3 RISK ASSESSMENT

44 CFR Requirement §201.6(c)(2): [The plan shall include] A risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.

The goal of the risk assessment is to estimate the potential loss in the planning area, including loss of life, personal injury, property damage, and economic loss, from a hazard event. The risk assessment process allows communities and school/special districts in the planning area to better understand their potential risk to the identified hazards. It will provide a framework for developing and prioritizing mitigation actions to reduce risk from future hazard events.

Changes in this version:
The risk assessment in this plan consolidates, updates, and streamlines content from the 2010 approved plan. Content has been restructured to cover a broad range of emerging hazards, vulnerabilities, and risk issues. Significant changes have been made that include standardized terminology, new GIS-based ranking methodology which assesses hazard risk by jurisdiction,

new analysis for all major hazards, development of annualized loss by jurisdiction and review of local risk assessments, land use planning, and development.

This chapter is divided into four main parts:

- **Section 3.1 Hazard Identification** identifies the hazards that threaten the planning area and provides a factual basis for elimination of hazards from further consideration;
- **Section 3.2 Assets at Risk** provides the planning area's total exposure to natural hazards, considering critical facilities and other community assets at risk;
- **Section 3.3 Future Land Use and Development** discusses areas of planned future development
- **Section 3.4 Hazard Profiles and Vulnerability Analysis** provides more detailed information about the hazards impacting the planning area. For each hazard, there are three sections: 1) Hazard Profile provides a general description and discusses the threat to the planning area, the geographic location at risk, potential severity/magnitude/extent, previous occurrences of hazard events, probability of future occurrence, risk summary by jurisdiction, impact of future development on the risk; 2) Vulnerability Assessment further defines and quantifies populations, buildings, critical facilities, and other community/school or special district assets at risk to natural hazards; and 3) Problem Statement briefly summarizes the problem and develops possible solutions.

3.1 Hazard Identification

Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the type…of all natural hazards that can affect the jurisdiction.

Natural hazard can be complex, occurring with a wide range of intensities. Some events are instantaneous and offer no window of warning, such as earthquakes. Some offer a short warning in which to alert the public to take actions, such as tornadoes or severe thunderstorms. Others occur less frequently and are typically more expensive, with some warning time to allow the public time to prepare, such as flooding.

Each year there are increases in human-caused incidents, which can be just as devastating as natural disasters. For the purpose of this plan "human-caused hazards" are technological hazards and terrorism. These are distinct from natural hazards primarily in that they originate from human activity. In contrast, while the risks presented by natural hazards may be increased or decreased as a result of human activity, they are not inherently human-induced. The term "technological hazards" refers to the origins of incidents that can arise from human activities such as the manufacture, transportation, storage, and use of hazardous materials. For the sake of simplicity, this guide assumes that technological emergencies are accidental and that their consequences are unintended.

3.1.1 Review of Existing Mitigation Plans

The MPC previously developed a multi-jurisdiction Hazard Mitigation Plan dated 2010 and the City of Louisiana, Bowling Green, Curryville, Frankford, Annada, Eolia, Paynesville, Clarksville, and Pike County participated in the multi-jurisdictional county-wide plan. The 2010 Hazard Mitigation Plan was consulted in development of the risk assessment and information included and updated where appropriate. The hazards included in the 2010 Pike County Hazard Mitigation Plan are listed in Table 3.1

Table 3.1 Hazards Included in the Pike County 2010 Hazard Mitigation Plan

- Tornado
- Flood
- Drought/Heat Wave
- Dam Failure
- Levee Failure
- Sinkholes
- Thunderstorm
- Severe Winter Weather
- Earthquake
- Wildfire
- Landslide

To facilitate consistency within the planning efforts in the State, and to enable comprehensive statewide analysis, of local plans the MPC considered each of the 21 hazards included in the 2013 Missouri State Hazard Mitigation Plan. The MPC reviewed data and discussed the impacts of each of these hazards. Table 3.2 below provides the full list of hazards in the State Hazard Mitigation Plan.

