City of Broken Arrow, Oklahoma

Multi-Jurisdictional
Multi-Hazard Mitigation Plan Update - 2017

Participating Jurisdictions:

City of Broken Arrow

Broken Arrow Public School

Union Public School

October 2017

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RESOLUTION NO. 0000

A RESOLUTION OF THE BROKEN ARROW MAYOR AND CITY COUNCIL ADOPTING THE CITY OF BROKEN ARROW MULTI-HAZARD MITIGATION PLAN FOR THE CITY OF BROKEN ARROW, OKLAHOMA

WHEREAS, the Multi-Hazard Mitigation Plan (the Plan) for the City of Broken Arrow is presented in fulfillment of requirements of the Hazard Mitigation Grant Program (HMGP) as outlined by the Federal Emergency Management Agency (FEMA) according to Section 322 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C.4154, enacted under Section 104 of the Disaster Mitigation Act of 2000, (OMA 2000) P.L. 106-390, and;

WHEREAS, the purpose of this Plan is to provide guidance to the City and participating jurisdictions hazard mitigation activities for the next five years and to ensure that the City of Broken Arrow and participating jurisdictions and other partners implement activities that are most effective and appropriate for mitigating multiple hazards events, and;

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE

CITY OF BROKEN ARROW that this Multi-Hazard Mitigation Plan for the City of Broken Arrow, under the multi-jurisdictional planning participation and adoption process, presented in realization of requirements of the HMGP for the Federal Emergency Management Agency, according to the sections cited above, is hereby approved and adopted by the City of Broken Arrow Mayor and City Council.

This Resolution is approved in open meeting by the City Council of the City of Broken on this Adoption will be Pending Approval.

ATTEST:

PLACE HOLDER

For

Broken Arrow Public School District

Adoption Resolution

Once the plan has been reviewed and deemed approvable pending adoption by Oklahoma Emergency Management and the Federal Emergency Management Agency, the Broken Arrow Public School District intends to formally adopt the City of Broken Arrow Natural Hazard Mitigation Plan and provide an adoption resolution for approval.

PLACE HOLDER

For

Union Public School District

Adoption Resolution

Once the plan has been reviewed and deemed approvable pending adoption by Oklahoma Emergency Management and the Federal Emergency Management Agency, the Union Public School District intends to formally adopt the City of Broken Arrow Natural Hazard Mitigation Plan and provide an adoption resolution for approval.

CHAPTER ONE: INTRODUCTION

1.1 Overview of Planning Area

This is a hazard mitigation plan update for the City of Broken Arrow. Broken Arrow is located in eastern Oklahoma and is bordered by three cities; Tulsa to the north and west, Bixby to the West and South, and Coweta to the east, and is on the Muskogee and Creek Turnpikes, State Highway 51, fifteen miles east of Tulsa in Tulsa County, with a small part of the city in Western Wagoner County. It is the fourth largest City in the State. The City of Broken Arrow has two school districts, Broken Arrow Public School and Union Public School which participated in the plan. Total land area of City of Broken Arrow is 50 square miles.

The economy for City of Broken Arrow is a very diverse industry of retail, tourism and dining, which generates approximately $1.1 billion annually. Significant employers within the City of Broken Arrow are, Broken Arrow Public Schools, Wal-Mart, Flight Safety, and the City of Broken Arrow, which employs over 2000 residents.

The population of Broken Arrow is approximately 105,726. Tulsa, which serves as the county seat, is the most heavily populated with approximately 639,242 residents.

There are a total of 17,947 students in the Broken Arrow Public School District, the number of students has grown 5% over the past 5 years. The total number of students in the Union Public Schools District is 15,526, the number of students has stayed relatively flat over the past five years.

1.2 Participating Jurisdictions

The following jurisdictions are participating in this plan:

City of Broken Arrow
Broken Arrow Public School
Union Public School

The term “Planning Area” refers to the participating jurisdictions previously listed.

CHAPTER TWO: PLANNING PROCESS

2.1 Overview of Planning Process

The City of Broken Arrow Hazard Mitigation Planning Committee was formed to provide guidance during the preparation of this plan. The committee worked toward limiting the loss of life and property and the associated costs from natural and man-made hazards through cost effective recommendations of publicly accepted, prioritized, and multi objective actions. Committee participants provided local history, reviewed NCDC data, addressed and analyzed issues of cost versus health/safety, and made recommendations to the plan. The committee discussed these items in open meetings, approved the plan, and provided their recommendations to the Broken Arrow City Manager and Broken Arrow City Council for plan approval.

The Broken Arrow Hazard Mitigation Plan was developed during a series of meetings and outreach methods from November 2016 to June 2017. Due to their unique mitigation needs, Broken Arrow Emergency Management held a separate meeting with school representatives in March 2017.

2.2 City of Broken Arrow Planning Committee Team

CITY OF BROKEN ARROW HAZARD MITIGATION PLANNING TEAM			
Name	**Affiliation**	**Position**	**Contribution**
Alex Mills, PE, CFM	Engineering and Construction	Director	Provided constant assistance in the formulation of this plan. Served as overall coordinator for city services.
Greg Kirby	Flood Plain &CRS	Coordinator	As a team member for the previous plan, he coordinated data, GIS mapping and other information
Jamie Ott-Plan Chairman	Broken Arrow Emergency Management	Director	Served as chairman to coordinate activities of the committee scheduling meetings and sending notices for meetings. Provided information related to previous disasters and emergency plans.
James Kooch	Police Officer	BAPD PIO	Provided appropriate public information to media.
Jeff Bigby, P.E.	Stormwater Manager	Floodplain Administrator	Primary source of floodplain and stormwater information for the plan.
Michael Skates	Development Services	Director	Provided information on Mitigation Projects
Mark Stewart	Asst. Fire Chief	Broken Arrow Fire Department	Interacted with Team discussions on hazards and projects.
Beth Anne Childs	City of Broken Arrow Legal Department	Broken Arrow City Attorney	Provided support information as necessary.

Steve Arant	Streets and Stormwater	Director	Provided information on Mitigation Projects
Grant Moore	Broken Arrow Public Schools	Executive Director of Facilities	Contributed in source information for BA Schools.
Derek Blackburn	Broken Arrow Public Schools	Executive Director of Student Support	Contributed in source information for BA Schools.
Tyoto Wardlow	Union Public Schools	Director of Security	Contributed in source information for Union Schools.

2.3 Other Stakeholders

Neighboring Communities, Businesses, and Non-Profit Agencies Contacted				
Name	**Title**	**Agency Represented**	**How Agency Was Invited**	**Contributions to Plan**
Heath Underwood	Emergency Manager	Wagoner County Emergency Management	Email	Provided information on county capabilities and aid agreements.
Samantha Henry	Regional Coordinator	American Red Cross	Email	Provided information on Red Cross programs during disasters
Loyd Beeson	Amateur Radio Volunteer	Broken Arrow Amateur Radio Club	Email	Provided information on amateur radio communications

State and Federal Agencies Contacted				
Name	**Title**	**Agency Represented**	**How Agency Was Invited**	**Contributions to Plan**
Nicholas Rutledge	Hazard Mitigation Planner	OEM	Email	Provided guidance on plan requirements.
Jim Rosser	Hazard Mitigation Planner	OEM	Email	Provided guidance on plan requirements.
William Smiley	Emergency Manager	US Army Corp of Engineers	Email	Provided information on dam safety

Matt Rollins	State Hazard Mitigation Officer	OEM	Phone and email	Provided guidance on plan requirements.
Linda Adams	Hazard Mitigation Planner	OEM	Phone and email	Provided guidance on plan requirements.
Daniel Piltz	Northeast Regional Coordinator	OEM	Phone and email	Provided guidance on regional resources.

2.4 Public Involvement

All public meetings were designed to encourage and invite input from private citizens and local officials. The public was invited to attend all planning committee meetings held at the Public Safety Center Building in Broken Arrow, Oklahoma. The Hazard Mitigation Plan Update was discussed with members of the public in open meetings during Civic group talks to encourage participation in the Mitigation process and items of interest to the public.

Feedback received from the public proved by way of survey's valuable in the development of the plan. Based on feedback, the top three public priorities are: 1) additional warning devices, 2) improved warning communication methods, and 3) increased education and training on hazards.

2.5 Plans, Documents, and Literature Reviewed

During plan development, the Broken Arrow Hazard Mitigation Planning Committee reviewed the following literature and resources (section 2.5.1), various plans, studies, reference, guidance, support for information regarding hazards, disaster history, and potential impacted areas.

2.5.1 Literature and Resources Reviewed

Agency/Document	**Relevant Information Used**
Broken Arrow Chamber of Commerce	Community Profile and Demographics
US Geological Survey on Earthquakes website, dated 05/02/2017	Data on increased seismic activity across OK.
US Census Bureau Population Data, dated 1/18/2017	Population data for Broken Arrow.
Public School Review	Data on student populations and demographics
Oklahoma Department of Transportation website	Data on county and US Highway routes was used when evaluating mitigation action items.
State Department of Mental Health, (SAMHSA) "Population Stresses During Disaster," updated 01/19/2017	Information on how vulnerable populations are affected by disasters.
State Health Department, "Health Considerations During Community Sheltering," dated 4/1/2012	Data on health safety precautions was used when evaluating mitigation action items.

Oklahoma Department of Environmental Quality	Water purity data on rivers in OK.
FEMA 3-2013	Local Mitigation Planning Handbook
FEMA 1-2013	Mitigation Ideas

2.5.2 Plans Reviewed

Plan Title	Relevant Information Used
State of Oklahoma All- Hazard Mitigation Plan, 2/10/2014	Hazard definitions, previous occurrence data, disaster history, and State goals.
Tulsa County All-Hazards Mitigation Plan 2015	Information was reviewed.
Okmulgee County All-Hazards Mitigation Plan 2017	Information was reviewed during this plan update.
Broken Arrow Capital Improvement Plan	Information was reviewed and integrated into the mitigation action items and critical facilities list.
Keystone Dam Issue Evaluation Study - Review Plan, Tulsa District, US Army Corps of Engineers 11/19/2012	Information was reviewed and integrated into the capability assessment, risk assessment, and mitigation strategy.
Broken Arrow Emergency Operations Plan, May 2017	Capability Assessment.

2.5.3 Additional Information on Plans Used

Keystone Lake Dam Emergency Action Plan

The flooding information from this plan was reviewed and incorporated into the City of Broken Arrow Multi-Hazard Mitigation Plan. Flooding from an isolated incidence in which the integrity of the Keystone Lake Dam may be violated, or a rain incident which results in the overflow of the dam, was addressed during the public meeting on June 1, 2016. According to the Emergency Management Safety and Dam Safety Program Manager at the Keystone Lake Dam, an active plan is in place in case of flooding or a damage incident occurrence. Warning and countywide evacuation protocols were discussed and incorporated into the evaluation of the City of Broken Arrow HM Plan's capabilities, risk assessment, and mitigation action items. There are on-going meetings with the U.S. Army Corps of Engineers, Tulsa District, Keystone Lake Project, and Tulsa County Emergency Management to receive and share updated information regarding the Arkansas River and Keystone Lake Dam Emergency Action Plan.

Capital Improvement Plan

Infrastructure information from multiple Capital Improvement Plans was reviewed and incorporated into the City of Broken Arrow HM Plan. The City of Broken Arrow has a Capital Improvement Plan in place with complete community inventory of public buildings and critical facilities. The Broken Arrow CIP is currently under review and update, May 2017. These plans were instrumental in determining the priority of mitigation action items.

2.6 Continued Public Involvement

City of Broken Arrow will involve the public directly in the continual reshaping and updating of the Hazard Mitigation Plan. This plan will be posted on the City of Broken Arrow website. Hardcopies for public viewing will be available at the City of Broken Arrow's Emergency Management Office.

Annual planning committee meetings will be open to the public. Meeting notices will be posted in accordance with the policies for the State of Oklahoma Open Meeting Law and will include advertisement in the local newspapers and posting the agenda and meeting time on the City of Broken Arrow's websites. An opportunity for public feedback will be scheduled into each meeting's agenda.

2.7 Plan Monitoring, Evaluation, and Updating

The Broken Arrow Emergency Manager will serve as the primary point of contact, and will be responsible for coordinating all meetings related to the review, monitoring, evaluation, and updating of the Broken Arrow Hazard Mitigation Plan.

Monitoring: All policies and procedures identified in the plan (i.e., Public Participation, Plan Evaluation, Plan Update, Capabilities, NFIP Participation, Action Prioritization and Administration, Incorporation into other planning mechanisms), will be monitored for progress and/or quality of performance over the next five years of approval. This will be accomplished by holding plan update meetings once a year; or following local disaster events, unexpected changes to vulnerabilities, and/or mitigation strategies; with the Tulsa County Emergency Management, Wagoner County Emergency Management Office, and the Broken Arrow Multi-Hazard Mitigation Planning Committee (BAHMPC).

Evaluation: Discussions and findings from these meetings will serve as the basis for changes to the risk assessment, mitigation strategy/actions, and other components of the Plan (i.e. capability assessment). Information from the update meetings deemed pertinent to other planning mechanisms will be forwarded to the respective plan manager for review and integration. The City of Broken Arrow, Broken Arrow Public Schools, Union Public Schools will provide a brief summary of how the plan met, or did not meet its specific mitigation needs during the review process.

Updating: The Plan will be updated every five years. Twenty-four months before the plan expiration, the plan update process will begin. The BAHMPC will conduct plan update meetings. These meetings will increase in frequency as the Plan update process progresses. These meetings may be in-person, by conference call, or other collaboration technology. This planning process will include discussing the findings of BAHMPC, City of Broken Arrow, Broken Arrow Public Schools, and Union

Public Schools. A Draft Plan will be submitted to the Oklahoma Department of Emergency Management for review before the plan expiration. Any revisions from ODEM will be incorporated into the document as necessary before submission to FEMA for review. Any revisions from FEMA will be incorporated into the Plan before it is submitted to the Broken Arrow City Manager/City Council, Broken Arrow Public School Board, and Union Public School Board for adoption by resolutions.

CHAPTER THREE: HAZARD IDENTIFICATION AND RISK ASSESSMENT

3.1 Introduction

Natural disasters fall into five (5) major categories: atmospheric, geological, hydrological, extraterrestrial, and biological. Natural disasters have resulted in enormous intangible losses and have had a profound effect on the population's resilience. Ten years of hazard data was reviewed and documented for usage in this plan.

During development of this plan, the Broken Arrow Hazard Mitigation Planning Committee identified hazards that are historical, typical, and possible within the planning area. These hazards were identified by incorporating Broken Arrow Hazard Vulnerability Assessment data, planning committee input, public feedback, review of current Flood Insurance Rate Map (FIRM) data, and through research of past disaster declarations.

3.2 List of Identified Hazards

City of Broken Arrow Hazards

Hazard	Jurisdictions Affected
Lightning	City of Broken Arrow, Broken Arrow Public Schools, Union Public Schools.
Hail	City of Broken Arrow, Broken Arrow Public Schools, Union Public Schools.
Tornado	City of Broken Arrow, Broken Arrow Public Schools, Union Public Schools.
High Wind	City of Broken Arrow, Broken Arrow Public Schools, Union Public Schools.
Winter Storm	City of Broken Arrow, Broken Arrow Public Schools, Union Public Schools.
Flood	City of Broken Arrow, Broken Arrow Public Schools, Union Public Schools.
Extreme Heat	City of Broken Arrow, Broken Arrow Public Schools, Union Public Schools.
Wildfire	City of Broken Arrow, Broken Arrow Public Schools, Union Public Schools.

Drought	City of Broken Arrow, Broken Arrow Public Schools, Union Public Schools.
Dam Failure	City of Broken Arrow, Broken Arrow Public School. Union Public Schools.
Earthquake	City of Broken Arrow, Broken Arrow Public Schools, Union Public Schools.

In addition to the hazards listed above, the Oklahoma Hazard Mitigation Plan also includes expansive soils, subsidence, and landslides as potential hazards. The City of Broken Arrow and the Broken Arrow and Union School Districts are susceptible to Expansive Soils, however the amount of Expansive Soils in the City of Broken Arrow is not known exactly because information is seldom received on this event. The soils in and around the City of Broken Arrow are clay-based, and attract and absorb water. As they dry, they become very hard and shrink in volume. These three hazards were **not** included in the Broken Arrow Hazard Mitigation plan for the following reasons:

a) The soil found in Broken Arrow consists of a low percentage of clay, which eliminates the potential for expansive soils.

b) Lack of clay in the soil also reduces the exposure to subsidence, along with a stable water table and no mining activities within the planning area.

c) Broken Arrow consists of flat terrain and is not at risk for landslides.

3.3 Disaster History

Tulsa County Federally-Declared Disaster History from 2006 to 2016

Disaster #	Declaration Date	Incident Type
DR-4222	5/26/2015	Tornado - Flooding
DR-1985	5/13/2011	Winter Snow Storm
DR-1876	2/25/2010	Winter Storm
DR-3308	1/20/2010	Winter Storm
DR-1735	12/18/2007	Winter Storm
DR-3280	12/10/2007	Winter Storm
DR-1677	2/1/2007	Winer Storm
DR-3272	1/15/2007	Winter Storm
DR-1623	1/10/2006	Wildfire Threat

3.4 Hazard Probability Rating

The probability rating in the hazards below is based on the following criteria:

High = Event probable in next year
Medium = Event probable in next 3 years
Low = Event probable in next 5 years

Very Low	=	Event probable in next 10 years

Based on history and using the previously mentioned probability statements, probability was quantified as follows:

High	=	Event has 1 in 1-year chance of occurring ……. 100%
Medium	=	Event has 1 in 3 years' chance ……. 33%
Low	=	Event has 1 in 5 years' chance ……. 20%
Very Low	=	Event has 1 in 10 years' chance ……. 10%

Which result in the following ranges of probability:

High	=	greater than 33%
Medium	=	greater than 20%, but less than or equal to 33%
Low	=	greater than 10%, but less than or equal to 20%
Very Low	=	10% or less

Example: Broken Arrow has had 158 Hail events recorded in the last 58 years.
158 / 58 =2.724 x 100% = 272%, which would make it "High."

3.5 Review of Natural Hazards

3.5.1 Lightning

Description

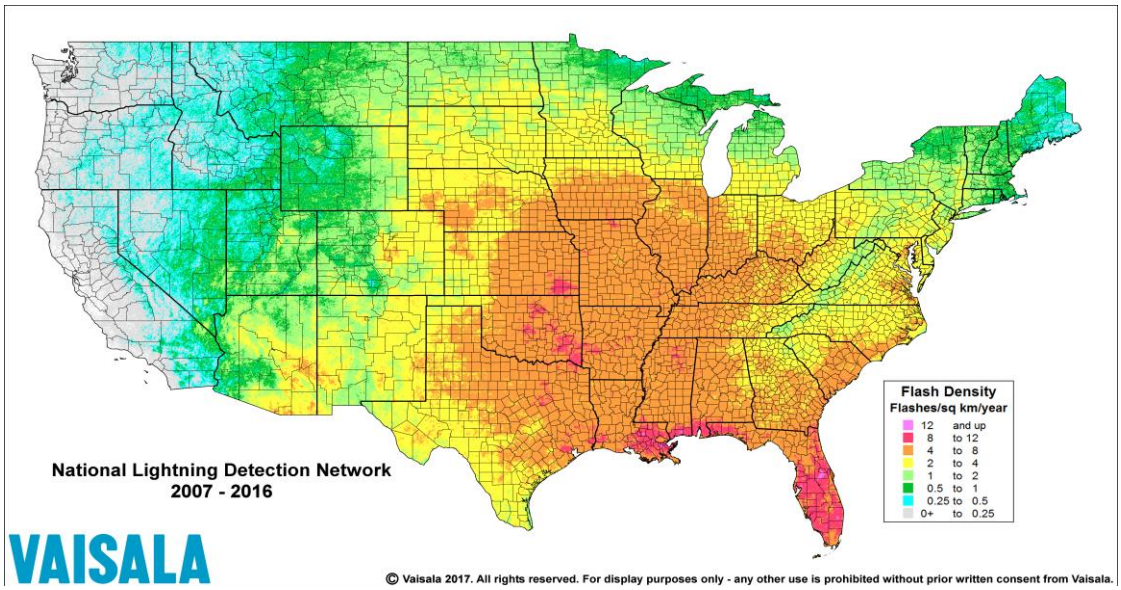
Lightning is a discharge of intense atmospheric electricity, accompanied by a vivid flash of light, from one cloud to another or from a cloud to the ground. Lightning is formed by the separation of positive and negative charges that occur when ice crystals collide high up in a thunderstorm cloud. As lightning passes through the atmosphere the air immediately surrounding it is heated, causing the air to expand rapidly. The resulting sound wave produces thunder.

Location

Lightning affects the entire planning area.

Extent

In the Planning Area thunderstorms with lightning can cause wildfires and downed power lines. Consequently, major crop damage and power outages occur. Lightning causes thousands of dollars in damages each year to homes, businesses, churches, barns, schools, and other structures. Businesses often are forced to close during power outages and, as a result, lose business. Thunderstorms with lightning have damaged buildings and power supplies, and downed electrical lines causing power outages.



The Vaisala map to the right shows a flash density of 4-8 flashes/square kilometer/year around the Planning Area. Records are not kept in the City of Broken Arrow or either School District on every lightning event, unless it causes major damage to structures or starts significant wildfires. The Planning Area considers all events which contain lightning to be severe events and warrant evasive actions.

Base on this information, this plan considers the following lightning events to be minor/major:

Minor severity: Any lightning strike that does not cause injury, death, or property damage.

Major severity: Any lightning strike that causes injury, death, or property damage.

Previous Occurrences

Lightning Events from 2005 to 2016

Date of Event	Disaster #	Location	Information/Damages
7/23/2005	N/A	City of Broken Arrow	Two teenagers were struck by lightning when it struck a tree under which they were playing. Both teenagers went into cardiac arrest as a result of the strike, but were revived and taken to the hospital. One of the teenagers later died (on October 11, 2005) from injuries and complications of those injuries. The other teenager was released after a prolonged period of hospitalization but must undergo extensive speech, physical and occupational health therapy as a result of the lighting strike.
7/24/2013	N/A	Union Public Schools	A lightning strike caused a large fire resulting in over $500,000 in damage to the Union 8th Grade Center.

Probability of Future Events

Considering history and the location of Oklahoma between the dry, arid southwest and the moist air from the Gulf of Mexico, the entire Planning Area has significant exposure to lightning events from storms. Lightning from associated storms can occur at any time of the year.

The probability of lightning events in the planning area is **high**.

Impact and Vulnerability

People, buildings, schools, trees, electrical systems and equipment, and electrical components are all vulnerable to a lightning strike. A few of the impacts of a lightning strike could include injury or death, structural damages, fire, downed electrical lines, and power loss to electrical substations.

The greatest vulnerability to lightning in the planning area is the potential loss of human life. Property damage can also occur to structures, electrical equipment, water wells, etc. Anyone outdoors during a thunderstorm is exposed to, and at risk of, injury from lightning. Most people are at risk for injury or death by lightning when participating in some form of outdoor recreation during a lightning event. The Family Aquatic Center swimming pool, Central Park, and Nienhuis Park Community Centers have installed early warning devices to further protect citizens. These devices due to age are needing to be replaced.

In the Planning Area, lightning has been responsible for setting fires to buildings causing loss of business, loss of employment, loss of homes, displacing the occupants and businesses. Electrical appliances and electronics often are destroyed by lightning, causing costly repairs or replacement.

The City of Broken Arrow has lighting detectors at our outdoor event parks. These devices are wearing out and must be replaced. Broken Arrow Public Schools and Union Public Schools have handheld lightning detection systems in place, but need to purchase more devices to cover more outdoor events. The cost of new handheld, and permanent mounted detection systems, are beyond the budgets of the Planning Area. In general, school officials will cancel outdoor events if lightning becomes a concern, although that system is vulnerable to varying perceptions of the severity of a lightning event.

3.5.2 Hail

Description

Hail is a form of solid precipitation that consists of balls or irregular lumps of ice, which are individually called hailstones. Hail formation requires an atmospheric environment of strong, upward moving air, called an updraft, within the subfreezing region of a thunderstorm cloud. Large hail stones greater than an inch in diameter (quarter size), can result from a severe thunderstorm and require a very powerful updraft to form. Most large hail is the product of supercell thunderstorms, which have a sustained rotating updraft that moves growing hailstones a long distance through the height of the cloud before falling to the ground.

Location

The entire Planning Area is susceptible to hail storms.

Extent

Oklahoma, including the City of Broken Arrow, has significant exposure to hail events. Stronger hail incidents are typically associated with severe thunderstorms and often extensively damage glass, roofs, vehicles, and vegetation. Based on the NOAA/TORRO Hailstorm Intensity scale, less intense thunderstorms frequently produce smaller, H2-size hail which may cause slight to significant damage to plants. The National Weather Service (NWS) and the Oklahoma Climatological Survey (OCS) have ongoing, early warning research to improve notification and threat information for the public. In spite of this research and the warning system currently available to the public, people are often injured trying to reach adequate shelter.

The onset of a hail event in our Planning Area depends on the severity of the thunderstorms. The information from the Tulsa National Weather Service in seeing hail cores in thunderstorms is very valuable information to prepare for these events. The duration of these hail events can last from just a few seconds to several minutes.

The City of Broken Arrow use the Hail Size/Diameter in Relation to TORRO Hailstorm Intensity Scale chart below when considering hail severity.

Minor severity: any hail of H3 and below.

Major severity: any hail of H4 or higher.

Hail Size/Diameter in Relation to TORRO Hailstorm Intensity Scale

Size code	Maximum Diameter (in)	Description
H0	up to 0.39	Pea
H1	0.40-0.60	Mothball
H2	0.61-0.80	grape
H3	0.81-1.20	Walnut
H4	1.21-1.60	Pigeon's egg > squash ball
H5	1.61-1.99	Golf ball > Pullet's egg
H6	2.00-2.40	Hen's egg
H7	2.41-2.99	Tennis ball > cricket ball
H8	3.00-3.50	Large orange > Soft ball
H9	3.51-3.99	Grapefruit
H10	4+	Melon

The City of Broken Arrow considers anything with a magnitude of H4 or higher as significant due to the economic hardship it creates for the citizens and visitors in the city. Once the size of hail reaches H5, it becomes disastrous to equipment, roofs and vehicles left outside unprotected.

Previous Occurrences

Hail Events of Major Severity from 2006 to 2016

Date of Event	Disaster #	Location	TORRO Size Code	Damages
7/28/2016	N/A	Planning Area	H5	Not known
7/14/2016	N/A	Planning Area	H5	Not known
3/25/2015	N/A	Planning Area	H5	Not known
5/30/3013	N/A	Planning Area	H4	Not known
4/17/2013	N/A	Planning Area	H5	Not known
4/22/2011	N/A	Planning Area	H4	Not Known

Information provided by the National Climate Data Center (NCDC)

Probability of Future Events

The entire Planning Area citizens and their property are vulnerable to hail storms. When damage occurs, it usually harms structural glass, roofs and vehicles. The City of Broken Arrow Hazard Mitigation Planning Team considered the possibility of future events based on past experience, and concluded severe thunderstorms, including hail, are expected in the future.

The probability of hail events of major severity in the planning area is **medium**.

Impact and Vulnerability

Stronger hail incidents are typically associated with severe thunderstorms and often causes extensive damage to glass, roofs, vehicles, and vegetation. Hail damage causes frequent roof replacements which is costly to both insurance companies and property owners. The Planning Area is susceptible to considerable damage to buildings and vehicles from hail. Although personal injury is not as likely during school activities, children waiting for school buses before school or during athletic events are at risk of injury. The Planning Area has a concern about roof top HVAC equipment being damaged due to a major hail event.

Some local builders and roofing companies offer high-impact roofing materials, but due to the additional costs these options are not widely used. These materials would be a valuable tool in the resilience to all buildings that support shelter operations for the citizens of our Planning Area.

All school districts have severe weather procedures in place to protect students from damaging hail. Neither school district, have bus barns to protect school buses. None of the schools in the Planning Area have high-impact roofing or impact-resistant window glass.

3.5.3 Tornado

Description

Tornados are violently rotating columns of air that reach from the bottom of a cumulonimbus cloud to the ground. Tornados are found in severe thunderstorms, but

not all severe thunderstorms produce tornados. While all tornados touch both the ground and the bottom of a cloud, it is possible for only part of the tornado to be visible. A tornado may be on the ground for only a few seconds, or last for over an hour. They can appear in a variety of shapes and sizes, ranging from thin, rope-like circulations to large, wedge-shapes greater than one mile in width. However, a tornado's size is not necessarily related to its wind speed. The strongest tornados can have wind speeds in excess of 200mph. In Oklahoma, most tornados occur between 3PM and 9PM, during the months of March through May, but may occur anytime the necessary atmospheric conditions of wind shear, lift, instability, and moisture are present.

Location

Tornados affect the entire Planning Area.

