 million.

- **May 9, 1993.** One of the most destructive thunderstorms in recent Oklahoma history dropped up to 12 inches of rain across the state and caused flooding on many rivers, including the Arkansas River and Polecat Creek in southern Tulsa County. Overall, between May 8 and 12, the combination of flash floods, river and stream flooding, hail, strong thunderstorm winds and tornadoes caused around $100 million in damage, injured 21 people and resulted in 5 fatalities in Oklahoma.
- **October 5, 1998.** A massive thunderstorm with tornadoes dropped over 6 inches of rain on Jenks and southern Tulsa County causing widespread flooding, road closures, and rescues of stranded motorists. 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 service.
- **April 25, 1999.** Heavy rainfall throughout Tulsa County caused widespread flooding, especially in the southeast. 4.34 inches of rain fell at Bixby, flooding several streets and houses. Haikey Creek overflowed its banks south of 101st St. Damage countywide was estimated at $130,000.
- **May 6, 2000.** Over 6 inches of rain fell over Tulsa County, causing widespread flooding. Flood damage was reported in Jenks, Bixby, Glenpool, south Tulsa and Broken Arrow. Numerous roads and intersections were flooded. Damage to roads, bridges and infrastructure was estimated at $200,000, with damages countywide estimated at $3 million. There was one fatality in south Tulsa when a woman attempted to drive across a street flooded by a nearby stream. Her car stalled, and with the water rising so quickly, she evacuated the vehicle and was swept away.
- **May 30, 2001.** Heavy rains caused flash flooding in Tulsa County. On Snake Creek in Bixby at 191st Street and Mingo Road a car that was driven around a barricade was swept away by flood waters.
- **May 17, 2002.** Heavy rainfall caused street flooding in the southern part of the Tulsa County and caused a bridge over Snake Creek to be washed out near the 19200 block of South Garnett.
- **May 28, 2002.** Up to 4 inches of rain fell across the southern part of the Tulsa metropolitan area just after rush hour. Lewis Avenue between 51st and 71st Streets South and Skelly Drive between Lewis and Peoria Avenues were barricaded due to high water. Two homes in south Bixby were flooded when excessive rains overwhelmed the storm drainage system around Perryman Ditch. Damages were estimated at $10,000.
- **August 23, 2006.** Heavy thunderstorm rains flooded roads and some houses near 111th Street South and Mingo. One vehicle stalled in high water in the same area.
- **April 9, 2008.** Heavy rain caused severe street flooding across the cities of Bixby and Broken Arrow. Several streets had to be closed. Water entered a few homes as well. Bixby and Broken Arrow schools cancelled classes due to flooded roads.

Probability/Future Events

Currently floodplain management is based on what is termed “100-year floods”. That terminology has been somewhat misleading, suggesting, as it does, that a 100-year flood only occurs once in a century. Since it is possible to have three 100-year floods in five years, it is more appropriate to refer to them as a 1% chance flood, which has a 1% chance of occurring in any given year.

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

Although considerable progress has been made in reducing the probability of flooding in Tulsa County and Bixby, because of the city’s location in the historic floodplains of the Arkansas River, Haikey Creek and Snake Creek, Bixby and Bixby Public Schools still have a high probability of a future flood event.

No probability has been assigned for other potential causes of Bixby flooding, such as waterline breaks or snowmelt, because such factors cannot be predicted statistically or are infrequent in Bixby.

Flooding hazards from dam breaks and flooding lake releases are discussed in Section 4.14.

4.1.3 Vulnerability

This section summarizes information about Bixby’s vulnerability to flooding, including the impact on people, structures and buildings, critical facilities, and infrastructure. This information, as well as information provided by the City and Public Schools, was used to determine the Vulnerability Criteria identified in Tables 4-2 and 4-3. HAZUS modeling was used to help generate this data. The City of Bixby and Bixby Public Schools were determined to be at High Risk to the Flood hazard. (See Tables 4-2, Hazard Risk Analysis, and Table 4-3, Summary of Hazard Risk Analysis Ranking Criteria for an explanation of how the rankings were derived.)

Population

The City of Bixby has 739 residential parcels with improvement values located in or adjacent to its regulatory floodplains. In a citywide 100-year flood, more than 739 households, including an estimated 1,900 individuals, could be displaced by flooding within or near the inundation area.

Those at greatest risk during major floods include persons living in residences located in repetitive flood areas. Also at risk are those traveling by car and on foot in areas that are known to experience flooding/flash flooding during heavy rain. Motorists continue to ignore barricades and warnings against driving on flooded roads and become stranded in their vehicles. Just two feet of water moving at 10 mph will float virtually any car, SUV or pickup. Too often the rate of the water’s rise is not appreciated and people become trapped in the vehicle – as reported in May 2000 when a woman was traveling on

Sheridan Avenue between 71st and 81st Streets in Tulsa and crossed a road that was flooded by a nearby creek. The vehicle stalled in the rapidly rising water forcing the woman out of the car where she was swept away and drowned.

Persons who are directed to evacuate an area due to rising water but are without appropriate transportation could be at increased risk, as well as those who are unwilling to leave their homes for fear of looting or leaving pets behind.

Additionally, persons new to the area, or those whose English language skills are limited, may not understand the true nature of the hazard and take the necessary precautions.

Structures/Buildings

In all, Bixby has 1,015 existing buildings of all kinds located in or adjacent to the 100-year floodplain of its rivers and streams.

Information related to the 100-year flood event and flood insurance policies in force in Bixby is shown in Table 2-1, and maps displaying NFIP policies in Figure 2-1, and NFIP Claims in Figure 2-2. Potential vulnerability (2003 and 2008) in Table 4-9 & 4-10.

Structural values used in this assessment were from the Tulsa County Assessor's Office. It is estimated that the average structure will experience two feet of flooding, which will result in 25% damage to the structure and 25% damage to contents.

Table 4–9: 2003 Floodplain Building Vulnerability

Type	Number of Parcels	Improvement Value	Contents Value	Total Value
Residential	1,026	$87,563,491	$43,781,746	$131,345,236
Agricultural	105	$3,331,341	$1,665,671	$4,997,012
Commercial	89	$13,874,442	$13,874,442	$13,874,442
Industrial	28	$3,988,425	$3,988,425	$7,976,850
Vacant (Undeveloped Parcels)	420	-	-	-
Special Populations / Govt.	159	$1,594,583	$797,292	$2,391,875
Total	**1,827**	**$110,352,282**	**$64,107,576**	**$174,459,858**

Table 4–10: 2008 Floodplain Building Vulnerability

Type	Number of Parcels	Improvement Value	Contents Value	Total Value
Residential	739	$73,048,616	$36,524,308	$109,572,924
Agricultural	105	$2,915,191	$1,457,596	$4,372,787
Commercial	33	$6,461,308	$6,461,308	$12,922,616
Industrial	40	$5,307,370	$5,307,370	$5,307,370
Vacant (Undeveloped Parcels)	412	-	-	-
Special Populations / Govt.	98	$1,516,576	$758,288	$2,274,864
Total	**1,424**	**$89,249,061**	**$50,508,870**	**$134,450,561**

Repetitive Losses

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."

Bixby currently has 10 properties on its FEMA Repetitive Loss list. The types of repetitive loss properties are one industrial, three commercial, and six residential properties. Bixby has developed a Repetitive Loss Plan that recommends measures for addressing the flooding problem of each property on the list. Bixby's strategies include:

- Construction of flood protection projects, such as channel improvements and stormwater detention ponds
- Construction of small local projects, such as storm sewers, culvert replacements, and drainage ditches
- Acquisition of the property and removal and demolition of the building

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

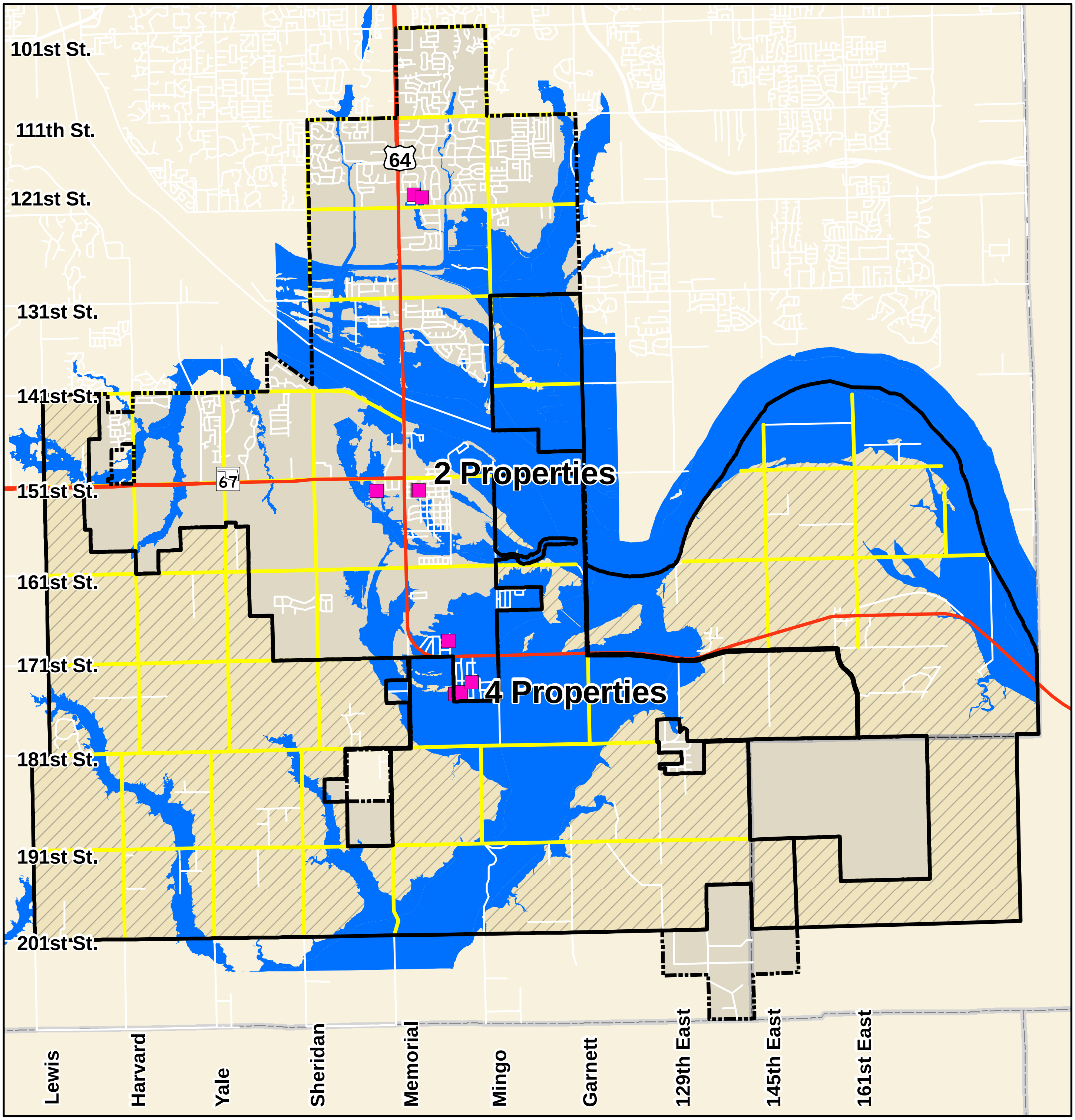
Critical Facilities

Bixby has four critical facilities located in or adjacent to floodplains. Critical facilities located in the floodplains pose a problem for the community. In the event of a flood, theyhave impacts beyond the flooding of the facility. For example, if child care centers cannot open, parents cannot go to work to provide important community services. First responder services are hampered if flooded police and fire stations cannot operate effectively.

Critical facilities located in the floodplain in the previous plan are listed in Table 4-11a and the updated list for 2010 is in Table 4-11b and are shown on the map in Figure 4-5. For a comprehensive list and addresses of Critical Facilities, see Table 1-12.

Table 4–11a: Bixby Critical Facilities Located in the Floodplain (from the 2004 plan)

ID	Name	ID	Name
44	8 Acres Camp Daycare	11	Central Elementary School
45	A Child's Dream Daycare	14	Dawes Building City Offices
6	Bixby City Hall	17	North Sewer Treatment
1	Bixby Community Center	21	Playland Day Care Center
5	Bixby Early Education Daycare – FBC	12	Southtown Nursing & Rehab.
7	Bixby Fire Station #1	23	Storybrook Inn
15	Bixby Maintenance Building	26	Tulsa Teacher's Credit Union
5	Bixby Police Dept.	16	Water Dept. Maintenance Building
8	Bixby Public Library	22	YMCA
3	Bixby USPS	47	YMCA Daycare – Wilson Building



LEGEND

- Repetitive Loss Properties
- Major Streets
- 100 yr. Floodplains
- City Limits
- Highways
- Fenceline

Flanagan & Associates, LLC
Planning Consultants

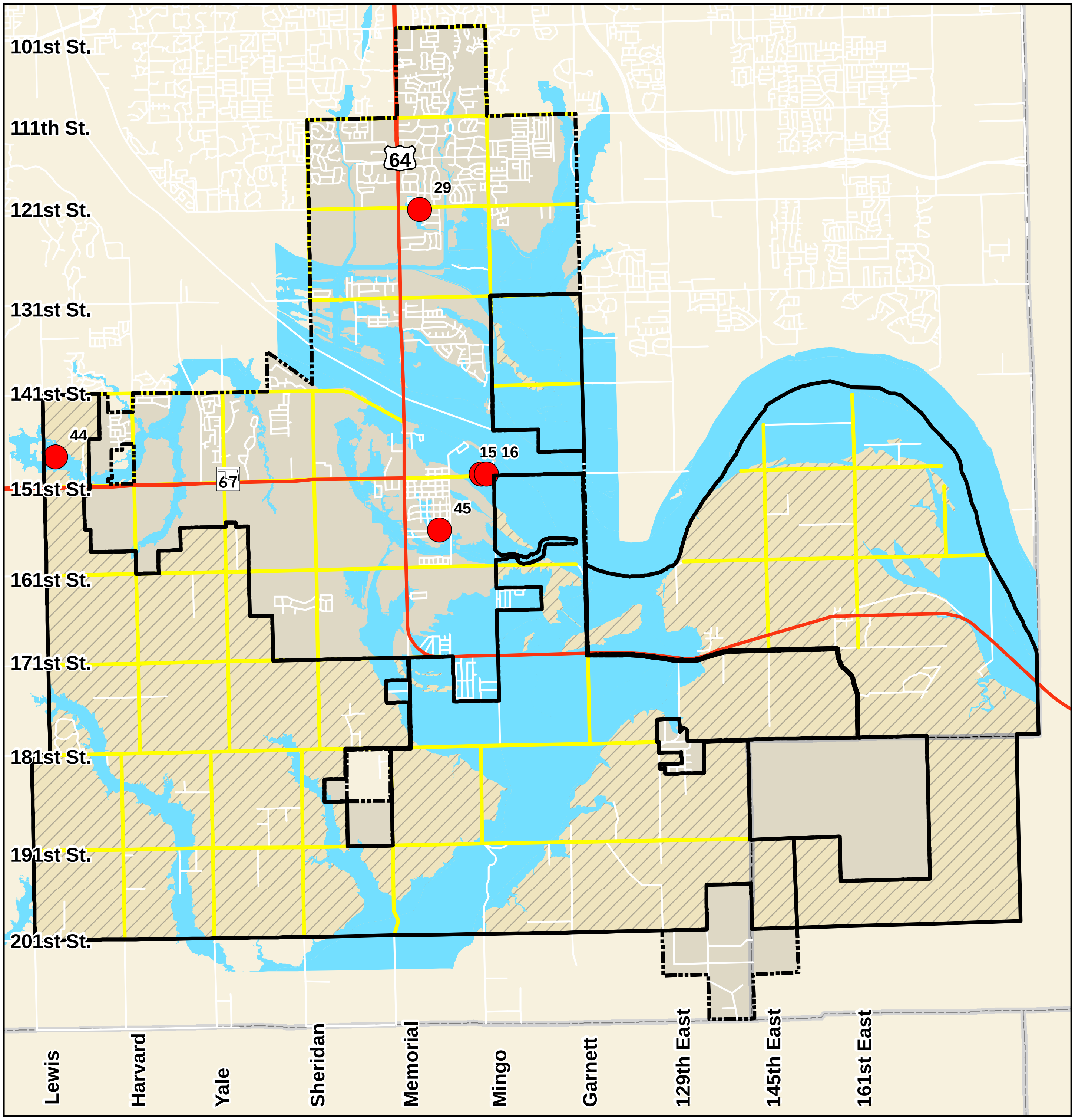
1 inch equals 8,375 feet

SEAL OF THE CITY OF BIXBY 1906 GARDEN SPOT OF OKLAHOMA

Figure 4-4

City of Bixby

Repetitive Loss Properties



LEGEND

- Crit. Facs
- 100 yr. Floodplains
- Highways
- Major Streets
- City Limits
- Fenceline

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Planning Consultants

1 inch equals 8,375 feet

Figure 4-5

City of Bixby

Critical Facilities in Floodplains

Table 4–11b: Bixby Critical Facilities Located in the Floodplain (for the 2010 plan)

ID	Name	Address
45	A Child's Dream Daycare	213 E Stadium Rd., 74008
29	Bixby Fire Station #2	8300 E. 121 St. S., 74011
15	Bixby Maintenance Building	9501 E. 151st St.
16	Water Dept. Maintenance Building	9575 E.151st St.

Infrastructure

Water Treatment –The most serious impact to Bixby's water supply would be the loss of electrical power. Flooding in the watershed could also impact the water quality in the lakes that are accessed by the city's 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 City of Tulsa's intakes. Deposition of sediments, nutrients and other contaminants by flooding has a long-term effect on the water supply lakes that provide water for Bixby.

Wastewater Treatment – As with water treatment, the most significant impact from at major hazard event would be the loss of electrical power. The flooding of wastewater treatment lagoons can spread pollutants and waste into communities and agricultural operations downstream. Localized flooding of the access road to the North Sewage Lagoons could prevent access to that facility during an emergency.

Utilities – The primary utility providers for Bixby's jurisdiction is 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) –** Flooded roadways and bridges would be the largest transportation system impact from a flood event. Several intersections within the City's jurisdiction have been repeatedly flooded during heavy rain events. Most street flooding is short-lived, but nevertheless creates potential life safety issues due to stranded motorists and blocked access for safety vehicles. Additionally, flooded bridges can be compromised in their integrity, especially aging structures.

Table 4–12: City of Bixby Overtopped Bridges

Source: Meshek & Associates, Inc.

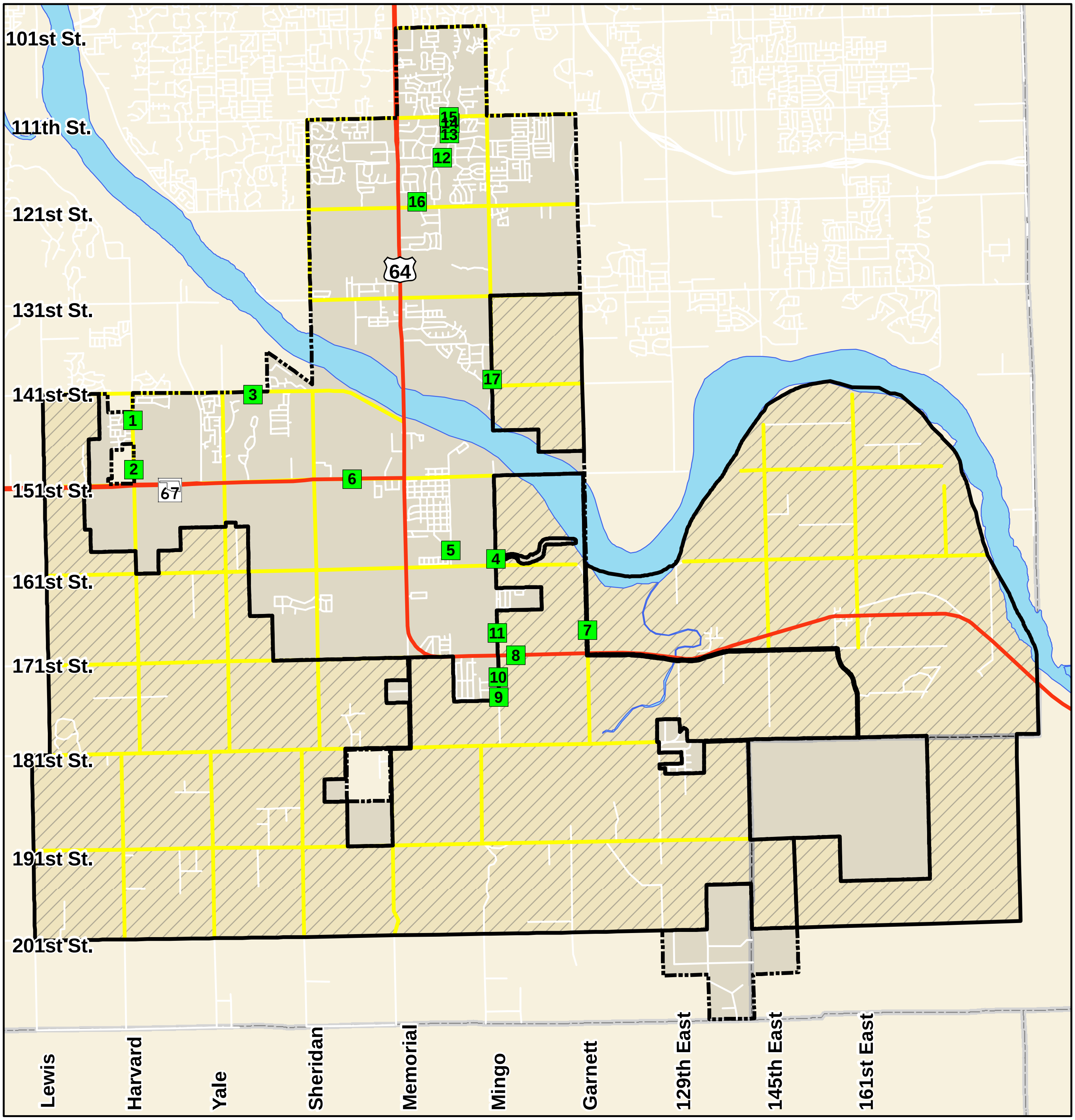
ID	Creek	Bridge/ Culvert Station	Bridge/ Culvert Location	Size	Top of Road	100-year WSEL	Depth of Overtopping	Information Source
1	Posey Trib.	23+00	Harvard	Unknown	633.3	637	3.70	FIS
2	Posey Creek	251+00	Harvard	Unknown	637.2	639.2	2.00	FIS
3	Posey E. Trib	0+47	141st St.	2-60-inch RCP	610	612	2.00	Sack LOMR
4	Bixby Creek	112+40	Mingo Road	7-10x6 RCB	597.5	598.5	1.00	Post-Project Model
5	Bixby Creek	139+50	Riverview	7-10x6 RCB	598.3	599.1	0.80	Post-Project Model

ID	Creek	Bridge/ Culvert Station	Bridge/ Culvert Location	Size	Top of Road	100-year WSEL	Depth of Overtopping	Information Source
6	Bixby Creek	224+59	151st St.	13-17-13x6 RCB	602.6	602.7	0.10	Post-Project Model
7	Little Snake Creek	45+70	Garnett Rd.	11x9 RCB	595	598.7	3.70	Revised Existing Model
8	Little Snake Creek	107+60	171st St.	2-10x8 RCB (4' of sediment)	598.2	600.8	2.60	Revised Existing Model
9	Little Snake Creek		Mingo Road - Little Snake Creek	2-8x7 RCB	596.2	603.7	7.50	FIS
10	Little Snake Creek Southtown Trib.	10+00	Mingo Road - Southtown Outlet	2-4x4 RCB	597	603.5	6.50	FIS
11	Little Snake Creek Saker Trib.	15+00	Mingo Road - Saker Outlet	2-4x4 RCB	597	603.2	6.20	FIS
12	Fry Creek No. 1	174+97	116th St.	10x7 RCB	626.9	628.85	1.95	FIS
13	Fry Creek No. 1	194+88	113th St.	42-inch RCP	634	639.81	5.81	FIS
14	Fry Creek No. 1	200+60	89th E. Ave.	36-inch RCP	639	641.81	2.81	FIS
15	Fry Creek No. 1	204+58	111th St.	16.5x4.5 RCB	643.1	645.09	1.99	FIS
16	Fry Creek No. 1 West Trib.	29+11	84th E. Ave.	3-8x5 RCB	608	609.29	1.29	FIS
17	Old Fry 2 Channel	Unstudied	Mingo Road	unknown	599.7	604	4.30	Arkansas River FIS

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 emergency response agencies, presenting various challenges to the agencies, in addition to the hazardous conditions and often dangerous work their personnel perform. When streets are flooded, law enforcement and fire personnel are stationed at intersections to ensure the safety of motorists who may try to enter these barricaded areas. Rescuing people stranded in cars or swept away by floodwaters can be as hazardous to public safety personnel as it is to the victim.

4.1.4 Flood Scenario

The worst case flood scenario for Bixby is an event similar to the 1986 flood (see above) caused by torrential rains and forced emergency releases from Keystone Dam. The emergency releases of 1986, which were gradually raised to 300,000 cfs by the Corps of Engineers over a period of several days, resulted on October 5 in a flood of record on the Arkansas River at Bixby of 25.21 feet. Damages caused by the event were $63.3 million in Tulsa County, and $13.4 million in Bixby. These damages are reflected in Table 4-13, and are shown in the map in Figure 4-7.



LEGEND

- Overtopped Bridges
- Major Streets
- Highways
- City Limits
- Fenceline

Flanagan & Associates, LLC Planning Consultants

1 inch equals 8,375 feet

SEAL OF THE CITY OF BIXBY 1906 GARDEN SPOT OF OKLAHOMA

Figure 4-6

City of Bixby

Overtopped / Inadequate Bridges

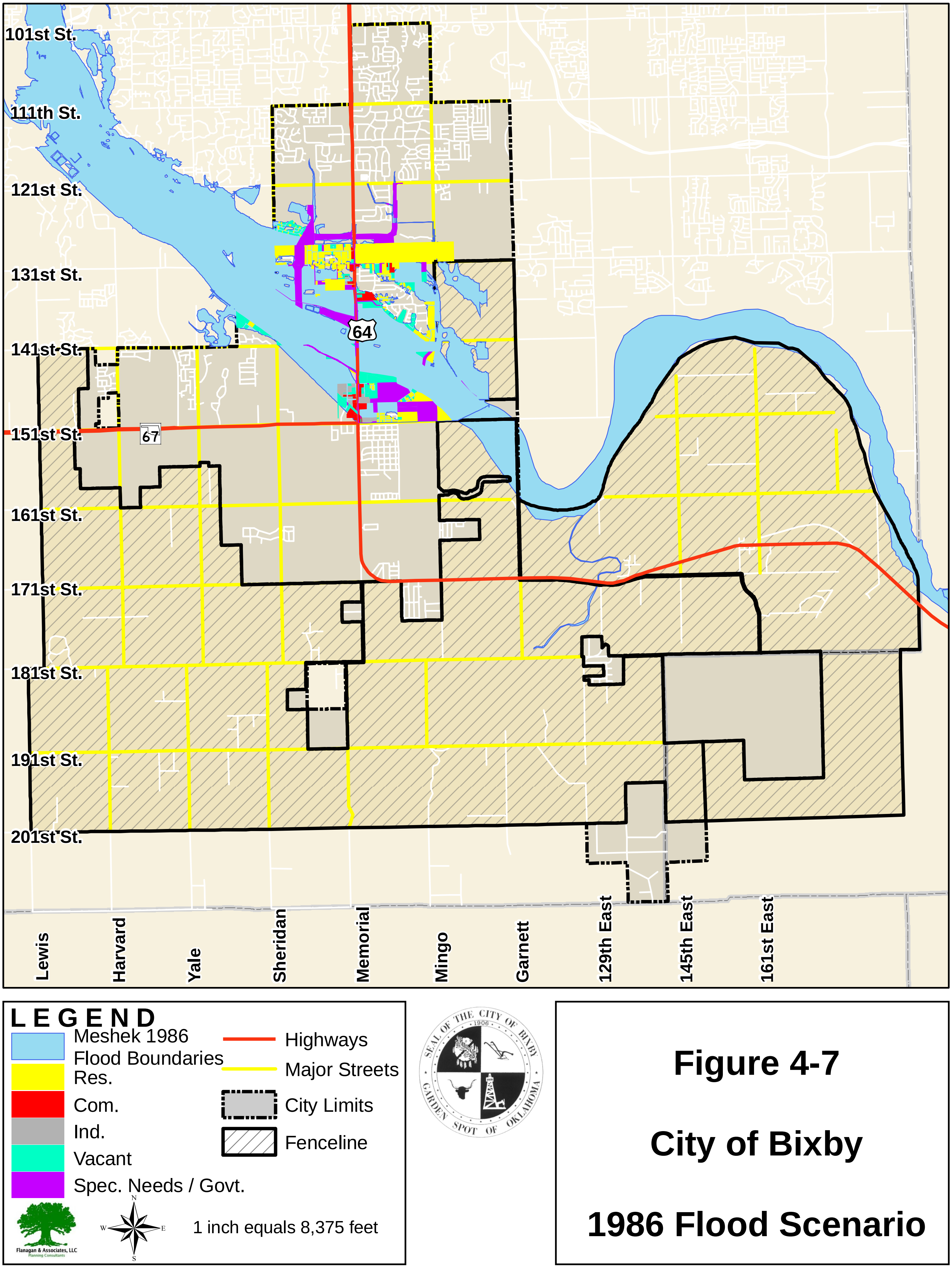
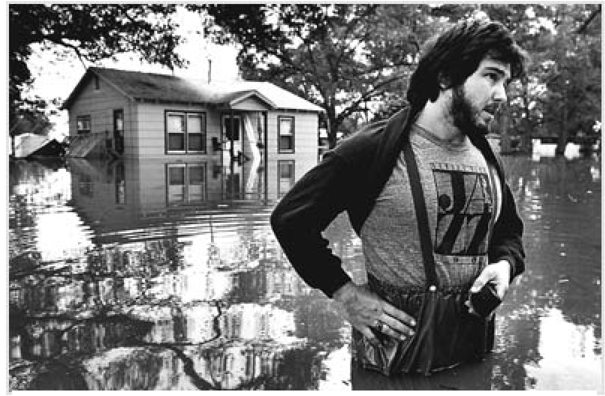


Figure 4-7

City of Bixby

1986 Flood Scenario

Scenario



A citizen of Bixby surveys the damage to his property from the 1986 flood.

Torrential rains drop 20 to 25 inches of rain on northeastern Oklahoma between September 28 and October 4. Although the flood pools of the region's reservoirs were empty on September 23, by October 4 every reservoir in the region is full, forcing emergency releases into rain-swollen rivers. Bixby was already experiencing flooding along Snake Creek on the south side of the Arkansas River on September 29-30 and on Haikey Creek on the north side. As the storm worsens, the Corps of Engineers activates its EOC, distributes over 500,000 sandbags to threatened communities, loans water pumps to Sand Springs, Jenks and Bixby, and sends out liaison officers to the major cities downstream, including Bixby. The storm is made worse by the arrival on October 4 of massive amounts of moist air from the remnants of a hurricane in the Gulf of California. Both the Arkansas and Cimarron Rivers begin to report floods of record above Keystone Dam. With 350,000 cfs surging into an already full Keystone Lake, the Corps of Engineers is forced to open the floodgates and begin releasing 300,000 cfs on the afternoon of October 4. The resulting downstream flooding along the Arkansas River Corridor is extensive. One Arkansas River levee in Sand Springs is breached. Garden City in West Tulsa is again flooded to the rooftops, and low-lying homes along the river in northwest Tulsa are standing in 6 feet of water. Bixby, which, as noted, was already experiencing flooding in the days preceding the release, is inundated.

Table 4–13: 1986 Flood Scenario Damages

Parcel Count	Assessed Value	Structure Damage (25%)	Contents	Contents Damage	Total Damage
Residential Parcels					
397	$26,295,487	$6,573,872	$13,147,744	$3,286,936	$9,860,808
Commercial Parcels					
46	$10,009,394	$2,502,349	$10,009,394	$2,502,349	$5,004,698
Industrial Parcels					
34	$4,441,304	$1,110,326	$4,441,304	$1,110,326	$2,220,652
Tax Exempt Parcels					
64	-	-	-	-	-
Other (VP, 300)					
226	-	-	-	-	-
Scenario Total					
767	$40,746,185	$10,186,546	$27,598,442	$6,899,611	$17,086,158

4.1.5 Future Trends

For a map of future development areas, and their relationships to the floodplains, see Figure 1-17.

As stated in Chapter 1, Bixby is one of the fastest growing communities in Tulsa County, with a growth rate of 4.04%. This growth has primarily taken place north of the Arkansas River, because of the large floodplain on the south side. Much of the existing development in the south pre-dates FEMA's FIRM (Flood Insurance Rate Maps) maps.

Bixby's Comprehensive Plan (2002) discourages development in flood-prone areas—a policy supported by the City's Floodplain Regulations (City Code Title 13), and the community's strict drainage standards and stormwater control measures.

The area from 101st Street S. to 111th Street S. between Memorial Dr. and Mingo Rd. has experienced prime residential and commercial development, as has the area between 111th St. S. and 121st Street S., and between Sheridan and Garnett Rd., with commercial focused along Memorial Dr. and residential in other areas. Development from 121st St. S. to the Arkansas River has historically been limited, due to restrictions on development in the floodplain. However, development in this area has picked up since the completion of the Corps of Engineers' Fry Ditch Project.

Some development is now taking place south of the river to the west of the low-lying "Old Town Bixby" and out of the reach of floodwaters. This area, between Yale and Sandusky Ave., and between 141st and 151st St. S., was originally tagged for commercial and industrial development, but residential uses have predominated.

Table 4-14 shows values of floodplain properties within the fenceline of the City of Bixby that may be annexed in the future.

Table 4–14: Floodplain Property Data for Future Development Areas/Trends

Type	Number of Parcels	Improvement Value	Contents Value	Total Value
Residential	162	$15,967,147	$7,983,574	$23,950,721
Agricultural	123	$546,400	$273,200	$819,600
Commercial	1	$0	$0	$0
Industrial	1	$227,925	$227,925	$455,850
Vacant (Undeveloped Parcels)	21	-	-	-
Special Populations / Govt.	6	$0	$0	$0
Total	316	$16,844,472	$8,534,698	$25,379,170

Population

With more recreational opportunities being developed along the banks of the Arkansas River, there will naturally be an increase in population taking advantage of those areas. Many times, people who are unfamiliar with waterway recreational areas are unaware of the dangers of swiftly moving waters. In times of heavy rains and flood conditions in the Bixby area, the Arkansas River flows at a much deeper level, producing a swifter and stronger current, even along the banks. A combination of all these factors equates to an increase in the number of those vulnerable to the secondary flood risk of wading in to or getting too close to swift moving waters.

News reports have proven that even with an aggressive campaign designed to alert people to the dangers of flash floods, there are those who will continue to defy the odds and attempt to drive through standing water on roadways. Without stronger penalties for violating road barriers and warning signs, this trend will most likely continue to put such 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. The reduction of the earthen footprint in the community can potentially create water run-off to another area that was previously at low to no risk for flooding.

Additionally, development in areas along the outer perimeters of the City's boundaries that have been identified as potential flood risk areas could have a substantial impact on the integrity and capacity of existing drainage systems. Current systems are frequently overwhelmed during events that produce slow-moving heavy volume rainfall because of shear volume or the presence of debris present in the storm drains. An aggressive and ongoing public awareness program should be maintained to ensure new and existing development comply with ordinances and policies in place that are designed to address this issue.

City officials have demonstrated awareness and concern in protecting the integrity of stormwater management in recent events, and should be supported in continuing this diligence in all future development efforts.

Critical Facilities

With Bixby's strong commitment to maintaining current floodplain zoning guidelines, it is not anticipated that any new development of critical facilities will occur within these types of areas of currently undeveloped sections of the jurisdiction.

Any renovations or improvements made to existing critical facilities in floodplains should be evaluated to ensure the prescribed improvements assist in the mitigation of potential damages to these facilities in the event of a flood.

Infrastructure

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Currently, the City of Bixby's most likely ongoing threat from flooding would be a flash flood event. During a storm event that is producing a large amount of rainfall over a short period of time, it is highly likely that several roadway intersections will become impassable due to water over that roadway. With this in mind, plans being developed or implemented for street/roadway improvements within the jurisdiction should take these potential conditions into account.

4.1.6 Conclusions

Over recent years, progress has been made in protecting the lives and property of Bixby's citizens from flooding, but much work remains to be done to make the city flood-safe. It is important that Bixby residents avoid being lulled into a false sense of security that could make them vulnerable to unanticipated flood events.

Because of the number of streams that run through the city, the seasonal thunderstorms that dump massive amounts of rainfall in brief time-spans, the presence of aging levees and a high hazard dam upstream on the Arkansas River, and the community's history of flooding, Bixby and Bixby Public Schools continue to have a High Risk to frequent moderate flooding and have the potential for infrequent catastrophic flooding.

To protect citizens, property, and the community from flooding, this study has identified several flood mitigation measures to be implemented, which are discussed in Chapter 6 and Appendix B.

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.

Update Changes

Identified significant changes made from the 2004 City of Bixby Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.1.7 Sources

Extreme Weather and Climate Events at National Climatic Data Center website: www.ncdc.noaa.gov/oa/climate/severeweather/extremes.html

FEMA Flood Insurance Statistics at Website: www.fema.gov/nfip/10110309.shtm

FEMA Flood Insurance Study, Tulsa, Oklahoma, Tulsa County. FEMA, Revised May 4, 1998.

4.2 Tornadoes

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

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.

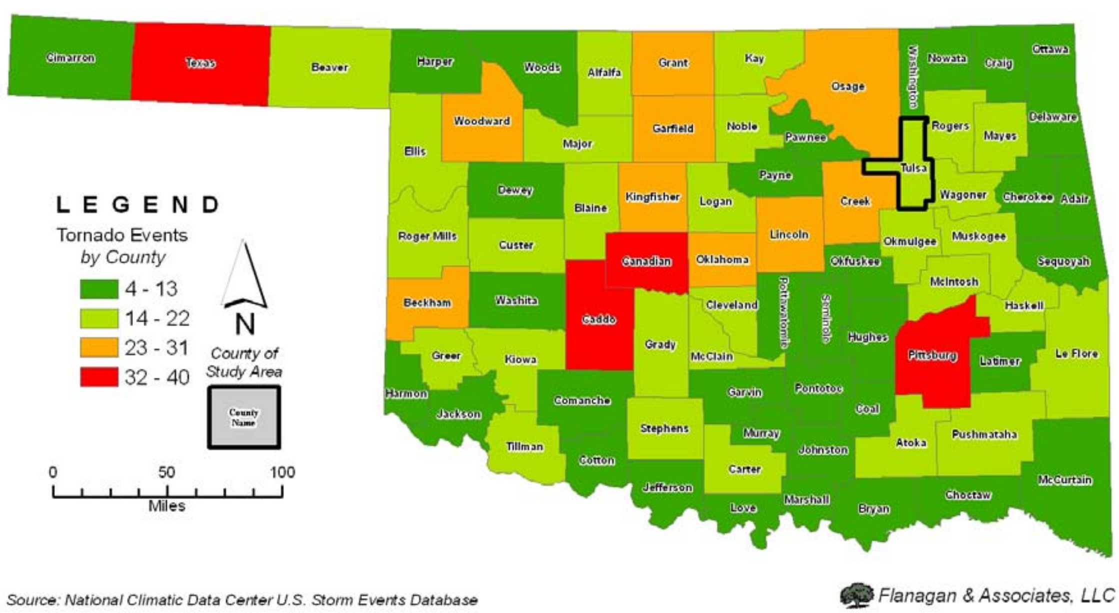
4.2.1 Hazard Profile

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.

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 the City of Bixby is considered to be vulnerable to the effects of a tornado event. See map below for the number of tornado events per county in Oklahoma.

Figure 4–8: Tornado Events in Oklahoma from 1989-2008



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 4-15. 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 are caused by F4 and F5 storms, which represent only 1% of all tornadoes.

Extent (Magnitude/Severity)

The City of Bixby may experience a tornado ranging from EF0 to EF5.

In the National Weather Service's ranking of the Top Ten Costliest Oklahoma Tornadoes (1950 – 2008), the Tulsa area 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 Storm Prediction Center's 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 were adjusted to reflect 2007 dollars.

The NCDC's ranking of the 25 Deadliest U.S. Tornadoes shows two entries for Oklahoma. The Woodward Tornado of April 9, 1947 is ranked 6th, with 181 fatalities and 970 injuries, and the Snyder Tornado of May 10, 1905 is 18th, with 97 deaths.

Oklahoma's neighbors to the north, south and east (Kansas, Texas and Arkansas) share in this rich environment for deadly and destructive tornado events and often share the effects of the same storm systems.

On April 21, 1996, Fort Smith, AR was hit by an F3 tornado that struck in the dead of night with no warning. The result was 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 twister 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, on May 4, 2007, Greensburg, KS was hit by an EF5 tornado at 9:45 p.m. CDT. 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 have been destroyed, with the other five percent severely damaged. The National Weather Service estimated winds of the tornado to reach 205 mph (330 km/h). This was the first tornado to 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.

Table 4–15: 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

Bixby considers a minor severity tornado 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 1989 – 2008, the National Climatic Data Ctr. reported 1,234 tornadoes (an average of 61.7 tornadoes each year) for Oklahoma, with 20 of these in Tulsa County (an average of 1 tornado every year). In the state, 17 of those events received Federal disaster declarations. Oklahoma experiences more tornadoes each year on average than does any other state except Texas, which has twice as many, but is also more than twice the size of Oklahoma.

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 between 1950 and 2008, 1,132 occurred in May and 605 in April. It is important to point out that there are tornadoes reported in every month of the year during that period.

Figure 4–9: Historical Tornado Paths in Tulsa County 1950-2008

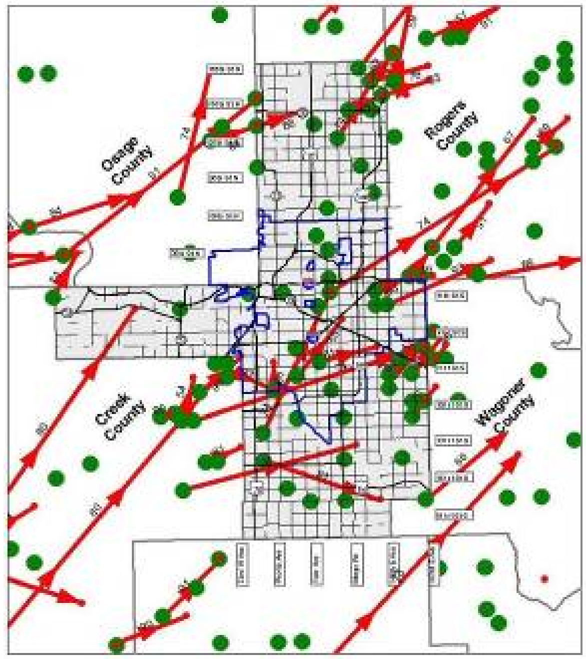


Table 4–16: Tornadoes in Oklahoma and Tulsa County from 1995 thru 2009

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 – 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

Since the starting or ending point of many tornadoes are not observed, it is not always possible to isolate whether tornadoes occurred within specific City Limits.

The City of Bixby has been affected by two tornadoes in the last 58 years, the first on June 8, 1974, which did $250,000 in damage, and the second on April 19, 1981, which resulted in 5 deaths, 49 injuries, and $2,500,000 in damage. Between 1995 and the end of 2009 Tulsa County experienced 13 tornado events (several of which may have had multiple tornado touchdowns).

Impact

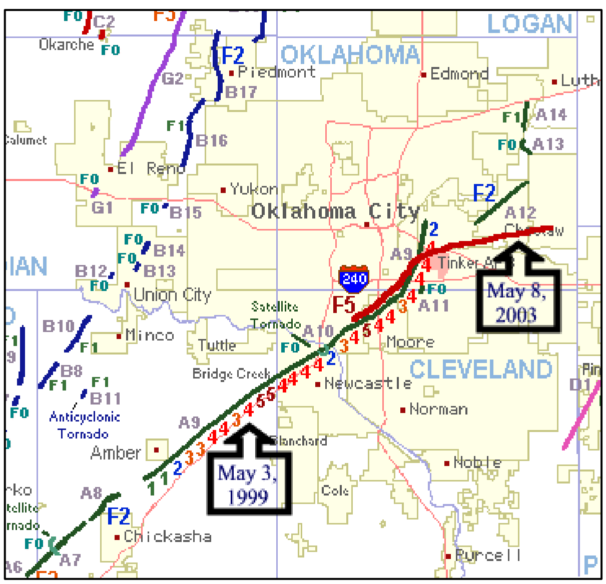
The impact of this hazard occurs during times of severe storms. Storms that generate tornadoes also have the ability to cause lightning, hail, high winds, and flooding damage. This can result in the direct loss of homes, businesses, and lives and indirectly cause the loss of income, medical care, and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

4.2.2 History/Previous Occurrences

Oklahoma has a long history of deadly and destructive tornadoes. Some of the more notable of these events include:

May 5, 1960- Three separate tornadoes killed a total of 26 people. An F-5 tornado reportedly touched down in southern Creek County, traveled 29 miles northeast traveling across the City of Sapulpa. No injuries or deaths occurred, but $2.5 million in property damages were accrued throughout the county.

Figure 4–10: May 1999 Tornadoes and May 8 Tornado Path through Moore, OK



The May 3, 1999 tornadoes caused over $1 billion in damage. The May 8, 2003 tornado caused $100 million in damage

June 8, 1974- Eighteen fatalities – including three in Tulsa - and damage to 1,400 buildings occurred when 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.

May 3, 1999- A series of severe thunderstorms from the southwest produced several tornadoes that intensified as they moved across the state. One of the tornadoes in the outbreak was an F5, which occurred southwest of Oklahoma City, was measured at 318 mph, and stayed on the ground about four hours, leaving a path approximately thirty-eight miles long. 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.

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. Oklahoma's Department of Emergency Management reported that 3,009 homes, 117 businesses, and 10 public buildings were destroyed, including 645 in Oklahoma City, 6 in Bixby and 95% of Mulhall. Sixteen counties were declared Federal disaster areas.

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.

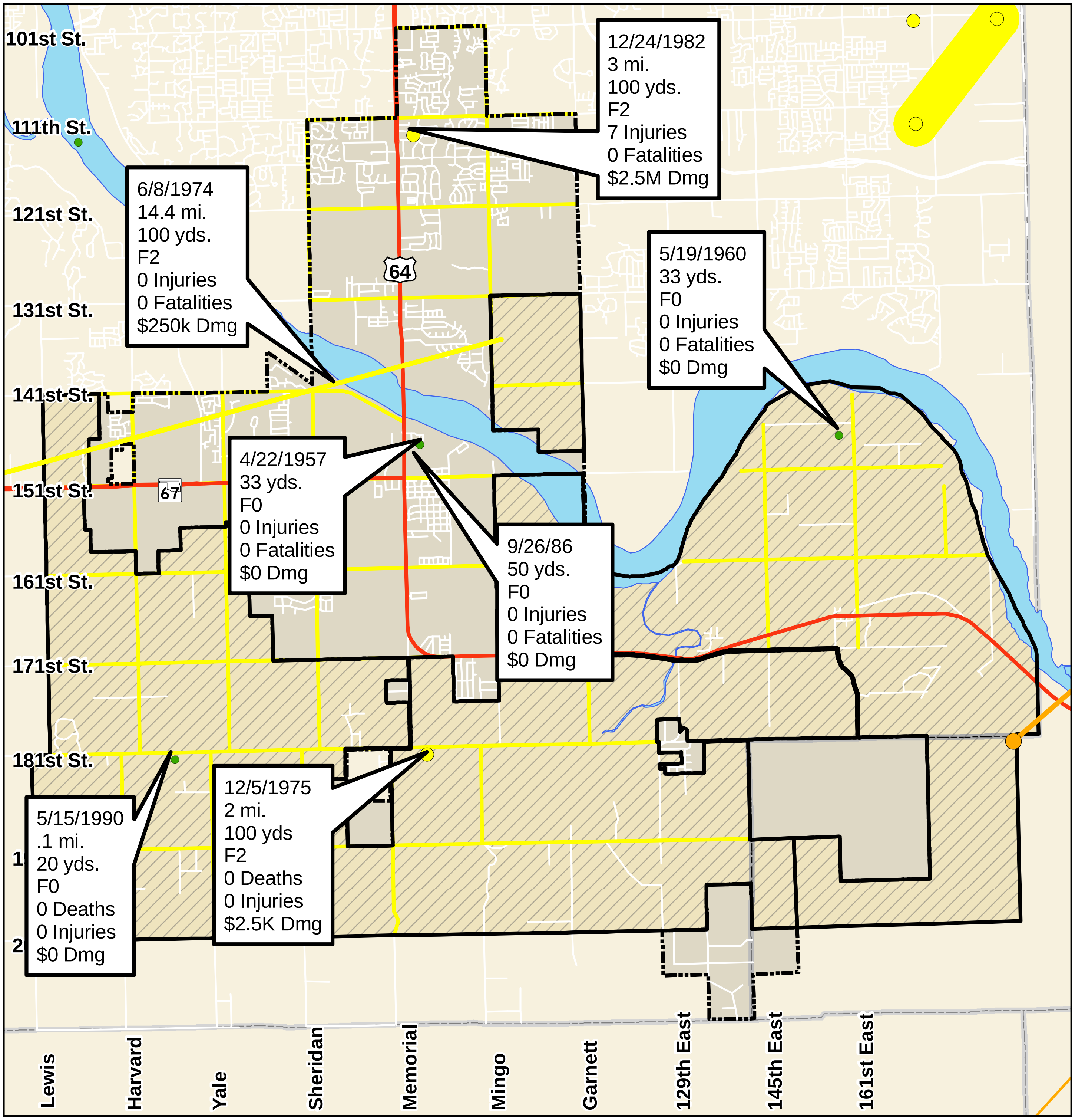
March 8, 2010 – A tornado hit Hammon, OK destroying 5 homes and a county barn.

Bixby Historic Tornado Events

NCDC data show 63 tornado events for Tulsa County between 1950 and 2008, killing eight people, injuring 234, and doing $369.5 million in damage. Of these tornadoes, 24 were recorded as F0, 16 as F1, 14 as F2, 7 as F3 and 1 as F4. The event that had a direct impact on the City of Bixby has little information recorded, but was described by the National Climatic Data Center as occurring on July 4th, 1995 at approximately 4:00 pm. It was approximately 30 yards wide, at F0 intensity, produced no casualties, and caused $1,500 in reported property damage.

The following is a list of tornadoes that, at some point, were seen or touched down within Bixby's fenceline. (It should be noted that this list was taken from the NCDC database, which is somewhat sketchy in its depiction of events, often with only one coordinate given without specifying if this was the tornado's start or end point, or in what part of the path damage occurred.)

- **April 22, 1957 –** An F0 tornado was sighted at 147th St. S. and east of Memorial Dr., No Damage was done.



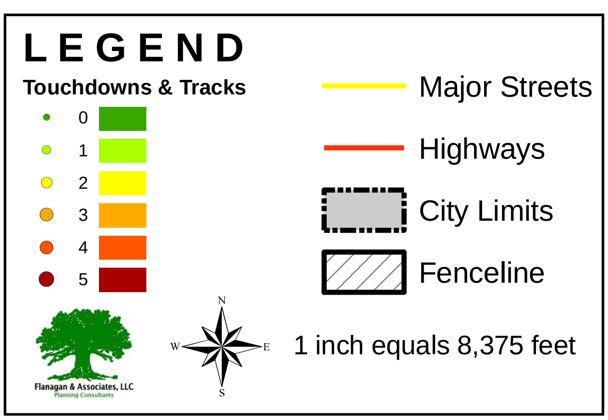


Figure 4-11

City of Bixby

Historic Tornadoes

- **May 19, 1960 –** A small tornado was sighted at 146th St. S. and 161st E. Ave. No damage.
- **December 5, 1975 –** An F2 tornado, 100-yards wide and 2 miles long, touched down just southeast of 181st St. S. and Memorial Dr., doing $2,500 in damage.
- **April 19, 1981 –** An F3 tornado 10 miles long and 880 yards wide touched down in Glenpool and lifted at Bixby near 129th E. Ave. and 181st St. S., killing 5 people, injuring 49 and doing $2.5 million in damage.
- **December 24, 1982 –** An F2 tornado 3 miles long and 100 yards wide touched down near 112th St, S. and Memorial Dr., causing 7 injuries and $2.5 million in damage.
- **September 26, 1986 –** An F0 tornado, 50 yards wide, touched down near 146th St. S. and Memorial Dr., doing no damage.
- **15 May 1990 -** An F0 twister, 20 yards wide, sighted at 181st and S. Lewis. No damage reported.
- **July 4, 1995 –** An F0 tornado, 30 yards in width, hit 5 miles west southwest of Bixby, doing $1,500 in damage.

Probability/Future Events

Bixby 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 have, appeared in 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.

Bixby and Bixby Public Schools have a low probability of a future tornado event.

4.2.3 Vulnerability

This section summarizes information about Bixby's vulnerability to tornadoes, including the impact on people, structures and buildings, critical facilities, and infrastructure. This information, as well as information provided by the City and Public Schools, was used to determine the Vulnerability Criteria identified in Tables 4-2 and 4-3. The National Weather Service advises that tornadoes strike at random. The City of Bixby and Bixby Public Schools were determined to be at High Risk to the Tornado hazard. (See Tables 4-2, Hazard Risk Analysis, and Table 4-3, Summary of Hazard Risk Analysis Ranking Criteria for an explanation of how the rankings were derived.).

Population

Table 4-17 shows the numbers of tornado-related fatalities in the United States for the 10-year period from 1999 to 2008 and where the deaths occurred. It illustrates that those living 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, nearly 45% of all tornado deaths during that ten-year period occurred in mobile homes.

Table 4–17: Tornado Fatalities in the United States from 1999 - 2008
Source: National Weather Service Storm Prediction Center

Year	Home	Mobile Home	Business	School	Vehicle	In the Open	Other	Total for Year
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
2005	4	32	0	0	1	1	0	38
2006	16	22	0	0	3	2	24	67
2007	16	52	10	0	2	1	0	81
2008	43	56	10	0	14	3	0	126
Totals	***194***	***308***	***36***	***1***	***39***	***25***	***28***	***631***

Not to be dismissed is the number of tornado-related deaths in vehicles. While a relatively small number in recent years, 2008 is shaping up to be comparable to 1998 in numbers. According to NOAA's Storm Prediction Center in Norman, OK, by June 15, 2008, 115 deaths had been recorded for the year – making it the deadliest year since 1998. Fourteen of these individuals were killed while in their vehicle. This statistic and alarming trend places individuals traveling in their vehicles during threatening weather at increased risk.

Also at an increased risk for these events are members of the hard-of-hearing/deaf community, people for whom English is not their primary language and those without access to broadcast media messages (television or radio) alerting them of approaching severe weather. While much progress has been made in expanding communication resources for these individuals, there are still a large number of residents facing these challenges unable to receive vital warnings in a timely manner.

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 susceptible to lift, and the way foundations and roofs are constructed 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 tornado damage. Wind-driven debris (wood, metal, other 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 the City of Bixby and Bixby Public Schools jurisdiction 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 impacts, such as power disruption, water damage from accompanying rain, injury to workers / residents / students, etc. For a complete list of critical facilities for the City of Bixby, see Table 1-12.

Infrastructure

Water Treatment – The most significant impact from a tornado would be the loss of electrical power. The City of Bixby is serviced by the water treatment plants in nearby Tulsa. Each of Tulsa's two water treatment plants features dual electrical feeds, which supply power from independent substations. Additionally, these two plants are located in separate geographic areas of the city, which reduces the likelihood of both plants being affected by the same event.

Wastewater Treatment – The most significant threat to the operation of Bixby's wastewater treatment lagoons from a tornado would be power outages.

Utilities- The primary utility providers for Bixby's jurisdictions are AEP/PSO (electricity) and ONG (natural gas). The service stations and substations for both of these providers would be vulnerable to damage by a tornado. **Electricity:** During a tornado, providers of electrical service could experience any combination of the following challenges in meeting the needs of Bixby's jurisdictions: Destruction of distribution and transmission poles, downed broken power lines, danger to civilians or work crews from downed power lines, and fallen debris from trees, or insufficient field and/or office staff to effectively handle the workload. **Gas:** During a tornado, providers of gas service to a community could be challenged to meet the needs of the Bixby jurisdiction because of falling power lines or tree debris; inaccessibility to underground gas meters from fallen debris; downed power lines, extreme temperatures, insufficient field and/or office staff to effectively handle workload generated by the event.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Flight delays cost an average of $3.2 billion annually for air carriers in the United States. Tornado conditions could result in the interruption of normal operations at Tulsa's International Airport and the private business airports that provide air transportation services to Bixby. Small airports, hangers and aircraft are also at risk from tornadoes, as shown by the twisters that hit Tinker Air Base and Ada Municipal Airport in March 1948 and April 1973, respectively.

Emergency Services – Fire, Police and Medical Services would all be similarly at risk to secondary effects of a tornado. Downed power lines or debris blocking city streets could limit or eliminate access to affected areas. Excessive debris in the streets could lead to damage to emergency vehicles, potentially reducing the number of vehicles available for response. Medical Services (including treatment facilities) could be strained in responding to large numbers of injuries.

4.2.4 Tornado Scenario

A typical tornado path is reported to be approximately 600 feet in width, and 2.5 miles in length. The typical path in Oklahoma runs generally from southwest to northeast with the area of destruction being about 181 acres per event. Approximately 16 mi² of Oklahoma's 69,919 mi² are impacted by tornadoes each year. The yearly chance of a tornado of any magnitude hitting any location in Bixby, for example, is roughly .02%. Bigger and more devastating tornadoes can and do occur, as evidenced by the 1999 Oklahoma City tornado, which stayed on the ground for 38 miles. However, these events are much rarer. The chance of an F4 or F5 striking an area is less than .01% per year.

Bixby Tornado Scenario

To anticipate the damage from a "worst case" tornado event, a portion of Tornado A9 from the Oklahoma City tornado outbreak of May 3, 1999, was placed through the center of the community. An additional scenario shows a tornado placed through the northern residential areas. Shown in Figure 4-12, the tornado scenarios would affect both downtown critical facilities and a major portion of Bixby's residential area.