Table 3.2 Hazards Included in the 2013 Missouri State Hazard Mitigation Plan

- Riverine Flooding (Major and Flash)
- Levee Failure
- Dam Failure
- Earthquake

- Land Subsidence/Sinkholes
- Tornadoes
- Severe Thunderstorm (includes damaging winds, hail and lightening
- Severe Winter Weather/Snow/Ice/Severe Cold
- Droughts
- Extreme Temperatures
- Fires (Structural, Urban, and Wild)
- Attack (Nuclear, Conventional, and Biological)
- Civil Disorder
- Cyber Disruption
- Hazardous Materials Release (Fixed Facility Accidents/Transportation Accidents)
- Mass Transportation Accident
- Nuclear Power Plants (Emergencies and Accidents)
- Public Health Emergencies/Environmental Issues
- Special Events
- Terrorism
- Utilities (Interruptions and System Failures)

The MPC decided to include only natural hazards, as only natural hazards are required by federal regulations to be included. The human-caused and technological hazards were eliminated from further analysis due to these hazards are not necessary for plans to meet the requirements of the Disaster Mitigation Act of 2000.

3.1.2 Review Disaster Declaration History

Declarations may be granted when the severity and magnitude of an event surpasses the ability of the local government to respond and recover. Disaster assistance is supplemental and sequential. When the local government's capacity has been surpassed, a state disaster declaration may be issued, allowing for the provision of state assistance. If the disaster is so severe that both the local and state governments' capacities are exceeded; a federal emergency or disaster declaration may be issued allowing for the provision of federal assistance.

FEMA also issues emergency declarations, which are more limited in scope and do not include the long-term federal recovery programs of major disaster declarations. Determinations for declaration type are based on scale and type of damages and institutions or industrial sectors affected.

Table 3.3 FEMA Disaster Declarations that included Pike County, Missouri, 1990-Present

Disaster Number	Description	Declaration Date Incident Period	Individual Assistance (IA)
DR-4238	Severe Storms, Tornadoes, Straight-line Winds and Flood	August 7, 2015 May 15, 2015 to July 27, 2015	Public Assistance
DR-4130	Severe Storms, Tornadoes, Straight-line Winds and Flood	July 18, 2013 May 29, 2013 to June 11, 2013	Public Assistance
DR-1961	Severe Winter Storms and Snow Storms	March 23, 2011 January 31, 2011 to February 5, 2011	Public Assistance
DR-1934	Severe Storms, Flooding and Tornadoes	August 17, 2010 June 12, 2010 to July 31, 2010	Public Assistance

DR-1773	Severe Storms and Flooding	June 25, 2008 June 1, 2008 to August 13, 2008	Individual Assistance and Public Assistance
DR-1736	Severe Winter Storms	December 27, 2007 December 6, 2007 to December 15,2007	Individual Assistance and Public Assistance
DR-1673	Severe Winter Storms	December 29, 2006 November 30, 2006 to December 2, 2006	Public Assistance
DR-1635	Severe Storms, Tornadoes and Flooding	April 6, 2006 March 30, 2006 to April 3, 2006	Individual Assistance and Public Assistance
DR-1463	Severe Storms, Tornadoes and Flooding	May 6, 2003 May 4, 2003 to May 30, 2003	Individual Assistance and Public Assistance
DR-1412	Severe Storms and Tornadoes	May 6, 2002 April 24 to 2002 to June 10, 2002	Public Assistance
DR-1403	Ice Storm	February 6, 2002 January 29, 2002 to February 13, 2002	Public Assistance

Source: Federal Emergency Management Agencyhttp://www.fema.gov/disasters

3.1.3 Research Additional Sources

List the additional sources of data on locations and past impacts of hazards in the planning area:

- Missouri Hazard Mitigation Plans (2010 and 2013)
- Previously approved planning area Hazard Mitigation Plan (date)
- Federal Emergency Management Agency (FEMA)
- Missouri Department of Natural Resources (MDNR)
- National Drought Mitigation Center Drought Reporter
- US Department of Agriculture's (USDA) Risk Management Agency Crop Insurance Statistics
- National Agricultural Statistics Service (Agriculture production/losses)
- Data Collection Questionnaires completed by each jurisdiction
- State of Missouri GIS data
- Environmental Protection Agency
- Flood Insurance Administration
- Hazards US (HAZUS)
- Missouri Department of Transportation
- Missouri Division of Fire Marshal Safety
- Missouri Public Service Commission
- National Fire Incident Reporting System (NFIRS)
- National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC);
- Pipeline and Hazardous Materials Safety Administration
- County and local Comprehensive Plans to the extent available
- County Emergency Management

- County Flood Insurance Rate Map, FEMA
- Flood Insurance Study, FEMA
- SILVIS Lab, Department of Forest Ecology and Management, University of Wisconsin
- U.S. Army Corps of Engineers
- U.S. Department of Transportation
- United States Geological Survey (USGS)
- Various articles and publications available on the internet (you should state that you will give citations to the sources in the body of the plan)

The only centralized source of data for many of the weather-related hazards is the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC). Although it is usually the best and most current source, there are limitations to the data which should be noted. The NCDC documents the occurrence of storms and other significant weather phenomena having sufficient intensity to cause loss of life, injuries, significant property damage, and/or disruption to commerce. In addition, it is a partial record of other significant meteorological events, such as record maximum or minimum temperatures or precipitation that occurs in connection with another event. Some information appearing in the NCDC may be provided by or gathered from sources outside the National Weather Service (NWS), such as the media, law enforcement and/or other government agencies, private companies, individuals, etc. An effort is made to use the best available information but because of time and resource constraints, information from these sources may be unverified by the NWS. Those using information from NCDC should be cautious as the NWS does not guarantee the accuracy or validity of the information.

The NCDC damage amounts are estimates received from a variety of sources, including those listed above in the Data Sources section. For damage amounts, the NWS makes a best guess using all available data at the time of the publication. Property and crop damage figures should be considered as a broad estimate. Damages reported are in dollar values as they existed at the time of the storm event. They do not represent current dollar values.

The database currently contains data from January 1950 to March 2014, as entered by the NWS. Due to changes in the data collection and processing procedures over time, there are unique periods of record available depending on the event type. The following timelines show the different time spans for each period of unique data collection and processing procedures.

1. Tornado: From 1950 through 1954, only tornado events were recorded.
2. Tornado, Thunderstorm Wind and Hail: From 1955 through 1992, only tornado, thunderstorm wind and hail events were keyed from the paper publications into digital data. From 1993 to 1995, only tornado, thunderstorm wind and hail events have been extracted from the Unformatted Text Files.
3. All Event Types (48 from Directive 10-1605): From 1996 to present, 48 event types are recorded as defined in NWS Directive 10-1605.

Note that injuries and deaths caused by a storm event are reported on an area-wide basis. When reviewing, a table resulting from an NCDC search by county, the death or injury listed in connection with that county search did not necessarily occur in that county.

3.1.4 Hazards Identified

List the hazards that significantly impact the planning area and were chosen for further analysis in alphabetical order. Explain that not all hazards impact every jurisdiction. Insert a table providing a summary of the jurisdictions impacted by each hazard. Explain the symbols used, such as the fact that an “x” indicates the jurisdiction is impacted by the hazard, and a "-" indicates the hazard is not applicable to that jurisdiction. If there are variations in the assessed hazard risk for hazards that usually are area-wide in risk, such as thunderstorms, include the rationale for that variation. Example: a community with a high percentage of housing comprised of mobile homes could be more at risk to damages from a tornado. This information could be conveyed using footnotes to explanations at the bottom of the page.