Extent

The range of magnitude from a tornado event in the Planning Area can experience the full range of the Enhanced Fujita scale below, mostly during the springtime of the year. But, in our Planning Area because of our location in the plains we can experience a tornado at any time of the year. The onset of a tornado event is dependent upon the thunderstorm itself or a line of thunderstorms associated with high gust front winds. The warning times for a tornado event can be from just a few minutes to a week of early notice with a forecast from the Tulsa National Weather Service. The duration of a tornado can be as quick as a few minutes to several minutes depending upon movement of the storm itself through the Planning Area.

The Fujita Scale has been used to rate tornados since its development in 1971. In 2007 the scale was further developed into the Enhanced Fujita Scale, which has been used since. Tornado wind speeds are estimated after-the-fact based on the damage they produce.

Enhanced Fujita (EF) Scale

EF Category	Wind Speed (mph)	Potential Damage
EF0	65-85	**Light Damage** Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over
EF1	86-110	**Moderate Damage** Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111-135	**Considerable Damage** Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object

		missiles generated; cars lifted off ground.
EF3	136-165	**Severe Damage** Entire stories of well-constructed houses destroyed; sever damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	166-200	**Devastating Damage** Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.

Previous Occurrences

Tornado Events from 2006 to 2016

Date of Event	Disaster #	Location	EF Scale	Damages
4/26/2016	N/A	2 miles SW of Planning Area	EF1	This tornado damaged industrial buildings, damaged the roofs of homes, and blew down trees and power lines. Based on this damaged, maximum estimated wind in the tornado was 90 to 100 mph. Most damage in Bixby area.
5/30/2013	N/A	2 miles SE of Planning Area	EF1	This is the first of two segments for this tornado. This tornado developed south of E 96th Street South and west of S 16th Street where it damaged roofs of homes, snapped or uprooted large trees, and destroyed barns as it moved northeast. Based on this damage, maximum estimated wind in this segment of the tornado was 100 to 110 mph. The tornado continued into Wagoner County, crossing County Line Road near E 94th Street South.

Information provided by the National Climate Data Center (NCDC)

Probability of Future Events

The probability of tornados in the planning area is **low**.

Impact and Vulnerability

Every structure in the planning area is vulnerable to tornados. Loss of utility service can affect large segments of the population for long periods of time. Economic losses to homeowners and businesses can be devastating. Cascading effects of power loss may include loss of water and sewer services, inability to fuel vehicles, and food spoilage, adding new challenges to disaster-stricken communities.

If a large tornado hit the center of the Planning Area, significant damage would occur to the economy of the area. The damage to infrastructure would be enormous with lost power, water, sewer, gas, and communications. Many key businesses could be destroyed or damaged enough to close for a long time. The Broken Arrow Expressway could be damaged or become blocked by debris from nearby homes, businesses and vehicles. In such a case interstate and intrastate commerce could be delayed or interrupted for days or even weeks. At best it would be detoured which would cost time and money for the affected businesses and companies. Drivers would need to find alternate transportation routes. Schools, hospitals, grocery stores, and other critical need and economically important facilities could sustain damage and close for extended periods. Business closings and employee lay- offs from loss of commerce would affect the area. Some businesses never re-open after a tornado and in fact some homes are abandoned without being cleared of debris. Damage and debris may block roads and bridges. Continuity of government would be severely limited and emergency response greatly hindered. The Broken Arrow School District in the Planning Area only has one out of twenty-four schools that have a FEMA standard safe room located at the Sequoyah Middle School. Union School District, also in the Planning Area, has no FEMA standard safe rooms.

3.5.4 High Wind

Description

High winds can result from thunderstorms, strong cold front passages, or gradient winds between high and low pressure. Damaging winds are often called “straight-line” winds to differentiate the damage they cause from tornado damage. Downdraft winds are a small-scale column of air that rapidly sinks toward the ground, usually accompanied by precipitation as in a shower or thunderstorm. A downburst is the result of a strong downdraft associated with a thunderstorm that causes damaging winds near the ground.

Location

High Wind affects the entire Planning Area.

Extent

The Beaufort wind scale is used to measure wind classifications between 1 and 12. Broken Arrow and its participating jurisdictions may be impacted by winds encompassing the entire range shown in the scale. The speed at which a Wind event can occur is very quick with little to no warning at all. The duration of such an event can be very quick such as a micro-burst, from a thunderstorm collapsing over the Planning Area.

The City of Broken Arrow considers high wind dangerous if the winds exceed 70 mph. Mobile homes are often negatively affected by winds of this speed. Winds in excess of 80 mph can cause damage to buildings and power service.

Beaufort Wind Chart – Estimating Winds Speeds

Beaufort Number	MPH Range	MPH Average	Terminology	Description
0	0	0	Calm	Calm. Smoke rises vertically.
1	1-3	2	Light air	Wind motion visible in smoke.
2	4-7	6	Light breeze	Wind felt on exposed skin. Leaves rustle.
3	8-12	11	Gentle breeze	Leaves and smaller twigs in constant motion.
4	13-18	15	Moderate breeze	Dust and loose paper is raised. Small branches begin to move.
5	19-24	22	Fresh breeze	Smaller trees sway.
6	25-31	27	Strong breeze	Large branches in motion. Whistling heard in overhead wires. Umbrella use becomes difficult.
7	32-38	35	Near gale	Whole trees in motion. Some difficulty when walking into the wind.
8	39-46	42	Gale	Twigs broken from trees. Cars veer on road.
9	47-54	50	Severe gale	**Light structure damage.**
10	55-63	60	Storm	**Trees uprooted. Considerable structural damage.**
11	64-73	70	Violent storm	**Widespread structural damage.**
12	74-95	90	Hurricane	**Considerable and widespread damage to structures.**

Webpage: http://www.weather.gov/iwx
Twitter: @nwsiwx
Facebook: NWSNorthernIndiana

Probability of Future Events

High winds affect the entire Planning Area.

Previous Occurrences

High Wind Events from 2006 to 2016

Date	Disaster #	Location	Information/Damages
7/28/2016	N/A	Planning Area	70 mph wind. Thunderstorms developed during the afternoon of the 28th along an outflow boundary that settled across northeast Oklahoma from earlier thunderstorms over southeast Kansas. The strongest storms produced damaging winds.
7/14/2016	N/A	Planning Area	75 mph wind. A small complex of thunderstorms developed across northeastern Oklahoma during the early morning hours of the 14th. The strongest of these storms produced damaging wind as they moved southeast across the area. Another complex of severe thunderstorms developed along a cold front over southern Kansas and central Oklahoma. These storms became very organized and intensified as they moved into unstable air over eastern Oklahoma during the late morning hours. The complex evolved into a fast-moving line of severe thunderstorms that produced widespread damaging wind that likely gusted to over 100 mph at times across northeastern Oklahoma. Widespread, significant wind damage resulted from these storms. Several gust front vortices, or so-called gustnadoes, were observed along the leading edge of the outflow from this complex. Some people were without power for nearly two weeks after this event. Some large hail and locally heavy rainfall also occurred with this storm system as it moved southeast across the area. Wind damage from these storms continued through the afternoon and evening hours across southwestern Arkansas, northern Louisiana, and western Mississippi, thus meeting the definition of a derecho.
3/25/2015	N/A	Planning Area	60 mph wind. Severe thunderstorms developed during the afternoon hours to the east of a surface low pressure system located over southwestern Oklahoma and near a stationary frontal boundary that was draped across northeastern Oklahoma. Several of these storms developed supercell characteristics due to a very unstable air mass that was in place over the region coupled with strong vertical wind shear.
10/2/2014	N/A	Planning Area	60 mph wind. Thunderstorms developed across eastern Oklahoma as a strong cold front moved through the region, and damaging wind gusts up to 85 mph.
5/30/2013	N/A	Planning Area	75 mph wind. A complex of storms that had been over portions of eastern Oklahoma during the early morning hours intensified during the late morning and afternoon resulting in isolated reports of large hail and damaging wind. A much more widespread severe weather event occurred later in the day as severe thunderstorms redeveloped across central and eastern Oklahoma during the afternoon hours ahead of a dry line over central Oklahoma and along an outflow boundary across northeastern Oklahoma. The storms produced damaging winds. A bow echo type of storm produced a

			brief tornado in northern Creek County during the afternoon. Two supercell thunderstorms moved along the outflow boundary from the morning thunderstorms and produced several tornadoes during the evening. Strong thunderstorm winds likely associated with the rear flank downdraft of the tornadic supercell snapped numerous large tree limbs south, north, and east of the intersection of E 101st Street South and Lynn Lane, in the Planning Area.
4/17/2013	N/A	Planning Area	64 mph winds. Thunderstorms developed along and south of a stationary frontal boundary that extended across southeastern Kansas through southwestern Oklahoma during the evening hours of the 17th. This frontal boundary surged southward as a cold front overnight, increasing the thunderstorm activity over eastern Oklahoma as it moved into warm, moist, and unstable air. The thunderstorms evolved into a bow echo that moved rapidly east-northeast across the region producing damaging winds. Tornadoes developed across northeastern Oklahoma in the storms that moved along the frontal boundary. Strong thunderstorm winds blew down large tree limbs in the Planning Area.
6/04/2012	N/A	Planning Area	65 mph thunderstorm wind estimated gusts snapped large tree limbs.
8/16/2012	N/A	Planning Area	74 mph winds. Strong thunderstorm wind blew down several trees location no identified in the report. Just that this happened in our Planning Area.
8/6/2011	N/A	Planning Area	70 mph winds. Late afternoon thunderstorms caused high winds in the Planning Area.
8/14/2010	N/A	Planning Area	70 mph winds. Strong thunderstorm wind blew down trees, fences, and damaged roofs of several homes, according to a report from the Tulsa National Weather Service, specific locations were not identified.
8/29/2007	N/A	Planning Area	70 mph wind. Micro-burst with wind speeds estimated at 70 mph.

Information provided by the National Climate Data Center (NCDC)

Probability of Future Events

Considering the history and location of Oklahoma between the dry, arid southwest and the moist air from the Gulf of Mexico, the entire Planning Area has significant exposure to high wind events. High Winds events occur in the Planning Area at any time of the year, the potential for a high wind event or even the possibility of a micro-burst is possible with each thunderstorm event.

The probability of high winds in the planning area is **high**.

Impact and Vulnerability

Damages from high winds may exceed those caused by tornados. Structural impacts might include window and roof damage, and inundation of facilities by heavy rain. In addition to structural issues, high winds can also affect electrical and other utilities

with service outages due to power lines grounding out or being knocked down. Transportation can be disrupted with the loss of stop lights and street lights, and dangerous cross winds could make travel difficult. The Broken Arrow and Union Public School Districts are vulnerable to high wind events. Their vulnerabilities are buses that are staged outside uncovered that could be impacted by flying debris/downed trees, having buses out of commission could cause delay and disruption to school transportation operations of moving students to/from school. Schools could also suffer from rooftop air conditioning/heating units being damaged from high wind, causing environmental discomforts within the school class rooms while the school is in session, outside awnings covering sidewalks or bus loading/unloading that protect students from the outside weather elements, could separate from their frame and cause injury to school property or children.

Wind-driven debris can penetrate windows, roofs, and even reinforced masonry walls, posing a threat to both property and occupants. The potential for injury or property damage due to flying debris exists in the entire Planning Area, but increases in population-dense areas and areas that are under construction/development. Given the high volume of population and housing development on the north and east side of Broken Arrow, the risk of injury due to flying debris is higher in these areas. The City of Broken Arrow also has 2 mobile home communities; Joanne Woods and Arrow Village. Due to the less-stable nature of mobile home construction, these communities are more vulnerable to high winds. In addition to increased injury risks, high wind damage can result in large amounts of debris for the City of Broken Arrow to pick up and dispose of in the landfill, increasing the cost of labor and equipment.

3.5.5 Winter Storm

Description

Winter Storm can refer to a combination of winter precipitation, including snow, sleet and freezing rain. A severe winter storm can range from freezing rain or sleet to moderate snow over a few hours to blizzard conditions and extremely cold temperatures that last several days.

Blowing snow is wind-driven snow that reduces visibility and causes significant drifting. Blizzards occur when falling and blowing snow combine with high winds of 35 mph or greater, reducing visibility to near zero.

Freezing rain is precipitation that falls, as liquid, into a layer of freezing air near the surface. When the precipitation makes contact with the surface, it forms into a coating or glaze of ice and even a small accumulation can cause a significant hazard.

Sleet is frozen precipitation that has melted by falling through a warm layer of the atmosphere and then refreezes into ice pellets before reaching the ground. Sleet usually bounces when hitting a surface and can accumulate like snow and cause a hazard to motorists.

Ice storms are extended freezing rain events, lasting several hours to sometimes days, when the freezing rain accumulates a thick enough glaze on surfaces to damage trees,

utility lines, and cause major travel hazards. Ice loads on overhead power lines, combined with windy conditions, may cause the lines to "gallop." This forceful motion often causes the lines to break away from the connectors and poles, resulting in widespread power failure.

Wind Chill is used to describe the relative discomfort and danger to people from the combination of cold temperatures and wind. The wind chill chart below from the National Weather Service shows the apparent temperature derived from both wind speed and temperature.

Location

The entire Planning Area has the potential for winter snow and ice storms.

Extent

The speed and onset of a Winter Storms in the past has had longer warning times giving the Planning Area more time to prepare for these events. The duration of these events has the potential to last for a few hours to more than a week. Due to the strength or magnitude of a potential Winter Storm the entire Planning Area must adjust its daily schedules in preparation for the event.

Wind Chills in the Planning Area can reach -19 as shown on the National Weather Service Wind Chill Chart below. A typical winter storm in Broken Arrow will deposit 1-3 inches of snow, accompanied by sleet and ice. A severe winter storm is one that drops 4 or more inches of snow during a 12-hour period, or 6 or more inches during a 24-hour span.

An index scale used by the utility industry to anticipate impact and damage of an icing event to transmission lines is the Sperry-Piltz Ice Accumulation Index (SPIA). As a tool for risk management and winter weather preparedness, the index uses National Weather Service forecast parameters to predict the spatial coverage, total ice accumulation, and potential damage from ice storms. The entire Planning Area considers:

Minor Severity: 1 or below on the SPIA chart.

Major Severity: 2 or above on the SPIA chart.

NWS Windchill Chart

Wind (mph)	Temperature (°F)																	
Calm	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	19	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 Sperry-Piltz Ice Accumulation Index, or "SPIA Index" – Copyright, February, 2009

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

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

Previous Occurrences

Winter Storm Events from 2006 to 2016

Date	Disaster #	Location	Information/Damages
2/5/2015	N/A	Planning Area	An arctic cold front moved through eastern Oklahoma late on the 14th and early on the 15th. A strong upper level disturbance moved into the Southern Plains late on the 15th, resulting in widespread precipitation developing across the region as warm and moist air was lifted over the low level cold air. A brief period of light rain quickly changed to freezing rain and sleet over much of northeastern Oklahoma. Some convection embedded in the precipitation resulted in rapid accumulations of sleet over a light accumulation of glaze. Some areas received between half an inch and an inch of sleet before precipitation changed over to snow during the early morning hours of the 16th. Much of the region received between three and six inches of sleet and snow. The rain gradually changed over to sleet over east central and southeastern Oklahoma during the late evening of the 15th. Sleet accumulations across this region were also in the half inch to nearly two inch amounts, with some embedded convection responsible for rapid accumulations.
3/2/2014	N/A	Planning Area	Arctic air surged south into eastern Oklahoma late on March 1st ahead of a strong upper level disturbance that moved from the Southern Rockies into the Southern Plains. Precipitation developed over the region as this system approached during the late evening of the 1st. Periods of light freezing rain and sleet occurred across much of the area through the morning of the 2nd. Thunderstorms developed over the shallow cold air near the ground and resulted in heavy sleet across a lot of the region through late afternoon. Snow developed into the area during the evening of the 2nd as the strong upper level disturbance finally translated across the area. The precipitation ended during the early morning hours of the 3rd. Several inches of snow and sleet covered much of the region and resulted in travel difficulties.
2/2/2014	N/A	Planning Area	A strong upper level disturbance moved into the Southern Plains from the southwest on February 2nd. Arctic air was already in place across eastern Oklahoma ahead of this system. Precipitation developed during the morning hours and continued into the late afternoon and evening hours. Light freezing rain and sleet fell across portions of southeastern Oklahoma early in the event, otherwise the precipitation fell as snow across the area. Portions of southeastern Oklahoma received between one half and one and a half inches of sleet with up to two tenths of an inch of ice. Four to seven inches of snow occurred across much of east central and northeastern Oklahoma during this event. Roads were snow and ice covered, resulting in numerous automobile accidents.
12/5/2013	N/A	Planning Area	Arctic air spread across eastern Oklahoma on the 4th as a strong storm system developed across the western United States. Several upper level disturbances moved through

			the south central part of the country on the 5th through the 6th, resulting in widespread wintry precipitation across the region beginning during the morning hours of the 5th. The precipitation fell as mainly freezing rain across southeastern Oklahoma and as snow and sleet across northeastern Oklahoma. The precipitation changed to all snow by the time it ended on the 6th. Several inches of snow fell atop the ice across southeastern Oklahoma while portions of northeastern Oklahoma received up to eight inches of snow from this storm. Roads were snow and ice covered across much of the region for days as temperatures remained below freezing.
2/8/2011	N/A	Broken Arrow	Record cold followed this storm with temperatures falling well below zero degrees Fahrenheit. Six to twelve inches of snow fell across the city.
1/28/2010	N/A	Planning Area	One quarter of an inch ice glaze occurred across the City, along with six inches of snow.
3/3/2008	N/A	Planning Area	Four inches of snow fell across the Planning Area.

Information provided by the National Centers for Environmental Information (NOAA)

Probability of Future Events

Not every Winter Storm is a hazardous event in our Planning Area. The Hazard Planning Committee used the previous charts and information from the Tulsa National Weather Service to determine the likelihood of this event occurring.

The probability of winter storms in the planning area is **high**.

Impact and Vulnerability

Ice accumulations of only ½ inch can immobilize the town and cause damage to infrastructure. As little as 2 inches of snow combined with strong winds can cause blizzard conditions.

The aftermath from a damaging winter storm can continue to impact a region for weeks and even months. Water systems being shut down or frozen can disrupt social services, schools. Personal health can be affected in a variety of ways including mental and physical stress, and frostbite.

Historically, power outages due to downed lines have occurred in both urban and rural areas of the Planning Area, and have lasted for periods of days to weeks. As a result, electric utilities have contingency plans and mutual aid agreements with neighboring utility providers. These plans identify priority facilities such as hospitals that need power service restored as quickly as possible. As new lines are considered and/or replacement lines are needed, the providers should thoroughly investigate underground lines. Due to the power outages with these events, stand-by generators are needed at the City of Broken Arrow Community Centers, and Police – Fire Training Center to be stood up as warming centers for our citizens and visitors who may be traveling through our city. The City of Broken Arrow has 376 lane miles to

keep clear of snow and ice from a winter storm. The City of Broken Arrow has 10 vehicles that are able to be used as snow plows. This equipment is becoming very worn and in some cases needs to be replaced. Because of this, significant delays in the clearing of roadways cause commuter traffic to become slower and causes delays for the citizens. The primary impact of winter storms on school districts in the Planning Area are school closures, sometimes for extended periods of time. Therefore, school districts have plans for early dismissal of students, as well as protection of buildings from the effects of extreme cold during periods of inaccessibility. The school districts are dependent upon the City of Broken Arrow to keep the main roadways clear of snow and ice. If the City of Broken Arrow is not able to clear the roadways of snow, ice or debris the school districts will need to cancel classes until the roadways are cleared.

3.5.6 Flood

Description

River flooding is when a river rises to its flood stage and spills over the banks. The amount of flooding is usually a function of the amount of precipitation in an area, the amount of time it takes for rainfall to accumulate, previous saturation of local soils, and the terrain around the river system. A river located in a broad, flat floodplain will often overflow to create shallow and persistent flood waters in an area that do not recede for extended periods of time. The excess water can be from snowmelt or rainfall far upstream. Flood effects can be local, impacting a neighborhood or community. The can also be very large, affecting entire river basins and multiple states.

Riverine flooding occurs when a stream becomes so full as to overflow onto adjacent lands. Sheet flooding occurs when excessive rainfall exceeds the design capabilities of drainage facilities and ponding occurs.

Location

The entire Planning Area is susceptible to flooding

Extent

The onset of a flooding event has a longer warning time due to the amount of rainfall that has occurred over the area, allowing for more time for the Planning Area to prepare for such an event. The duration can be from a few hours to several days depending on the amount of water in our streams and creeks. In the Planning Area flooding that peaks and retreats in a matter of hours is typically less damaging than flooding of the same depth that remains in place for several days. Severity of flooding is determined by several factors including rainfall intensity, duration, and location. Topography and ground cover are contributing factors for floods. The extent of flooding in Broken Arrow will be estimated by the Zone A and Zone AE 100-year flood hazard areas on the FIRM Panels. (See Appendix A Maps). The

maximum observed flood depths is up to twenty feet deep on major creeks like Haikey Creek or Broken Arrow Creek.

Previous Occurrences

Flooding Events from 2006 to 2016

Date	Disaster #	Location	Information/Damage
5/23/2015	N/A	Planning Area	A slow-moving upper level trough of low pressure moved from the Rockies into the Plains on the 23rd and 24th. Very moist and slightly unstable air was in place across the Southern Plains ahead of this system. Several rounds of thunderstorms developed and moved across eastern Oklahoma, resulting in widespread heavy rainfall and flash flooding. The road was flooded at E 81st Street and S 129th E Avenue and a vehicle stalled in the high water. Two other roadways were closed on Albany between County Line and South 209th EA, and the 13800 block of South 177th EA.
3/25/2015	N/A	Planning Area	Severe thunderstorms developed during the afternoon hours to the east of a surface low pressure system located over southwestern Oklahoma and near a stationary frontal boundary that was draped across northeastern Oklahoma. Several of these storms developed supercell characteristics due to a very unstable air mass that was in place over the region coupled with strong vertical wind shear. The storms evolved into a line during the evening hours and moved swiftly across eastern Oklahoma producing wind and hail to golf ball size. Locally heavy rainfall as a result of storms moving repeatedly across the same locations resulted in flash flooding. The river gage at Haikey Creek reported that the creek was out of its banks.
4/18/2013	N/A	Planning Area	Thunderstorms developed along and south of a stationary frontal boundary that extended across southeastern Kansas through southwestern Oklahoma during the evening hours of the 17th. This frontal boundary surged southward as a cold front overnight, increasing the thunderstorm activity over eastern Oklahoma as it moved into warm, moist, and unstable air. The thunderstorms evolved into a bow echo that moved rapidly east-northeast across the region, locally heavy thunderstorms moved repeatedly across the same areas causing flooding concerns. Flooding was reported near 111th Street South and Mingo Road.

Information provided by the National Climate Data Center (NCDC)

Probability of Future Events

The entire Planning Area is sometimes host to the remnants of hurricanes from the Gulf of Mexico. By the time they arrive in the Planning Area, however, they have been downgraded to Tropical Depressions. These storms tend to produce extremely heavy rains over a sustained period and often lead to flooding in the Planning Area.

The probability of flood events occurring in entire Planning Area is **low**.

Impact and Vulnerability

Floods in the Planning Area usually come in two forms: riverine and sheet flooding. Riverine flooding occurs when a stream becomes so full as to overflow onto adjacent lands. Sheet flooding occurs when excessive rainfall exceeds the design capabilities of drainage facilities and ponding occurs.

Flooding is a destructive force in the Planning Area, whether it occurs from the river streams, dam failure, or most often by the flash floods transpiring from overtaxed water drainage. Neither property nor lives are exempt from its ravages. In the Planning Area, numerous drivers steered their vehicles into flooded roadways and rendered them powerless because the water was higher and swifter than the person anticipated. Flood currents can sweep vehicles from the roadway into inundated ditches or rivers, or wash them downstream when motorists unknowingly drive into water covering "hidden washed-out roadway. It takes only 12 inches of flood water to float most vehicles. Flooded roadways often force people to find alternate transportation routes. Flooding impacts of the Planning Area includes many areas along streams and creeks that will eventually drain into the Arkansas River, south of the Planning Area closing some roadways, as in the May 25, 2015 flooding. One vulnerability is the erosion of Elm Creek on the south side of the bridge on West Shreveport Street, is in need of rip-rap to be added along stream or creek beds to prevent soil erosion around bridge and roadway. During the past ten years both the Broken Arrow and Union Public Schools Districts in the Planning Area have not experienced a flood event to any of their schools. In the event of a high rainfall event, drains or drainage creeks could become clogged with debris and cause water to back up into the parking lots that could cause water to back up into the schools. This could cause damage to floors and equipment that are located on or close to the floors.

Another issue all jurisdictions face is the general public not heeding public safety notifications, going around barricades, and driving through flooded roadways. The City of Broken Arrow distributes “Turn Around Don’t Drown” calendars prepared each year sponsored by the Oklahoma Flood Plain Managers Association to Broken Arrow citizens as an education and outreach project. The Oklahoma Floodplain Managers Association and Oklahoma Water Resources Board offers a program to distribute roadway signs to communities to place at known roadway overtopping locations. The City of Broken Arrow does participate in this program.

3.5.7 Extreme Heat

Description

Summertime temperatures routinely climb above the 100-degree mark, which can create very uncomfortable conditions when combined with high dew point. Temperatures that hover 10 degrees or more above the average heat temperature for an area, and last for several days or longer is one measure of extreme heat. In addition, humid or muggy conditions can persist and air quality can deteriorate during the summer when a dome of high atmospheric pressure creates a temperature inversion that traps a stagnant air mass near the ground.

Location

The entire Planning Area is at risk for extreme heat.

Extent

The onset of Extreme Heat is slow to progress, which allows time for the entire Planning Area to plan and prepare themselves. The duration of Extreme Heat can last from days, to weeks, and possible months. The Extreme Heat in the Planning Area can start as early as June and continue through September, or start as late as August and continue into the first part of October.

There are no uniform set of attributes that define extreme heat, although the NOAA/NWS Heat Index is widely used to gauge disorders due to prolonged heat exposure. The Planning Area during an Extreme Heat event will monitor the temperature and relative humidity values from the Tulsa National Weather service and use the chart below to determine the levels of caution needed for our area.

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution Extreme Caution Danger Extreme Danger

Previous Occurrences

Extreme Heat Events from 2006 to 2016

Date	Disaster #	Location	Information/Damage
8/10/2016	N/A	Planning Area	A strong ridge of high pressure in the middle and upper atmosphere over the south central and southeastern United States resulted in unseasonably hot weather across eastern Oklahoma during the middle of August. Afternoon temperatures in the upper 90s to near 100 prevailed across much of the area. This heat, combined with very humid conditions, resulted in heat index values in the 110 to 115 degree range during the afternoons of August 10th and 11th.
7/6/2016	N/A	Planning Area	A strong ridge of high pressure aloft centered over Texas resulted in a period of unseasonably hot weather over the area in early July. Temperatures on the 6th climbed into the upper 90s to near 100 degrees, and combined with very high humidity, this heat resulted in afternoon heat index values of 110 to 115 degrees across portions of northeastern Oklahoma.
6/15/2016	N/A	Planning Area	A strong ridge of high pressure aloft was anchored over the south central United States during the middle of the month. This pattern resulted in temperatures in the mid-90s to near 100 across much of eastern Oklahoma. This heat combined with unseasonably high humidity resulted in heat indices in the 110 to 115 degree range during the afternoons of the 15th through the 17th. Two heat-related fatalities occurred in Tulsa County during this period. One of the fatalities was the result of a man doing roofing work, and the other was a woman who was found dead in her home with no air conditioning. During this period, at least 29 other people were treated for heat-related illness in Tulsa County that required medical assistance.
7/14/2015	N/A	Planning Area	A ridge of high pressure in the middle and upper atmosphere centered over northern Texas promoted strong subsidence across eastern Oklahoma on July 14th. Sunny skies, unseasonably hot temperatures in the upper 90s, and unseasonably humid conditions resulted in heat index values of 110 to 115 degrees. Overnight low temperatures only fell into the upper 70s to near 80, allowing little relief from the heat
7/25/2014	N/A	Planning Area	The subtropical ridge of high pressure strengthened over the south central United States after it had weakened for a few days. Another period of dry and hot weather resulted across northeastern Oklahoma. High temperatures in the middle 90s to near 100 combined with high humidity resulted in afternoon heat index values in the 105 to 110-degree range. Overnight temperatures provided little relief from the heat, only falling into the middle to upper 70s.
5/26/2013	N/A	Planning Area	Unseasonably hot temperatures combined with very high humidity resulted in excessive heat across much of eastern Oklahoma. Temperatures climbed into the mid 90s to near 100 and heat index values ranged from 105 to 110 degrees. Very little relief was realized at night with temperatures only falling into the mid 70s to near 80

7/28/2012	N/A	Planning Area	Extremely hot temperatures and high humidity combined to produce dangerously hot weather conditions across much of eastern Oklahoma. Daily heat index values climbed into the 105 to 111 degree range with little relief occurring at night as temperatures only fell into the upper 70s to mid-80s. The temperature at the Tulsa International Airport only fell to 88 degrees the mornings of the 30th and 31st, becoming the all-time warmest daily low temperatures on record for the area.
7/9/2011	N/A	Planning Area	A strong ridge of high pressure in the middle and upper atmosphere redeveloped across the south central United States in mid-July resulting in strong subsidence over the region. High temperatures climbed to above 100 degrees on all but two days during the remainder of the month at the Tulsa International Airport and July 2011 went down as the second warmest July on record for that area since records began in 1905. Numerous record temperatures were exceeded this month across eastern Oklahoma. This heat combined with fairly high relative humidity values resulted in afternoon heat index values, or apparent temperatures, in the 105 to 115-degree range. Very little relief was realized during the overnight period as temperatures only fell into the upper 70s to mid-80s. This period of excessive heat continued into August
8/1/2010	N/A	Planning Area	A strong subtropical high pressure system reestablished itself over the south central United States during the end of July and this pattern persisted through the first several days of August. Exceptionally hot weather was the result with above normal daytime temperatures of 101 to 106 degrees, which combined with high humidity resulted in 110 to 115-degree heat index values. Little relief was felt at night as temperatures only fell to near 80 degrees during the overnight hours. The overnight low temperature recorded at the Tulsa International Airport the morning of August 3rd and 4th was 85 and 83 degrees, respectively, which are both usually warm even for northeastern Oklahoma in the summertime.
7/11/2009	N/A	Planning Area	A prolonged period of excessive heat occurred across eastern Oklahoma in mid-July. Daytime maximum heat indices ranged from 105 to 115 degrees with overnight low temperatures only falling to around 80 for several consecutive days. One direct fatality resulted from this period of excessive heat in Tulsa County.
8/1/2008	N/A	Planning Area	A prolonged period of excessive heat occurred across much of eastern Oklahoma during the early part of August. Daytime high temperatures reached the 100 to 105 degree range, daily maximum heat index values reached the 105 to 115 degree range, and morning low temperatures only fell into the upper 70s to lower 80s
8/6/2007	N/A	Planning Area	A strong ridge of high pressure developed over the south central United States early in the month. Few clouds under this ridge resulted in abundant sunshine and hot temperatures. The humidity was also high as a result of the spring rains that continued well into the summer. The combination of hot temperatures and high humidity resulted in daytime heat index values from 105 to 113 degrees across much of eastern Oklahoma. Overnight temperatures remained above 75 degrees, which didn't allow much relief from the heat.

https://www.ncdc.noaa.gov/stormevents/

Probability of Future Events

While extreme heat is a hazard for Oklahomans, efforts are being made throughout the state to mitigate the effects of the Extreme Heat Hazard. The National Weather Service now issues Excessive Heat Warnings by county through the NOAA Weather Radio. They are issued when the combined effect of high temperatures and high humidity result in daytime heat indices greater than or equal to 105 degrees Fahrenheit and nighttime ambient temperatures greater than or equal to 80 degrees Fahrenheit, persisting for two days or longer.