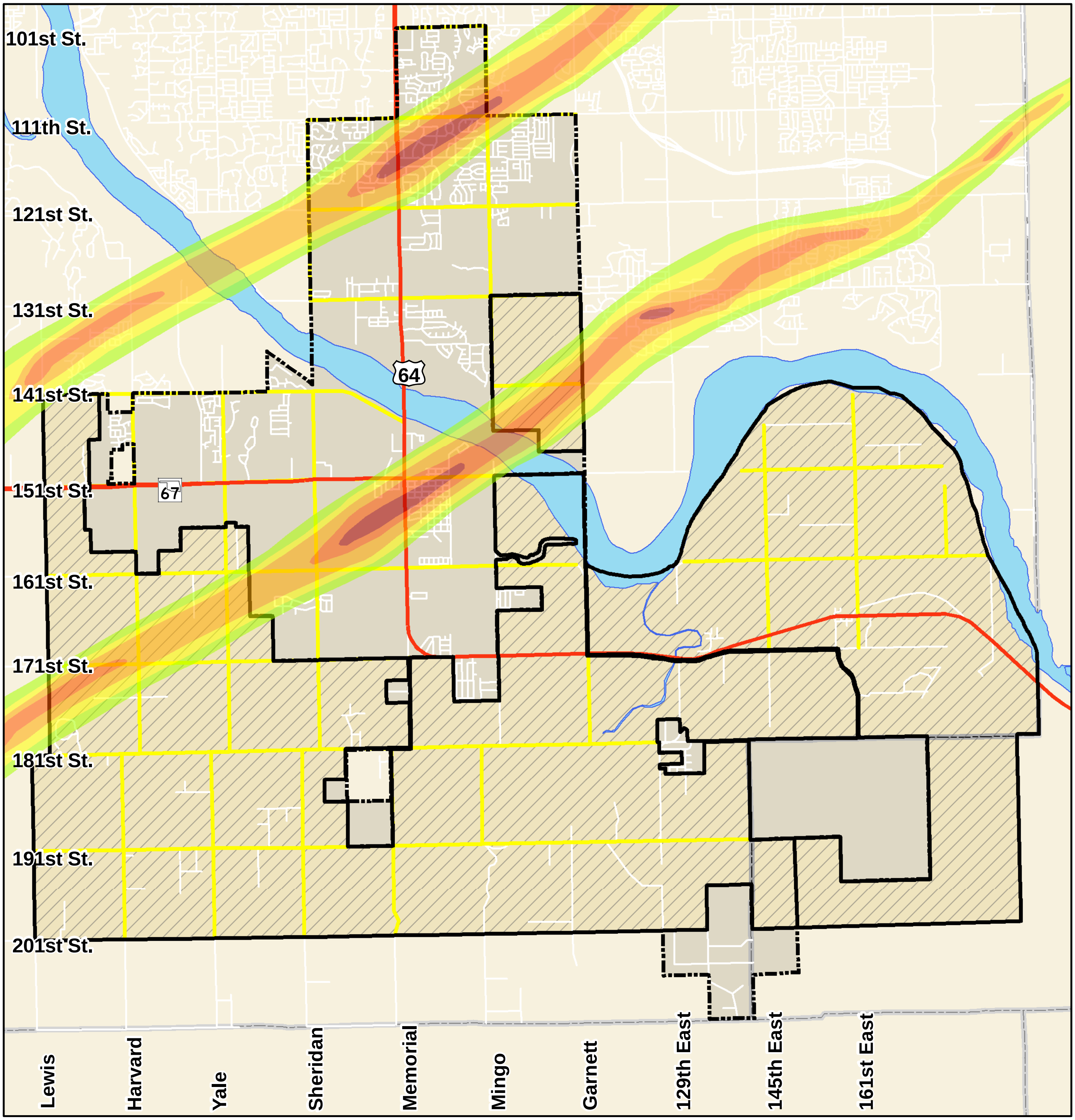
The damages from the events are listed in 4-18a and 4-18b. Damages in the tornado path, including buildings and contents, approached $46 Million in the Southern Bixby scenario, and $201 Million in the Northern.

Table 4–18a: Bixby Tornado Scenario - North

F-Scale	Market Value	Damage Factor	Structure Damage	Contents Value	Contents Damage	Total Damage
1	$60,837,874	.10	$20,978,605	$3,041,894	$266,951	$21,245,556
2	$41,908,142	.40	$16,763,257	$8,381,629	$3,352,651	$20,115,908
3	$60,984,797	.80	$48,787,829	$24,393,915	$19,515,132	$92,696,875
4	$28,061,253	1.0	$28,061,253	$14,030,627	$14,030,627	$42,091,880
5	$16,713,532	1.0	$16,713,532	$8,356,766	$8,356,766	$25,070,298
Totals	$208,505,588		$131,304,476	$58,204,829	$45,522,127	$201,220,517

Table 4–18b: Bixby Tornado Scenario - South

F-Scale	Market Value	Damage Factor	Structure Damage	Contents Value	Contents Damage	Total Damage
1	$13,899,922	.10	$1,389,992	$693,996	$34, 700	$1,424,692
2	$12,407,844	.40	$4,963,137	$2,481,569	$496,314	$5,459,451
3	$13,099,849	.80	$10,479,879	$5,240,120	$2,096,048	$12,575,927
4	$8,546,735	1.0	$8,546,735	$4,273,368	$4,273,368	$12,820,103
5	$7,622,081	1.0	$7,622,081	$3,811,041	$3,811,041	$11,433,122
Totals	$55,576,431		$33,001,824	$16,500,912	$10,711,471	$43,713,295



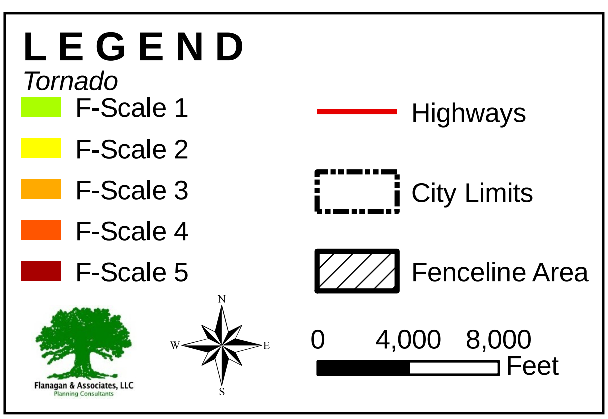


Figure 4-12

City of Bixby

Worst Case Tornado Scenarios

4.2.5 Future Trends

Although historically Bixby and Bixby Public Schools have presented a relatively small target for tornadoes to strike, as the City and its school system grow, the probability of a tornado hitting the jurisdictions will certainly increase.

Population

As the “baby-boomer” population begins to move more aggressively into retirement, it could be anticipated that the number of people pursuing outdoor sports and/or social activities could also increase. Attention should be given to the task of ensuring continuing the process of educating the community of the dangers associated with tornadoes. Also adding to this increase in out-of-doors activity could be the ever changing and challenging economic climate. With more families looking for activities closer to home, parks and other outdoor recreation areas may become more attractive. These facilities, and the persons frequenting them, should be considered especially vulnerable to the effects of tornado events.

Technological advances in mobile entertainment could also factor into the increase of already escalating number of tornado-related fatalities in automobiles. An ever-increasing market in satellite radio is making it possible for more drivers to enjoy non-local network radio programming – thus adding to the “disconnectedness” of those driving during severe weather conditions. Additionally, more devices allowing the interface of personal MP3 devices with automobile radios are becoming more affordable which in turn allows more drivers to listen to their own selection of music while traveling – again, decreasing the amount of localized and vital information that may be transmitted over the airwaves.

Structures/Buildings

As uninhabited areas continue to be developed and existing structures are renovated to accommodate new purposes in their use, actions to lessen the potential effects of tornado events should be considered. The inclusion of certified Safe Rooms, reinforced exterior materials (windows, doors, etc.), reinforced skeletal structure of new buildings able to withstand the effects of high winds accompanying the strongest of storms, etc., should be considered an integral part of this development. Additionally, location of outdoor warning systems (sirens) should be noted and considered when possible in any new development plans.

Critical Facilities

As the threat from the effects of tornado events themselves cannot be eliminated, any critical facilities undergoing expansion, renovation or rebuilding should consider following updated techniques for such projects. The addition of certified Safe Rooms, reinforced exterior materials such as windows, doors, siding, etc. can do much to improve the safety of critical facilities. Additionally, all efforts to guard against potential secondary effects should also be implemented. These secondary effects may include, but not be limited to, compromise of structural integrity, broken windows/doors from wind-strewn debris, water damage from accompanying rains, power interruptions/surges and communication interruption from lightning or wind damage.

Infrastructure

Ensuring local government facilities are well protected against the potential effects of tornado events is an on-going endeavor. Investigating and implementing new technology as it is made available will help ensure the continuity of operations at all levels of operation – uninterrupted communications and protection of the ever-growing mountain of electronic data gathered in day-to-day operations should be considered priorities in any plans developed for future development.

4.2.6 Conclusions

Due to the nature of Bixby's climate, severe thunderstorms and tornadoes will remain a threat to the City of Bixby and Bixby Public Schools, and their risk should be considered high. The absence of recent, reported tornados should not be considered an indication of a reduction in that risk; but as opportunity for educating, preparing for and fortifying against such an event. 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.

Data Limitations

There are many "intangibles" in tornado spotting. Low hanging "scud" clouds may be mistaken for a lowering funnel. Tornadoes are frequently reported more often near inhabited areas and major highways, due to the greater likelihood of people being present when a tornado appeared that caused little or no damage. In addition, there is frequently disagreement on whether wind damage was caused by a tornado or just severe straight-line winds or downdrafts. Therefore, fully accurate reports of number of tornadoes or tornado damage may be skewed by these factors.

Update Changes

Identified significant changes made from the 2004 City of Bixby Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.2.7 Sources

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National Weather Service Storm Prediction Center, at Website:
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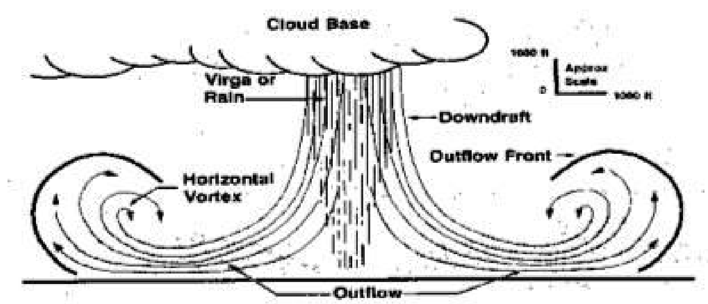
4.3 High Winds

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 to 12 mph, with frequent speeds of 50 mph and occasional wind speeds of greater than 70 mph. Tropical cyclone winds along coastal areas from Texas to Maine may exceed 100 mph.

Figure 4–13: Microburst Diagram



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

4.3.1 Hazard Profile

Location

Bixby and Bixby Public Schools is at risk from damaging winds. Winds are always part of severe storms, but do not have to accompany a storm to be dangerous.

Down-slope windstorms, straight-line winds, derechoes (a widespread and long-lived, violent straight-line windstorm that is associated with a fast-moving band of severe thunderstorms), and microbursts (a very localized column of sinking air, producing damaging straight-line winds that are similar to but distinguishable from tornadoes) can all cause death, injury, and property and crop damage.

Measurement

While there are several scales that measure wind speeds besides the Fujita and Enhanced Fujita scales (described in the preceding Tornado section), the most appropriate for the purposes of Oklahoma plans would be the Beaufort Scale of Wind Strength. The City of Bixby and Bixby Public Schools may experience a wind force of 9-12, as measured on the Beaufort Scale shown in Table 4-19.

Bixby 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.

Extent (Magnitude/Severity)

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 (*FEMA Multi-Hazard Identification & Risk Assessment Guide, 1997*). Out of the primary sources of high winds, severe local windstorms accounted for 51.3% of the expenditures. See Table 4-20 for data related to casualties and damages caused by high wind events.

Cladding damage, especially glass damage, is not only costly but 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 Bixby on June 6, 2006, can topple trees, damage houses and power lines, and break up sidewalks and streets

Table 4–19: Beaufort Scale of Wind Strength

Source: Huler, Scott (2004). ***Defining the Wind: The Beaufort Scale***

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

Frequency

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. In that 20-year period, deaths from winds 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.

Impact

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

4.3.2 History/Previous Occurrences

Historic High Wind Events

Since 1995, Tulsa County has experienced 317 high wind events, almost all connected to thunderstorm activity. Bixby has had 43 reported thunderstorm/high wind events in the last 15 years, with wind speeds ranging between 85-100 mph.

High winds generated by Oklahoma's spring and autumn storms can be devastating to older homes and mobile homes

April 26, 1999 – Thunderstorm winds up to 57 mph flipped a mobile home over near 181st Street and Yale Avenue. Damage was $20,000.

May 23, 1999 - Several trees were blown down near Mingo and 117th Street in Bixby.

November 22, 1999 – Large trees were blown down by winds as high as 80 mph in Bixby and South Tulsa.

August 1, 2003 - Thunderstorm winds estimated at 70 miles an hour blew down several trees and power lines, causing $10,000 damage.

August 12, 2003 - Thunderstorm winds estimated at 60 miles an hour blew power poles down.

July 9, 2004 – Thunderstorm winds estimated at 70 mph uprooted a tree in Bixby.

April 24, 2006 - A pole barn under construction, near the intersection of 6^{th} St. and Country Club Rd. was lifted and thrown over 8 city blocks. A storm survey in Bixby determined that a half-mile long damage path about 40 yards wide was caused by high winds. Damage to trees...homes...and other structures in the path was consistent with wind speeds of about 70 mph.

June 6, 2006 - A microburst with winds estimated at over 85 mph occurred at approximately 4:45am CDT. The Tulsa County Fairgrounds received an estimated $2.5 Million in damages – most notably the destruction of an 80-year old Ferris Wheel, and major damage to the roofs at the Trade Center and the Exchange Center. 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; four people were transported to the hospital for treatment of minor injuries.

October 17, 2007 - At approximately 7:23 pm, straight-line winds clocked in excess of 80 mph accompanying an energetic upper-level system caused 2 large and several smaller tents to collapse at the local Oktoberfest celebration. More than 7,000 people were in attendance at the time of the storm – a light attendance as it was the preview "corporate night". EMS crews arriving on scene treated 29 people with 24 being transported to local hospitals – 3 in critical condition. Authorities estimate that an additional 20-30 people self-transported to medical facilities seeking treatment. Damages were estimated at $100,000.

May 7, 2008 - Thunderstorm winds estimated to 60 mph blew down large tree limbs near 101st St. S. and Memorial.

Table 4–20: High Wind Events in Bixby 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*
Bixby	43	0	0	8	$142,000
Tulsa County	317	1	56	83	$8,243,000
Oklahoma	9,174	8	196	2,525	$959,603,000

Probability/Future Events

With 43 events recorded within the City of Bixby in a 15-year period, and 8 of those producing reported economic damages, it is apparent that this is a common event and we can expect on the order of 2-3 events a year, some with potential economic loss. Deaths and injuries are more likely in tornadoes, the most severe wind events, but even though recent wind events in Bixby produced no casualties, wind in larger Tulsa County produced 1 death and 56 injuries. Bixby and Bixby Public Schools have a high probability of a future high wind event.

4.3.3 Vulnerability

This section summarizes information about Bixby's vulnerability to high winds, including the impact on people, structures and buildings, critical facilities, and infrastructure. This information, as well as information provided by the City and Public Schools, was used to determine the Vulnerability Criteria identified in Tables 4-2 and 4-3.


A downburst did extensive damage in Midtown Tulsa on June 6, 2006

The Midwest is especially at risk from high winds because of the powerful thunderstorms that frequent the region. The City of Bixby and Bixby Public Schools were determined to be at High Risk to the High Winds hazard. (See Tables 4-2, Hazard Risk Analysis, and Table 4-3, Summary of Hazard Risk Analysis Ranking Criteria for an explanation of how the rankings were derived.)

Population

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 1-15 for Mobile Home Park Locations. However, as demonstrated by the October 17, 2007 Oktoberfest event in nearby Tulsa, those participating in outdoor activities in high-risk weather conditions are particularly at risk from wind-driven debris and falling or collapsing structures. Also facing increased risk are those operating motor vehicles during high-wind events. Higher profile vehicles (RV's, full-sized vans, semi's, etc.) are at greatest risk for turn-overs during these fast moving, strong wind events; smaller, lower profile vehicles are not as high risk, but can be moved from their designated lane of travel. It should be noted that anyone operating a vehicle at highway speeds during a sudden burst of high winds is at risk of losing control of their vehicle.

Structures/Buildings

Property damage from windstorms is 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.*

The glass-clad Bank One Tower, Fort Worth TX, following the March 2000 storms. (Photo by Doug Smith, AAWE)

Critical Facilities

All critical facilities within the City of Bixby jurisdiction 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 impacts, such as power disruption, water damage from accompanying rain, injury to workers/residents, etc. The City of Bixby's critical facilities are listed in Table 1-12, and are mapped in Figure 1–18.

Infrastructure

Water Treatment – The most significant effect during a high wind event would be the loss of electrical power. Both Tulsa water treatment plants supporting Bixby and Bixby Public Schools would be vulnerable to these risks, although both plants feature dual electrical feeds which supply power from independent substations. Additionally, these two plants are located in different geographic areas of the city, which reduces the likelihood of both plants being affected by the same storm.

Wastewater Treatment – The most significant threat to the operation of Bixby's wastewater treatment lagoons during a high wind event would be power outages.

Utilities – The primary utility providers for Bixby and Bixby Public Schools is 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 high wind event. **Electricity:** During a high wind event, providers of electrical service could experience any combination of the following challenges in meeting the needs of the Bixby jurisdiction: Destruction of distribution and transmission poles, downed broken power lines, danger to workers derived from downed power lines, and fallen debris from trees or insufficient field and/or office staff to effectively handle the workload. **Gas:** During a high wind event, providers of gas service to a community could experience a variety of challenges in meeting the needs of Bixby and Bixby Public Schools, such as: falling power lines or tree debris causing inaccessibility to underground gas meters; downed power lines, extreme temperatures, insufficient field and/or office staff to effectively handle workload generated by such an event.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Flight delays cost an average of $3.2 billion annually for air carriers in the United States. High wind conditions could result in the interruption of normal operations at Tulsa's International Airport and the private business airports that provide air transportation services to Bixby. At least eight fatal aircraft incidents since 1975 have been attributed to microbursts.

Emergency Services- Fire, Police and Medical Services would all be similarly at risk to the secondary effects of a high wind event. Downed power lines or debris blocking city streets could limit or eliminate access to affected areas. Medical services (including treatment facilities) could be strained in responding to large numbers of injuries such as those from the October 2007 high winds at the City of Tulsa Oktoberfest.

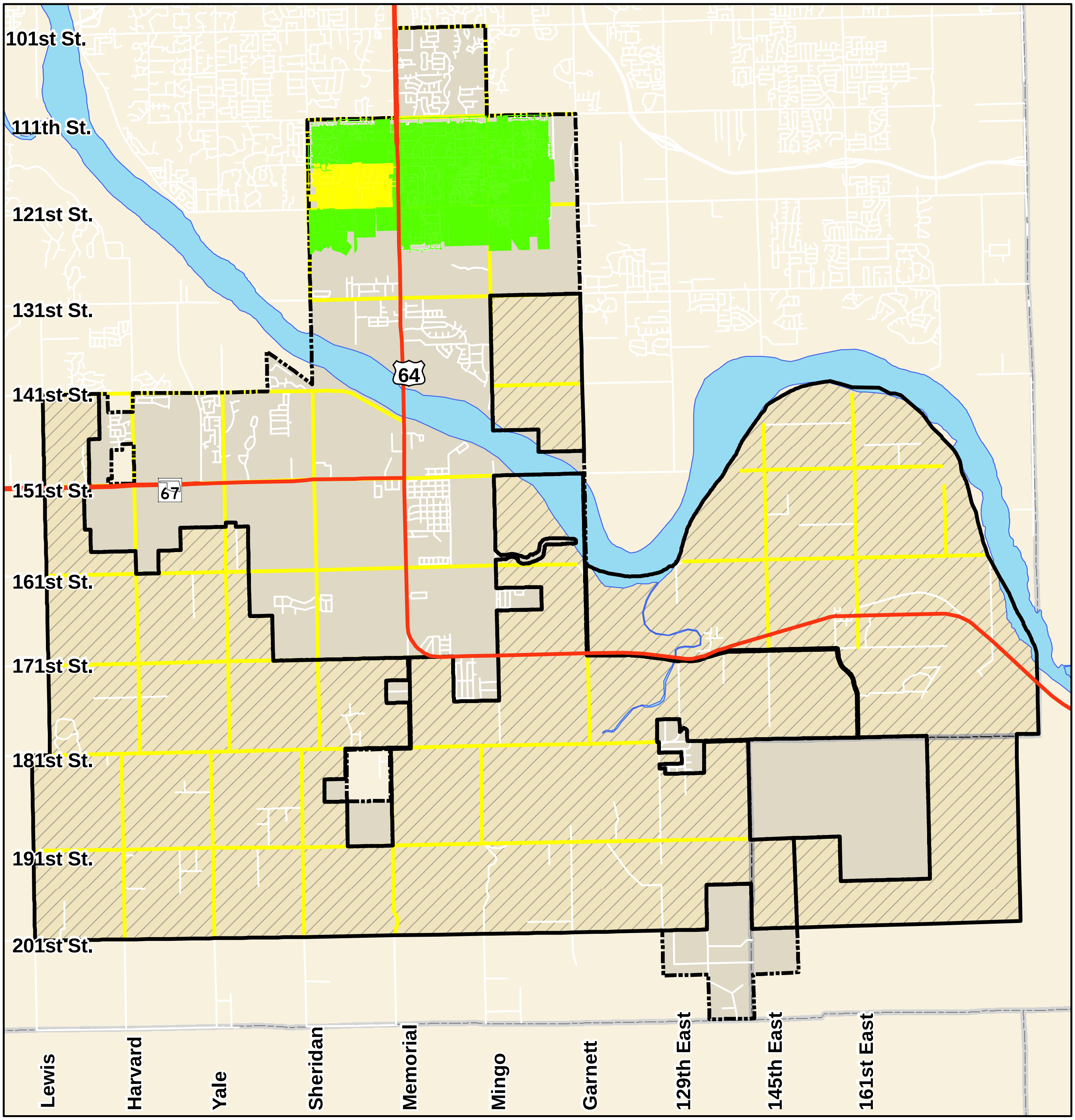
4.3.4 High Wind Scenario

Scenario

The microburst in Tulsa OK of June 6, 2006, at 4:45 am, with winds estimated at over 85 mph, could be considered a worst-case scenario for a high wind event anywhere in Tulsa County.

In that event, while it only lasted for minutes, 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 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. with the greatest damage in a ½ sq. mi area near the center of the downburst. Residential properties affected consisted predominately of 1930's – 1950's construction.



LEGEND

F0 Parcels

F1 Parcels

Highways

Major Streets

City Limits

Fenceline

Flanagan & Associates, LLC
Planning Consultants

1 inch equals 8,375 feet

Figure 4-14

City of Bixby

High Wind Scenario

By laying this storm footprint on a predominantly residential area in Bixby, damages detailed on Table 4-22 could be expected. In addition, expenses on infrastructure in the scenario could be similar to the City of Tulsa figures listed in Table 4-21:

Table 4–21: City of Tulsa Infrastructure Expenses from High Wind Scenario

Department	Expenses
Tulsa Police Department	$3,000 (overtime)
Tulsa Fire Department	$15,662 (overtime for 108 personnel logging 533 overtime hours) + $1,000 (equipment and materials)
Tulsa Public Works	$99,400 (vegetation & drainage)
Street Maintenance	$104,720 (labor and equipment)
Traffic & Engineering	$3,115
TOTAL	**$226,897**

Approximately 6,786 cubic yards of debris from an affected 1,420 homes was picked up by the city. This breaks down to approximately $159.68 per affected home in infrastructure expense and 4.77 cubic yards of debris per affected home.

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 the Tulsa 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. Based on this rate of restoration, the economic value of the loss of power for these customers would be estimated at $1.64 Million. (Records for the Rate of Restoration for the actual event were unavailable, so this was estimated based on periodic reports located in different sources.)

Based on these calculations, the infrastructure damages in the City of Bixby in a similar 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.

Table 4–22: High Wind Worst Case Scenario Damages

F-Scale	Parcel Count	Damage Factor	Averaged Damage	Parcel Count	Debris Factor	Averaged Debris (yds.)
Residential Properties						
0	2,351	159.68	$375,408	2,351	4.77	11,214
1	288	159.68	$45,988	288	4.77	1,374
Total	2,639	159.68	$421,396	2,639	4.77	12,588
Commercial Properties						
0	40	159.68	$6,387	40	4.77	191
1	1	159.68	$159.68	1	4.77	4.77

F-Scale	Parcel Count	Damage Factor	Averaged Damage	Parcel Count	Debris Factor	Averaged Debris (yds.)
Total	41	159.68	$6,547	41	4.77	196
Industrial Properties						
0	4	159.68	$639	4	4.77	19
1	0	159.68	0	0	4.77	0
Total	4	159.68	$639	4	4.77	19
Tax Exempt Properties						
0	65	159.68	$10,379	65	4.77	310
1	8	159.68	$1,277	8	4.77	38
Total	73	159.68	$11,656	73	4.77	348
Totals						
	2,757	159.68	$440,238	2,757	4.77	13,151

4.3.5 Future Trends

All potential development areas for the City of Bixby and Bixby Public Schools are equally at risk from high-wind events, with the following considerations.

Population

As fuel costs continue to rise, more people may turn to lighter-weight vehicles for transportation both in the city and on the highways. Studies have yet to correlate the increase in risk associated with driving these more fuel efficient yet lighter vehicles in dangerous weather conditions, but that possibility certainly merits close monitoring. With increased discussion of development along the River Parks area for public use, an increase in people participating in activities conducted in these new facilities could also be anticipated. An increase in such outdoor activities would also increase those vulnerable to the dangers of high wind events, much like that in October 2007, or the more recent wind event in Pryor, OK during the *Rocklahoma* Concert (July 13, 2008), where two tents were downed during the storm and one person suffered a broken arm after slipping in the mud while running to safety.

Structures/Buildings

In the continuing development and revitalization in and around Bixby, areas with large volumes of construction materials should be considered at high risk for wind-strewn debris during a high-wind event. Construction companies and crews should be cautioned to exercise care in securing apparatus and supplies that could become wind-borne during storms. Following Hurricane Alicia, a group of glass distributors determined that more than 80% of glass breakage was caused by wind borne debris. Sources of the debris include roof gravel, construction material, broken glass and insufficiently secured rooftop appurtenances.

According to a report on “Performance of building cladding in urban environments under extreme winds”, close observation often reveals large areas of pits, nicks, and scratches indicative of wind borne debris impact. Although some abraded windows remain completely intact, they are eventually replaced as their decreased glass strength could lead to poor performance in future storms.

Critical Facilities

As the threat from the effects of high wind events themselves cannot be eliminated, any critical facilities undergoing expansion, renovation or rebuilding should consider following updated techniques for such projects. The addition of reinforced exterior materials such as windows, doors, siding, etc. can do much to improve the safety of these facilities. Additionally, other measures to guard against potential secondary effects should also be implemented. These secondary effects may include, but are not limited to, compromise of structural integrity, broken windows/doors from wind-strewn debris, water damage from accompanying rains, power interruptions/surges and communication interruption from lightning or wind damage.

Infrastructure

Ensuring a minimized effect on the delivery of utility service requires forethought and planning while in the development stage. Any plans for areas currently under development or consideration of development should include the provision for underground utility supply when possible, well trimmed vegetation (to limit falling debris) and multiple access routes for emergency services vehicles.

4.3.6 Conclusions

Due to the nature of Bixby’s climate, severe thunderstorms and the high winds they frequently produce will remain a threat to the City and its Public Schools. The probability and accompanying Risk of events occurring is High. Recent events both in Bixby and in the surrounding areas demonstrate that sporadic high winds events continue to produce life- and property-threatening conditions. Improved building technologies, advances in public communication, and opportunities for collaboration among community agencies should remain prominent in the communities’ planning and response endeavors.

Data Limitations

In many cases, tornadoes and high wind events occur during the same storm incident. For example, a 2006 storm event produced damage at Tulsa International Airport from both a downburst and a tornado. In some cases, unless there is direct observation, it may never be known whether damage was produced by a tornado or a downburst. This Section should be read and analyzed in conjunction with the Tornado section. (It should be noted that NCDC data often contains multiple reports of the same event, which can lead to an inflation of the actual number of storms a community is likely to experience in a given period. For example, a high wind event on June 2, 2004, generated seven reports from Collinsville to Jenks in the space of 15 minutes. A hasty review of the data could erroneously conclude that Tulsa County experienced seven storm events instead of just one. We have tried to avoid inflating the frequency of storms in this manner.)

Update Changes

Identified significant changes made from the 2004 City of Bixby Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.3.7 Sources

NCDC Storm Event Database, at Web address: 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: http://www.nws.noaa.gov/om/hazstats.shtml.

Mighty Thunderstorm hits town (6/7/06) Tulsa World at www.tulsaworld.com.

"Performance of building cladding in urban environments under extreme winds" by Tiphaine Williams and Ahsan Kareem of NatHaz Modeling Lab, University of Notre Dame

Bashor, Rachel and Kareem, Alisan. *Performance of Glass Cladding of High Rise Buildings in Hurricane Katrina.* Newsletter of American Association for Wind Engineering, December 2006. Also on Website: www.aawe.org.

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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 electricity in the form 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 National Oceanic and Atmospheric Administration (NOAA) Storm Data studies, an average of 90 people per year have been killed by lightning since 1959 in the United States. From an article in the *TMCNET Newsletter* dated September 14, 2006, "Lightning is responsible for more than $5 billion in total insurance industry losses annually, according to Hartford Insurance Co."

When a person is struck by lightning, serious burns or deaths are obvious outcomes. According to *Storm Data* (NWS Publication),

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

Fire is a potential outcome from a cloud-to-ground lightning strike. During 2002-2004 U.S. fire departments responded annually to about 31,000 fires caused by lightning with $213,000,000 in direct property damages.*(*Source: NFPA Report, January 2008.) From 2000-2006, 12,000 wild land fires were started by lightning per year, resulting in an average of 5.2 million acres burned annually. *(*Source: National Interagency Fire Center, 2007).

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 equipment located in the business sector and critical facilities in a community. Some 30% of all power outages annually are lightning-related, on average, with total costs approaching $1 billion dollars. *(Source: Ralph Bernstein, EPRI; Diels, et al (1997))*

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 largely because people wait until the last minute to seek shelter – not fully comprehending the true danger of lightning.

As lightning is a by-product of thunderstorms, the entire jurisdictions of the City of Bixby and Bixby Public Schools are subject to the exposure and effects of lightning events.

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).

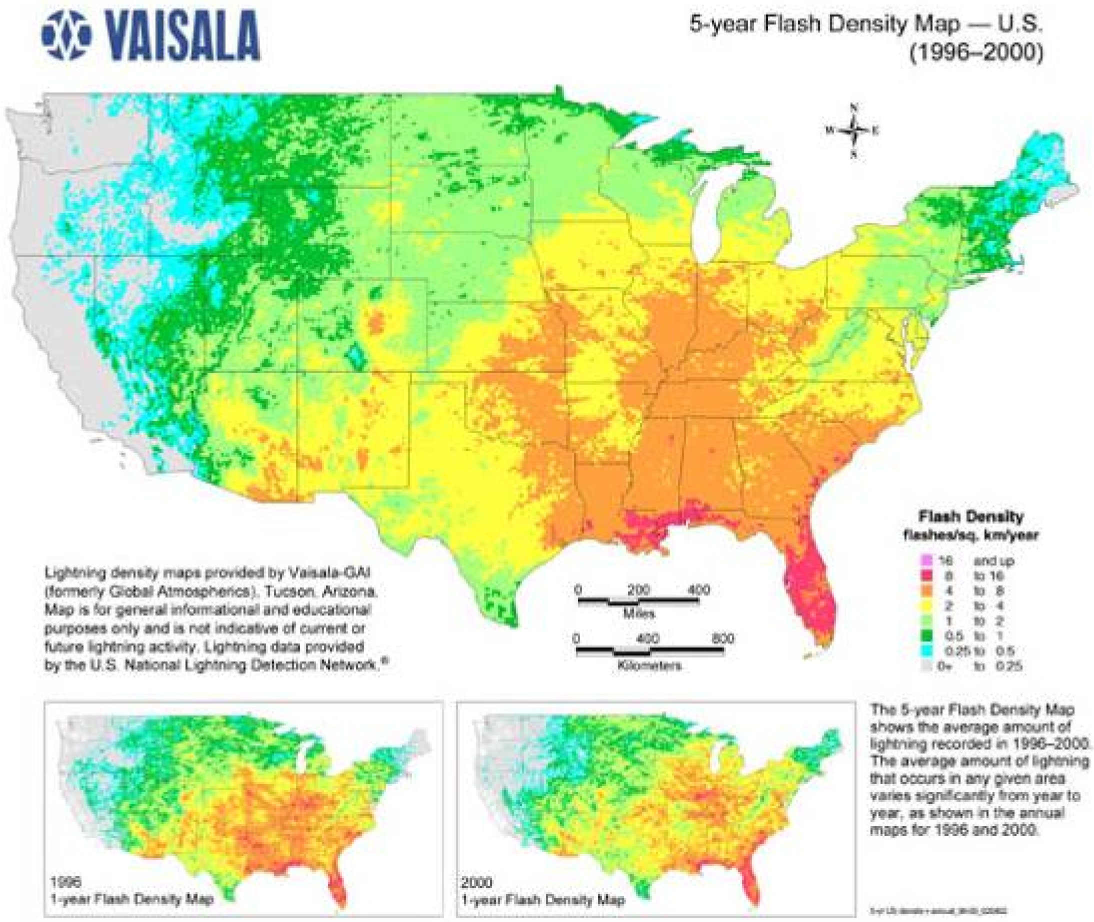
A daily product is also produced over the same area with the number of flashes occurring in each pixel during a 24 hr period (00 UTC to 00 UTC). The binned values are scaled by 5 such that a value of 1 corresponds to 1-5 flashes, 2 from 6-10, etc. A value of 255 indicates more than 1270 flashes occurred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

Tulsa County has reported 12 lightning events between 1995 and 2009 that resulted in $2.34 Million in damages, no deaths or injuries. The City of Bixby reported one lightning strike event during that period with $25,000 in damage, although it is highly likely that there were many more unreported incidents producing damage. This data demonstrates that Tulsa County can anticipate approximately one significant lightning strike each year, with damages averaging $195,000, with Bixby and Bixby Public Schools having a 10% chance per year of being struck. Although the entire community of Bixby and Bixby Public Schools are at risk from lightning, the probable extent of a damaging strike depends upon the type of structure that is hit, 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.

Figure 4–15: Vaisala Flash Density Map



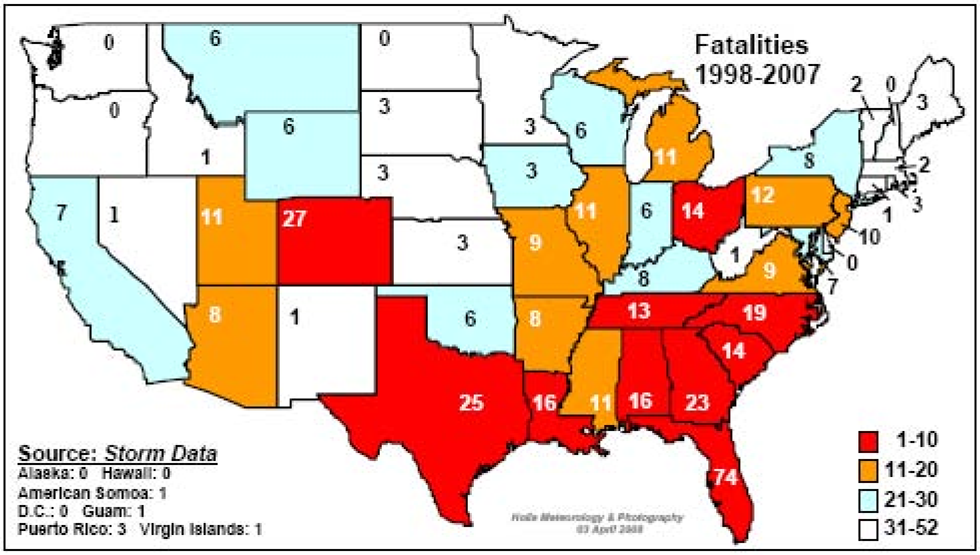
The City of Bixby may experience Lightning flashes between 4 and 8 per Sq Km per year as shown on the Vaisala Scale.

Bixby and Bixby Public Schools consider a minor severity to be a lightning strike that does not cause bodily injury or causes less than $1,000 in damages; a major severity event is considered a lightning strike that causes bodily injury or more than $1,000 in damage.

Frequency

National Geographic reports that lightning strikes the surface of the earth approximately 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. In a report released by the NLDN in 2006, for the time period between 1996 and 2005, Oklahoma was ranked 9th in the country for Average Lightning Flashes per Year (966,295 flashes/year), which represents an average of 13.8 Lightning Flashes per Square Mile—about twice the number estimated by the Vaisala Scale.

Figure 4–16: Lightning Deaths by State 1998-2007



Lightning casualties and damages increase gradually through the spring when thunderstorm season begins for most of the country, and peak during the summer months. The months most notorious for lightning incidents were June (21%), July (30%) and August (22%). The most injurious lightning strikes have been shown to occur on Sundays, Wednesdays and Saturdays between the hours of 12:00noon and 6:00pm.

Impact

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

4.4.2 History/Previous Occurrences

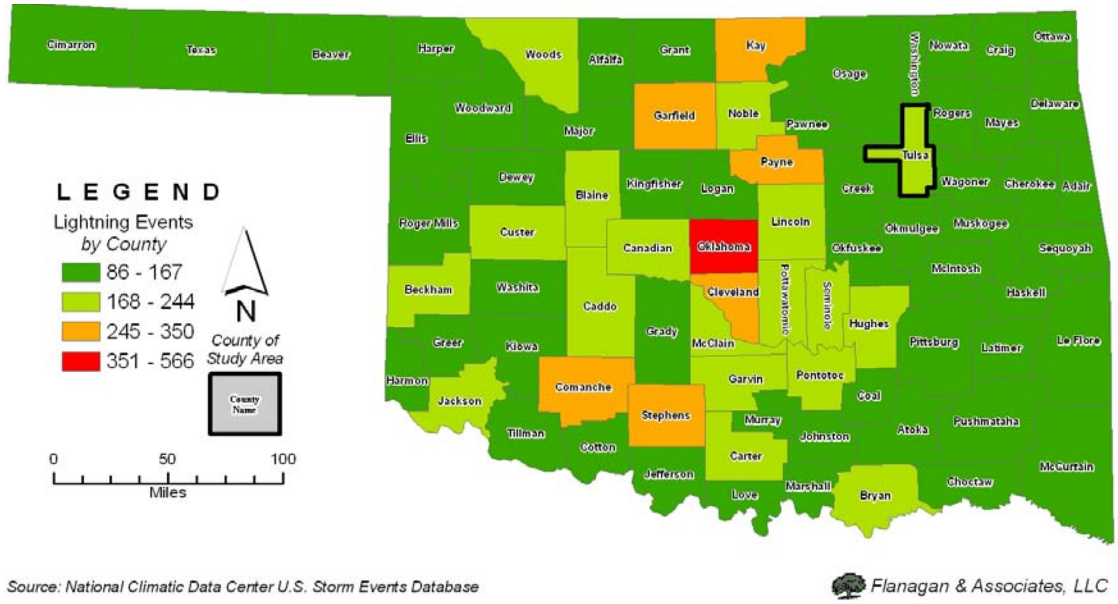
Historic Lightning Events

In 2007, there were 43 deaths from lightning strikes in the United States. Florida was hardest hit with 10 deaths, followed by Texas with 7. Other states experiencing fatalities were Georgia (3), New Jersey, Missouri, South Carolina, Colorado (2 each) and 15 additional states with 1 each.

Between 2000 and 2006 it was reported that an average of 12,000 wildland fires were started by lightning each year. This amounts to an average of 5.2 million acres annually. In 2005, a lightning-caused methane gas explosion in West Virginia killed twelve miners.

According to the National Climatic Data Center, between 1995 and 2009, there have been 374 lightning events recorded for the state of Oklahoma, with 11 deaths, 76 injuries and $26.0 Million in reported damages. In that same time period, Tulsa County experienced 12 events with no deaths or injuries but had $2.34 million in damages, and the City of Bixby had 1 event with no deaths or injuries but had $25,000 in damage.

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



Other significant events in Tulsa County include:

Tulsa, OK (6/10/2003) – A 17-year-old was boy struck by lightning while outside in a residential area, and was transported to a local hospital for treatment of injuries.

Broken Arrow, OK (7/23/2005) – Two teenagers were struck by lightning while playing under a tree. Both went into cardiac arrest, but were revived on scene and transported to a nearby hospital. One teenager later died from his injuries; the other was eventually released from the hospital, but required lengthy rehabilitation as a result of his injuries.

Glenpool, OK (6/12/2006) – A fuel tank containing 5 million gallons of fuel was struck by lightning, igniting an 800,000-gallon tank fire. About 4 million gallons of fuel was pumped out. Five homes were voluntarily evacuated, and US Hwy 75 was rerouted for a time. No deaths, no injuries occurred. Estimated damages were $2 million.

Bixby, OK (8/21/2006) – Lightning struck a house causing a fire in the attic that resulted in $25,000 damage.

Table 4–23: 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*
Bixby	1	0	0	1	25,000
Tulsa County	12	0	0	9	$2,340,000
Oklahoma	374	11	76	301	$26,077,000

Probability/Future Events

Oklahoma, Tulsa County and Bixby are all subject to frequent thunderstorms and convective weather patterns, and are therefore vulnerable to lightning, which is a constant and widespread threat during the thunderstorm season. Bixby and Bixby Public Schools have a moderate probability of future lightning strikes, but their location and impacts are unpredictable.

4.4.3 Vulnerability

This section summarizes information about Bixby's vulnerability to lightning, including the impact on people, structures and buildings, critical facilities, and infrastructure. This information, as well as information provided by the City and Public Schools, was used to determine the Impact Criteria identified in Tables 4-2 and 4-3. The City of Bixby and Bixby Public Schools were determined to have a Moderate Risk from the Lightning hazard. (See Tables 4-2, Hazard Risk Analysis, and Table 4-3, Summary of Hazard Risk Analysis Ranking Criteria for an explanation of how the rankings were derived.)

Population

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

Table 4–24: 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

The City of Bixby 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 community is at risk to lightning-caused fires, damages and casualties.

Critical Facilities

All critical facilities within Bixby's jurisdiction 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 Bixby can be found in Table 1-12.

Infrastructure

Lightning-caused problems are one of the most common troubles faced by American businesses. A recent study by Carnegie-Mellon University showed that 33% of U.S. businesses are affected by lightning, and that more businesses are impacted 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 strikes. 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 of Bixby's and Bixby Public Schools' 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 from a lightning event would be the loss of electrical power and damage to electrical equipment at the two water treatment plants in Tulsa that provide water to the City of Bixby. These water plants experience power outages related to lightning and thunderstorms on a regular basis. Outages are usually of short duration and affect only a portion of the facility. Both of Tulsa's water treatment plants have sustained equipment damage in the past that required repair or replacement and are at continued risk to this type of event.

Wastewater Treatment – The most significant threat to the operation of Bixby's two wastewater treatment facilities during a lightning event would be power outages. Both lagoons and lift stations should have backup generators, and existing generators checked for appropriate size and functionality.

Utilities- The primary utility providers for Bixby's jurisdiction are AEP/PSO (electricity) and ONG (natural gas). The service stations and substations for both of these providers are vulnerable to the risks from a lightning event. **Electricity**: During a lightning event, providers of electrical service could experience any combination of the following challenges in meeting the needs of the Bixby jurisdiction: Damage to transformers or other transmission components, downed broken power lines, danger to workers derived from downed power lines, and fallen debris from trees or insufficient field and/or office staff to effectively handle the workload. **Gas**: During a lightning event, providers of gas service to a community could experience a variety of challenges, such as falling power lines or tree debris; inaccessibility to underground gas meters from fallen debris; downed power lines, and insufficient field and/or office staff to effectively handle the workload generated by such an event.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Transportations systems would experience the same vulnerability to lightning events as other city facilities, including local electrical blackouts, traffic signal outages over wide areas, communication outages, etc.

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 limit or eliminate access to affected areas. A potential secondary effect on these services would be interruption of control and communication capabilities due to a lightning strike.

4.4.4 Lightning Scenario

Scenario

A graphic scenario demonstrating the effects of a major lightning event for this jurisdiction would be difficult to assemble, and even more difficult to analyze due to the sporadic and erratic behavior of lightning itself. However, it is possible to examine recent major lightning strikes and parallel those to similar situations found in this jurisdiction.

October 14, 2007 - The city of Holdenville, OK (est. 2007 population 4,582, located in Hughes County) experienced a thunderstorm that was accompanied by lightning that struck the City Hall building, crippling the community's 911 system. While repairs were being made, those requiring emergency assistance were asked to call a local 7-digit phone number.

In addition to the 911 system, the Holdenville Police Department reported major damage to its radio system. Damages reported were approximately $26,600. This was not the first time Holdenville has had to contend with lightning damages. Over a period of 14 months (March 29, 2007 through May 27, 2008), the city experienced three different strikes resulting in damages in excess of $36,000.

The Tulsa 911 Dispatch Center also covers Bixby. It currently handles an average of 1,050,000 emergency calls each year. The Center had 1,430 incidents with the Pickup City listed as Bixby, and 1,042 of those resulted in transports. In the planning and construction of this facility, many disaster resistant techniques were utilized to strengthen the integrity of the infrastructure. City records show that state-of-the-art lightning and electrical surge protection systems have been installed to protect the facility's operational equipment. Additionally, the interior spaces of the 911 Call Center were built in accordance with FEMA 361 standards for Community Safe Rooms, and the exterior offices built to withstand an F3 tornadic event. By employing such techniques, it is highly improbable that the 911 Call Center would experience an outage as extensive as that at Holdenville. However, should a catastrophic event result in the prolonged disabling of this system for even a 4-hour time period, it would mean the disruption of nearly 480 emergency calls, with some of them likely to be from Bixby.

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

This figure is based on an annual average of calls handled, and would not account for a spike in 911 calls in the event of a major disaster/emergency affecting a large portion of the city. In such a catastrophic event, the volume and the critical nature of the incoming calls would increase dramatically, demonstrating the criticality of providing lightning surge protection measures for the city's vital infrastructure.

The most frequently reported incidents involving injuries and/or deaths from lightning strikes occur during common outdoor activities such as hunting, swimming, and other outdoor team events such as soccer and football. According to the website “struckbylightning.org”, by mid-October there had been 36 fatalities and 245 injuries attributed to lightning strikes in the United States in 2009.

September 11, 2008 – During a football game in Bonaire Georgia, at approximately 3:30pm, officials, who were using a hand-held lightning detector, decided to end the game when the detector went into alarm mode due to an 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 in Dorchester MA on July 20, 2008, also at approximately 3:30pm. This time, the sporting event was a local soccer game. There were 10 injuries reported, four of them critical. Seven or eight of the players were knocked unconscious, and the injuries reported ranged from burns to cardiac conditions. The victims ranged in age from 13 – 41yrs, and all were males.

Using these two events as worst-case models, a similar scenario can be developed for Bixby and Bixby Public Schools, as both jurisdictions sponsor frequent outdoor gatherings for football, soccer and other sports.

There are at least 750 kids in Bixby Youth Soccer, 550 in Bixby Youth Baseball, 250 girls in Bixby Girls Softball, and many more in the Bixby Rodeo Club. They play on 13 soccer fields, 11 baseball fields, 3 softball fields, and 1 rodeo arena. When the Bentley Park recreation area is completed, there will be an additional 8 baseball fields and another soccer field. This does not account for the numerous school/community-based soccer teams whose information was not available in time for this writing. There are children as young as 5 yrs old on teams, as well as players well into their adult years participating in soccer in the Bixby area. Add to this list the usual range of spectators – parents, grandparents, schoolmates, friends, co-workers, siblings, etc., and the number of people exposed to the lightning hazard each week from spring to fall increases dramatically.

In the Bixby area, football is a most popular and widely promoted activity. Youth leagues begin at a very young age with flag football, and continue through Junior High School. High School football is a competitive and highly attended social activity, and places a large number of people at risk during a lightning event.

As with many reports pertaining to lightning, specific numbers of people in attendance were not available in the lightning incidents mentioned above. So for this discussion it will be assumed that the same number of players would be on the field(s) for a similar event in the Bixby jurisdiction.

In the case of the football game described above, 13 people were injured, with 12 being transported to the hospital. Assuming that those transported to the hospital would have been admitted overnight for observation (at the minimum) the economic value of those hospitalizations, according to "What is a Benefit", would be $187,200 (12 patients x $15,600 each). The economic value for 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 frame noted for the injured coach in Georgia), total economic value of those lost wages would be $3,385.60. These two costs represent a total loss of $190,585.60. This does not take into account the cost to the school for additional counselors working with the students the following week, or property damages (if any) sustained from the strike.

In the soccer match event, 10 people were injured, four of whom were critical. Injuries ranged from burns to cardiac-related issues. Utilizing the same calculation method for economic values, the cost of related hospitalizations for a similar event would be $156,000. There were several adult males injured, so the time lost from work would also be a factor. The economic value for lost wages is $21.16/hour per person. If it is assumed that one-half of those injured were employed, and the time away from their jobs averaged 10 days each, lost wages would be $8,464.00, bringing the total to $164,464. This figure does not factor in a lengthier hospitalization for a critically injured victim.

4.4.5 Future Trends

Population

As the "baby-boomer" population begins to move more aggressively into retirement, it could be anticipated that the number of people pursuing outdoor sports and/or social activities will also increase. Priority should be given to continuing the process of educating the community about the dangers associated with lightning. Also adding to this increase in out-of-doors activity could be the changing and challenging economic climate. With more families looking for activities closer to home, parks and other outdoor recreation areas may become more attractive.

An increase in new construction or large renovation projects would also increase the number of outdoor workers in a wide variety of functions. These groups should be included in public education programs regarding the dangers of lightning.

Structures/Buildings

As uninhabited areas continue to be developed and existing structures are renovated, actions to lessen the potential effects of lightning strikes should be considered. Installation of surge protectors for electricity and phone lines should be actively encouraged. Utility companies should be encouraged to relocate above-ground utility lines to underground.

Critical Facilities

As technology continues to advance, the need to protect power sources supporting that technology should advance as well. Working with local utility companies to coordinate the relocation of above-ground utilities (phone, electricity, etc.) to underground should be considered a top priority when new facilities are constructed or existing ones upgraded.

Infrastructure

Ensuring local government facilities are well protected against the potential effects of lightning strikes is an on-going endeavor. Investigating and implementing new technology as it becomes available will help ensure the continuity of operations at all levels. Particularly important is the protection of communication and control systems and the massive amounts of data they both generate and require for operation. The protection of these critical functions should be considered priorities in any future development plans.

4.4.6 Conclusions

Lightning is one of the most deadly and costly hazards in the United States. People outside can have a false sense of security, thinking that they are safe because a storm front has not yet reached 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.

Electronic equipment, from personal computers to enterprise-level communications and control 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 recent years, new technology has provided many opportunities for communities and individuals to provide increased warning and alerts, increased surge protection, and increased building strike protection. Nevertheless, because of Bixby's location, both the City and its Public Schools are subject to convective thunderstorms and the lightning hazard these generate. The risk of injury, death, or property damage in the City of Bixby and Bixby Public Schools is Moderate.

Data Limitations

Accurate data on the effects of lightning events is difficult to obtain for several reasons. *Regarding injuries* – many survivors do not seek immediate medical care and only come to the attention of medical personnel when they seek care for effects of the shock that have not resolved by a few days after their injury. In addition, many lightning deaths and injuries are attributable to nervous system disruption with no visible signs of injury, and are consequently misdiagnosed as heart attacks or other ailments.

Regarding property damages – home and business owners often choose not to report lightning strikes or submit insurance claims in connection with their damages. Typically, the events that do get documented are the more widespread occurrences affecting several business/residential locations.

Regarding data collection – much of the data utilized is taken from newspaper accounts, so if people or structures affected by lightning do not make the news, they are not likely to be included in statistical storm data.

Update Changes

Identified significant changes made from the 2004 City of Bixby Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for

Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.4.7 Sources

eMedicine – Lightning Injuries: Article by Mary Ann Cooper at www.emedicine.com/emerg/TOPIC299.HTM

Lightning Fatalities, Injuries, and Damage Reports in the United States from 1959-1994. NOAA Technical Memorandum NWS SR-19, 1997 and at Web Address: http://www.nssl.noaa.gov/papers/techmemos/NWS-SR-193/techmemo-sr193.html.

Mulkins, Phil. "If you can hear thunder—find cover now!" *Tulsa World*, May 23, 2002.

Multi-Hazard Identification and Risk Assessment, p. 30. Federal Emergency Management Agency, 1977.

National Lightning Safety Institute, at Web address: http://www.lightningsafety.com/.

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

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

"Securing the Supply of Electrical Services" by Jay Apt, Carnegie Mellon University

Lightning mortality statistics can be found at www.struckbylightning.org, W. Yarmouth, MA.

4.5 Hailstorm

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.

4.5.1 Hazard Profile

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

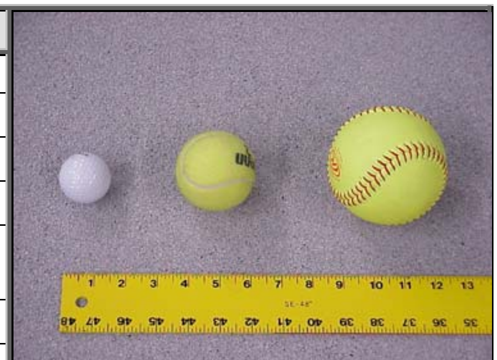
Location

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 401 hailstorms each year with hailstones measuring at least 1 inch in diameter. All buildings and agricultural areas in the City of Bixby and Public School facilities are at risk.

Measurement

Table 4–25: Common Measures 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

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.

Table 4–26: Combined NOAA/TORRO Hailstorm Intensity Scales

Size Code	Intensity Category	Typical Hail Diameter (inches)	Approximate Size	Typical Damage Impacts
H0	Hard Hail	up to 0.33	Pea	No damage
H1	Potentially Damaging	0.33-0.60	Marble or Mothball	Slight damage to plants, crops
H2	Potentially Damaging	0.60-0.80	Dime or grape	Significant damage to fruit, crops, vegetation
H3	Severe	0.80-1.20	Nickel to Quarter	Severe damage to fruit & crops, to glass & plastic structures, paint/wood scored
H4	Severe	1.2-1.6	Half Dollar to Ping Pong Ball	Widespread glass damage, vehicle bodywork damage
H5	Destructive	1.6-2.0	Silver dollar to Golf Ball	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries
H6	Destructive	2.0-2.4	Lime or Egg	Aircraft dented, brick walls pitted
H7	Very destructive	2.4-3.0	Tennis ball	Severe roof damage, risk of serious injury
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

Extent (Magnitude/Severity)

The damages expected from a hail event are a function of the diameter of the hailstones and the wind speed, or hailstone velocity. There have been numerous instances of hailstones reaching four inches in diameter, or softball size. The largest hailstone ever measured in the United States fell at Coffeyville, Kansas, on September 3, 1970. It weighed 1.67 pounds and measured 17.5 inches in circumference. When hailstones reach large dimensions, they can be extremely dangerous to property, agriculture and the vulnerable populations of the jurisdiction.

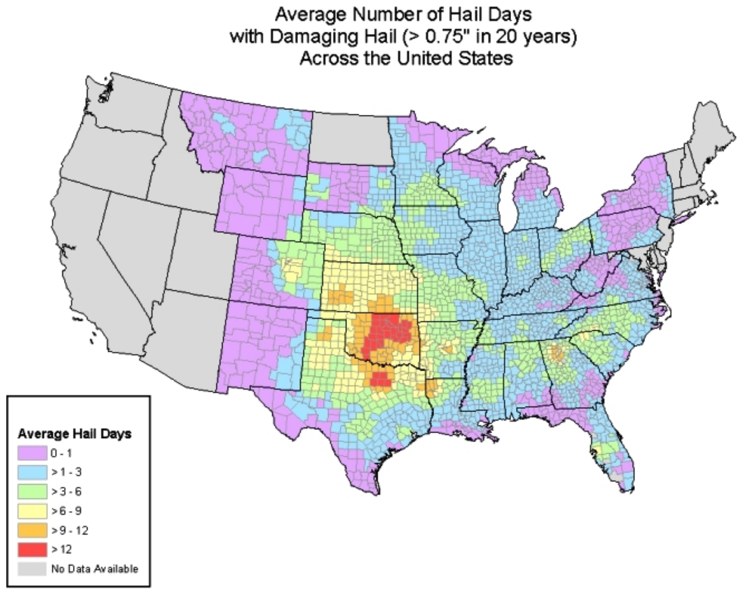
The size of hailstones is a direct function of the severity and size of a storm. High velocity updraft winds keep hail in suspension in thunderclouds. The greater the intensity of heating at the Earth’s surface, the stronger the updraft will be. Higher temperatures relative to elevation result in increased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

Bixby 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.

Figure 4–18: Hail Storm Days per Year



Source: Institute for Business & Home Safety, 2004.

Any specific location in the Bixby metropolitan area can expect to receive hail an average of two to three times each year. Hail has been reported in every month, with the highest frequency during the transitional months in the spring. The peak time of year falls right in the middle of that transition period from mid-April to mid-May. Another small peak occurs in November as the weather pattern transitions back into winter.

Impact

When hail hits, it can damage cars, shred roof coverings, and lead to water damaged ceilings, walls, floors, appliances, and personal possessions. Large hailstones can also cause serious bodily injury.

However the impact of this hazard remains mainly financial due to 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

In the state of Oklahoma, there were 318 severe hail events in 2006, with the largest reported hailstone 4.25 inches in diameter (grapefruit- to softball-size) falling in Harmon County, resulting in $832,000 in property damages and $150,000 in crop losses for the year. There were 210 severe hail events in 2007, with the largest reported hail 4.25 inches in diameter (in Harper County), resulting in $167,000 in property damage.