Table 3.1. Hazards Identified for Each Jurisdiction

Jurisdiction	Dam Failure	Drought	Earthquake	Extreme Heat	Wild Fires	Flooding (River and Flash)	Land Subsidence/Sinkholes	Levee Failure	Severe Winter Weather	Thunderstorm/Lightning/Hail/ High Wind	Tornado
Pike County	x	x	x	x	x	x	x	x	x	x	x
Bowling Green	x	x	x	x	x	x	x	x	x	x	x
Louisiana	x	x	x	x	x	x	x	x	x	x	x
Clarksville	x	x	x	x	x	x	x	x	x	x	x
Paynesville	x	x	x	x	x	x	x	x	x	x	x
Annada	x	x	x	x	x	x	x	x	x	x	x
Frankford	x	x	x	x	x	x	x	x	x	x	x
Curryville	x	x	x	x	x	x	x	x	x	x	x
Louisiana R-2	x	x	x	x	x	x	x	x	x	x	x
Bowling Green R-1	x	x	x	x	x	x	x	x	x	x	x
Clopton/Pike Lincoln Tech	x	x	x	x	x	x	x	x	x	x	x
Boncl	x	x	x	x	x	x	x	x	x	x	x

3.1.5 Multi-Jurisdictional Risk Assessment

This Hazard Mitigation Plan for Pike County is an update of the 2011 plan. This is a multi-jurisdictional plan that addresses the unincorporated area of Pike County, the seven communities within its boundaries and the four associated school districts.

The plan is set up to address each hazard with an individual profile to detail risks associated with the hazard across the region and specifically for each jurisdiction participating. Each hazard profile will address hazard risk variations and describe variances.

Pike County is uniform in terms of climate, topography and building construction characteristics. Most of the town centers date back to the middle years of the last century with very little new construction.

The hazards that vary across the planning area in terms of risk include dam failure, flash flood, wildland fire, levee failure, and river flood. The details of these differences are recorded in each hazard profile under a separate heading. The unincorporated areas of the county have experienced limited damage from winter storms, tornadoes, thunderstorms, heat waves, drought, dam failure, and wildfires. The primary impact of natural hazards in the unincorporated areas of Pike County is to agriculture.

3.2 Assets at Risk

This section assesses the population, structures, critical facilities and infrastructure, and other important assets in the planning area that may be at risk to natural hazards. Table 3.3 shows the total population, building count, estimated value of buildings, estimated value of contents and estimated total exposure to parcels by jurisdiction.

3.2.1 Total Exposure of Population and Structures

Table 3.2 shows the total population and building count by usage type for Pike County.

Table 3.3 that follows provides the building value exposures for Pike County broken down by usage type.

Table 3.2. Maximum Population and Building Exposure for Pike County

Population (2010)	Residential	Commercial	Industrial	Agricultural	Religion	Government	Education	Total
18,516	7,890	427	107	89	52	32	13	8,610

Source: 2013 Missouri State Hazard Mitigation Plan

Table 3.3. Building Values/Exposure by Usage Type for Pike County

Residential	Commercial	Industrial	Agricultural	Religion	Government	Education	Total
1,334,652	213,706	51,486	16,974	28,316	24,578	63,243	1,732,955

Source: 2013 Missouri State Hazard Mitigation Plan

3.2.2 Critical and Essential Facilities and Infrastructure

This section will include information from the Data Collection Questionnaire and other sources concerning the vulnerability of participating jurisdictions' critical, essential, high potential loss, and transportation/lifeline facilities to identified hazards. Definitions of each of these types of facilities are provided below.

- Critical Facility: Those facilities essential in providing utility or direction either during the response to an emergency or during the recovery operation.
- Essential Facility: Those facilities that if damaged, would have devastating impacts on disaster response and/or recovery.
- High Potential Loss Facilities: Those facilities that would have a high loss or impact on the community.
- Transportation and lifeline facilities: Those facilities and infrastructure critical to transportation, communications, and necessary utilities.