The probability of a future extreme heat event in the Planning Area is **high.**

Impact and Vulnerability

It is often extremely hot and humid during the summer in Oklahoma, including the Planning Area. The often extended higher than normal temperatures can result in the heat becoming a hazard to life and property. The City of Broken Arrow considers any extended period with temperatures above 90 degrees, and 60% humidity, as hazardous and cause for concern. Periodic health checks of the elderly and other at-risk populations are encouraged during these periods.

Extreme heat has many negative consequences. Most significant is its impact on humans and animals, because prolonged exposure to extreme heat can result in death. Young children, elderly people, and those who are sick or overweight are more likely to become victims to extreme heat. When temperatures reach 90 degrees and above, people and animals are more likely to suffer sunstroke, heat cramps, and heat exhaustion.

The humidity in the entire Planning Area is higher than Western Oklahoma counties because of its location in relation to the Gulf of Mexico, causing a higher heat index.

Increases in electrical power outages in the City of Broken Arrow are often due to high use of air conditioners. Some elderly citizens do not have air conditioners or fans that work, or refuse to use them because of high electric costs. Consequently, they often become victims of the severe high temperatures. Even senior citizens are often the victims of extreme heat deaths; persons with disabilities and the very young are also vulnerable. People working outside are susceptible to extreme temperatures. Work crew supervisors must take preventative measures to care for their work crews and watch for the signs of heat exhaustion and heat stroke. Additional rest (cool off) breaks, and reduced output due to the heat, can cause work projects to run behind schedule, which can be costly. Loss of employees who become ill due to the heat can also be costly.

The City of Broken Arrow utilizes three community centers as cooling stations for citizens who do not have access to air conditioning. These centers will also be used in times of disasters for sheltering areas for the Planning Area. These Centers do not have generator system backups. Therefore, a generator and power transfer switches are needed in these facilities in case of a power outage to maintain cooling areas.

The Planning Area Public School Districts are vulnerable when schools are starting their school year. The loss of air conditioning in the class rooms can cause issues with school children with the need for the school to move children to other parts of

the school or other school campus, putting pressure on other campuses with the extra student population.

3.5.8 Wildfire

Description

A wildfire is an uncontrolled fire in a rural or wilderness area. The majority of wildfires in Oklahoma occur in the late fall through winter and into early spring, which coincides with dormant vegetation and low precipitation. A wildfire often begins unnoticed and can spread quickly, lighting brush, trees, and structures. There are three different classes of wildfires. A surface fire is common in grasslands, or areas with open vegetation, and can spread quickly. A ground fire is a dense, very hot fire that has a thick fuel source and significantly damages the soil health where it occurs. Crown fires are those that move by jumping along the tops of trees. Wildfires often begin unnoticed, but are usually signaled by dense smoke that fills the area for miles around.

Location

The entire Planning Area is affected.

Extent

The onset of this hazard can be forecasted due to contributing factors such as, extreme heat, and drought, allowing the Planning Area a time to prepare and evacuate an area if needed. These contributing factors allow first responders to be on alert for wildland fires. The duration of a wildfire typically will last from a few hours to several days.

The Keetch-Byram Drought Index is useful for indicating the likelihood of wildfire based on soil moisture conditions. The National Fire Danger Rating System is used to convey the relative potential over a large area for fires to ignite, spread, and require suppression action. The Keetch-Byram Drought Index is more useful during the growing season to show the amount of dead fuel available during the fall and spring season. With the contributing factors and relative potential for dead fuels the Keetch-Byram Drought Index provides our Planning Area a guide to the type of wildland fires that has a potential of occurring in our area.

The Keetch-Byram Drought Index with Fire Danger Rating Data Incorporated	
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 thorough the night and heavier fuels will actively burn and contribute to fire intensity

Fire Danger Rating System

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 very fast rate	Fires start easily from all causes and immediately after ignition, spread rapidly and increase quickly in intensity. Spot fires are a constant danger. Fires burning in light fuels may quickly develop high-intensity characteristics - such as long-distance spotting - and fire whirlwinds, when they burn into heavier fuels. 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.

source: http://www.wfas.net/content/view/34/51/

Previous Occurrences

There have been no reported wildfires in the past 10 years.

Probability of Future Events

The probability of wildfire in the planning area is **low**.

Impact and Vulnerability

The entire Planning Area is south of the Snow Belt, leaving its grassy fuels exposed and vulnerable to fire in the dormant season. Located far enough north of the Gulf of Mexico, it is influenced by the continental climate in the winter. Summers are hot and usually dry with daytime highs in the mid-90s, and generally have less than six inches of rain in July and August. The Planning Area recognizes 10 months as fire season. Wildland fuels are prone to burning from July through April. Only May and June are not considered —fire season. Adding to the natural problem is an abundance of cedar trees near structures, which, along with the natural winds, cause fires to spread quickly. Based on past experience; dry conditions during 10 months of the year.

Periods of drought, dry conditions, high temperatures, and low humidity set the stage for wildfires. The sparsely populated tall grassed range lands are capable of experiencing large sweeping fires. Ironically, fire suppression is capable of creating larger fire hazards, because live and dead vegetation is allowed to accumulate in areas where fire has been excluded.

Based on past experience; and dry conditions 10 months out of the year; numerous small grass fires occur, and are quickly extinguished. The wooded areas in and around the Planning Area having a significant amount of tall grasses and weeds, there is the potential of future grass and wildland fires in the Planning Area. (see Appendix B for Broken Arrow Wildfire Urban Interface map). As shown on this map the entire planning area is vulnerable to wildfire.

Four out of five wildfires are human caused. The Planning Committee considers this to be the greatest risk to the Planning Area. For example, in the northeast area of Broken Arrow there is an open large field close to the Broken Arrow High School and a 40-acre housing development. A fire started carelessly could quickly spread across both areas. Likewise, in the northwest area of Broken Arrow, the Union Middle School and a Church are also situated near a large field to the east, and next to a highway. A stray cigarette thrown out a car window during dry conditions could easily ignite a dangerous wildfire. The impacts of a quickly spreading grass fire could be devastating to Broken Arrow, Broken Arrow PS, and Union PS. Many homes could be destroyed if a fire spread through the dense, 40-acre housing development in the northeast area of Broken Arrow, causing many citizens to lose their homes. A loss of a school due to wildfire would significantly disrupt the education of all high school students in the Planning Area, and the financial impact on the community would be devastating. Likewise, the loss of the Union Middle School due to wildfire would disrupt education services to a sizeable portion of students in the Planning Area, and the financial cost to restore the school facility would be a burden to the community.

Mitigation and rapid emergency response are the most effective activities for reducing the impact of wildfires**.** The City of Broken Arrow Fire Department participates with other fire departments in mutual – aid responses during wildfire events.

3.5.9 Drought

Description

A drought is a period of drier-than-normal conditions. If dry weather persists and water supply problems develop, the dry period can become a drought.

Location

The entire Planning Area is subject to drought conditions.

Extent

The strength of a drought in our Planning Area has the potential of causing wildfires and contribute to extreme heat. The onset of this hazard is slow to progress, this allows the Planning Area to plan and prepare, allowing time to warn our citizens, to conserve water, or water rationing if needed. The duration of this hazard can last from a few months to several years.

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 from the Climate Prediction Center. The planning area may experience -4.0 on the PDSI.

Palmer Drought Severity Index

	< -4.0	Extreme Drought
	-3.99 to -3.0	Severe Drought
	-2.99 to -2.0	Moderate Drought
	-1.99 to -1.0	Mild Drought
	-0.99 to -0.5	Incipient Drought
	-0.49 to 0.49	Near Normal
	0.5 to 0.99	Incipient Moist Spell
	1.0 to 1.99	Moist Spell
	2.0 to 2.99	Unusual Moist Spell
	3.0 to 3.99	Very Moist Spell
	> 4.0	Extreme Moist Spell

Previous Occurrences

According to the National Climatic Data Center (NCDC) records, (5) droughts have occurred in the Planning Area, from January 2015 through August 2011. The term, drought year, is used for identification in this plan because NCDC may consider several drought events during a single year.

Drought Events from 2006 to 2016

Date	Disaster #	Location	Information/Damage
5/1/2015	N/A	Planning Area	Widespread and locally heavy rainfall occurred across all of eastern Oklahoma during May 2015. As a result, severe drought (D2) to extreme drought (D3) conditions had been eliminated across Tulsa, Washington, Pawnee, and Osage Counties during the month. Monetary damage estimates resulting from the drought were not available.
4/1/2015	N/A	Planning Area	All of northeastern Oklahoma experienced below normal precipitation during the month of April. A large portion of the region only received between 25 and 75 percent of normal precipitation for the month. As a result, severe drought (D2) conditions continued across portions of Pawnee, Osage, Tulsa, and Washington Counties, while extreme drought (D3) conditions continued across portions of Pawnee and Osage Counties. Severe drought conditions improved into the moderate drought category across much of Creek County during the first two weeks of the month. Monetary damage estimates resulting from the drought were not available.
3/1/2015	N/A	Planning Area	All of northeastern Oklahoma experienced below normal precipitation during the month of March. A large portion of the region only received between 10 and 50 percent of normal precipitation for the month. As a result, severe drought (D2) conditions continued across portions of Pawnee, Osage, Creek, and Tulsa Counties and expanded into portions of Washington County during March. Extreme drought (D3) conditions developed across portions of Pawnee and Osage Counties. Monetary damage estimates resulting from the drought were not available.
2/1/2015	N/A	Planning Area	All of eastern Oklahoma experienced below normal precipitation during the month of February, despite several winter storms in the latter half of the month. A large portion of east central Oklahoma received below 25 percent of normal precipitation and most of northeastern Oklahoma received below 50 percent of normal values. As a result, severe drought (D2) conditions continued across portions of Pawnee, Osage, Creek, and Tulsa Counties during February. Monetary damage estimates resulting from the drought were not available.
1/1/2015	N/A	Planning Area	Most of northeastern Oklahoma received well below normal precipitation during January 2015. A large portion of the region only received between 25 and 50 percent of normal precipitation for the month. As a result, severe drought (D2) conditions continued across portions of Pawnee, Osage, Creek, and Tulsa Counties during January. Monetary damage estimates resulting from the drought were not available.
12/1/2014	N/A	Planning Area	Most of eastern Oklahoma received below normal rainfall during December 2014, and much of northeastern Oklahoma received less than 75 percent of normal precipitation for the month. As a result, severe drought (D2) conditions continued across portions of Pawnee, Osage, Creek, and Tulsa Counties during the month. Monetary damage estimates resulting from the drought were not available

11/1/2014	N/A	Planning Area	All of eastern Oklahoma received below normal rainfall during November 2014, with the exception of areas of Pawnee and Okfuskee Counties, and much of northeastern Oklahoma received less than 50 percent of normal precipitation for the month. As a result, severe drought (D2) conditions continued across portions of Pawnee, Osage, Creek, and Tulsa Counties during the month. Monetary damage estimates resulting from the drought were not available.
10/1/2014	N/A	Planning Area	Most of eastern Oklahoma received above normal rainfall during October 2014, with the exception of areas of Pawnee, Creek, Osage, and western Tulsa Counties where between 50 and 75 percent of normal rainfall occurred. Severe drought (D2) conditions continued across portions of those counties during the month with some improvement to the drought noted in Washington County by mid-month. Monetary damage estimates resulting from the drought were not available.
9/1/2014	N/A	Planning Area	Most of eastern Oklahoma received below normal rainfall during September 2014, with the exception of areas along the Kansas border, eastern Choctaw County, and portions of Sequoyah and northern Le Flore Counties. A lot of the region received between 25 and 50 percent of normal average precipitation for the month. Severe drought (D2) conditions continued across portions of northeastern Oklahoma, including Osage, Washington, Pawnee, Creek, and Tulsa Counties with some improvement noted in Nowata and Craig Counties during the month. Monetary damage estimates resulting from the drought were not available.
8/1/2014	N/A	Planning Area	Most of eastern Oklahoma received below normal rainfall during August 2014 with some areas not even receiving 10 percent of their normal average precipitation for the month. Severe drought (D2) conditions continued across much of northeastern Oklahoma, including Osage, Washington, Nowata, Craig, Tulsa, Rogers, Okfuskee, and Okmulgee Counties with extreme drought (D3) conditions persisting across portions of Creek and Pawnee Counties. Monetary damage estimates resulting from the drought were not available.
7/1/2014	N/A	Planning Area	Several unseasonably strong cold fronts passed through eastern Oklahoma during July 2014. Along with the mild temperatures that came with the fronts, some widespread rainfall fell across the area, especially across southeastern Oklahoma where rainfall was between 100 and 300 percent of the long-term climatological normal. Far northeastern Oklahoma experienced conditions that were drastically different during the month with a lot of the region only receiving between 25 and 50 percent of average rainfall for the month. The long-term drought conditions improved over southeastern Oklahoma but remained across much of northeastern Oklahoma. Severe drought (D2) conditions persisted during the month across portions of Okfuskee, Okmulgee, Tulsa, Washington, Rogers, Nowata, and Craig Counties with extreme drought (D3) conditions continuing across portions of Creek, Pawnee, and Osage Counties. Monetary damage estimates resulting from the drought were not available.

6/1/2014	N/A	Planning Area	June 2014 saw a number of organized, convective systems move through eastern Oklahoma. Although some widespread rainfall did occur across the region a few times during the month due to these thunderstorm events, much of the area, with the exception of far northeastern Oklahoma, received below average rainfall for the month. Extreme drought (D3) conditions improved to the severe drought (D2) category during June across Okfuskee, Washington, Nowata, and Craig Counties but remained across portions of Creek, Pawnee, and Osage Counties. Severe drought (D2) conditions also remained across portions of Rogers, Tulsa, Okmulgee, and Choctaw Counties. Monetary damage estimates resulting from the drought were not available.
5/1/2014	N/A	Planning Area	Isolated areas across eastern Oklahoma received slightly above average rainfall in May 2014 but most of the region experienced below average rainfall during the month. In fact, a lot of the area only received between 25 and 50 percent of normal rainfall. The continued dry weather in May, combined with the rather dry conditions that have prevailed across much of the region since the winter, promoted the spread of severe drought (D2) conditions across much of northeastern Oklahoma and far southeastern Oklahoma. Drought conditions worsened into the extreme drought (D3) category across portions of Okfuskee, Creek, Pawnee, Osage, Washington, Nowata, and Craig Counties. Monetary damage estimates resulting from the drought were not available.
5/1/2013	N/A	Planning Area	Widespread and heavy rainfall fell across much of eastern Oklahoma during May 2013. The region generally received between four and ten inches of rain during the month with some areas receiving in excess of fifteen inches. This month's rainfall, combined with rainfall over the past couple months, helped alleviate drought conditions across all of eastern Oklahoma. Severe (D2) to extreme (D3) drought conditions across a large portion of northeastern Oklahoma early in the month improved to abnormally dry (D0) to moderate drought (D1) by month's end. Monetary damage estimates as a result of the drought were not available.
4/1/2013	N/A	Planning Area	Several rainfall events during April 2013, combined with rainfall from previous months, helped to alleviate short-term drought conditions across much of eastern Oklahoma. Rainfall that fell during the month ranged from about 3 inches to as much as 10 inches across portions of the region. The lightest amounts generally occurred across far northeastern Oklahoma while the heaviest fell across east-central and southeast Oklahoma. As a result of this month's rainfall, drought conditions had improved from extreme (D3) to severe (D2) across Washington, Nowata, Craig, Pawnee, Tulsa, Rogers, and Creek Counties. Portions of Osage County remained in extreme drought (D3) during the month. Monetary damage estimates as a result of the drought were not available.
3/1/2013	N/A	Planning Area	Widespread and much needed rainfall fell across portions of eastern Oklahoma during March 2013. The exception was much of northeastern Oklahoma, where most locations received below half of the normal average precipitation for the month. Given the appreciable precipitation amounts that some of the area received in previous months, the additional rainfall that occurred this month helped to alleviate the long-

			term drought across some of the region. By the middle of the month, severe drought (D2) conditions had improved to moderate drought (D1) conditions over much of far eastern Oklahoma. Despite the improvement across some of the region, extreme drought (D3) conditions persisted across Creek, Osage, Pawnee, Washington, and Nowata Counties while severe drought (D2) conditions remained across Choctaw, Pushmataha, Pittsburg, McIntosh, Okfuskee, Okmulgee, Muskogee, Wagoner, Tulsa, Mayes, Rogers, and Craig Counties. Monetary damage estimates as a result of the drought were not available.
2/1/2013	N/A	Planning Area	Widespread and much needed precipitation fell across eastern Oklahoma during February 2013. All of the region with the exception of the far southeastern portion of the state received above average precipitation for the month. Several precipitation events affected the area during February with the most significant occurring in the latter portion of the month, bringing widespread rain and snow to the region. This precipitation resulted in improved drought conditions across all of the area, with the exception of Choctaw and Pushmataha Counties, which remained in extreme drought (D3) for the entire month. Much of Creek, Pawnee, Osage, Washington, and Nowata Counties also ended the month in extreme drought (D3) but this was an improvement from the exceptional drought (D4) conditions that had persisted in that region for several months. Monetary damage estimates as a result of the drought were not available.
1/1/2013	N/A	Planning Area	Several storm systems brought generally light precipitation to eastern Oklahoma during early to mid-January 2013. Toward month's end, a strong storm system moved across the region producing one half to more than three inches of rain as widespread showers and thunderstorms tracked across the area. As a result of this rain event on the 29th, portions of northeastern Oklahoma ended up receiving near normal to well above normal monthly precipitation while much of southeastern Oklahoma received well below normal precipitation. Due to the persistent dry pattern the area had experienced for much of 2012, the rainfall during January 2013 generally resulted in only a very slight improvement in the overall drought conditions over eastern Oklahoma. Much of the region remained in extreme drought (D3) conditions during the month while Osage, Pawnee, Washington, Creek, and Nowata Counties remained in exceptional drought (D4) conditions. Monetary damage estimates resulting from the drought were not available.
12/1/2012	N/A	Planning Area	Precipitation over eastern Oklahoma continued below normal during December 2012, ranging from 0.25 inches near the Kansas/Missouri border to nearly four inches locally in southeastern Oklahoma. Much of southeastern Oklahoma received between 75 and 90 percent of normal precipitation while much of northeastern Oklahoma north of I-44 only received between 10 and 25 percent of normal precipitation. As a result of this continued dry weather, most of eastern Oklahoma remained in extreme drought (D3) conditions while exceptional drought (D4) conditions continued across much of Osage, Pawnee, Washington, and Creek Counties. Monetary damage estimates resulting from the drought were not available.

11/1/2012	N/A	Planning Area	November 2012 was extremely dry across all of eastern Oklahoma. In fact, the entire region received less than 50 percent of its normal average precipitation for the month with much of the region south of I-44 receiving less than 25 percent of normal precipitation. Portions of far southeastern Oklahoma only received about 5 percent of normal precipitation for the month. For the southeastern climate region of the state, November 2012 was the second driest on record and rainfall received during the Autumn months also went down as the second driest Autumn period on record. As a result of this continued dry weather, most of eastern Oklahoma remained in extreme (D3) drought conditions while exceptional (D4) drought conditions persisted across much of Pawnee, Osage, Washington, and Creek Counties. Monetary damage estimates resulting from the drought were not available.
10/1/2012	N/A	Planning Area	Rainfall during October 2012 was once again below normal across much of eastern Oklahoma. The exception was across northern Tulsa County and much of Rogers County, where thunderstorms brought locally heavy rainfall to those areas during the middle of the month. Most of eastern Oklahoma received between 25 and 75 percent of normal rainfall for the month, while the east-central portion of the state received less than 25 percent of normal rainfall for that region. Severe (D2) to extreme (D3) drought conditions persisted across all of eastern Oklahoma during the month while exceptional (D4) drought conditions persisted across much of Pawnee, Osage, Washington, and Nowata Counties. Monetary damage estimates resulting from the drought were not available.
9/1/2012	N/A	Planning Area	Rainfall was once again sporadic across eastern Oklahoma during September 2012 with hot and dry weather dominating the region throughout much of the month. A few cold frontal passages did yield some much needed rainfall but it was too spotty to make a real difference in the ongoing drought conditions across the area. Despite a few locations actually receiving slightly above normal precipitation during the month, the area as a whole received between 25 and 75 percent of normal. Much of Osage and Pawnee Counties received less than 25 percent of normal average rainfall for the month. Exceptional (D4) drought conditions persisted during the month across much of northeastern Oklahoma along and north of I-44 while extreme (D3) drought conditions persisted across the remainder of eastern Oklahoma. Monetary damage estimates resulting from the drought were not available.
8/1/2012	N/A	Planning Area	Rainfall was typically sporadic for August across eastern Oklahoma. Much of the region received below average rainfall for the month with areas north of I-44 only receiving between 10 and 25 percent of normal rainfall. Given the prolonged period of unusually dry weather that the region has experienced, the precipitation that was received in August 2012 did little to improve the drought, which had slipped into the extreme (D3) category across much of eastern Oklahoma early in the month. Much of the area north of I-40 had moved into the exceptional drought (D4) category by the middle of the month. Monetary damage estimates resulting from the drought were not available.

7/1/2012	N/A	Planning Area	Very hot temperatures combined with a lack of appreciable rainfall resulted in significantly worsening drought conditions across all of eastern Oklahoma during the month of July. Much of northeastern Oklahoma received less than 25 percent of average precipitation for the month while much of the southeastern portion of the state received less than 50 percent of average monthly precipitation amounts. By the end of the month, much of eastern Oklahoma was considered to be in extreme drought (D3). The USDA declared all counties in eastern Oklahoma disaster areas due to the drought. Monetary damage estimates resulting from the drought were not available.
11/1/2011	N/A	Planning Area	Several precipitation events resulted in widespread, significant rainfall across much of eastern Oklahoma during the month with much of the region receiving between four and eight inches of precipitation. Rainfall totals for the month were from about 2.50 inches across portions of Osage and Pawnee Counties (about 75 percent of normal rainfall for the month) to 15 to 20 inches across southern Le Flore County (from 200 to 300 percent of normal rainfall for the month). As a result of this rainfall, drought conditions across much of eastern Oklahoma improved during the month with the exception of Osage, Pawnee, Washington, and Nowata Counties where severe drought conditions persisted. Monetary damage estimates resulting from the drought were not available.
10/1/2011	N/A	Planning Area	Several precipitation events during the month produced beneficial rainfall across portions of east-central Oklahoma but given the long-term shortage of precipitation across the area, it had little impact on the long-term drought. The northeastern and southeastern portion of the state experienced another month of below normal precipitation with some areas receiving between 10 and 25 percent of normal precipitation, so drought conditions in those regions persisted or even worsened in some cases. Severe to extreme drought conditions continued across all of northeastern and east-central Oklahoma while southeastern Oklahoma continued to experience exceptional drought conditions in October. Monetary damage estimates resulting from the drought were not available.
9/1/2011	N/A	Planning Area	A persistent subtropical ridge of high pressure continued to dominate the weather across the south central United States during September, resulting in prolonged hot and dry weather across the region. Most of eastern Oklahoma received below normal precipitation for the month. Large areas of Choctaw and Pushmataha Counties in the southeastern portion of the state received as little as 5 to 25 percent of the normal average precipitation for the month. As a result, exceptional drought conditions continued across Okfuskee, Creek, and Pawnee Counties and developed across Choctaw County. Extreme drought conditions persisted across much of the remainder of southeastern Oklahoma while severe drought conditions continued across the northeastern portion of the state during September. Monetary damage estimates resulting from the drought were not available.

8/1/2011	N/A	Planning Area	A persistent subtropical ridge of high pressure continued to dominate the weather across the south central United States during much of August, resulting in prolonged hot and dry weather across the region. As a result, drought conditions worsened during the early half of the month across eastern Oklahoma with Okfuskee, Creek, and Pawnee Counties slipping into exceptional drought conditions while severe drought conditions developed across the remainder of the region with the exception of the far northeast part of the state. Some relief was felt by month's end across northeastern Oklahoma as several precipitation events that affected that region resulted in a lot of the area ultimately receiving near to slightly above normal precipitation amounts for the month. Being that August is typically one of the driest months of the year in this region of the country, the effects of the long-term drought were only subtly improved by this rainfall. Monetary damages as a result of the drought were not available.
7/1/2011	N/A	Planning Area	A persistent subtropical ridge of high pressure over the south central United States during the month of July resulted in prolonged hot and dry weather across the region. There were a few days on which isolated to widely scattered thunderstorms occurred but these were far too few to have much effect. Much of eastern Oklahoma received precipitation amounts during the month that were well below average and some locations only received a few hundredths of an inch of rainfall during the entire month. As a result, severe to extreme drought conditions had redeveloped across the majority of the region by month's end. Monetary damages as a result of this drought were not available.

Information provided by the National Centers for Environmental Information (NOAA)

Probability of Future Events

Based on the history of five drought years in the past ten years, the BAHMPT considered the probability of future events and concluded that drought is possible in the future. Due to the duration of how long droughts can last, and information of occurrences from the past ten years.

The probability of future events is **high.**

Impact and Vulnerability

The entire Planning Area is susceptible to the effects of drought. In a severe drought, the effects of drought include increased woodland fires. Parched vegetation can produce fires in grazing lands, spreading to nearby structures. The dry, cracking soil can cause water lines to break, which can result in water loss to segments of the entire Planning Area. Highway and street pavement can crack and produce hazardous driving conditions for residents, and force them to find alternate routes. As water sources dry or become extremely low during a drought, water rationing may become necessary. Consequently, the City of Broken Arrow will limit or stop lawn watering, car washing, and other non-critical water uses in order to have sufficient water for potential fire needs and normal day-to-day critical needs.

Drought is a concern for the entire Planning Area, but because it is primarily an urban area. In the event of a drought and a need for water rationing, the most vulnerable populations within the entire Planning Area are those requiring large volumes of water such as industries, landscapers, fire fighters, and those dependent on them. With water rationing there is the potential of loss of landscaping around government buildings and schools. Xeriscaping for the entire Planning Area is a way to help government buildings and both school districts to practice water conservation. The City of Broken Arrow's main water source is the Verdigris River in northeastern Oklahoma. With the potential for a drought or other disaster that could affect the Verdigris River, the City of Broken Arrow has established an agreement with the City of Tulsa as a secondary source of water.