On June 1, 2008, a large storm system moved across Oklahoma, dropping hail in several locations. The most devastating reports came from Mannford, in Creek County, where city officials estimated that every home in the community (approximately 1,100 homes) sustained some damage from hail stones 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. Between 1,000 and 1,500 vehicles also sustained heavy damage. Two non-life threatening hail-related injuries were also reported.

Tulsa County has reported 195 severe hail events from 1995 through 2009, with $90.7 Million in reported damage. Based on data from the National Climatic Data Center, 38 of these events were reported for the Bixby jurisdiction, with $75,000 in reported damages. Table 4-27 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 Bixby, Tulsa County, Oklahoma and the US.

Table 4–27: Reported Casualties and Damages Caused by Hail from 1995 to 2009

Location	Events	Deaths	Injuries	Damage Events	Property Damage
Bixby	38	0	0	2	$75,000
Tulsa County	465	0	0	29	$90,779.000
Oklahoma	12,722	0	2	239	$154,564,000

Significant Bixby and SE Tulsa County Hail Events

From 1995 through 2009, Bixby experienced a reported 38 hailstorms, which did $75,000 in damage. Some of the more recent and significant events are as follows:

March 16, 1996 – 1.75 inch hail at Bixby. 2.75 at Glenpool.

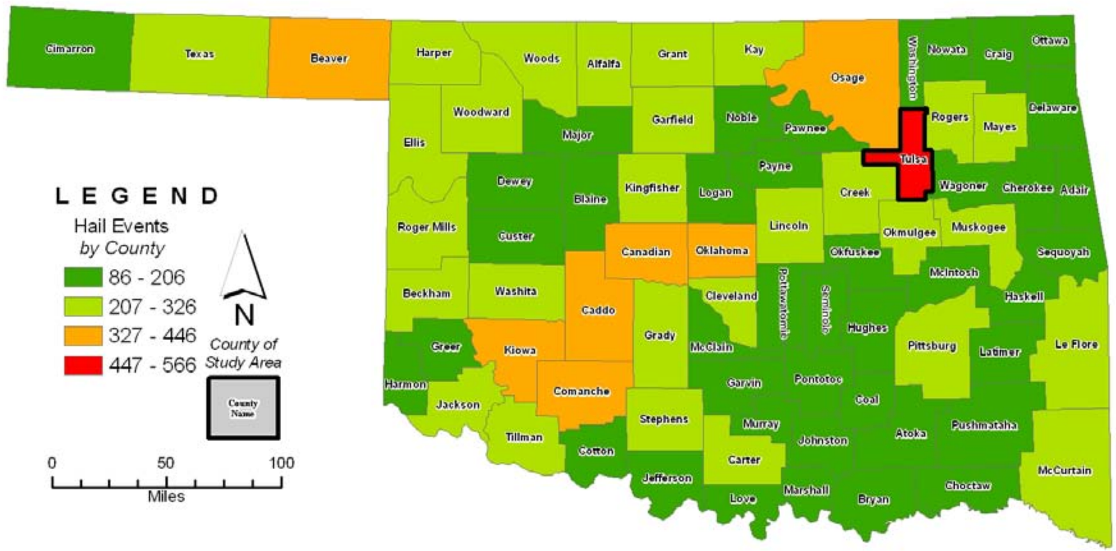
May 14, 1996 - Severe thunderstorms moved across northeast Oklahoma during the early morning of May 14th, dropping hail up to baseball size at Bixby and Broken Arrow, tennis ball size at Jenks, and golf ball size at Glenpool and southern Tulsa. The hail covered the ground at spots in Glenpool and south Tulsa. Golfball hail also fell at Oneta, 2 miles south of Bixby, and quarter to golf ball size 2 miles east of Bixby. Glenpool reported $50,000 in damage.

March 27, 1997 -A severe thunderstorm moved across northeast Oklahoma during the evening of March 27th. Thunderstorm winds gusted to 65 miles an hour at the intersection of Interstate 44 and 129th E. Ave. in Tulsa. Hail from dime size to 3.75 inches in diameter fell across Tulsa, golf ball size 3 miles west of Jenks, 2 miles northwest of Jenks, and at Catoosa.

June 18-19, 1998 – 2.75-inch hail fell at Glenpool. An approaching cold front and a vigorous upper level low moving into the southern plains helped ignite an outbreak of severe thunderstorms on the late afternoon of June 18, lasting into the early morning of June 19. This outbreak of severe weather 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 even 2-inch diameter hail covering the ground in an area stretching from Jenks through south Tulsa as far east as US Hwy 169 between 61st and 101st Street South. 2-inch hail fell at Jenks, and 2.5-inch hail at Tulsa.

Figure 4–19: Hail Events in Oklahoma from 1989 – 2009



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

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December 3, 1999 –Golf ball size hail was reported at the corner of 81st Street and Oak Avenue in Broken Arrow, causing $50,000 damage.

May 5-6, 2000 – Baseball size hail fell in southeast Tulsa, doing $1.5 million in damage. 2.75-inch hail fell at 81st and Yale, with golf ball size falling at 81st and Sheridan and 91st and Memorial. 1-inch hail was reported at Bixby. 2.5-inch (tennis ball size) hail fell on the north side of Tulsa.

May 27, 2001 – 1.75-inch hail fell at Bixby, doing $50,000 damage to cars and roofs of buildings. High winds blew down trees.

May 1, 2002 – Thunderstorms and high winds were reported in Tulsa County, with 0.75-inch hail reported at Bixby and Broken Arrow, and 3.5-inch hail (teacup to grapefruit size) hail falling at Leonard, just east of Bixby.

November 18, 2003 – Baseball-size hail was reported at 21st and 31st and Harvard, with lesser-size hail reported in Collinsville, Broken Arrow and Sand Springs. The hail broke windows and damaged numerous roofs of buildings and cars. Damage is estimated; pending supplemental insurance reports.

April 5, 2005 – A supercell thunderstorm moved north-northeast across the central portion of Tulsa County producing a several-mile-wide swath of large, damaging hail. Reports of golfball or larger hail were common in a densely populated area of the county from Jenks to eastern Tulsa County. The largest hailstones reported were 3 inches in diameter. Many automobiles, homes, and businesses were damaged by the hailstorm. 3-inch hail was reported in Jenks. Damage is estimated at $65 million.

May 9, 2006 – Thunderstorms and high winds dropped golf ball size hail at Bixby, doing $25,000 in damage.

June 9, 2007 – 1.75 inch hail fell in south Tulsa. Golf ball size hail fell near the intersection of Sheridan and 81st St. S. Severe thunderstorms produced hail, damaging winds and flash floods across eastern Oklahoma.

April 7-8, 2008 – Quarter size hail fell near the intersection of 121st St. S. and Memorial Ave., and golf ball size hail (1.75 inches) near the intersection of Mingo Road and 91st St. Sl., doing an estimated $1 million damage to homes, businesses and automobiles.

Probability/Future Events

As hail is a direct by-product of thunderstorm activity, and Oklahoma enjoys a climate-rich environment most suitable for this weather activity, it is accepted that the jurisdictions of Bixby and Bixby Public Schools will continue to experience thunderstorms of varying severity with hail present in many of those events.

Based on history and previous occurrences from the past 15 years, Bixby and Bixby Public Schools have a high probability of a future hail event.

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

4.5.3 Vulnerability

This section summarizes information about Bixby's vulnerability to hailstorms, including the impact on people, structures and buildings, critical facilities, and infrastructure. This information, as well as information provided by the City and Public Schools, was used to determine the Vulnerability Criteria identified in Tables 4-2 and 4-3. The City of Bixby and Bixby Public Schools were determined to be at High Risk to the Hail hazard. (See Tables 4-2, Hazard Risk Analysis, and Table 4-3, Summary of Hazard Risk Analysis Ranking Criteria for an explanation of how the rankings are derived.)

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.

Population

Given the climatic environment of Tulsa County and Bixby, all demographic groups located within the jurisdiction are vulnerable to the effects and potential damage from hailstorm events. Those of particularly high vulnerability are those engaged in farming and/or ranching activities, as crop damage is the highest percentage of reported hail damage. In addition, people engaging in outdoor recreational activities, such as soccer, golfing and camping, may find themselves in a situation where sufficient shelter is unavailable.

Structures/Buildings

Severe hailstorms also cause considerable damage to buildings and automobiles but rarely result in loss of life. Oklahoma has significant exposure to hailstorms, and virtually all buildings and crops in the storms are at risk. The City of Bixby and Bixby Public Schools are no exception. Both jurisdictions are vulnerable to the damaging effects of hail.

Critical Facilities

All critical facilities in Bixby are vulnerable to the damaging effects of hail (for a complete list of City of Bixby critical facilities, see Table 1-12). Hail, however, is unlikely to render a building non-operational.

Infrastructure

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

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

Utilities – The primary utility providers for Bixby's jurisdiction are AEP/PSO (electricity) and ONG (natural gas). Neither service would suffer a major disruption from a hailstorm event.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – During a hail event, public transportation vehicles may sustain damage. If severe enough (such as the hail events of April 5, 2005 in Jenks and Tulsa, or on June 1, 2008 in Mannford) there could be some risk of serious damage to these vehicles. During a major storm that is producing hail, it is reasonable to assume that flights leaving and arriving at Tulsa International Airport or Jones Airport (business aviation) could be delayed. Aircraft on the runway during a significant event could potentially experience some damage if the winds are high and 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 during a hail event would all face the same risk of damage, most likely to windows and/or windshields. A secondary effect could be an increased call volume related to traffic accidents should the hail event occur during heavy traffic flows.

If a major hail event were to occur between 7:30–8:30 am or 5–6 pm on any weekday, the likelihood of commuters being caught in the event is substantially higher. The daytime population of Bixby decreases by over 3,000 people due to commutes to Tulsa and neighboring communities (www.city-data.com). Additionally, the majority of workers in the city have a commute time of 15-20 minutes, creating a high volume of exposed traffic on city streets.

4.5.4 Hail Scenario

Overview

On Sunday June 1, 2008, the town of Mannford, OK (Creek County, approximately 30 miles west of Tulsa) experienced a major hail event. The storm struck at approximately 9 am, and lasted for nearly 20 minutes, damaging virtually every home (approximately 1,100 homes). Nearly 600 homes had broken windows, and every home 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.

Bixby Comparison

By applying storm data from the Mannford event to housing density figures from the same period for Bixby, certain conclusions can be drawn regarding the projected impact of a similar event on Bixby.

According to 2005 housing demographics, the City of Bixby contained 273 houses/condos per square mile and an area of 25.1 square miles. Based on this information, a storm the size and severity of the June 1, 2008 event would impact 1,884 residential structures in a major residential area within Bixby's city limits. With an estimated average repair cost of $4,500 per structure (damages ranging anywhere from a few windows and shingles, to several windows broken and/or destroyed and total roof replacement), total housing damages would be $8,478,000.

Comparing the housing density of Mannford to that of Bixby (165 vs. 273 units per square mile), it is noted that Bixby's density is approximately 1.65 times that of Mannford. Applying this increase to the number of vehicles potentially affected would mean that approximately 3,616 vehicles are likely to sustain some form of damage. Using average repair cost of $500 per vehicle (mostly broken windows/windshields and some with very heavy body damage), vehicle damage would be about $1,808,000.

Using the same method of analysis, Bixby would experience 3 injuries, none of which would require hospitalization. Using the values provided by "What is a Benefit?" the cost of 3 minor injuries would be $4,680 ($1,560 per injury).

Total losses for a Bixby hail event of the severity of the Mannford hail storm would be $10,290,680. These losses are summarized in the following table.

Table 4–28: Hail Scenario Damages

Damage Type	Number of Units	Damage $
Housing	1884	$8,478,000
Vehicles	3616	$1,808,000
Injuries	3	$4,680
TOTAL		**$10,290,680**

Scenario Conclusions

This methodology and data comparison provides a conservative estimate of the damage Bixby could expect from a very severe hail storm. The analysis does not include the economic value of such things as time lost to cleanup activities, inspections, filing insurance claims, etc., or business losses.

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. These factors make it difficult to accurately analyze the true economic impacts of hail storms.

4.5.5 Future Trends

For maps of Bixby's potential future development areas, see Figure 1-17.

Population

Because deaths or injuries from hail events are rare, the vulnerability of populations in newly developed areas will be low, and will be 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 utilize impact resistant materials and components, when available. As buildings are considered for renovation and converted from one purpose to another, strong emphasis should be placed on using these same materials in reconstruction. The two primary areas of concern are roofing and window systems.

Critical Facilities

Any future development and renovation should also include the improvement of existing critical facilities to help ensure the community's sustainability. Hail resistive materials should become standard in this class of facility along with the use of protective screens for external equipment (i.e. air filtration/conditioning systems, backup generators, communication terminals, etc.) to protect damaging weather events.

Infrastructure

As research and development of alternative fuel sources progresses, it is anticipated that "bio-fuels" will begin to play a much larger role in energy resources. As this technology evolves, it is possible that more agricultural land will be given over to the development of crops for use by this technology. Since harvestable crops are more vulnerable to hail damage than grazing land or some other land uses, the result could be even higher economic impacts to the farming sector from severe hail storms.

4.5.6 Conclusions

The states in the middle of the Great Plains, particularly Oklahoma, are the most likely to be hit with severe thunderstorms and hail events. The peak season for hail is in the late spring and early summer. Oklahoma experiences an average of 401 hailstorms each year with hailstones measuring at least 1 inch in diameter. All buildings and crops in the State are at risk.

The City of Bixby has high vulnerability to hailstorms.

Data Limitations

The property losses due to hail are not well defined and conflicting information exists. For example, in 1992 the Property Claims Service declared, "Hailstorms across the country (in 1992) ran up a bill of $1.57 billion." Yet, their data on all weather catastrophes shows that hail plus other conditions caused $3.9 billion in insured losses in 1992, and only one storm was a hail-only event, and it caused losses listed at $275 million. This is just one demonstration of the lack of good data on the property losses due to hail. In addition, since a hailstorm is seldom a nationally declared disaster, there may be no agency gathering aggregate data across a region on losses. Insurance companies are reluctant to reveal hard data to researchers. In addition, the NCDC data will often list six different hail events, for example, for what is basically one storm that had impacts in six different locations.

Update Changes

Identified significant changes made from the 2004 City of Bixby Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.5.7 Sources

The Weather Channel Storm Encyclopedia at Website: www.weather.com/encyclopedia/thunder/hail.html

National Weather Service Forecast Office – Tulsa, OK at www.srh.noaa.gov/tsa/climate/tulhail.html

"Trends in Hail in the United States" by Stanley Changnon, Chief Emeritus & Principla Scientist at Illinois State Water Survey – Mahomet, IL at http://sciencepolicy.colorado.edu/socasp/weather1/changnon.html

National Climatic Data Center at www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Tulsa World (Vol. 103, No 262) at www.tulsaworld.com

City-Data.com at www.city-data.com/city/bixby-oklahoma.html

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 could make 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.

Bixby is vulnerable to ice storms produced by warm, moist Gulf air colliding with arctic air from the Canadian Shield

Location

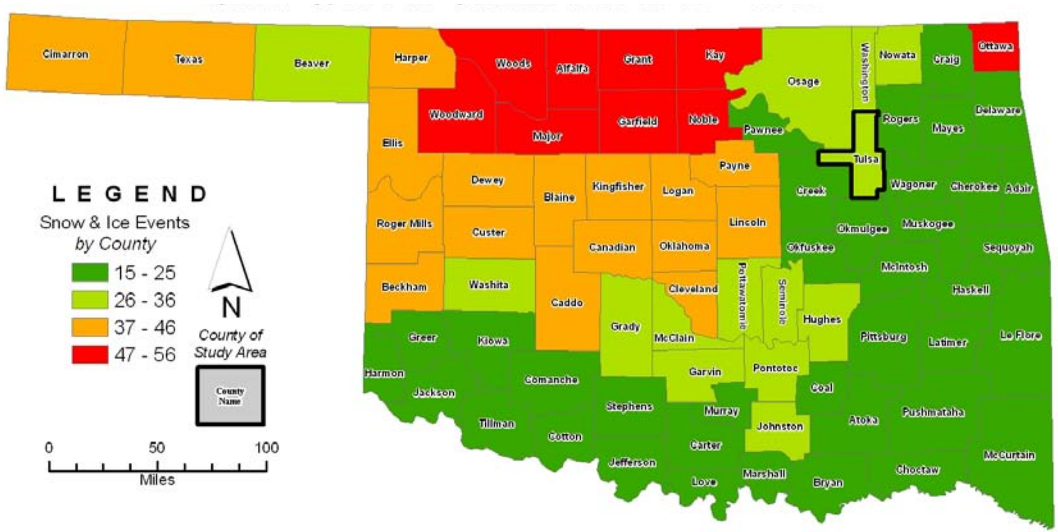
The northeast corner of Oklahoma experiences the periodic collision of warm, moist Gulf air and arctic air from the Canadian Shield. Because of this climatic positioning, Bixby experiences winter weather ranging from extreme sub-zero temperatures, snow and freezing rain to mild, spring-like days. Therefore, the jurisdictions of the City of Bixby and Bixby Public Schools are considered vulnerable to the effects of a severe winter ice/snow event.

Measurement

There are multiple ways to measure the impact of winter storms on a jurisdiction, including the Wind Chill Index, a NOAA Winter Storm Severity Index, and the recently developed Sperry-Piltz Utility Ice Damage Index. The Sperry-Piltz Index is a program currently being refined by the National Weather Service Forecast Office. The three indexes are outlined below.

The familiar *Wind Chill* temperature is simply a measure of how cold the wind makes real air temperature feel to living bodies. Since wind can dramatically accelerate heat loss from the body, a blustery 30° day would have the same physiological effect on a person 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 we use today. Here is a chart for calculating wind chill. (Please note that it is not applicable in calm winds or when the temperature is over 40°.)

Figure 4–20: Winter Storm Events in Oklahoma 1989-2009



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

Flanagan & Associates, LLC

Table 4–29: NWS – 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

The NOAA Winter Storm Severity Index, shown in table 4-30, gives a range of physical intensities from winter storms along with the potential effect on the City of Bixby and Bixby Public Schools. The Sperry-Pilz Ice Damage Index shows what damage can be expected from varying amounts of ice accumulation

Table 4–30: NOAA Winter Storm Severity Index

Level 1 – Nuisance No Major Impact	Little snow/ice accumulation. Roads not hazardous	Little to no effect on the Jurisdiction.
Level 2 – Minor 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 **Isolated Emergency Conditions In the Jurisdiction**	Significant Snow Accumulations 2-8 inches. Ice Accumulations of ¼ to ½ inch. 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 **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 4–31: The Sperry-Piltz Utility Ice Damage Index.
Categories are based upon combinations of precipitation totals, temperature and wind speed.
For additional information, go to http://ams.confex.com/ams/pdfpapers/141246.pdf

ICE INDEX	RADIAL ICE AMOUNT (inches)	WIND (mph)	DAMAGE AND IMPACT DESCRIPTIONS
1	**< 0.25**	**15 - 25**	**Some localized utility interruptions possible, typically lasting only 1 or 2 hours maximum.**
	0.25 – 0.50	**< 10**	
2	**< 0.25**	**> = 25**	**Scattered utility interruptions expected, typically lasting less than 8 – 12 hours maximum.**
	0.25 – 0.50	**15 - 25**	
	0.50 – 1.00	**< 10**	
3	**0.25 – 0.50**	**> = 25**	**Numerous utility interruptions, with some damage to main feeder lines expected, with outages lasting from 1 to 5 days.**
	0.50 – 0.75	**15 - 25**	
	0.75 – 1.00	**< 10**	
4	**0.50 – 0.75**	**> = 25**	**Prolonged & widespread utility interruptions, with extensive damage to main distribution feeder lines and possibly some high voltage transmission lines. Outages lasting 5 – 10 days.**
	0.75 – 1.00	**15 - 25**	
	1.00 – 1.50	**< 10**	
5	**0.75 – 1.00**	**> = 25**	**Catastrophic damage to entire utility systems, including both distribution and transmission. Outages could last from 1 to several weeks in some areas. Shelters needed.**
	1.00 – 1.50	**15 - 25**	
	> 1.50	**< 10**	

Extent (Magnitude/Severity)

Winter storms cause great inconvenience, injuries and deaths. Everyone is affected by the loss of mobility. Streets and highways are slick and hazardous. 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 electric power to their homes. Above-ground electrical and telephone lines and tree limbs are often coated in a heavy build-up of accumulating ice, which break when under the stress of sufficient weight. Falling trees also often bring down power lines. When electrical lines are damaged, other utilities, such as natural gas, can become inoperable.

Physical damage to homes and facilities can occur from wind damage, and the accumulation of snow, ice, and hail from accompanying winds. 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 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 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.

Table 4–32: Casualties and Damages Caused by Winter Storm from 1995-2009

Location	Events	Deaths	Injuries	Damage Events	Property Damages
Tulsa County	29	0	0	3	$50,154,000
Oklahoma	365	2	7	67	$732,234,000

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

Bixby and Bixby Public Schools consider a minor severity winter storm to be no loss of function of transportation, no loss of life, and no loss of electrical or water service, and a major severity event to be one that results in loss of transportation function, loss of life, or loss of electrical or water service.

Frequency

The National Climatic Data Center shows 365 snow and ice events reported for Oklahoma between 1995 and 2009. This calculates to an average of 24 winter storm events each year for the state. 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 reported 29 snow and ice events for this same period (1995-2009). Winter storms are, by nature, not isolated events. Therefore it could be stated that winter weather events affecting the Tulsa County area will also impact the City of Bixby and Bixby Public Schools to varying degrees.

Impact

The impact of a winter storm 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 snow or ice, roads buckle and or become slick and hazardous, electrical poles and lines break, and people lose electricity and heat, water lines freeze and burst, and people and livestock have no water. People and livestock are also susceptible to frostbite and death from exposure

January 30, 2002, winter storm caused widespread damage in Bixby

4.6.2 History/Previous Occurrences

Historic Winter Storms

The most significant Oklahoma winter storms bear out the frequency of occurrence across the jurisdiction, with 6 severe storms occurring over an 8 year period.

Table 4–33: Significant Oklahoma Ice Storms

Storm Event Dates	Category
December 25-27, 2000	Sperry-Piltz Level 4
January 28-30, 2002	Sperry-Piltz Level 5
December 3, 2002	Sperry-Piltz Level 5
December 18-20 & 28-29, 2006	Sperry-Piltz Level 5
January 12-15, 2007	Sperry-Piltz Level 5
December 8-11, 2007	Sperry-Piltz Level 5

December 2000 (McIntosh, Latimer & Pittsburg counties): 64 of 77 counties affected, with power outages to 120,000+ homes for 2-3 weeks, property damage of approximately $170 million, and 27 reported fatalities.

January 2002 (large section of Northwest and Central Oklahoma): 45 counties affected, with power outages to 255,000+ homes (some for up to 38 days), property damage exceeding $200 million, and seven fatalities directly attributed to the storm.

December 2002 (West Central to North Central Oklahoma): Mostly rural areas affected, power outages to approximately 30,000 homes, damages primarily to electrical distribution systems of approximately $4.5 million.

January 2007 (Eastern one-third of Oklahoma): Power outages to 100,000+ homes (some for up to 3 weeks), damages estimated at $50+ million, 32 deaths and 3,919 injuries linked to this storm. More than 100 cases of possible carbon monoxide poisoning cases were reported in the state, involving those seeking alternate methods of heat and/or power sources. Prolonged power outages combined with extreme temperatures created water supply crises in some of the more rural, isolated communities.

December 2007 (Central to Northeastern Oklahoma also referred to as the I-44 Corridor): The worst power outages in Oklahoma history. Power outages to 260,000+ homes across the state – 25-30% of homes in Bixby were affected; 29 deaths statewide – 6 deaths in Tulsa (4 fire fatalities, 1 traffic fatality, 1 hypothermia fatality); Tulsa International Airport was closed to incoming/departing flights for 24+ hours; 3 Tulsa hospitals were forced to rely on emergency generators.

Both fire stations and City Hall in Bixby had to revert to generator power during this storm to maintain operations.

Probability/Future Events

Based on the number of storms and weather patterns reported between 2000 and 2007, both Bixby and Bixby Public Schools have a high probability of a future severe winter snow/ice event. Of course, with the unpredictability of the region's fluctuating weather patterns, this can occur more or less often.

4.6.3 Vulnerability

This section summarizes information about Bixby's vulnerability to winter storms, including the impact on people, structures and buildings, critical facilities, and infrastructure. This information, as well as information provided by the City and Public Schools, was used to determine the Impact Criteria identified in Tables 4-2 and 4-3. The City of Bixby and Bixby Public Schools were determined to have an Extreme Risk to the Winter Storm hazard. (See Tables 4-2, Hazard Risk Analysis, and Table 4-3, Summary of Hazard Risk Analysis Ranking Criteria, above, for an explanation of how the rankings were derived.)

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, since 70% of winter storm-related deaths occur in cars--more than the number of people caught out in the storm. The elderly are 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 likely causes of winter storm-related deaths.

The homeless population in the Bixby area is served by the multiple shelters in the City of Tulsa and the Tulsa County Emergency Services shelter. During the December 2007 ice storm, all shelters reported that they were operating at or above capacity. The homeless population is obviously at high-risk to the effects of severe winter weather.

As witnessed to by the 29 winter storm events between 1995 and 2009 and the four Presidential Disaster Declarations for Tulsa County, the Bixby area, including the city, public schools, and all their future development areas, have a High Risk to Winter Storms.

Structures/Buildings

A direct threat to structures/buildings from a severe winter event would be excessive snow/ice accumulation on flat or low-grade, sloped roof surfaces. This is especially true for older structures not constructed to withstand such stress. More indirect threats to structures/buildings are from power outages causing interruption to heating (loss of supplies, food, sensitive equipment), frozen water pipes (along with flooding from broken pipes that damages interiors and sensitive electronic equipment), and; fires caused by power lines being torn away from structures, or from power surges when lost power is restored. During the peak period of the December 2007 Ice Storm, Bixby Fire Department responded to one structure fire in a ten day period.

Critical Facilities

During a winter event, all critical facilities in the Bixby jurisdiction would be vulnerable to the same potential effects, including power outages that interrupt vital services and road closures or blockages from ice/snow accumulation or debris from ice-damaged trees.

During the December 2007 ice storm, three Tulsa area hospitals were dependent on generator power for an extended time and a nursing home facility in Collinsville was forced to evacuate its 90 residents due to loss of electricity. Several Bixby critical facilities, including City Hall, had to use generator power to maintain operations.

Infrastructure

Water Treatment – The most significant effect from a winter event would be the loss of electrical power, delays of chemical deliveries (road inaccessibility), and personnel and staffing issues. Both of the City of Tulsa water treatment plants supplying Bixby would be vulnerable to this threat.

During the 2007 ice storm, the Tulsa Mohawk Water Treatment Plant was offline for a period of approximately 4 days. Due to the severity of the storm, electrical 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 its customers. Due to widespread power outages in the area, the overall water demand was significantly reduced.

Wastewater Treatment – The most significant threat to the operation of Bixby's wastewater treatment lagoons during a winter storm would be power outages to the 23 sewage lift stations**.**

Utilities: Damage to utilities infrastructure can result in losses of up to $2 billion per winter storm event. The primary utility providers for Bixby'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 effects of 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 Bixby jurisdiction: Destruction of distribution and transmission poles, downed or broken power lines, staffing shortages due to impassable roads, danger to workers from downed power lines, hazardous road conditions, fallen 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 area customer base), 750-800 distribution poles broken, approximately 150 transmission poles broken, and countless miles of power lines down. Additionally, 4,600 restoration workers were utilized (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 can experience a variety of challenges in meeting the needs of the Bixby jurisdiction, including: damage to gas meters from ice accumulation, fallen power lines or tree debris, inaccessibility to underground gas meters from debris, danger to field employees from road conditions, extreme temperatures, and insufficient field and/or office staff to effectively handle workload generated by such an event.

During the December 2007 Ice Storm, ONG reported approximately 50 above-ground gas meters damaged due to power lines and falling 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 downed electric lines and tree limbs. ONG had no customer outages related to the storm.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – All forms of transportation in the Bixby jurisdiction would be at some risk during a winter storm. Road closures due to ice/snow accumulation can result in loss of retail trade, wages and tax revenue. Losses from road closures sometimes exceed $10 million/day in the eastern part of the US. The inability of public transportation (taxis, buses) to function after a winter event can also contribute to increased risk to the population if it hampers access to necessary medical care or shelter. Fortunately, MTTA (which serves Tulsa and the surrounding communities) experienced only minor disruptions in their operations during the December 2007 ice storm, and was able to provide essential services to the local community during the event.

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. Major ice or snow accumulations can impact runway safety and force flight cancellations or major schedule delays. The December 2007 storm resulted in all flights being cancelled for over 24 hours by airlines servicing TIA. In addition to delaying the transportation of goods and materials on courier flights, passengers were stranded with no real timeline for resumption of services. The impassability of roads in the area stranded many fliers at the airport.

Emergency Services- Fire, Police and Medical Services would all be vulnerable to the same potential affects of a winter storm event. 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, fallen debris from trees, and insufficient field and/or office staff to effectively handle the workload can be expected in all areas.

Additionally, fallen debris or impassable roads can lengthen response times for emergency calls, and hazardous road conditions add to the risk of accidents for responders, potentially reducing both fleet resources and manpower (injuries).

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 of the same year wreaking havoc on holiday planning all across Oklahoma, but greatly impacting the Tulsa County area, including Bixby. Both of these events resulted in an Emergency Declaration issued by the Governor of Oklahoma for all 77 counties in the state. The major effect of the storms was widespread and prolonged power outages. These outages had a profound impact on the residential and business communities alike.

The response phase of the January 2007 winter event was longer in duration than that in December – attributed largely to the lower temperatures during and immediately following the precipitation. Roads were inaccessible longer, smaller communities experienced severe potable water shortages due to power outages at pump stations, and larger numbers of people sought shelter outside their homes for longer periods. Daytime temperatures during and after the January event remained at or near freezing, with nighttime temperatures dipping into the teens and twenties for several days.

By contrast, temperatures following the December ice storm rose well above freezing during the day, with nighttime temperatures remaining in the upper twenties to lower thirties. The relatively mild daytime temperatures allowed roadways and power lines to be cleared of debris and ice, and recovery to begin more quickly.

That the first storm mainly affected small, rural communities, and the second a largely metropolitan area, make it difficult to compare the two events. However, by applying key assumptions such as (a) Equivalent Temperature Conditions, (b) Equivalent Ice Accumulations, and (c) Equivalent Resource Response, some basic correlations between the Muskogee/January event and the Bixby/December event may be made. Many officials have discussed the potential ramifications of an event as widespread and geographically located as the December storm occurring in the same temperature conditions as the January storm. All agree that the frigid nighttime and lower daytime temperatures of the January storm hampered the ability of the communities to recover from the damage – a challenge that Bixby was not faced with.

To examine the potential effect of a January-type storm on the City of Bixby and Bixby Public Schools, an analysis of key points of data was performed and applied to the base information from the Bixby 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 Bixby scenario.

Summary of Muskogee Event – January 2007

SitReps including information for the Muskogee area began on January 13th with a report of 11,095 customers without power, and concluded with a final report on January 23rd showing a remaining 92 customers still without power. The rate of restoration throughout the reporting period (based on daily SitReps) as a percentage has been calculated and is presented in the following table.

Table 4–34: Summary of Muskogee Event – January 2007

Source: National Climatic Data Center and Oklahoma Department of Emergency Management

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 to 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 an average of approximately 526 shelter residents per night. Many of those without power and heat chose to remain either at their own homes or with a family member/friend, primarily because of fear of looting. The Red Cross and the Salvation Army served approximately 70,000 meals through mobile and fixed feeding stations.

Prolonged freezing temperatures created the largely undocumented side effect of ruptured water lines. Many older, less insulated homes had burst water pipes that flooded the homes when the lines thawed. Depending on where the breaks occurred, this could cause anywhere from minimal to catastrophic damage to a residence. No official data on this aspect of the storm has been made available to date.

Summary of Tulsa Metro Area Event – December 2007

The first SitRep reporting customer power outages for the Tulsa Metro area (including Bixby) was issued on December 10th with a total of 75,000 customers without power. As precipitation continued to fall, outages rose to 225,769 on 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 4-35 demonstrates the Rate of Restoration.

Table 4–35: Summary of Tulsa Metro Area Event – December 2007
Source: AEP/PSO, National Climatic Data Center

Date	Daily High	Daily Low	Customers Without Power	% increase / decrease restoration
11-Dec	36	32	225,769	--
12-Dec	*35*	*32*	178,507	-20.93%
13-Dec	*34*	*31*	169,724	-4.92%
14-Dec	*41*	*30*	81,000	-52.28%
15-Dec	*38*	*25*	62,454	-22.90%
16-Dec	*44*	*20*	42,145	-32.52%
17-Dec	*55*	*25*	30,205	-28.33%
18-Dec	*56*	*35*	8,344	-72.38%
19-Dec	*62*	*27*	2,000	-76.03%
20-Dec	*61*	*36*	1,000	-50.00%
21-Dec	*65*	*31*	--	-100.00%

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 aggressive warming trend contributed greatly to the elimination of ice accumulation on streets, power lines, and trees, and allowed the recovery phase to begin quickly. Crews were out almost immediately clearing of toppled trees and broken/downed power poles/lines.

Twenty-nine fatalities were reported for this event: Sixteen were related to motor vehicle accidents, nine to house fires, two to carbon monoxide poisoning and two to hypothermia. One injury was reported in the SitReps, a lineman who was injured on duty and required hospitalization.

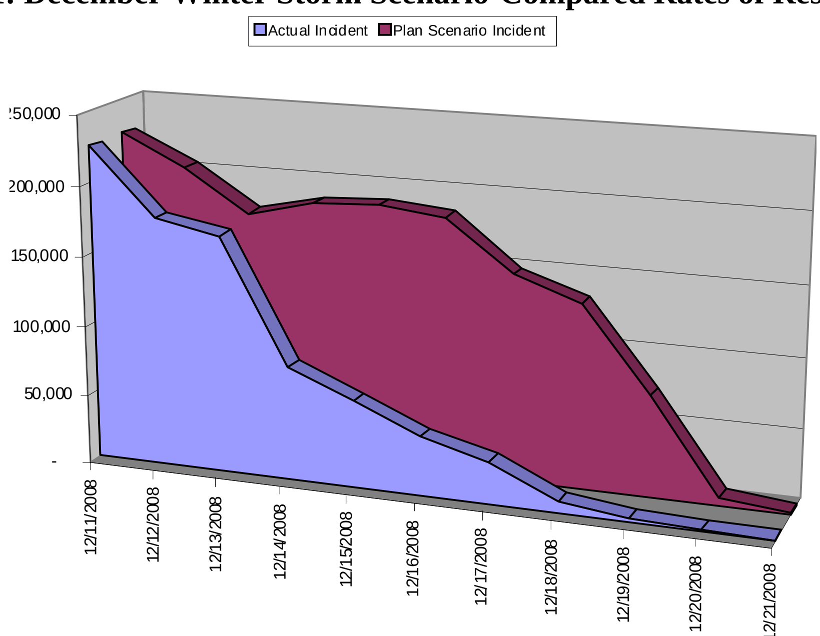
Shelter populations for this event were much greater than for the one in January. The American Red Cross reported that over 2,000 people sought shelter the night of December 11th, 860 on the 17th, 30 the night of the 19th and all shelters closed the following day. The average for the event was 1,836 shelter residents per night. But as noted, the shelter populations fell off rapidly in 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 Metro/December event, a comparison of certain Economic Values can be made. A chart demonstrating the differences between the Actual Tulsa Metro Area Rate of Restoration to the Scenario Rate of Restoration is shown in Figure 4-21.

What this demonstrates is that under the proposed conditions, the number of customers without power is higher and longer. For the 11 days used in this analysis, the Actual Tulsa Metro Area reported outages averaged 72,832 customers/day without power. For the same time period, if temperatures had remained below freezing as they did in the Muskogee event, the average number of customers without power would increase to 138,664 customers/day.

Figure 4–21: December Winter Storm Scenario-Compared Rates of Restoration



This can be translated into an economic value of loss for utilities and the community. 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 following chart provides comparisons between the Actual and Scenario Economic Values for both of these categories.

Table 4–36: Actual vs. Projected Economic Losses for Tulsa Metro Winter Storm Scenario

Scenario Event Economic Values				Tulsa Metro Area Actual Event Economic Values		
Dates	Customers	Economic Value of Loss of Utilities ($0.06/kwh)	Economic Value of Interruption of Daily activities ($21.16/ customer/ hr - 12hrs)	Customers	Economic Value of Loss of Utilities ($0.06/kwh)	Economic Value of Interruption of Daily activities ($21.16/ customer/hr – 12 hrs)
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

The same comparison can be made regarding the Economic Value of the Interruption of Daily Activities for the community. 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.

Conclusions / Additional Considerations

These comparisons are just two of the many areas to consider in this type and scope of event. These numbers reveal an increase of 47% in the value of economic losses under the scenario utilizing the colder temperatures and 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 such 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 of 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 Bixby 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 remained impassable for several days, effectively isolating many residents in their homes. Aside from the impact of not being able to get out to care for basic needs, stress from 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 Bixby 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, and would translate into more businesses reporting larger losses.

4.6.5 Future Trends

For a map of Bixby's potential future development areas, see Figure 1-17.

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 of retirees relying on fixed incomes could very easily translate into a larger percentage of people 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 city's inventory should consider the placement of trees and large shrubs to reduce the risk of power line interference. Burying of electrical power lines, when possible, is a more favorable way of avoiding this impact. 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 apply equally, if not more, to critical facilities. Several mitigation measures included in this plan address the issue of power outages at City of Bixby fueling stations and water 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 Emergency Backup Generator Hazard Mitigation Plan Annex (EBGHMP) which reviews the capabilities of all City and Public School facilities, their necessity in the response and recovery process, their current capabilities to stay up and running during an extended power outage, and the costs of retrofitting them to a workable 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 Conclusions

Due to the rich, moist atmosphere present in Bixby, the entire jurisdiction should expect to be repeatedly affected by winter snow and ice events. The degree of severity is dependant greatly on the temperature fluctuation between daytime and nighttime, and the duration of any extreme temperature conditions. The City of Bixby and Bixby Public Schools risk to Winter Storms is considered Extreme.

Data Limitations

Data kept by the National Climatic Data Center cannot separate out geographically the effects of winter storms that may encompass an extremely wide area. With that in mind, casualties, damages, and the effects of historic events are frequently aggregate numbers for storms that extend outside the geographical boundaries of the designated area.

Update Changes

Identified significant changes made from the 2004 City of Bixby Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the *Local Multi-Hazard Mitigation Planning Guidance* document of July 1, 2008.

4.6.7 Sources

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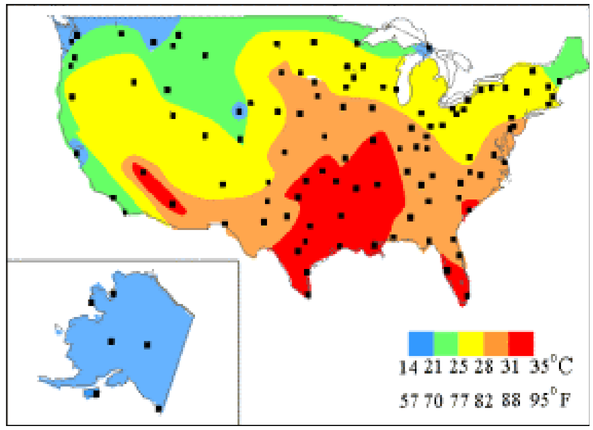
4.7 Extreme Heat

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.

Figure 4–22: Average July Temperatures



Tulsa County's average high temperature in July is 94° Fahrenheit

The City of Bixby and Bixby Public Schools have experienced major heat waves seven times in the past 20 years: in 1994, 1996, 1998, 2001, 2006, 2007, and 2008. Extreme heat impacts the entire population of Bixby and can be expected every summer. The population at most risk to extreme heat is the 10.7% of the Bixby population aged 65 and above, the 5.4% of the population 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.

4.7.1 Hazard Profile

Each year in the United States, the cause of death for approximately 200 people is listed as heat-related[3], 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 an internal temperature of 98.6° Fahrenheit. When heat gain exceeds what 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.

[3] 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 also affects local workforce capabilities. Workers exposed to these elements must be monitored for heat exhaustion and heat stroke.

Heat-related illnesses can include the following:

- **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 jurisdictions of Bixby and Bixby Public Schools, but particularly the aged, the poor, the obese, those with heart problems, and people who work out of doors. See Figures 1-9, and 1-10 for demographic data on locations of elderly and low income in the City of Bixby.

Measurement

The Heat Index and Heat Disorders table 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 with no humidity.

Table 4–37: Heat Index

Heat Index (Apparent Temperature)

Air Temperature (°F) by Relative Humidity (%)

°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

Extent (Magnitude/Severity)

Over the past ten years, the average high temperature for July and August in the Bixby area has been 94° 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 those particularly at risk are 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.

Bixby and Bixby Public Schools consider a *minor* severity to be a heat index of 95 or less and a *major* severity to be a heat index greater than 95.

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 4-38 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 4–38: Casualties and Damages Caused by Extreme Heat

Location	Events	Deaths	Injuries	Damage Events	Property Damages
Tulsa County	16	13	52	0	$0
Oklahoma	47	91	157	1	$10,000

Source: National Climatic Data Center

Frequency

Bixby jurisdictions have experienced major heat waves seven times in the past 20 years, these being 1994, 1996, 1998, 2001, 2006, 2007, and 2008. Based on this limited data, sustained periods of temperatures above 100° Fahrenheit can be expected on the average of once every two to three years.

Impact

The impact of extreme heat is primarily the danger to people, resulting in muscle cramps, nausea, heat exhaustion, heat stroke, and death, but it can also increase the risk of and impacts from wildfire and drought.

4.7.2 History/Previous Occurrences

Historic Extreme Heat Events

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 *(Source: National Weather Service: Office of Climate, Water & Weather Svcs.)*. In the summer of 1936, temperatures across two-thirds of the United States rose well above 110° Fahrenheit, and to as high as 121° 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.

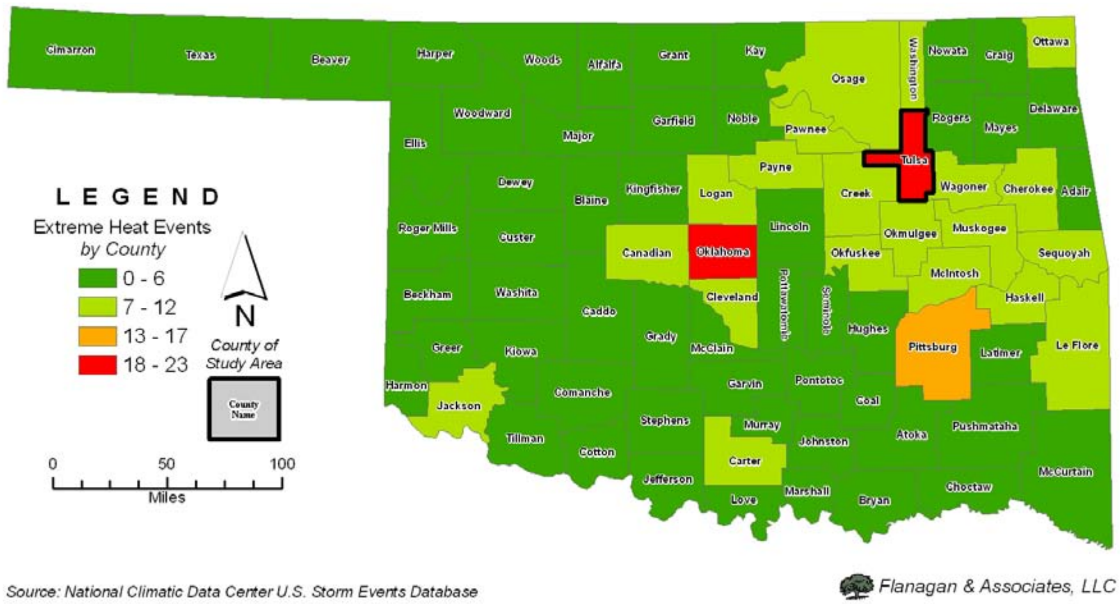
A 1988 drought and heat wave affecting the central and eastern United States caused approximately $40 billion in livestock and crop damage. Another in 1993 in the southeastern United States caused approximately $1 billion in livestock and crop damage and an undetermined number of deaths.

The Central Plains and Corn Belt States experienced a heat wave July 11-19, 1995, when temperatures climbed above 120° Fahrenheit. A significant portion of the Eastern United 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 the City of 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.

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*).

Figure 4–23: Extreme Heat Events in Oklahoma from 1989 – 2008



The table below shows that 91 deaths resulted from extreme heat episodes from 1995 to 2009 in Oklahoma compared with 2,504 deaths in the United States. The table also illustrates the percentage of fatalities in the United States that were people over 60 years of age.

Table 4–39: Deaths from Extreme Heat
From NOAA National Climatic Data Center Annual Summaries

Year	Oklahoma	United States	Over 60, US
1995	0	1,021	73%
1996	10	36	84%
1997	0	81	65%
1998	24	173	68%
1999	10	502	67%
2000	5	158	68%
2001	9	166	62%
2002	0	167	52%
2003	3	36	61%
2004	0	6	50%
2005	1	158	56%
2006	24	253	48%
2007	1	105	51%
2008	3	71	55%
2009	1	-	-
Totals	**91**	**2,933**	**68.2%**

Bixby and Tulsa County Extreme Heat Events

Bixby and Bixby Public Schools have experienced extreme heat on seven occasions since 1993: in 1994, 1996, 1998, 2001, 2006, 2007, and 2008.

June 27, 1994 – Temperatures climbed to above 110° in southwest Oklahoma with readings in excess of 100° F in northwest and central Oklahoma during the afternoon hours on June 27. The high temperature of 120° four miles south of Tipton tied the record for the highest temperatures ever recorded in the state. In Bixby, temperatures were in the triple-digits for over 10 days.

July 1-7, 1996 – High temperatures topped 100°F in central Oklahoma through the first week of July. During this prolonged period of high temperatures, seven deaths were attributed to excessive heat. All of the victims were elderly and all but one was in a home without air conditioning. One of the deaths was a 67-year-old man in Cushing in nearby Payne County.

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 6, 2001 – An extended period of excessive heat affected all of western and central Oklahoma in July. Most areas regularly experienced high temperatures at or above 100°, particularly western and north central Oklahoma. Eight fatalities resulted from the heat. A 78 year-old male died in Tulsa on July 6, while loading equipment at a storage facility.

July-August, 2006 – Temperatures reached above 100° starting in mid-July and continued through the middle of August. Many locations at times reached 105° or greater. The heat caused 10 fatalities across the area.

August, 2007 – Due to spring rains, humidity remained high well into the summer and increased the health risks of the elevated temperatures. The combination of heat and humidity resulted in daytime heat index values from 105 to 113° across much of eastern Oklahoma. Two men died in Tulsa as a direct result of the heat. Two hundred other people were treated by EMS in the Tulsa Metro Area for heat related illnesses. Many of those 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

The residents of Bixby will continue to be vulnerable to extreme heat events. Due to aggressive heat plans in the Tulsa County Emergency Operations Plan, which includes the City of Bixby jurisdiction, the impact of these heat waves has been considerably reduced. The impact of future events will be directly related to the continuation of this aggressive program, and other mitigation measures that may be implemented by the community to reduce the effect of the urban heat island, particularly in central Bixby. Bixby and Bixby Public Schools have a high probability of a future extreme heat event.

4.7.3 Vulnerability

This section summarizes information about Bixby's vulnerability to extreme heat, including the impact on people, structures and buildings, critical facilities, and infrastructure. This information, as well as information provided by the City and Public Schools, was used to determine the Vulnerability Criteria identified in Tables 4-2 and 4-3. The City of Bixby and Bixby Public Schools were determined to have a Moderate risk to the Extreme Heat hazard (See Table 4-2 Hazard Risk Analysis, and Table 4-3, Summary of Hazard Risk Analysis Ranking Criteria for an explanation of how the rankings were derived.)

Population

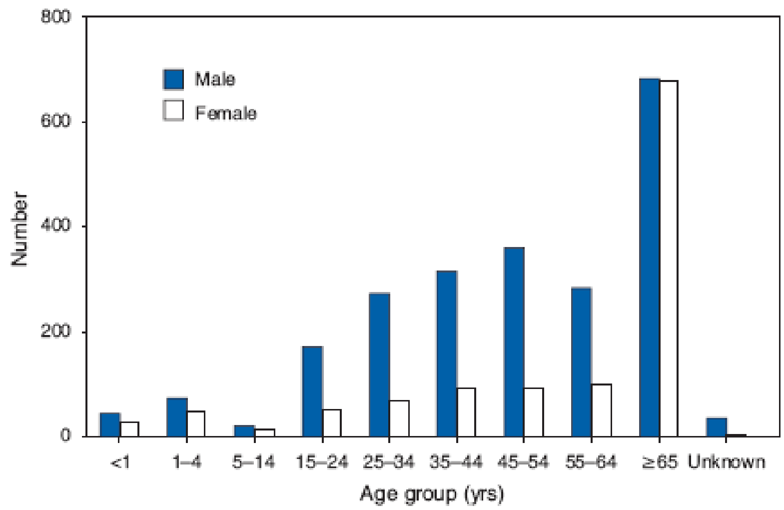
Every person is subject to health problems during a heat wave. However, the following groups are more exposed to the hazard:

- 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., high blood pressure, insomnia, etc.)
- 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 require strenuous labor out-of-doors in the heat and humidity.

Studies indicate that, all things being equal, the severity of heat disorders tends 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, what causes heat cramps in a 17-year-old may cause heat exhaustion in a person who is 40, and heat stroke in a person over 60. Figure 4-24, from the Center for Disease Control's Morbidity & Mortality Report for July 2006, demonstrates vulnerability created by age.

Figure 4–24: Number of heat-related deaths, by sex and age group – United States, 1999-2003



*** Exposure to extreme heat is reported as the underlying cause of or a contributing factor to death.**

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 reducing the contribution of moving air to evaporative and convective cooling.

The average high temperature in Bixby for July is 93.6° F, with an average afternoon humidity of 56%. This calculates to a heat index of 106° F, 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. Therefore, the City of Bixby is vulnerable to extreme heat on a yearly basis. This is especially true of the 10.7% of the city's population that is age 65 and above, and the 5.4% who are living in poverty. All future development areas are also at risk from extreme heat events.

Structures/Buildings

During an extreme heat event, it is likely to be hotter in cities than in surrounding rural areas, especially at night. Temperatures typically rise from the outer edges of the city and peak in the centre. This impact of this urban heat island phenomenon can be significant. A number of factors contribute to creating the UHI effect, such as:

- **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 should take the above factors into account, 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. In addition, a great many city facilities, such as City of Bixby recreation centers, may be designated as cooling centers for vulnerable neighborhoods. When so designated, these facilities should include this function in their plans.

Especially vulnerable to high heat are medical and long-term care facilities. During an extreme heat event, power outages are not uncommon. While the larger medical treatment facilities that serve Bixby are equipped with dependable, redundant generator backup systems, an alarming number of long-term care or 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 at the time.

Infrastructure

Water Treatment – Water demand increases significantly during extreme heat events. Demand could possibly exceed the delivery capacity of the City of Tulsa’s water treatment plants, which supply the City of Bixby and Bixby Public Schools. A City Ordinance is in place to restrict outdoor and non-essential water use during drought or in times of water emergency.

Given that extreme heat conditions also increase the demand for electricity, power outages can be a potential secondary effect. However, the City of Tulsa water treatment plants are high priority customers and would not be impacted by planned rolling outages.

Wastewater Treatment – The most significant threat of extreme heat to the operation of Bixby’s wastewater treatment lagoons would be power outages to the 23 sewage lift stations.

Utilities: The primary utility providers for Bixby’s jurisdictions are AEP/PSO (electricity) and ONG (natural gas).

Electricity - During periods of extreme heat, providers of electrical service could experience any combination of the following challenges in meeting the needs of the Bixby jurisdiction: Failure of vital delivery components due to high heat, outages or brownouts due to peak loads, 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 from 4-7 pm as workers are returning to their homes and adjusting thermostats accordingly. This results in an overwhelming demand placed on power station and transformer components, sometimes resulting in power outages across the jurisdiction.

High temperatures and heavy loading can also cause transmission lines to sag into trees and flashover to ground, potentially causing widespread power outages.

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) – No significant vulnerabilities to the City of Bixby's transportations systems during an extreme heat event have been identified.

Emergency Services- Fire, Police and Medical Services would all be similarly exposed to the effects of an Extreme Heat Event. Fire and Medical Services typically receive a higher volume of heat-related calls, taxing the response capabilities of both services. Fire and Police services would both be exposed to secondary effects of extreme heat by having to perform inherently stressful outdoor work under hazardous temperatures. While extreme heat is not an immediate threat to delivery of Police and Fire services, the demand for additional personnel could potentially increase the cost for these resources.

4.7.4 Heat Scenario

Extreme 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 such fatalities were reported, with 12 of those from the Tulsa Metro Area. Eight of these fatalities were Tulsa Area residents, while the other four were individuals overcome/injured by the extreme heat and transported to Tulsa hospitals where they passed away. The ages of the Tulsa Area residents ranged from 54 to 87 years of age, with 50% over the age of 65.

Between June 25 and September 19, 1980, Tulsa International Airport reported 58 days with temperatures of 100° 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 soared as high as 108-109°. The average daytime high for July was 103.6°. These relentless conditions provided no relief to those most vulnerable to the cumulative effects of such extreme heat conditions, and prompted local social service agencies to examine possible measures to implement during periods of extreme heat.

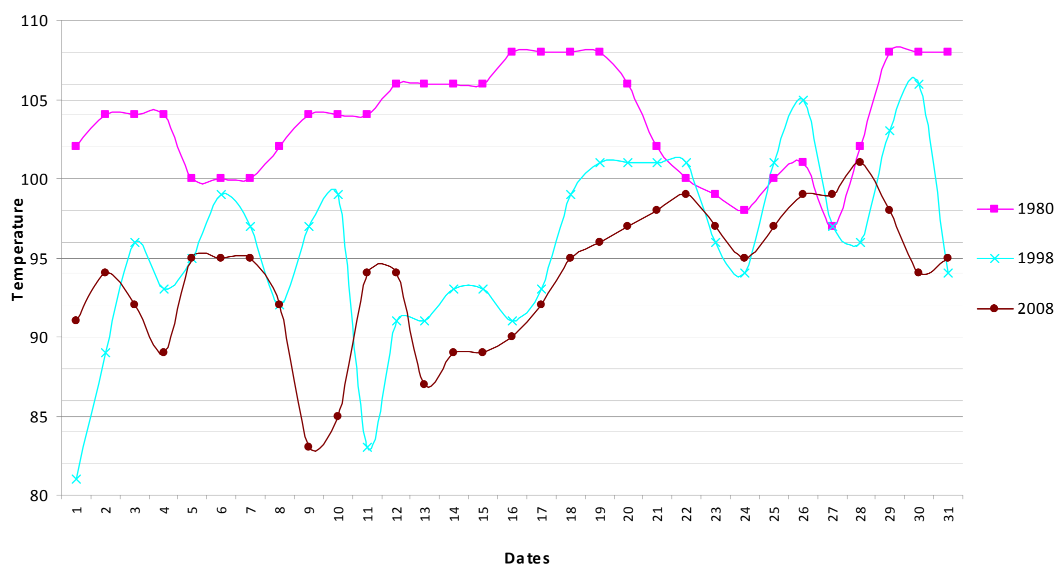
Tulsa's Community Service Council initiated a Weather Coalition Air Conditioner Loan Program the following year. This innovative program is designed to provide window air conditioners to the area's vulnerable population during an extreme heat event; including the homebound elderly, those with medical conditions placing them at a higher risk, and people on fixed incomes. Applications are accepted each year for the temporary placement of these life-saving appliances.

Tulsa's LIFE Senior Services, founded in 1983, provides adult day service for senior citizens at three area locations (one in Broken Arrow and two in Tulsa) as well as two separate senior centers in Tulsa. The Bixby Community Center is a location where vulnerable residents can escape from the hottest part of the day.

Bixby has experienced several extreme heat periods since 1980, but two periods of note are the summers of 1998 and 2008.

The summer of 1998 delivered a heat wave and accompanying drought that led to 173 heat-related deaths in the country and 28 in Oklahoma. Three fatalities occurred in the Tulsa Metro Area—all three being 40-year old males in varying circumstances. The year 1998 is ranked number eight in Bixby's top ten 100-degree days since 1938. The first 100-degree day was recorded on July 19th, and the last on September 22nd – a total of 22 days with temperatures at or above 100°. The average daytime high for that July was 95.7degrees. Only eight days in the month were below 100°.

The summer of 2008 presented its own level of heat-related concerns for Bixby. Nationwide, *USA Today* reported that by August 1st, approximately 50 people had died due to heat-related illness. This was before many states had gone through their hottest



month.

Figure 4–25: July Daily High Temperatures 1980, 1998, and 2008

The Emergency Medical Services Authority (EMSA) reported 64 heat-related calls were received from July 11th through July 31st. The average age of the patients was 41.1 years, some male and some female. Two heat-related fatalities were reported for the Tulsa Area between mid-July and mid-August, neither of which occurred in Bixby.

A worst-case scenario for Bixby would be a repeat of the extreme heat event of 1980, without the community protections that were developed in the wake of the 1980 heat wave—such as the air conditioner loan program, utility bill assistance, and cooling rooms. Tulsa's Weather Coalition has provided between 200 and 220 window air conditioning units to qualified applicants each year.