Table 3.4 includes a summary of the inventory of critical and essential facilities and infrastructure in the planning area. The list was compiled from the Data Collection Questionnaire as well as the following sources:

- Mark Twain Regional Council of Governments list of critical facility inventory

Table 3.4. Inventory of Critical/Essential Facilities and Infrastructure by Jurisdiction

Jurisdiction	Airport Facility	Bus Facility	Childcare Facility	Communications Tower	Electric Power Facility	Emergency Operations	Fire Service	Government	Housing	Shelters	Highway Bridge	Hospital/Health Care	Military	Natural Gas Facility	Nursing Homes	Police Station	Potable Water Facility	Rail	Sanitary Pump Stations	School Facilities	Storm water Pump Stations	Tier II Chemical Facility	Wastewater Facility	Total
Pike County						1		1			1					1								4
Louisiana							1	1	1	1		1		1		1	1	1	1	2			1	
Bowling Green	1		3			1	1	1	1	4		2		1	2	1	1	1	1	2			1	24
Clarksville							1	1		1							1						1	5
Paynesville								1																1
Frankford																								
Curryville			1				1	1										1		1			1	
Louisiana R-II		1																		3				4
Boncl R-5																				2				2
Pike-Lincoln Tech/Clopton Sc																				5				5
Totals	1	1	4			2	4	6	2	6	1	3		2	2	3	3	3	2	15			4	

Source: Data Collection Questionnaires; HAZUS, etc.

<u>Bridges:</u> This term refers to one of the database elements in the National Bridge Inventory. This element is quantified using a “scour index”, which is a number indicating the vulnerability of a bridge to scour during a flood. Bridges with a scour index between 1 and 3 are considered “scour critical”, or a bridge with a foundation determined to be unstable for the observed or evaluated scour condition. There were no bridges indicated as “scour critical” in the planning area.

Figure 3.1. Pike County Bridges

County	Count	# Str Def	# Func Obs	Total Def	Area	Stru Def Area	Func Obs Area	Total Def Area
Pike	226	49	11	60	60,197	13,331	1,387	14,719

Source: www.fhwa.dot.gov/bridge/nbi/no10/county15b.cfm#mo

3.2.3 Other Assets

Assessing the vulnerability of the planning area to disaster also requires data on the natural, historic, cultural, and economic assets of the area. This information is important for many reasons.

- These types of resources warrant a greater degree of protection due to their unique and irreplaceable nature and contribution to the overall economy.
- Knowing about these resources in advance allows for consideration immediately following a hazard event, which is when the potential for damages is higher.
- The rules for reconstruction, restoration, rehabilitation, and/or replacement are often different for these types of designated resources.
- The presence of natural resources can reduce the impacts of future natural hazards, such as wetlands and riparian habitats which help absorb floodwaters.
- Losses to economic assets like these (e.g., major employers or primary economic sectors) could have severe impacts on a community and its ability to recover from disaster.

Include in the plan specific natural, historic, cultural, and economic assets in the planning area, which could include the following:

Threatened and Endangered Species: Insert a table **(Table 3.1)** showing Federally Threatened, Endangered, Proposed and Candidate Species in Pike, County, Missouri.

Table 3.1. Threatened and Endangered Species in Pike County

Common Name	Scientific Name	Status
Indiana Bat	Myotis sodalist	Endangered
Gray Bat	Myotis grisecens	Endangered
Northern Long-Eared Bat	Myotis septentrionalis	Threatened
Decurrent False-AsterFat pocketbook	Boltonia decurrens Potamius capax	ThreatenedEndangered
Sheepnose Mussel	Plethobasus cyphuys	Endangered
Fat Pocketbook	Potamilus capax	Endangered

Source: U.S. Fish and Wildlife Service, http://www.fws.gov/midwest/Endangered/lists/missouri-cty.html; see also http://ecos.fws.gov/ipac/

Natural Resources: Pike County has twenty conservation and recreational areas. The Missouri Department of Conservation (MDC) provides a database of lands the MDC owns, leases or manages for public use. **Table 3.2** provides the names and location of parks and conservation areas in the planning area owned by Missouri Department of Conservation.