3.5.10 Dam Failure

Description

A dam is an artificial barrier usually constructed across a stream channel to impound water. Timber, rock, concrete, earth, steel or a combination of these materials may be used to build the dam. In Broken Arrow, four dams are situated on private property, but are subjected to State regulation. A dam that impounds water in the upstream area is referred to as a reservoir. The amount of water impounded 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. As a function of upstream topography, even a very small dam may impound or detain acre-feet of water. Two factors influence the potential severity of a full or partial dam failure: the amount of water impounded, and the density, type, and value of development and infrastructure located downstream.

Oklahoma Dam Failure Hazard Classification:

LOW HAZARD POTENTIAL: Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses.

SIGNIFICANT HAZARD POTENTIAL: Dams where failure or misoperation results in no probable loss of human life, but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant Hazard Potential dams are often located in predominantly rural or agricultural areas, but could be located in areas with population and significant infrastructure.

HIGH HAZARD POTENTIAL: Dams where failure or misoperation will probably cause loss of human life.

Location

Dam failure affects the entire Planning Area.

There is one High Hazard Potential dam in Tulsa County; the Keystone Lake Dam. It is owned and maintained by the Tulsa District, U S Army Corp of Engineers. Keystone Lake is located on the Arkansas River, about 35 miles northwest of Broken

Arrow in Tulsa County. It covers 4,100 acres and has a shoreline of 45 miles. The project was authorized by the Flood Control Act of 1950. It was designed by the Tulsa District, U S Army Corps of Engineers and built under the supervision of the Corps. Construction of the dam began in December 1956, and was completed for flood control operation in September 1964.

Extent

Keystone Dam is a federally regulated, High Hazard dam which falls under the jurisdiction of the US Army Corps of Engineers. The general location of the Keystone Lake Dam break inundation area is the floodplain along the Arkansas River through south Broken Arrow. The emergency action plan for this dam was prepared by the Corps of Engineers. Its inundation maps are classified as "for official use only" and are not distributed to the general public. The inundation area maps are on file with Tulsa Area Emergency Management Agency.

The damage caused by dam failure can vary widely depending on the level of failure. The table below shows the volume of water that would be released from the Keystone Lake Dam should the Surcharge Pool or the Flood Pool be discharged. If a complete failure of Keystone Lake Dam were to occur, flood waters could reach the Planning Area within 20 minutes.

Based on the information evaluated, the Planning Team considers:

Minor Severity Event: A dam failure when seepage or small breach where the water stays within the downstream river channel.

Major Severity Event: A breach large enough to exceed the capacity of the river or creek channel and overflow causing damage to homes, businesses, critical facilities, and state buildings, and putting people at risk.

Keystone Lake **Purpose:** Flood control, water supply, hydroelectric power, navigation, and fish and wildlife.	**Elevation**	**Incremental Storage**		**Cumulative Storage**	
	(feet)	**(inches)**	**(acre-feet)**	**(inches)**	**(acre-feet)**
Surcharge Pool:	757.00	0.14	166559	0.14	1727123
Flood Control Pool:	754.00	0.95	1128530	1.31	1560564

Previous Occurrences

There is no history of dam failure within Broken Arrow, or from the Keystone Lake Dam in Tulsa County.

Probability of Future Events

The probability a dam failure occurring in Planning Area is **low**.

Impact and Vulnerability

A Keystone Lake Dam failure, would affect personal safety, property, the economy, power and utilities, roadways and travel, recreation, and the environment within the Planning Area.

In the Planning Area the City of Broken Arrow would be affected by high water damage to city parks, buildings, and equipment. This would include the City of Broken Arrow's Sewer Treatment Plant located just north of the Arkansas River. The City of Broken Arrow also has one City Parks Office building and two equipment garages, that house park equipment, mowers and vehicles for city employees to use, 300 yards north of the Arkansas River. Losses to local residences from a Keystone Lake Dam failure or a high water release. Both Broken Arrow, Union Public Schools would be affected by water backing up in the creeks near the schools and in student's neighborhoods. Broken Arrow Public School does have one Elementary School in the flood plain of a dam failure, Indian Springs Elementary would be affected. Indian Springs Elementary is not being used for students, this school was moved to a newer school built three years ago, but could be used as back-up classrooms for the Broken Arrow School District if needed. According to the Oklahoma Water Resources Board (OWRB) and the National Inventory of Dams (NID), there are 4 earth dams in the Planning Area. All have been classified as Low Hazard Potential.

3.5.11 Earthquake

Description

An earthquake occurs when two blocks of the earth suddenly slip past one another. The surface where they slip is called the fault or fault plane. The location below the earth's surface where the earthquake starts is called the hypocenter, and the location directly above it on the surface of the earth is called the epicenter.

Most earthquakes occur as the result of slowly accumulating pressure that causes the ground to slip abruptly along a geological fault plane on or near a plate boundary. The resulting waves of vibration within the earth create ground motion at the surface that vibrates in a very complex manner.

Location

The entire Planning Area is at risk for earthquakes.

Extent

The size of an earthquake can be expressed quantitatively as a magnitude and the local strength of shaking as intensity. The inherent size of an earthquake is expressed using a magnitude. The following "Richter Scale" is the most commonly used scale.

Magnitude	Mercalli	Description	Earthquake Effects
2	I	Instrumental	Not felt except by a very few under especially favorable conditions.
	II	Feeble	Felt only by a few persons at rest, especially on upper floors of buildings.

Magnitude	Mercalli	Description	Earthquake Effects
3	III	Slight	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
	IV	Moderate	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
4	V	Rather Strong	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
5	VI	Strong	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
	VII	Very Strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
6	VIII	Destructive	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
7	IX	Ruinous	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
	X	Disastrous	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
8	XI	Very Disastrous	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
	XII	Catastrophic	Damage total. Lines of sight and level are distorted. Objects thrown into the air.

(http://earthquake.usgs.gov/learn/topics/mercalli.php)

The strength or magnitude of this hazard can be planned for in terms of a Major event. The durations of this hazard can be as short as a few seconds to a few minutes. The longer the duration of this hazard the more possible damage could possibly be affected. The use of the Mercalli scale included in this plan can be used as a planning tool for planning or response.

The Planning Area considers the following earthquake events to be minor/major:

Minor Event: An earthquake that registers as magnitude 3.9 or below.

Major Earthquake Event: An earthquake that registers as magnitude 4.0 or above.

Previous Occurrences

Tulsa County Earthquake Events from 2006 to 2016

Date	Disaster #	Location	Richter Scale Magnitude	Information/Damage

01/21/2011	N/A	Planning Area	1.7	Time 12:38:08 Depth of 0.59 km GPS 36.18656 x -95.9644
06/11/2011	N/A	Planning Area	2.2	Time: 04:05:01 Depth of 3.20 km GPS 36.23265 x -95.8401
10/18/2011	N/A	Planning Area	2.5	Time: 20:03:35 Depth of 5.00 km GPS 36.2244 x -95.8246
01/31/2013	N/A	Planning Area	2.1	Time 08:16:43 Depth of 8.20 km GPS 36.26583 x -95.8133
05/28/2013	N/A	Planning Area	2.2	Time 06:21:26 Depth of 6.30 km GPS 36.25032 x -95.833
05/28/2013	N/A	Planning Area	2.2	Time 06:03:05 Depth of 6.70 km GPS 36.18962 x -95.8341
5/28/2013	N/A	Planning Area	2.2	Time 06:08:54 Depth of 5.60 km GPS 36.22397 x -95.8346
09/08/2014	N/A	Planning Area	1.9	Time 16:02:24 Depth of 1.70 km GPS 36.22414 x -95.8427
11/16/2014	N/A	Planning Area	2.1	Time 10:03:00 Depth of 0.55 km GPS 36.22516 x -95.828
05/09/2016	N/A	Planning Area	1.7	Time 17:27:37 Depth of 8.7 km GPS 35.9065 x -95.9733

http://www.ou.edu/content/ogs/research/earthquakes/catalogs.html

Probability of Future Events

The entire Planning Area is at moderate risk for an earthquake as a result of its proximity to the New Madrid Seismic Zone. Northeast Oklahoma is the least active earthquake area in the state, including the entire Planning Area. Future felt earthquakes in the Planning Area are possible.

The potential of major severity earthquakes in the entire Planning Area is **low**.

Impact and Vulnerability

Earthquake damage can range from minor cracks in walls to collapse of buildings and roadways. Secondary impacts can include fires from ruptured pipelines, and catastrophic infrastructure failure leading to death, destruction, and long-term

displacement of business and commerce within affected areas. There is concern about the Keystone Dam located west of the Planning Area being damaged by an earthquake also. With the vulnerability of an earthquake and dam failure concerns of a possible flooding event could happen in our Planning Area.

Although Broken Arrow is in the geographic area of under the 2% peak ground acceleration (PGA) with a 10% chance of being exceeded over 50 years, it has seen a statistical uptick in earthquake activity over the past twenty years.

Despite the absence of injection well activity in Tulsa County, the issue of whether it leads to increased seismic activity is the subject of intense scrutiny which will be monitored by the mitigation team.

Most facilities in the Planning Area have not been constructed to withstand an earthquake, nor have residents been educated on what they can do to prevent injury from an earthquake event. More public education materials are needed to be distributed in the Planning Area

CHAPTER FOUR: MITIGATION STRATEGY

4.1 Capabilities Assessment

Each community has a unique set of capabilities, including authorities, policies, programs, staff, and funding, and resources to accomplish mitigation and reduce long-term vulnerability. By reviewing the existing capabilities in each jurisdiction, the planning committee identified capabilities that currently reduce disaster losses or could be used to reduce losses in the future. School Districts completed a capability assessment in March 2016, and that information is included at the end of this section.

4.1.1 Existing Institutions, Plans, and Ordinances

The checkmark (√) indicates that the City of Broken Arrow, Broken Arrow Public School, Union Public School has reported to have the authority to implement the specified regulatory tool and that the tool is currently in place.

Jurisdiction	Building Code	Zoning Ordinance	Subdivision Ordinance	Special Purpose Ordinance	Growth Management	Site Plan Review	Comprehensive Plan	Capital Improvement	Economic Development	Emergency Operations	Post-Disaster Recovery
City of Broken Arrow	√	√	√	√		√	√	√	√	√	
Broken Arrow Public School							√	√		√	

Union Public School								√		√	

Legal and Regulatory Capabilities

Subdivision ordinances offer an opportunity to account for natural hazards prior to the development of land as they formulate regulations when the land is subdivided. Subdivision design that incorporates mitigation principles can reduce the exposure of future development to hazard events.

Building Code

Building codes regulate construction standards and are developed for specific geographic areas of the country. They consider the type, frequency, and intensity of hazards present in the region. Structures built to applicable building codes are inherently resistant to many hazards such as strong winds, floods, and earthquakes, up to certain levels of severity. Due to the location-specific nature of the building codes, they are very valuable tools for mitigation.

Zoning Ordinance

Zoning is a useful tool to consider when developing a mitigation strategy. It can be used to restrict new development, require low-density development, and designate specific uses, (e.g. recreational), in hazard-prone areas. Private property rights must be considered, but enacting a zoning ordinance can reduce or potentially eliminate damages from future hazard events. According to the State Multi-Hazard Mitigation Plan, all local communities in the State are encouraged to incorporate mitigation standards in zoning and land use ordinances.

Subdivision Ordinance

Subdivision ordinances offer an opportunity to account for natural hazards prior to the development of land as they formulate regulations when the land is subdivided. Subdivision design that incorporates mitigation principles can reduce the exposure of future development to hazard events.

Special Purpose Ordinance

A special purpose ordinance is a form of zoning in which specific standards dependent upon the special purpose or use must be met. For example, many special purpose ordinances include basic development requirements such as setbacks and elevations. The community's floodplain management ordinance may be a special purpose ordinance. The special purpose ordinance is a useful mitigation technique particularly when implemented to reduce damages associated with flooding.

Site Plan Review Requirements

Site plan review requirements are used to evaluate proposed development prior to construction. An illustration of the proposed work, including its location, site

elevations, exact dimensions, existing and proposed buildings, and many other elements are often included in the site plan review requirements. The site plan reviews offer an opportunity to incorporate mitigation principles, such as ensuring that the proposed development is not in an identified hazard area and that appropriate setbacks are included.

Comprehensive Plan

A comprehensive plan is a document which illustrates the overall vision and goals of a community. It serves as a guide for the community's future and often includes anticipated demographics, land use, transportation, and actions to achieve desired goals. Integrating mitigation concepts and policies into a comprehensive plan provides a means for implementing initiatives through legal frameworks, and also enhances the opportunity to reduce the risk posed by hazard events.

Capital Improvement Plan

Capital Improvement Plans schedule the capital spending and investments necessary for public improvements such as school, roads, libraries, and fire services. These plans can serve as an important mechanism to manage development in identified hazard areas through limited public spending.

Economic Development Plan

Economic development plans offer a comprehensive overview of the local or regional economic state, establish policies to guide economic growth, and include strategies, projects, and initiatives to improve the economy in the future. Economic Development Plans, similar to Capital Improvement Plans, offer an opportunity to reduce development in hazard prone areas by encouraging economic growth in areas less susceptible to hazard events.

Emergency Operations Plan

Emergency Operations Plans provide an opportunity for local governments to anticipate an emergency and plan the response accordingly. In the event of an emergency, a previously established Emergency Response Plan can reduce negative effects of an event by pre-determining the responsibilities and means by which resources are deployed.

Post-Disaster Recovery Plan

A post disaster recovery plan guides the physical, social, environmental, and economic recovery and reconstruction procedures after a disaster. Hazard mitigation principles are often incorporated into post-disaster recovery plans in order to reduce repetitive disaster losses. The post disaster recovery plan is included as a chapter of the comprehensive plan.

4.1.2 Administrative and Technical Capability

The ability of a local government to develop and implement mitigation projects, policies, and programs is contingent upon its staff and resources. Administrative capability is determined by evaluating whether there are an adequate number of personnel skilled in surveying and Geographic Information Systems.

The checkmark (√) indicates that the local government reported that they maintain a staff position for the given function.

Administrative and Technical Capability										
Jurisdiction	**Planner(s) or Engineer(s) with knowledge of land development and management practices**	**Engineer(s) or professional(s) trained in construction practices related to buildings and fire**	**Planner(s) or Engineer(s) with an understanding of natural and/or human caused hazards**	**Floodplain Manager**	**Surveyors**	**Staff with education or expertise to assess the communities vulnerability to hazards**	**Personnel skilled in GIS and/or HAZUS**	**Scientists familiar with the hazards of the community**	**Emergency Manager**	**Grant writers**
City of Broken Arrow	√	Contract only	√	√	Contract Only	√	√	Contract Only	√	√
Broken Arrow Public School						√			√	
Union Public School						√				

Staffing Resources

Having a planner or engineer trained in land development, construction practices, or one who has an understanding of natural or man-made hazards are great resources to a community. Having their level of knowledge and expertise will help in the process of assessing and mitigating risks while limiting risk to new development or redevelopment.

Floodplain Management

By employing floodplain management, the City of Broken Arrow can protect its citizens against much of the devastating financial loss resulting from flood disasters. Careful local management of development in the floodplains results in construction practices that can reduce flood losses and the high costs associated with flood disasters to all levels of government.

Surveyors

Surveyors gather information that is needed by the city engineers or city projects that involve development or redevelopment. A surveyor records geographic conditions and man-made features as they currently exist. Other noted information might include: terrain, drainage, property boundaries and ownership, soil condition, and other physical features.

GIS/HAZUS

Geographical Information Systems (GIS) and HAZUS are powerful resources that the jurisdictions can be used to identify important facts about the community. HAZUS is methodology for estimating potential losses from earthquakes and floods. HAZUS uses GIS technology to estimate physical, economic, and social impacts of disasters.

Emergency Manager

An emergency manager performs administrative and technical work in the development, implementation, and coordination of the community's emergency management program. This position also acts as the authority in four phases of emergency management, disaster recovery efforts, oversees the disaster training, exercises and public awareness programs, and performs related duties as assigned.

4.1.3 Financial Capabilities

Financial Capability								
Jurisdiction	**Capital Improvements Project Funding**	**Authority to levy taxes for specific purposes**	**Water, Sewer, Gas, or Electric service Fees**	**Incur fees for new development**	**Incur debt through general obligation funds and/or special tax bonds**	**Community Development Block Grant**	**Federal funding programs**	**State funding programs**
City of Broken Arrow	√	√	√	√	√	√	√	√
Broken Arrow Public School	√	√					√	√
Union Public School	√	√					√	√

4.1.4. Education and Outreach Capabilities

Education & Outreach Capability						
Jurisdiction	**Local citizen groups/Non-profit organizations willing to assist with mitigation activities**	**Ongoing public education or information programs**	**Natural disaster or safety related programs**	**StormReady Certification**	**Firewise Communities Certification**	**Public-Private partnership initiatives addressing disaster-related issues**
City of Broken Arrow	√	√	√	√		√
Broken Arrow Public School	√	√	√			
Union Public School	√	√	√			

StormReady

StormReady is a national voluntary program, administered through the National Weather Service, which gives communities the skills and education needed to cope with and manage potential weather-related disasters, before and during the event. The program encourages communities to take a new pro-active approach.

Firewise

Firewise communities are those that have taken appropriate measures to become more resistant to wildfire structure damage. Firewise techniques include minimizing the risk of home ignition by carefully landscaping around residential structures such as thinning trees and brush and choosing fire-resistant plants, selecting ignition-resistant building materials, and positioning structures away from slopes.

4.1.5 Opportunities for Public Education and Outreach

Education opportunities exist for disseminating emergency preparedness information to diverse populations. Most, if not all of the following entities / capabilities were identified in the entire Planning Area:

- Amateur radio organizations
- Business/fraternal groups
- Chamber of Commerce
- Coalition meetings
- Local Emergency Planning Committees (LEPCs)
- National Weather Service storm spotter training
- Neighborhood watch programs
- Public education campaigns
- Emergency Management Public lectures
- Public Service Announcement (PSAs) and other social media campaigns
- City of Broken Arrow Special events
- Volunteer Organizations

4.1.6 School District Capability Assessment

School Districts were asked to provide information on their capabilities as they relate to those outlined for each participating jurisdiction. Each School answered the following questions:

Broken Arrow Public School

1. Has your school district had positive responses to bond issues? **Yes, recently passed a 370-million-dollar bond to upgrade facilities.**

2. Based on population, is the school district population growing or declining? **The school district is seeing a growth rate of 2% at the time of this plan update.**

3. Has the school district taken any measures to protect students during hazard events? **Yes, the school district built a safe room for students and staff.**

4. List any damages your school has experienced during the last 10 years due to weather events or natural disaster: **2011-2012 Heavy snow collapsed an awning; 2015-2016 a small metal roof blew off protective bus stop and hit two vehicles, and during a high wind event damaged awnings at the High School that had to be removed, during the same event track equipment was damaged. This was over $100,000 in damages.**

Other capabilities identified include: Broken Arrow Public School has Capital Improvements Plan. The district has an Emergency Action Plan and an ongoing Continuity of Operations Plan, which include the schematics of utility cut-offs.

Additionally, a transportation director is on staff. Broken Arrow Public School conducts drills multiple times each year to meet the state requirements for safety drills. The District also identified the following: local citizen groups willing to assist with mitigation activities, ongoing public education or information programs, natural disaster or safety related programs, public-private partnerships addressing disaster related issues. A School Emergency Response Team was established with local educators to enhance their school safety programs, and to provide educators with advanced training in dealing with major emergencies. The district can continue to expand on capabilities through continued education and coordination with Broken Arrow Emergency Management.

Union Public Schools

1. Has your school district had positive responses to bond issues? **Yes, the District most recently passed a $26-million-dollar bond and has passed an annual bond for more than 25 years.**

2. Based on population, is the school district population growing or declining? **The school district population has steadily increased in recent years.**

3. Has the school district taken any measures to protect students during hazard events? **Regular safety drills.**

4. List any damages your school has experienced during the last 10 years due to weather events or natural disaster: **The District suffered over $500,000.00 in damage in 2013 as a result of a fire caused by lightning.**

Other capabilities identified, the district has an Emergency Action Plan and an ongoing Continuity of Operations Plan in place. Additionally, a transportation director is on staff. Union Public School conducts drills multiple times each year and hazardous weather awareness programs. The District also identified the following: local citizen groups willing to assist with mitigation activities, ongoing public education or information programs, natural disaster or safety related programs, and public-private partnerships addressing disaster related issues. The district can continue to expand on capabilities through continued education and coordination with Broken Arrow Emergency Management.

4.1.7 Conclusion

The capability assessment finds that City of Broken Arrow and the participating school districts collectively have a significant level of legal, technical, fiscal tools, and resources necessary to implement hazard mitigation strategies. The City of Broken Arrow, including school districts have the legal capabilities, ordinances, and codes in place that have the potential to reduce loss due to a disaster. The City of Broken Arrow, including school districts have a range of staff who have knowledge

about hazards and their impacts. The Broken Arrow Emergency Management Department stands ready to provide assistance when needed.

The City of Broken Arrow, including school districts have financial resources that can be used towards mitigation. Most of those resources are Capital Improvement funds or General Obligation Bonds.

The City of Broken Arrow, including school districts have local citizen groups that are willing to assist in emergency management efforts. While these jurisdictions participate in the safety related school programs with the City of Broken Arrow being StormReady certified, none of the jurisdictions are a Firewise community. Tulsa County and Wagoner County solely utilize burn bans. The City of Broken Arrow follows the counties or state burn bans.

The Broken Arrow Hazard Mitigation Planning Committee put a significant amount of effort into making this plan a useful document. Because the information in this plan is relevant and was developed by the planning team members directly, the plan will be more easily integrated into the plans and ordinances listed in this section. The Emergency Manager for the City of Broken Arrow and each respective jurisdiction will provide a copy of this plan to parties responsible for other planning processes in the planning area. This document can be integrated into other plans when determining future growth areas, Capital Improvement projects, building code and ordinance proposals, and prioritizing local funds.

4.2 NFIP Participation

The City of Broken Arrow has been a National Flood Insurance Program (NFIP) Community since October 18, 1977, CID # 400236, and has adopted a Flood Damage Prevention Ordinance that restricts development in floodplain areas through a floodplain development permit system. Habitable structures are not allowed to be constructed or placed within the regulatory floodplain. A copy of this ordinance can be found on the City of Broken Arrow web page at www.brokenarrowok.gov or at the City of Broken Arrow Operations Building. The City of Broken Arrow also participates in the NFIP Community Rating System and is classified as a Class 5 CRS community.

The City of Broken Arrow Flood Damage Prevention ordinance is reviewed annually for compliance. In addition, reference material on flood hazards, flood insurance, and proper construction methods to all builders and residents applying for building permits.

The City of Broken Arrow has five repetitive loss residential properties according to NFIP in Tulsa and Wagoner Counties. The City of Broken Arrow Flood Plain Administrator is seeking assistance with funding from local, state, and federal agencies to purchase these repetitive loss properties to remove them from further flooding. Each year the Flood Plain Administrator participates in open public forms to explain and discuss flood plain management issues within our Planning Area.

4.3 Mitigation Goals

During the update of the Broken Arrow Hazard Mitigation Plan the goals were reviewed and were found to be adequate for the update of the plan**:**

Goal 1: To increase citywide ability to communicate and respond quickly and efficiently to disasters.
Goal 2: To enhance public awareness and understanding of hazard mitigation.
Goal 3: To reduce repetitive flooding in flood-prone areas in the City of Broken Arrow.
Goal 4: To develop and educate responders and health care providers regarding mitigated measures for specific hazards.
Goal 5: To enhance pre-disaster and prevention activities.

4.4 Action Items

Action Item 1	**Additional and Upgrade City-Wide Outdoor Warning Devices**
Hazard(s) Addressed	Tornado, Flood, High Wind
Jurisdiction(s)	City of Broken Arrow
Action	Purchase and install additional outdoor warning devices for the City of Broken Arrow in order to supplement current devices. The Emergency Management Director should review the effectiveness of the current warning devices and upgrade as needed and funds become available. Some current devices are not reaching all areas of the communities as growth has caused expansion beyond the capabilities of the original devices. Current systems need additional capability to warn communities of more than one hazard. Due to the age of some sirens, replacements are needed.
Responsible Party	Broken Arrow City Manager, Broken Arrow Emergency Management
Potential Implementation Timeline	3 years
Cost	$30,000 per unit, 60 units city wide (total=$1,800,000)
Potential Funding Sources	HMGP, Community Budget, REAP funds, Dept. of Agriculture and Dept. of Public Safety, INCOG
Current Action Status	This is an update from past Action Project 6 to help enhance or update outdoor public warning system. Completion 3 years after funding becomes available.
Mitigation Action Type	5% Projects
Action Item 2	**Purchase and Installation of Generators to Power Critical Facilities Generator Backup for Nienhuis Park Community Shelter**
Hazard(s) Addressed	Lightning, Hail, Tornado, High Wind, Winter Storm, Flood, Extreme Heat, Wildfire, Dam Failure, Earthquake.
Jurisdiction(s)	City of Broken Arrow, Broken Arrow and Union Public Schools
Action	Install transfer switch and backup generator to Nienhuis Park Community Center. This center would be used as a community shelter in the event of an

	emergency or disaster. This location would also be used as a reunification center for both schools if a school needed to be evacuated.
Responsible Party	City of Broken Arrow Engineering, Broken Arrow Emergency Management
Potential Implementation Timeline	1 year
Cost	$210,000-transfer switch and generator
Potential Funding Sources	HMGP, CDBG, City Budget
Current Action Status	New project for plan update
Mitigation Action Type	5% Projects
Action Item 3	**Purchase and Installation of Generators to Power Critical Facilities Generator Backup for Central Park Community Shelter**
Hazard(s) Addressed	Lightning, Hail, Tornado, High Wind, Winter Storm, Flood, Extreme Heat, Wildfire, Dam Failure, Earthquake.
Jurisdiction(s)	City of Broken Arrow, Broken Arrow and Union Public Schools
Action	Install transfer switch and backup generator for Central Park Community Center. This building would be used as a community shelter in the event of an emergency or disaster. This location would also be used as a reunification center for both schools if a school needed to be evacuated.
Responsible Party	City of Broken Arrow Engineering, Broken Arrow Emergency Management
Potential Implementation Timeline	1 year
Cost	$210,000-transfer switch and generator
Potential Funding Sources	HMGP, CDBG, City Budget
Current Action Status	New project for plan update
Mitigation Action Type	5% Projects

Action Item 4	**Purchase and Installation of Generator to Power Critical Facilities**
Hazard(s) Addressed	Lightning, Hail, Tornado, High Wind, Winter Storm, Flood, Extreme Heat, Wildfire, Dam Failure, Earthquake.
Jurisdiction(s)	City of Broken Arrow
Action	Install transfer switch and backup generator for Fire and Police Training Center. This building would be used as a backup EOC and City Offices in the event of an emergency or disaster if the main building became unusable.