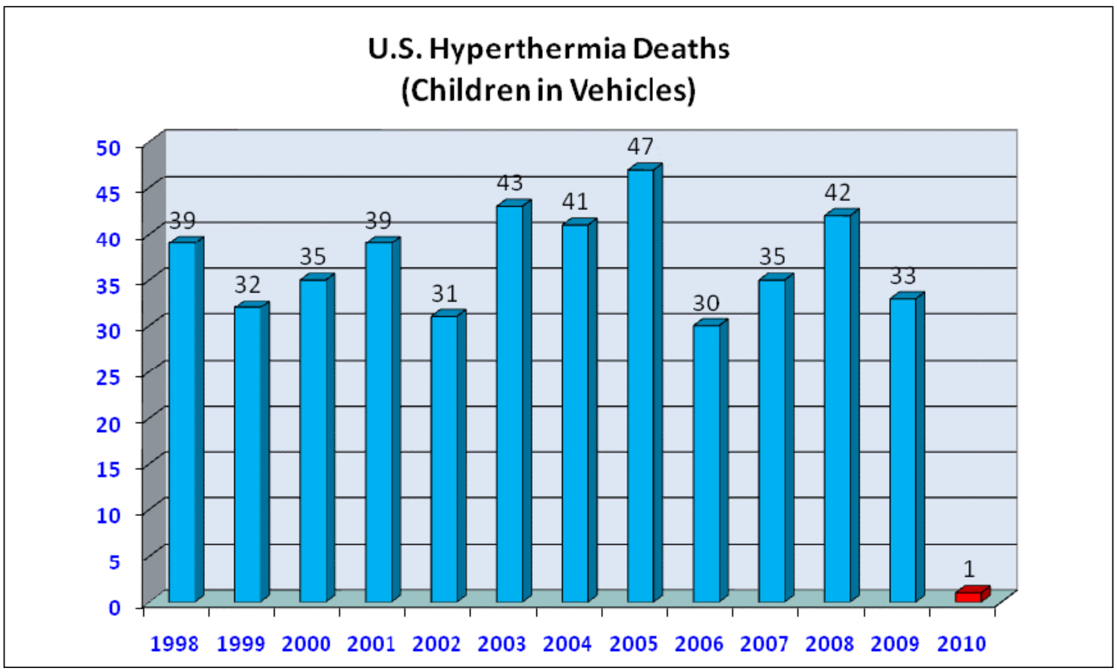
A disturbing trend is the increase in the number of heat-related deaths of children under the age of 13 in locked cars. Between 1990 and 1992, ten such deaths were reported. For 2004 through 2006, there were 110 deaths of children left in vehicles. This represents an increase of approximately 14 more deaths in this population group every two years. According to the San Francisco State University Department of Geosciences, the average number of U.S. child hyperthermia fatalities per year for 1998-2010 was 37.

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 in Tulsa (2005).

Review of the heat-related fatalities reported for the Tulsa Metro Area would support the conclusion that the Tulsa Weather Coalition Program has indeed had a positive impact in preventing deaths among the most vulnerable population. Without this program, or others that also facilitate that care, 200 additional people would be placed at grave risk in the event of a heat wave like that in 1980.

The statistics from previous extreme heat events would suggest that, should Bixby experience a heat wave similar to that of 1980, without the existing programs and with a continuation of current social trends, it could be reasonably assumed that there could be fatalities within the Bixby population.

Figure 4–26: US Hyperthermia Deaths of Children, as of March 8, 2010
Source: San Francisco State University, Department of Geosciences



4.7.5 Future Trends

For a map of Bixby's potential future development areas, see Figure 1-17.

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 venues close to home, such as public parks etc. As the number of people using local outdoor venues increases, vulnerability will also likely increase.

Also at risk is the homeless population. With the recent home mortgage situation and additional economic stressors on those already struggling to meet financial obligations, the number of homeless may also increase. Facilities designated as shelters (either daytime only or residential) will be further taxed to meet this need, should the number of homeless continue to grow.

If economic conditions remain stressed or worsen, those in the more vulnerable population (elderly, fixed income, compromised health situations) will likely have difficulty cooling their homes.

As development in Bixby continues, the number of outdoor workers will likely increase. Care should be exercised to ensure that the outdoor workforce is informed of the dangers of extreme heat.

Structures/Buildings

Structures and buildings are only vulnerable in a limited way, such as in damage from expansive soils. As development in and around Bixby continues, the health aspects of the urban heat island should be considered—that is, the temperature rise that occurs when large quantities of dense materials, such as stone, concrete, asphalt, and other construction materials absorb the heat from sunlight 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 that would provide relief during the night.

Critical Facilities

Any future development or renovation of existing critical facilities should include plans for dependable backup systems for delivery of critical power for both equipment and cooling.

Infrastructure

As developed areas of the city continue to age, the water delivery lines that serve these neighborhoods will also deteriorate, increasing the likelihood of line ruptures during peak use periods, such as extreme heat events. Any development in areas facing this possibility should be closely monitored to ensure existing water lines are capable of handling the additional load – and are replaced as necessary.

Sporadic power outages are commonplace during prolonged periods of high temperature. With an average of more than six hundred new residential building permits issued each year, the burden on power delivery systems will continue to grow. Developers building in previously undeveloped areas should work closely with utility companies to ensure that power stations are not overloaded.

4.7.6 Conclusions

Bixby and Bixby Public Schools can expect to be hit by the hazard of extreme heat every summer. Although Bixby Public Schools are generally out of session during the hottest summer months, there are activities in many of its facilities, such as Summer School, athletic events and maintenance. The severity of the hazard is dependent on a combination of temperature, humidity, and access to air conditioning. With July average high temperature being 93.6° Fahrenheit, and average afternoon humidity 56%, resulting in a heat index of 105° Fahrenheit, Bixby is at Moderate Risk to Extreme Heat.

The most effective proven way to mitigate casualties from extreme heat is through public information and education, although other community programs, such as cooling stations and air conditioner loan programs can also reduce extreme heat impacts.

While the documented deaths and medical transports appear to be dropping because of the above-mentioned Extreme Heat Action Plan, heat will continue to be an ongoing threat to the City of Bixby and Bixby Public Schools, although the risk factors are less for the less developed areas than for the major urban “concrete islands” due to less heat retention during the nighttime hours.

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 have resulted in substantially lower mortality/morbidity figures. In addition, death by other causes such as cardiac, with heat as a “contributing factor” can further confound the final statistics for deaths and injuries.

Update Changes

Identified significant changes made from the 2004 City of Bixby Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.7.7 Sources

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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.

The "Dust Bowl" of the 1930s, the greatest natural disaster in Oklahoma history, drove over 800,000 people off the land

4.8.1 Hazard Profile

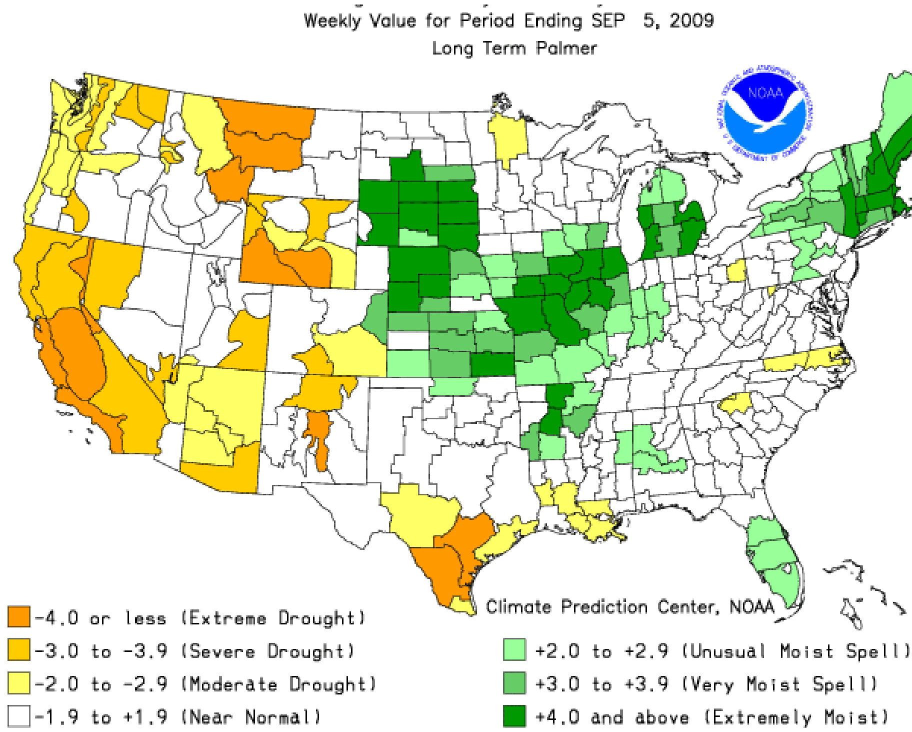
Drought is an insidious hazard of nature, characterized as a "creeping phenomenon." It is often difficult to recognize the occurrence of drought before being in the middle of one. Drought analysis is more subjective than that for floods, because droughts do not occur suddenly. They evolve over time as certain conditions are met and 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.

There are normally considered to be three kinds of drought, which occur at different stages, illustrated by Figure 4-28. **Climatological drought** is based on precipitation, temperature, runoff, and other meteorological indices. As this continues, it will result in **Agricultural drought,** measured by soil water deficiency and plant water stress. **Hydrologic drought** is the end result of climatological drought, when wetlands, reservoirs, and stream flow have substantially been reduced. This is the stage that can seriously affect urban/rural water supplies and the community infrastructure.

Location

Drought is a widespread phenomenon that occurs over broad regions encompassing not only multiple communities, but frequently multiple states. Over the last few years, western Oklahoma has been hit harder by water shortages than eastern Oklahoma, but no location in the state is immune. The City of Bixby and Bixby Public Schools are at risk from Drought. See the illustration below for recent information.

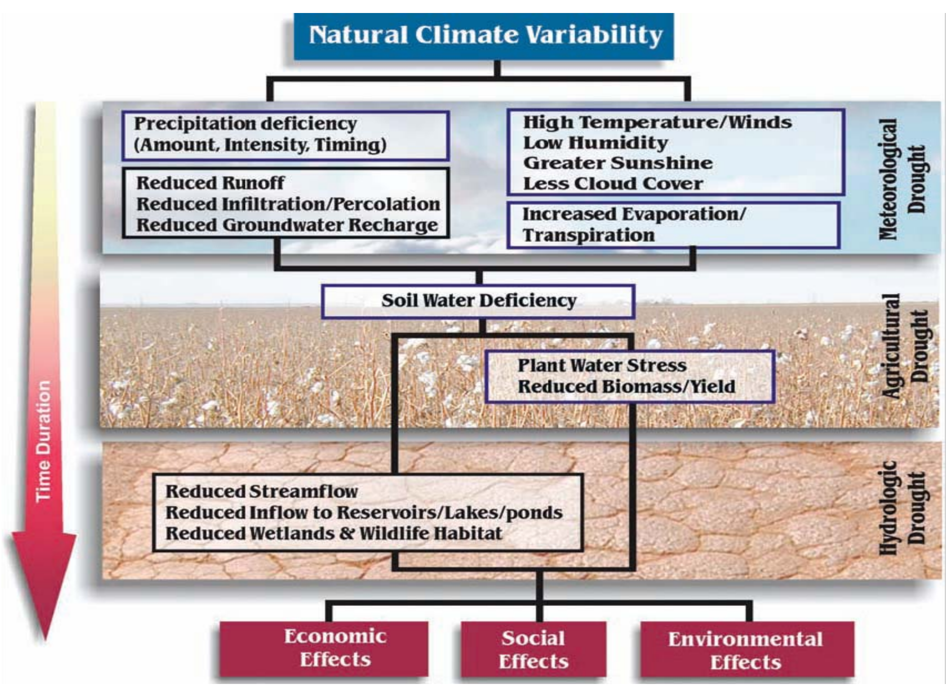
Figure 4–27: Drought Severity Index by Division ending September 5, 2009



Measurement

Different measures are used to predict severity and impact of droughts, but each 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.

Figure 4–28: Three Kinds of Drought



The Palmer Index, the most familiar and widely used, measures the departure from normal precipitation. This index uses a range from 4 (extremely wet) to –4 (extremely dry). It incorporates temperature, precipitation, evaporation, runoff, and soil moisture when designating the degree of drought. Hydrologic indices of drought (such as groundwater levels, reservoir volumes, or water levels) may be used to determine surface water supplies.

Palmer Drought Severity Index (PDSI)

In 1965, Palmer developed an index to "measure the departure of the moisture supply". Palmer based his index on the supply-and-demand concept of the water balance equation, taking into account more than only the precipitation deficit at specific locations. The objective of the Palmer Drought Severity Index (PDSI), as this index is now called, was to provide a measurement of moisture conditions that were "standardized" so that comparisons using the index could be made between locations and between months.

The Palmer Drought Index is based on precipitation and temperature. The Palmer Index can therefore be applied to any site for which sufficient precipitation and temperature data is available.

The Palmer Index varies roughly between -4.0 and +4.0. Weekly Palmer Index values are calculated for the Climate Divisions during every growing season and are on the World Wide Web at the National Drought Mitigation Center.

Table 4–40: PDSI Classifications for Dry and Wet Periods
Source: http://drought.unl.edu/whatis/indices.htm

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

Fire: Keetch-Byram Drought Index, fire danger rating system

The Keetch-Byram Drought Index (KBDI) is basically 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. It is also one of the only drought index systems specifically developed to equate the effects of drought with potential fire activities.

The result of this system is a drought index number ranging from 0 to 800 that accurately describes the amount of moisture that is **missing**. A rating of zero defines the point where there is no moisture deficiency and 800 is the maximum drought possible.

These numbers correlate with potential fire behavior as follows:

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. Source: http://www.wfas.us/content/view/32/49/

Extent

Because of the gradual nature of drought's onset, and its uneven impacts, it is often difficult to determine the beginning and end of a drought event. Bixby's jurisdictions have experienced drought three times in the past 7 years, characterized primarily by crop damage and wildfire. Based on the Palmer Drought Index, Bixby drought conditions can range from 4 to –4. This value is adjusted weekly through the Climate Prediction Center. Bixby's municipal water supply is strong, supplied, as it is, by the City of Tulsa. Tulsa's water is drawn from two separate watersheds, one originating in Kansas, which flows into Tulsa's Mohawk Water Treatment Facility, and one originating in Arkansas, which flows into the city's A.B. Jewell Water Treatment Facility. Tulsa's water supply and treatment capacity is three times its current maximum demand.

Although Tulsa's (and Bixby's) water supply is plentiful, 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 2007 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.

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.

Bixby considers a drought of minor severity to be a -2 to 0 on the Palmer Drought Index and a major severity to be -2 to -4.

Frequency

Bixby has experienced drought of varying length and severity four times in the past 10 years, characterized primarily by crop damage and wildfire.

Given that six major drought events have occurred in Oklahoma over the past 50 years and that nine notable droughts occurred nation-wide in the twentieth century, one may conclude that Oklahoma can expect a drought every decade and expect droughts to occur more frequently 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 Corps 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.

Impact

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. During droughts crops do not mature, wildlife and livestock are undernourished, land values decrease, and unemployment increases.

In addition, water shortages affect fire-fighting capabilities through reduced water flows and pressures. Drought also affects power production, since 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. (See the section, "Wildfires")

4.8.2 History/Previous Occurrences

Historic Drought Events

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 has become 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.

Nine notable droughts occurred during the twentieth century in the United States. 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 drought cost $39 billion including agricultural losses, river transportation disruption, economic impacts, water supply problems, and wildfires.

In recent years, the nation has been fighting a nationwide drought. However the 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. In 2007, gigantic portions of the Southeast were in the worst drought in more than a century, sparking water wars among Georgia, Alabama and Florida… There have been less than half a dozen occasions since the late 1800s when drought has been as sparse as it is now, Le Comte said. (*National Drought Mitigation Center –* www.drought.unl.edu/monitor/news/2010/february.htm)

In Oklahoma, five major drought events were reported over the past 50 years resulting in damage to crops estimated at $900 million.

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.

Bixby and Tulsa County Drought Events

Bixby and Bixby Public Schools has experienced drought of varying length and severity four times in the past 10 years, characterized primarily by crop damage and wildfire. These events are summarized in the following paragraphs based on available information. These events are listed in the NCDC database as affecting Tulsa County but do not specify which communities within the county they affect.

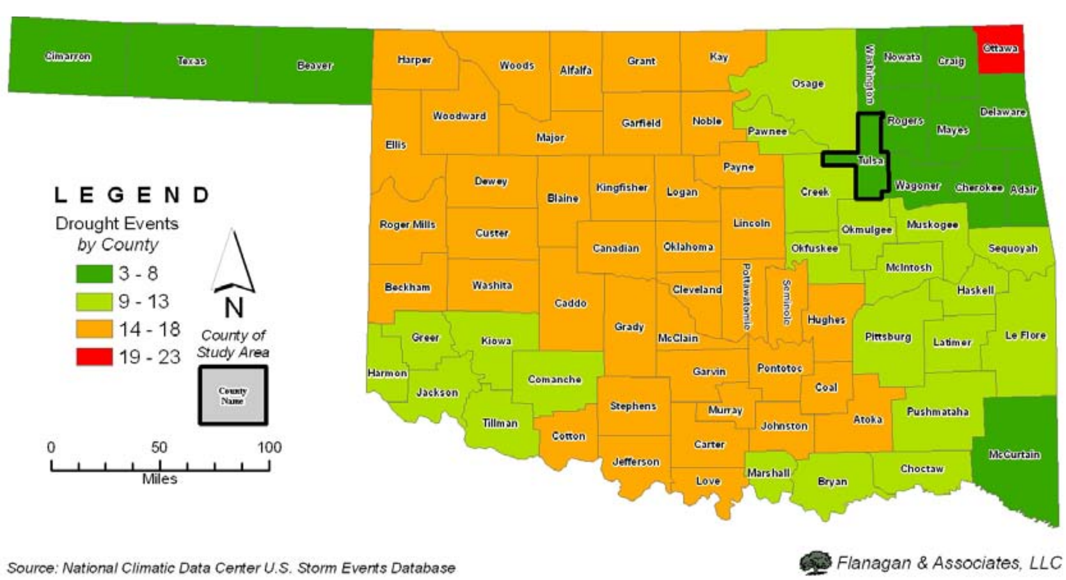
August 2000. Oklahoma began the new century with drought conditions. In early August 2000, an extended period of unusually dry weather lasted for 2 months. Many parts of the state did not receive rain in August, and portions of southern and south central Oklahoma remained dry for almost 90 days, starting 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.

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 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*, below) 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 figure 4-30, 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 4–29: Drought Events in Oklahoma from 1989 - 2008

Table 4-41 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 4–41: 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

Probability/Future Events

Based on history and previous occurrences from the past 50 years, Bixby and Bixby Public Schools have a moderate probability of a future drought event. However, as in the past, it can be expected that drought effects will be more severe in western Oklahoma than in the eastern part of the state, and will have a more devastating effect on rural areas and the agricultural and ranching community than on urban residents.

4.8.3 Vulnerability

This section summarizes information about Bixby's vulnerability to drought, including the impact on people, structures and buildings, critical facilities, and infrastructure. This information, as well as information provided by the City and Public Schools, was used to determine the Impact Criteria identified in Tables 4-2 and 4-3. The City of Bixby and Bixby Public Schools were determined to have a Moderate Risk to the Drought hazard (See Table 4-2 Hazard Risk Analysis, and Table 4-3, Summary of Hazard Risk Analysis Ranking Criteria for an explanation of how the rankings were derived.)

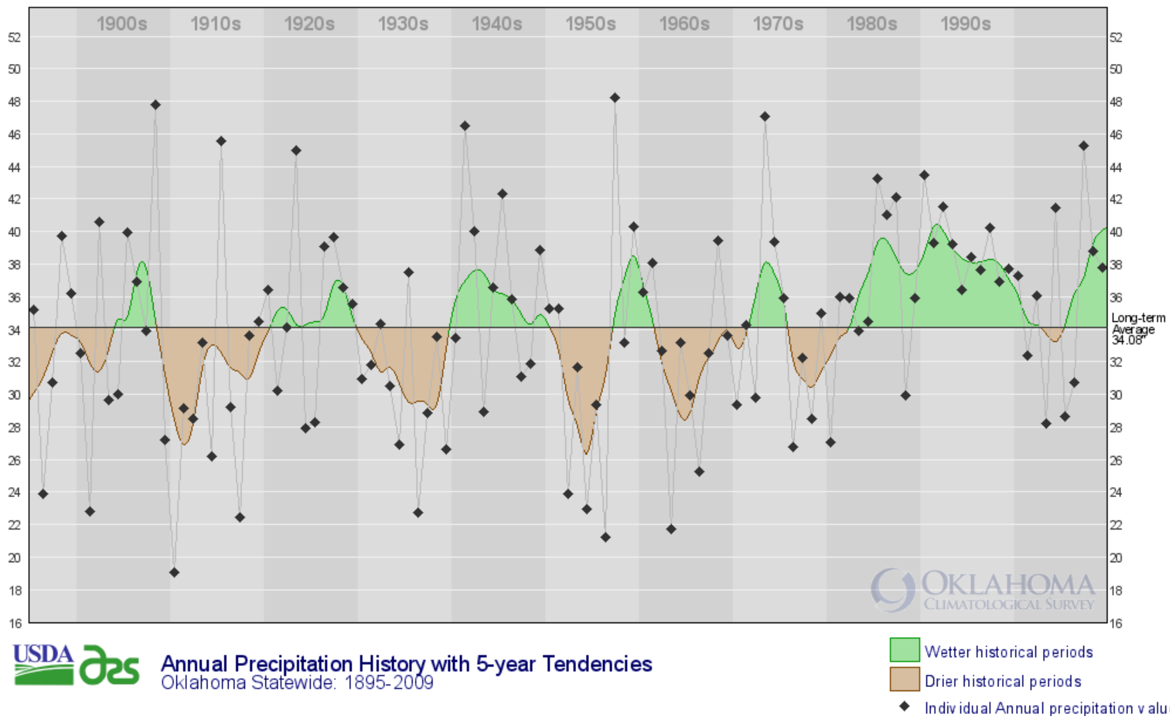
Drought and Water Conditions in Tulsa County and Bixby

Bixby draws its water supply from the City of Tulsa, which gets 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 plants 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. Bixby has not had to impose any kind of rationing in decades.

The primary impacts of drought in Tulsa County have been to farming and ranching. A secondary impact for both Tulsa County and Bixby, 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 were burned by wildfire. This fire complex resulted in a Presidential Disaster Declaration. As illustrated in the graph, Oklahoma has gone through six drought cycles, state-wide, since the early 1900s, with the latest cycle being an almost 20-year period of wet weather lasting from about 1983 to 2003.

Figure 4–30: Annual Rainfall History from 1895-2009

Large reservoirs may have several target storage levels, each level planned to ensure a



usable amount of water at a certain time of year. For instance, in addition to its normal or Full Supply level, a reservoir may have a Conservation Storage Level (i.e., the desirable level for a flood-control reservoir at the start of each flooding period), a Flood Storage Level (the maximum desirable level that is permitted for reservoir safety during floods), a Dead Storage Level (the level below which water may not be withdrawn for consumptive uses) and various other target levels established to meet such needs as summer recreational use, irrigation uses and hydropower discharges throughout the year.

A reservoir used for municipal purposes will be designed to have no shortages because the users (people in cities) cannot tolerate periods without water. When uses are such that shortages, although they may be inconvenient, will not cause severe economic hardship, reservoirs are often designed to allow for an acceptable percentage of shortages in critically dry years.

Birch, Skiatook and Grand lakes were at low levels in the winter of 2002. Skiatook Lake was between five and six feet below normal, about 17% down, according to a U.S. Army Corps of Engineers report. Birch was nearly 3 feet down, and Grand Lake was 8 feet down. However, none have dropped as dramatically in recent years as Copan Lake and Hulah Lake.

Population

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.

According to the University of Nevada's Drought Monitor, the primary drought impact currently to the Bixby area would be on wheat production.

Structures/Buildings

The primary threat to structures in the City of Bixby and Bixby Public School system lies in the effect of drought on Expansive Soils. More information on this hazard is available in Section 4.9.

Critical Facilities

See Critical Facilities in Table 1-12. Drought should produce no effects impacting the effectiveness of critical facilities that are not already indicated.

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 Bixby's water supply is significantly robust enough that the Bixby 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 Bixby, through the City of Tulsa water supply, monitors and regulates lake levels to mitigate the impacts of drought and conserve water. In addition, Tulsa's primary water supply lakes (Eucha, Spavinaw and Oolagah) are located in different watersheds. 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- 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 the 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, the City of Bixby and Bixby Public Schools have Low vulnerability to electric power shortages due to drought.

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 the primary impact of drought is in the areas of agriculture, recreational outdoor activities, and the impact on the City's water system, it is not considered necessary to include a specific Drought Scenario in the Hazard Mitigation Plan. Due to Tulsa's and Bixby's innovative water supply engineering in the 1970's and 1980's, the impact of drought on the water supply for Bixby is minimal. Additionally; Bixby's economic climate is not as heavily dependent on agricultural and outdoor recreational activities as it is with many communities in Oklahoma.

4.8.5 Future Trends

For a map of Bixby's potential future development areas, see Figure 1-17.

Population

As drought is primarily an agricultural threat in nature, and Bixby is a largely urban jurisdiction, the population vulnerable to this threat would remain basically unchanged. The only additional note might be that should the area surrounding Bixby become affected by a drought severe enough to have an impact on local agricultural businesses, those Bixby residents dependent on outdoor labor or recreational opportunities for income could be affected by this event.

Structures/Buildings

The primary threat to structures in the City of Bixby and Bixby Public Schools lies in the effect of drought on expansive soils, therefore any future development/renovations undertaken by the city involving structures/buildings should consider this possibility. More information on this hazard is available in Section 4.9.

Critical Facilities

As with other structures/buildings in the City of Bixby and Bixby Public Schools, the most severe threat to Critical Facilities would be from Expansive Soils triggered by a severe drought in this area. Critical Facilities that have been identified as being located on grounds subject to potential shrink/swell activity should monitor the integrity of their facilities and plan for that potential. For a discussion of critical facilities in potential expansive soil problem areas, see Section 4.9.2.

Likewise, these facilities should plan for the possibility of water shortages during drought events – as this would have a severe impact on daycare, nursing home and other medical clinic/hospital facilities.

Infrastructure

The impact of drought on infrastructure is, for the most part, similar to its effect on structures: the primary danger is from expansive soils.

As development within the city's jurisdiction continues (both new and existing projects), the water delivery systems for the city should be reviewed on a regular basis to ensure the integrity is consistent with meeting the demand of increased and/or relocated populations; location and composition of roadways must be reviewed to ensure appropriate techniques and materials are utilized to allow for shrink/swell fluctuation in the event of a major drought; and the city's main water supply sources should be monitored during severe heat events to ensure trigger points for water emergencies are accurate and sufficient. The recent projected drought events in Oklahoma should serve as a stimulus for the jurisdiction to review its emergency plans to ensure they are adequate for such a contingency.

4.8.6 Conclusions

The severe droughts of the 1930s led to the construction of Oklahoma's numerous hydroelectric dams and reservoirs, as well as to the implementation of new farming and conservation policies. However, more recent drought response and recovery activities in Oklahoma, both at the state and local level, 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 drought crises. There is 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."

In all droughts, agriculture feels the impact, especially in non-irrigated areas such as dry land farms, and rangelands. Other heavy water users, such as landscapers, are also negatively impacted. Water-related activities of residential users might be restricted. Droughts may exacerbate the impact of expansive soils (see Section 4.9), as well as result in power shortages, since much of the state's power comes from hydroelectric plants. Heavy power users can be negatively impacted by brownouts, blackouts, and spiking prices.

The City of Bixby and Bixby Public Schools have a Moderate Risk of drought.

Data Limitations

There are signs that drought is becoming an increasing problem in the United States, including Oklahoma, although as indicated above, the current drought concern seems to have abated. However, it is difficult to predict drought probabilities for the near future due to the nature and complexity of the hazard.

Update Changes

Identified significant changes made from the 2004 City of Bixby Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

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, also called shrink/swell soils, are sometimes referred to as swelling clays because clay materials attract and absorb water. Dry clays will increase in volume as water is absorbed and, decrease as they dry.

4.9.1 Hazard Profile

Changes in soil volume present a hazard primarily to buildings or infrastructure 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.

Location

Based on surveys of underlying soils, Figure 4–32 shows a generalized map of the areas of Bixby where soils have from low to very high expansive qualities.

Generally, many Bixby lowlands along the river and waterways have low shrink-swell soils. Many higher elevations have moderate to high potential, including stretches of central and east Bixby within the fenceline but, for the most part, outside the city limits, particularly along Highway 64. Localized sites with very highly expansive soils have also been identified in the far northern section of the city and the southern portion. High shrink/swell soils predominate in future growth areas to the East.

Less than half of the soils in Bixby rank in the moderate to very high classification for expansive potential. Specifically, soils classified with "low" shrink/swell properties cover 53.3% of the Bixby land area. Soils classified as "moderate" and "very high" rank second and third, covering 20.4% and 11.4% respectively. Soils with a "high" classification are the least common in Bixby, as they cover 9.8% of the total land area. Overall, the City of Bixby and Bixby Public Schools have a High Risk to the damaging effects of expansive soils.

Table 4–42: City of Bixby Expansive Soils

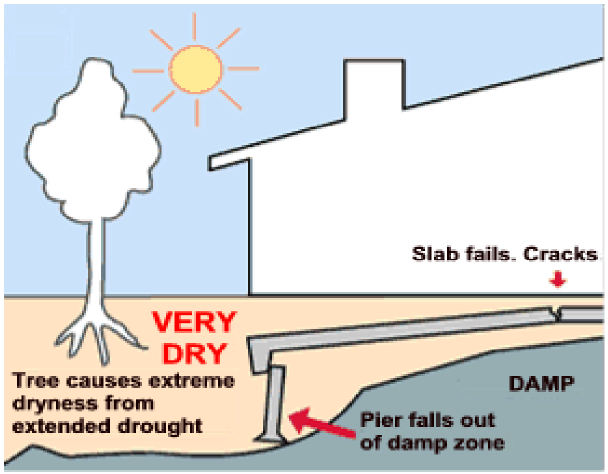
Expansion Potential	Area (mi²)	% of Total City Limits
Very High	2.9	11.4
High	2.5	9.8
Moderate	5.2	20.4
Low	13.6	53.3
Water	1.3	5.1

Measurement

The risk associated with expansive soil is related to shrink/swell potential in a qualitative manner: very high, high, moderate and low.

The National Resource Conservation Service (NRCS), in its Soil Survey Geographic Database (SSURGO), identified expansive soils for the City of Bixby as shown in Figure 4–32. 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 up to 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.

Figure 4–31: Effects of Expansive Soils



Bixby is underlain by soils with shrink-swell potentials ranging from low to very high.

Extent

Property damage can vary greatly across a jurisdiction, based on soil types, long-term weather conditions, the type and quality of construction, and materials used in construction. 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.

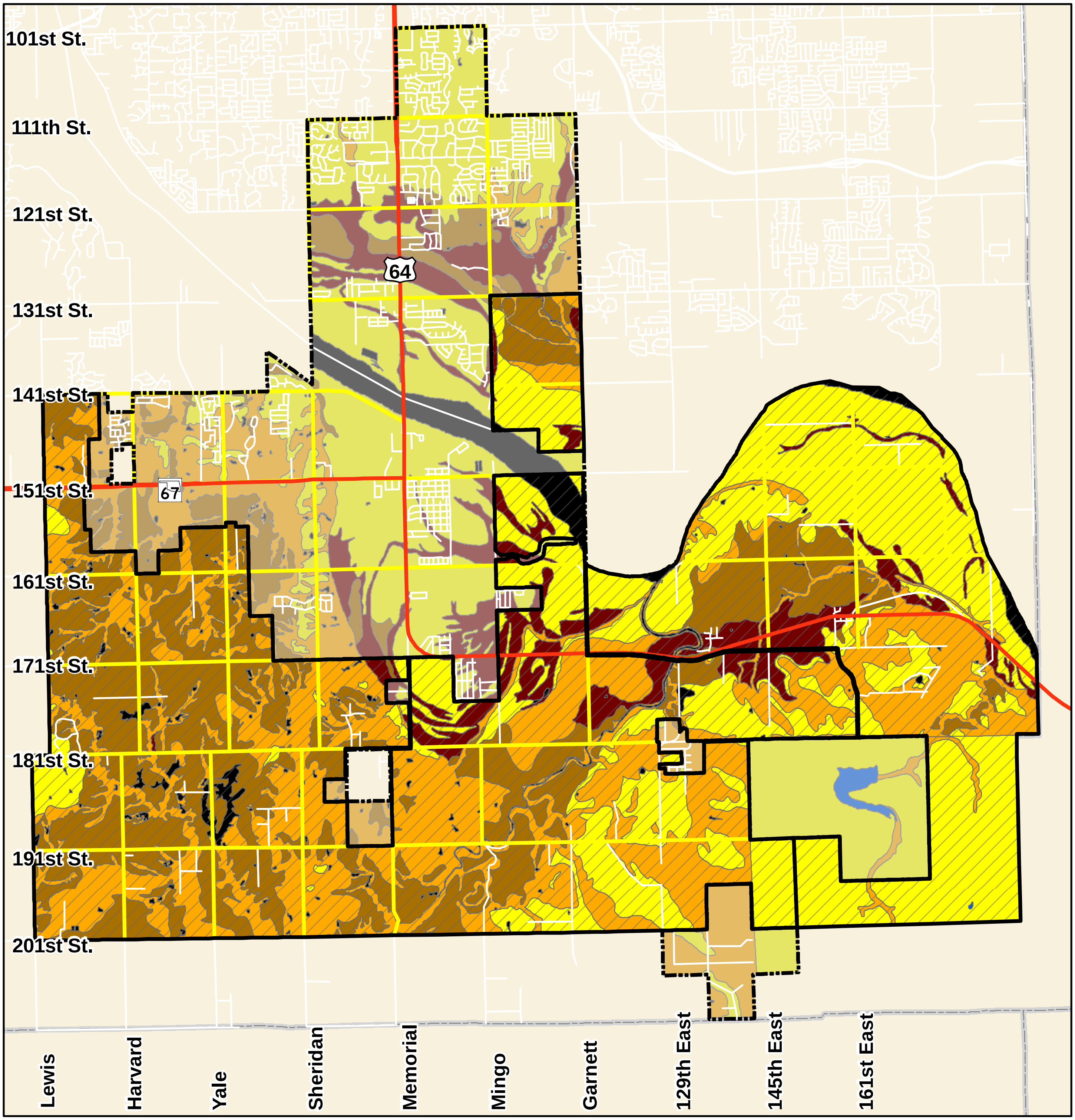
The effects of expansive soils are most prevalent in regions of moderate to high precipitation, where prolonged periods of drought are followed by long periods of rainfall. The most problematic soil type for expansive soils is found in the semiarid west-central United States.

The extent of damage from expansive soils can be reduced by mapping the soils in the jurisdiction and by notifying property owners and prospective buyers and builders of potential soil hazards and the techniques that can be used to limit their impacts.

The City of Bixby and Bixby Public Schools consider low and moderate shrink-swell soils to be of minor severity and high and very high soils to be of major severity.

Frequency

Local 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.



LEGEND

- Low
- Moderate
- High
- Very High
- Other / Water
- Highways
- Major Streets
- City Limits
- Fenceline

Flanagan & Associates, LLC
Planning Consultants

1 inch equals 8,375 feet

SEAL OF THE CITY OF BIXBY 1906 GARDEN SPOT OF OKLAHOMA

Figure 4-32

City of Bixby

Expansive Soils

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 the affected structures.

4.9.2 History/Previous Occurrences

Historic Events

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 (million gallons a day) 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.

Cracks in exterior walls caused by soil expansion

The City of Bixby and Bixby Public Schools do not maintain records of specific structures or infrastructure that have been damaged by expansive soils. If the City or Public School System begins to identify such damage, it will be noted in future updates of this Plan.

Probability/Future Events

Bixby and Bixby Public Schools have a high probability of a future expansive soils event. Areas of particular concern are those with highly expansive soils between 121st and 131st St. S., and between Sheridan and Garnett Rds. on the north side of the river, and between 151st and 181st St. S. and from Sheridan Rd. to 161st St. E. Ave. on the south side. Much of the high shrink/swell soils on the south side of the Arkansas River are outside Bixby's city limits, but within its fenceline. A considerable amount of land in the western and southwestern part of Bixby's fenceline has soils with a high shrink/swell potential. The City and Public Schools should continue their efforts to educate builders and property owners in these parts of its future growth areas of soil conditions and remediation measures.

4.9.3 Vulnerability

This section summarizes information about Bixby's vulnerability to expansive soils, including the impact on people, structures and buildings, critical facilities, and infrastructure. This information, as well as information provided by the City and Public Schools, was used to determine the Impact Criteria identified in Tables 4-2 and 4-3. The City of Bixby and Bixby Public Schools were determined to have a High Risk to the Expansive Soils hazard (See Table 4-2 Hazard Risk Analysis, and Table 4-3, Summary of

Hazard Risk Analysis Ranking Criteria for an explanation of how the rankings were derived.)

Many researchers show that expansive soil is one of the most costly hazards in the United States, in terms of property damage from shifting soils.

For example, out of the 250,000 homes built each year on expansive soils, 10% sustain significant damage during their useful lives, some are damaged beyond repair, and 60% sustain minor damage. For all types of building construction, annual losses of $740 million are estimated.

Despite its costly effects, expansive soil presents, in many ways, a silent hazard. Because the hazard develops gradually and seldom presents a threat to life, expansive soils have received limited attention. Many problems are not recognized as being related to expansive soils or may be considered only nuisances and therefore are never repaired.

The total annual cost of expansive soil-related damage and preventive design of moderate- to high-risk structures throughout the United States has been conservatively estimated at between $2.5 billion and $10 billion (in 1995 dollars).

Population

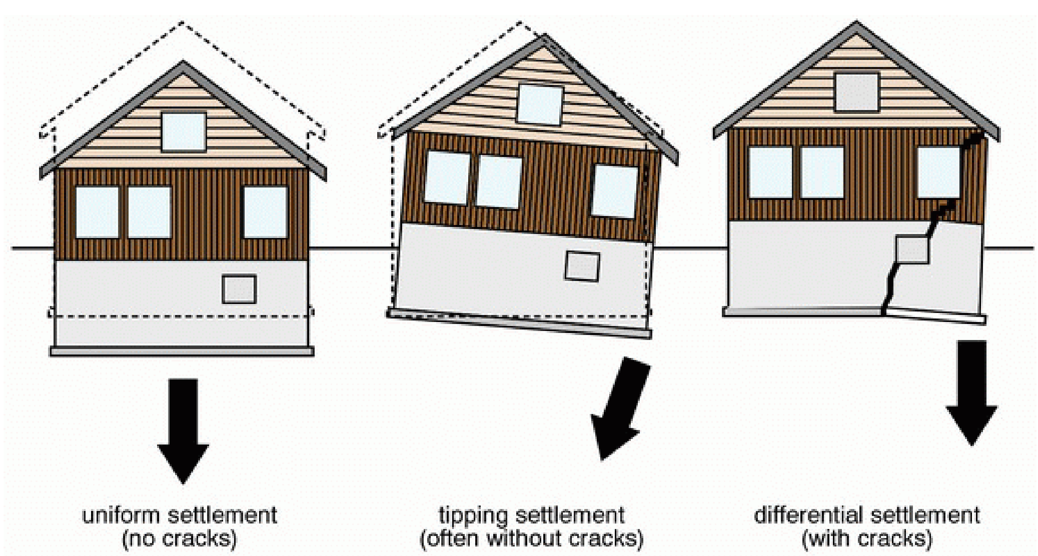
Due to the nature of the hazard, direct threats to life or personal injury from expansive soils are minimal.

Structures, Buildings

The increase in soil volume that results from expanding soil can cause damage to foundations. The most obvious manifestations of such damage are sticking doors, uneven floors, and cracked foundations, floors, walls, ceilings, and windows. If damage is severe, the cost of repair may exceed the value of the building.

It does not take much movement to damage buildings. As little as a differential movement of 0.25 inches between adjacent columns can cause cracking in load-bearing walls of a 2-foot wide bay.

Figure 4–33: Types of Expansive Soil Damage



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 subsequent soaking rains swell the clay. Other cases of damage involve increases of moisture from broken or leaking water and sewer lines, over-watering of lawns and landscape, and surface modifications that produce ponding.

Critical Facilities

Ten of Bixby's 51 critical facilities, identified in Table 4–43, are built upon soils classified as having "high" or "very high" shrink/swell potential, while two are on "moderate" soils. The remainder of Bixby's critical facilities are on "low" shrink/swell soils.

Table 4–43: Critical Facilities on High to Moderate Shrink/Swell Soils
(All other Critical Facilities are on soil with a Low Coefficient.)

ID	Facility Name	Shrink – Swell Potential	ID	Facility Name	Shrink – Swell Potential
44	8 Acres Camp Daycare	Moderate	51	Liberty Public Schools	High
30	Bank of Oklahoma	Very High	24	Midwest Childcare	High
32	Bank of the West	Very High	49	Sand Plum Retirement	Moderate
29	Bixby Fire Station #2	Very High	43	Warren Clinic (S. Memorial)	Very High
31	IBC Bank	Very High	47	YMCA Daycare – Wilson Bldg	Very High

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. In addition, as mentioned above, expansive soils pose a significant threat to aging pipelines, particularly corroded water and sewer lines and pipelines for volatile petroleum products.

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. (Reference Section 4.9.5). 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

Although about 75% of the soils in Bixby's city limits are classed as "Low" and "Moderate", soils with a "High" shrink-swell potential are also present, along with a few areas that are "Very High." Of particular concern, more than 6.2% of the land in areas zoned for future industrial development in the north and northeast quadrants of the city are classed as "Very High." With 65.18% of the soils within the future growth area being categorized as having "moderate" to "very high" shrink/swell potential, the City of Bixby will continue to have High vulnerability to the damaging effects of expansive soils. It is important to note that Bixby's future industrial development areas are also on soils with a "high" shrink-swell potential. Expansive Soils in the Future Growth Areas are listed in Table 4-44, and are shown in Figure 4-34.

Table 4–44: City of Bixby Expansive Soils – Bixby FGA

Expansion Potential	% of Total FGA
Very High	6.2
High	26.25
Moderate	32.73
Low	32.57
Water	2.25

Population

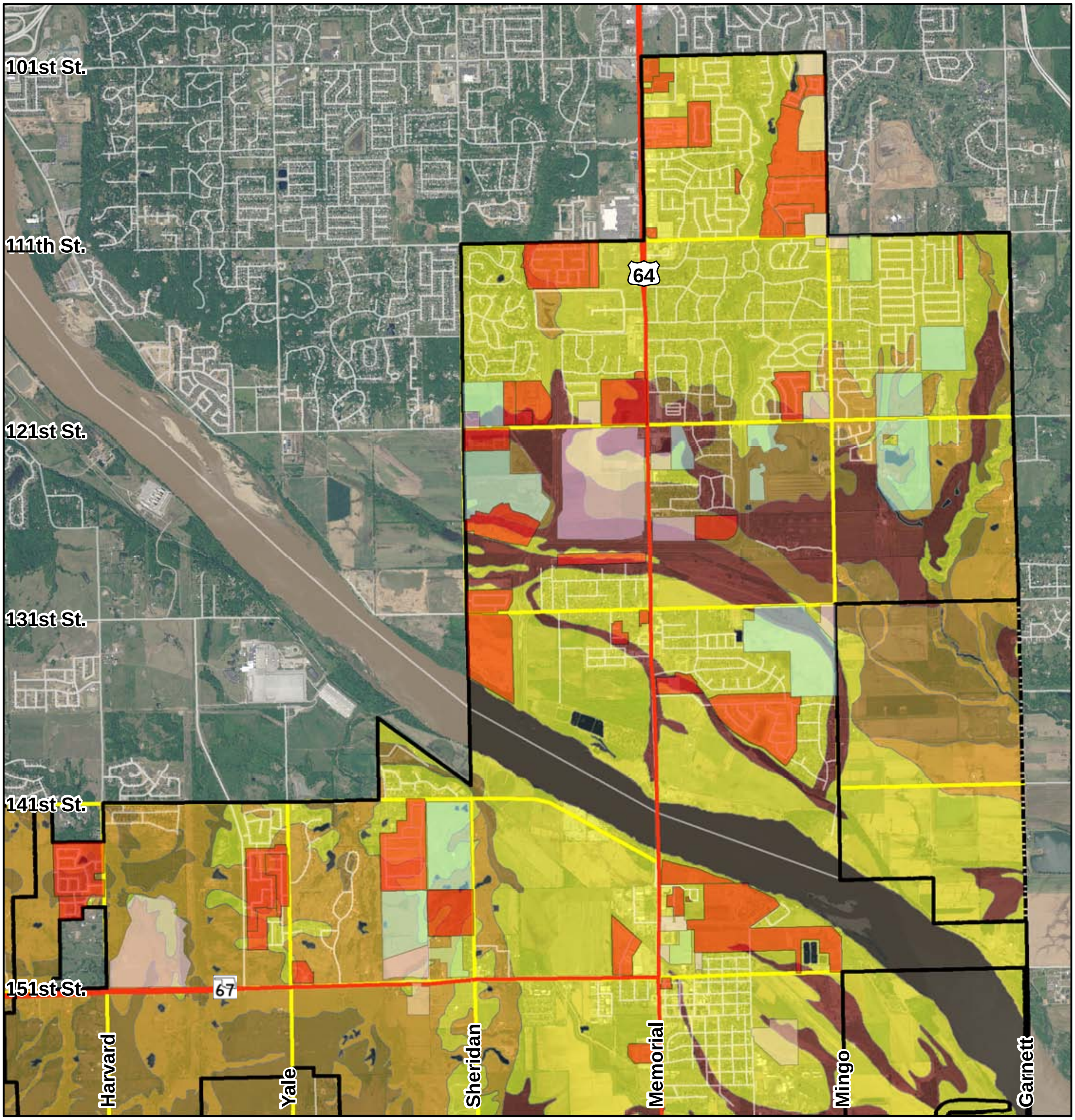
Direct threats to life or personal injury have not generally been documented or projected for expansive soils because of the nature of the hazard. The primary threat is economic.

Structures / Buildings

Damage to structures in Bixby 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. As the City of Bixby and Bixby Public Schools expand into future growth areas with high and very high shrink/swell soils, builders and property owners should be informed of the expansive soil hazard and measures to lessen their impacts.

Critical Facilities

As the City of Bixby and Bixby Public Schools grow, expansive soils could cause damage to new critical facilities if built without structural mitigation strategies in mind. While this will not be an immediate impact to the ability of the City of Bixby to respond to emergencies, it could shorten the effective lifespan of such facilities, thereby requiring expenditures in the future to replace these structures. In addition, long-term structural damage to buildings housing vulnerable populations – schools, long-term care facilities, childcare centers – could place the residents at risk when the building is exposed to a natural hazard event in a sub-standard condition.



LEGEND

Development Since 2004

Future Growth Areas

Type

- Commercial/Industrial
- Multifamily Residential
- Single Family Residential
- Other (Church, School, Civic)

- Low
- Moderate
- High
- Very High
- Other / Water

0 1,450 2,900 5,800 Feet

Flanagan & Associates, LLC

Figure 4-34

City of Bixby

Expansive Soils in Growth Areas

Infrastructure

Long referred to as the "unknown hazard," expansive soils may be a hazard with more of a future than a past. As the infrastructure of Bixby and Bixby Public Schools continues to age – particularly water and sewer lines that were 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. 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 city's 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 Conclusions

The history of Bixby's expansive soil hazard is difficult to track. Neither the City, the School District, nor the Insurance Companies monitor damage to structures from expansive soils as the impact of a specific natural hazard. The City and School District treats all such damage as a maintenance issue. According to City engineers, the expansive soil hazard is routinely taken into account in engineering studies and construction practices for infrastructure projects, but not specifically documented.

Expansive soils develop gradually and are seldom a threat to the population, but can cause severe damage to improvements built upon them. With 42% of the soils within the city limits classified as having moderate to high shrink/swell potential and 11% in the "very high" category, the City of Bixby has a **Moderate** Risk to the damaging effects of expansive soils. Increased damage to structures could be expected during and following a period of extended drought, particularly for structures built during a drought.

The majority of the critical facilities at greater risk from this hazard are privately owned, indicating that information and education of builders, developers and owners is an effective strategy to implement.

Future growth areas (FGA) are at somewhat higher risk than the current developed areas, with 59% of the soils having a moderate to high potential and 6.2% having very high.

Data Limitations

Data are limited for Bixby-specific hazard risk, vulnerability, impacts, preventive measures, costs, and benefits for damage to buildings, critical facilities, and infrastructure due to a lack of specific record keeping, as referenced in Section 4.9.5.

Update Changes

Identified significant changes made from the 2004 City of Bixby Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.9.7 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.

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.

Soil Surveys of Tulsa County, Oklahoma, U.S. Department of Agriculture, Soil Conservation Service, 1977.

Tulsa’s Physical Environment, Bennison, A.P., et al. Tulsa Geological Society, 1973.

4.10 Urban Fires

Structure 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. Fire kills more Americans than all natural disasters combined. It also ranks as the leading cause of death for children under the age of 15 at home. Approximately 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. In 2005 (the most recent year the *National Center for Health Statistics* compiled data), Oklahoma ranked third in number of per capita fire deaths with 28.7 deaths per million residents.

Fire Fighters responding to a house fire, one of thousands that occur every year across the state

4.10.1 Hazard Profile

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 occuring 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.

Historic properties in particular, due to a lack of applicable modern fire codes at the time of construction, and the reliance on older building materials, are at an increased risk of the initiation of fire, and an increased damage level. Alternative heating methods often used in older homes can also increase the potential for fire.

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 (Magnitude/Severity)

Various factors can determine the extent of an urban fire. The contents and age of a structure influence the extent of an urban fire, as do the local weather conditions. Damages from urban fire can range from minor to substantial with damages far exceeding the value of the structure. In recent years, the impact of urban fire has been greatly reduced due to the improvements in firefighting technology and training of local fire management officials. Improvements in building codes and technology have also enhanced a jurisdiction's ability to contain and mitigate the damage caused by urban fire.

Although the extent of an urban fire cannot be qualitatively measured until the fire has occurred and damage assessed, the likely impact of an urban fire can be affected by public information about common fire hazards, notification techniques and procedures, fire department response speed, structure type and age, density of development, presence of flammable substances, water pressure and availability, and the use of smoke alarms.


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.

Eighty-three percent of all civilian fire deaths occur in residences, and careless smoking is the leading cause of those fire deaths. In 2002 alone, lighted tobacco products caused an estimated 14,450 residential fires, 520 civilian deaths, 1,330 injuries, and $371 million in residential property damage.

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 the third leading cause of both structural fires and structural fire deaths. In commercial properties, arson is the major cause of deaths, injuries and dollar loss. Arson resulted in an estimated $664 million in property damage in 2005 (approximately 6.9% of all fire property loss). *(Source: National Fire Protection Association)*

In addition, fires are an excellent example of how natural hazards interact in ways that spiral out of control. Lightning, high winds, earthquakes, volcanoes, and floods can all trigger or exacerbate fires. Flammable liquid containers or pipelines may be breached. Downed power lines may provide an ignition source. Leaking gas lines and damaged or leaking propane containers, tanks or vehicles may explode or ignite. In addition, when the power is out, unsafe alternative heating sources, candles, or improperly used generators may trigger fire and asphyxiation dangers. Moreover, the disaster conditions may hinder or prevent firefighters from being able to suppress or even reach a fire event.

Bixby considers an event of minor severity to be $5,000 or less in damages and no loss of life or injury and an event of major severity to be more than $5,000 in damages or loss of life or injury.

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 or some of the other by-products of modern building and upholstery materials can cause loss of consciousness or death within minutes. Fire generates a black, impenetrable smoke that blocks vision and stings the eyes, making it often impossible to navigate and evacuate a burning building. Fire can also produce temperatures in a room far more quickly and far greater than many people anticipate. Where temperatures close to the floor may be survivable, 5-6 feet above the floor the temperature may be hundreds of degrees, and temperatures near the ceiling may reach 1000-1500° Fahrenheit very quickly.

Frequency

According to the U.S. Fire Administration, for the 10-year period from 1999 through 2007, there was an average 1,664,800 fires each year in the United States, in which an average 3,940 Americans lost their lives and another 19,485 injured. Average dollar loss was $14,294 million. Structure fires accounted for approximately 34.1% of all fires and 87% of all deaths and injuries. Approximately 78% of all structure fires were residential. (*Source: National Fire Protection Association Fire Loss in the U.S. 2007.)*

From 2002-2006 Bixby had 66 structure fires that resulted in the loss of $2,228,900 and 1 injury and 4 deaths (all civilian). There were 5 fires in critical facilities during this period, but no reported losses, injuries or deaths. Given this limited data, Bixby can expect 13 structure fires per year that result in one death and $500,000 in losses, and 1 critical facility fire.

Impact

The impact of urban fire can be death and injury to civilians or emergency personnel, the loss of homes and businesses, and the loss of employment and local revenue streams. The loss of homes, businesses, and jobs can be devastating to families and communities.

4.10.2 History/Previous Occurrences

Historic Urban Fire Events

In the United States during 2008, structural fires caused 3,320 civilian deaths – roughly 10 people per day – and 16,705 injuries, and resulted in an estimated $15.5 billion in damage. In addition, many persons were hospitalized for severe burns, and some disfigured for life.

Table 4–45: Structure Fires, Deaths, Injuries & Dollar Loss in the US from 1998-2008

Source: National Fire Protection Association Fire Loss in the U.S. 2008

Year	Structure Fires	Civilian Deaths	Civilian Injuries	Direct Dollar Loss (Millions)
1998	517,500	3,420	19,425	6,717
1999	523,000	3,404	18,525	8,490
2000	505,500	3,535	19,600	8,501
2001[4]	521,500	3,220	17,225	8,874
2002	519,000	2,775	15,600	8,742
2003[5]	519,500	3,385	15,600	8,678

[4] In 2001, there were an additional 2,451 civilian deaths and 800 civilian injuries that occurred as a result of the events of September 11, 2001. The total property loss due to September 11, 2001 was $33,440,000,000.
[5] In 2003, the estimate for fire deaths includes 100 fire deaths in the Station Nightclub Fire in Rhode Island, and 31 deaths in two nursing home fires in Connecticut and Tennessee.

Year	Structure Fires	Civilian Deaths	Civilian Injuries	Direct Dollar Loss (Millions)
2004	526,000	3,305	15,525	8,314
2005	511,000	3,105	15,325	9,193
2006	524,000	2,705	14,350	9,636
2007	530,500	3,000	15,350	10,638
2008	515,000	3,320	16,705	$15,478
TOTAL	**5,197,500**	**31,854**	**166,525**	**87,783**

The City of Bixby, during the 5-year period from 2004 to 2008, (the latest year the State Fire Marshall has complete local data) experienced a total of 70 structural fires, 5 casualties, and over $2,300,000 in fire damage, excluding critical facilities. Table 4-46 details the type and number of fires, along with damages and casualties related to these fires during this 5-year period.

Table 4–46: City of Bixby Urban Fire Damages, Injuries & Deaths 2004-2008
Source: Oklahoma State Fire Marshal

Type of Structure	***2004***		***2005***		***2006***		***2007***		***2008***		***Total***	
	#	Damage	#	Damage	#	Damage	#	Damage			#	Damage
Single Family	7	$65,900	15	$813,000	7	$65,900	13	$349,000	8	$527,750	**50**	**$1,821,550**
Apartments	0	$0	0	$0	0	$0	0	$0	1	$0	**1**	**$0**
Mobile Homes	0	$0	0	$0	0	$0	0	$0	1	$0	**0**	**$0**
Commercial	2	$1,000	1	$0	2	$1,000	1	$0	0	$0	**6**	**$2,000**
Warehouse	0	$0	2	$101,500	0	$0	0	$0	0	$0	**2**	**$101,500**
Industrial	0	$0	0	$0	0	$0	0	$0	1	$900	**1**	**$900**
Office	1	$0	0	$0	1	$0	0	$0	1	$11,000	**1**	**$11,000**
Other	0	$0	1	$0	0	$0	1	$0	1	$115,000	**2**	**$115,000**
Total	**10**	**$66,900**	**21**	**$914,500**	**11**	**$66,900**	**15**	**$349,000**	**13**	**$654,650**	**70**	**$2,307,550**

Fire-Related Casualties

Casualty	***2004***	***2005***	***2006***	***2007***	***2008***	***Total***
Civilian Injuries	1	0	0	0	0	**1**
Civilian Deaths	1	0	0	1	0	**2**
Firefighter Injuries	0	0	0	0	0	**0**
Firefighter Deaths	0	0	0	0	0	**0**
Total Injuries	**1**	**0**	**0**	**0**	**0**	**1**
Total Deaths	**1**	**0**	**0**	**1**	**0**	**4**

Critical facilities are also vulnerable to fire, and are of special importance because the impact of a fire in these facilities may be especially detrimental to the community's ability to continue normal operation or have a major impact on the city's vulnerable populations. Critical facilities deserving special attention include nursing and retirement homes, hospitals and clinics, child care centers, correctional institutions, schools and colleges.

Bixby experienced 5 fires in critical facilities between 2004-2008, which resulted in no injuries or deaths, and no reported financial losses, as shown in Table 4-47.

Table 4–47: City of Bixby Critical Facility Fires, 2004-2008
Source: Oklahoma State Fire Marshal

Type of Structure	2004		2005		2006		2007		2008		Total	
	#	Damage	#	Damage	#	Damage	#	Damage	#	Damage	#	Damage
School, University	0	$0	0	$0	0	$0	0	$0	0	$0	**0**	**$0**
Public Assembly	0	$0	2	$0	1	$0	2	$0	0	$0	**5**	**$0**
Hospital	0	$0	0	$0	0	$0	0	$0	0	$0	**0**	**$0**
Correctional Facilities	0	$0	0	$0	0	$0	0	$0	0	$0	**0**	**$0**
Child Care	0	$0	0	$0	0	$0	0	$0	0	$0	**0**	**$0**
Nursing/ Retirement	0	$0	0	$0	0	$0	0	$0	0	$0	**0**	**$0**
Total	**0**	**$0**	**2**	**$0**	**1**	**$0**	**2**	**$0**	**0**	**$0**	**5**	**$0**

Real progress has been made nationally 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, both figures have been reduced by almost half to 1,687,500 fires, and 2,670 fire-related deaths.

Probability/Future Events

Based on historical data available and existing building materials, Bixby and Bixby Public Schools have a high probability that they will continue to be affected by urban fires.

4.10.3 Vulnerability

This section summarizes information about Bixby's vulnerability to urban fires, including the impact on people, structures and buildings, critical facilities, and infrastructure. This information, as well as information provided by the City and Public Schools, was used to determine the Impact Criteria identified in Tables 4-2 and 4-3. The City of Bixby and Bixby Public Schools were determined to have a Moderate Risk to the Urban Fire hazard (See Table 4-2 Hazard Risk Analysis, and Table 4-3, Summary of Hazard Risk Analysis Ranking Criteria for an explanation of how the rankings were derived.)

Population

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 highest density of populations tend to have the greatest number of fire-related fatalities. Some of the vulnerabilities peculiar to Oklahoma are related to flooding and lightning events, both of which can trigger urban fires.