Table 3.2. Parks and Conservation Areas in Pike County

Area Name	Address	City
Dupont Reservation CA	Hwy 79 to Route TT	Ashburn
Prairie Slough CA	Route P	Elsberry
Ranacker CA	Route RA West	Frankford
Shanks (Ted) CA	Hwy 79 & Route TT	Ashburn
Ashley Access	Hwy161	Bowling Green
Louisiana Access	Georgia Street	Louisiana
Calumet Creek Access	Hwy 79 North	Clarksville
Clarence Cannon National Wildlife Refuge	County Road 206	Annada

http://mdc4.mdc.mo.gov/applications/moatlas/AreaList.aspx?txtUserID=guest&txtAreaNm=s

Park Name	Address	City
Jack Floyd Memorial Lake	County Rd 282	Bowling Green
West Lake	County Rd 282	Bowling Green
Clarksville Riverfront Park	One Block East of Hwy 79	Clarksville
Sunset Park	Georgia Street	Louisiana
VFW park	Fairgrounds Rd	Louisiana
Riverview Park	North Main	Louisiana
Bowling Green City Park	South Court	Bowling Green
15th Street Park	15th Street	Bowling Green
Visitors Center Park	Hwy 61/161	Bowling Green
Frankford City Park	Main Street	Frankford
Riverfront Park	First Street	Clarksville
City Park	Main Street	Curryville

Historic Resources: The National Register of Historic Places is the official list of registered cultural resources worthy of preservation. It was authorized under the National Historic Preservation Act of 1966 as part of a national program. The purpose of the program is to coordinate and support public and private efforts to identify, evaluate, and protect our historic and archeological resources. The National Register is administered by the National Park Service under the Secretary of the Interior. Properties listed in the National Register include districts, sites, buildings, structures and objects that are significant in American history, architecture, archeology, engineering, and culture.

Table 3.3. Pike County Properties on the National Register of Historic Places

Property	Address	City	Date Listed
Charles Bacon House	819 Kentucky St.	Louisiana	7/19/1990
Captain George & Attella Bernard House	2109 Georgia St.	Louisiana	2009
Bethel Chapel AME Church	Jct. of 6th and Tennessee Sts.	Louisiana	7/28/1995
City Market	125 S. Main St.	Louisiana	3/23/2005
James Beauchamp Clark House	204 E Champ Clark Dr.	Bowling Green	12/08/1976
Clarksville Historic District	Lewis, Front, Virginia and 3rd Sts.	Clarksville	5/09/1991
Clifford-Wirick House	105 S 2nd St.	Clarksville	7/09/1984
George Street Historic District	Georgia St. between Main and Seventh	Louisiana	5/06/1987
Goodman-Stark House	601 N 3rd St.	Louisiana	10/22/1994
Griffith-McCune Farmstead Historic District	MO WW E of jct. with MO D	Eolia	8/18/1992
Louisiana Chicago and Alton Railroad Depot	801 S Third St.	Louisiana	6/07/2006
Louisiana Public Library	121 N Third St.	Louisiana	4/12/1996
Luce-Dyer House	220 N 3rd St.	Louisiana	9/23/1982
Meloan, Cummins and Co., General Store	Jct. of Middle and Water Sts.	Paynesville	6/24/1993
North Third Street Historic District	Georgia, Noyes, North Third and North	Louisiana	8/24/2005
Northern Methodist Episcopal Church of	309 Smith St.	Clarksville	5/09/1991
Pike County Hospital	2407 West Georgia St.	Louisiana	9/19/2006
St. John's Episcopal Church (Old)	0.25 mile N of Eolia on CR D, and 0.25 mile E on CR H	Eolia	7/08/1970
Stark, Gov. Lloyd Crow, House and Carriage	1401 Georgia St.	Louisiana	12/21/1987
Turner-Pharr House	101 N 4th St.	Clarksville	5/09/1991

Source: Missouri Department of natural Resources – Missouri National Register Listings by County
http://dnr.mo.gov/shpo/mnrlist.htm

Economic Resources: Major non-government employers in the planning area (**Table 3.4**).