Responsible Party	City of Broken Arrow Engineering and Broken Arrow Emergency Management
Potential Implementation Timeline	1 year
Cost	$210,000-transfer switch and generator
Potential Funding Sources	HMGP, CDBG, City Budget
Current Action Status	New project for plan update
Mitigation Action Type	5% Projects

Action Item 5	**Erosion of Elm Creek on West Shreveport St. Bridge**
Hazard(s) Addressed	Flood
Jurisdiction(s)	City of Broken Arrow
Action	Apply rip-rap to bridge embankment on West Shreveport Street between baseball and soccer fields to prevent deterioration of the roadway and bridge bed. Heavy rains frequently cause erosion of the creek banks.
Responsible Party	City of Broken Arrow Flood Plain Coordinator, City of Broken Arrow Streets and Stormwater Division.
Potential Implementation Timeline	3 years
Cost	$20,000
Potential Funding Sources	City Budget, OFMA grant, HMGP
Current Action Status	New project for plan update
Mitigation Action Type	Structure and Infrastructure Projects

Action Item 6	**Develop and Distribute Digital Mapping of Appropriate Areas Which Impact Disaster Mitigation and Disaster Recovery**
Hazard(s) Addressed	Lightning, Hail, Tornado, High Wind, Winter Storm, Flood, Extreme Heat, Wildfire, Drought, Dam Failure, Earthquake.
Jurisdiction(s)	City of Broken Arrow, Broken Arrow and Union Public Schools.
Action	GPS Identification and Mapping
Responsible Party	Emergency Management Director, City of Broken Arrow Floodplain Coordinator and GIS Coordinator

Potential Implementation Timeline	1 year
Cost	$25,000
Potential Funding Sources	City Budget, HMPG, OKFPM Grant
Current Action Status	Completion 1 year after funding becomes available.
Mitigation Action Type	5% Projects

Action Item 7	**Equipment & Training to Mitigate Wildfires**
Hazard(s) Addressed	Wildfires
Jurisdiction(s)	City of Broken Arrow
Action	Equip and train Broken Arrow Fire personnel to combat wildfires in the county.
Responsible Party	Broken Arrow Fire, Oklahoma State Forestry Services, Oklahoma State University Fire Service Training Center
Potential Implementation Timeline	3 years
Cost	$110,000
Potential Funding Sources	OK Forestry Service, City Budget
Current Action Status	Completion 3 years after funding becomes available.
Mitigation Action Type	N/A
Action Item 8	**Public Service Announcements**
Hazard(s) Addressed	Dam Failure, Drought, Earthquake, Extreme Heat, Flood, Hail, High Winds, Lighting, Tornado, Wildfire, Winter Storm
Jurisdiction(s)	City of Broken Arrow, Broken Arrow and Union Public Schools
Action	Develop PSA's to educate the public on hazards items on local cable channel
Responsible Party	Broken Arrow Emergency Management, Broken Arrow Communications
Potential Implementation Timeline	1 year
Cost	$10,000
Potential Funding Sources	Local budget funding, State and Federal Grants

Current Action Status	Completion 1 year after funding becomes available.
Mitigation Action Type	Education and Awareness Programs

Action Item 9	**Hazard Information**
Hazard(s) Addressed	Dam Failure, Drought, Earthquake, Extreme Heat, Flood, Hail Storm, High Winds, Lighting, Tornado, Wildfire, Winter Storm
Jurisdiction(s)	City of Broken Arrow
Action	Provide the different hazards information in monthly utility bills.
Responsible Party	Broken Arrow Communications, Broken Arrow Emergency Management
Potential Implementation Timeline	6 months
Cost	$5,000
Potential Funding Sources	Local Budget Funding
Current Action Status	Completion 6 months after funding becomes available.
Mitigation Action Type	Education and Awareness Programs

Action Item 10	**Lightning Detection Equipment**
Hazard(s) Addressed	Lightning
Jurisdiction(s)	City of Broken Arrow, Broken Arrow Public School, Union Public School
Action	Expand and upgrade the lightning warning systems at City owned buildings, Parks and sport complexes, and Public School grounds where students would be playing outside.
Responsible Party	Broken Arrow Parks and Recreation, Broken Arrow, and Union Public Schools
Potential Implementation Timeline	1 year
Cost	$150,000
Potential Funding Sources	Local Budget Funding, State and Federal Grants, HMGP
Current Action Status	Completion 1 year after funding becomes available.
Mitigation Action Type	5% Projects

Action Item 11	**Upgrade Construction Technique for Future Buildings**
Hazard(s) Addressed	Lightning, Hail, Tornado, High Winds, Winter Storm
Jurisdiction(s)	City of Broken Arrow, Broken Arrow Public School, Union Public School
Action	Use hail and wind resistant construction techniques when constructing new critical facilities. This will reduce loss of life and property, and continued operability of facilities during weather events. A continuous load path will also strengthen the integrity of facilities during winter storm events.
Responsible Party	City of Broken Arrow Engineering and Construction
Potential Implementation Timeline	3 years
Cost	$1,2000,000
Potential Funding Sources	HMPG, State and Federal Grants
Current Action Status	Completion 3 years after funding becomes available.
Mitigation Action Type	Structure and Infrastructure Projects

Action Item 12	**Emergency Responder Family Safety**
Hazard(s) Addressed	Winter Storms, Tornados, High Wind, Dam Failure, Flood, Earthquake
Jurisdiction(s)	City of Broken Arrow
Action	Take measures to assure safety for families of those responding to emergency hazards. Designate and upgrade training center to serve as temporary shelter place for responders' families to assemble in emergency or disaster conditions.
Responsible Party	Broken Arrow Emergency Management
Potential Implementation Timeline	1 year
Cost	$150,000
Potential Funding Sources	Local Budget Funding, State and Federal Grants
Current Action Status	Completion 1 year after funding becomes available.
Mitigation Action Type	N/A

Action Item 13	**Arkansas River Flood Plan**
Hazard(s) Addressed	Dam Failure, Flood
Jurisdiction(s)	City of Broken Arrow, Broken Arrow Public School, Union Public School
Action	Develop pre- and post-flood plans for the Arkansas River Floodplain
Responsible Party	City of Broken Arrow Flood Plain Manager and Broken Arrow Emergency Management
Potential Implementation Timeline	2 years
Cost	$50,000
Potential Funding Sources	Local Budget, State and Federal Grants
Current Action Status	Completion 2 years after funding becomes available.
Mitigation Action Type	N/A

Action Item 14	**Promote Xeriscaping**
Hazard(s) Addressed	Drought
Jurisdiction(s)	City of Broken Arrow, Broken Arrow Public School, Union Public School
Action	Promote the use of native plants for landscaping. These plants are better suited to withstand Oklahoma weather extremes and reduce the need for watering during drought periods.
Responsible Party	City of Broken Arrow Development Services, Broken Arrow Public and Union Public School Administration
Potential Implementation Timeline	2 years
Cost	$10,000
Potential Funding Sources	Local Budget, State and Federal Grants, HMGP
Current Action Status	Completion 2 years after funding becomes available.
Mitigation Action Type	Natural System Protection

Action Item 15	**Debris Management**
Hazard(s) Addressed	Dam Failure, Earthquake, Flood, High Winds, Tornado, Winter Storm
Jurisdiction(s)	City of Broken Arrow
Action	Update the City of Broken Arrow Debris Management to include devices that consume vegetative debris and smoke.
Responsible Party	City of Broken Arrow Streets and Stormwater, Broken Arrow Emergency Management
Potential Implementation Timeline	1 year
Cost	$250,000
Potential Funding Sources	Local Budget, State and Federal Grants
Current Action Status	Draft Debris Management Plan has been updated and submitted for local approval before sending to State of Oklahoma and FEMA Region VI. Completion 1 year after funding becomes available.
Mitigation Action Type	N/A

Action Item 16	**NOAA Weather Radio Program**
Hazard(s) Addressed	Dam Failure, Drought, Earthquake, Extreme Heat, Flood, Hail, High Winds, Lightning, Tornado, Wildfire, Winter Storm
Jurisdiction(s)	City of Broken Arrow, Broken Arrow and Union Public Schools
Action	Purchase, program and distribute NOAA weather radios to citizens of the Broken Arrow Community and Public Schools to receive hazard information from the National Weather Service.
Responsible Party	Broken Arrow Emergency Management
Potential Implementation Timeline	6 months
Cost	$1,000.00
Potential Funding Sources	HMPG, State and Federal Grants
Current Action Status	Completion 6 months after funding becomes available.
Mitigation Action Type	5% Projects

Action Item 17	**Safe Room Rebate Program**
Hazard(s) Addressed	High Winds, Tornado
Jurisdiction(s)	City of Broken Arrow, Broken Arrow Public, and Union Public School
Action	Implement grants for safe rooms for the Broken Arrow Community. All schools within the Planning Area are in need of FEMA approved storm shelters.
Responsible Party	Broken Arrow Emergency Management, Broken Arrow Public School, and Union Public School Administration
Potential Implementation Timeline	3 years
Cost	$1,000,000.00
Potential Funding Sources	HMPG, State and Federal Grants
Current Action Status	Deferred due to lack of funding at the local and state and federal level- ongoing
Mitigation Action Type	Structure and Infrastructure Project

Action Item 18	**Damage Resistant Glass**
Hazard(s) Addressed	Earthquake, Hail, High Wind, Tornado
Jurisdiction(s)	City of Broken Arrow, Broken Arrow Public School, and Union Public School
Action	Seek funding to provide damage-resistant glass replacements and/or install impact resistant window film on all city, school and critical facilities.
Responsible Party	City of Broken Arrow Engineering and Construction, Broken Arrow Public School, Union Public Center Administration
Potential Implementation Timeline	3 years
Cost	$100,000
Potential Funding Sources	Local Funding, State and Federal Grants, HMGP
Current Action Status	Completion 3 years after funding becomes available.
Mitigation Action Type	Structure and Infrastructure Projects

Action Item 19	**Inventory and Inspect Permitted Dams**
Hazard(s) Addressed	Dam Failure, Flood
Jurisdiction(s)	City of Broken Arrow
Action	Coordinate dam inspections and maintenance requirements, and appropriate documentation with dam owners. Maintain current list of Oklahoma Water Resource Board Permitted dams within Broken Arrow
Responsible Party	City of Broken Arrow Flood Plain Manager, City of Broken Arrow Engineering and Construction
Potential Implementation Timeline	1 year
Cost	$30,000
Potential Funding Sources	Local Budget, State and Federal Grants
Current Action Status	Completion 1 year after funding becomes available.
Mitigation Action Type	N/A

Action Item 20	**Repetitive Loss Properties**
Hazard(s) Addressed	Dam failure, Flood
Jurisdiction(s)	City of Broken Arrow
Action	Seeking funding options to acquire and remove Repetitive Loss Properties and repeatedly flooded properties where City plans identify acquisition to be the most cost effective and desirable mitigation measure.
Responsible Party	City of Broken Arrow Floodplain Administrator
Potential Implementation Timeline	3 years
Cost	$1,000,000.00
Potential Funding Sources	Local Budget, HMPG, PDM, FMA, SRL, RFC, State and Federal Assistance
Current Action Status	Completion 3 years after funding becomes available.
Mitigation Action Type	Structure/ Infrastructure Projects

Action Item 21	GIS Updating Storm Shelter Locations
Hazard(s) Addressed	High Winds, Tornado
Jurisdiction(s)	City of Broken Arrow
Action	Update GIS data base to include storm shelter layer, GPS coordinates on each shelter to be updated quarterly. Current Database is out dated.
Responsible Party	City of Broken Arrow Information Systems, Broken Arrow Emergency Management
Potential Implementation Timeline	3 years
Cost	$28,000
Potential Funding Sources	Local Budget funding, State and Federal Grants
Current Action Status	Completion 3 years after funding becomes available.
Mitigation Action Type	5% Projects

Action Item 22	Local CERT, SERT, Training
Hazard(s) Addressed	Dam Failure, Wildfire, Extreme Heat, Flood, High Winds, Tornado, Winter Storm, Earthquake, Drought, Lightning, Hail
Jurisdiction(s)	City of Broken Arrow, Broken Arrow and Union Public Schools
Action	Provide Neighborhood Community Emergency Response Training and supplies for local Neighborhoods of the Broken Arrow Community, and school districts that would like to provide instruction to their students.
Responsible Party	Broken Arrow Emergency Management, Broken Arrow and Union Public Schools.
Potential Implementation Timeline	1 year
Cost	$3500.00
Potential Funding Sources	HMGP, Local Budget Funding, State and Federal Grants
Current Action Status	Completion 1 year after funding becomes available.
Mitigation Action Type	Education and Awareness Programs

Action Item 23	Surge Protection
Hazard(s) Addressed	Extreme Heat, Hail, High Winds, Lightning, Tornado, Winter Storm, Earthquake
Jurisdiction(s)	City of Broken Arrow, Broken Arrow Public School, and Union Public School
Action	Install surge protection devices on all computer, electronics, and radio equipment critical facility operations of the City of Broken Arrow, Broken Arrow Public School, and Union Public School
Responsible Party	City of Broken Arrow Information Technology, Broken Arrow Public School, and Union Public School Administrations
Potential Implementation Timeline	1 year
Cost	$64,000
Potential Funding Sources	HMGP, Local Budget funding, State and Federal Grants
Current Action Status	Completion 1 year after funding becomes available.
Mitigation Action Type	5% Projects

Action Item 24	Stream Gauge Network
Hazard(s) Addressed	Dam Failure, Flood
Jurisdiction(s)	City of Broken Arrow
Action	Seek funding to implement a rain and stream gauge network for flood warnings through real-time data monitoring.
Responsible Party	City of Broken Arrow Floodplain Administrator
Potential Implementation Timeline	3 years
Cost	$975,000
Potential Funding Sources	OWRB, Local Budget Funding, HMPG, State and Federal Grants
Current Action Status	Completion 3 years after funding becomes available.
Mitigation Action Type	5% Projects

Action Item 25	Multi Language Public Information
Hazard(s) Addressed	Dam Failure, Drought, Earthquake, Expansive Soil, Extreme Heat, Flood, Hail, High Winds, Lightning, Tornado, Wildfire, Winter Storm.
Jurisdiction(s)	City of Broken Arrow, Broken Arrow Public School, Union Public School
Action	Ability to obtain or translate educational public safety information into other languages of residents living in the Broken Arrow Community.
Responsible Party	City of Broken Arrow Communications, Broken Arrow Public School, Union Public School Administration.
Potential Implementation Timeline	1 year
Cost	$50,000
Potential Funding Sources	Local Budget Funding, HMPG, State and Federal Grants.
Current Action Status	Completion 1 year after funding becomes available.
Mitigation Action Type	Education and Awareness Programs.

Action Item 26	Generator Power Backup
Hazard(s) Addressed	Lightning, Hail, Tornado, High Wind, Winter Storm, Extreme Heat, Wildfire, Earthquake
Jurisdiction(s)	City of Broken Arrow
Action	Install Generator Power Backup Systems on all Water and Sewer Lift Stations to supply power during a power outage. Without power to lift stations sewage in the Planning Area would a backup of sewage or no sewage flow.
Responsible Party	City of Broken Arrow Engineering and Construction
Potential Implementation Timeline	2 years
Cost	$975,000
Potential Funding Sources	Local Budget Funding, HMPF, State and Federal Grants
Current Acton Status	New action project for plan update
Mitigation Action Type	5% Projects

Action Item 27	Radio Communications System
Hazard(s) Addressed	Lightning, Hail, Tornado, High Wind, Winter Storm, Flood, Extreme Heat, Wildfire, Dam Failure, Earthquake
Jurisdiction(s)	City of Broken Arrow, Broken Arrow Public School, Union Public School
Action	Radio Communications Systems for interoperable communications between community partners. For preparedness and response to disasters
Responsible Party	City of Broken Arrow, Broken Arrow Public Schools, Union Public Schools
Potential Implementation Timeline	Three Years
Cost	$ 100,000
Potential Funding Sources	Local Budget, State and Federal Funds
Current Acton Status	Completion 3 years after funding becomes available.
Mitigation Action Type	N/A

4.5 Action Item Prioritization

The Broken Arrow Hazard Mitigation Planning Committee reviewed, analyzed, and prioritized the action items using the Social, Technical, Administrative, Political, Legal, Economic, and Environmental (STAPLEE) Method. This enabled the committee to ensure that an appropriate Cost Benefit performance was maintained. The mitigation goals previously listed were determined to have the greatest benefit in hazard reduction to the City of Broken Arrow. This priority remains the same from the previous plan, and will be readdressed in the five-year update to account for any growth and development in the planning area.

STAPLEE Evaluation

Category	Evaluation
Social	Is this project socially acceptable to the general public? Will the public at large be in favor of completing this project?
Technical	What kind of technical problems could arise? Do you need and engineering study? Land Owners consent? Historical, EPA, restrictions? Does the jurisdiction have staff with the technical knowledge that will be required to complete this project?
Administrative	Staffing for proper implementation of the plan will rely on existing members of the various agencies involved. It is the opinion of the committee that current staffing levels are insufficient, and this is due to budget constraints. Technical assistance is available from Indian Nation Council of Governments (INCOG) and various State agencies.

Political	Will the local government officials approve of this project and back it with the authority of their office?
Legal	Is there anything illegal involved in the project? Would this project result in a lawsuit or legal issues?
Economic	Economic issues were the predominant issues discussed by all concerned. Each entity felt the projects selected would help the community be better prepared for a disaster and would have a positive effect, including attracting additional business and recreation to the area. 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 projects. Special emphasis was given to cost benefit analysis during prioritization/
Environmental	Would there be any environmental impacts for this project? How will it affect the environment or your neighbors?

4.6 Integration of Data, Goals, and Action Items

The Broken Arrow Hazard Mitigation Plan will be incorporated into all plans with mitigation in mind, through a committee process to ensure mitigation efforts are maintained. To begin with, the mitigation goals and action items will be posted publicly to begin the process of public "buy-in." This is an important first step in educating the public on the benefits of hazard mitigation and encouraging communities to invest in proposed projects.

The tables listed in sections 4.1.1, 4.1.2, 4.1.3, and 4.1.4 outline the planning mechanisms that City of Broken Arrow, Broken Arrow Public Schools, and Union Public Schools have to incorporate hazard mitigation data, goals, and action items. This plan will be reviewed annually to look for opportunities for hazard mitigation into existing Emergency Action Plans, Capital Improvement Plans, building codes, and local regulations.

The City of Broken Arrow, Broken Arrow Public School, and Union Public School will evaluate all applicable mitigation action items annually to determine which ones can be incorporated into proposed bond issues.

CHAPTER FIVE: PLAN UPDATE PRIORITIZATION AND REVIEW

5.1 Changes in Jurisdictional Development

The City of Broken Arrow, Broken Arrow Public Schools, and Union Public Schools experienced some changes in development since the previous plan. There was a steady increase in population and new housing growth over the past three years. The City of Broken Arrow currently has 16 new housing subdivisions in construction, with another planned to break ground in 2018. The Broken Arrow All-Hazard Mitigation Plan was reviewed by members of the Broken Arrow Hazard Mitigation Planning Team. Who determined updating

was required to update information of Mitigation Action Items to reflect changes in development of mitigation needs for the City of Broken Arrow, Broken Arrow Public School, and Union Public School. Broken Arrow and Union Public Schools saw an increase in enrollment every year the past five years.

In general, the changes in development in the Planning Area has made our community more vulnerable to hazards. The upside of the new housing developments is that they are being built on open land areas which are vulnerable to wildfire, and this reduces that vulnerability. However, the developments cause other concerns. For example, the influx makes more citizens vulnerable to hazards like tornado and winter storm damage. Increased housing also changes the drainage structure, potentially causing more areas to be susceptible to flooding. In addition, increased population puts a strain on aging water treatment and sewer facilities, potentially impacting communities during times of drought.

5.2 Status of Previous Mitigation Action Items

Action Items Accomplished

Action Item	Hazard Mitigated	Jurisdiction Impacted
New Water Source	Drought, Wildfire	City of Broken Arrow
Public Education/Awareness Book	All Hazards	City of Broken Arrow
Annual Inspections	Dam Failure, Flood, Wildfire	City of Broken Arrow
Master Drainage Plan	Dam Failure, Floods	City of Broken Arrow

Action Items Not Accomplished

Action Item	Hazard Mitigated	Jurisdiction Impacted	Reason Not Accomplished	Is Action Item Still Relevant?
Safe room installation	Tornado, high wind, hail	City of Broken Arrow, Broken Arrow Schools, Union Public Schools	Lack of Funding, Broken Arrow Public Schools has two safe rooms under construction at this update	Y
Upgrade of Outside Warning Sirens	Tornado, High Winds, Flood	City of Broken Arrow, Broken Arrow Schools, Union Public Schools	Lack of Funding	Y
Water Treatment Process	Drought, Flood	City of Broken Arrow, Broken Arrow Schools, Union Public Schools	Lack of Funding	Y
Hazard Information	All Hazards	City of Broken Arrow	Ongoing	Y

Water Line Upgrade	Drought, Wildfire	City of Broken Arrow, Broken Arrow Schools, Union Public Schools	Lack of Funding	Y
Lightning Detection Equipment	Lightning	City of Broken Arrow, Broken Arrow Schools, Union Public Schools	Lack of Funding	Y
Sanitary Manhole Inspections	Dam Failure, Flood	City of Broken Arrow	Lack of Funding	Y
Emergency Responder Family Safety	Dam Failure, Earthquake, Flood High Wind, Tornado, Winter Storm	City of Broken Arrow	Ongoing, Lack of Funding	Y
Annual MHMP Meetings	All Hazards	City of Broken Arrow, Broken Arrow Schools, Union Public Schools	Not needed	N
Debris Management Plan	Dam Failure, Earthquake, Flood, High Winds, Tornado, Wildfire, Winter Storm	City of Broken Arrow	Waiting on City approval	Y

5.3 Changes in Jurisdictional Priorities

There has been a slight shift in priorities since the 2011 update of this plan. Due to the complexities of having safe room's accessible to the public, all jurisdictions have begun encouraging homeowners and landlords to install individual safe room's and on-site safe room's. The intent is to reduce the road traffic during a hazardous weather event and to encourage residents to shelter-in-place.

In addition, the City of Broken Arrow and all participating school districts have also experienced an increase of earthquake activity. Although no damage has been reported, the community is interested in receiving more education as to how earthquake damage can be mitigated.

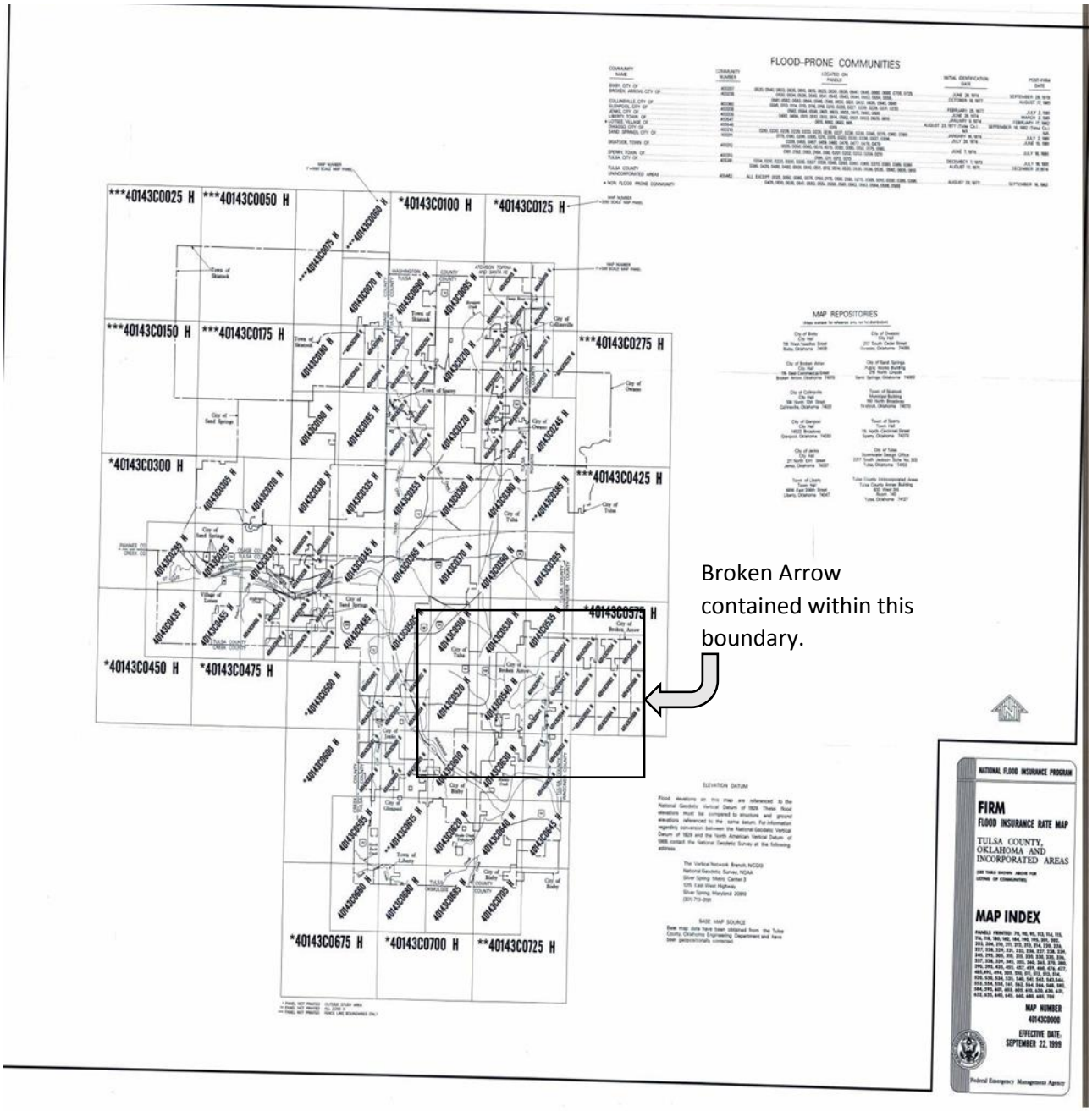
5.4 Conclusion

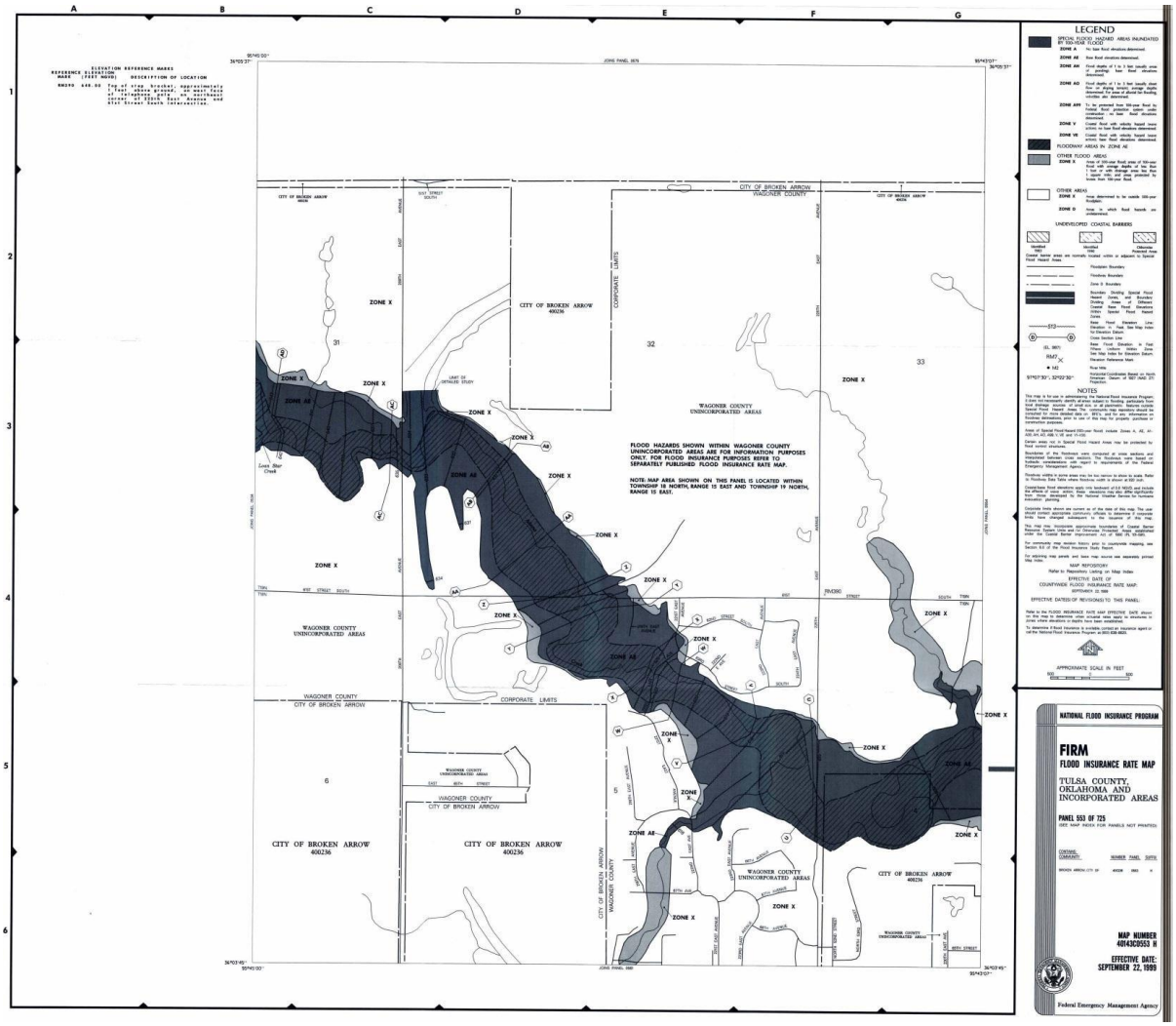
The Broken Arrow Planning Committee understands the importance of regular evaluation of this plan, to include the action items listed, The Committee will guarantee that this plan serves as a useful tool for all participating jurisdictions. The public also has a vital role to serve in this process. Continuing to canvas public feedback and incorporating it into the evaluation process is a critical step in ensuring our mitigation resources and actions will benefit the highest number of Broken Arrow citizens.