Structures/Buildings

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.

Critical Facilities

Critical Facilities are prone to the same caveats as listed under Structures/Buildings above. Many critical facilities, from retirement homes to Emergency Operations Centers, are located in older buildings with their intrinsic greater fire susceptibility. The City of Bixby's critical facilities are listed in Table 1-12, and are mapped in Figure 1–18.

All critical facilities in Bixby's jurisdictions should be considered vulnerable to the effects of an urban fire event. Structural integrity may be compromised with even a small fire, rendering the structure unusable.

Infrastructure

Water Treatment – The most significant effect during an urban fire event would be from loss of electrical power. Both of the City of Tulsa water treatment plants supporting the City of Bixby and Bixby Public Schools would be vulnerable to these risks, although the structures themselves are relatively fire-resistant.

Wastewater Treatment – The most significant threat to the operation of Bixby's 2 wastewater treatment facilities during an urban fire event would be a power outage.

Utilities – The primary utility providers for Bixby's jurisdiction is AEP/PSO (electricity) and ONG (natural gas). The service stations and substations for both of these providers would be vulnerable to the risks from an urban fire event. **Electricity:** During an urban fire event, providers of electrical service could experience any combination of the following challenges in meeting the needs of the Bixby jurisdiction: Destruction of distribution and transmission poles, downed broken power lines, and danger to workers derived from downed power lines. **Gas:** During an urban fire event, providers of gas service could experience a variety of challenges in meeting the needs of the Bixby jurisdictions: downed power lines, inaccessibility to underground gas meters, and extreme temperatures.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Highways and main thoroughfares in Bixby could potentially be vulnerable to secondary effects from an urban fire event. Smoke blowing across the highway could create limited visibility. Depending on location of event, an increased presence of emergency vehicles could slow or inhibit traffic flow on main thoroughfares into and out of the city.

Emergency Services- Fire, Police and Medical Services would all be similarly at risk to the secondary effects of an urban fire event. Emergency personnel on scene would be vulnerable to the cumulative affects of heat generated by the fire itself. Call volume to all emergency service agencies could increase dramatically if the event is of a large scale. Likewise, medical services in the area could become taxed should the fire event encompass several units / buildings and include multiple injuries.

4.10.4 Urban Fire Scenario

Most Urban structure fires are limited to one structure. Fire departments are usually very successful at limiting the exposure of surrounding structures, and containing the damage. With this in mind, there are too many variables to attempt to create a “worst case scenario” for an urban fire event. It would vary depending on the time of day, type of occupancy at the time of event, season of the year, and many other factors. A worst-case event would likely be a fire in one of the city’s primary employers/revenue generating enterprises, a school fire, or a fire in a facility containing hazardous chemicals.

4.10.5 Future Trends

All potential development areas for the City and the Public Schools are equally at risk from structure fires, with the following considerations.

Population

Seniors are frequently at higher risk from fire injury or death in connection with a decrease in mobility skills, or due to living in older residential structures. With the aging of the population, educational programs that target seniors and senior living centers may become increasingly significant.

With a more challenging economy comes the increased inability to afford adequate daycare resources for young children. Younger children left on their own, or caring for younger siblings are at a higher risk from accidental fires and their potential injuries.

Structures/Buildings

All structures / buildings built or refurbished are vulnerable to the potential effects of an Urban Fire event.

Ensuring that all future commercial and residential development includes appropriate fire detection / protection devices is of considerable importance. The need for fire / smoke detector systems (hardwired with battery backup), sprinkler systems (where appropriate) and fire extinguishers should be considered for all new construction projects.

Properties being refurbished should be evaluated for their resistance to fire, and their compliance to current City codes.

Critical Facilities

Regarding the Urban Fire hazard, critical facilities need to be especially cognizant of "code plus" fire safety requirements. Sprinkler systems, alarm systems, fire resistant roofing and building materials, fire resistant landscaping, and other features become especially important for facilities that cannot afford to be put out of commission.

Infrastructure

Ensuring a minimized effect on the delivery of firefighting service requires forethought and planning while in the development stage. Any plans for areas currently under development or being considered for development should include the provision for adequate water supplies for firefighting over and above residential or business usage. Adequate streets design to support the arrival, deployment, and departure of firefighting units should also be taken into account.

4.10.6 Conclusions

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. Advances in building codes have made large inroads into the number of fire casualties and damages. In addition, public information and education on fire safety and smoke alarms have proven very successful in reducing residential fires and fire-related deaths. Information campaigns can be particularly effective, if geared around the times of year and populations outlined above.

A number of factors influence the degree of risk from urban fires for the City of Bixby:

- The percentage of older structures (built before 1970) is below the state average (23% vs. 45.9%);
- The history of casualties due to urban fires listed above is somewhat higher than the state numbers (1 casualty per 13 fires vs. state figures of 1 casualty per 19.2 structure fires);
- The City of Bixby has a number of public information and education programs in place that include fire safety;
- The City of Bixby has an ISO Fire Protection Rating of 5 (see Section 2.1.3 for more information).

These factors place the City of Bixby and Bixby Public Schools at Moderate Risk to Urban Fires. As the most common type of disaster, public information should be a strong mitigation response and other possible mitigation measures should be reviewed.

Data Limitations

Data to the State Fire Marshall's office is sometimes turned in over a year after the year in which events occurred, and it takes time for it to be entered into the state database. Consequently, complete data is frequently 1-2, or more, years behind. In addition, the Fire Marshall's office does not list actual number of events, but number of "fire department runs." The Bixby Fire Department may send a unit for "smoke in a building" at a retirement home, but the units will return to station quickly, and no damage will occur. Because of this, the number of "structure fires" in the above tables may be higher than the occurrence of significant events.

A statement from the U.S. Fire Administration *Residential Structure and Building Fires* October 2008 report highlights some of these issues:

> "As troublesome as insufficient data for the various NFIRS [National Fire Incident Reporting System] data items can be, equally challenging is the apparent nonreporting of injuries and property loss associated with the fire incident (although the latter is notoriously difficult to quantify). It is exceedingly rare that a fire department experiences no firefighter injuries of any type. Yet there are fire departments, large and small, that report no firefighter injuries or a minuscule number of them, but report fires. Fire, by its nature, is destructive. Yet there are many reported fires where the flame spread indicates damage but no property loss is indicated."

Update Changes

Identified significant changes made from the 2004 City of Bixby Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.10.7 Sources

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Multi-Hazard Identification and Risk Assessment, p. 264, 266–267. Federal Emergency Management Agency, 1997.

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Talking About Disaster: Guide for Standard Messages, "Fire," p. 51. National Disaster Coalition, Washington, D.C., 1999.

The Oakland Berkeley Hills Fire: Abstract, at Web address: http://www.firewise.org/pubs/theOaklandBerkeleyHillsFire/abstract.html.

4.11 Wildfires

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.

While many people associate wildfires with forest fires, fast-moving grass and wildland fires are the biggest threat in Oklahoma

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, forest and grassland fires are a natural process, and help to maintain healthy ecosystems. 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.

According to FEMA, as stated in the report *Multihazard, Identification and Risk Assessment*, there are four categories of wildfires experienced throughout the United States:

- **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.

Location

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.

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)*

Within the Bixby/Tulsa County jurisdiction development in more remote and wooded areas, also referred to as the Wildland Urban Interface (WUI) continues to take place. Residential and business structures developed in close proximity to grassy and woody fuels will be natural risks for this event. In addition, wildland/grassland fires are a strong threat to agricultural areas such as farms and/or ranches, especially during the high risk fire season.

The U.S. Forest Service (USFS) figures indicate that 25.7% of wildfires reported were caused by arson, debris burns caused 24% 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.

Hazard events other than lightning have the potential to cause wildfires, such as earthquakes and high winds. For example, in the dry autumn of 2005, gusting winds downed power lines in south central Oklahoma, sparking wildfires.

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 4-48, 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 **Burning Index**, Table 4-49, 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 line intensity and flame length. The higher the number, the more difficult the wildfire is to fight. The **Fire Danger Rating System**, Table 4-50, combines the combustibility of vegetation and weather conditions to derive the easily understood Green-Blue-Yellow-Orange-Red fire danger alerts. These three wildfire measures are summarized in the following tables.

Bixby considers a reading of Moderate and below on the Fire Danger Rating system (Table 4-28) to be a Minor Severity Level and a rating of High and above to be of Major Severity.

Table 4–48: 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 4–49: 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.

Table 4–50: Fire Danger Rating System
Source: 2008 Oklahoma Hazard Mitigation Plan

Rating	Basic Description	Detailed Description
CLASS 1: Low Danger (L) COLOR CODE: Green	Fires not easily started	Fuels do not ignite readily from small firebrands. Fires in open or cured grassland may burn freely a few hours after rain, but wood fires spread slowly by creeping or smoldering and burn in irregular fingers. There is little danger of spotting.
CLASS 2: Moderate Danger (M) COLOR CODE: Blue	Fires start easily and spread at a moderate rate	Fires can start from most accidental causes. Fires in open cured grassland will burn briskly and spread rapidly on windy days. Woods 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.
CLASS 3: High Danger (H) COLOR CODE: 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 fuel. Fires may become serious and their control difficult, unless they are hit hard and fast while small.
CLASS 4: Very High Danger (VH) COLOR CODE: Orange	Fires start very easily and spread at a vary 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. Direct attack at the head of such fires is rarely possible after they have been burning more than a few minutes.
CLASS 5: Extreme (E) COLOR CODE: Red	Fire situation is explosive and can result in extensive property damage	Fires under extreme conditions 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 Danger class (4). 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.

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 and Bixby are 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.

Between 2004 and 2008, the Bixby Fire Department made a total of 163 runs related to wildfires that burned 1,224 acres and did $7,600 in reported damage.

Tulsa Fire, January, 2006

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 Bixby and 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 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. South Tulsa County is clearly at risk from wildfire, due to its open, grassy landscape, as shown by the wildfires of 2005-2006 (see below).

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. In this regard, South Tulsa County east of Glenpool and south and southeast of Bixby are particularly vulnerable. 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.

Frequency

According to the National Interagency Fire Center statistics for fires on federal lands from 1985 to 1994 (the latest year with full figures available), 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.

Tulsa County experienced an average of 944 grass, wildland and crop fires a year during the 2004-2008 period, with nearly 37,000 acres burned and almost $2 Million in reported damages.

The Bixby area has three primary wild land fire seasons. The most volatile 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.

Between 2004 and 2008 Bixby's Fire Department made a total of 163 runs related to wildfires that burned 2,149 acres. Based on this limited data, Bixby can expect about 33 wildfires each year that burn 250 acres per year and do approximately $1,520 in damage.

Impact

The impact of the Wildfire hazard can increase during times of drought, high wind and extreme heat. Wildfire can cause loss of life, loss of homes, loss of business, and devastating economic impacts to individual homeowners, ranchers and farmers, and to the community. The Bixby Fire Department is confident that it can respond quickly and effectively enough to limit damage from wildfires in their jurisdiction. A worst-case scenario, in Bixby's view, would be the destruction of 4 structures and the injury or death of one person, either civilian or firefighter. Bixby has not experienced a wildfire event as severe as those which have struck south central Oklahoma or Oklahoma City suburbs.

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. (FEMA 1990). (ibid., Multi Hazard, p. 239)

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

From 1999 through 2008, Oklahoma's Fire Departments reported 151,921 wildfire runs that burned a total of 3.8 million acres and did $109.5 million in damage. The average fire for this 10-year period burned 25 acres and caused $721 damage. It should be noted that the particularly brutal wildfire outbreaks of 2005 and 2006 burned almost twice as many acres (per fire) and resulted in almost twice the damage—42 acres per fire and $1,137 damage. Some particularly severe historic Oklahoma wildfires include:

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, one business and six homes 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.

Tulsa County wildfire during the catastrophic 2005-2006 wildfire season

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:

- 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, a 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

Between 1999 and 2003 Tulsa County fire departments fought an average of 944 grass, wildland and crop fires a year during the 2004-2008 period, with nearly 37,000 acres burned and almost $2 Million in reported damages. One of the worst wildfire seasons 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.

Bixby Wildfires

Between 2004 and 2008, the Bixby Fire Department made a total of 163 runs related to wildfires that burned 1,224 acres and did $7,600 in damage. Based on this limited data, Bixby can expect about 32 wildfires each year that burn 245 acres per year (7.6 acres per fire) and do approximately $1,520 in damage.

Table 4–51: City of Bixby Grass and Crop Fires, 2004-2008
Source: Oklahoma State Fire Marshal

Year	Runs	Acres Burned	Damages
2004	32	459	$0
2005	48	310	$1,100
2006	39	300	$2,500
2007	21	27	$0
2008	23	128	$4,000
Total	**163**	**1,224**	**$7,600**
Average	**32.6**	**245**	**$1,520**

The National Fire Incident Reporting System (NFIRS) has Bixby Fire Department runs for a single year, 2006, which can be used to verify the accuracy of the above projections. NFIRS states that during 2006, Bixby had 39 grass or brush fire runs that burned 300 acres and resulted in a reported loss of $2,500. The great majority of these wildfires occurred between January and April (22 fires), June and July (12 fires), and October and November (5 fires). The largest of these wildfires are summarized below.

- **January 9, 2006 –** A brush and grass fire burned 120 rural acres near Sheridan Rd. and caused $2,500 damage.
- **February 9, 2006 –** A brush and grass fire burned 10 acres along 171st St. in a Bixby rural area.
- **February 26, 2006 –** A wildland/urban interface fire burned 15 acres near 91st Ave. in Bixby.
- **March 26, 2006 –** A rural fire in natural vegetation burned 11 acres along 181st St. in Bixby.
- **March 26, 2006 –** A grass fire burned 60 acres in a rural section of Harvard Ave. in Bixby.
- **June 29, 2006 –** A brush and grass fire burned 20 acres in Bixby's wildland/urban interface, near 142nd Ave.

- **July 9, 2006 –** A rural brush and grass fire burned 15 acres along 137th Ave. in Bixby.

For information concerning potential data limitations, see Section 4.11.5.

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 (two ice storms within 12 months) – combined with the historical data available demonstrates that the threat of future wildland/grass fires have a high probability of occurring in and around the City of Bixby and Bixby Public Schools. In addition, suburban growth in the wildland interface will be a significant factor in the potential increase in the number of wildfires occurring.

4.11.3 Vulnerability

This section summarizes information about Bixby's vulnerability to wildfires, including the impact on people, structures and buildings, critical facilities, and infrastructure. This information, as well as information provided by the City and Public Schools, was used to determine the Impact Criteria identified in Tables 4-2 and 4-3. The City of Bixby and Bixby Public Schools were determined to have a Moderate Risk to the Wildfire hazard (See Table 4-2 Hazard Risk Analysis, and Table 4-3, Summary of Hazard Risk Analysis Ranking Criteria for an explanation of how the rankings were derived.)

Because more people are choosing to build expensive homes on acreage in rural settings, surrounded by grasslands and forest, the danger of wildland urban interface fire has increased enormously. This is particularly true of Bixby, with its growing population and upscale economy. While most grasslands of the U.S. have a fuel load of 1,000 to 2,000 lb. per acre, around Bixby it is between 6,000 and 10,000 lbs. per acre.

The wildland fire danger in the Bixby urban fringe is made even higher by the spread of Eastern Red Cedar, which grows close to the ground, has fine foliage, thin bark and contains volatile oils. When it catches fire, the Eastern Red Cedar explodes into flame, showering sparks to the wind. Vulnerable Urban-Wildland Interface areas are shown on the map in Figure 4-35.

Population

As evidenced by the 2005-2006 wildfire outbreaks, the rural and urban/wildland interface areas of Bixby are vulnerable to wildfires. 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 in Bixby at risk are listed in Table 4-52 and are shown in Figure 4-35.

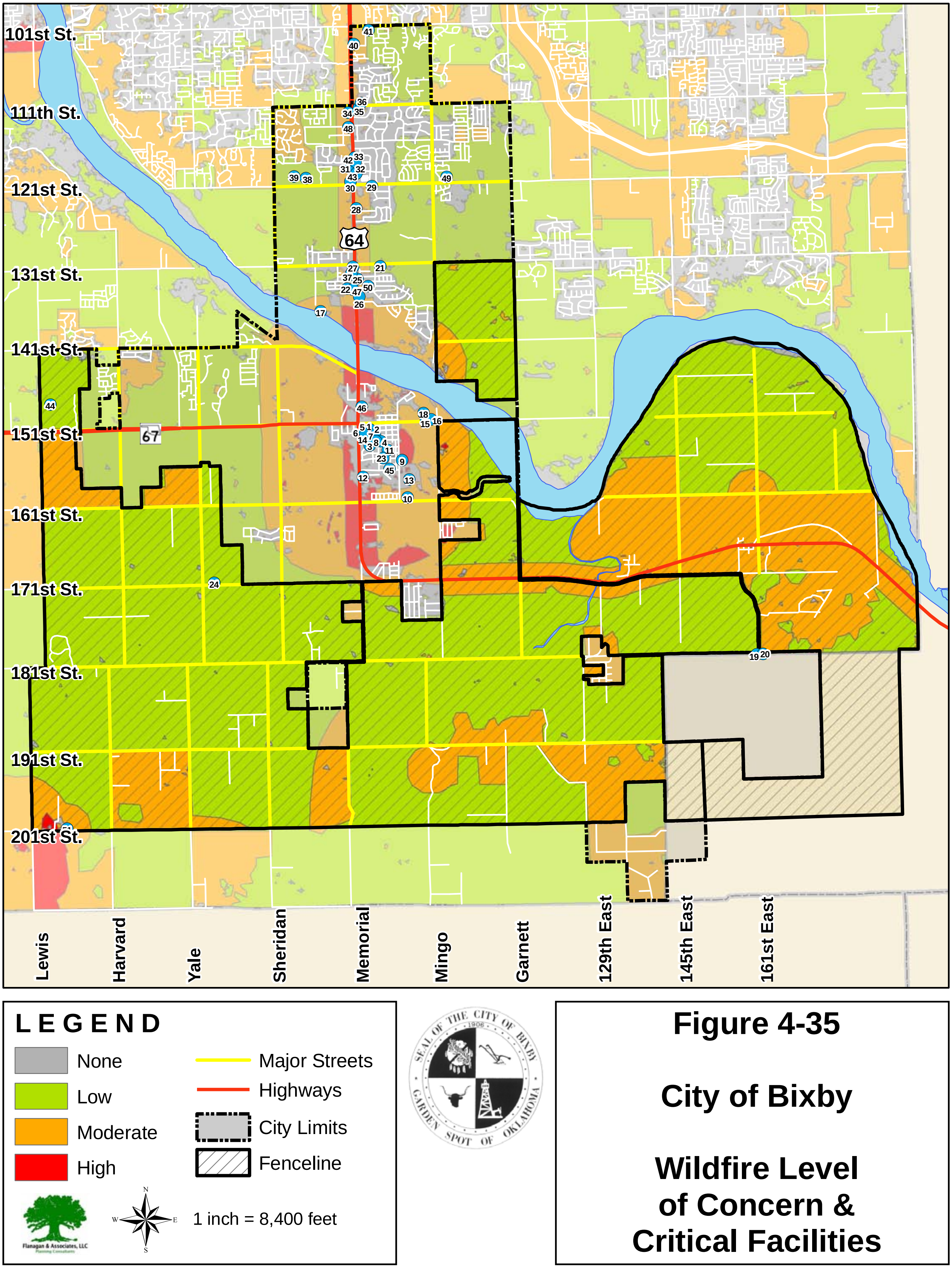

Figure 4-35

City of Bixby

Wildfire Level of Concern & Critical Facilities

Table 4–52: Critical Facilities with some Vulnerability to Wildfire
(SFRAS – Level of Concern Calculations)

ID	Name	Address	Threat	ID	Name	Address	Threat
50	Autumn Park Retirement	8401 E 134th St S	Moderate	18	South Sewer Treatment	9501 E. 151st St.	Moderate
40	BancFirst	10275 S. Memorial	Moderate	26	Tulsa Teacher's Credit Union	13475 S. Memorial	Moderate
30	Bank of Oklahoma	10122 S Memorial Dr	Moderate	43	Warren Clinic	11911 S. Memorial Dr.	Moderate
10	Bixby Middle School	9401 E 161st St S	Moderate	16	Water Dept. Maintenance Bldg	9575 E. 151st St.	Moderate
46	Citizens Security Bank	14821 S Memorial Dr	Moderate	39	Bixby North 5th and 6th Grade Center	6941 E 121st St S	Low
28	Grand Bank	12345 S. Memorial Dr.	Moderate	38	Bixby North Elementary	7101 E 121st St S	Low
31	IBC Bank	11886 S. Memorial	Moderate	24	Midwest Child Care	7101 E 121st St S	Low
34	MidFirst Bank	11122 S. Memorial Dr.	Moderate	49	Sand Plum Retirement	9999 E 121st St	Low
17	North Sewer Treatment	13700 S. Memorial	Moderate				

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.

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 Bixby'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. **Gas:** As most gas delivery lines are below ground, this critical system is not highly vulnerable to the Wildfire hazard.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Roadway inaccessibility would be the transportation system's largest vulnerability from a Wildfire event. Wildfires may make it necessary to close a section of a major highway or to divert traffic along that route. Roads and bridges in the more rural portions of the City's jurisdiction 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. While an event of that scope affecting the entire community of Bixby would be improbable, the possibility of a more remote portion of the city located on the outlying boundaries is likely. These small pockets of residential developments in the more rural settings of the city, 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

Scenario

The Bixby Fire Department has determined that their emergency response would be sufficient in any identified high vulnerability areas, and that structural loss or loss of life would be minimal compared to a wildfire in a rural area, or a community with a greater percentage of exposure. The Public Information Officer for the Fire Department states "The worst case scenario…would be injury to one civilian or firefighter, or loss of a piece of property." In such a worst case event, fewer than 4 to 5 structures would be affected, with no more than 1 or 2 suffering major damage before the incident was brought under control. Bixby has two "grass rigs" which can respond to the interface areas on the fringes of the City. This being said, there are a growing number of rural estates within the southwestern, southern and southeastern boundaries of Bixby's fenceline. If not carefully planned and landscaped, these developments and individual residences could be at risk at some future point to wildfire under worst-case conditions, similar to those of 2006-2007.

4.11.5 Future Trends

Population

With many locations of planned development lying within the urban/rural interface to the west and south of the city, future development areas will be at higher risk to wildfires. It is not anticipated that the risk of deaths and injuries would be a greater percentage than it already is.

Structures/Buildings

As development in areas identified as "at risk" within the Wildland Urban Interface progresses, any structures and/or buildings constructed as a part of that development would be at risk during a wildfire event. As stated above, if structures in the "high" and "moderate" areas of concern are not carefully planned and landscaped, they could be at risk under worst-case conditions, similar to those of 2006-2007.

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 utilizing proper fire resistant building and landscaping practices.

Infrastructure

As these areas continue to 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. Infrastructure improvements, such as highway upgrades and transmission lines in predominantly rural and urban interface areas, can also increase the risk of wildfire from tossed cigarettes and downed power lines.

4.11.6 Conclusions

Wildfires are a serious and growing hazard because people continue to build homes in woodland areas and on grassy knolls. The value of the property exposed to wildfires is increasing rapidly, especially in the western states.

There were fire suppression measures taken in the past that caused an even greater fire hazard, because they allowed ground cover to build up that was naturally burned over by "prairie fires" at regular intervals. Western ecosystems had adapted to and become dependent on wildfires, which acted to thin forests and allow the development of different plant species. Land management agencies are now changing their policies concerning the control of naturally occurring wildfires.

As shown during the rash of wildfire in the winter of 2005-2006, the areas of the City of Bixby that are in the wildland/urban interface are at Moderate Risk to wildfires, and at Severe Risk during times of high wind and drought. However, that vulnerable area is a low percentage of the total area of the community, and is primarily limited to the areas immediately to either side of major roads. Overall, the City of Bixby's Wildfire Risk is considered Moderate.

Data Limitations

Data is sometimes turned into the State Fire Marshall's office over a year after the events occur. Consequently, complete data is frequently one, two or more years behind. In addition, the Fire Marshall's office does not list the actual number of wildfire events, but number of "fire department runs." The Bixby Fire Department 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 for a period of time. As a result, while the National Climatic Data Center might list only a few wildfires for Bixby between 1999 and 2008, Bixby's Fire Department might actually have made several hundred runs related to wildfire.

Update Changes

Identified significant changes made from the 2004 City of Bixby Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.11.7 Sources

Insurance Information Institute at Web address: www.iii.org

FireWise Communities USA at Web address: www.firewise.org

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Multihazard, Identification and Risk Assessment, p. 234, 236, 239. *Federal Emergency Management Agency*, 1997.

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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, the Meers Fault, located in southwestern Oklahoma near Lawton, and the Nemaha Fault, running north from Oklahoma up through Topeka KS.

4.12.1 Hazard Profile

Although located in the relatively quiet Central Plains Province, nearness to the New Madrid, Missouri, fault exposes some Oklahoma communities 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. (Source:

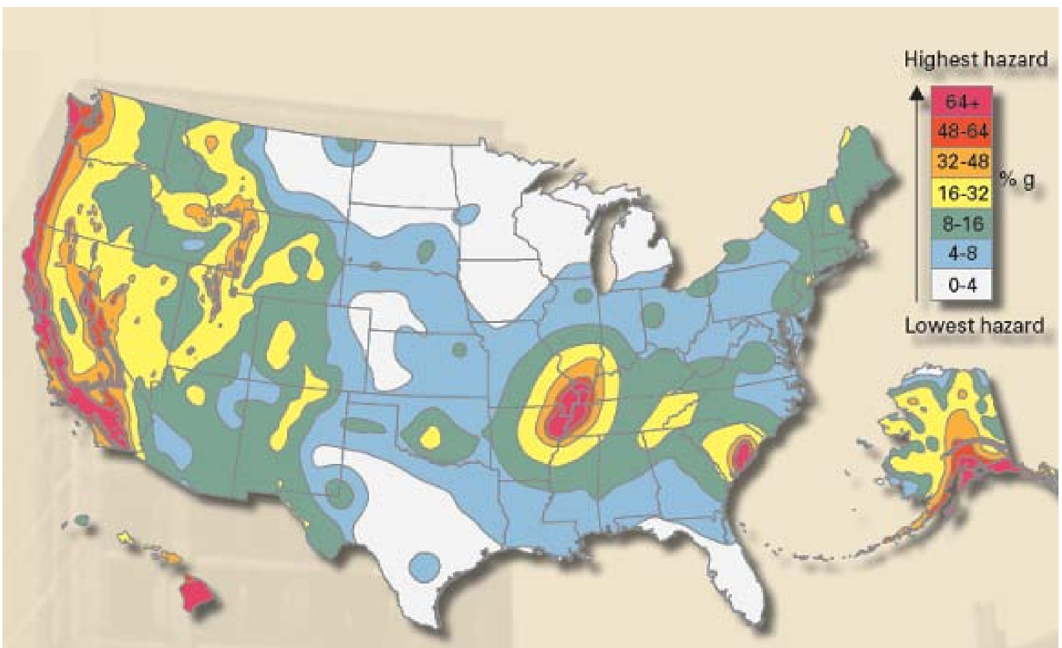
FEMA). However, these severe quakes resulted in relatively little loss of life or damage, since all but one occurred in uninhabited areas.

Location

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 records have been kept by the Oklahoma Geological Survey. Most of these earthquakes were so small that they could not be felt by people. Only about two or three per year have been large enough to be felt and most were so small they 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 City of Bixby and Bixby Public Schools is at Low-Risk from earthquakes.

Figure 4–36: Seismic Hazard Locations in the United States



Colors on this map show the levels of horizontal shaking that have a 2-in-100 chance of being exceeded in a 50-year period. Shaking is expressed as a percentage of g (g is the acceleration of a falling object due to gravity.) – (Source: USGS, 2008 US Nat'l Seismic Hazard Maps)

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.

Scientists use two standard measures to classify an earthquake's extent: *magnitude* and *intensity*. These measures are sometimes referred to as the Richter Scale (magnitude) and the Modified Mercalli (intensity).

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. The Modified Mercalli and Richter Scales are compared in Table 4-53.

Table 4–53: 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.

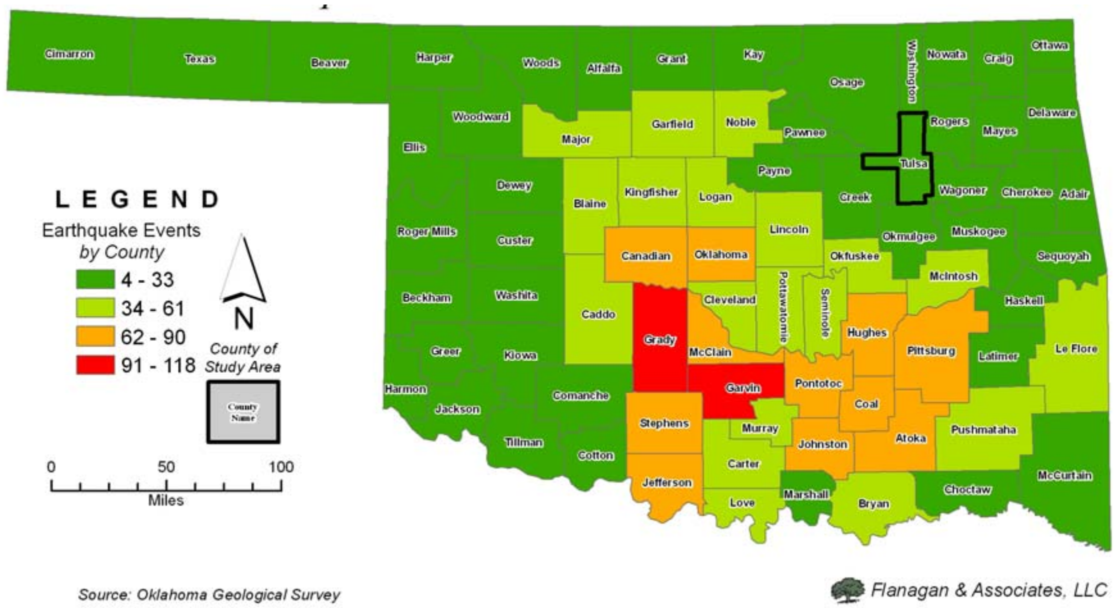
Extent

Tulsa County has experienced 10 reported earthquakes since 1900, but only one of these was a "felt" event, and that one was in December, 1900, centered in Cushing.

FEMA's HAZUS software application 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 calculate potential losses from a specified earthquake event. The historic 5.5 magnitude El Reno earthquake event of April 9, 1952 (see below), was used as a "worst case" input event in the HAZUS model and run for the City of Bixby.

Bixby considers a reading of 4.8 and below on the Richter Scale a minor severity and a reading of 4.8 and above to be a major severity.

Figure 4–37: Earthquakes in Oklahoma, 1989-2009



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.

Frequency

Tulsa County experienced six earthquakes between 1977 and 2009 (when formal seismic records were initially recorded), or 0.19 per year, none of which were "felt" earthquakes. None of the earthquakes were centered in the City of Bixby, so a low probability score was entered in the hazard analysis.

The Meers Fault has had two major ruptures in the last 3,000 years, the last one about 1,600 years ago. If the fault has a 1,500-year periodicity, it could be due for a major event in the next one or two hundred years.

The most likely major earthquake event that could impact the area would probably originate in the New Madrid Fault Zone, which has been relatively quiet for 150 years. Seismologists estimate the probability of a 6 to 7 magnitude earthquake in the New Madrid area in the next 50 years to be higher than 90 percent.

According to Randy Keller, interim State Geologist for the Oklahoma Geological Survey, "The New Madrid seismic zone, centered in New Madrid, Mo., produced major earthquakes in the past, and the area affected was quite large. Oklahomans would feel an earthquake from that area if another large one happens."

"It would shake Tulsa quite a bit. I'm not saying it would be a huge amount of damage, but we would know it had occurred," he said. "It would cause some minor damage in the eastern part of the state. And whether or not damage happened here, Oklahoma would be a key player in providing relief."

"The biggest impact in Oklahoma will be dealing with victims and dealing with other states," said Gary Patterson, geologist with the Center for Earthquake Research and Information at the University of Memphis in Tennessee.

Oklahoma officials have agreed to aid other states in case of an earthquake. The Sooner State is one of nine associate members of the Central United States Earthquake Consortium.

Impact

The impact of this hazard depends on the intensity of the earthquake. A 5.7 magnitude event centered on the Nemaha fault in the El Reno area would not adversely affect any structures in the City of Bixby, and would not adversely affect Bixby Public Schools.

4.12.2 History/Previous Occurrences

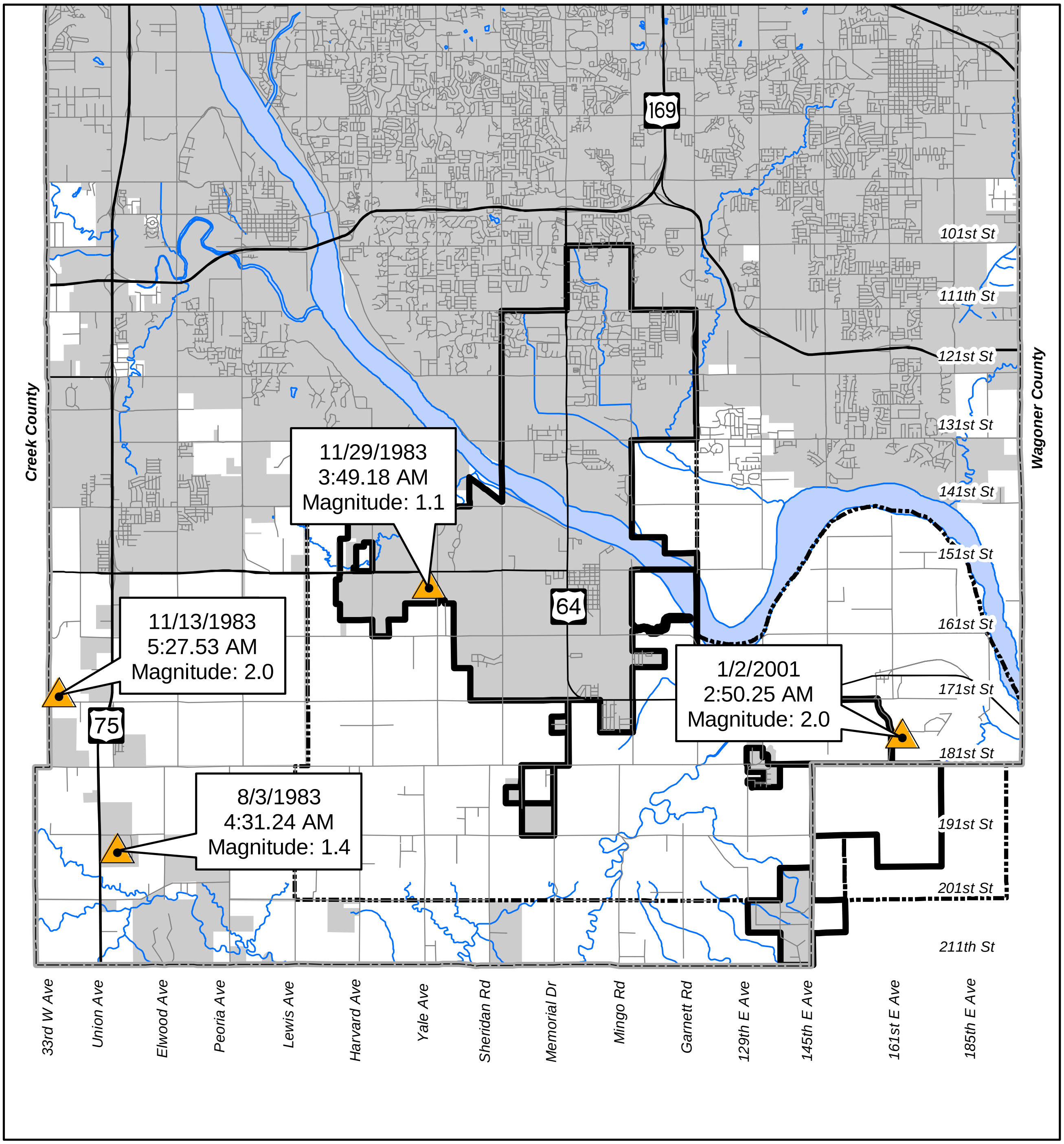
World history is punctuated with hundreds of earthquake catastrophes. In 1556 the Shansi, China, earthquake killed 800,000 people. An earthquake in Lisbon in 1775 took 70,000 lives. More recently, a moderate 6.7-magnitude earthquake struck Northridge, California, on January 17, 1994, killing 57 people, injuring 9,000, and causing over $25 billion in damage. A year later, in Kobe, Japan, a 6.9 magnitude tremor killed 5,100 people, injured 27,000, destroyed 100,000 buildings, and did $120 billion in damage.

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 bells in church steeples 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 significant Oklahoma earthquakes include the following:

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.



LEGEND

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

0 1 2 Miles

Figure 4-38

City of Bixby

South Tulsa County Historic Earthquakes

May 2, 1969 – A 4.6 magnitude, V intensity quake occurred at Wewoka, in Seminole County, causing cracks in plaster walls.

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.

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, which shook houses with a kind of rolling sensation rather than hard shaking. Pictures were knocked over on dressers.

Tulsa County Earthquakes

Tulsa County experienced six earthquakes between 1977 (when formal seismic records were initially recorded) and 2009, or 0.19 per year. None of these events were "felt" earthquakes (i.e., all were below 2.1 on the Richter scale). Four of these six events took place in South Tulsa County, near, but not within the city limits of Bixby. Two events, however, were within Bixby's fenceline. See 4-38 for a map of the earthquake epicenters within South Tulsa County.

Probability/Future Events

The City of Bixby and Bixby Public Schools have a low probability of a future earthquake event. Any earthquake risk would most likely come from proximity to the New Madrid and Meers faults. 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 Bixby 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

This section summarizes information about Bixby's vulnerability to earthquakes, including the impact on people, structures and buildings, critical facilities, and infrastructure. This information, as well as information provided by the City and Public Schools, was used to determine the Impact Criteria identified in Tables 4-2 and 4-3. HAZUS modeling was used to help generate these data. The City of Bixby and Bixby Public Schools were determined to have a Low Risk to the Earthquake hazard (See Table 4-2 Hazard Risk Analysis, and Table 4-3, Summary of Hazard risk Analysis Ranking Criteria for an explanation of how the rankings were derived.)

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.

HAZUS estimates that an El Reno-size earthquake would result in zero damage to populations, structures, critical facilities and utilities in Bixby. Consequently, these areas of vulnerability will not receive detailed discussion.

4.12.4 Earthquake Scenario

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 conclude an estimate on potential damages and losses to be expected within the region 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 the City of Bixby. Affecting most of the State and parts of Arkansas, Iowa, Kansas, Missouri, Nebraska, and Texas, historically, this is Oklahoma's largest earthquake event.

For Bixby, HAZUS estimated 144,139 buildings in the region with a total building replacement value of $35,361,000,000. Approximately 96% of the buildings and 72% of the building values are for residential housing.

HAZUS estimates that no structures would have any damage. All essential facilities, including schools, the EOC, and Police and Fire Stations would not receive damage either. Functional losses to these facilities are considered non-existent.

Transportation system damages and economic losses associated with these systems are estimated at 0%. All utility system facilities, pipeline activity, electric power and potable water should be at 100% following the event. It is estimated that none of the buildings in Bixby would be affected with a power failure or loss of potable water. HAZUS estimates that no debris will be generated by the earthquake.

The scenario estimates casualties for three peak occupancy loads throughout the day, 2:00 AM (residential occupancy peak), 2:00 PM (non-residential occupancy peak) and 5:00 PM (commute peak). Zero minor injuries requiring medical attention is expected from the event at 2:00 AM, 2:00 PM, or 5:00 PM.

The total economic loss for the earthquake is estimated at $0. This includes building and lifeline related losses.

4.12.5 Future Trends

Based on a HAZUS analysis that worst-case scenario creates no damage to life, health, and structural integrity for the City of Bixby or Bixby Public Schools, it is reasonable to assume that future development will also not be impacted by a worst-case earthquake event.

4.12.6 Conclusion

Tulsa County experienced six earthquakes between 1977 and 2009 or 0.19 per year, none of which were "felt" earthquakes. None of the earthquakes was centered in the City of Bixby. A low probability score for an earthquake event was entered in the hazard analysis. As calculated using HAZUS software, an El Reno earthquake similar to the 1952 quake would cause an estimated $0 in damages. Virtually all Oklahoma earthquakes are too small to be felt and cause no visible damage.

Data Limitations

While the HAZUS software is very comprehensive, structural integrity and Code requirements for a jurisdiction can greatly affect the actual damage taken by structures. Earthquake resistant construction is not something routinely considered in Oklahoma, so damages are not as accurate as they might be in a jurisdiction such as a California community, where earthquake resistant construction and analysis are routinely more studied.

Update Changes

Identified significant changes made from the 2004 City of Bixby Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.12.7 Sources

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4.13 Hazardous Materials 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.

4.13.1 Hazard Profile

With 7 Tier II sites located within Bixby city limits, the City of Bixby is vulnerable to hazardous materials events

Hazardous materials, for regulatory purposes, are divided into two general categories: fixed sites, and transportation facilities.

Fixed sites 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. The City of Bixby has 7 facilities located within city limits, 2 sites located directly adjacent to city limits and 3 facilities located within the City of Bixby's fenceline.

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).

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 US 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 Substance

Location

Bixby and Bixby Public Schools has inventoried local businesses and industry to identify dangerous chemicals that are being manufactured and/or stored in their communities. Known hazardous materials sites for Bixby and Bixby Public Schools are shown on the map in Figure 4–39.

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 summaries. This allows the number of hazardous materials events that a community has to be measured against state and national averages.

Extent

The extent of a fixed-site hazardous materials event can range from relatively harmless to one that is catastrophic, with numerous long-term health and environmental effects. The extent of the hazard is dependent upon the amount of the chemical involved, and the local conditions at the release site, including number of people at risk, wind speed and general weather conditions. The extent of an event can be reduced by such things as 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.).

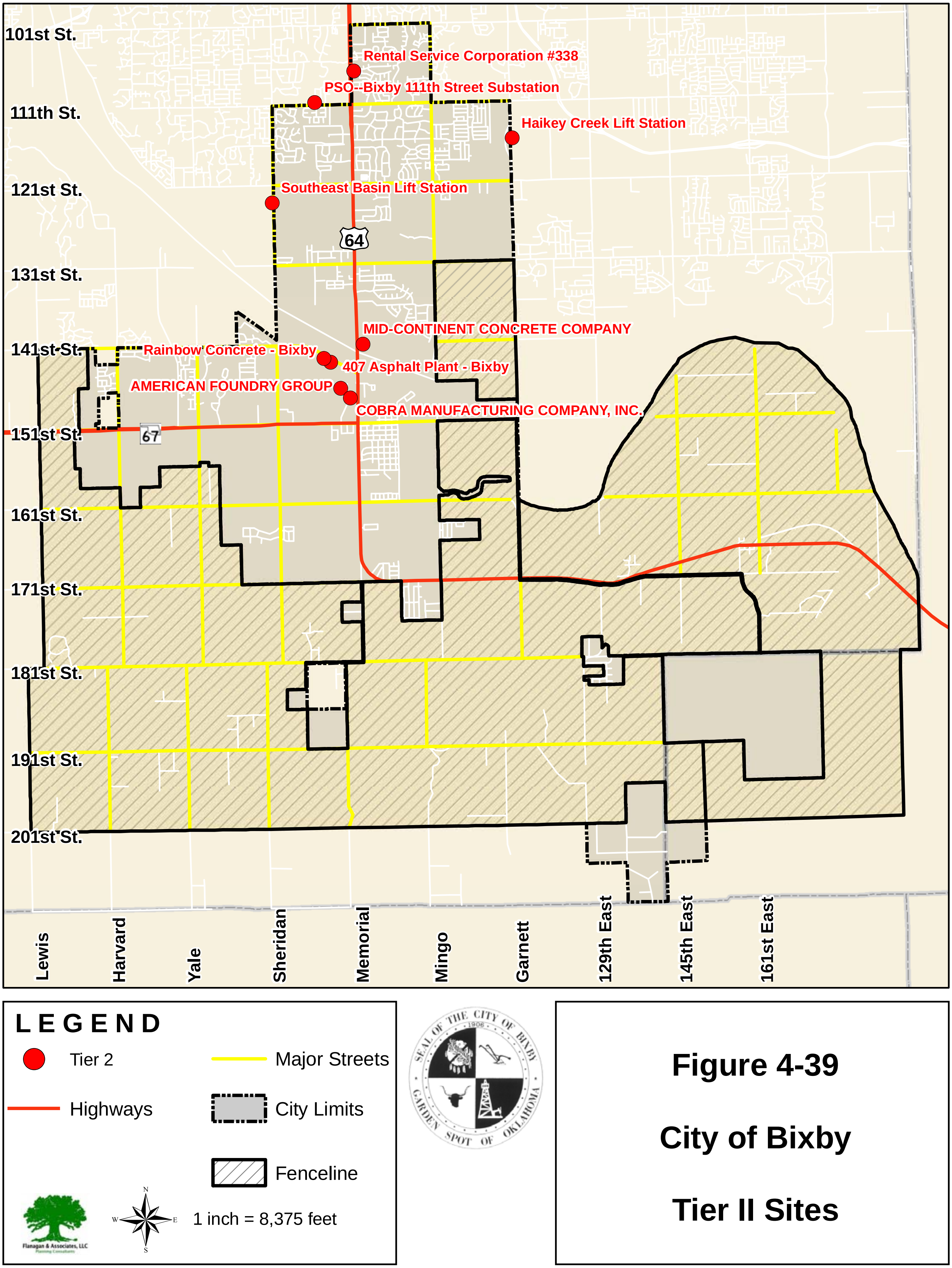


Figure 4-39

City of Bixby

Tier II Sites

Bixby considers a minor severity event 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 event to be the release of a toxic chemical which has the likelihood of producing serious injury or death, or which meets the definition of a “large spill” for a particular chemical according to the most current edition of the Emergency Response Guidebook.

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.

Frequency

The National Response Center reports that an average of approximately 32,185 hazardous materials events occur each year in the United States, as shown in Table 4-54. Annually, on the average, about 12,000 events are from fixed-site locations, the largest number of any of the defined incident types.

Table 4–54: U.S. Hazardous Materials Incidents 2000-2009

Source: National Response Center

Incident Type	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fixed	11,813	12,441	11,917	11,975	12,975	13,017	13,621	11,913	10,909	10,123
Unknown Sheen	4,016	4,147	3,426	3,733	3,411	3,934	3,797	4,199	4,278	4,254
Vessel	3,945	4,378	3,919	3,962	4,385	4,611	4,767	4,931	5,030	4,597
Mobile	3,597	3,216	2,942	2,947	3,192	3,215	3,267	3,297	3,238	2,854
Pipeline	1,618	1,841	1,621	1,643	1,574	1,896	1,839	1,580	1,379	1,275
Platform	1,428	1,355	1,233	1,344	1,198	1,395	1,606	1,407	1,362	1,761
Storage Tank	1,379	3,140	3,044	2,808	2,838	2,687	2,577	2,519	2,460	1,973
Railroad Non-Release	1,335	1,235	1,124	1,173	1,476	1,685	1,868	1,913	1,482	1,435
Railroad	1,332	1,241	1,200	1,074	1,276	1,532	1,451	1,390	1,649	1,306
Continuous	938	238	393	462	112	189	150	284	62	94
Aircraft	248	297	278	262	277	211	217	214	204	175
Drill/Exercise	669	789	908	743	1,073	1,223	1,578	1,584	1,829	2,039
Unknown	84	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Terrorist Non-Release	33	42	180	105	125	119	117	43	0	0
TOTAL INCIDENTS	32,435	34,360	32,185	32,231	33,912	35,714	36,855	35,274	33,882	31,886

Oklahoma was ranked 31st by the EPA in controlled toxic releases reported from industrial practices in the year 2000. Over 43 million pounds of toxic substances were released by air emissions, water discharges, underground injections, landfills and disposal facilities by industries in Oklahoma during 2000.

There have been no reported fixed-site hazardous material spills in Bixby in the past 10 years.

Impact

The impact on the community of this hazard can include interrupted business operations, disrupted transportation systems, short- or long-term ecological damage or degradation, diminished emergency response, and 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.

On January 22, 2001, carbon monoxide was released from gas equipment owned by Reliant Energy Arkla Gas Company into a Chickasha residence causing two fatalities.

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, 1989 to December 31, 2008, there were 492 fixed-site incidents in Tulsa County reported to the NRC. Of those 492 events, the great majority were harmless (but reportable) releases of materials used in manufacturing, such as nitrogen oxide, hydrogen sulfide, anhydrous ammonia, sulfur dioxide and sulfuric acid.

City of Bixby Fixed Site Hazardous Material Events

There were no hazardous materials events in the City of Bixby reported to the NRC in the 1989-2008 time period.

Probability/Future Events

Bixby, like Oklahoma, is vulnerable to hazardous materials incidents, and therefore its vulnerability is a constant and widespread threat. Hazardous materials incidents can, and do occur in nearly all months of the year at all hours of the day, so it is important that even when not responding to an incident, education and preparations continue to move forward. Bixby and Bixby Public Schools have a low probability of a future hazardous materials event.

4.13.3 Vulnerability

This section summarizes information about Bixby's vulnerability to fixed site hazardous materials events, including the impact on people, structures and buildings, critical facilities, and infrastructure. This information, as well as information provided by the City and Public Schools, was used to determine the Impact Criteria identified in Tables 4-2 and 4-3. The City of Bixby and Bixby Public Schools were determined to have a Low Risk to the Fixed Site Hazardous Materials hazard (See Table 4-2 Hazard Risk Analysis, and Table 4-3, Summary of Hazard Risk Analysis Ranking Criteria for an explanation of how the rankings were derived.)

A hazardous material event can occur anywhere due to the widespread use of hazardous chemicals. However, the populations most at risk to a fixed-site incident are the workers in the facility where the release occurs, and the population that lives nearest to the machinery, refineries, or manufacturing plants that use or produce the hazardous materials. Therefore, the 9 Tier II sites within the City of Bixby have been identified and are shown on the map in Figure 4-39. Altogether, there are seven Tier II sites located within Bixby city limits, two Tier II sites on the boundaries of the city (Haikey Creek Lift Station and Southeast Basin Lift Station), and three Tier II Sites within the fenceline of Bixby.

Assessment of vulnerability to a hazardous material release can be meticulous due to the relationship that exists between the toxicity of the material, the amount of material released, the type of release, and the climatic conditions present at the time of the release. However, for the purposes of this report, general community risk is assessed based on the protective action distances defined by CAMEO and RMP* Comp, two software programs used to plan for hazardous material emergencies. The worst-case protective action distances are based on the physical characteristics of the material and the specified amount of material housed within the largest container at each Tier II site. For chemicals that do not have definable protective action distances, evacuation distances for large spills, as listed in the Emergency Response Guide, were used. The Tier II facilities are listed in Table 4-55, along with the number of people within a quarter mile of the facility.

Table 4–55: Tier II Sites - City of Bixby.

Facility	*Address*	*Contains EHS*	*People within 1/4 mile*
407 Asphalt Plant	7500 E. 141st St.	N	0
American Foundry Group	14602 S. Grant St.	N	0
Cobra Manufacturing Co. Inc.	7909 E. 148th St.	N	0
Haikey Creek Lift Station	11601 S. Garnett Rd.	Y	0
Mid-Continent Concrete Company	14100 S. Memorial	N	0
PSO – Bixby 111th St. Substation	111th St. b/w Memorial & Sheridan	Y	1
Rainbow Concrete – Bixby	7602 E. 141st St.	N	0
Rental Service Corporation #338	10601 S. Memorial Dr.	N	238
Southeast Basin Lift Station	12600 S. Sheridan	Y	0

Table 4–56: Tier II Sites within City of Bixby Fenceline (Future Growth Areas)

Facility	*Address*	*Contains EHS*
Allen / O'Hern Tank Battery	19800 S. Memorial Dr.	N
B. Etheridge, Inc. – Leonard	Hwy 64 and 161st St.	N
Ferrellgas - Bixby	13722 E 169th St.	N

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 239 people, or 1.8% of the population of Bixby, 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 or understand warning messages.

Most Tier II sites that pose a risk to Bixby populations are in the jurisdiction of other cities within Tulsa County, like Tulsa or Broken Arrow. Likewise, hazardous materials releases in Bixby could possibly 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.

Critical Facilities

There is one critical facility in Bixby within a quarter mile of a Tier II facility. It is listed in the table below.

Table 4–57: Bixby Critical Facilities within 0.25 mi. of Tier II Sites

ID	*Name*	*Address*
46	Citizens Bank Security & Trust	14821 S. Memorial Dr.

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. One Bixby critical facility is located close to Tier II 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 lagoons process contaminated waste.

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 and bermed.

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 fires, explosions or 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 Bixby, there are currently no emergency services within the evacuation distance of a Tier II facility. Fire, Police and Medical Services would have a surge of demand for services in the case of a Tier II event. While not an immediate threat to delivery of these services, the demand for additional personnel to provide an effective response could potentially increase the cost for these resources.

4.13.4 Fixed-Site Event Scenario

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 an accidental fire involving a propane tank at American Foundry Group, due either to operator error or equipment failure. The population most at risk will be employees working at the plant and those living closest to the facility when the fire occurs.

The area shown on Figure 4-40 is for a propane fire designated by a circle that shows a 5,280 feet isolation distance. The area affected by a propane fire would include four hundred forty-one residential properties, twenty agricultural properties, one hundred eight commercial properties, fifty-nine industrial properties, one hundred thirty-five tax-exempt properties, seventeen critical facilities, and four additional Tier II sites.

4.13.5 Future Trends

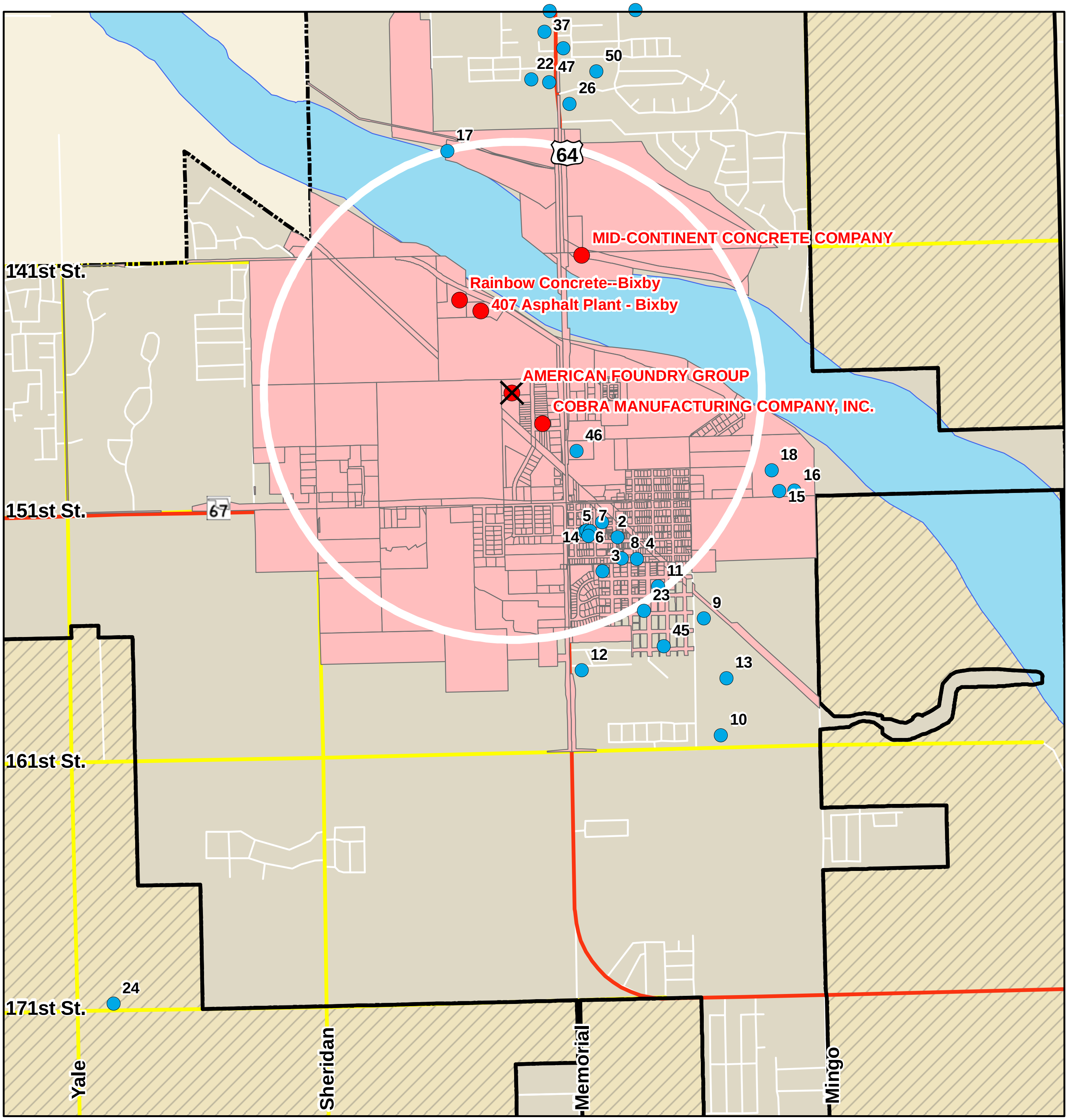
For a map of Bixby's potential future growth areas, see Figure 1-17.

Population

Development in Bixby will continue to expose the population to hazardous material spills.

Structures/Buildings

Structures and buildings in future development areas 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.



LEGEND

- Critical Facilities
- Parcels
- Major Streets
- Highways
- City Limits
- Fenceline

1 inch = 3,000 feet

Figure 4-40

City of Bixby

Tier 2 Propane Fire Scenario

Critical Facilities

There are no plans to locate critical facilities in close proximity to existing 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.

With only one of the City of Bixby's critical facilities within a quarter mile of a Tier II site, the City can be considered to have a Low Risk to a fixed-site hazardous material incident. A number of mitigation measures may be considered in order to lessen the consequences of serious impact from an event.

4.13.7 Sources

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4.14 Dam 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.” Dams typically are constructed of earth, rock, concrete, or mine tailings. A dam failure is the collapse, breach, overtopping or other failure resulting in downstream flooding.