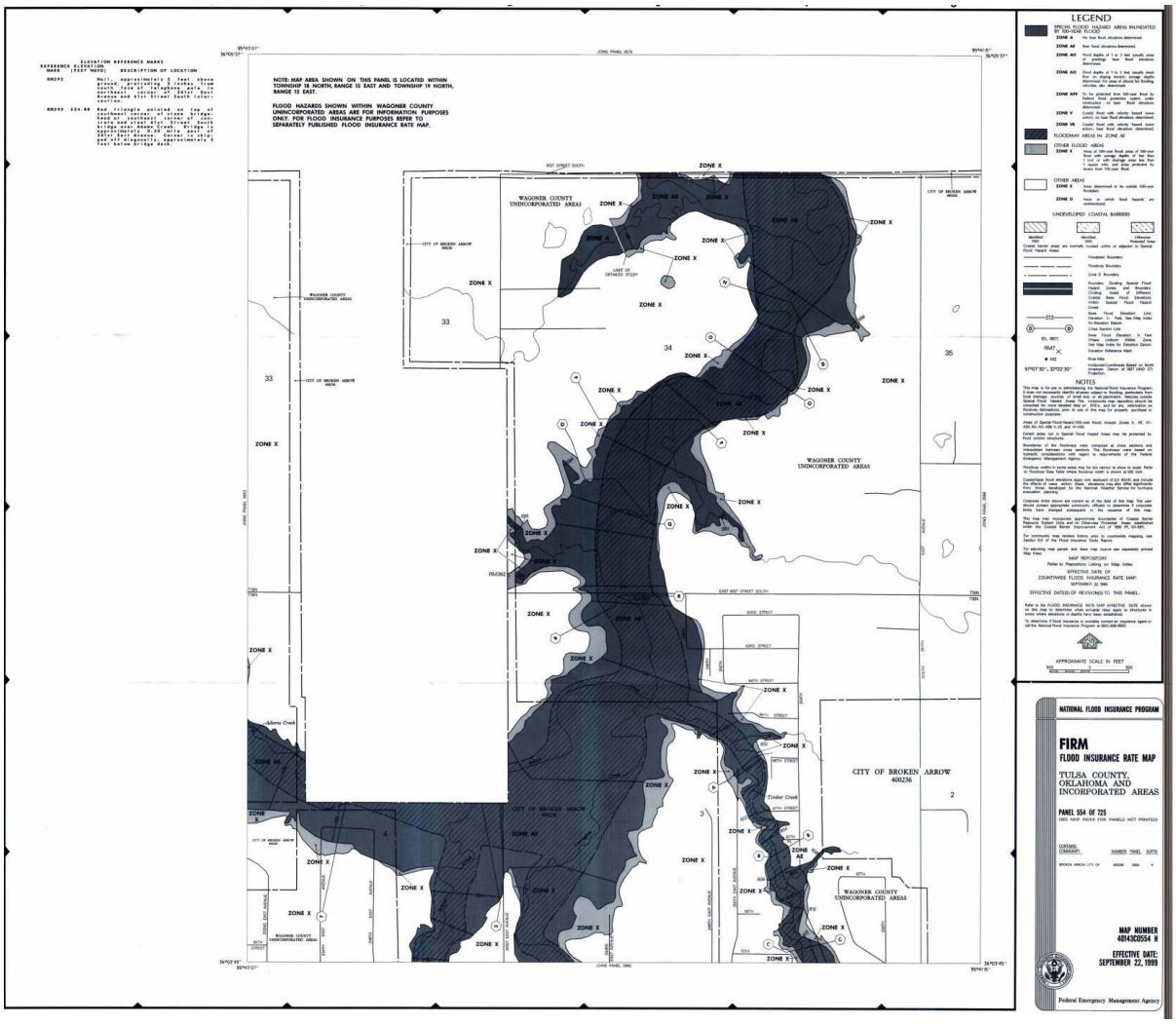
The City of Broken Arrow, Broken Arrow Public School, and Union Public School will submit plan for adoption pending approval from State of Oklahoma and Federal Emergency Management Agency (FEMA)

Appendix A Maps:

FIRMS Maps – Broken Arrow, Wagoner County




LEGEND
NOTES
FLOOD HAZARDS SHOWN WITHIN WAGONER COUNTY UNINCORPORATED AREAS ARE FOR INFORMATION PURPOSES ONLY. FOR FLOOD INSURANCE PURPOSES REFER TO SEPARATELY PUBLISHED FLOOD INSURANCE RATE MAP.
NOTE: MAP AREA SHOWN ON THIS PANEL IS LOCATED WITHIN TOWNSHIP 18 NORTH, RANGE 15 EAST AND TOWNSHIP 19 NORTH, RANGE 15 EAST.
ZONE X
ZONE AE
CITY OF BROKEN ARROW 400236
WAGONER COUNTY UNINCORPORATED AREAS
CORPORATE LIMITS
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
TULSA COUNTY, OKLAHOMA AND INCORPORATED AREAS
PANEL 553 OF 725
MAP NUMBER 40143C0553 H
EFFECTIVE DATE: SEPTEMBER 22, 1999
Federal Emergency Management Agency


NOTE: MAP AREA SHOWN ON THIS PANEL IS LOCATED WITHIN TOWNSHIP 18 NORTH, RANGE 15 EAST AND TOWNSHIP 19 NORTH, RANGE 15 EAST.
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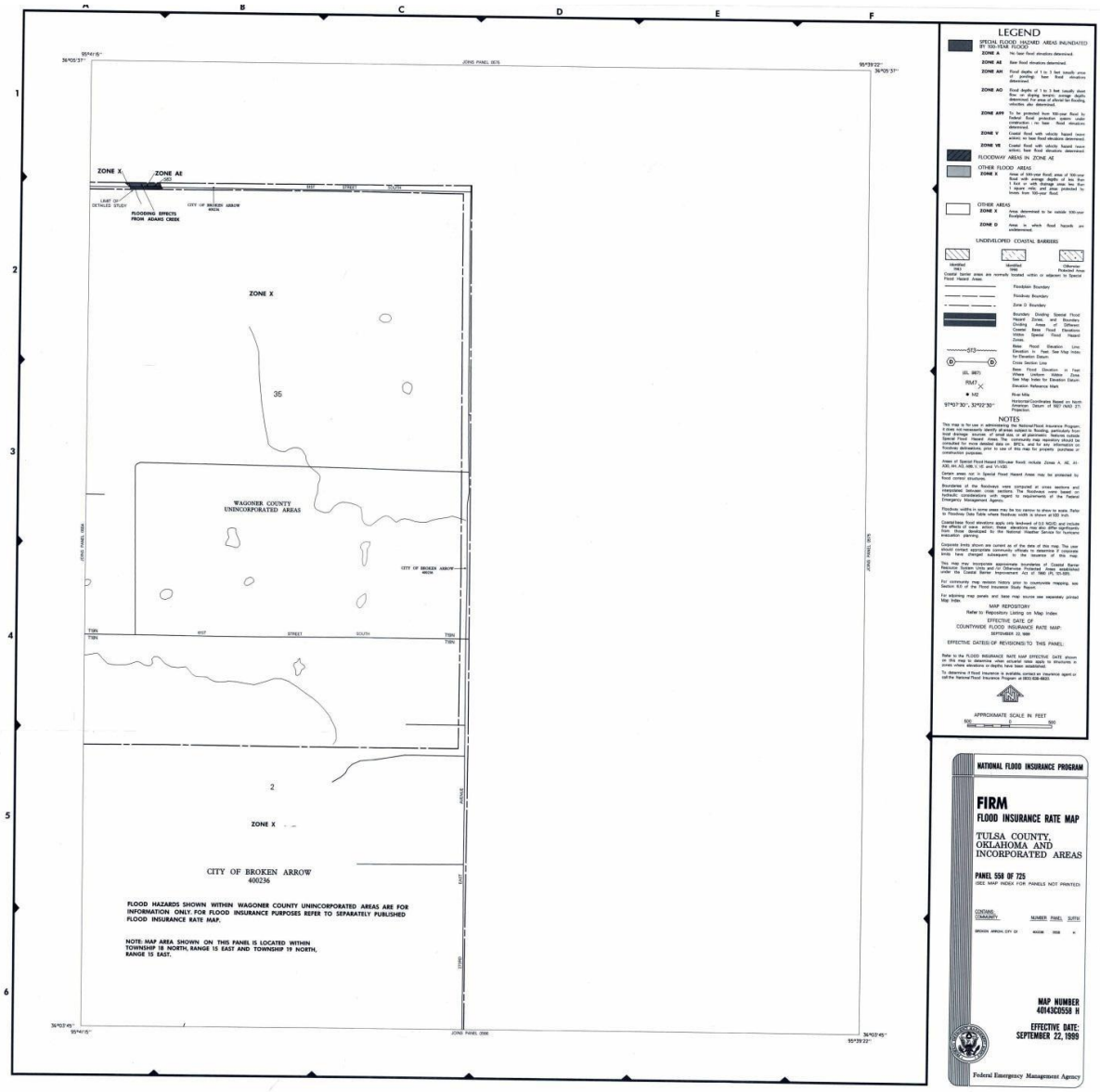
ELEVATION REFERENCE MARKS
LEGEND
NOTES
WAGONER COUNTY UNINCORPORATED AREAS
CITY OF BROKEN ARROW 400236
ZONE X
ZONE AE
LIMIT OF DETAILED STUDY
Tiadaw Creek
Adams Creek
JOINS PANEL 0575
JOINS PANEL 0582
JOINS PANEL 0555
JOINS PANEL 0580
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
TULSA COUNTY, OKLAHOMA AND INCORPORATED AREAS
PANEL 554 OF 725
MAP NUMBER 40143C0554 H
EFFECTIVE DATE: SEPTEMBER 22, 1999
Federal Emergency Management Agency


ZONE X
ZONE AE
FLOODING EFFECTS FROM ADAMS CREEK
ZONE X
35
WAGONER COUNTY UNINCORPORATED AREAS
2
ZONE X
CITY OF BROKEN ARROW
400236
FLOOD HAZARDS SHOWN WITHIN WAGONER COUNTY UNINCORPORATED AREAS ARE FOR INFORMATION ONLY. FOR FLOOD INSURANCE PURPOSES REFER TO SEPARATELY PUBLISHED FLOOD INSURANCE RATE MAP.
NOTE: MAP AREA SHOWN ON THIS PANEL IS LOCATED WITHIN TOWNSHIP 18 NORTH, RANGE 15 EAST AND TOWNSHIP 19 NORTH, RANGE 15 EAST.
LEGEND
NOTES
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
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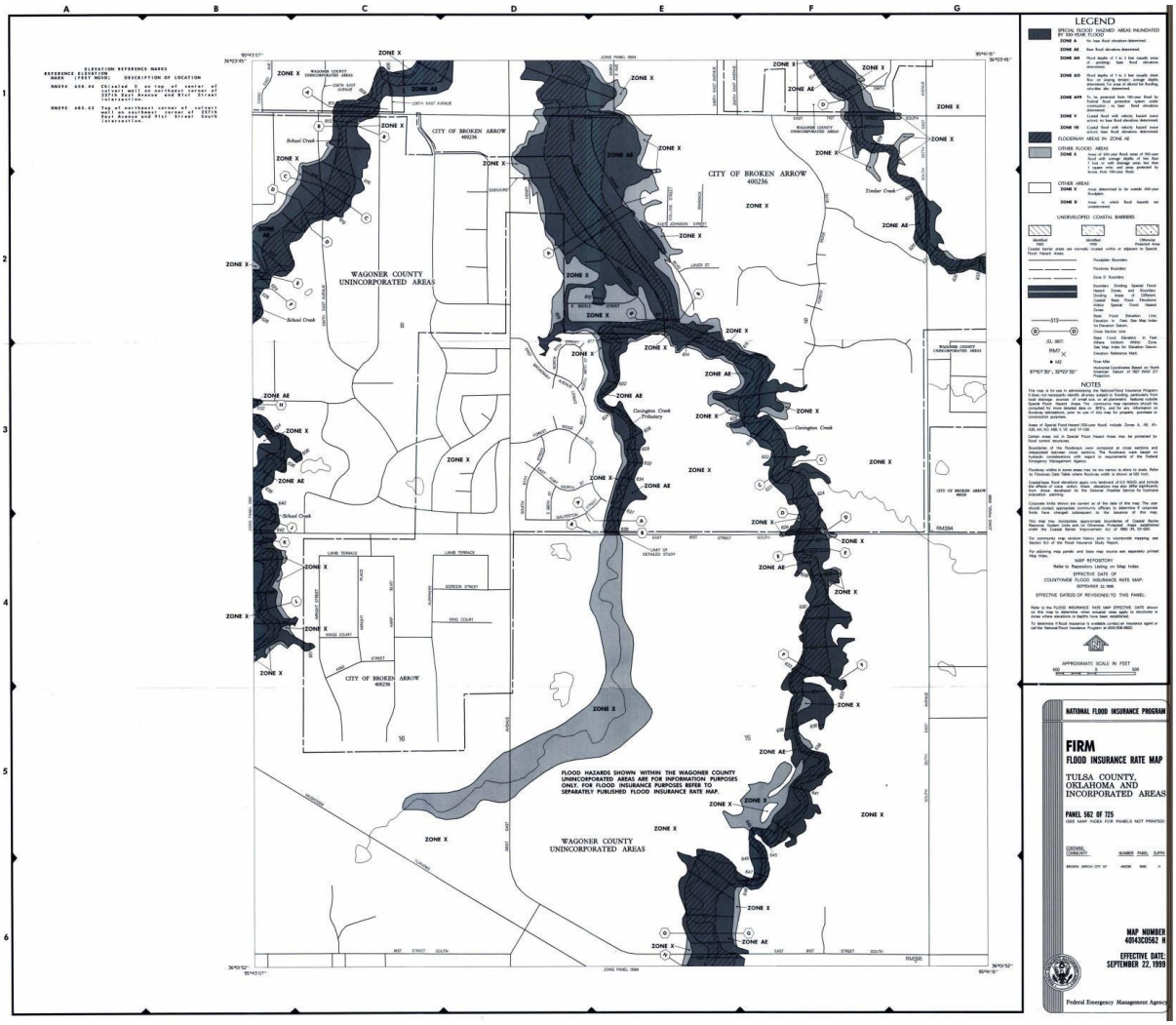
PANEL 558 OF 725
MAP NUMBER 40143C0558 H
EFFECTIVE DATE: SEPTEMBER 22, 1999
Federal Emergency Management Agency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NOTES
CITY OF BROKEN ARROW
400236
WAGONER COUNTY
UNINCORPORATED AREAS
FLOOD HAZARDS SHOWN WITHIN THE WAGONER COUNTY UNINCORPORATED AREAS ARE FOR INFORMATION PURPOSES ONLY. FOR FLOOD INSURANCE PURPOSES REFER TO SEPARATELY PUBLISHED FLOOD INSURANCE RATE MAP.
NATIONAL FLOOD INSURANCE PROGRAM
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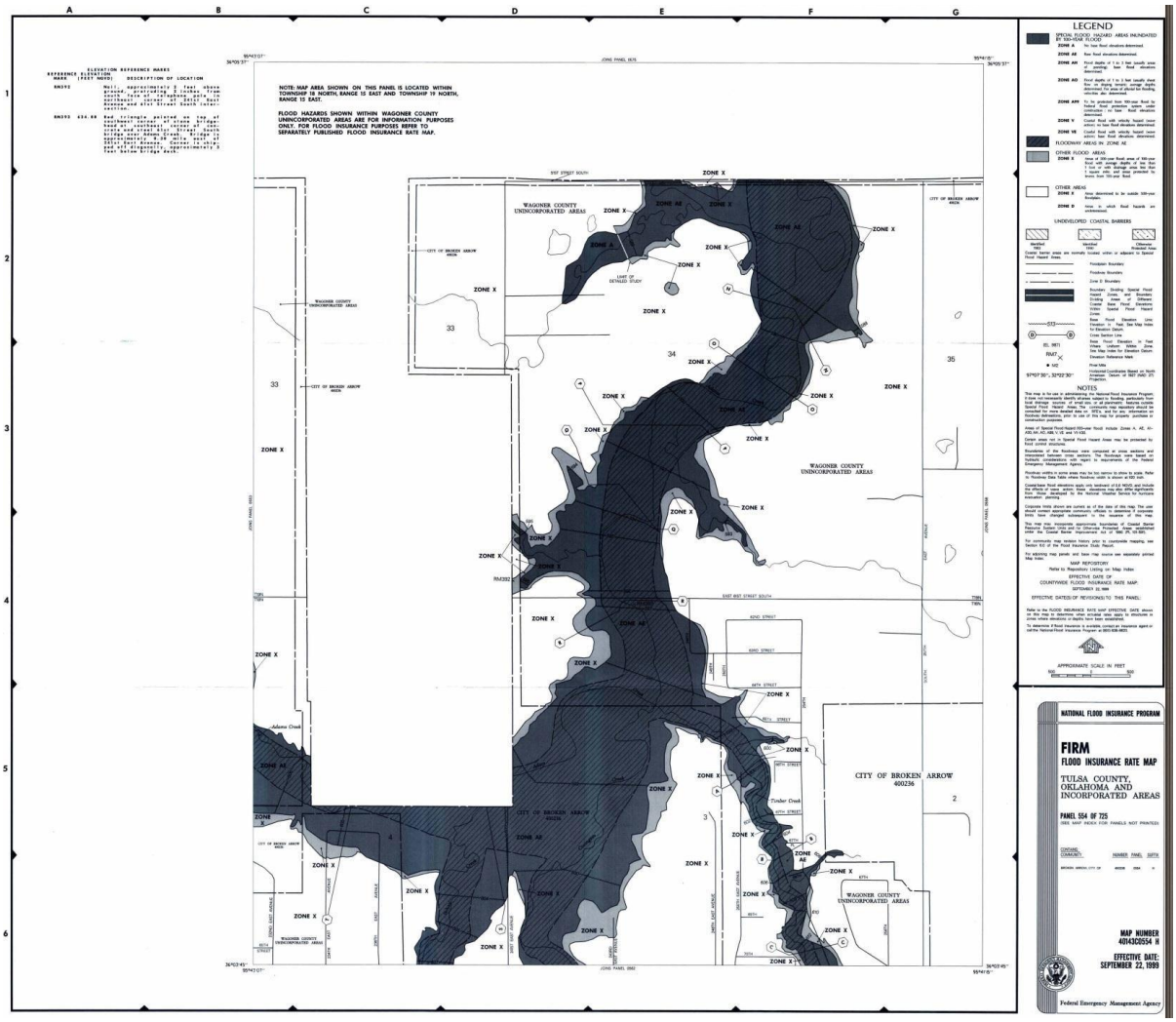
FLOOD INSURANCE RATE MAP
TULSA COUNTY, OKLAHOMA AND INCORPORATED AREAS
PANEL 562 OF 725
MAP NUMBER
40143C0562 H
EFFECTIVE DATE:
SEPTEMBER 22, 1999
Federal Emergency Management Agency


NOTE: MAP AREA SHOWN ON THIS PANEL IS LOCATED WITHIN TOWNSHIP 18 NORTH, RANGE 15 EAST AND TOWNSHIP 19 NORTH, RANGE 15 EAST.
FLOOD HAZARDS SHOWN WITHIN WAGONER COUNTY UNINCORPORATED AREAS ARE FOR INFORMATION PURPOSES ONLY. FOR FLOOD INSURANCE PURPOSES REFER TO SEPARATELY PUBLISHED FLOOD INSURANCE RATE MAP.
WAGONER COUNTY UNINCORPORATED AREAS
CITY OF BROKEN ARROW
ZONE X
ZONE AE
LEGEND
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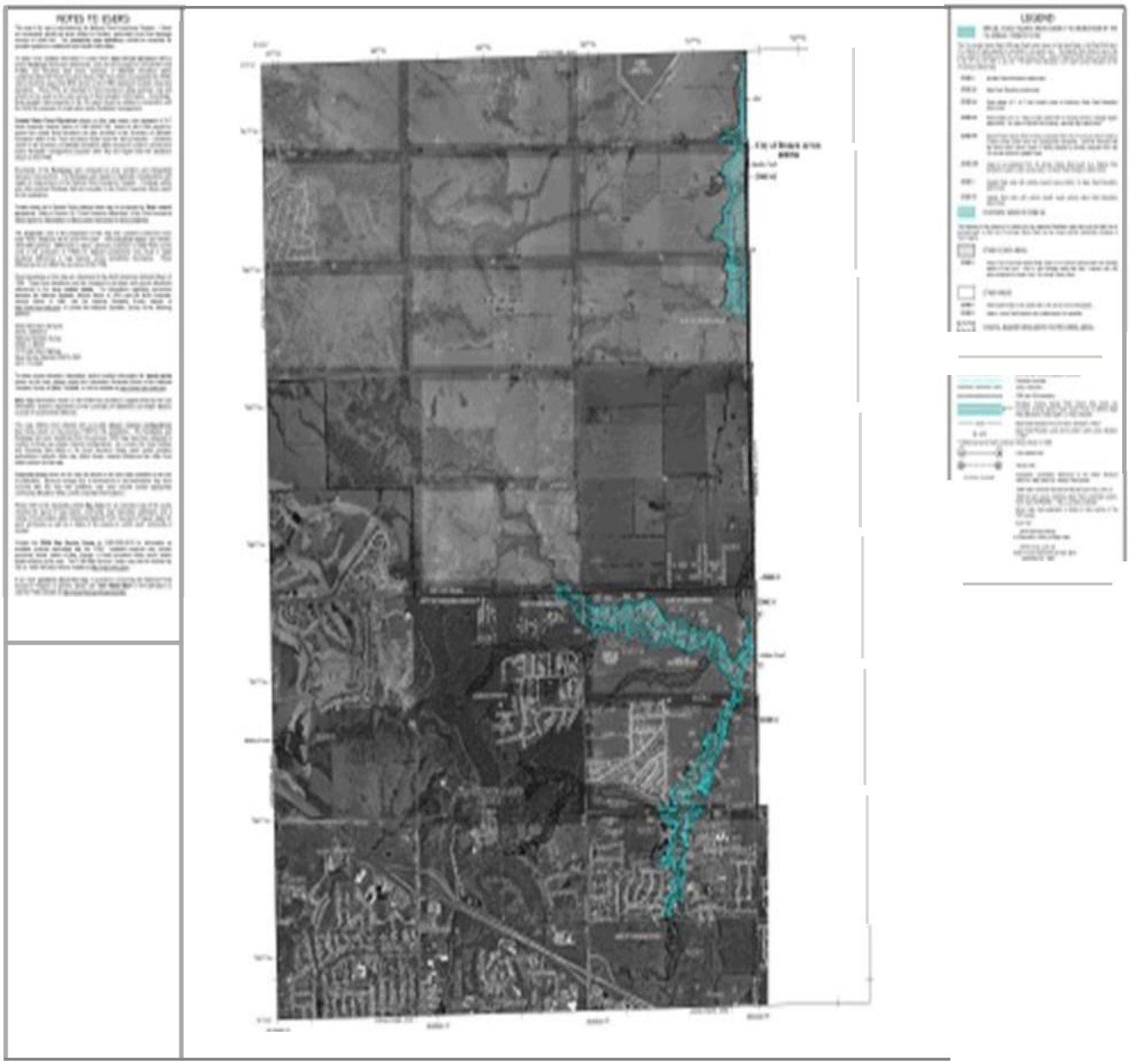
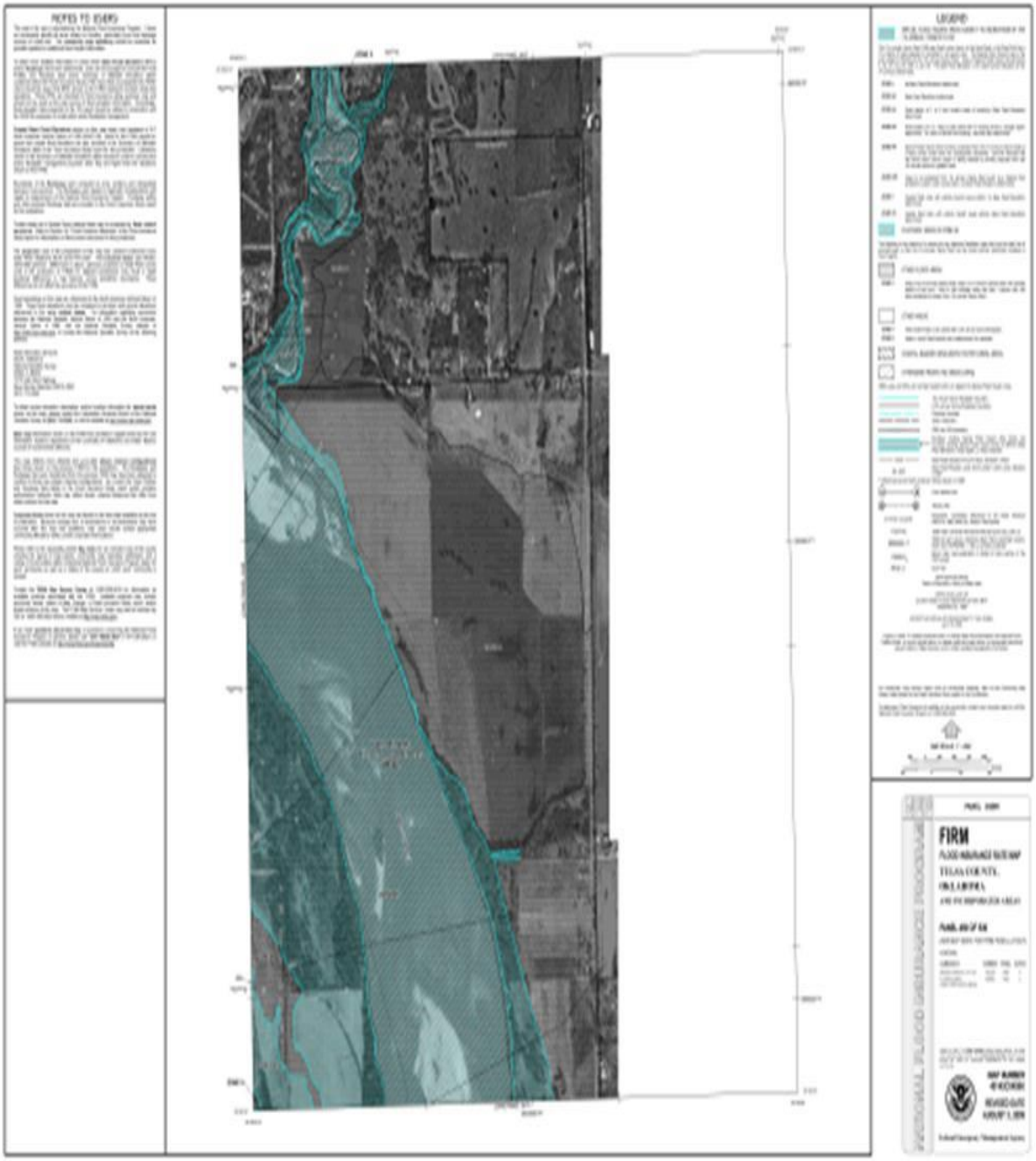
FLOOD INSURANCE RATE MAP
TULSA COUNTY, OKLAHOMA AND INCORPORATED AREAS
PANEL 554 OF 725
MAP NUMBER 40143C0554 H
EFFECTIVE DATE: SEPTEMBER 22, 1999
Federal Emergency Management Agency

FIRM MAPS – Broken Arrow, Tulsa County:

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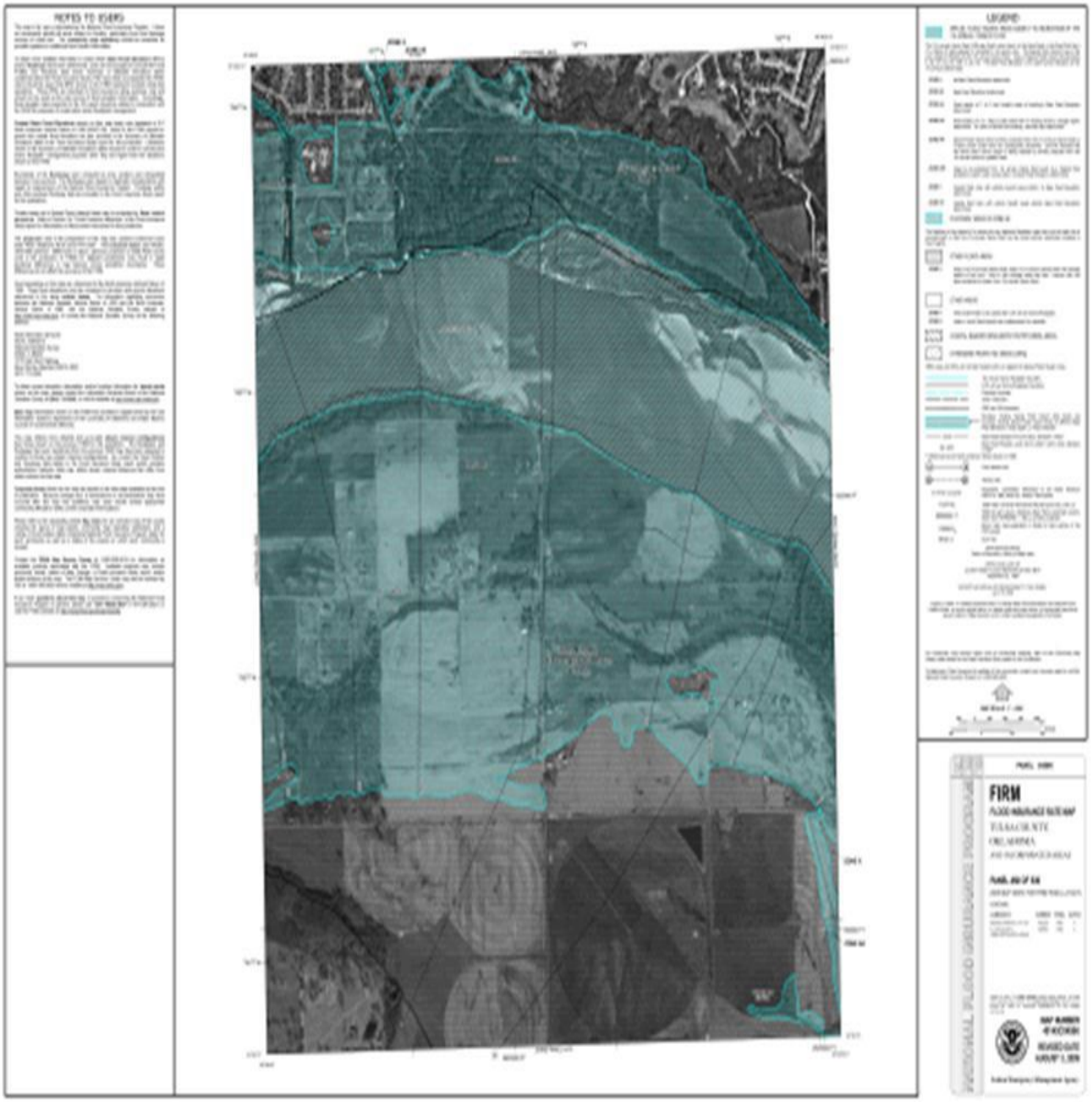
NOTES TO USERS
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TULSA COUNTY
OKLAHOMA
NATIONAL FLOOD INSURANCE PROGRAM

NOTES TO USERS
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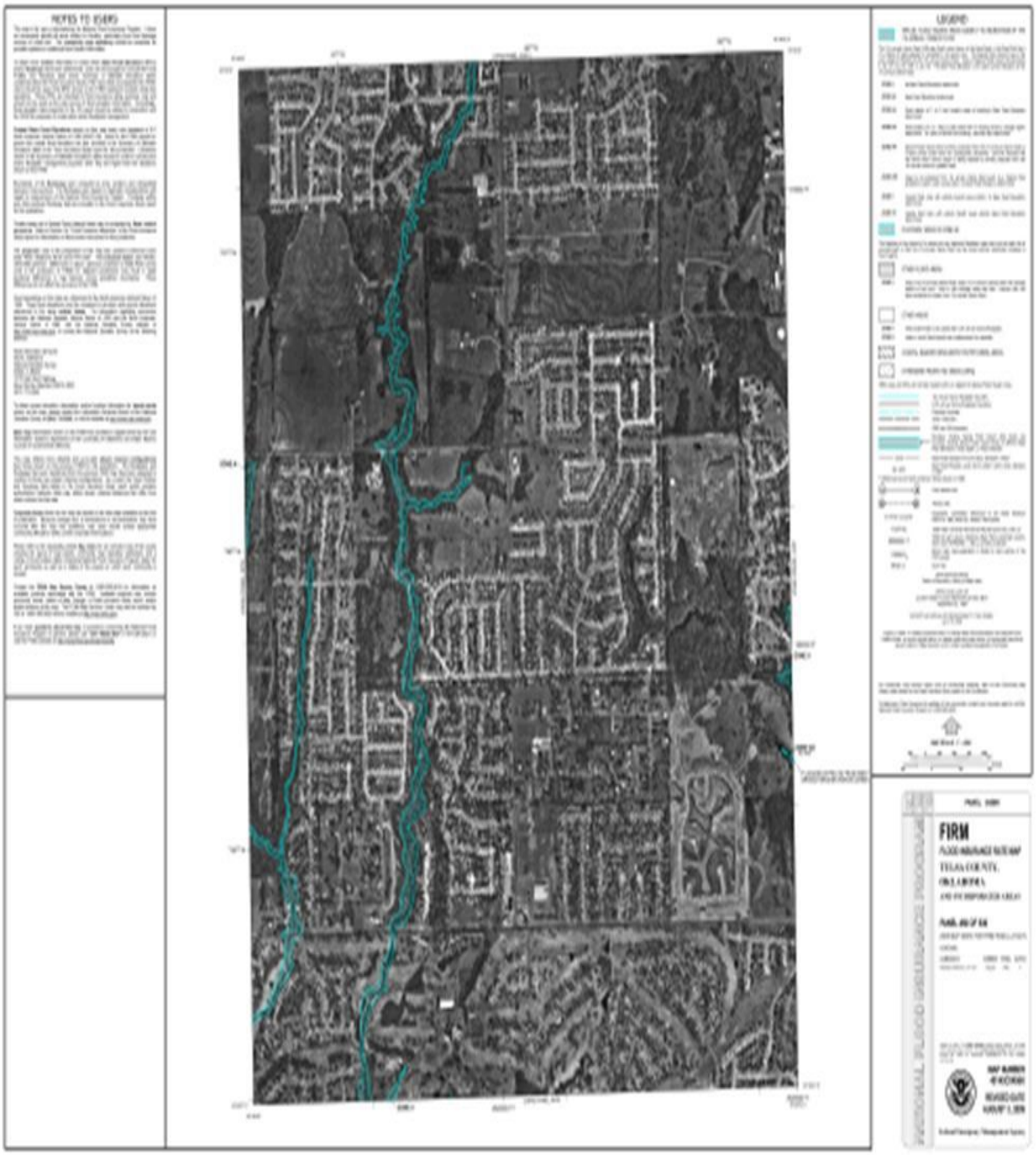
NATIONAL FLOOD INSURANCE PROGRAM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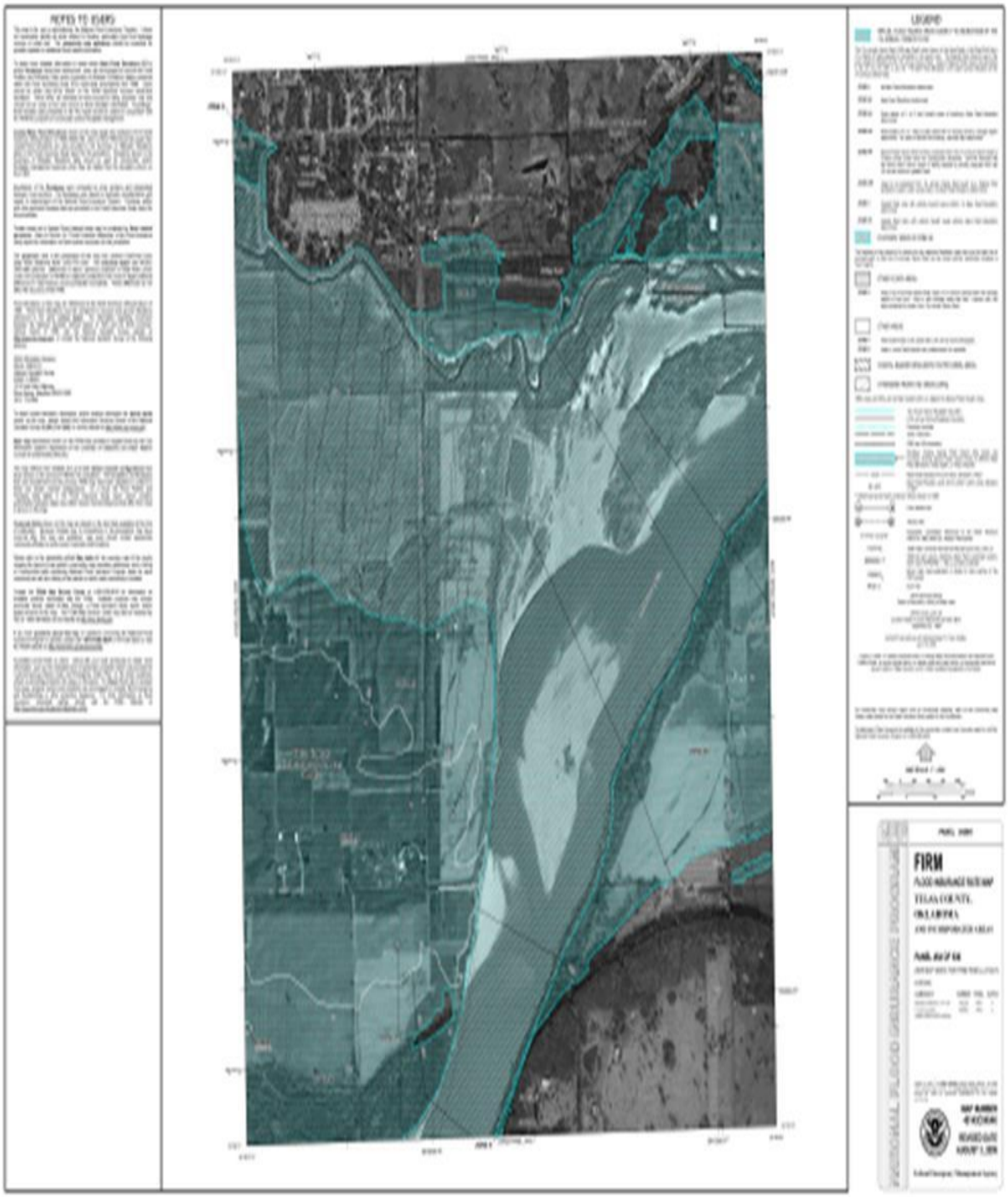
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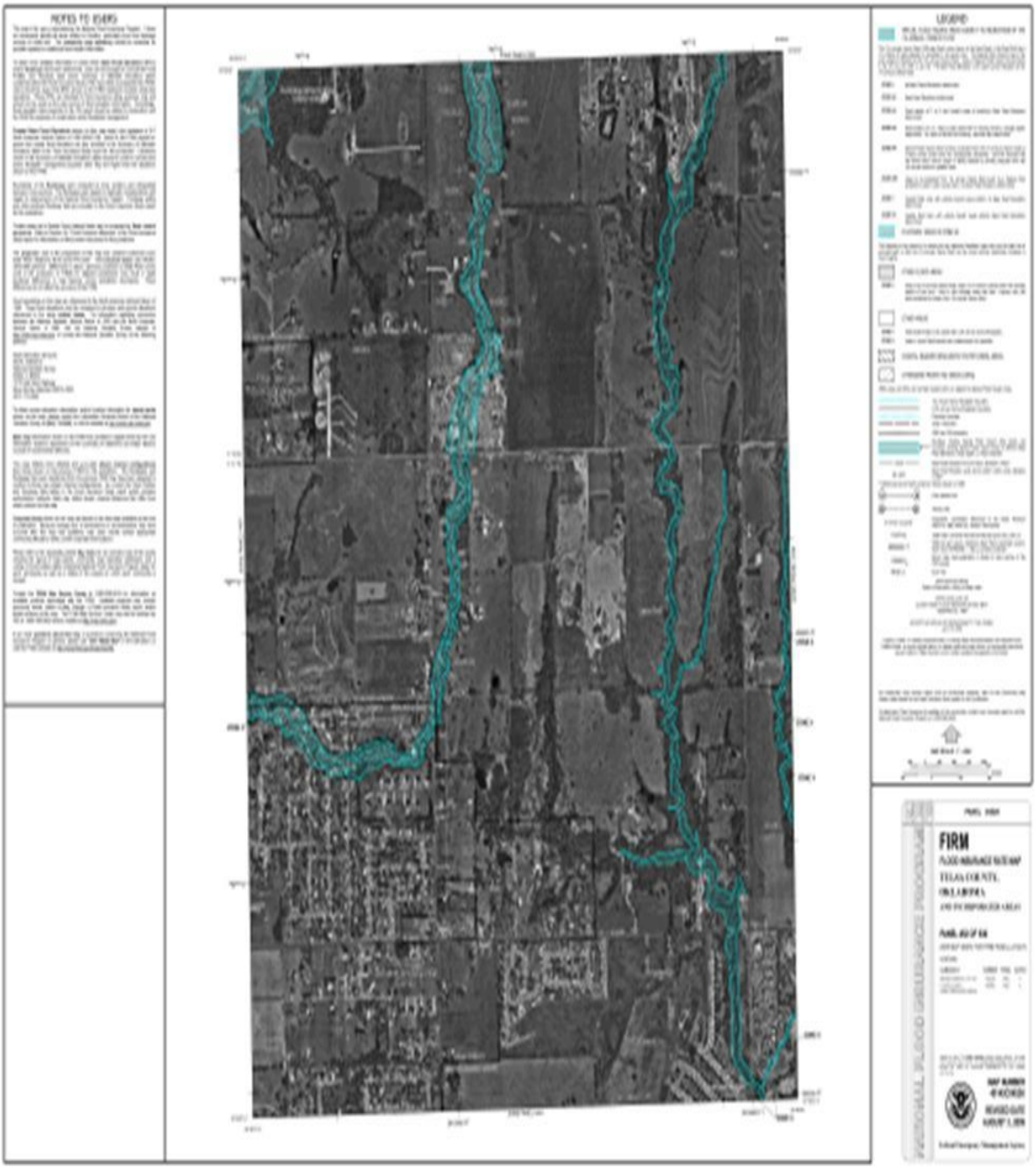
TEXAS COUNTY,
OKLAHOMA
AND INCORPORATED AREAS
PANEL 400 OF 1150
NATIONAL FLOOD INSURANCE PROGRAM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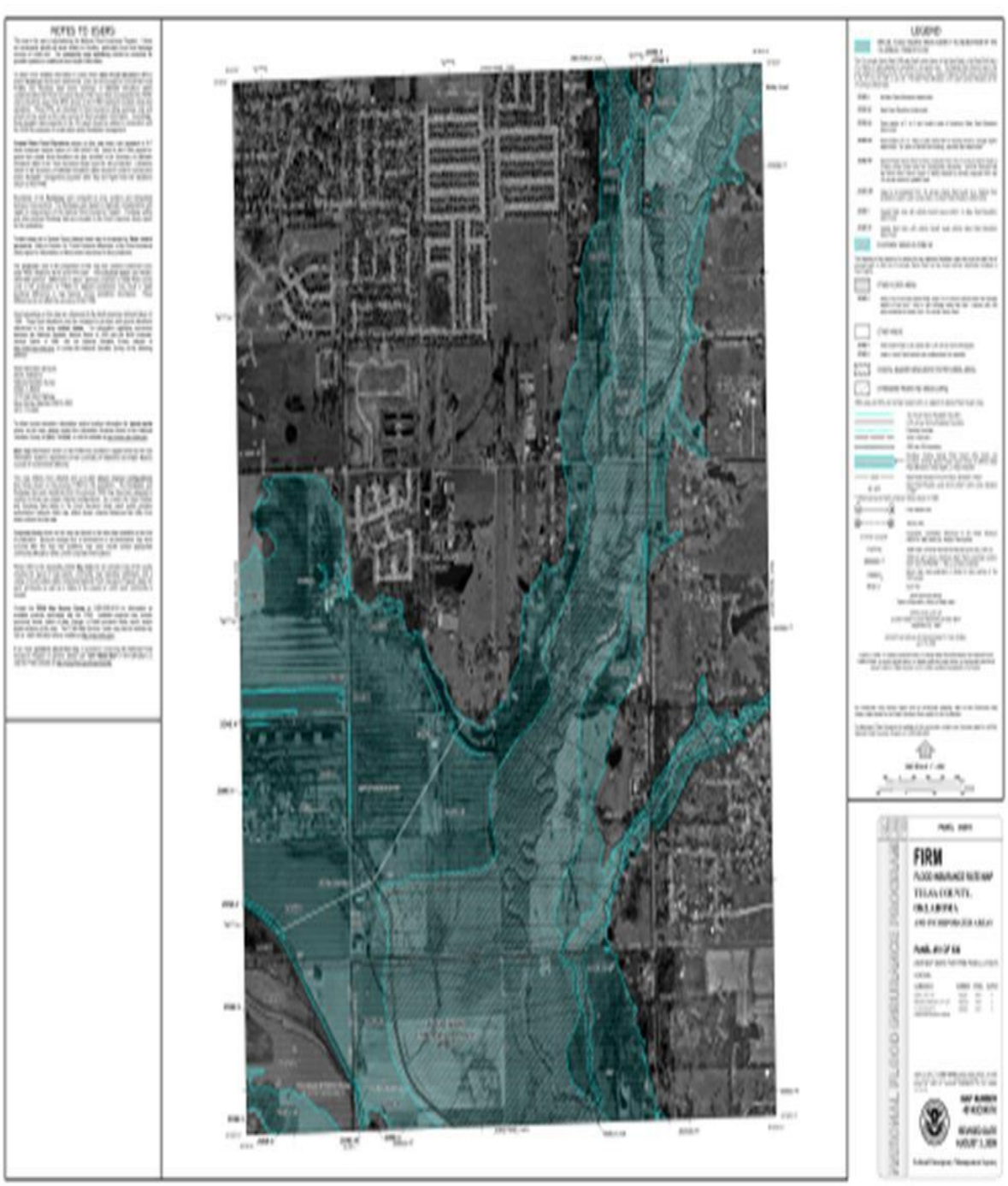
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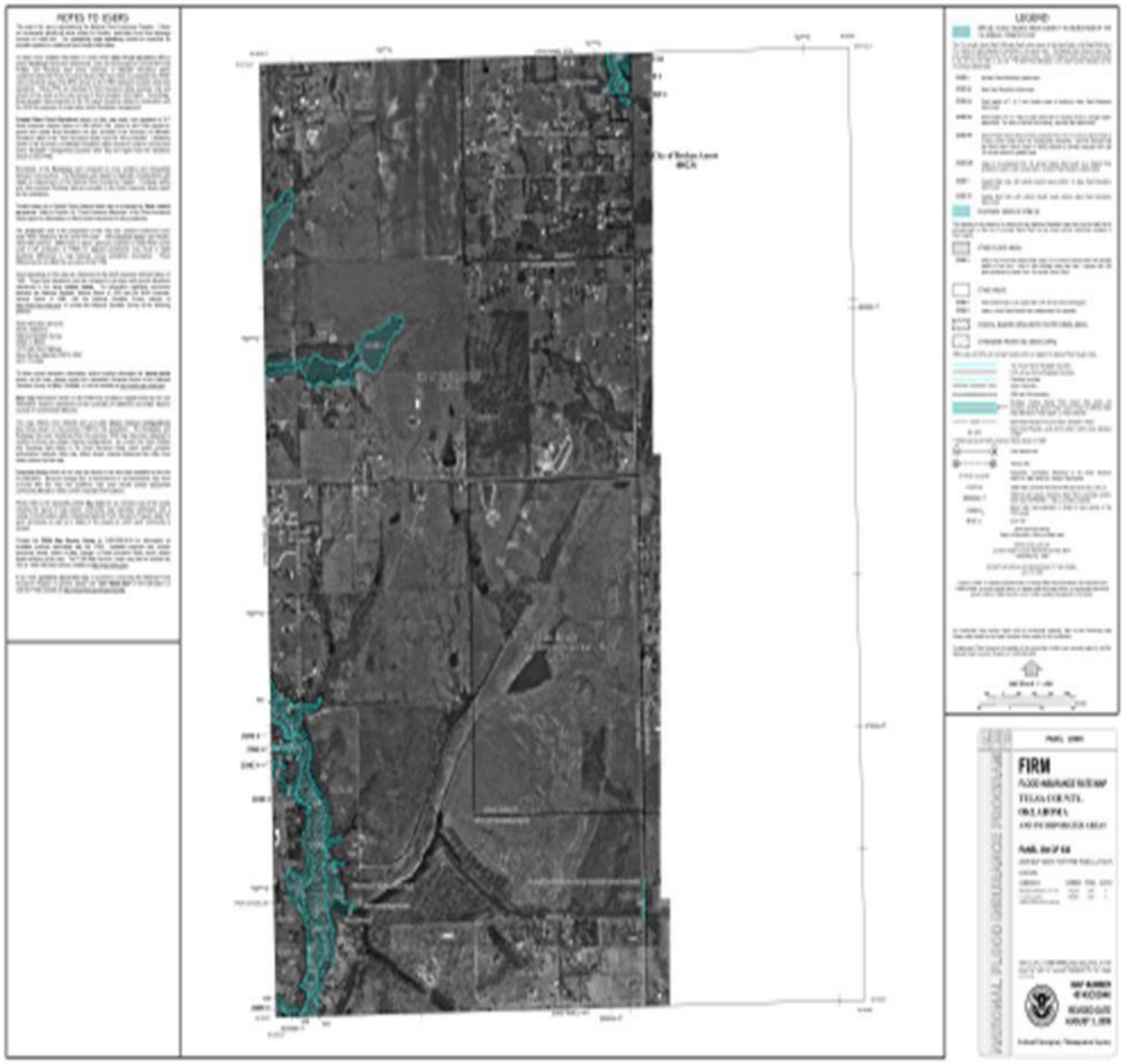
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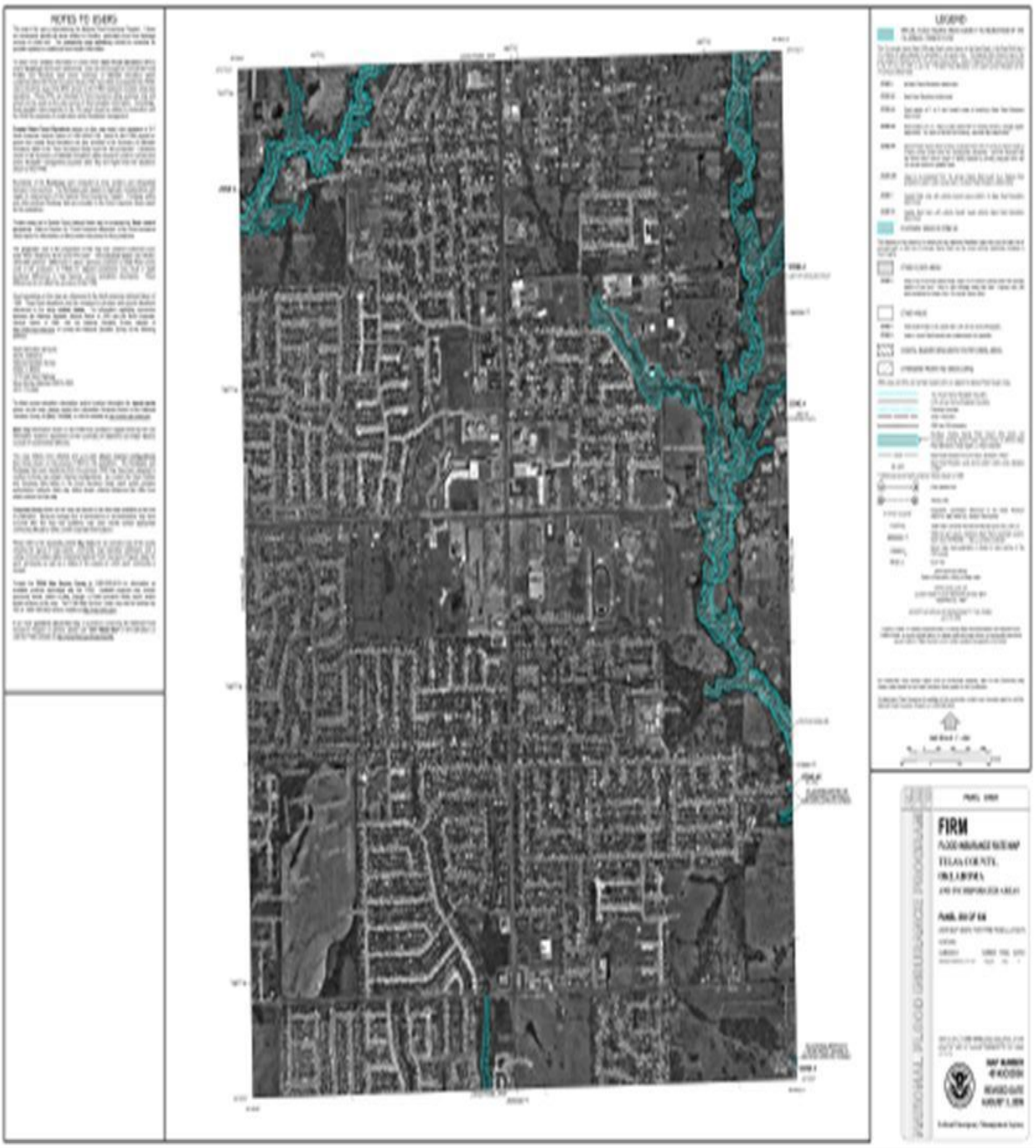
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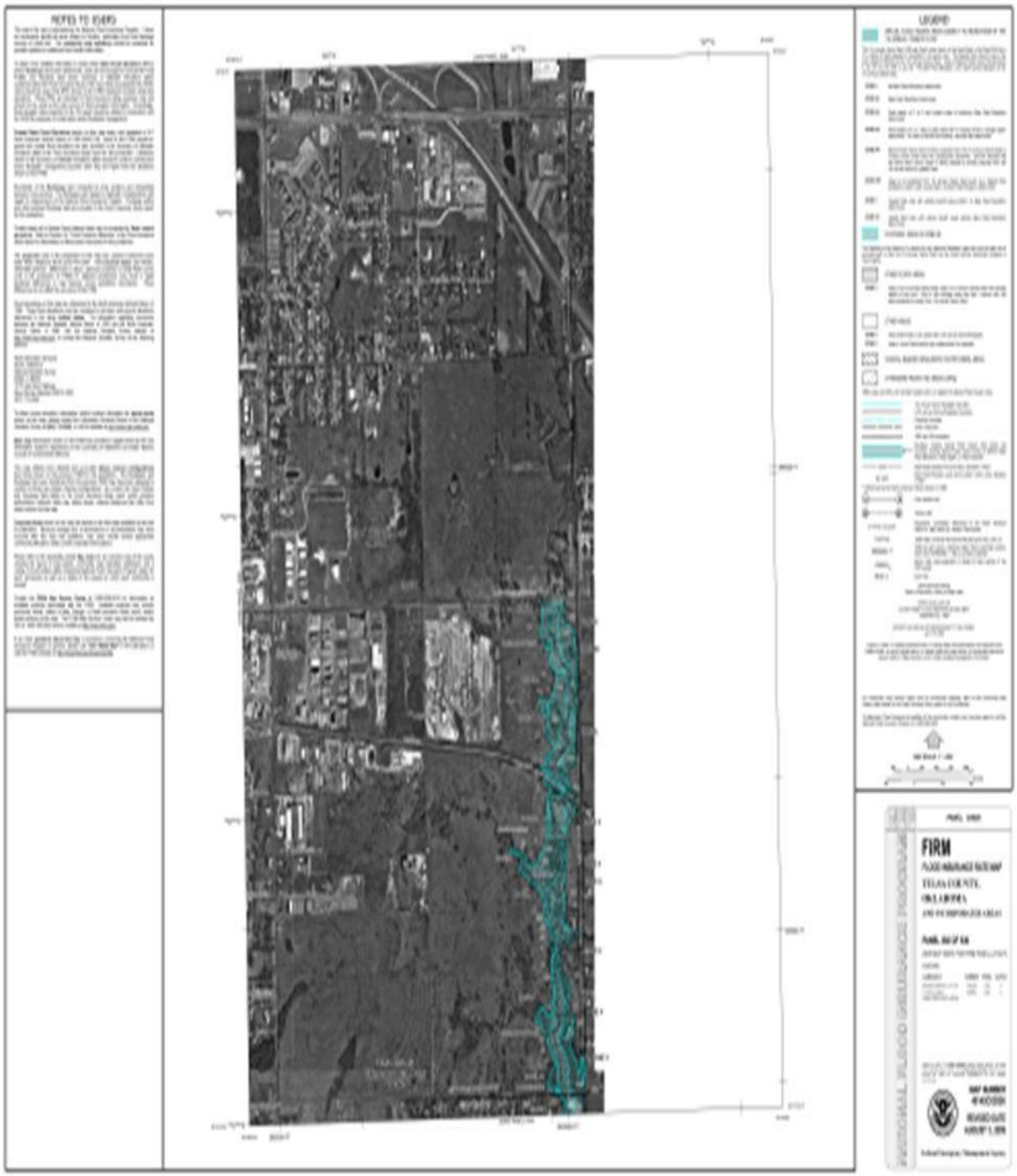
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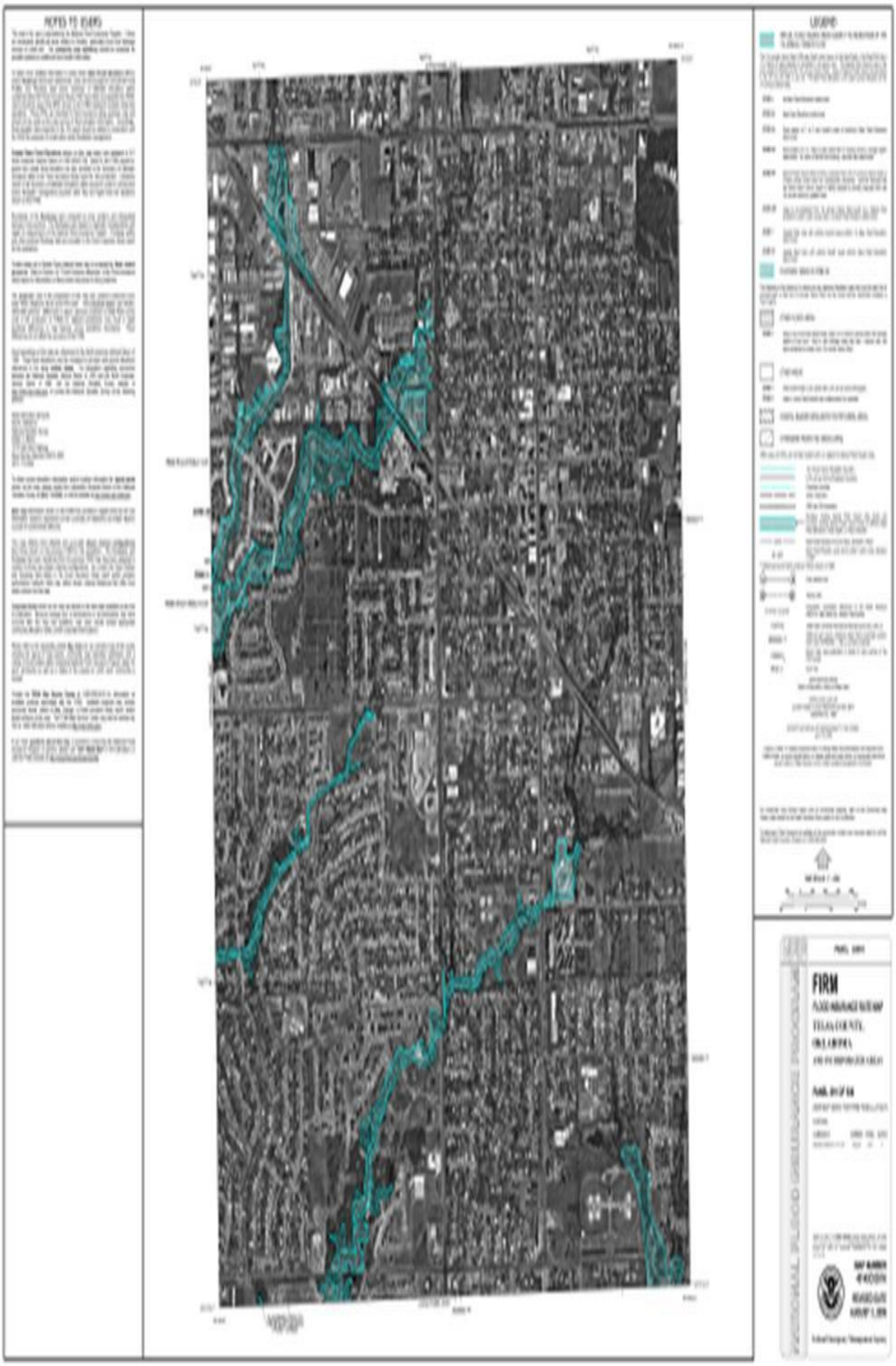
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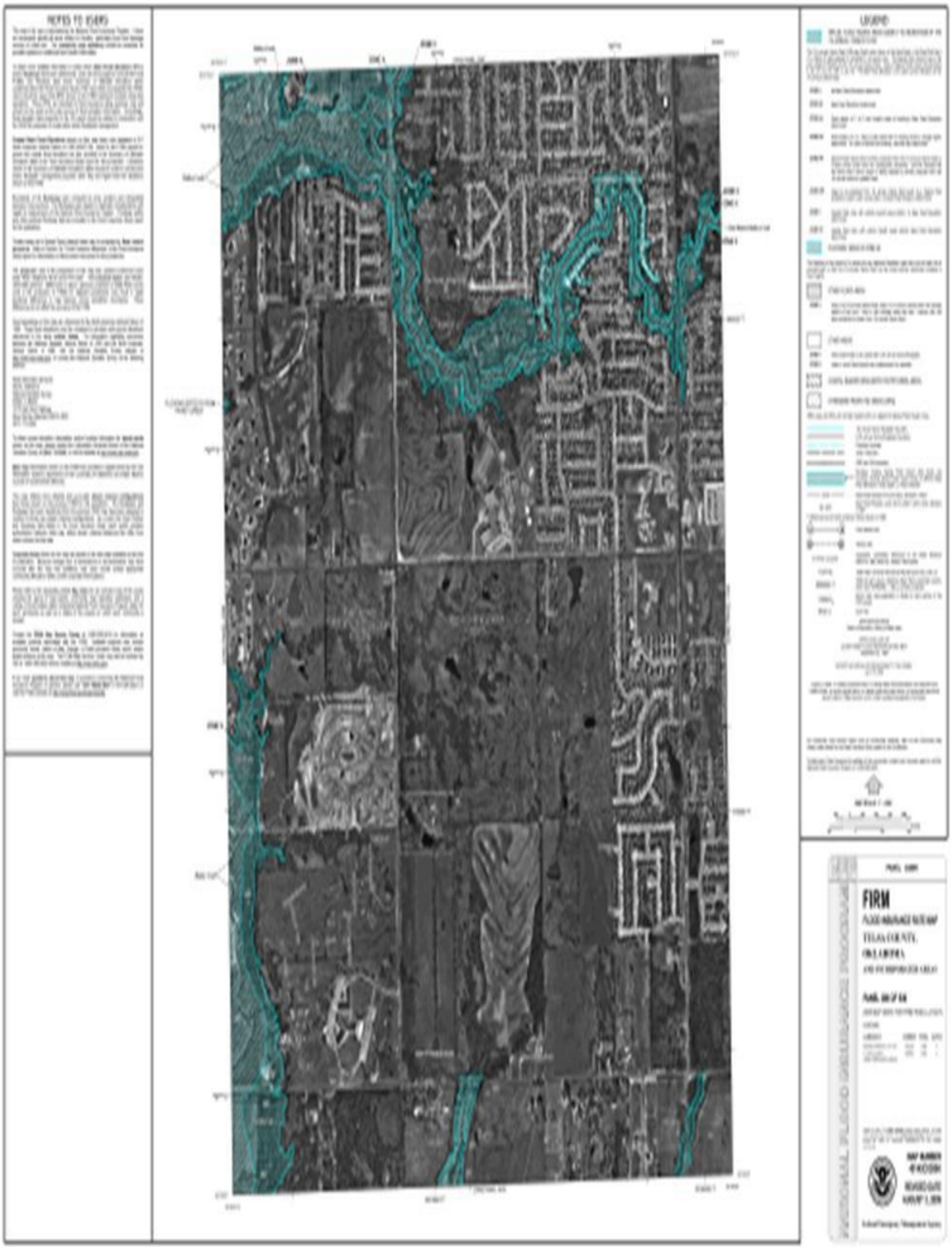
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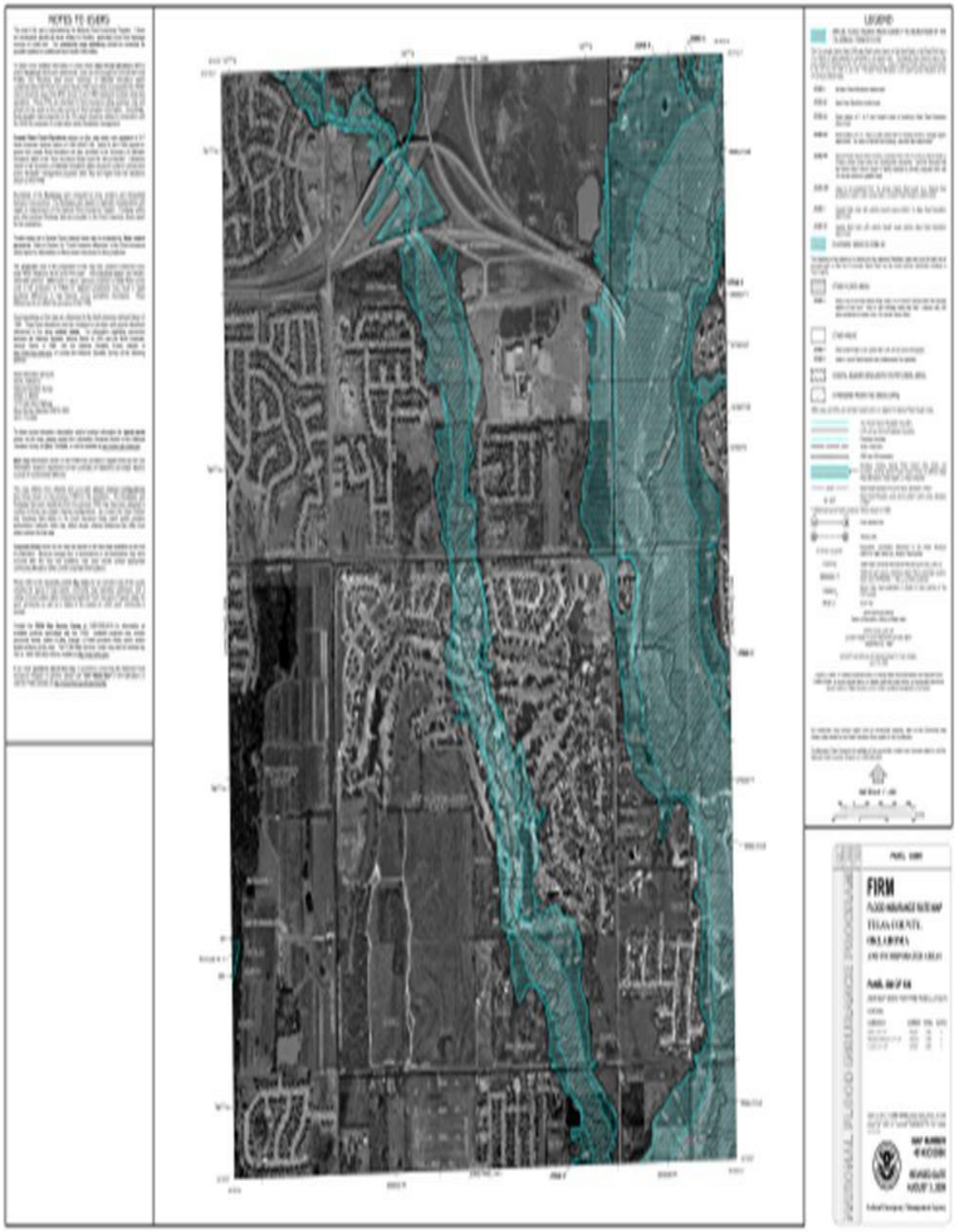
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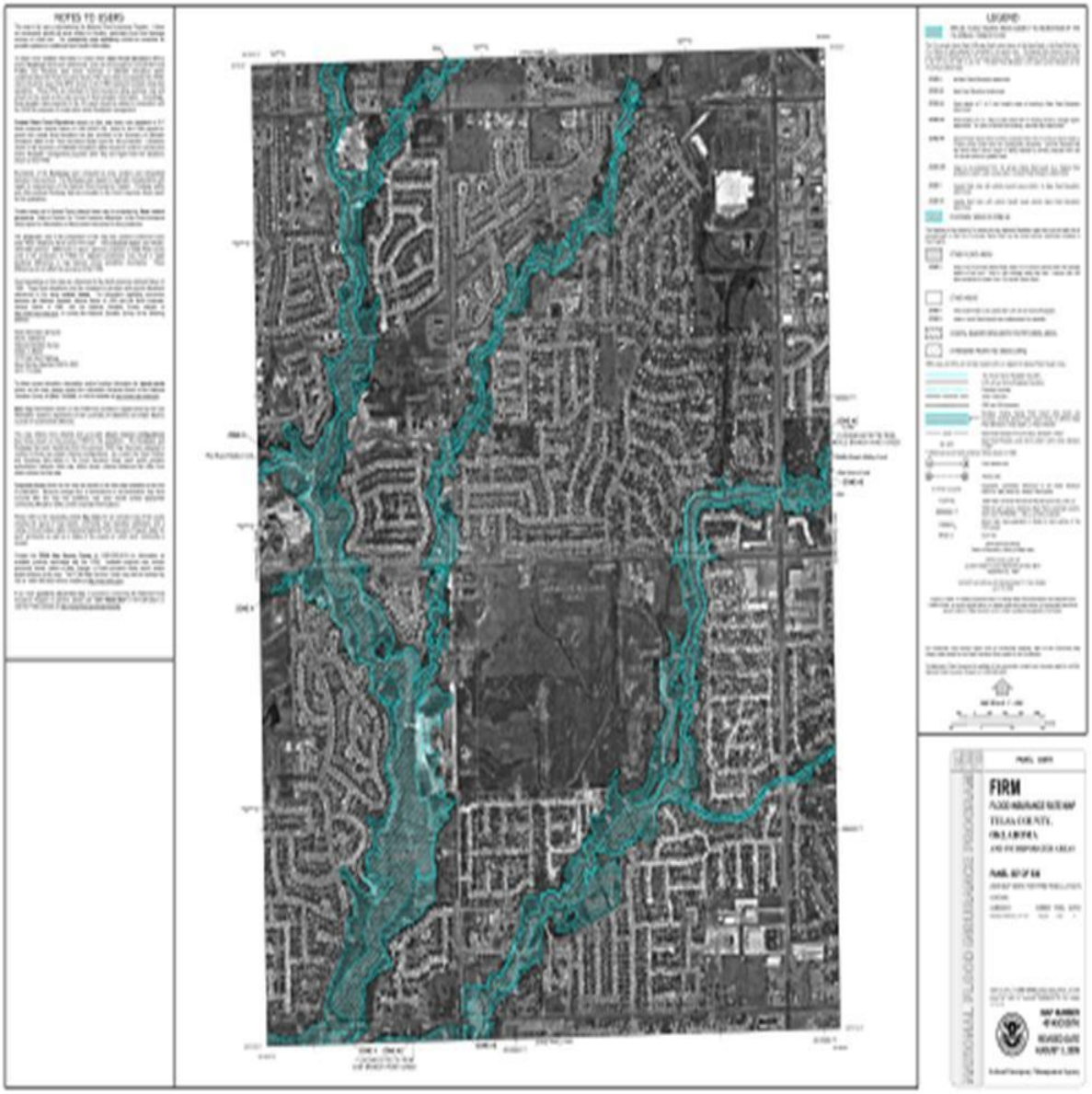
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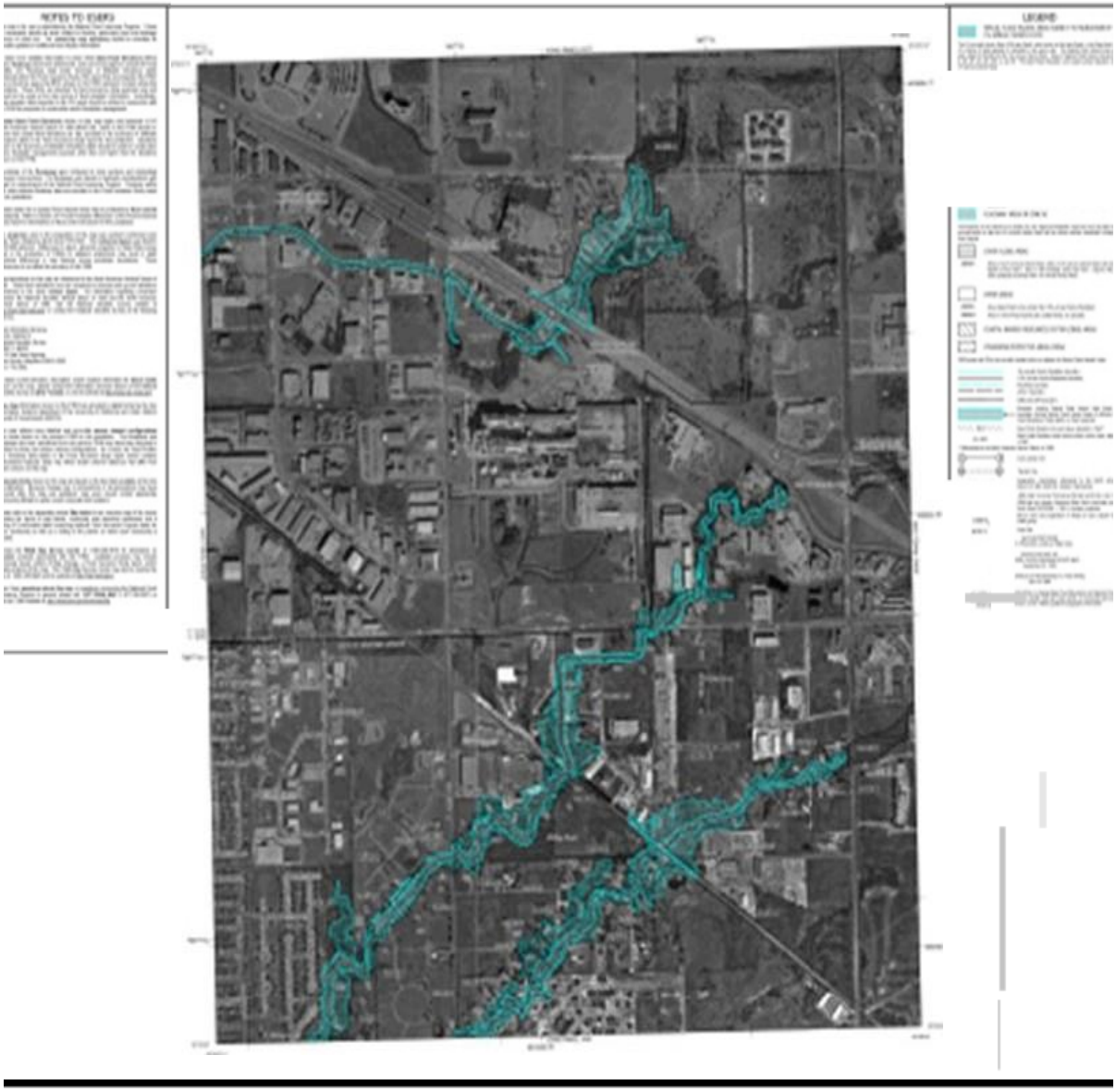