4.14.1 Hazard Profile

A break in a dam produces an extremely dangerous flood situation because of the high velocities and large volumes of water. In the event of a dam failure, the potential energy of the water stored behind even a small dam can cause great property damage, as well as loss of life if there are people downstream from the dam.

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.

A release of 40,000 cubic feet per second (cfs) from Keystone Dam, upstream of the City of Bixby

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. The extent of the inundation that results may be minimal to uninhabited farmland or catastrophic in nature in an urban environment.

Thus, dams may create a false sense of security, increasing the amount of property at risk of flooding as people and businesses locate downstream of dams, believing they are totally safe. In addition, dams, and other structural measures are extremely costly and can disrupt or destroy the natural environment.

Location

There are two dams of concern to residents of Bixby: Keystone Lake Dam in western Tulsa County, and Lake Bixhoma Dam shown in Figure 4-42, near 162nd St. S. and 161 E. Ave. These dams are described in Table 4-58 and 4-59.

Table 4–58: Keystone Lake High Hazard Dam

Keystone Dam	
Location	On Arkansas River, 10 miles west of Tulsa
Source...............................	Arkansas River
Owner/operator..................	U.S. Army Corps of Engineers
Year built...........................	1964 (with an estimated useful life of 50 years)
Length/ Height....................	4,600 feet/ 121 feet
Construction material.........	Masonry and earth-fill
Use of Dam........................	Water storage, flood control, hydroelectric, and recreation
Capacity.............................	250,700 acre-feet of water
Land Area	23,610 surface acres of water
Flood damage history	Keystone has not failed, but high releases in 1986 caused significant downstream damages
Results of failure	Inundation of Sand Springs, Tulsa, Jenks, and Bixby
Emer. Action Plan (EAP) ...	Yes

Table 4–59: Lake Bixhoma Significant Hazard Dam

Lake Bixhoma	
Source....................................	Mountain Creek
Owner/operator....................	City of Bixby
Year Completed......................	1965
Length/ Height	1300 feet / 95 feet
Hazard	Significant
Surface Area...........................	110 surface acres

Bixby 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 event. Bixby 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 event.

Arkansas River Corridor

Much has been done over the past 40 years to control flooding in the Arkansas River Basin and in the City of Bixby. The U.S. Army Corps of Engineers completed the Arkansas River's Keystone Dam above Tulsa in 1964. The Dam has functioned well with the exception of the 1986 flood, when the threat to the Dam by record flows on the Cimarron and Arkansas Rivers forced the release of floodwaters into the Arkansas upstream from the city of Tulsa.

The City of Bixby has funded flood mitigation projects totaling over $28,500,000 through a Corps of Engineers project, grants, bonds, storm water management funds, and the City's general fund.

Keystone Dam

Keystone Dam, 10 miles west of Tulsa provides flood control, hydropower, water supply, water quality, navigation, irrigation, recreation, and fish and wildlife management. The areas of Bixby that would be flooded by a Keystone Dam break or emergency release are shown in Figure 4-41.

Arkansas River Regulation

It is important to note that the City of Bixby regulates land use within the Arkansas River corridor only to the standard of the National Flood Insurance Program, that is, the 100-year floodplain based on existing watershed development. It is arguable that this standard is justified because of the size of the Arkansas watershed and the presence of Keystone Dam. However, the standard is less stringent than the City's regulation of floodplains in the rest of Bixby. This lower standard is of concern because the Arkansas offers far greater potential for catastrophic flooding than the other Bixby streams. City staff has proposed adjusting City codes so that regulation of Bixby's Arkansas River floodplains would be based on the 1986 flood, the current flood of record.

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. Even a very small dam may contain many acre-feet or millions of gallons of water.

Water discharge is measured in cubic feet per second (cfs). A cubic foot contains about 7.5 gallons of water. One cubic feet per second equals about 450 gallons per minute.

An artificial water barrier 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). The OWRB classifies dams as high-hazard, significant-hazard, and low-hazard, depending on the amount of water stored and downstream populations.

A **high-hazard dam** is one that has occupied dwellings immediately downstream – it does not mean that the dam is at risk of failing. A **significant hazard dam** is one that poses no threat to life, but whose failure may interrupt some road or pubic utility services. If a high-hazard dam fails, there probably will be loss of life. This designation does not mean that a dam is in need of repair—it could be in excellent condition or in poor condition. "High-hazard" simply reflects a dam's potential for doing damage downstream if it were to fail.

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.

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 the 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.

The failure of a major dam upstream on the Arkansas River could cause catastrophic damage to the City of Bixby and Bixby Public Schools. In the words of the Corps of Engineers, a failure of Keystone Dam "would be catastrophic in terms of property damage, potential for loss of life, and environmental destruction."

The Corps has developed GIS layers showing the areas that will be inundated by a failure of Keystone Dam. These areas are shown in Figure 4–41.

Frequency

In the area of chief concern for Bixby, the Arkansas River corridor, the frequency of flooding has been dramatically reduced by Keystone and Kaw dams. Only one significant flood event (1986) has occurred along the Arkansas at Bixby since the dams at Keystone and Kaw Lakes were completed.

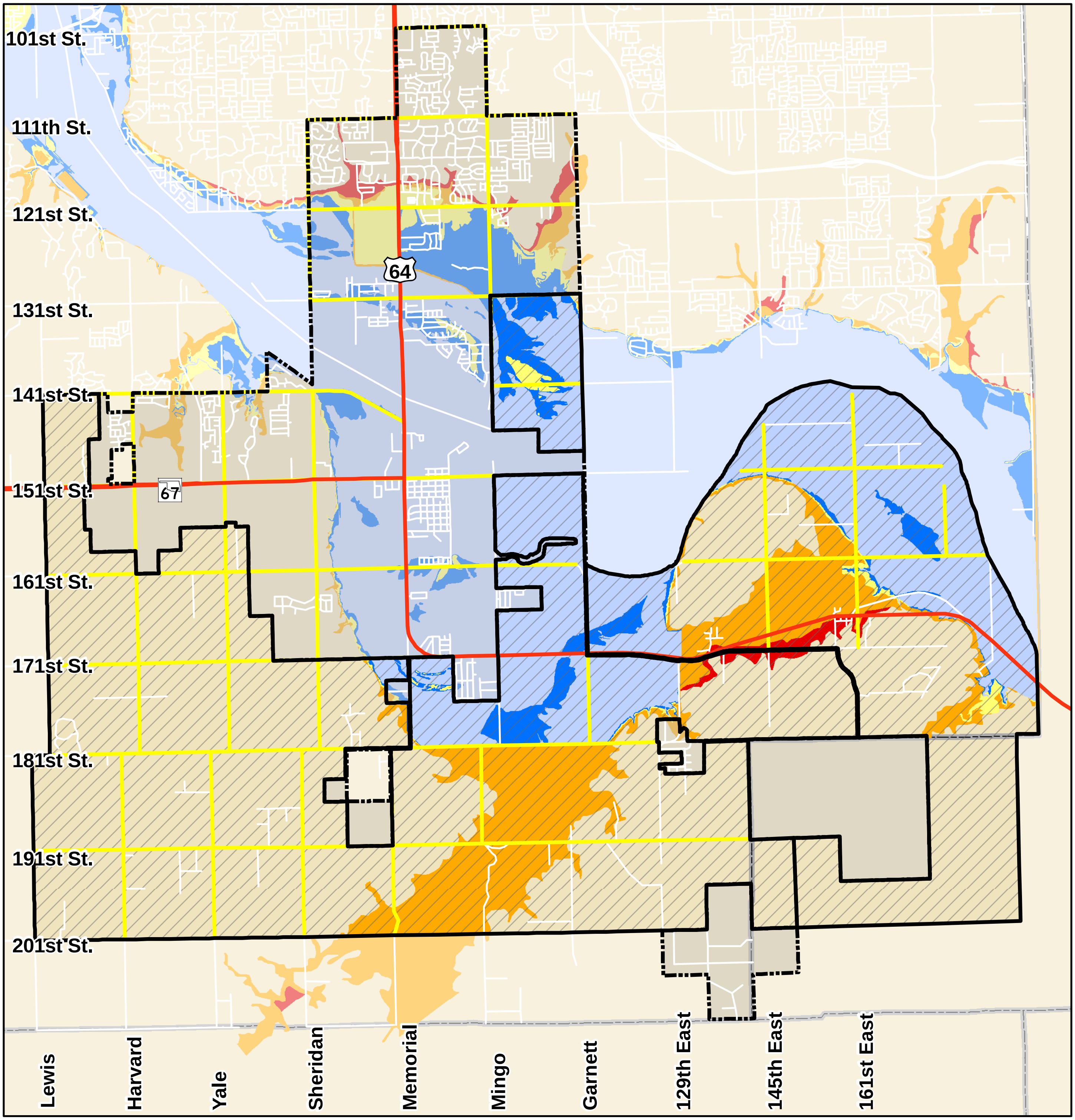
As noted above, the Corps projects that Keystone and Kaw together provide an estimated 15-year level of flood control storage.

Impact

The impact of this hazard can affect homes, business, agriculture, and infrastructure that are 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. Emergency releases from a dam, to avoid the imminent failure of the structure can also cause catastrophic downstream flooding, as occurred in 1986.

The economic impacts resulting from a 350,000 cfs emergency release from Keystone Dam (similar to the 1986 release) would impact 2,347 improved properties in Bixby, including Bixby Public Schools facilities, and do an estimated $161,809,059 in damage.

A breach of Bixhoma Lake Dam would impact one potential residence downstream and 4 other structures (barns or sheds).



LEGEND

- 250,000 CFS
- 350,000 CFS
- 450,000 CFS
- Max. Discharge
- Dam Break
- Highways
- Major Streets
- City Limits
- Fenceline

Flanagan & Associates, LLC
Planning Consultants

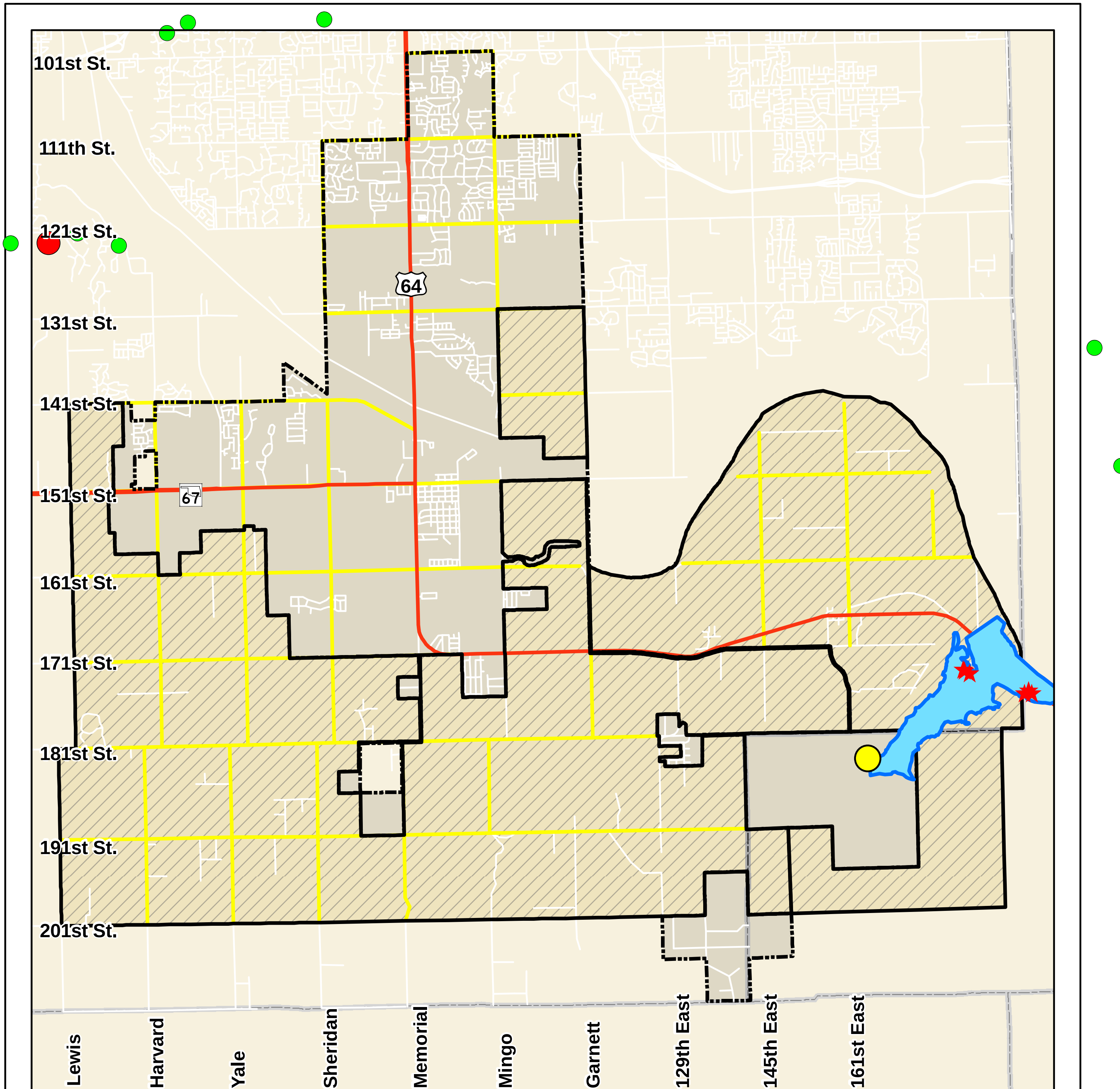
1 inch equals 8,375 feet

SEAL OF THE CITY OF BIXBY 1906 GARDEN SPOT OF OKLAHOMA

Figure 4-41

City of Bixby

Keystone Dam Failure



LEGEND

- Structures
- High Haz.
- Sig. Haz.
- Low Haz.
- Pot. Inundation Area (Bixhoma)
- Highways
- Major Streets
- City Limits
- Fenceline

1 inch equals 8,375 feet

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Figure 4-42

City of Bixby

Bixhoma Lake Potential Inundation Area

4.14.2 History/Previous Occurrences

Historic Dam Failure Events

In Oklahoma, there have been three significant documented dam failures, each after sudden and heavy rainfall events:

- 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.
- After 14.6 inches of rain fell in the Wewoka area the night of April 13-14, 1945, heavy flows on Coon Creek overtopped and breached the 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. Eighty people were forced from their homes. (Kuhnert)

A Sand Springs levee gives way during the 1986 flood on the Arkansas River

In 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 Keystone Dam, the Corps of Engineers opened floodgates and released 310,000 cfs of water through Sand Springs, Tulsa, Jenks and Bixby. No one knew if the levees would hold, and a catastrophic failure of the levee system was widely feared. In fact, the Sand Springs levee was breached, but volunteers quickly plugged it with sandbags.

On the west bank, the private levees failed during the 1986 Arkansas River flood, and the river swamped a number of Garden City houses up to the rooftops, causing $1.3 million in damages to 64 buildings. The disaster was complicated by pollution from old, underground refining and chemical storage and dumps. In all, more than 1,800 homes and businesses were flooded in Tulsa County, and 1986 damages were estimated at $63.5 million (in '86 dollars).

Damage from the flood in Bixby was estimated by the Corps of Engineers to have been $13.4 million, all of it to urban properties and structures.

Probability/Future Events

It is widely believed that there is a low probability that Keystone Dam will fail, because it is operated by the Corps of Engineers and inspected at least once each year. Nonetheless, the Corps has projected the effects of a failure of Keystone Dam: it would send a 20-foot-high wall of water rushing down the Arkansas River valley, destroying or damaging almost everything in its path, and reaching Bixby in approximately six hours. The average building within the inundation area would be in ten to twenty feet of water, including the downtown area, and Bixby High School and Middle School.

The age of Keystone Dam is an issue of concern for the community. When Keystone Dam was built in 1964, the Corps estimated it would have a 50-year useful life. In addition, a great deal of silt has collected upstream from the dam, including in the flood pool. The Keystone flood pool filled completely in 1974 and 1986.

Although a dam break is unlikely, there is a very high probability that the Corps will be forced to make future forced releases from the reservoir similar to that of 1986. Even without a breach of the dam, emergency releases could cause extensive property damage and disruption, as well as safety risks. The Corps has studied and mapped the areas that would be inundated by forced releases of 250,000 cfs, 350,000 cfs, 450,000 cfs and maximum discharge. (The dam's maximum discharge could be as high as 940,000 cfs, while a "100-year" discharge would be around 200,000 cfs.)

Bixby and Bixby Public Schools have a moderate probability of a dam failure event.

4.14.3 Vulnerability

This section summarizes information about Bixby's vulnerability to dam failures, including the impact on people, structures and buildings, critical facilities, and infrastructure. This information, as well as information provided by the City and Public Schools, was used to determine the Impact Criteria identified in Tables 4-2 and 4-3. The City of Bixby and Bixby Public Schools were determined to have a High Risk to the Dam Failure hazard (See Table 4-2 Hazard Risk Analysis, and Table 4-3, Summary of Hazard Risk Analysis Ranking Criteria for an explanation of how the rankings were derived.)

The vulnerabilities from four release scenarios are quantified: 250,000 cfs, 350,000 cfs, 450,000 cfs, and maximum discharge. These scenarios are presented graphically in Figures 4-41 and 42. The damages from each scenario are presented in Table 4-61. The impacts of a dam failure are covered in 4.14.4 Worst-Case Dam Failure Scenario.

Population

People, property, critical facilities, and infrastructure downstream of dams would be subject to devastating damage in the event of forced releases of as great or greater magnitude as in 1986 (i.e., 350,000 cfs and higher). The number of fatalities or injuries resulting from such releases is influenced by the number of people in the inundation area, the amount of warning they receive, and the effectiveness of pre-event public education and planning. People at risk include those who are living, working, attending school, or traveling through vulnerable areas when the releases occur.

According to the Corps of Engineers, there is sufficient time after an emergency release to evacuate citizens, if necessary, and prepare the city for the flood surge. The travel time of such a surge is about six hours.

Dams

Keystone Dam: A major release from Keystone Dam could impact an estimated 5,491 people. Of those citizens impacted by the release, approximately 620 people would be over age 65 (11.3%) and approximately 241 (4.4%) below the poverty level.

Structures/Buildings

Tables 4-60 and 4-61 summarize damages to properties from four Keystone Dam release scenarios: 250,000 cfs, 350,000 cfs, 450,000 cfs, and maximum release. (See Section 4.14.4, for impacts from a failure of Keystone Dam.)

As shown in Table 4-60, there are between 2,500 and 3,700 properties in Bixby that would be impacted by forced releases from Keystone Dam, representing total potential losses of between $200 and $344 million. Included are from 1,500 to 2,213 residential dwellings, 62 to 85 agricultural parcels, 146 to 163 commercial properties, 69 to 71 industrial structures, and from 156 to 189 government/special population buildings.

The industrial properties impacted include nine Tier II sites containing hazardous materials. Major damage to these facilities could trigger cascading disasters, such as chemical releases and explosions.

Table 4–60: Impacts from Four Keystone Release Scenarios and Dam Failure

Release Rate	Parcels	Improvement Value	Contents Value	Total Value
250,000 cfs	2,596	$124,467,964	$77,709,996	$200,121,210
350,000l cfs	3,170	$162,343,926	$98,052,772	$258,267,248
450,000 cfs	3,584	$201,405,026	$118,831,983	$320,237,009
Maximum Release	3,703	$217,262,984	$126,760,962	$344,023,946

Critical Facilities

Figure 4–43 shows critical facilities in the areas vulnerable to a Keystone Dam break. These are listed in Table 4-61. There are 39 critical facilities in the area that would be affected by Keystone Dam releases.

Infrastructure

Water Treatment – Water treatment plants serving the Bixby area from Tulsa are outside the Keystone dam inundation area and would not be affected, although delivery pipelines could be impacted.

Wastewater Treatment – Wastewater treatment lift stations would be inundated.

Utilities: The primary utility providers for Bixby's jurisdiction are AEP/PSO (electricity) and ONG (natural gas). **Electricity –** The primary danger for electric power would be the loss of the high-tension towers along the river corridor. The replacement could be both long and costly to get power restored. **Gas** – Transmission pipelines could be breached both through trees being uprooted, affecting the lines in their dripline, and ground being washed out, exposing the pipelines to damage.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Bridges crossing the river would be affected, effectively cutting off access to Bixby from the north, the primary route of access. The railway also crosses the river and would be affected. A Keystone Dam Failure would impact Interstate 44, a major interstate highway, and the Cherokee Yard, a major intermodal regional transportation hub for the BNSF Railroad Corporation.

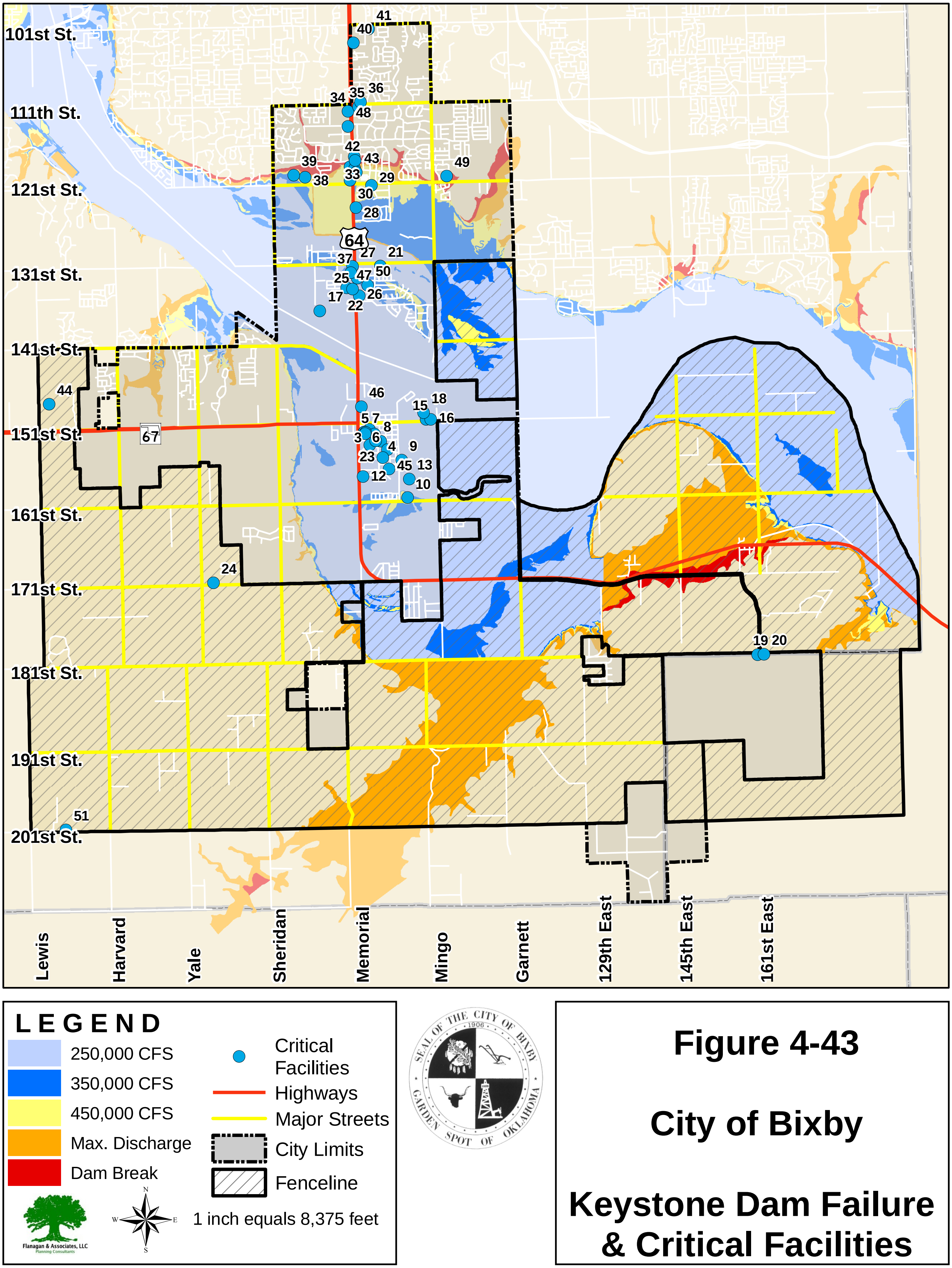

Figure 4-43

City of Bixby

Keystone Dam Failure & Critical Facilities

Table 4–61: Keystone Dam Releases – Bixby Critical Facilities Impacted

ID	Name	Address	250,000	350,000	450,000	Max
45	A Child's Dream Daycare	213 E. Stadium	x	x	x	x
25	After the Bell Student Center	13201 S. Memorial		x	x	x
50	Autumn Park Retirement	8401 E. 134th St.		x	x	x
30	Bank of Oklahoma	12052 S. Memorial			x	x
32	Bank of the West	11845 S. Memorial			x	x
6	Bixby City Hall	116 W. Needles	x	x	x	x
1	Bixby Community Center	211 N. Cabanis	x	x	x	x
4	Bixby Early Ed/Daycare – FBC	114 E. Breckenridge	x	x	x	x
7	Bixby Fire Station #1	116 W. Needles	x	x	x	x
29	Bixby Fire Station #2	8300 E. 121st St.			x	x
13	Bixby High School	601 S. Riverview	x	x	x	x
15	Bixby Maintenance Building	9501 E. 151st St.	x	x	x	x
10	Bixby Middle School	9401 E. 161st St.			x	x
39	Bixby North 5th and 6th Grade Center	501 S. Riverview			x	x
5	Bixby Police Dept.	116 W. Needles	x	x	x	x
8	Bixby Public Library	20 E. Breckenridge	x	x	x	x
2	Bixby Public Schools Admin Building	109 N. Armstrong	x	x	x	x
3	Bixby USPS	16 S. A Ave.	x	x	x	x
9	Brassfield 5th and 6th Grade Center	501 S. Riverview	x	x	x	x
10	Central Elementary School	201 S. Main	x	x	x	x
46	Citizens Bank Security & Trust	14821 S. Memorial	x	x	x	x
14	Dawes Building City Offices	113 W. Dawes	x	x	x	x
37	DeStiny Learning Academy	13164 S. Memorial	x	x	x	x
42	ERgent Care of Green Country	11717 S. Memorial				
28	Grand Bank	12345 S. Memorial		x	x	x
17	North Sewer Treatment	13700 S. Memorial	x	x	x	x
21	Playland Day Care Center	8510 E. 131st St.	x	x	x	x
18	South Sewer Treatment	9501 E. 151st St.	x	x	x	x
12	Southtown Nursing & Rehab.	76 W. Rachel St.	x	x	x	x
23	Storybrook Inn	210 S. Main St.	x	x	x	x
26	Tulsa Teachers Credit Union	13475 S. Memorial	x	x	x	x
27	Valley National Bank	13112 S. Memorial	x	x	x	x
43	Warren Clinic	11919 S. Memorial			x	x
16	Water Dept. Maintenance Building	9575 E. 151st St.	x	x	x	x
22	YMCA	7910 E. 134th St.	x	x	x	x
47	YMCA Daycare – Wilson Building	13406 S. Memorial	x	x	x	x

Emergency Services- Emergency responders would be extremely taxed. With the loss of vital utilities, emergency services would be even more heavily impacted. Mutual Aid agreements with the surrounding towns would provide some assistance, but several of these communities (e.g., Tulsa, Jenks and Broken Arrow) would also be affected by a major dam release, thus limiting their ability to assist.

4.14.4 Dam Failure Scenario

The worst-case scenario for Bixby would be similar to that used for the Flood Scenario, except this event could involve a complete failure—or an equivalent forced release of more than 450,000 cfs to prevent a failure of the dam.

Scenario

Torrential rains drop 20 to 25 inches of rain on northwestern Oklahoma between September 28 and October 4. Although the flood pools of the region's reservoirs were empty on September 23, by October 4 every reservoir in the region is full, forcing emergency releases into rain-swollen rivers. Bixby has already been experiencing flooding along Snake, Bixby and Posey Creeks on the south side of the Arkansas River on September 29-30 and on Haikey Creek on the north side. As the storm worsens, the Corps of Engineers activates its EOC, distributes over 500,000 sandbags to threatened communities, loans water pumps to Sand Springs, Jenks, Broken Arrow and Bixby, and sends out liaison officers to the major cities downstream. The storm is made worse by the arrival on October 4 of massive new amounts of moist air from the remnants of a hurricane in the Gulf of Mexico. Both the Arkansas and Cimarron Rivers report floods of record above Kaw Reservoir and Keystone Dam. Kaw Reservoir is forced to open it floodgates to prevent an imminent failure of the dam, sending a surge of water into Keystone Lake. With over 700,000 cfs flowing into an already full Keystone Reservoir, the Corps of Engineers is forced to open its floodgates on the afternoon of October 4 and allow a flow equivalent to a dam break into the already swollen Arkansas River. The resulting downstream flooding is extensive. Arkansas River levees in Sand Springs and Tulsa are breached. Garden City in West Tulsa is again flooded to the rooftops, and low-lying homes along the river in northwest Tulsa are standing in 6 feet of water. Bixby, which, as noted, was already experiencing flooding in the days preceding the release, is inundated in the worst flooding in its history.

The impacts of a near catastrophic failure of Keystone Dam and subsequent release of dam-break equivalent amounts of water into the Arkansas River basin are illustrated in Figure 4-41 and are listed in Tables 4-62 and 4-63.

Table 4–62: Keystone Dam Break Impacts – Bixby City Limits

Type	Parcels	Improvement Value	Contents Value	Total Value
Residential – Single Family	2,284	$205,596,565	$102,798,282.50	$308,394,847.50
Residential – Multi Family	35	$19,949,722	$9,974,861.00	$29,924,583.00
Residential – Mobile Home	136	$189,562	$94,781.00	$284,343.00
Residential – Mobile Home Parks	5	$734,515	$367,257.50	$1,101,772.50
Agricultural – Single Family	36	$3,812,891	$3,812,891.00	$7,625,782.00

Type	Parcels	Improvement Value	Contents Value	Total Value
Agricultural	85	$268,600	$268,600.00	$537,200.00
Commercial	166	$27,087,131	$27,087,131.00	$54,174,262.00
Industrial	71	$12,326,231	$18,489,346.50	$30,815,577.50
Vacant (Undeveloped Parcels)	906	-	-	-
Special Population / Govt.	196	$1,594,583	$1,594,583.00	$3,189,166.00
Total	3,920	$271,559,800	$164,487,733.50	$436,047,533.50

Table 4–63: Keystone Dam Break Impacts - Bixby Critical Facilities

ID	*Name*	*Address*
45	A Child's Dream Daycare	213 E. Stadium
25	After the Bell Student Center	13201 S. Memorial
50	Autumn Park Retirement	8401 E. 134th St.
30	Bank of Oklahoma	12052 S. Memorial
32	Bank of the West	11845 S. Memorial
6	Bixby City Hall	116 W. Needles
1	Bixby Community Center	211 N. Cabanis
4	Bixby Early Education Daycare – FBC	114 E. Breckenridge
7	Bixby Fire Station #1	116 W. Needles
29	Bixby Fire Station #2	8300 E. 121st St.
13	Bixby High School	601 S. Riverview
15	Bixby Maintenance Building	9501 E. 151st St.
10	Bixby Middle School	9401 E. 161st St.
39	Bixby North 5th and 6th Grade Center	501 S. Riverview
5	Bixby Police Dept.	116 W. Needles
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11	Central Elementary School	201 S. Main
46	Citizens Security Bank & Trust	14821 S. Memorial
14	Dawes Building City Offices	113 W. Dawes
37	DeStiny Learning Academy	13164 S. Memorial
42	ERgent Care of Green Country	11717 S. Memorial
28	Grand Bank	12345 S. Memorial Ste. 117
17	North Sewer Treatment	13700 S. Memorial
21	Playland Day Care Center	8510 E. 131st St.
18	South Sewer Treatment	9501 E. 151st St.
12	Southtown Nursing & Rehab.	76 W. Rachel St.
23	Storybrook Inn	210 S. Main St.
26	Tulsa Teachers Credit Union	13475 S. Memorial
27	Valley National Bank	13112 S. Memorial
43	Warren Clinic	11919 S. Memorial

ID	Name	Address
16	Water Dept. Maintenance Building	9575 E. 151st St.
22	YMCA	7910 E. 134th St.
47	YMCA Daycare – Wilson Building	13406 S. Memorial

4.14.5 Future Trends

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 community chooses. Various planning exercises offer possibilities for redefining local commitment to economic development, resource preservation, and hazard management along the river.

This analysis of future trends is drawn from 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 Bixby);
- Adopted Master Drainage Plans (currently in development);
- Tulsa County Vision 2025 plans and proposals (which include river-development projects such as low-water dams).

The riverfront future may hinge on how Bixby defines the term “development” along the river. The future may be very different if “development” in the Arkansas River floodplain is defined as building parks and recreation areas, rather than low-lying homes and businesses.

No additional control structures are currently planned that would reduce 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 citizens of the community decide to manage and use the floodplain lands in Bixby’s segment of the Arkansas Valley.

Figure 1-17 shows areas that may be considered future development areas.

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).

Structures/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. As a result, 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. Future vulnerability may hinge on whether leaders consider hazard management in expansion 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

Bixby is at High Risk of flooding from failure of the Keystone high-hazard dam. There would be 6,500 people, 3,014 improved properties, and 39 critical facilities exposed to damage if Keystone Dam failed or suffered a major forced release. However, the Corps of Engineers believes that the potential for failure is low because Keystone is operated by the Corps and is inspected at least once each year.

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.

People, property, critical facilities, and infrastructure downstream of dams could be subject to devastating danger and damage in the event of failure. The most important factor for public safety is the timeliness of warnings given to vulnerable populations, and the amount and effectiveness of pre-event public education and planning. Dams and levees often convey a false sense of security, by allowing people to think they will always be protected. As a result, dam and levee safety is not usually high in the public consciousness. The recent failures of the New Orleans and the Mississippi River levees may serve to focus more attention on these risks.

The worst-case event, failure of Keystone Dam, could impact 3,014 parcels with improvements within the city limits of Bixby, create a severe risk for an estimated 6,500 people, cause an estimated $ 436 million in damage to an estimated 3,000 buildings including 39 critical facilities. In addition, it could produce widespread power outages, loss of transportation access to the community, and release of hazardous chemicals.

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 that would have a short warning time.

Update Changes

Identified significant changes made from the 2004 City of Bixby Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.14.7 Sources

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Maher, Walied (Oklahoma Water Resources Board). Telephone and email interviews June 2, 2008.

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Partners in Dam Safety, at Web address: www.damsafety.org/resources/?p=08f31c3e-78f8-491c-87b8-09f4d5652692 . FEMA, National Dam Safety Program, Dam Safety Progress Through Partnerships.

Report on the Feasibility of Repair of the Tulsa and West Tulsa Local Protection Project. US Army Corps of Engineers, March 1991.

Rooftop to River: Tulsa's Approach to Floodplain and Stormwater Management, "Setting and History: Learning the Hard Way," p. 1–7 and at Web address: www.smartcommunities.ncat.org/articles/rooftop/index.shtml. City of Tulsa, 1994.

Water Management Analysis Report, Flood of September – October 1986, Northeastern Oklahoma and Southeastern Kansas. US Army Corps of Engineers Tulsa District, August 1987.

4.15 Transportation

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-disclosed quantity of pipelines. Each mode of transportation is used for 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.

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. 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.

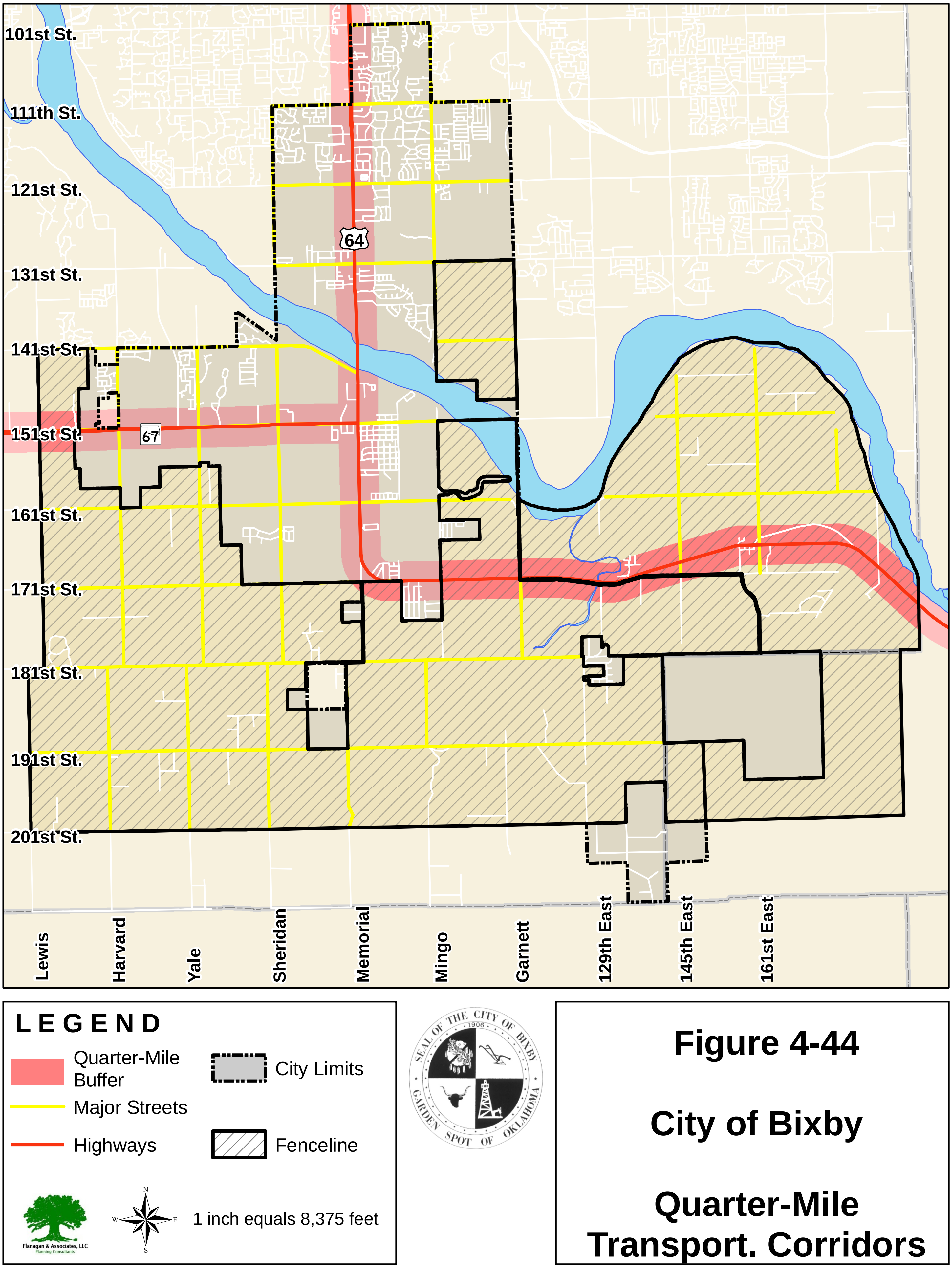


Figure 4-44

City of Bixby

Quarter-Mile Transport. Corridors

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.

Bixby is located at the intersection of Highway 67 and US Highway 64, both of which are travelled by commercial truckers with hazardous loads. The City has 12 miles of major highway within its jurisdiction.

Air: There are 8,228 certified air carrier aircrafts in the United States operated by 75 carriers of international, national and regional level. 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. There are two private airports in the Tulsa area, Richard Lloyd Jones (Riverside) Airport in Jenks, and Harvey Young Airport at 135th E. Ave. and S. 16th St.

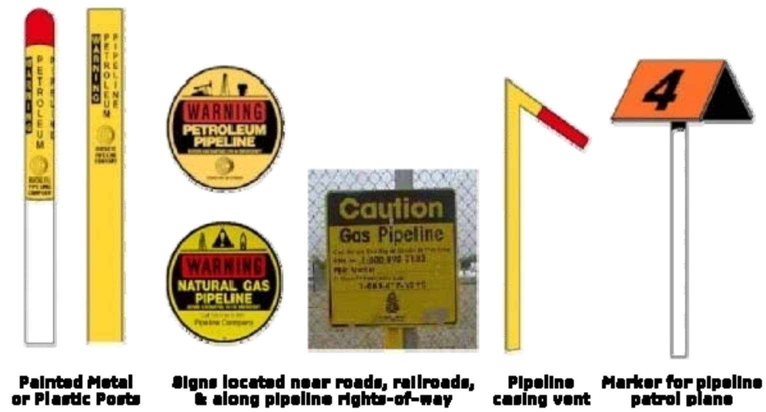
Rail: North American railroads operate over 173,000 miles of track, and earn $42 billion in annual revenues. U.S. freight railroads alone are the world’s busiest, moving 70% of all automobiles produced in the U.S. by train, 30% of the nation’s grain harvest, 65% of the nations coal and operating on over 143,000 miles of track. In the U.S., railroads account for more than 40% of all freight transportation.

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.

While the BNSF used to run a rail line through the City of Bixby, at the current time there are no working railroads in the area.

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 4–45: Pipeline Markers



Between 1989 and 2008, there were over 23,000 natural gas or oil pipeline accidents in the United States resulting in over 200 deaths. Most of the 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. (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 nine active pipeline operators within Bixby. Specific routes of pipelines and their operators within Bixby are not identified. For information on pipeline operators, see Table 4-64.

Table 4–64: Pipeline Operators in Bixby

Source: National Pipeline Mapping System (http://199.107.71.24/publicsearch/)

Pipeline Operator Name	Contact Address	Phone/Fax/Email
ConocoPhillips	1000 S. Pine St. Room 460-50st Ponca City, OK 74601	Ph: 580.767.7489 Fx: 580.767.5139 Email: Keith.H.Wooten@ConocoPhillips.com
Enogex Inc (Ex. Mustang Fuel Corp)	515 Central Park Dr., Ste. 600 Oklahoma City, OK 73105	Ph: 405.557.6804 Fx: 405.557.7908 Email: lillytc@oge.com
Explorer Pipeline	6846 S. Canton Ave. Ste. 300 Tulsa, OK 74136	Ph: 918.493.5103 Fx: 918.493.5162 Email: dhobart@expl.com

Pipeline Operator Name	Contact Address	Phone/Fax/Email
Oklahoma Natural Gas	P.O. Box 401 Oklahoma City, OK 73101	Ph: 405.551.6901 Fx: 405.552.1834 Email: bkenworthy@ong.com
OneOK Gas Transport, LLC	100 W. 5th Tulsa, Ok 74103	Ph: 918.588.7428 Email: lsiess@oneok.com
OneOK NGL Pipeline LP	P.O. Box 29 Medford, OK 73759	Ph: 580.395.6320 Fx: 580.395.2933 Email: mark.goodman@oneok.com
Scissortail Energy LLC	1307 S. Boulder Ste. 200 Tulsa, OK 74119	Ph: 918.588.5044 Fx: 918.588.5001 Email: jnelson@scissortailenergy.com
Abandoned	Contact information is currently not available for this operator.	
Magellan Pipeline, LP	Contact information is currently not available for this operator.	
Sold	Contact information is currently not available for this operator.	

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 explosion 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 4-65.

Air: According to a 1997 commodity flow study of hazardous materials; airlines represent 1.8% of hazardous material shipments in the United States. Bixby air transportation is currently supported by Tulsa International Airport, RL Jones Airport, and other commuter/business airfields located in other surrounding communities.

Rail: There are currently no rail lines operational within the City of Bixby's jurisdiction.

Pipeline: Between 1989 and 2008, pipelines experienced 2,100 accidents in Oklahoma, or an average of 105 per year.

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

The City of Bixby from U.S. Highway 64 and State Highway 67 has 18 miles of highway within the city limits – all of which carry volatile and toxic chemical products through the jurisdiction. The transportation corridor covers 15.81 square miles within Bixby, which is 43% of the total land area. Approximately, 4,264 residents, or 21% of the population of the community, live within the transportation corridor. In addition, 31 of Bixby's 51 critical facilities are within the corridor.

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.

The City of Bixby and Bixby Public Schools consider 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, and/or loss of life and/or major injuries.

Table 4–65: 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.	

Frequency

Bixby had one minor reported mobile hazardous materials event in the 20 years between 1989 and 2008 and 3 aircraft incidents involving private aircraft. In light of this experience, Bixby and Bixby Public Schools can expect less than one aviation accidents every five years, and very rare mobile hazardous materials events. However, with the amount of traffic on US Hwy 64 and Hwy 67, more significant incidents are quite possible.

Impact

The impact of transportation events may include lost revenue, highway disruptions, injuries and sometimes even loss of life. Transportation accidents are frequently a "cascade" disaster, occurring 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.

4.15.2 History/Previous Occurrences

Historic Transportation Events

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 barges on the navigation system can carry the equivalent load of 15 railcars or 80 semi-trucks. On June 4, 2002, the Federal Highway Administration committed an initial $3 million in emergency relief funds to aid in reconstruction.

Conoco Phillips Tank Fire, Glenpool, Oklahoma

The ConocoPhillips tank fire caused the evacuation of over 400 people in the 1.5 square miles directly south and east of the tank farm

On the evening of April 8, 2003, around 9:00 P.M., a Conoco Phillips holding tank exploded at a storage and transfer facility located east of United States Highway 75 near 131st Street and Elwood Avenue, north of downtown Glenpool. The tank, which contained diesel fuel, ignited after receiving a delivery of 8,400 barrels of diesel from a pipeline that branched off the Explorer Pipeline Company's 1,400-mile main pipeline that connects the Gulf Coast to the upper Midwest. The explosion was reportedly felt over 1½-miles away. 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 and appeared under control that night. The following morning, around 5:30 A.M., live power lines melted by the flames fell onto spilled fuel in the containment basin and re-ignited the blaze. Strong northerly winds helped destabilize and blow the blaze into contact with a second tank containing a petroleum product called naphtha, which subsequently did not explode. Environmental contamination of Coal Creek, which drains directly through the storage and transfer facility, was minimal due to a pre-existing containment levee around the tank involved. 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 storage and transfer facility and closed down U.S. 75 in both directions, when a strong north wind spread a thick black plume of smoke across the City of Glenpool and into parts of Okmulgee County. Glenpool Schools were closed as a precautionary measure. The fire burned for 25 hours.

Local non-profit organizations assisted by setting up shelters for evacuated people. Firefighters from Glenpool, Jenks and Tulsa responded to the event and were supplied with a foam truck from Sun Refinery. Equipment from Conoco Phillips headquarters in Houston, Texas, was also shipped to the scene. The National Transportation Safety Board concluded that static electricity in a fuel line ignited the fire.

U.S. 75 Hazardous materials (Hydrogen) Spill near Ramona, Oklahoma

In May of 2001, a tanker truck carrying 10 cylinders of hydrogen gas was pushed off the road when a vehicle traveling along side the tanker lost control and forced both vehicles into a roadside ditch. The collision broke a seal on one of the cylinders causing an initial explosion and a 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, which due to high winds cascaded to a grass fire. Emergency management remained on the scene until all of the ten leaking cylinders were emptied with the 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 for the duration of the response and rural water districts in the area were contacted to help to maintain a consistent and necessary supply of water for the fire fighters.

Explorer Pipeline Tank Fire, Glenpool Oklahoma

Explorer Pipeline tank fire

On June 18, 2006, just after 9 A.M., the Explorer Pipeline tank farm experienced a similar blaze when lightning struck a tank containing over 5 million gallons of unleaded gasoline. Explorer Pipeline is also in the 131st & Elwood area, east of Highway 75, southwest of the City of Tulsa. A mandatory evacuation for the area was ordered due to smoke and fumes which, over the course of the next 11 hours, continued to switch direction as the wind shifted. Over 800,000 gallons of fuel was lost, but the loss would have been far greater as the company was able to salvage over 4.3 millions gallons, pumping it out from under the area of the tank that was burning. The firefighters were able to keep adjacent tanks from being affected, which reduced the catastrophic effect of the blaze, unlike the 2003 fire. Responders were prepared to dam adjacent Coal Creek with sand in order to avoid runoff from foam and petroleum. Five families in the area evacuated their homes 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, Texas.

The City of Bixby Transportation Events

According to the National Response Center, during the period from 1989 to 2008, there was one reported incident of mobile or pipeline hazardous materials events in the City of Bixby. This involved a minor spill from a refueling tanker at a local convenience store.

According to the NTSB database, the City of Bixby has had 3 airplane accidents in the last 10 years, resulting in 1 fatality.

Probability/Future Events

With one event recorded within the City of Bixby in the past 10-year period, and none of those producing reported casualties, it is apparent that transportation events involving hazardous materials or significant public or economic impacts are not common to Bixby.

Bixby and Bixby Public Schools have a moderate probability of a future transportation event.

4.15.3 Vulnerability

This section summarizes information about Bixby's vulnerability to transportation incidents, including the impact on people, structures and buildings, critical facilities, and infrastructure. This information, as well as information provided by the City and Public Schools, was used to determine the Impact Criteria identified in Tables 4-2 and 4-3. The City of Bixby and Bixby Public Schools were determined to have a Low Risk to the Transportation hazard (See Table 4-2 Hazard Risk Analysis, and Table 4-3, Summary of Hazard Risk Analysis Ranking Criteria for an explanation of how the rankings were derived.)

Communities close to highway, railroad, pipeline, air and water transportation systems are at risk from transportation accidents and possible subsequent hazardous material events.

Population

The City of Bixby has approximately 12 miles of United States and State highways within its boundaries. A ¼ mile buffer was placed around these transportation features, as shown in Figure 4-46, to identify vulnerable populations.

Table 4–66: Transportation Corridor Statistics

Name	Town Area (sq. mi)	Buffer Area (sq. mi)	% of Town Area	Total Pop.	Pop. In Buffer	% of Pop. In Buffer
Highways	25.5	10.93	43	20,091	4,264	21

Approximately 21% (4,264) of the City's population lives within the corridor. In addition, the transportation corridor (highways) covers a total of approximately 15.81 square miles.

Structures/Buildings

While there are 1,336 buildings within the transportation corridors, structure damage is unusual from a Transportation event; therefore this is not considered a significant vulnerability.

Critical Facilities

A ¼ mile buffer was placed around transportation features, as shown in Figure 4-46, to identify critical facilities. Thirty-one (61%), listed in Table 4-67, of the fifty-one critical facilities in Bixby are located within the corridor. The City of Bixby and Bixby Public Schools critical facilities have high vulnerability to transportation hazards.

Table 4–67: Bixby Critical Facilities in Transportation Corridors

ID	*Name*	*Address*
25	After the Bell Student Center	13201 S. Memorial
33	Arvest Bank	11709 S. Memorial
50	Autumn Park Retirement	8401 E. 134th St.
40	BancFirst	10275 S. Memorial
30	Bank of Oklahoma	12052 S. Memorial
32	Bank of the West	11845 S. Memorial
6	Bixby City Hall	116 W. Needles
1	Bixby Community Center	211 N. Cabanis
7	Bixby Fire Station #1	116 W. Needles
29	Bixby Fire Station #2	8300 E. 121st St.
5	Bixby Police Dept.	116 W. Needles
8	Bixby Public Library	20 E. Breckenridge
2	Bixby Public Schools Administration Building	109 N. Armstrong
3	Bixby USPS	16 S. A Ave.
46	Citizens Security Bank & Trust	14821 S. Memorial
48	Citizens Security Bank	11402 S. Memorial
14	Dawes Building City Offices	113 W. Dawes
37	DeStiny Learning Academy	13164 S. Memorial
42	ERgent Care of Green Country	11717 S. Memorial
28	Grand Bank	12345 S. Memorial
31	IBC Bank	11886 S. Memorial
34	MidFirst Bank	11122 S. Memorial
35	Primary Concepts Preschool	8180 E. 111th St.
12	Southtown Nursing & Rehab.	76 W. Rachel St.
26	Tulsa Teachers Credit Union	13475 S. Memorial
27	Valley National Bank	13112 S. Memorial
41	Warren Clinic	8414 E. 101st St.
43	Warren Clinic	11919 S. Memorial
36	Western Sun Federal Credit Union	8315 E. 111th St.
22	YMCA	7910 E. 134th St.
47	YMCA Daycare – Wilson Building	13406 S. Memorial

Infrastructure

Water Treatment – The most significant impact from a transportation event on water treatment facilities would be from loss of access due to their proximity to hazardous materials. Both of Tulsa's water treatment plants (which serve Bixby) would be vulnerable to this risk. Since these plants are widely separated geographically, it is unlikely that both plants would be affected by the same event.

Wastewater Treatment – Loss of access to the wastewater treatment plants serving Bixby would be the primary impact from a transportation event.

Utilities – The primary utility providers for Bixby's jurisdiction is AEP/PSO (electricity) and ONG (natural gas). **Electricity:** The service stations and substations for electrical service would be vulnerable to the risks from a transportation event, although since the majority of the substations are unmanned, the effect of loss of access would be low unless there were additional issues. **Gas:** The primary danger to the ONG infrastructure would be if damage to a pipeline affected the supply of natural gas.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – The primary threat would be the shutdown of major highways in the event of a transportation incident. In previous cases, highways have been shut down for hours at a time, disrupting both commuter and commercial traffic and creating lengthy delays in commutes and deliveries.

Emergency Services- Fire, Police and Medical Services are all at risk to a transportation incident. The release of hazardous materials as a result of a transportation incident could limit or eliminate access to affected areas. Medical Services (including treatment facilities) could be strained in responding to large numbers of casualties, whether real or psychological.

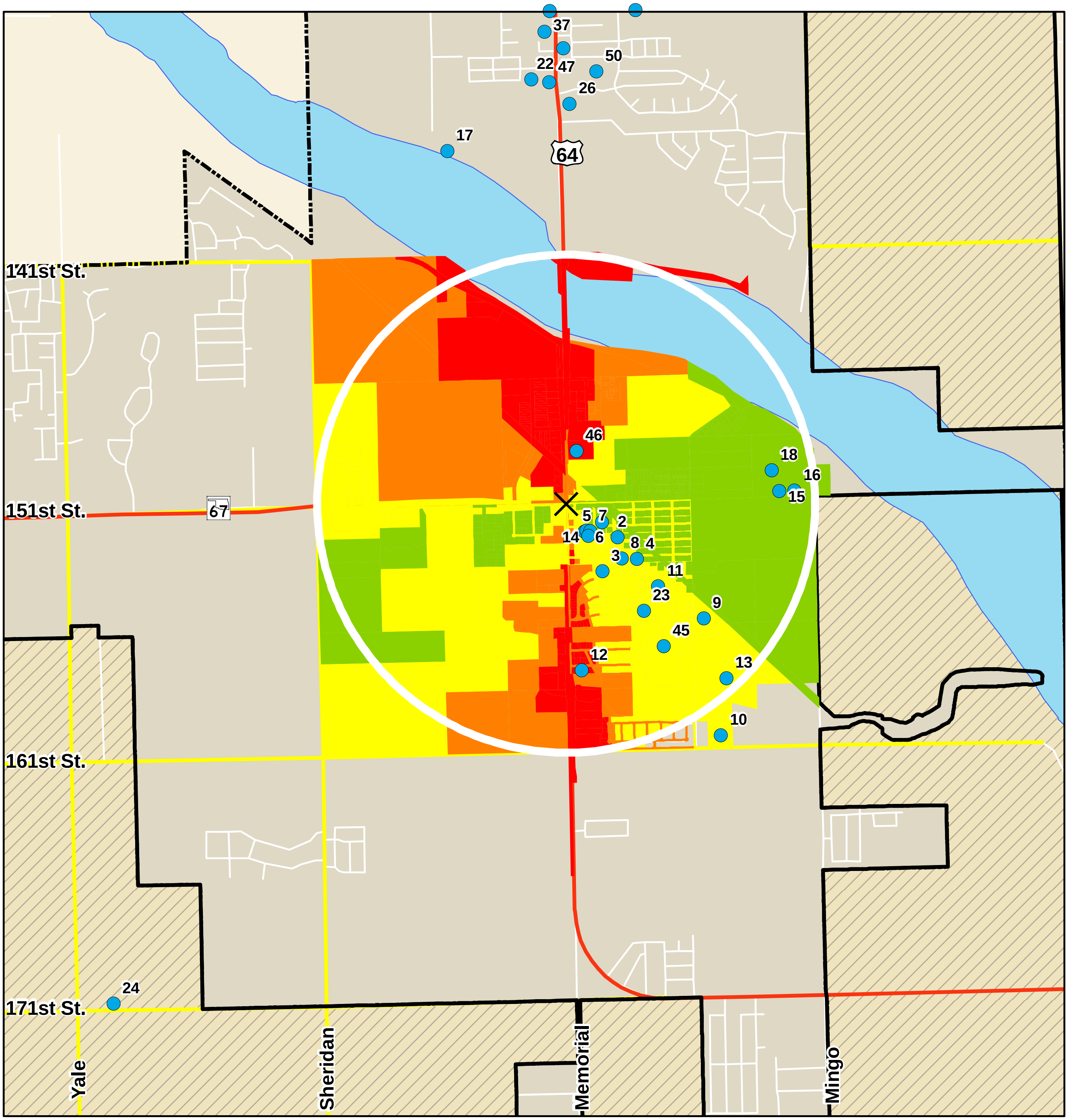
4.15.4 Transportation Scenario(s)

Scenario

The worst-case scenario for Bixby, given the type of traffic through the community, would likely be a highway tanker accident and spill of a toxic load, such as anhydrous ammonia.

To estimate the impacts from a tanker truck anhydrous ammonia accident, the potential area of impact from such an event (including standoff distances and potential need to evacuate areas) was overlain on a heavily populated area in Bixby. There are a total of 1,577 properties within the area impacted by the event. The danger from this type of event is primarily to people from the toxic nature of the material. Based on average wind directions and speed for Bixby, the chance of any type of structure being affected by the event was calculated and is displayed in Table 4-70. Four minor injuries were assumed for the event, none requiring hospitalization. The economic value of these injuries was estimated at $6,240, or $4.39 per affected resident.

The economic impacts of this hypothetical worst-case event are detailed on Table 4-68. In addition, expenses on infrastructure in the scenario are listed in Table 4-69.