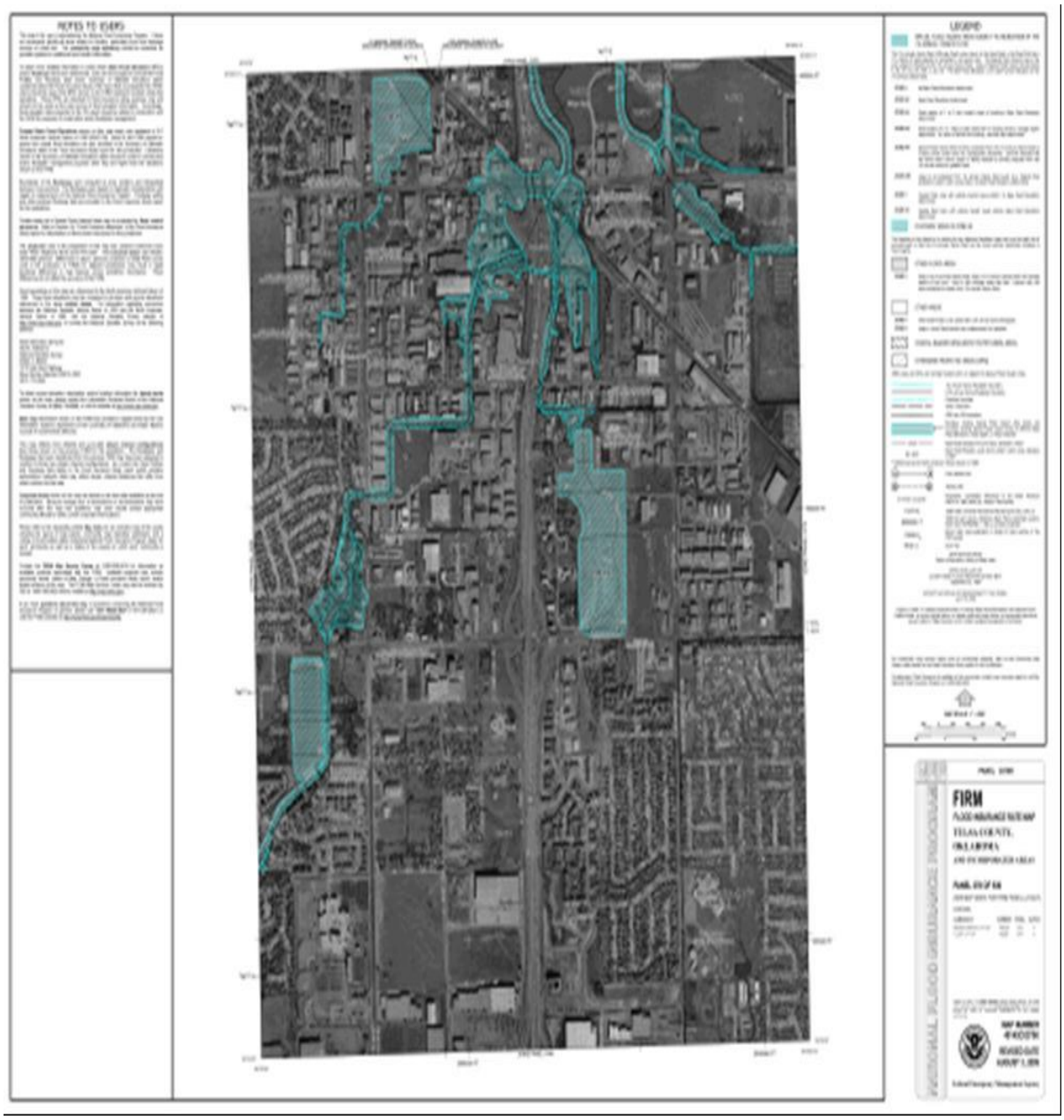
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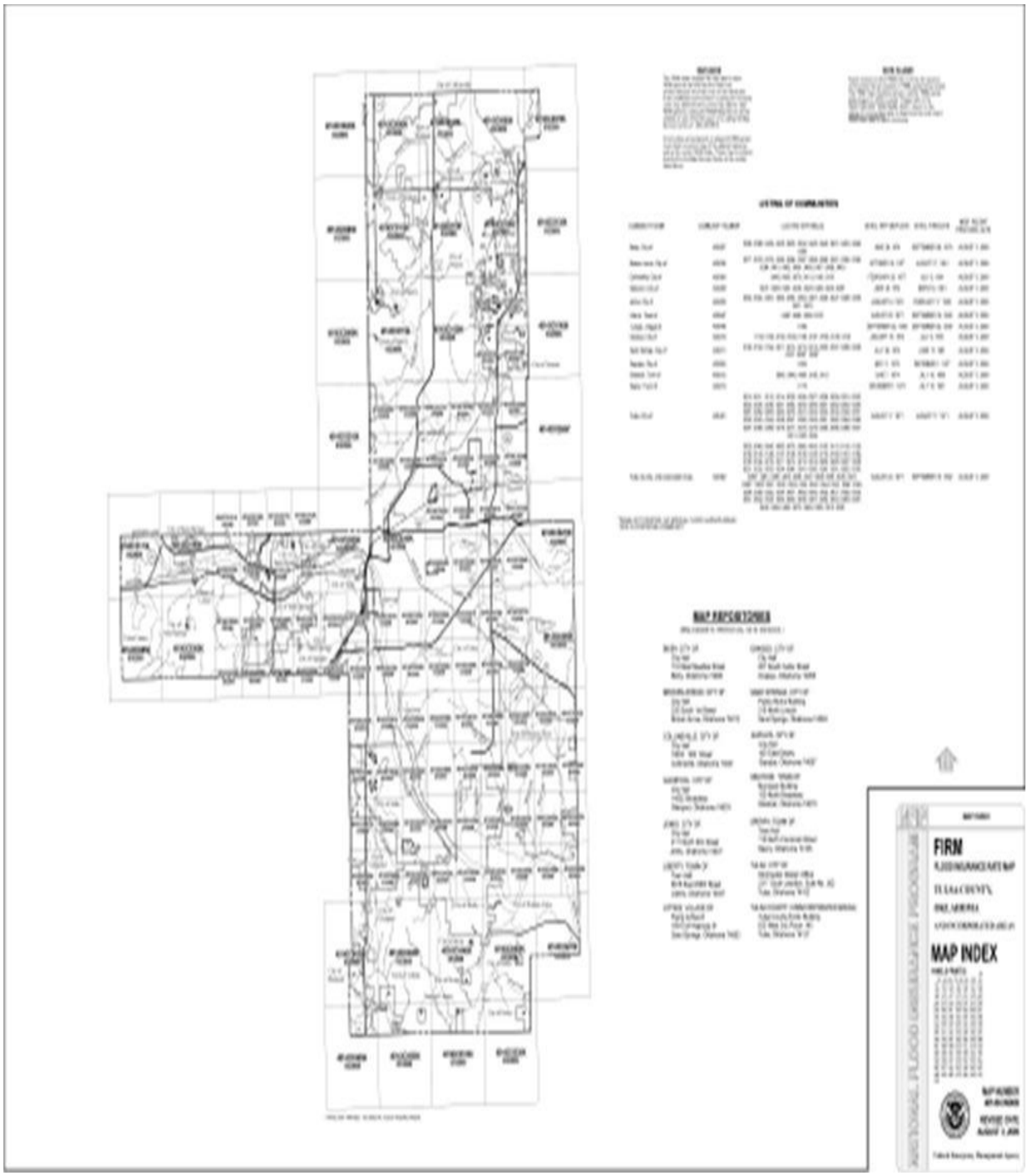
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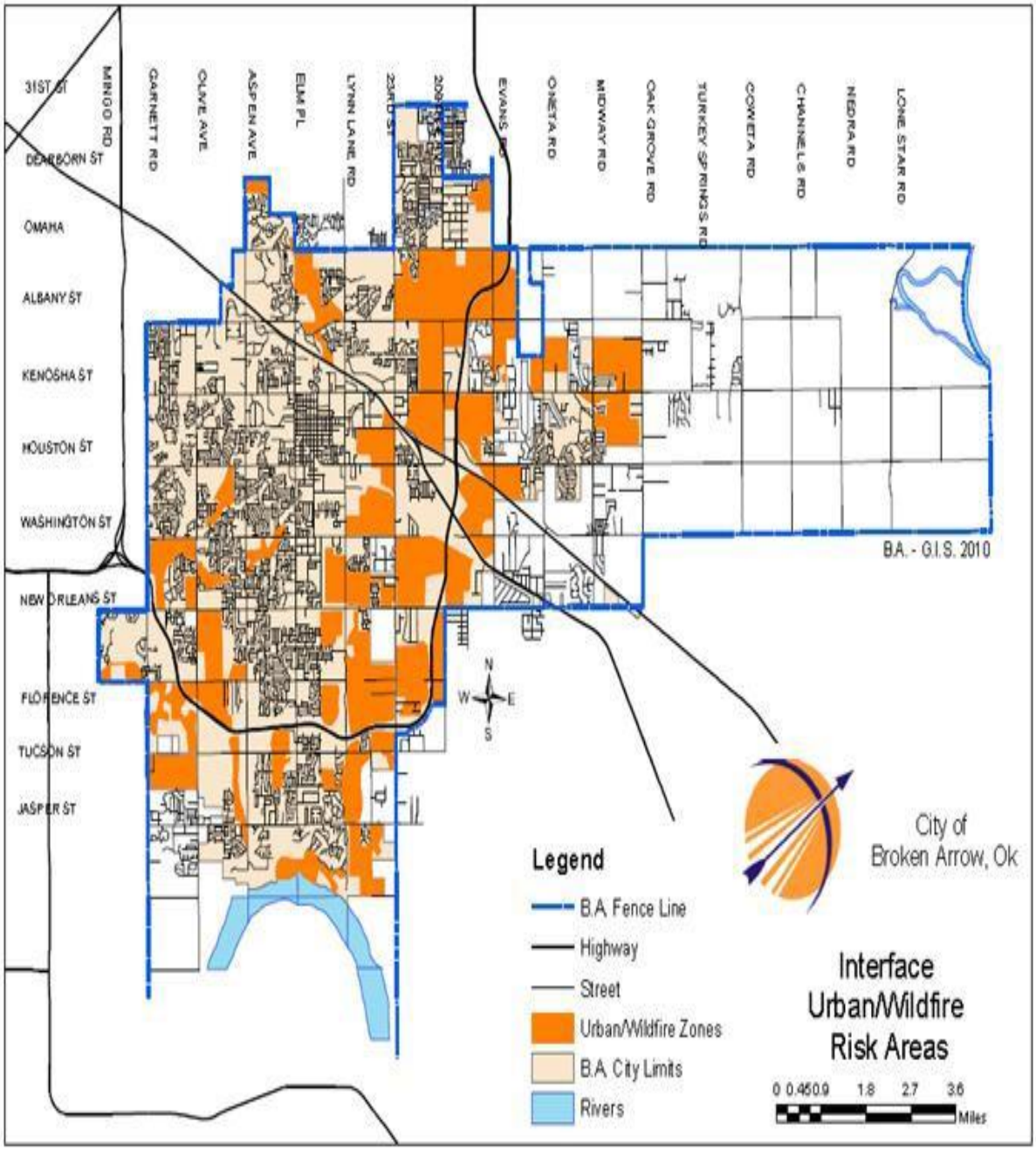
MAP INDEX

Appendix B Map:

Broken Arrow Wildfire Urban Interface (WUI)