LEGEND

Avg. %

- 0.01 - 3.5%
- 3.5 - 6.14%
- 6.14 - 9.5%
- 9.51 - 15.0%

- Major Streets
- Highways
- City Limits
- Fenceline

Flanagan & Associates, LLC
Planning Consultants

1 inch equals 3,000 feet

SEAL OF THE CITY OF BIXBY 1906 GARDEN SPOT OF OKLAHOMA

Figure 4-46

City of Bixby

Transportation Scenario

Table 4–68: Transportation Scenario Damages

Parcel Type	Number of Parcels	Average % Chance (Based on Wind History)
Residential	998	4.9%
Agricultural	17	6.46%
Commercial	110	6.17%
Industrial	62	7.2%
Vacant (Undeveloped Parcels)	214	6.4%
Special Populations / Government	176	5.3%
Total	1,577	5.2%

Table 4–69: City of Bixby Infrastructure Expenses from Transportation Scenario

Department	Expenses
Bixby Police Department	$735 (5 officers logging 25 overtime hours)
Bixby Fire Department	$1,323 (9 personnel logging 44 overtime hours) + $1,000 (equipment and materials)
Bixby Public Works	$99,400 (vegetation & drainage)
Street Maintenance	$104,720 (labor and equipment)
Traffic & Engineering	$3,115
Civilian or Responder Injuries	$6,240
TOTAL	**$216,533**

4.15.5 Future Trends

All potential development areas for the City are at risk based on their proximity to the previously defined transportation corridors.

Population

With greater and greater population density in the City of Bixby, greater efforts need to be made in the following areas:

- Upgraded warning and notification procedures for non-weather events, such as targeted calling systems like Reverse911 or Code Red;
- Resident education on procedures for sheltering in place vs. evacuating in the event of a hazardous materials incident, particularly for residents in identified risk areas;
- Creation of notification methods targeting people with sensory disabilities – individuals who are deaf, hard of hearing, blind, visually impaired, or deaf-blind.
- Upgrading the capabilities of local emergency responders to provide fast, effective intervention during hazmat events, including the ability to provide mass decontamination.

Structures/Buildings

In the past, the ability to effectively and quickly evacuate commercial buildings has often been an afterthought of the designers. It was often geared more toward an internal structure fire than to an external threat. With the development of new protocols and parameters for the effective, emergency movement of building occupants, new structures need to have this included in their design parameters from the project's inception. In addition, facility managers for structures with a large number of residents, both permanent and visiting, need to have effective shelter-in-place plans, especially if the structure is in one of the greater at-risk areas.

Critical Facilities

As the threat from the effects of transportation events themselves cannot be eliminated, so any critical facilities undergoing expansion, renovation or rebuilding should consider following updated techniques for such projects. Critical facilities should be designed with the ability to either shelter in place or evacuate quickly in the event of a hazardous materials incident.

Infrastructure

Ensuring a minimized effect on the delivery of utility service requires forethought and planning while in the development stage. Any plans for areas currently under development or consideration of development should include the provision for effective emergency access and staging for emergency vehicles and personnel.

4.15.6 Conclusions

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, where incidents usually result from ignorance or carelessness in using flammable or combustible materials.

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.

The majority of Bixby's Tier II sites and hazardous material events are related to the extraction and storage of hydrocarbons. One mobile hazardous material incident in the City of Bixby has been reported to the NRC from 1989 to 2008. This history coupled with a large number of reporting sites indicates the City of Bixby and Bixby Public Schools have a Low Risk of a transportation-related hazardous material event.

Data Limitations

In the National Response Center database, many reports come from a caller who only supplies preliminary information. Follow-up information, unless the event is significant, is usually not pursued, so data is frequently incomplete. A caller, for instance, may call in "unknown sheen" on a body of water in a community. If the material on the water's surface is gone before investigators arrive, the material may never be known. Location may be similarly vague if the caller is not familiar with the area and cannot give precise location of what they are reporting.

Update Changes

Identified significant changes made from the 2004 City of Bixby Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.15.7 Sources

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4.16 Hazard Composite

Most natural hazards- tornadoes, high winds, lightning, hail storms, winter storms, extreme heat, drought, and earthquakes- are not geographic area specific, and can impact the entire community equally and randomly.

Other natural hazards, such as floods, dam and levee failures, wild fires, and expansive soils, are geographic area specific, and the vulnerable areas of the community can be identified. The Hazard Composite map in Figure 4-47 identifies the areas of the City of Bixby that are vulnerable to geographic specific hazards.

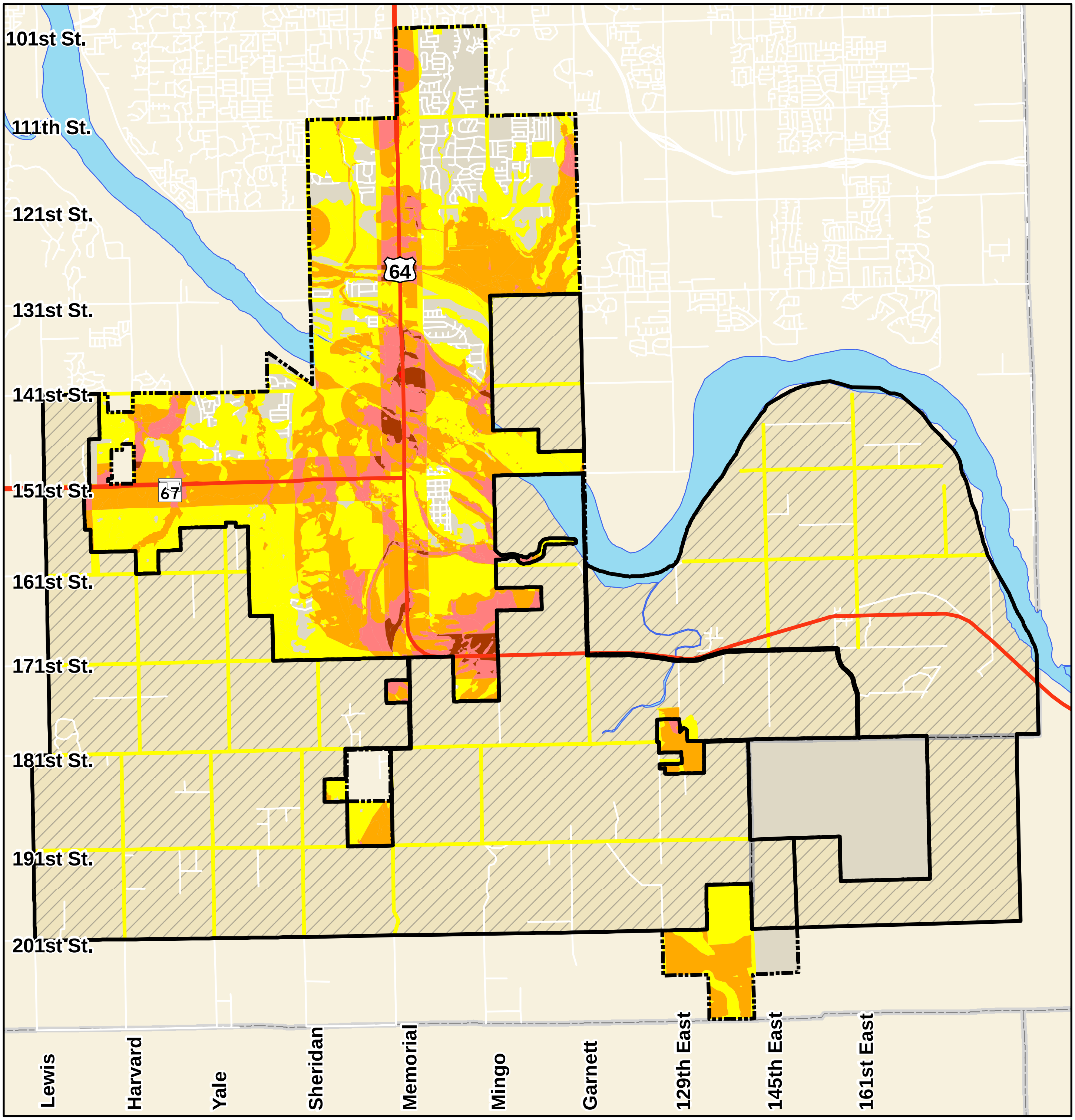


Figure 4-47

City of Bixby

Hazards Composite

Chapter 5: Mitigation Goals and Objectives

This chapter identifies the hazard mitigation goals set by the City of Bixby and Bixby Public Schools and discusses the mitigation projects, or measures, to be taken to achieve those goals.

The Research, Review, and Prioritization Process

Included in this Chapter:

The Hazard Mitigation Planning Committee (HMPC) and supporting staff identified and prioritized the measures that will help protect the lives and property of the residents of Bixby and Bixby Public Schools.

Initially, Goals from the 2004 City of Bixby Hazard Mitigation Plan were reviewed and evaluated by the Technical Advisory Committee based on both progress and actions taken based on the 2004 plan, and on development or review of other pertinent City of Bixby plans. Goals that were deemed to be effective and pertinent to the current plan were retained and incorporated into the 2010 plan update.

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 Bixby area.

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. Existing community plans were used wherever possible. Members of the Media were contacted and invited to attend all HMPC meetings.

Evaluation Category	Sources of Information
Technical	The following Persons/Agencies were consulted as to the technical feasibility of the various projects: Bixby City Council, Bixby Public Works Department, Oklahoma State University Extension Service, Soil Conservation Service, National Weather Service, the Corps of Engineers, County and State Health Departments, and Oklahoma Forestry Service. All of these had their comments and suggestions incorporated.
Administrative	Staffing for proper implementation of the plan currently relies on existing members of the various agencies involved. Technical assistance is available from contractors and various State Agencies. Some local jurisdictions have incorporated Hazard Mitigation efforts into their Capital Improvement Plans. The Hazard Mitigation Advisory Committee has agreed to an annual review and assessment of the Plan and its progress. Operations Costs are under discussion by the relevant department heads.
Political	A representative of the Bixby City Council and the Mayor or his representative attended the HMPC meetings and were consulted on all aspects of the Plan.
Legal	Members of the HMPC discussed legal issues with the City Council, 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. Reliance on outside grants will be relied on heavily for completion of some 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 and 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

Bixby's hazard mitigation planning process involves community residents in every phase

This chapter is organized by mitigation category, with the HMPC mitigation mission statement and goals listed first in section 5.1.

5.1 Hazard Mitigation Goals

5.1.1 Mission Statement

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

5.1.2 Mitigation Goal

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

5.1.3 Goals for All 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 injuries and loss of life; trauma; damage to property, equipment and infrastructure; community disruption; and economic, environmental, and other losses caused by floods and flash floods.***	
Objective 1.	**Public Information & Education.** Improve public awareness of flood and flash flood hazards in general and at specific high-risk locations; and give people knowledge about measures they can use to protect themselves, their property and their community.
Objective 2.	**Preventive Measures.** Expand mapping, regulations, and loss-prevention programs in areas with high risks and catastrophic potential, such as local portions of multi-jurisdictional riverine floodways and floodplains where additional safety considerations are warranted. Bixby does not have jurisdiction to regulate upstream and downstream runoff, blockages, or other actions that can affect resident safety.
Objective 3.	**Structural Projects.** Obtain funding for and implement projects that can reduce flood and drainage hazards, with consideration for comprehensive solutions in accord with watershed-wide management plans.
Objective 4.	**Property Protection.** Identify and protect people, structures, critical facilities, and critical infrastructure that are vulnerable to flood and flash flood hazards.
Objective 5.	**Emergency Services.** Identify the needs and implement additional emergency operations plans and services for areas at high risk of flooding, including additional prediction and forecasting capability, emergency alerts, and evacuation plans.
Objective 6.	**Natural Resource Protection.** Protect and enhance natural floodplain and stormwater resources by adopting and implementing sustainable flood-management policies that have few or no negative impacts and have positive environmental effects whenever possible.

Tornado	
GOAL: ***To reduce injuries and loss of life; trauma; damage to property, equipment and infrastructure; community disruption; and economic, environmental and other losses caused by tornadoes.***	
Objective 1.	**Public Information & Education.** Improve public awareness of tornado hazards, in general and in specific high-risk situations; and give people knowledge about measures they can use to protect themselves, their property, and their community.
Objective 2.	**Preventive Measures.** Prevent or reduce tornado losses by strengthening buildings and by publicizing, training, and creating market options for fortified new construction, retrofits, code changes and code-plus innovations.
Objective 3.	**Structural Projects.** Provide safe tornado shelters, SafeRooms, and fortified buildings for vulnerable populations, including children; offer training and incentives to encourage people of means to include shelters and SafeRooms in new and retrofit building projects.
Objective 4.	**Property Protection.** Identify and protect people, structures, and critical infrastructure that are vulnerable to tornado hazards, with emphasis on critical facilities.
Objective 5.	**Emergency Services.** Identify the needs for and implement additional emergency operations plans and services to expand tornado safety, including Community Emergency Response Team training.

Tornado	
Objective 6.	**Natural Resource Protection.** Take advantage of opportunities for tornado programs and policies that reduce negative environmental impacts. Examples include sustainable programs for debris management and recycling, and fortified construction with environmentally friendly materials.

High Wind	
GOAL: ***To reduce injuries and loss of life; trauma; damage to property, equipment and infrastructure; community disruption; and economic, environmental and other losses caused by high winds.***	
Objective 1.	**Public Information & Education.** Improve public awareness of high-wind hazards, in general and in specific high-risk situations; and give people knowledge about measures they can use to protect themselves, their property, and their community.
Objective 2.	**Preventive Measures**. Prevent or reduce high-wind losses by strengthening buildings and by publicizing, training, and creating market options for fortified new construction, retrofits, code changes and code-plus innovations.
Objective 3.	**Structural Projects.** Provide fortified buildings for critical public facilities and vulnerable populations, including children; offer training and incentives to encourage people of means to build stronger structures in new and retrofit building projects.
Objective 4.	**Property Protection.** Identify and protect people, structures, and critical infrastructure that are vulnerable to high winds, with emphasis on critical facilities.
Objective 5.	**Emergency Services.** Identify needs for and implement additional emergency operations plans and services to expand safety in dangerous windstorms, including Community Emergency Response Team training.
Objective 6.	**Natural Resource Protection.** Take advantage of opportunities for high-wind programs and policies that reduce negative environmental impacts. Examples include sustainable programs for debris management and recycling, and fortified construction with environmentally friendly materials.

Lightning	
GOAL: ***To reduce injuries, loss of life, and damage to property, equipment and infrastructure caused by Lightning strikes.***	
Objective 1.	**Public Information & Education.** Improve public awareness of Lightning hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	**Preventive Measures.** Identify the costs and the benefits of loss-prevention programs, such as whole building surge protection, with consideration for uncalculated benefits such as data or work productivity loss.
Objective 3.	**Structural Projects**. Provide for necessary construction, renovation, retrofitting or refurbishment of city infrastructure to protect vulnerable populations from the effects of lightning strikes.
Objective 4.	**Property Protection**. Identify ways to protect structures, infrastructure, and critical facilities and their occupants from damage caused by lightning strikes.
Objective 5.	**Emergency Services**. Establish or expand emergency services protocols that adequately address response scenarios in the event of incidents with the possibility of severe lightning.

Lightning	
Objective 6.	**Natural Resource Protection**. Ensure that lightning damage mitigation policies have no negative impacts and, whenever possible, provide positive enhancements to the environment.

Hail	
GOAL: ***To reduce the high costs of property and infrastructure damage caused by Hailstorms.***	
Objective 1.	**Public Information and Education.** Improve public awareness of Hailstorm hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	**Preventive Measures**. Identify the costs and the benefits of loss-prevention ordinances, such as building codes, with consideration for uncalculated benefits such as employee downtime or loss of city services.
Objective 3.	**Structural Projects**. Identify costs and benefits of loss-prevention programs, such as covered vehicle parking, with consideration for uncalculated benefits such as averting response delays and business losses.
Objective 4.	**Property Protection.** Identify, fund, and implement projects to protect people and public and private property from losses in hail events, including critical infrastructure such as utilities or public vehicles.
Objective 5.	**Emergency Services**. Establish or expand emergency services protocols that adequately address response scenarios in the event of severe hail events.
Objective 6.	**Natural Resource Protection**. Ensure that Hail mitigation policies have no negative impacts and, whenever possible, provide positive enhancements to the environment. Encourage homeowners, for example, to use Class 4 roofing made of recycled materials.

Winter Storms	
GOAL: ***To reduce injuries and loss of life; trauma; loss of critical utilities; damage to property, equipment and infrastructure; community disruption; and economic, environmental and other losses caused by winter storms. Winter hazards can include extreme temperatures, ice and snow, high winds, and cascading hazards such as loss of utilities.***	
Objective 1.	**Public Information & Education.** Improve public awareness of winter storm hazards and give people knowledge about measures they can use to protect themselves, their property and their community.
Objective 2.	**Preventive Measures.** Identify costs and the benefits of loss-prevention programs such as burying power lines to reduce utility outages or building snow-load roofs, with consideration for uncalculated benefits such as averting environmental and business losses.
Objective 3.	**Structural Projects.** Identify, fund, and implement measures, such as winterization retrofits to homes, critical facilities, transportation systems and infrastructure, to avert or reduce losses from winter storms. Provide additional protection, such as generators and emergency shelters, for agencies and facilities that serve vulnerable populations.
Objective 4.	**Property Protection.** Identify, fund, and implement projects to protect people and public and private property from losses in winter storms.

Winter Storms	
Objective 5.	**Emergency Services.** Identify and expand emergency services for people who are at high risk in winter storms, such as the homeless, elderly, disabled, and oxygen-dependent people.
Objective 6.	**Natural Resource Protection.** Evaluate options and take advantage of opportunities for sustainable winter-storm policies and programs to reduce negative environmental impacts; examples include programs for debris management, streets snow removal, tree trimming and replacement, energy conservation, and winterization.

Heat	
GOAL: ***To reduce heat-related illnesses, loss of life, and exacerbation of other hazards such as drought and expansive soils caused by extreme Heat conditions.***	
Objective 1.	**Public Information and Education.** Improve public awareness of extreme heat hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	**Preventive Measures.** Identify and protect people and critical infrastructure that are vulnerable to extreme heat conditions.
Objective 3.	**Structural Projects.** Provide for necessary construction, renovation, retrofitting or refurbishment of city properties to protect vulnerable populations from the effects of extreme heat.
Objective 4.	**Property Protection.** Implement construction and retrofitting measures to minimize the risk to public properties and their occupants caused by extreme heat.
Objective 5.	**Emergency Services.** Ensure that the Tulsa County Heat Emergency Action Plan is followed and that heat alerts are issued in a timely manner. Establish or expand emergency services protocols that adequately address response scenarios in the event of extreme heat.
Objective 6.	**Natural Resources Protection.** Ensure that extreme Heat mitigation policies have no negative impacts and, whenever possible, provide positive enhancements to the environment, such as the creation and development of urban green spaces.

Drought	
GOAL: ***To reduce the impact of Drought on property, infrastructure, natural resources and local government response functions.***	
Objective 1.	**Public Information and Education.** Improve public awareness of Drought and measures by which people can protect themselves, their property, and their community.
Objective 2.	**Preventive Measures.** Identify and protect resources and critical infrastructure that are vulnerable to Drought.
Objective 3.	**Structural Projects.** Provide for necessary construction, renovation, retrofitting or refurbishment to protect vulnerable structures from the effects of drought.
Objective 4.	**Property Protection.** Implement measures to minimize the risk to public property caused by drought events.
Objective 5.	**Emergency Services.** Establish or expand emergency services protocols that adequately address response scenarios in the event of drought.

Drought	
Objective 6.	**Natural Resource Protection.** 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 and economic losses caused by expansive soils on property and local infrastructure.	
Objective 1.	**Public Information & Education.** Improve public awareness of expansive-soil hazards, with both general and site-specific information, and provide knowledge about available measures by which people can protect their property and their community.
Objective 2.	**Preventive Measures.** Avoid expansive-soils locations, whenever possible. Explore options for loss-mitigation from expansive soils, including building codes and code-plus options. Examine expansive soils before building critical facilities and infrastructure.
Objective 3.	**Structural Projects.** Identify and implement measures to reduce or avert expansive-soils damages and losses to structures and infrastructure, with emphasis on critical facilities and utilities.
Objective 4.	**Property Protection.** Identify and protect resources and critical infrastructure that are vulnerable to expansive soils.
Objective 5.	**Emergency Services.** Survey emergency and critical facilities for potential expansive-soil problems; repair and retrofit as needed; and consider soils when building emergency facilities.
Objective 6.	**Natural Resource Protection.** Protect and enhance natural resources by adopting and implementing sustainable expansive-soils policies that have few or no negative impacts and have positive environmental effects whenever possible.

Wildfire	
GOAL: ***To reduce injuries, loss of life, and damage to property, equipment and infrastructure caused by Wildfires.***	
Objective 1.	**Public Information & Education.** Improve public awareness of Wildfire hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	**Preventive Measures.** Identify and protect populations, structures, and critical infrastructure that are vulnerable to Wildfires.
Objective 3.	**Structural Projects**. Include wildfire considerations in landscaping, public park, and other properties that would fall into wildland-urban interface or other areas of wildfire risk. Include infrastructure improvements that support effective firefighting.
Objective 4.	**Property Protection**. Implement building materials and techniques in retrofitting or in new construction to minimize the risk to public property caused by wildfires.
Objective 5.	**Emergency Services**. Establish or expand emergency services protocols that adequately address response scenarios in wildfire events.
Objective 6.	**Natural Resource Protection.** Ensure that Wildfire mitigation policies have no negative impacts and, whenever possible, provide positive enhancements to the environment.

Earthquake	
GOAL: ***To reduce injury, loss of life, and damage to property, equipment and infrastructure caused by Earthquakes.***	
Objective 1.	**Public Information and Education.** Improve public awareness of earthquake hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	**Preventive Measures.** Identify and protect populations, structures, and critical infrastructure that are vulnerable to earthquakes.
Objective 3.	**Structural Projects.** Provide for necessary construction, renovation, retrofitting or refurbishment to protect vulnerable structures from the effects of earthquakes.
Objective 4.	**Property Protection.** Implement building materials and techniques in retrofitting or in new construction to minimize the risk to public properties and their occupants caused by earthquakes.
Objective 5.	**Emergency Services.** Establish emergency services protocols that adequately address response scenarios in the event of earthquake.
Objective 6.	**Natural Resource Protection.** Take advantage of opportunities for earthquake programs and policies that reduce negative environmental impacts. Examples include sustainable programs for debris management and recycling, and fortified construction with environmentally friendly materials.

Dam and Levee Break	
GOAL: ***To reduce injuries and loss of life; trauma; damage to property, equipment, critical facilities, and infrastructure; community disruption; and economic, environmental, and other losses caused by partial or total dam and levee failures.***	
Objective 1.	**Public information & education**. Improve public awareness of dam break hazards, in general and at specific high-risk locations; and give people knowledge about measures they can use to protect themselves, their property, and their community.
Objective 2.	**Preventive measures.** Expand mapping, regulations, and loss-prevention programs in areas with high risks, including extension of flood insurance regulations; updated risk mapping downstream of high-risk dams; and pre-disaster evacuation and hazard-mitigation programs.
Objective 3.	**Structural projects.** Analyze safety of existing high-risk dams, including maintenance programs and funding; and implement highest-priority measures to strengthen the structures and reduce risks.
Objective 4.	**Property protection measures.** Identify and protect people, structures, critical facilities, and critical infrastructure that are vulnerable to dam break hazards.
Objective 5.	**Emergency services.** Identify needs for and implement additional emergency operations plans and services in areas at high risk from dam breaks, including additional prediction and forecasting capability, emergency alerts, and evacuation plans.
Objective 6.	**Natural resource protection.** Protect and enhance natural resources by adopting and implementing sustainable dam break policies that have few or no negative impacts and have positive environmental effects whenever possible. Include analysis of downstream impacts on environment and wildlife in planning.

Chapter 6: Action Plan

The City of Bixby and Bixby Public Schools have reviewed and analyzed the risk assessment studies for the natural hazards and hazardous material events that may impact their communities. The Bixby Hazard Mitigation Technical and Citizens' Advisory Committees prioritized the mitigation measures, and developed an Action Plan for the highest priority measures. This chapter identifies specific high priority actions to achieve the City's and the Bixby School'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. It also lists the Prioritized Mitigation Measures for each hazard in the Public Information and Education, Preventive Measures, Structural Projects, Property Protection, Emergency Services, and Natural Resource Protection categories.

Included in this Chapter:

Table 6–1: High Priority Measures per Hazard

Hazard	Measures Addressing	Hazard	Measures Addressing
Tornadoes	19	High Winds	19
Winter Storms	19	Lightning	14
Earthquakes	14	Floods	10
Extreme Heat	9	Hazardous Materials	6
Hail	5	Dam Failures	5
Urban Fires	5	Wildfires	5
Transportation Hazards	4	Drought	3
Expansive Soils	3		

Recommended High Priority 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: Public Works

Time Schedule: 2010-ongoing

Estimated Cost: $875,600

Facility	Staff	Size x 6 sq. ft.	Cost x $200/ sq. ft.
Emerg. Opns. Cntr.		1,600	320,000
9-1-1 Dispatching		1,500	300,000
Maintenance Facility	10	60	12,000
Totals	**243**	**4,378**	**$875,600**

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. Install Safe-Rooms in Schools.

Lead: Superintendent, Bixby Public Schools

Time Schedule: 2010-ongoing

Estimated Cost: $4,723,125 (see below)

School	Staff	Students	Total	Size, Sq. Ft.	Cost
Administration	20	-	20	100	$ 16,500
Bixby North (PK-03)	48	990	1,038	5,190	856,350
Bixby North (4,5,6)	26	616	642	3,210	529,650
Brassfield (5&6)	21	306	327	1,635	269,775
Central Elem. (PK-04)	48	892	940	4,700	775,500
New N E (PK-06)	44	600	644	3,220	531,300
Bixby Middle School	47	680	727	3,635	599,775
Bixby High School	84	1,303	1,387	6,935	1,144,275
Totals	**338**	**5,387**	**5,725**	**28,625**	**$4,723,125**

Source of Funding: Local/General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: Safe Rooms in, or in close proximity to all Public School buildings, to provide safe shelter for staff and students in the event of High Winds, Tornadoes, and Earthquakes.

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 regulatory ordinances.**

Lead: City Manager, Chief 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: 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 an ordinance requiring that all safe rooms comply with the ICC/NSSA standard.

Resource: Appendix B.3.1 Safe Rooms

Floods, Tornadoes, High Winds, Severe Winter Storms, Extreme Heat, Drought, Urban Fires, Wildfires, Earthquakes, Fixed Site Hazardous Materials Events, Dam Failures, Transportation Events

4. **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: Emergency Management

Time Schedule: 2010-2012

Estimated Cost: 8,298 addresses X $1.91 per address per year = $15,850, (1 Year Start-up + 1 year operation = $31,700.

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 and delivering specific emergency/hazard messages to the occupants.

Floods, Tornadoes, High Winds, Hail, Severe Winter Storms, Earthquakes

5. **Develop / Review / Update the Bixby Debris Management Plan.**

Lead: City Manager/Public Works

Time Schedule: 2010-2012

Estimated Cost: $ 8,500

Source of Funding: Local Budget

Work Product/Expected Outcome: 1) Identify locations clean up crews can deposit debris before a final disposal. Public safety and efficiency in relocating debris piles should be considered; 2) Assess priorities for clearing routes involving critical structures or facilities.3) Purchase tub grinder for areas serviced by Bixby Landfill.

Resource: Appendix B.5.10 Debris Management

Tornadoes, High Winds

6. **Provide employee shelters/safe-rooms at critical facilities, such as 911 Center, fire stations and police stations to protect first responders.**

Lead: City Manager/Emergency Management/City Engineer

Time Schedule: 2010-1015

Estimated Cost: $450,000

Source of Funding: HMGP, PDM, Local Share

Work Product/Expected Outcome: Construction of shelters or safe rooms with the intent of protecting first responders from tornadoes and high winds.

Lightning

7. **Provide lightning warning systems for City of Bixby public outdoor sports areas, pools, golf courses, and parks.**

Lead: Parks Department/Emergency Management

Time Schedule: 2010-2012

Estimated Cost: $52,000

Source of Funding: Local, FEMA HMGP and PDM

Work Product/Expected Outcome: Lightning sensing and warning systems for Bixby's parks, and golf courses.

Resource: Appendix B.2.10 Lightning Warning Systems

Lightning

8. **Provide lightning warning systems for Bixby Public Schools outdoor sports areas and play grounds.**

Lead: Parks Department/Emergency Management

Time Schedule: 2010 - Ongoing

Estimated Cost: $36,000

Source of Funding: Local, FEMA HMGP and PDM

Work Product/Expected Outcome: Lightning sensing and warning systems for Bixby's parks, golf courses, and schools.

Resource: Appendix B.2.10 Lightning Warning Systems

Extreme Heat

9. Develop a Heat Emergency Action Plan/Heat Emergency Annex to the Emergency Operations Plan for the jurisdiction.

Lead: Emergency Management

Time Schedule: 2010 - 2011

Estimated Cost: To be determined

Source of Funding: Local and FEMA HMGP/PDM.

Work Product/Expected Outcome: Minimize the loss of life due to the extreme heat of summer months in Oklahoma.

Expansive Soils

10. Establish an administrative procedure or change in City codes that require builders to check for expansive soils when applying for new residential construction permits, and to consider the use of foundations that mitigate expansive soil damages when in a moderate to high-risk area.

Lead: City Manager

Time Schedule: 2010

Estimated Cost: Minimal

Source of Funding: Local/General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: Adoption of an ordinance, administrative procedure or City code that requires builders to check for expansive soils when applying for new residential building permits, and to consider the use of foundations that mitigate expansive soil damage in moderate to high-risk areas.

Resources: Appendix B.2.6 IBHS Fortified Homes program

Floods

11. 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.

Lead: Department of Public Works

Time Schedule: 2010-2015

Estimated Cost: $450,000

Source of Funding: Local Funds, FEMA HMGP/PDM

Work Product/Expected Outcome: A comprehensive Flood & Drainage Annex to the Hazard Mitigation Plan for all watersheds within the community that identifies flooding problems and provides guidance for cost-effective and politically acceptable actions to correct the problems, and to address future development impacts and appropriate mitigation measures.

Resource: Appendix B.2.1

Floods

12. 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.

Lead: Public Works

Time Schedule: Ongoing

Estimated Cost: To be determined

Source of Funding: Local Funds and FEMA HMGP/PDM

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.

Floods, Dam Failure

13. Continue Compliance with, and Participation in the National Flood Insurance Program (NFIP) and the Community Rating System (CRS).

Lead: City Manager/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).

Resource: Appendix B.4.2 Insurance

Tornadoes, High Winds, Flooding, Dam Failure, Hazardous Materials

14. Evaluate, upgrade and maintain community-wide outdoor omni-directional voice/siren warning systems.

Lead: Emergency Management

Time Schedule: 2010 - Ongoing

Estimated Cost: $75,000

Source of Funding: Local and FEMA HMGP/PDM.

Work Product/Expected Outcome: 1) Identify locations were warning siren coverage is less than adequate; 2) Routinely test sirens for operational adequacy and maintenance/system required updates, and 3) Upgrade 3 existing sirens with modern multi functional capabilities.

Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat

15. **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 emergency generator needs, costs of installation for pads/transfer panels only, or for complete generator assembly installation.**

Lead: Emergency Management

Time Schedule: 2010

Estimated Cost: $8,500

Source of Funding: Local Funds and FEMA HMGP, and PDM.

Work Product/Expected Outcome: An Emergency Back-up Generator Hazard Mitigation Plan Annex that inventories Bixby Critical Facilities, including City Hall, Police Station, Public Works, Bixby EMS, Parkland Nursing Home, Early Childhood Center, Community Emergency Shelter; sets priorities, evaluates current electrical usage, emergency electrical load/needs, fuel sources (natural gas/diesel/propane), pad location, wiring, transfer switches, contract or on-site, and generator type and size.

Resource: Appendix B.2.12 Back-Up Generators

Floods, Tornadoes, High Winds, Lightning, Severe Winter Storms, Urban Fires, Wildfires, Earthquakes, Fixed Site Hazardous Materials Events

16. **Based on the results of the Emergency Back-up Generator Hazard Mitigation Plan Annex, provide wiring and transfer switches to accommodate emergency generators during disaster power outages for critical facilities including Emergency Operations Centers, City Hall, Dispatch, Police, Fire, Community Centers used for emergency housing during disasters, critical facilities, lift stations, water treatment plants, and community medical facilities.**

Lead: Department of Public Works

Time Schedule: 2010-Ongoing

Estimated Cost: Costs to be determined based on findings of the Emergency Back-up Generator Hazard Mitigation Plan Annex.

Source of Funding: Local/General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: Adequate pre-installed wiring and required automatic transfer switches in Critical Facilities that will accommodate emergency generators during power outages in a disaster.

Resource: Appendix B.2.12 Back-Up Generators

Tornadoes, High Winds, Lightning, Severe Winter Storms

17. Obtain emergency generators for continuity of government/use during disaster power outages for critical facilities including Emergency Operations Centers, City Hall, Dispatch, Police, Fire, Community Centers used for emergency housing during disasters, critical facilities, lift stations, water treatment plants, and community medical facilities, as identified in the Emergency Back-up Generator Hazard Mitigation Plan Annex.

Lead: Department of Public Works

Time Schedule: 2010-Ongoing

Estimated Cost: To be determined

Sources of Funding: Local, FEMA HMGP/PDM

Work Products/Expected Outcome: This will provide sufficient generators or access to generators during a disaster that will provide sufficient power for critical community functions. This will aid in the recovery and response effort after a disaster.

Resource: Appendix B.2.12 Back-Up Generators

Tornadoes, High Winds, Lightning, Severe Winter Storms

18. Obtain generator for the booster pump

Lead: Department of Public Works

Time Schedule: 2010-2011

Estimated Cost: $35,000

Sources of Funding: Local, FEMA HMGP/PDM

Work Products/Expected Outcome: This will provide a generator to enable continued operations during a disaster.

Tornadoes, High Winds, Lightning, Severe Winter Storms

19. Obtain emergency generators for 23-26 lift stations

Lead: Department of Public Works

Time Schedule: 2010 -2015

Estimated Cost: To be determined based on the Emergency Back-up Generator Hazard Mitigation Plan Annex.

Sources of Funding: Local, FEMA HMGP/PDM

Work Products/Expected Outcome: This will provide emergency power to the lift stations to minimize sanitation sewer backup in the event of power failure.

Severe Winter Storms, Tornadoes, High Winds

20. Provide routine trimming of trees to reduce power outages during storms.

Lead: City Manager/ Public Works Director

Time Schedule: On going

Estimated Cost: Undetermined

Source of Funding: Local/General budget, local Utility Providers.

Work Product/Expected Outcome: The City of Bixby will inspect main power lines and feeder lines to the individual building Weatherheads, and provide routine trimming of overhanging trees to reduce power outages during Tornadoes, High Winds, and Severe Winter and Ice Storms.

Resource: Appendix B.2.11 Power Outages from Winter Storms

Floods, Tornadoes, High Winds Lightning, Hail, Severe Winter Storms, Extreme Heat, Drought, Expansive Soils, Urban Fires, Wildfires, Earthquakes, Fixed Site Hazardous Materials Events, Transportation Events

21. Develop an All-Hazard Public Information, Education, and Awareness Program.

Lead: Emergency Management

Time Schedule: 2010-2015

Estimated Cost: $ 14,250

Source of Funding: Local/General budget, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: An All-Hazards Public Information and Education Strategy to inform the public of the imminent natural and man-made hazards, and actions the public can take to protect themselves and their property from damage and destruction, and themselves from injury and death.

Resource: Appendix B.1.1 Public Information Program Strategy

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

22. 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.

Lead: Emergency Manager

Time Schedule: 2010- On going

Estimated Cost: $ 750

Source of Funding: Local/General budget, State Emergency Management, Red Cross, Federal Emergency Management Agency (FEMA) PDM and/or HMGP.

Work Product/Expected Outcome: Informational kiosks and display racks easily available to the public that contain brochures and materials on various natural and man-made hazards, and how citizens can prepare for, mitigate, respond to, and recover from disasters.

Resource: Appendix B.1.3 Outreach Projects

Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat, Earthquakes

23. Identify and encourage Private Critical Facilities (Financial Institutions, Elder 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: City Manager

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.

Resource: Appendix B.2.12 Back-Up Generators

Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat, Earthquakes

24. 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: City Manager

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.

Resource: Appendix B.2.12 Back-Up Generators

Tornadoes, High Winds, Hail, Earthquakes

25. When replaced, install Break/Shatter Resistant Glass in Schools.

Lead: Superintendent, Bixby Public Schools

Time Schedule: 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: Impact-, break- and shatter-resistant windows and frames in schools and administrative buildings that protect staff, teachers, and students from broken glass and projectiles resulting from tornadoes, high winds, and earthquakes.

Resource: Appendix B.4.7 Impact resistant Windows & Doors

Lightning

26. Provide surge and lightning protection for computer-reliant critical facilities (e.g. City Hall, 911 Center, EOC, Police and Fire stations, water/wastewater treatment plant and public works buildings).

Lead: City Manager

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.

Resource: Appendix B.4.9 Lightning Protection Systems; B.4.10 Surge Protection

Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat, Earthquakes

27. 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: City Manager

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.

Resource: Appendix B.5.8 Mutual Aid/Inter Agency Agreements

Hail

28. Provide covered shelters for City First Response/government vehicles to protect against hail damage.

Lead: City Manager

Time Schedule: 2010 - 2012

Estimated Cost: To be determined

Source of Funding: Local, HMGP, PDM

Work Product/Expected Outcome: Covered parking to provide protection against Hail Damage for emergency/critical vehicles (government, Police, Fire, ambulance, etc.), so that emergency and First Responder/City personnel can meet the needs of the community in times of emergency.

Table 6-2: Prioritized Mitigation Measures for Bixby

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	Structural Projects	Install safe-rooms in schools.
3	Tornadoes, High Winds, Earthquakes	Preventive Measures	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 regulatory ordinances
4	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.
5	Floods, Tornadoes, High Winds, Hail, Severe Winter Storms, Earthquakes	Preventive Measures	Develop / Review / Update the debris management plan.
6	Tornadoes, High Winds, Earthquakes	Structural Projects	Provide employee shelters/safe-rooms at critical facilities, such as 911 Center, fire stations and police stations to protect first responders.
7	Lightning	Preventive Measures	Provide lightning warning systems for City of Bixby public outdoor sports areas, pools, golf courses, and parks.
8	Lightning	Preventive Measures	Provide lightning warning systems for Bixby Public Schools outdoor sports areas and play grounds
9	Extreme Heat	Preventive Measures	Develop a Heat Emergency Action Plan/Heat Emergency Annex to the Emergency Operations Plan for the jurisdiction.
10	Expansive Soils	Preventive Measures	Establish an administrative procedure or change in City codes that require builders to check for expansive soils when applying for new residential construction permits, and to consider the use of foundations that mitigate expansive soil damages when in a moderate to high-risk area.

Rank	Hazard	Mitigation Category	Mitigation Measure
11	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.
12	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.
13	Floods, Dam Failures	Property Protection	Continue Compliance with, and Participation in the National Flood Insurance Program (NFIP) and the Community Rating System (CRS)
14	Tornadoes, High Winds, Lightning, Hail	Emergency Services	Evaluate, upgrade and maintain community-wide outdoor omni-directional voice/siren warning systems
15	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.
16	Floods, Tornadoes, High Winds, Lightning, Severe Winter Storms, Urban Fires, Wildfires, Earthquakes, Fixed Site Haz Mat Events	Preventive Measures	Based on the results of the Emergency Back-up Generator Hazard Mitigation Plan Annex, provide wiring and transfer switches to accommodate emergency generators during disaster power outages for critical facilities including Emergency Operations Centers, City Hall, Dispatch, Police, Fire, Community Centers used for emergency housing during disasters, critical facilities, lift stations, water treatment plants, and community medical facilities
17	Tornadoes, High Winds, Lightning, Severe Winter Storms	Emergency Services	Obtain emergency generators for continuity of government/use during disaster power outages for critical facilities including Emergency Operations Centers, City Hall, Dispatch, Police, Fire, Community Centers used for emergency housing during disasters, critical facilities, lift stations, water treatment plants, and community medical facilities, as identified in the Emergency Back-up Generator Hazard Mitigation Plan Annex.
18	Tornadoes, High Winds, Lightning, Severe Winter Storms	Emergency Services	Obtain 1 generator for a booster pump
19	Tornadoes, High Winds, Lightning, Severe Winter Storms	Emergency Services	Obtain emergency generators for 23-26 lift stations
20	Tornadoes, High Winds, Severe Winter Storms	Preventive Measures	Provide routine trimming of trees to reduce power outages during storms.

Rank	Hazard	Mitigation Category	Mitigation Measure
21	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.
22	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.
23	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
24	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.
25	Tornadoes, High Winds, Hail, Earthquakes	Preventive Measures	When replaced, install break/shatter resistant glass in schools
26	Tornadoes, High Winds, Lightning, Severe Winter Storms, Extreme Heat, Earthquakes	Preventive Measures	Provide surge and lightning protection for computer-reliant critical facilities (e.g. City Hall, 911 Center, EOC, Police and Fire stations, water/wastewater treatment plant and public works buildings)
27	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
28	Hail	Property Protection	Provide covered shelters for City First Response/government vehicles to protect against hail damage.
29	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	Adopt the International Code Council codes that support multi-hazard mitigation planning

Rank	Hazard	Mitigation Category	Mitigation Measure
30	Urban Fires, Wildfires	Structural Projects	Replace/continue replacing inadequately sized hydrants & water mains/lines with sufficient size hydrants & water lines to provide proper fire protection to annexed and existing areas.
31	Extreme Heat	Natural Resources Protection	Increase urban vegetation and improve landscaping to reduce the effects of "urban heat islands."
32	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.
33	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.
34	Tornadoes, High Winds, Earthquakes	Preventive Measures	Perform tornado, high wind, and earthquake evaluations of schools to determine the best ways to retrofit or remodel buildings to make them more disaster resistant.
35	Tornadoes, High Winds, Earthquakes	Property Protection	Cover all exposed fluorescent lighting tubes in city and school facilities with impact resistant plastic coverings
36	Fixed Site Haz Mat Events, Transportation Events	Preventive Measures	Adopt ordinances regulating hazardous material & buoyant material protection measures
37	Drought, Wildfires	Emergency Services	Pre-identify and inventory "water-moving" equipment, including pumps, pipeline, tanker trucks, "water buffaloes" and other resources to include local private sector equipment.
38	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
39	Floods	Public Information and Education	Inform floodplain residents of the availability of flood insurance to eligible National Flood Insurance Program communities
40	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.
41	Expansive Soils	Structural Projects	Identify and repair critical facilities that show evidence of or have expansive soils-related damage.
42	Severe Winter Storms	Property Protection	Upgrade communities’ equipment and vehicles for combating ice storm damage/adverse impact to public infrastructure.

Rank	Hazard	Mitigation Category	Mitigation Measure
43	Fixed Site Haz Mat Events	Emergency Services	Develop and reinforce hazardous materials emergency equipment and response teams.
44	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.
45	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.
46	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.
47	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	Institute Continuity of Operations (COOP) within local utilities, government departments and social service agencies so that operations during and after an emergency incident are still accessible and operable.
48	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	Conduct regular testing of emergency communications, warning and response systems.
49	Floods, Tornadoes, High Winds, Severe Winter Storms, Extreme Heat, Earthquakes, Dam Failures	Preventive Measures	Supply NOAA weather radios to all local government facilities, schools, hospitals, and critical facilities.
50	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 community and critical facilities as a result of power outages due to natural and man-made hazards, such as the McGuire plan.
51	Floods, Dam Failures	Structural Projects	Obtain and install flood level monitoring equipment in area creeks

Rank	Hazard	Mitigation Category	Mitigation Measure
52	Floods, Dam Failures	Natural Resources Protection	Maintain natural and beneficial functions of streams and floodplains
53	Dam Failures	Preventive Measures	Provide dam monitoring equipment
54	Transportation Events	Preventive Measures	Study routing of hazardous materials through the jurisdiction.
55	Floods	Structural Projects	Eliminate storm-water infiltration and inflow (I&I) into the sanitary sewer system.
56	High Winds	Structural Projects	Secure rooftop equipment, such as air conditioners, to rooftops on critical facilities to withstand high wind loads.
57	Drought	Structural Projects	Develop a secondary, tertiary or extended water supply system.

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 Bixby City Council and the Bixby Public Schools.

7.1 Monitoring, Evaluating, and Updating the Plan

The City of Bixby and Bixby Public Schools will ensure that a regular review and update of the *Multi-Jurisdictional Multi-Hazard Mitigation Plan* occurs. The Hazard Mitigation Planning Committee (HMPC) will continue to meet on a semi-annual basis, or as conditions warrant, to oversee and review updates and revisions to the plan. The Bixby City Planner will continue to head the Staff 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 prior to the 5-year approval period expiration, as per FEMA requirements.

Monitoring the Plan- Monitoring of the Plan, the Action Plan, and Mitigation Measures is the responsibility of the Emergency Manager, City Manager, School Superintendent, 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 HMPC on progress and/or impediments to progress of the mitigation measures.

Evaluating the Plan- The *City of Bixby and Bixby Public Schools Multi-Jurisdictional Multi-Hazard Mitigation Plan* will be continually evaluated by the Project Manager, and a report will be made to the HMPC 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 City's Capital Improvements Plan process, and the Public Schools planning process. These programs will continue to be monitored and updated on an annual basis, if not more often.

Updating the Plan- The *City of Bixby and Bixby Public Schools Multi-Jurisdictional Multi-Hazard Mitigation Plan* will be updated according to the following schedule:

1. Revise and Update- the City will incorporate revisions to the plan document identified during the monitoring and evaluation period, as well as items identified in the previous 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 Bixby City Council, and the updated plan sent to FEMA prior to the expiration of the 5-year approval period.

7.2 Public Involvement

The City of Bixby, and the Bixby Public Schools are committed to involving the public directly in updating and maintaining the *Multi-Jurisdiction Multi-Hazard Mitigation Plan*.

Copies of the Plan will be maintained at the public library, and the plan will be placed on the City of Bixby's Website.

A public meeting will be held prior to submission of the update of the *City of Bixby and Bixby Public Schools Multi-Jurisdictional Multi-Hazard Mitigation Plan*. This meeting will be advertised to the general public, and will update citizens on the progress that has been made in implementing the plan and related capital projects. The meeting 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 public will be solicited as to how the mitigation process can be more effective.

7.3 Incorporating the Multi-Hazard Mitigation Plan

The City of Bixby's local planning mechanisms available for incorporating the recommendations and requirements of the Hazard Mitigation Measures are listed below. The *City of Bixby and Bixby Public Schools Multi-Jurisdictional Multi-Hazard Mitigation Plan* will be approved by the Bixby School Board, adopted by the Bixby City Council as an amendment to the City's Comprehensive Plan and as a guide to City mitigation activities. Appropriate Action Items and Mitigation Measures from the plan will be incorporated into the following plans and codes:

- Capital Improvements Plan and planning process
- City of Bixby Building Code
- Bixby Emergency Operations Plan
- City of Bixby Water and Sewer Plan
- Bixby Public Schools planning process
- Various Flood & Drainage Annexes to the Hazard Mitigation 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 HMPC on an 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 *City of Bixby and Bixby Public Schools Multi-Jurisdictional Multi-Hazard Mitigation Plan*:

1. Bixby City Council
2. Bixby Board of Education

RESOLUTION No. 2010-06

CITY OF BIXBY, OKLAHOMA

A RESOLUTION ADOPTING THE CITY OF BIXBY AND BIXBY PUBLIC SCHOOLS MULTI-JURISDICTIONAL MULTI-HAZARD MITIGATION PLAN.

WHEREAS, the City of Bixby and its environs are subject to danger and damage from tornadoes, high winds, lightning, wildfire and other natural hazards;

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 City and measures that are and can be brought to bear on them;

WHEREAS, the City of Bixby participates in the National Flood Insurance Program and would benefit from the development and adoption of a comprehensive basin-wide Master Drainage Plan for all watersheds within the City;

WHEREAS, the City of Bixby has approximately 740 structures in the 100-year floodplain;

WHEREAS, the 2000 Stafford Act mandates that communities must have a hazard mitigation plan before they can apply for funds from the Hazard Mitigation Grant Program, and Pre-Disaster Mitigation Grant Program;

WHEREAS, the City of Bixby was awarded a Hazard Mitigation Grant Program planning grant in the amount of $19,832 to prepare a hazard mitigation plan for the City of Bixby and Bixby Public Schools;

WHEREAS, the Bixby City Council, 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 the City of Bixby to approve such a plan.

NOW, THEREFORE, BE IT RESOLVED BY THE MAYOR AND CITY COUNCIL OF THE CITY OF BIXBY, OKLAHOMA:

Section 1. That the *City of Bixby and Bixby Public Schools Multi-Jurisdictional Multi-Hazard Mitigation Plan* (hereinafter, "the Plan"), made a part of this resolution, together with any and all graphic representations referenced in this *Multi-Jurisdictional Multi-Hazard Mitigation Plan*, are hereby approved;

Section 2: That upon its adoption, this plan should be considered as an amendment to the *Bixby Comprehensive Plan 2001-2020*;

Section 3: That upon its adoption of the Plan, all previous versions of the document shall be repealed; and

Section 4: That copies of the Plan will be maintained in City Hall and the Bixby Public Library.

PASSED BY THE CITY COUNCIL AND APPROVED BY THE MAYOR OF THE CITY OF BIXBY, OKLAHOMA, THIS 23rd DAY OF May, 2010.

Ray Bowen

Mayor

SEAL

CITY OF BIXBY * OKLAHOMA * INCORPORATED

ATTEST:

Jeanie Scott

City Clerk

APPROVED AS TO FORM:

City Attorney

RESOLUTION NO. __________

A RESOLUTION ADOPTING THE *CITY OF BIXBY AND BIXBY PUBLIC SCHOOLS MULTI-JURISDICTIONAL MULTI-HAZARD MITIGATION PLAN*

WHEREAS, the Bixby Public Schools are subject to danger and damage from tornadoes, high winds, lightning, wildfire and other natural hazards;

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 City of Bixby and Bixby Public Schools and measures that are and can be brought to bear on them;

WHEREAS, the 2000 Stafford Act mandates that jurisdictions must have a hazard mitigation plan before they can apply for funds from the Hazard Mitigation Grant Program, and the Pre-Disaster Mitigation Grant Program;

WHEREAS, the City of Bixby was awarded a Hazard Mitigation Grant Program planning grant in the amount of $19,830 to prepare a hazard mitigation plan for the City and the Public Schools;

WHEREAS, the Bixby Board of Education, after due and proper notice and hearing, has considered said *Multi-Jurisdictional Multi-Hazard Mitigation Plan* and has determined that it is in the best interest of the Bixby Public Schools to approve such a plan.

NOW, THEREFORE, BE IT RESOLVED BY THE BIXBY BOARD OF EDUCATION:

Section 1. That the *City of Bixby and Bixby Public Schools Multi-Jurisdictional Multi-Hazard Mitigation Plan*, made a part of this resolution, together with any and all graphic representations referenced in this *Multi-Jurisdictional Multi-Hazard Mitigation Plan*, are hereby approved;

Section 2: That copies of the *Multi-Jurisdictional Multi-Hazard Mitigation Plan* will be maintained in the Office of the Superintendent of Bixby Public Schools.

PASSED BY THE BIXBY BOARD OF EDUCATION THIS 13 **DAY OF** September**, 2010.**

President
Bixby Board of Education

Superintendent
Bixby Public Schools

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

Agency	Web Address
Winter Storms	
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:

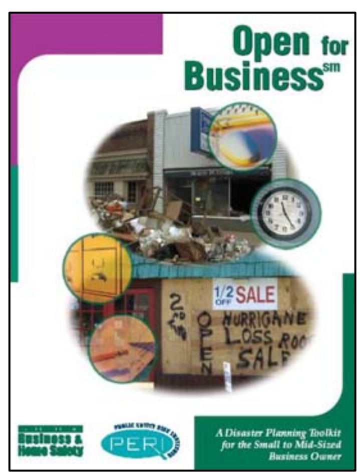
- absenteeism from employees who are affected or who have affected family members;
- psychological trauma from losing co-workers;
- loss of an irreplaceable executive or manager;
- economic stress on the business from having to make repairs and replenish stock over and above what may be covered by insurance;
- 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 plans 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 Plans — 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.

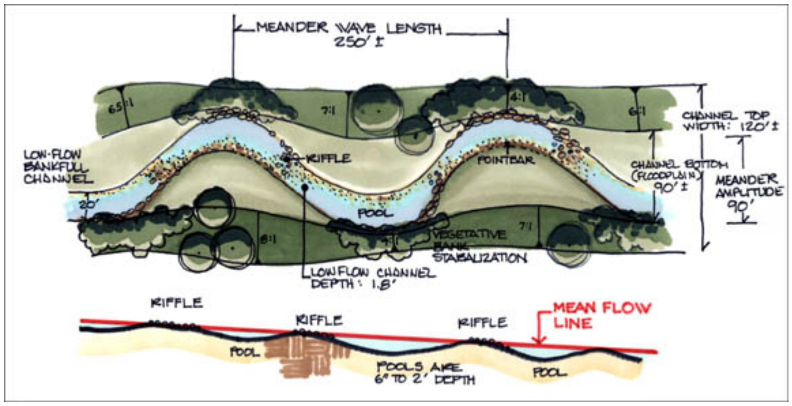
B.2.4 Stormwater Management

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.

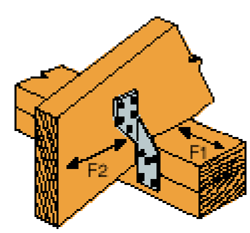
B.2.7 Smoke Detectors

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.

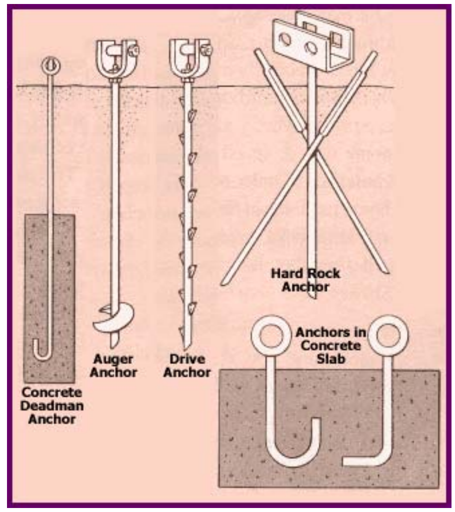
Test smoke detectors every month, change the batteries twice per year, clean detectors at least once per year and replace smoke detectors every 10 years. For more facts about smoke detectors see www.firemar.state.ok.us/forms/lg-alarm.pdf.

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.

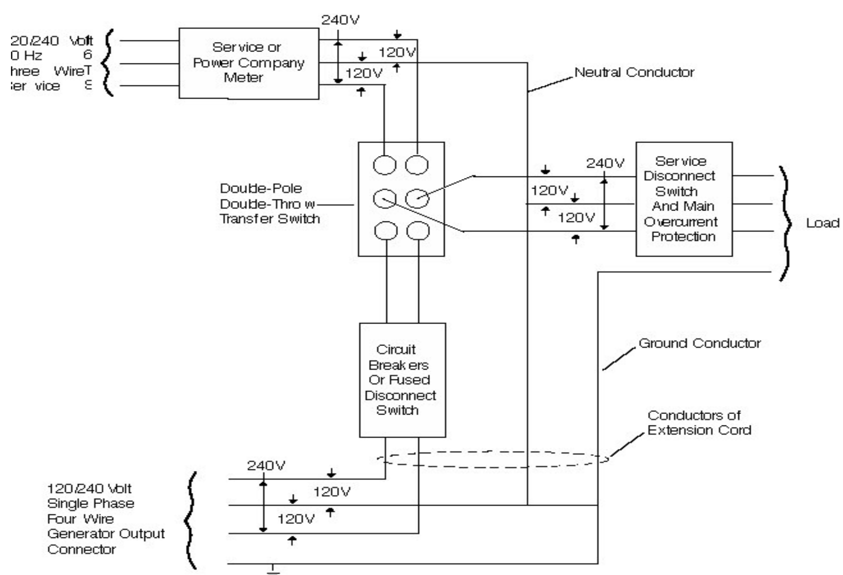
- Proper voltage – It's usually best for an emergency generator to match your standard incoming voltage, whether it's single-phase 120/240 or three-phase 277/480, which is the more common commercial application.
- Power requirements – this will entail (a) identifying your critical functions, and (b) 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.

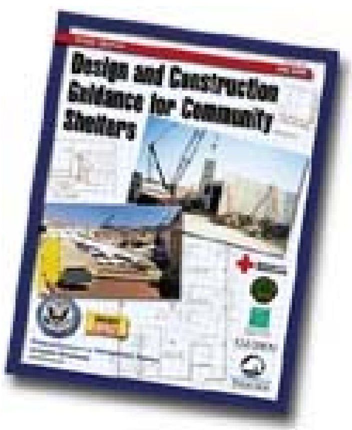
National Storm Shelter Association

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

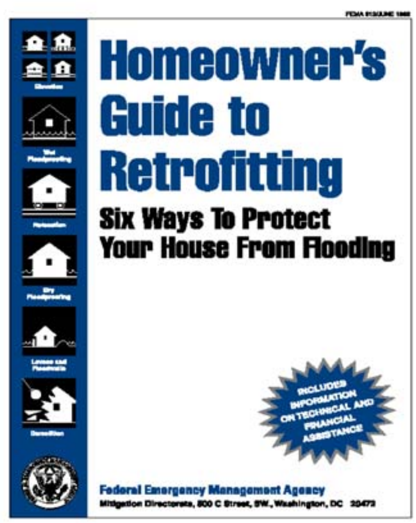
Raising a building above the flood level is the best on-site property protection method for flooding. Water flows under the building, causing little or no damage to the structure or its contents. Alternatives are to elevate on continuous foundation walls (creating an enclosed space below the building) 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

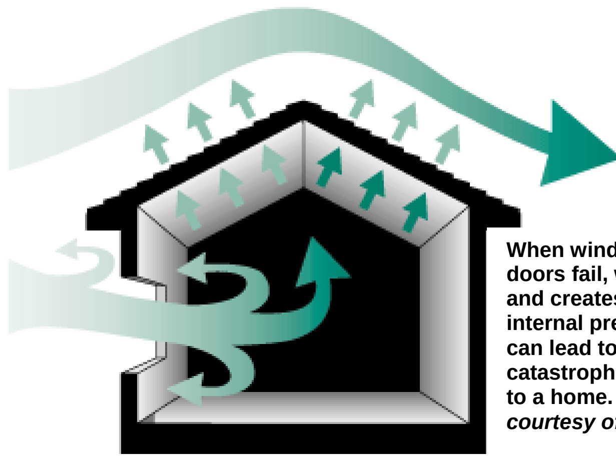
From the above lists, it can be seen that certain approaches can help protect from more than one hazard. These include:

- 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

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.



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*)

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

(Provided by CGI Windows, www.cgiwindows.com.)

The pricing table to the right is for estimating purposes only. Changes in dimensions, glass types, finishes, hardware selection, volume discounts, and other variables could raise or lower prices.

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

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.)*

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.

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)

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.

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.

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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.

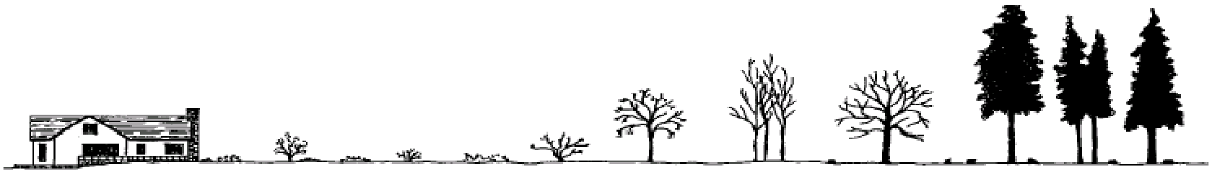
Whole house surge protectors offer the first line of defense against high-energy, high-voltage surges. These devices thwart the energy of the initial surge and reduce it before it reaches electrical appliances. In many cases this level of protection is enough to protect the home. Surge protectors should 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.

Appendix C: Meeting Agendas and Sign-in Sheets

This appendix has the Agendas and Sign-in sheets for meetings that were held during the planning process. See Chapter 3 for list of meetings and dates.

CITY COUNCIL MEETING
COUNCIL CHAMBERS
116 W. Needles, Bixby, OK 74008
October 27, 2008 6:00 P.M.

CALL TO ORDER CHAIRMAN BOWEN

ROLL CALL CITY CLERK

CONSENT AGENDA

CITY CLERK'S REPORT
Consider and approve:

a) Minutes of 10/13/08 City Council Meeting.
b) Blanket Purchase Orders for November, 2008.
c) Acceptance of IRS Form 8283 from Noah and Betty Easton for property donation and authorize the City Manager to sign.
d) Acceptance of payment in the amount of $1,462.60 from Trident Insurance for damage received 41/7/2008 on 2003 Crown Vic., Vin #0807.
e) Tulsa County Health Department to administer Flu Shots to all employees at no cost to the city.
f) Purchase of Stalker police radars from Applied Concepts for the new police cars in the amount of $25,545.00.
g) Sending Bill May to Construction Inspection Workshop at a cost of $1,600.00 to include registration, airfare, lodging and meals for the week of November 18-20, 2008.
h) Waiver of earth change permit fees for Bixby Schools on Bixby Central Campus parking lot as deemed appropriate by City Attorney.
i) Authorizing Staff to prepare project scope and estimate for sidewalk extension along 121st Street between Fox Hollow and Bixby North Elementary.
j) Payment in the amount of $12,485.00 to Consolidated Traffic Controls for emitter module and switch in Police Department.
k) Payment in the amount of $3,290.00 to Cobalt Signs & Design for graphic design package for police vehicles.
l) Payment in the amount of $254,424.00 to United Ford for 12 police vehicles.
m) Payment in the amount of $395.88 to O'Reilly Auto Parts for police vehicles floor mats.
n) Payment in the amount of $208.83 to Sirchie Finger Print Laboratories for barrier tape for Police Department.
o) Request from Bixby Rotary Club for Bixby Christmas Parade on December 12, 2008. Streets to be closed from 6pm until 8pm or until parade is finished. Parade route: High School

North on Riverview to Dawes through the middle of downtown Bixby to Cabaniss South 1 block to Breckenridge to First Baptist Church parking lot Main Street where parade will end.

p) Educational Materials for the Bixby Fire Department to distribute to Bixby Public Schools, grades 3-7 during Fire Prevention Week. Amount of purchase $2,489.50.

REGULAR AGENDA

I. Discuss and/or approve Citizen Agenda Request in regards to the light and noise from the Spirit Event Center. Kyle Conaway

II. Discuss and/or take action on an Earth Change Permit for Bixby Public Schools North Elementary 5th & 6th Grade Center.
Jared Cottle, City Engineer

III. Discuss and/or take action on awarding Bid for the Lake Bixhoma Interim Drainage Repairs to Tri-Star Construction, Inc., the lowest, responsive, responsible bidder in the bid amount of $19,460.00.
Jared Cottle, City Engineer

IV. Discuss and/or take action on Change Order No. 1 for the substitution of concrete streets in the amount of $15,746.95 for Bentley Park Phase II. Jared Cottle, City Engineer

V. Discuss and/or take action for competitive bids for the Fry Creek 2 Bank Stabilization project north of 121st Street between Memorial and Sheridan (North reaches of Fry Creek Local Protection Project) and waive the 21 day bid requirement because the emergency work must be completed as soon as possible to avoid additional damage and cost. Jared Cottle, City Engineer

VI. Discuss and/or take action on hourly contract with Meshek & Assoc. in an amount not to exceed $8,000 to provide hydrologic and hydraulic data from Fry Creek H&H models for use in the design of the Fry Creek No. 2 Bank Stabilization.
Jared Cottle, City Engineer

VII. Discuss and/or approve authorizing City Attorney to prepare interlocal agreements with the Tulsa County, the City of Tulsa, and the City of Broken Arrow for signalization of the 111th & Sheridan intersection and the 111th & Mingo intersection.
Jared Cottle, City Engineer

VIII. Discuss and/or approve a Final Plat for 101 South Memorial Plaza (PUD 63), located in a part of 101 South Memorial Center and the NW/4 NW/4 of Section 25, T18N, R13E, located south of 101st Street South and east of Memorial Drive.

Erik Enyart, City Planner

IX. Presentation on updating the Bixby Multi-Hazard Mitigation Plan.

Erik Enyart, City Planner

X. Discuss and/or approve a contract with R.D. Flanagan & Associates to update the Bixby Multi-Hazard Mitigation Plan utilizing FEMA grant funds (25% local match).

Erik Enyart, City Planner

XI. Discuss and/or approve posting properties for possible abatement. Proper notification made to owners with no response or action taken in specified time:

A. 08-09145 14404 S. Urbana Place Lot 15/Blk 3 Falcon Ridge High grass/weeds, trash/debris New Construction
B. 08-09128 8115 E. 112th Street Lot 10/Blk 2 Southwood High Grass/weeds, tree limb debris

Mike Webster, Asst. City Manager

XII. Discuss performance of City audit's Cross and Robinson and review of contract. Councilor Steve Todoroff

XIII. Recess Regular Meeting and Enter Executive Session.

Mayor Bowen

XIV. Executive Session:

a. Discuss the proposed contract with I.A.F.F. (International Association Fire Fighters) 2008/2009 Contract, pursuant to 25 O.S. Sec. 307 (b) 2.

XV. Exit Executive Session and Reconvene Regular Meeting.

Mayor Bowen

XVI. Take any necessary action in regard to contract with I.A.F.F.

Mayor Bowen

XVII. New Business Mayor Bowen

XVIII. Adjournment Mayor Bowen

Dated this 24th day of October, 2008 at 2:00 p.m., at City Hall, 116 W. Needles, Bixby, Oklahoma.

Respectfully Submitted,

Cheryl Sasser
City Clerk

BIXBY PUBLIC WORKS AUTHORITY

Board of Trustees
Council Chambers
116 W. Needles, Bixby, OK 74008
October 27, 2008
Time: Following City Council Meeting

CALL TO ORDER — Chairman Bowen

ROLL CALL — City Clerk

CONSENT AGENDA

CITY CLERK'S REPORT
Consider and approve:

- **a)** Minutes of 10/13/08 City Council Meeting.
- **b)** Blanket Purchase Orders for November, 2008.
- **c)** Tulsa County Health Department to administer Flu Shots to all employees at no cost to the city.
- **d)** Purchasing 3/4 x 5/8 Neptune Meters from Water Products in the amount of $3,650.00.

REGULAR MEETING

I. Discuss and/or approve equipment for conference room in Dawes Building. — Becky Byers, Finance Director

II. Discuss and/or take action Bixhoma Lake Yield Analysis Study. — Councilor Tom Daniels

III. New Business — Mayor Bowen

IV. Adjournment — Mayor Bowen

Dated this 24th day of October, 2008 at 2:00 p.m., at City Hall, 116 W. Needles, Bixby, Oklahoma.

Respectfully Submitted,
Cheryl Sasser
Cheryl Sasser
City Clerk

Meeting Sign in Sheet

R.D. FLANAGAN & ASSOCIATES
Planning Consultants
www.rdflanagan.com

Project:	CITY OF Bixby, OK - MULTI-HAZARD MITIGATION PLAN Update		
Purpose of Meeting:	CAC/TAC Meeting		
Date of Meeting:	Nov. 7, 2008	**Time Begin:** 10:00 am	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
RDF	Flanagan, Ron	Consultant		918-749-2696	rdflanagan@rdflanagan.com
TH	1. Holland, Thomas	Planning Commission	C	918 232-2931	Thol46@aol.com
	2. Powell, Jim	Planning Commission	C		jpowell@olp.net
S.Sutton	3. Sutton, Steve	Planning Commission	C		ssutton@spiritbank.com
	4. Whisman, Lance	Planning Commission	C		lancewhisman@hotmail.com
L.W.	5. Whiteley, Larry	Planning Commission	C	Cel. 694-1661 Home 366-4774	
[signature]	6. Aamodt, Bea	Director, Public Works	T		baamodt@bixby.com
	7. Abel, Steve	Fire Chief	T		bixbyfirechief@bixby.com
KC	8. Coody, Kaylin	Assoc. Superintendent Bixby Public Schools	T	W 366-2200 C 640-0787 H 369-3633	kcoody@bixbyps.org
JWC	9. Cottle, Jared	City Engineer	T		jcottle@bixby.com
EBE	10. Enyart, Erik	City Planner	T	918-366-0427	eenyat@bixby.com

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
[illegible]	11. Hayes, Gabe	Safety Director, Bixby Public Schools	T	918-366-2279 918-237-1379 Cell	ghayes@bixbyps.org
[illegible]	12. Shirley, Ike	Police Chief Emergency Manager	T	366-0421 O. 344-8510 C.	ishirley@bixby.com
[illegible]	13. Sweeden, Jim	Fire Marshall	T	918-366-0436 Cell 381-1748	firecode@bixby.com
	14. Webb, Mickey	City Manager	T		ctymgr@olp.net
	15. Webster, Mike	Asst. City Manager	T		mwebster@bixby.com
	16.				
	17.				
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	24.				
	25.				
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Meeting Sign in Sheet

R.D. FLANAGAN & ASSOCIATES
Planning Consultants
www.rdflanagan.com

Project:	**CITY OF Bixby, OK - MULTI-HAZARD MITIGATION PLAN Update -**		
Purpose of Meeting:	**CAC/TAC Meeting – Urban Fire / Wildfire Presentation & Discussion**		
Date of Meeting:	**Nov. 20, 2008**	**Time Begin: 10:00 am**	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	Flanagan, Ron	Consultant		918-749-2696	rdflanagan@rdflanagan.com
	1. Holland, Thomas	Planning Commission	C	918-232-2931	Thol46@aol.com
[signature]	2. Powell, Jim	Planning Commission	C	918-369-3093	jpowell@olp.net 918-629-2503 (C)
	3. Sutton, Steve	Planning Commission	C		ssutton@spiritbank.com
	4. Whisman, Lance	Planning Commission	C		lancewhisman@hotmail.com
	5. Whiteley, Larry	Planning Commission	C	918-694-1661 C 918-366-4774 H	
[signature]	6. Aamodt, Bea	Director, Public Works	T	366-0404	baamodt@bixby.com
[signature]	7. Abel, Steve	Fire Chief	T	606-2911	bixbyfirechief@bixby.com
	8. Coody, Kaylin	Assoc. Superintendent Bixby Public Schools	T	918-366-2200 W 918-640-0787 C 918-366-3633 H	kcoody@bixbyps.org
	9. Cottle, Jared	City Engineer	T		jcottle@bixby.com

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	10. Enyart, Erik	City Planner	T	918-366-0427	eenyat@bixby.com
	11. Hayes, Gabe	Safety Director, Bixby Public Schools	T	918-366-2279 918-237-1379 C	ghayes@bixbyps.org
	12. Shirley, Ike	Police Chief Emergency Manager	T	918-366-0421 918-344-8510 C	ishirley@bixby.com
	13. Sweeden, Jim	Fire Marshall	T	918-366-0436 918-381-1748 C	firecode@bixby.com
	14. Webb, Mickey	City Manager	T		ctymgr@olp.net
	15. Webster, Mike	Asst. City Manager	T		mwebster@bixby.com
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Meeting Sign in Sheet

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Project:	**CITY OF Bixby, OK - MULTI-HAZARD MITIGATION PLAN Update -**		
Purpose of Meeting:	**CAC/TAC Meeting – Severe Winter Storms Presentation & Discussion**		
Date of Meeting:	**Dec. 18, 2008**	**Time Begin: 9:30 am**	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	Flanagan, Ron	Consultant		918-749-2696	rdflanagan@rdflanagan.com
[signature]	1. Holland, Thomas	Planning Commission	C	918-232-2931	Thol46@aol.com
[signature]	2. Powell, Jim	Planning Commission	C	919-369-3093 C: 629-2503	jpowell@olp.net
	3. Sutton, Steve	Planning Commission	C		ssutton@spiritbank.com
	4. Whisman, Lance	Planning Commission	C		lancewhisman@hotmail.com
[signature]	5. Whiteley, Larry	Planning Commission	C	**918-694-1661 C** **918-366-4774 H**	
	6. Aamodt, Bea	Director, Public Works	T	918-366-0404	baamodt@bixby.com
	7. Abel, Steve	Fire Chief	T	918-606-2911	bixbyfirechief@bixby.com
	8. Coody, Kaylin	Assoc. Superintendent Bixby Public Schools	T	**918-366-2200 W** **918-640-0787 C** **918-366-3633 H**	kcoody@bixbyps.org

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	9. Cottle, Jared	City Engineer	T		jcottle@bixby.com
EBE	10. Enyart, Erik	City Planner	T	918-366-0427	eenyart@bixby.com
	11. Hayes, Gabe	Safety Director, Bixby Public Schools	T	**918-366-2279** **918-237-1379 C**	ghayes@bixbyps.org
	12. Shirley, Ike	Police Chief Emergency Manager	T	**918-366-0421** **918-344-8510 C**	ishirley@bixby.com
	13. Sweeden, Jim	Fire Marshall	T	**918-366-0436** **918-381-1748 C**	firecode@bixby.com
	14. Webb, Mickey	City Manager	T		ctymgr@olp.net
	15. Webster, Mike	Asst. City Manager	T		mwebster@bixby.com
AC	16. Andy Choate	Police Dept.		918-366-0445 344-8224	achoate@Bixby.com
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Project:	CITY OF Bixby, OK - MULTI-HAZARD MITIGATION PLAN Update -		
Purpose of Meeting:	CAC/TAC Meeting – Hazardous Mat. & Transportation Presentation & Discussion		
Date of Meeting: Jan. 8, 2009		**Time Begin:** 9:30 am	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
✓	Flanagan, Ron	Consultant		918-749-2696	rdflanagan@rdflanagan.com
✓	Bob Roberts				
[signature]	1. Holland, Thomas	Planning Commission	C	918-232-2931	Thol46@aol.com
[signature]	2. Powell, Jim	Planning Commission	C	918-369-3093 918-629-2503 C	jpowell@olp.net
	3. Sutton, Steve	Planning Commission	C		ssutton@spiritbank.com
	4. Whisman, Lance	Planning Commission	C		lancewhisman@hotmail.com
[signature]	5. Whiteley, Larry	Planning Commission	C	918-694-1661 C 918-366-4774 H	
	6. Aamodt, Bea	Director, Public Works	T	918-366-0404	baamodt@bixby.com
[signature]	7. Abel, Steve	Fire Chief	T	918-606-2911	bixbyfirechief@bixby.com
	8. Coody, Kaylin	Assoc. Superintendent Bixby Public Schools	T	918-366-2200 W 918-640-0787 C 918-366-3633 H	kcoody@bixbyps.org

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	9. Cottle, Jared	City Engineer	T		jcottle@bixby.com
EBE	10. Enyart, Erik	City Planner	T	918-366-0427	eenyart@bixby.com
✓	11. Hayes, Gabe	Safety Director, Bixby Public Schools	T	918-366-2279 918-237-1379 C	ghayes@bixbyps.org
[illegible]	12. Shirley, Ike	Police Chief Emergency Manager	T	918-366-0421 918-344-8510 C	ishirley@bixby.com
✓	13. Sweeden, Jim	Fire Marshall	T	918-366-0436 918-381-1748 C	firecode@bixby.com
	14. Webb, Mickey	City Manager	T		ctymgr@olp.net
	15. Webster, Mike	Asst. City Manager	T		mwebster@bixby.com
	16. Choate, Andy	Police Department		918-366-0445 918-344-8724	achoate@bixby.com
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Project:	**CITY OF Bixby, OK - MULTI-HAZARD MITIGATION PLAN Update -**	
Purpose of Meeting:	**CAC/TAC Meeting –Earthquakes & Expansive Soils Presentation & Discussion**	
Date of Meeting: Jan. 22, 2009	**Time Begin:** 9:30 am	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
RDF	Flanagan, Ron	Consultant		918-749-2696	rdflanagan@rdflanagan.com
[signature]	1. Holland, Thomas	Planning Commission	C	918-232-2931	Thol46@aol.com
	2. Powell, Jim	Planning Commission	C	918-369-3093 918-629-2503 C	jpowell@olp.net
	3. Sutton, Steve	Planning Commission	C		ssutton@spiritbank.com
	4. Whisman, Lance	Planning Commission	C		lancewhisman@hotmail.com
	5. Whiteley, Larry	Planning Commission	C	918-694-1661 C 918-366-4774 H	
	6. Aamodt, Bea	Director, Public Works	T	918-366-0404	baamodt@bixby.com
	7. Abel, Steve	Fire Chief	T	918-606-2911	bixbyfirechief@bixby.com
	8. Coody, Kaylin	Assoc. Superintendent Bixby Public Schools	T	918-366-2200 W 918-640-0787 C 918-366-3633 H	kcoody@bixbyps.org

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	9. Cottle, Jared	City Engineer	T		jcottle@bixby.com
EBE	10. Enyart, Erik	City Planner	T	918-366-0427	eenyart@bixby.com
[illegible]	11. Hayes, Gabe	Safety Director, Bixby Public Schools	T	918-366-2279 918-237-1379 C	ghayes@bixbyps.org
[illegible]	12. Shirley, Ike	Police Chief Emergency Manager	T	918-366-0421 918-344-8510 C	ishirley@bixby.com
[illegible]	13. Sweeden, Jim	Fire Marshall	T	918-366-0436 918-381-1748 C	firecode@bixby.com
	14. Webb, Mickey	City Manager	T		ctymgr@olp.net
	15. Webster, Mike	Asst. City Manager	T		mwebster@bixby.com
	16. Choate, Andy	Police Department		918-366-0445 918-344-8724	achoate@bixby.com
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Project:	**CITY OF Bixby, OK - MULTI-HAZARD MITIGATION PLAN Update -**		
Purpose of Meeting:	**CAC/TAC Meeting –Lightning and Hail Presentation & Discussion**		
Date of Meeting:	**February 12, 2009**	**Time Begin: 9:30 am**	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
RDF	Flanagan, Ron	Consultant		918-749-2696	rdflanagan@rdflanagan.com
[illegible]	1. Holland, Thomas	Planning Commission	C	918-232-2931	Thol46@aol.com
[illegible]	2. Powell, Jim	Planning Commission	C	918-369-3093 918-629-2503 C	jpowell@olp.net
	3. Sutton, Steve	Planning Commission	C		ssutton@spiritbank.com
	4. Whisman, Lance	Planning Commission	C		lancewhisman@hotmail.com
	5. Whiteley, Larry	Planning Commission	C	918-694-1661 C 918-366-4774 H	
	6. Aamodt, Bea	Director, Public Works	T	918-366-0404	baamodt@bixby.com
	7. Abel, Steve	Fire Chief	T	918-606-2911	bixbyfirechief@bixby.com
	8. Coody, Kaylin	Assoc. Superintendent Bixby Public Schools	T	918-366-2200 W 918-640-0787 C 918-366-3633 H	kcoody@bixbyps.org

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	9. Cottle, Jared	City Engineer	T		jcottle@bixby.com
EBE	10. Enyart, Erik	City Planner	T	918-366-0427	eenyart@bixby.com
	11. Hayes, Gabe	Safety Director, Bixby Public Schools	T	918-366-2279 918-237-1379 C	ghayes@bixbyps.org
[illegible]	12. Shirley, Ike	Police Chief Emergency Manager	T	918-366-0421 918-344-8510 C	ishirley@bixby.com
[illegible]	13. Sweeden, Jim	Fire Marshall	T	918-366-0436 918-381-1748 C	Firenforce@Bixby.Com ~~firecode@bixby.com~~
	14. Webb, Mickey	City Manager	T		ctymgr@olp.net
	15. Webster, Mike	Asst. City Manager	T		mwebster@bixby.com
	16. Choate, Andy	Police Department		918-366-0445 918-344-8724	achoate@bixby.com
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Project:	**CITY OF Bixby, OK - MULTI-HAZARD MITIGATION PLAN Update -**		
Purpose of Meeting:	**CAC/TAC Meeting – High Winds and Tornadoes - Presentation & Discussion**		
Date of Meeting:	**March 5, 2009**	**Time Begin: 9:30 am**	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
RDF	Flanagan, Ron	Consultant		918-749-2696	rdflanagan@rdflanagan.com
	1. Holland, Thomas	Planning Commission	C	918-232-2931	Thol46@aol.com
	2. Powell, Jim	Planning Commission	C	918-369-3093 918-629-2503 C	jpowell@olp.net
	3. Sutton, Steve	Planning Commission	C		ssutton@spiritbank.com
	4. Whisman, Lance	Planning Commission	C		lancewhisman@hotmail.com
	5. Whiteley, Larry	Planning Commission	C	918-694-1661 C 918-366-4774 H	
	6. Aamodt, Bea	Director, Public Works	T	918-366-0404	baamodt@bixby.com
[illegible]	7. ~~Abel, Steve~~ JD McBrayer	Fire Chief	T	918-606-2911	bixbyfirechief@bixby.com
	8. Coody, Kaylin	Assoc. Superintendent Bixby Public Schools	T	918-366-2200 W 918-640-0787 C 918-366-3633 H	kcoody@bixbyps.org

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	9. Cottle, Jared	City Engineer	T		jcottle@bixby.com
EBE	10. Enyart, Erik	City Planner	T	918-366-0427	eenyart@bixby.com
	11. Hayes, Gabe	Safety Director, Bixby Public Schools	T	918-366-2279 918-237-1379 C	ghayes@bixbyps.org
[illegible]	12. Shirley, Ike	Police Chief Emergency Manager	T	918-366-0421 918-344-8510 C	ishirley@bixby.com
	13. Sweeden, Jim	Fire Marshall	T	918-366-0436 918-381-1748 C	fireenforce@bixby.com
	14. Webb, Mickey	City Manager	T		ctymgr@olp.net
[illegible]	15. Webster, Mike	Asst. City Manager	T		mwebster@bixby.com
	16. Choate, Andy	Police Department		918-366-0445 918-344-8724	achoate@bixby.com
TR	17. Riley, Tanner	Fire Dept		918-520-7811	
TM	18. ~~F~~ McKinzie, Ty	Fire Dept		918-520-7811	
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Meeting Sign in Sheet

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Project:	**CITY OF Bixby, OK - MULTI-HAZARD MITIGATION PLAN Update -**		
Purpose of Meeting:	**CAC/TAC Meeting – Floods and Dam Failures - Presentation & Discussion**		
Date of Meeting:	**March 12, 2009**	**Time Begin: 9:30 am**	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
RDF	Flanagan, Ron	Consultant		918-749-2696	rdflanagan@rdflanagan.com
	1. Holland, Thomas	Planning Commission	C	918-232-2931	Thol46@aol.com
	2. Powell, Jim	Planning Commission	C	918-369-3093 918-629-2503 C	jpowell@olp.net
	3. Sutton, Steve	Planning Commission	C		ssutton@spiritbank.com
	4. Whisman, Lance	Planning Commission	C		lancewhisman@hotmail.com
LW	5. Whiteley, Larry	Planning Commission	C	918-694-1661 C 918-366-4774 H	
	6. Aamodt, Bea	Director, Public Works	T	918-366-0404	baamodt@bixby.com
	7. McBrayer, J.D.	Fire Chief	T	918-606-2911	bixbyfirechief@bixby.com
	8. Coody, Kaylin	Assoc. Superintendent Bixby Public Schools	T	918-366-2200 W 918-640-0787 C 918-366-3633 H	kcoody@bixbyps.org

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
JWC	9. Cottle, Jared	City Engineer	T	(918) 366-0437	jcottle@bixby.com
EBE	10. Enyart, Erik	City Planner	T	918-366-0427	eenyart@bixby.com
	11. Hayes, Gabe	Safety Director, Bixby Public Schools	T	918-366-2279 918-237-1379 C	ghayes@bixbyps.org
	12. Shirley, Ike	Police Chief Emergency Manager	T	918-366-0421 918-344-8510 C	ishirley@bixby.com
	13. Sweeden, Jim	Fire Marshall	T	918-366-0436 918-381-1748 C	fireenforce@bixby.com
	14. Webb, Mickey	City Manager	T		ctymgr@olp.net
	15. Webster, Mike	Asst. City Manager	T		mwebster@bixby.com
	16. Choate, Andy	Police Department		918-366-0445 918-344-8724	achoate@bixby.com
	17. Riley, Tanner	Fire Department		918-520-7811	
	18. McKinzie, Ty	Fire Department		918-520-7811	
	19. Thomas Mike	Public works		918-671-0155	MikeT @ bixby.com
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Project:	**CITY OF Bixby, OK - MULTI-HAZARD MITIGATION PLAN Update -**		
Purpose of Meeting:	**CAC/TAC Meeting – Floods (Revised)- Presentation & Discussion**		
Date of Meeting:	**March 26, 2009**	**Time Begin: 9:30 am**	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	Flanagan, Ron	Consultant		918-749-2696	rdflanagan@rdflanagan.com
[signature]	1. Holland, Thomas	Planning Commission	C	918-232-2931	Thol46@aol.com
[signature]	2. Powell, Jim	Planning Commission	C	918-369-3093 918-629-2503 C	jpowell@olp.net
	3. Sutton, Steve	Planning Commission	C		ssutton@spiritbank.com
	4. Whisman, Lance	Planning Commission	C		lancewhisman@hotmail.com
	5. Whiteley, Larry	Planning Commission	C	918-694-1661 C 918-366-4774 H	
[signature]	6. Aamodt, Bea	Director, Public Works	T	918-366-0404	baamodt@bixby.com
	7. McBrayer, J.D.	Fire Chief	T	918-606-2911	bixbyfirechief@bixby.com
	8. Coody, Kaylin	Assoc. Superintendent Bixby Public Schools	T	918-366-2200 W 918-640-0787 C 918-366-3633 H	kcoody@bixbyps.org

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
[illegible]	9. Cottle, Jared	City Engineer	T	918-366-0437	jcottle@bixby.com
[illegible]	10. Enyart, Erik	City Planner	T	918-366-0427	eenyart@bixby.com
[illegible]	11. Hayes, Gabe	Safety Director, Bixby Public Schools	T	918-366-2279 918-237-1379 C	ghayes@bixbyps.org
[illegible]	12. Shirley, Ike	Police Chief Emergency Manager	T	918-366-0421 918-344-8510 C	ishirley@bixby.com
[illegible]	13. Sweeden, Jim	Fire Marshall	T	918-366-0436 918-381-1748 C	fireenforce@bixby.com
[illegible]	14. Webb, Mickey	City Manager	T		ctymgr@olp.net
[illegible]	15. Webster, Mike	Asst. City Manager	T		mwebster@bixby.com
	16. Choate, Andy	Police Department		918-366-0445 918-344-8724	achoate@bixby.com
	17. Riley, Tanner	Fire Department		918-520-7811	
	18. McKinzie, Ty	Fire Department		918-520-7811	
	19. Thomas, Mike	Public Works		918-671-0155	miket@bixby.com
	20. STEVE ABEL	FIRE DEPT		918-606-2911	bixbyfirechief@bixby.com
	21.				
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Meeting Sign in Sheet

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Project:	**CITY OF Bixby, OK - MULTI-HAZARD MITIGATION PLAN Update -**
Purpose of Meeting:	**CAC/TAC Meeting – Heat & Drought Presentation & Discussion**
Date of Meeting:	**April 9, 2009** — **Time Begin:** **9:30 am** — **Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	Flanagan, Ron	Consultant		918-749-2696	rdflanagan@rdflanagan.com
[signature]	1. Holland, Thomas	Planning Commission	C	918-232-2931	Thol46@aol.com
[signature]	2. Powell, Jim	Planning Commission	C	918-369-3093 918-629-2503 C	jpowell@olp.net
	3. Sutton, Steve	Planning Commission	C		ssutton@spiritbank.com
	4. Whisman, Lance	Planning Commission	C		lancewhisman@hotmail.com
	5. Whiteley, Larry	Planning Commission	C	918-694-1661 C 918-366-4774 H	
	6. Aamodt, Bea	Director, Public Works	T	918-366-0404	baamodt@bixby.com
	7. Abel Steve	Fire Chief	T	918-606-2911	bixbyfirechief@bixby.com
	8. Coody, Kaylin	Assoc. Superintendent Bixby Public Schools	T	918-366-2200 W 918-640-0787 C 918-366-3633 H	kcoody@bixbyps.org

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	9. Cottle, Jared	City Engineer	T	918-366-0437	jcottle@bixby.com
EBE	10. Enyart, Erik	City Planner	T	918-366-0427	eenyart@bixby.com
	11. Hayes, Gabe	Safety Director, Bixby Public Schools	T	918-366-2279 918-237-1379 C	ghayes@bixbyps.org
[illegible]	12. Shirley, Ike	Police Chief Emergency Manager	T	918-366-0421 918-344-8510 C	ishirley@bixby.com
JHS	13. Sweeden, Jim	Fire Marshall	T	918-366-0436 918-381-1748 C	fireenforce@bixby.com
	14. Webb, Mickey	City Manager	T		ctymgr@olp.net
	15. Webster, Mike	Asst. City Manager	T		mwebster@bixby.com
	16. Choate, Andy	Police Department		918-366-0445 918-344-8724	achoate@bixby.com
	17. Riley, Tanner	Fire Department		918-520-7811	
	18. McKinzie, Ty	Fire Department		918-520-7811	
	19. Thomas, Mike	Public Works		918-671-0155	miket@bixby.com
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Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	24. Duffy McAnallen	Director EMSA	T	918 830-4478	mcanallen@emsa.net
	25.				
	26.				
	27.				

Meeting Sign in Sheet

R.D. FLANAGAN & ASSOCIATES
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www.rdflanagan.com

Project:	**CITY OF Bixby, OK - MULTI-HAZARD MITIGATION PLAN Update -**		
Purpose of Meeting:	**CAC/TAC Meeting – Hazards Review**		
Date of Meeting:	**April 30, 2009**	**Time Begin: 9:30 am**	**Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
RDF	Flanagan, Ron	Consultant		918-749-2696	rdflanagan@rdflanagan.com
	1. Holland, Thomas	Planning Commission	C	918-232-2931	Thol46@aol.com
	2. Powell, Jim	Planning Commission	C	918-369-3093 918-629-2503 C	jpowell@olp.net
	3. Sutton, Steve	Planning Commission	C		ssutton@spiritbank.com
	4. Whisman, Lance	Planning Commission	C		lancewhisman@hotmail.com
	5. Whiteley, Larry	Planning Commission	C	918-694-1661 C 918-366-4774 H	
[signature]	6. Aamodt, Bea	Director, Public Works	T	918-366-0404	baamodt@bixby.com
	7. McBrayer, J.D.	Fire Chief	T	918-606-2911	bixbyfirechief@bixby.com
	8. Coody, Kaylin	Assoc. Superintendent Bixby Public Schools	T	918-366-2200 W 918-640-0787 C 918-366-3633 H	kcoody@bixbyps.org

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
JWC	9. Cottle, Jared	City Engineer	T	918-366-0437	jcottle@bixby.com
EBE	10. Enyart, Erik	City Planner	T	918-366-0427	eenyart@bixby.com
	11. Hayes, Gabe	Safety Director, Bixby Public Schools	T	918-366-2279 918-237-1379 C	ghayes@bixbyps.org
[illegible]	12. Shirley, Ike	Police Chief Emergency Manager	T	918-366-0421 918-344-8510 C	ishirley@bixby.com
JAL	13. Sweeden, Jim	Fire Marshall	T	918-366-0436 918-381-1748 C	fireenforce@bixby.com
	14. Webb, Mickey	City Manager	T		ctymgr@olp.net
	15. Webster, Mike	Asst. City Manager	T		mwebster@bixby.com
	16. Choate, Andy	Police Department	T	918-366-0445 918-344-8724	achoate@bixby.com
	17. Riley, Tanner	Fire Department	T	918-520-7811	
	18. McKinzie, Ty	Fire Department	T	918-520-7811	
	19. Thomas, Mike	Public Works	T	918-671-0155	miket@bixby.com
[illegible]	20. McAnallen, Duffy	EMSA Director	T	918-830-4478	mcanallen@emsa.net
	21.				
	22.				
	23.				

Meeting Sign in Sheet

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Project:	**CITY OF Bixby, OK - MULTI-HAZARD MITIGATION PLAN Update -**
Purpose of Meeting:	**CAC/TAC Meeting – Goals and Objectives**
Date of Meeting:	**May 14, 2009** | **Time Begin:** 9:30 am | **Time End:**

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
RDF	Flanagan, Ron	Consultant		918-749-2696	rdflanagan@rdflanagan.com
JH	1. Holland, Thomas	Planning Commission	C	918-232-2931	Thol46@aol.com
	2. Powell, Jim	Planning Commission	C	918-369-3093 918-629-2503 C	jpowell@olp.net
	3. Sutton, Steve	Planning Commission	C		ssutton@spiritbank.com
	4. Whisman, Lance	Planning Commission	C		lancewhisman@hotmail.com
	5. Whiteley, Larry	Planning Commission	C	918-694-1661 C 918-366-4774 H	
	6. Aamodt, Bea	Director, Public Works	T	918-366-0404	baamodt@bixby.com
	7. McBrayer, J.D.	Fire ~~Chief~~ Captain	T	918-606-2911	bixbyfirechief@bixby.com
	8. Coody, Kaylin	Assoc. Superintendent Bixby Public Schools	T	918-366-2200 W 918-640-0787 C 918-366-3633 H	kcoody@bixbyps.org

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	9. Cottle, Jared	City Engineer	T	918-366-0437	jcottle@bixby.com
EBE	10. Enyart, Erik	City Planner	T	918-366-0427	eenyart@bixby.com
[signature]	11. Hayes, Gabe	Safety Director, Bixby Public Schools	T	918-366-2279 918-237-1379 C	ghayes@bixbyps.org
[signature]	12. Shirley, Ike	Police Chief Emergency Manager	T	918-366-0421 918-344-8510 C	ishirley@bixby.com
[signature]	13. Sweeden, Jim	Fire Marshall	T	918-366-0436 918-381-1748 C	fireenforce@bixby.com
	14. Webb, Mickey	City Manager	T		ctymgr@olp.net
	15. Webster, Mike	Asst. City Manager	T		mwebster@bixby.com
	16. Choate, Andy	Police Department	T	918-366-0445 918-344-8724	achoate@bixby.com
	17. Riley, Tanner	Fire Department	T	918-520-7811	
	18. McKinzie, Ty	Fire Department	T	918-520-7811	
	19. Thomas, Mike	Public Works	T	918-671-0155	miket@bixby.com
	20. McAnallen, Duffy	EMSA Director	T	918-830-4478	mcanallen@emsa.net
[signature]	21. Abel, Steve	Fire Chief		918-606-2911	bixbyfirechief@bixby.com
	22. Michael Wisner	Planning Commissioner			
	23.				

Meeting Sign in Sheet

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Project:	**CITY OF Bixby, OK - MULTI-HAZARD MITIGATION PLAN Update -**		
Purpose of Meeting:	**CAC/TAC Meeting – Mitigation Measures**		
Date of Meeting: **July 9, 2009**		**Time Begin:** **9:30 am**	**Time End:** 11:15

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	Flanagan, Ron	Consultant		918-749-2696	rdflanagan@rdflanagan.com
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[signature]	2. Powell, Jim	Planning Commission	C	918-369-3093 918-629-2503 C	jpowell@olp.net
	3. Sutton, Steve	Planning Commission	C		ssutton@spiritbank.com
	4. Whisman, Lance	Planning Commission	C		lancewhisman@hotmail.com
	5. Whiteley, Larry	Planning Commission	C	918-694-1661 C 918-366-4774 H	
	6. Wisner, Michael	Planning Commission	C	918-360-4551	
	7. Aamodt, Bea	Director, Public Works	T	918-366-0404	baamodt@bixby.com
	8. Abel, Steve	Fire Chief	T	918-606-2911	bixbyfirechief@bixby.com

Initial	Name	Position or Organization	T/C	Phone(s)	E-mail
	9. Coody, Kaylin	Assoc. Superintendent Bixby Public Schools	T	918-366-2200 W 918-640-0787 C 918-366-3633 H	kcoody@bixbyps.org
	10. Cottle, Jared	City Engineer	T	918-366-0437	jcottle@bixby.com
	11. Enyart, Erik	City Planner	T	918-366-0427	eenyart@bixby.com
	12. Hayes, Gabe	Safety Director, Bixby Public Schools	T	918-366-2279 918-237-1379 C	ghayes@bixbyps.org
	13. McBrayer, J.D.	Fire Captain	T	918-606-2911	
	14. Shirley, Ike	Police Chief Emergency Manager	T	918-366-0421 918-344-8510 C	ishirley@bixby.com
	15. Sweeden, Jim	Fire Marshall	T	918-366-0436 918-381-1748 C	fireenforce@bixby.com
	16. Webb, Mickey	City Manager	T		ctymgr@olp.net
	17. Webster, Mike	Asst. City Manager	T		mwebster@bixby.com
	18. Choate, Andy	Police Department	T	918-366-0445 918-344-8724	achoate@bixby.com
	19. Riley, Tanner	Fire Department	T	918-520-7811	
	20. McKinzie, Ty	Fire Department	T	918-520-7811	
	21. Thomas, Mike	Public Works	T	918-671-0155	miket@bixby.com
	22. McAnallen, Duffy	EMSA Director	T	918-830-4478	mcanallen@emsa.net

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	24.				
	25.				

Appendix D: Status of 2004 Mitigation Measures

Priority	Category	Measure	Current Status (Complete, Ongoing, In Progress, Not yet begun, Modified, Dropped)
1	General	Install an emergency communication network for Fire, Police, 911, EMSA and other emergency operations. Provide backup facilities for the 911 Center and the Emergency Operations Center.	Complete
2	Tornadoes and High Winds	Provide safe rooms in fire and police stations to protect first responders.	Ongoing
3	Dam Failure	Develop warning and evacuation plans and systems for areas at risk from dam failure or large release flooding.	Ongoing
4	General	Provide emergency equipment for City Emergency Teams	Complete
5	Tornadoes and High Winds	Provide safe rooms at schools.	In Progress
6	Lightning	Provide surge protection for computer-reliant critical facilities, e.g. 911 Center, Emergency Operations Center, police sub-stations, fire stations, and so on.	In Progress
7	General	Examine optimum methods of implementing public information and education objectives concerning tornadoes, high winds, lightning, winter storms, extreme heat, fire, hazardous material events, expansive soils, and wise use of water resources.	In Progress
8	Floods	Construct regional detention ponds to compensate for future urban development	Complete
9	Tornadoes and High Winds	Based on research results, 1. Educate the public about adequate building systems for resistance to tornadoes and high winds. 2. Inspect City of Bixby schools for tornado and high wind vulnerability.	Complete

Priority	Category	Measure	Current Status (Complete, Ongoing, In Progress, Not yet begun, Modified, Dropped)
10	General	Provide Certified Disaster Training for City employees, as well as working with local CERT Teams	In Progress
11	General	Build City of Bixby partnerships involving local government leaders, civic, business and volunteer groups to work together to make a safer community	In Progress
12	Floods	Acquire accurate or verify accuracy of existing flood plain maps and develop land use ordinances to avoid construction in flood-prone locations.	Complete
13	Floods	Acquire floodplain properties where acquisition is the most cost effective mitigation measure	Ongoing
14	Floods	Acquire and remove Repetitive Loss Properties and repeatedly flooded properties where the City's Repetitive Loss and master drainage plans identify acquisition to be the most cost effective and desirable mitigation measure	Ongoing
15	Winter Storms	Develop a contingency plan for responding to a massive power outage due to severe winter storm, ice and snow.	Complete
16	Hazardous Materials Events	Develop and reinforce Hazardous Materials event equipment and response teams.	Ongoing
17	General	Provide Security and Surveillance equipment for Police and Fire Stations	Complete
18	General	Evaluate and upgrade warning systems	Ongoing
19	Floods	Launch an automatic monitoring and warning system for spot flooding	In Progress
20	Floods	Evaluate proper mitigation measures for homes located in the floodplain	Ongoing
21	Tornadoes and High Winds	Provide City of Bixby tornado safe-rooms and shelters.	Ongoing
22	Hazardous Materials Events	Identify and plan for hazardous materials and incidents on major transportation routes through the City of Bixby.	Complete
23	Floods	Continue to update and revise basin-wide master drainage plans where changed conditions warrant	Ongoing

Priority	***Category***	***Measure***	***Current Status (Complete, Ongoing, In Progress, Not yet begun, Modified, Dropped)***
24	Floods and Tornadoes	Educate the public on what the multi-sound sirens mean.	Complete
25	Floods	Implement structural and non-structural flood mitigation measures for flood-prone properties as recommended in the basin-wide master drainage plans.	Ongoing
26	Hail Storms	Provide hail resistant roofing for City of Bixby buildings.	Ongoing
27	Wildfires	Develop a fire emergency plan that guarantees access by fire vehicles to all areas included in the rural/urban interface fire danger area.	Complete
28	Wildfires	Train and coordinate City of Bixby fire, police and public works how to respond to a wildfire emergency.	In Progress
29	Dam Failure	Develop GIS (digitized) mapping program for results of appropriate cfs dam release rates	Dropped
30	General	GIS update to include public utility infrastructure	Complete
31	General	Develop a City of Bixby debris management plan	In Progress
32	General	Teach City of Bixby employees the symptoms of common, life-threatening emergencies and how to give CPR and first aid	In Progress
33	General	Sponsor a "***Helping Your Neighbors***" program through the Bixby school system to encourage children to think of people who require special assistance such as elders, infants, and people with disabilities during dangerous weather conditions such as severe winter storms and extreme heat.	In Progress
34	Floods	Identify ways of securing and elevating important equipment inside a building.	Ongoing
35	Tornadoes and High Winds	Supply NOAA Weather Radio to all local government buildings, schools, hospitals, and critical facilities (cost of NOAA Weather Radio: about $70.00 ea.).	In Progress

Priority	*Category*	*Measure*	*Current Status (Complete, Ongoing, In Progress, Not yet begun, Modified, Dropped)*
36	Tornadoes and High Winds	Investigate building codes/incentives for adequacy for tornadoes and high winds	Ongoing
37	Tornadoes and High Winds	Investigate voluntary pilot/demonstration project for mobile home communities providing a shelter and/or safe rooms for residents.	Ongoing
38	Lightning	Provide educational demonstrations on whole-house surge protection technology.	Ongoing
39	Extreme Heat	Install window air conditioners for elderly shut-ins for whom extreme heat can be a life-threatening hazard.	Ongoing
40	Urban Fires	Develop public education project addressing the advantages of individual fire suppression in residences, including fire extinguishers.	Ongoing
41	Urban Fires	Implement a fire suppression system for City Hall.	Ongoing
42	Urban Fires	Continue education and get funding to inform people on proper evacuation plans for city buildings, businesses, and residential homes.	In Progress
43	Hazardous Materials Events	Update the study for routing of hazardous materials through the City of Bixby.	Ongoing
44	Floods	Obtain elevation certificates for homes located in the floodplain	Complete
45	Floods	Construct adequate bridges to pass 100-year regulatory flood without overtopping.	Ongoing
46	Tornadoes and High Winds	Identify and develop public information and education programs and provide materials and mitigation measures that protect a building’s roof, all outside openings, and the building envelope. Also research ways to improve quality of construction related to wind resistance. Top priority should be given to protection of the roof system, typically the most vulnerable and most expensive component to replace.	Ongoing

Priority	Category	Measure	Current Status (Complete, Ongoing, In Progress, Not yet begun, Modified, Dropped)
47	Tornadoes and High Winds	Safe Room Rebates for low income and vulnerable populations.	Dropped
48	Tornadoes and High Winds	When replaced, install break resistant glass in county offices and critical facilities.	Ongoing
49	Tornadoes and High Winds	Begin a revolving fund for families to build safe rooms.	Dropped
50	Tornadoes and High Winds	Incorporate proper shingle installation into City of Bixby ordinance.	Complete
51	Lightning	Provide educational demonstrations and information in whole-house surge protection technology.	Ongoing
52	Lightning	Construct lightning rods for protection of Critical Facilities.	Ongoing
53	Hail Storms	Institute public information program for residents informing them of the advantages and costs of hail resistant roofing.	Ongoing
54	Winter Storms	Reduce the number of overhead power lines through moving existing lines and building new lines below ground.	Ongoing
55	Winter Storms	Provide for routine trimming of trees to reduce power outages during storms.	Ongoing
56	Expansive Soils	Develop and implement a public information strategy for informing citizens and the building industry of the dangers and costs to buildings of expansive soils.	Ongoing
57	Urban Fires	Make sure fire extinguishers are strategically placed and serviced in all City of Bixby facilities.	In Progress
58	Urban Fires	Replace inadequately sized water lines with lines of sufficient size to provide proper fire protection.	Ongoing
59	Hazardous Materials Events	Identify most common household pollutants and make hazard and disposal information available to local populace through media, schools, public offices, police, and fire stations.	Ongoing

Priority	Category	Measure	Current Status (Complete, Ongoing, In Progress, Not yet begun, Modified, Dropped)
60	Dam Failure	Install/obtain flood level monitoring equipment/Stream Gauges in local steams and rivers.	Ongoing
61	General	Execute daytime population maps for the Bixby Community.	In Progress
62	General	Translate current public information to other languages	Ongoing
63	Lightning	Add lightning warning into the current warning siren system.	Ongoing
64	Lightning	Educate the City of Bixby about proper lightning safety through public service announcements and other media outlets.	In Progress
65	Lightning	Study other communities that have lightning warning systems intact.	Ongoing
66	Lightning	Reinstate lightning prevention information materials and programs with PSO.	Ongoing
67	Hail Storms	Provide hail-resistant measures/materials to protect existing public infrastructure improvements.	Ongoing
68	Winter Storms	Develop a plan for educating residents on effective ways to monitor and avoid ice damaging, freezing pipes, and snow loads on roof systems.	Ongoing
69	Winter Storms	Investigate winterizing exposed elements of residential and commercial structures.	Ongoing
70	Winter Storms	Update the debris management plan.	In Progress
71	Extreme Heat	Develop a Heat Emergency Action Plan for the City of Bixby.	In Progress
72	Extreme Heat	Obtain funding for distribution of public information and education materials to vulnerable populations through participating City of Bixby agencies.	Ongoing
73	Drought	Develop public information program designed to communicate the potential severity of a drought and the appropriate responses of the local population.	Ongoing

Priority	Category	Measure	Current Status (Complete, Ongoing, In Progress, Not yet begun, Modified, Dropped)
74	Expansive Soils	Identify and repair Critical Facilities that show, or have expansive soils-related damage.	Ongoing
75	Expansive Soils	Investigate codes/incentives for the construction of new foundations to avoid expansive soil problems.	Ongoing
76	Urban Fires	Continue education and get funding to inform people on proper evacuation plans for offices and residential homes.	Ongoing
77	Urban Fires	Apply for mitigation funding for detection check backflow meters.	Ongoing
78	Urban Fires	Use City money for a fire suppression demonstration project.	Ongoing
79	Urban Fires	Review and evaluate the City of Bixby fire alarm system.	In Progress
80	Wildfires	Develop a contingency plan for evacuating population endangered by a wildfire.	Ongoing
81	Wildfires	Develop a phased alert and warning plan based on drought conditions and moisture measurements to alert City of Bixby officials of increased risk of wildfire.	Ongoing
82	Wildfires	Investigate and raise public awareness of fire-resistant materials for buildings.	Ongoing
83	Earthquakes	Building reinforcements against wind and tornado damage will also protect against the minor earthquakes projected for the area.	Ongoing
84	Hazardous Materials Events	Distribute information identifying hazardous materials to at risk citizens, such as the elderly, infirm, poor, and outside workers.	Ongoing
85	Hazardous Materials Events	Contact agencies that distribute data and information to at-risk population, such as the elderly, infirm, poor, and outside workers.	Ongoing

Appendix E: 2009 Plan Update Changes

The following items are the identified significant changes made from the 2004 City of Bixby Multi-Hazard Mitigation Plan. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008. The changes are indicated on a Chapter-by-Chapter and section-by-section basis, when appropriate.

The FEMA guidance document identified 5 major areas of significance, including:

- Planning Process
- Risk Assessment
- Mitigation Strategy
- Prerequisites
- Plan Maintenance.

In addition, changes in the process for continued public involvement are noted.

Table E–1: Significant Plan Update Changes

Section	**Significant Changes**
Introduction and general overview	
1.1.5	2009 update reflects the most recent Oklahoma and FEMA goals, as stated in the most recent Oklahoma Enhanced State Mitigation Plan.
1.2	The 2009 update reflects updated governance, and maps for land area and land usage. It contains updated and more comprehensive climatology based on information from the National Weather Center in Norman, OK.
1.2.5	An enhanced section on Historic Properties and Cultural Resources was added.
1.2.6 and All Chapters	While still based primarily on the 2000 U.S. Census, the 2009 update incorporates the most recent 2008 estimates of population numbers, ethnicity, income, etc. when available.

Section	Significant Changes
1.2.6.1 & All Chapter	Additional consideration is given here, and throughout the plan, to identified Special Needs populations, based on the increasing federal and state priorities in that area. Maps identifying such categories as the U.S. Census “People with Disabilities” and Indian Nations Council of Governments Social Environment maps are used to assist in assessing vulnerabilities.
1.27	Information on Bixby Public Schools has been added, since this is now a multi-jurisdictional plan.
1.2.8	Lifeline information has been reviewed and, if needed, updated, based on the most current information available from utility, telecommunications and transportation companies.
1.2.9	The Major Employers’ List has been updated based on the most current City of Bixby information from Chamber of Commerce and Oklahoma Department of Commerce.
1.2.10	Enhanced or updated information on Development has been included. Additional information on growth trends and other future development has been added.
1.2.11 & All Chapters	Critical Facilities has been reviewed and modified as needed based on the most current information from local and state government, Emergency Management, the Chamber of Commerce, and other pertinent entities. It takes into account that FEMA now includes financial institutions as potential critical facilities.
Planning Process	
3.1	Additional consultants were brought in to assure that the most recent protocols and methods were incorporated into the Planning Process.
3.2	A series of geographically specific, smaller public meetings were used in this iteration of the plan, as opposed to fewer, larger meetings in the last one. In addition, the opportunity for public input was provided on the City of Bixby website.
3.3	The list of Coordinating Agencies and Organizations was updated and enhanced to include representatives from the Business Community (Bixby Chamber of Commerce, Home Builders Association of Greater Tulsa), and the educational community (Universities, Public School Systems).
App. D	An Appendix was included documenting the previously identified mitigation measures from the 2004 Plan, identifying what actions have taken place or are continuing to take place. The Technical Advisory Committee reviewed the list of measures and the status of each for accuracy.

Section	Significant Changes
Chap. 1 & 2	In the 2004 plan, the Community Description and Existing Mitigation Measures were included in one Chapter. The plan consultant has successfully separated these two sections into two Chapters in previously completed plans in order to enhance readability of the Plan. The Bixby Technical Advisory Committee agreed it would be appropriate to continue that approach for the 2010 City of Bixby Mitigation Plan.
Risk Assessment	
Chap. 4 All hazards	All risk assessments were reviewed for recent events, using interviews with local response agencies, City of Bixby Public Works representatives, the state Fire Marshall's database, the National Climatic Data Center database, the National Response Center, the Oklahoma Geological Survey, National Transportation Safety Board, the National Weather Service Tulsa Forecast Office, and other partners.
Chap. 4 All hazards	With all hazards, risk assessment was analyzed from the specific standpoints of population, structures/buildings, infrastructure, and critical facilities. Not all hazards required an in-depth analysis in all four categories (Extreme Heat, for example, produces little building and structure damage directly). This four-part breakdown carried over into the analysis of Future Trends.
Chap. 4 All hazards	In the 2004 plan, scenarios were presented for Floods, Tornadoes, and Dam Breaks. In the 2009 plan, additional scenarios were created for High Winds, Lightning, Hailstorms, Winter Storms, and Extreme Heat.
Chap. 4 All hazards	Updated parcel values from the County Assessor's office and other data sources have been incorporated when available.
Chap. 4 All hazards	Analyses for Vulnerability and Future Trends are now subdivided into sections for Population, Structures, Infrastructure, and Critical Facilities when appropriate.
Chap. 4 All hazards	When estimating losses for Future Development areas, a more robust method for estimating property values has been used. Breaking down zoning based on residential, commercial, and office allows the plan to better estimate the type of development. Averaging property costs based on the most recent development in the Bixby area based on that type of zoning gives a more specific average parcel value.
4.1.3	Repetitive loss structures are addressed more strongly in the new plan, along with maps and a comprehensive list.
4.2	Description and appropriate tables for the Enhanced Fujita Scale, adopted in 2006 by the National Weather Service, were included, along with a comparison to the original Fujita Scale.

Section	Significant Changes
4.6.2	Two recent highly documented major winter storms allowed for a much more detailed estimate of potential damages from future storms and the development of a much more rigorous process for creating a Winter Storm Scenario which could illustrate a “worst-case scenario.” Information from the utility providers provided an overview of power recovery rates.
4.11.1	The Fire Danger Rating System Table from the updated Oklahoma Hazard Mitigation Plan was added to the Measurements section.
4.11.3	The increased spread of Eastern Red Cedar and its contribution to Oklahoma wildfire risk was studied in conjunction with the University of Oklahoma Department of Agriculture. These concerns were incorporated into the plan.
4.11.2 Fig. 4-32 Tbl. 4-53	Wildfire risk assessment was conducted using the recently released Southern Wildfire Risk Assessment Survey tools. With this, the plan was able to identify a significantly more detailed map of the areas of the community with a substantial level of concern.
4.12.1	An updated version of HAZUS allows for a much more effective hazard assessment of potential earthquake damage.
4.14	Dam Failures and Levee Failures, included in separate sections in the 2004 Plan, were combined into one section in the 2009 Plan. It was agreed by the TAC and CAC that the hazards are so closely interconnected that they could be dealt with more effectively as a combined hazard assessment.
Mitigation Strategy	
2004 Chapter 4	Goals and Objectives from the 2004 plan were individually reviewed and evaluated based on both progress made in mitigation strategies, and in other plan development for the City.
5.1 5.2	In the 2004 plans, general goals, and appropriate disaster-specific goals were enumerated in the Mitigation Strategy Chapter. In the 2009 update, a separate Chapter was developed for Goals and Objectives. An overall Mission Statement was developed along with an overall Mitigation Goal. This was followed by a series of Goals for all hazards to refine the overall goal. A Goal was then developed for each of the 15 addressed hazards, and a specific Objective was developed for each of the 6 mitigation categories: Public Information & Education, Preventive Measures, Structural Projects, Property Protection, Emergency Services, and Natural Resource Protection. This produced a total of 90 overall Objectives to more effectively define the City of Bixby Mitigation Strategies.
5.1 5.2	Goals and Objectives were evaluated in view of the changes in the development of current City Planning Documents, including updated Building codes, and completed items from the Capital Improvement plan.

Section	Significant Changes
5.1 5.2	Goals and Objectives were reviewed and evaluated in light of progress made in previous Mitigation Measures during the last 5 years. Also in light of issues that have arisen due to After Action Evaluations from recent disaster incidents. For example, recognizing that generator power for fueling stations is a critical issue occurred following adverse impacts during the 2007 Winter Ice Storm.
App. D	An Appendix was included documenting the previously identified mitigation measures from the 2004 Plan, identifying what actions have taken place or are continuing to take place. The Technical Advisory Committee reviewed the list of measures and the status of each for accuracy.
Prerequisites	
7.3	The City of Bixby and the Bixby School Board will adopt the 2009 Plan by resolution as an amendment to the City's Comprehensive Plan. In the 2004 plan, only "Appropriate Action Items" were incorporated into the Comprehensive Plan.
Plan Maintenance	
7.1	The ongoing Monitoring and Evaluation of the Mitigation Plan has been made more robust by requiring more frequent meetings of the Technical Advisory Committee, more frequent update reports to critical personnel in City Government, and by requiring semi-annual, as opposed to annual, reports to the Hazard Mitigation Planning Committee. This will simplify the update process by helping to ensure that ongoing revisions and updates are developed on an interim basis.
7.2	The City of Bixby is committed to involving the public directly in updating and maintaining the Multi-Hazard Mitigation Plan. Copies of the Plan will be maintained at the public library, and the plan will be placed on the website of the City of Bixby. In addition, the Plan Coordinator will be conducting small, area-specific meetings on no less than a semi-annual basis at Public Libraries or other public venues, similar to the public meetings used in the development of the 2009 plan.
7.3	The 2009 Plan Update will be incorporated into any updates of the Bixby Comprehensive or Capital Improvement Plans. In addition, the Plan Update will be closely correlated with recently developed and soon to be developed Master Drainage Plans.

Section	Significant Changes
Continued Public Involvement	
3.1 – 3.2	The Hazard Mitigation Advisory Board has met regularly over the previous 5 years to ensure that continued public involvement in the 2004 Hazard Mitigation Plan has been maintained.
7.2	As mentioned above in Plan Maintenance, the Plan Coordinator is committed to conducting small, geographic-specific meetings throughout the 5-year period before the next update. This will ensure that public involvement is continual and robust.