Table 3.4. Major Non-Government Employers in Pike County

Employer Name	Main Locations	Product or Service	Employees
True Manufacturing	Bowling Green	Refrigeration Products	370
Wal-Mart	Bowling Green	General Merchandise	200
Dyno Nobel	Louisiana	Chemical Manufacturing	50-99
All Parts	Louisiana	After-market Auto Parts	125
Daffron	Bowling Green	Computer Software	59
Stark Brothers	Bowling Green	Nursery	250
Fifth Gear	Louisiana	Outsourcing, Order	140
Trailer Man Trailers	Louisiana	Trailers	50
Calumet	Louisiana	Petroleum Refining	150-250

Source: Data Collection Questionnaires; local Economic Development Commissions

Agriculture

Agriculture plays a major role in the Pike County economy and one of the major employers is a supplier to the agriculture economy.

Table 3.5. Agriculture-Related Jobs in Pike County

Employer Name	2012	2007	% Change
Number of Farms	1,003	1,102	-9
Land in Farms	361,666 acres	373,142 acres	-3
Average Size of Farm	361 acres	339 acres	+6
Market Value of Products Sold	$87,355,000	$79,770,000	+10
Crop Sales	$54,922,000		
Livestock Sales	$32,433,000		
Average Per Farm	$87,093	$72,387	+20
Government Payments	$4,506,000	$4,156,000	+8
Average Per Farm Receiving Payments	$6,837	$6,166	+11

3.3 Future Land Use and Development

3.3.1 Development Since Previous Plan Update

Population data can sometimes be used to determine the potential for future development. An increase in population will spur a need for additional housing and attract commercial development. As indicated by the information in Table 3.6, Pike County has experienced a small increase in population.

Table 3.6. Pike County Population Growth, 2000-2010

Jurisdiction	Total Population 2010	Total population 2000	2000-2010 # Change	2000-2010 % Change
Pike County	18,516	18,314	+202	+1.0%
Louisiana	3,364	3,863	-499	-14%
Bowling Green	5,334	3,260	+2,074	+38%
Clarksville	442	490	-48	-9.7%
Annada	29	48	-19	-39.5%
Paynesville	77	91	-14	-15.8%
Frankford	323	351	-28	-7.9%
Curryville	225	251	-26	-10.3%

Source: U.S. Bureau of the Census, Decennial Census; Population Statistics are for entire incorporated areas as reported by the Census bureau

Along with the population increase there has been an increase in the number of housing units except for the city of Louisiana and Paynesville. Table 3.7 provides the change in number of housing units in the planning area from 2000 to 2010.

Table 3.7. Change in Housing Units, 2000-2010

Jurisdiction	Housing Units 2010	Housing Units 2000	2000-2010 # Change	2000-2010 % change
Pike County	7,875	7,493	+382	4.8%
Louisiana	1,667	1,843	-176	-9.5%
Bowling Green	1,445	1,290	+155	10%
Clarksville	294	278	-16	-5.7%
Annada	28	25	+3	+10.7%
Paynesville	28	35	-7	-20%
Frankford	222	179	+43	19.3%
Curryville	140	128	+12	+8.5%

Source: U.S. Bureau of the Census, Decennial Census; Population Statistics are for entire incorporated areas as reported by the U.S. Census Bureau

Population growth or decline is generally accompanied by increases or decreases in the number of housing units. With the trend of population increase for the entire county there is reason to expect increased development.

School District's Future Development

Pike-Lincoln Tech Center is looking to expand their main and west campuses. Also potential updates may be made to Clopton High School. The Louisiana school district has no plans to expand unless funding can be secured to build a tornado safe building.

3.4 Hazard Profiles, Vulnerability, and Problem Statements

Hazard Profiles

Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the…location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

Each hazard identified in Section 3.4 is profiled individually in this section. The level of information presented in the profiles will vary by hazard based on the information available. With each update of this plan, new information will be incorporated to provide better evaluation and prioritization of the hazards that affect the planning area. Detailed profiles for each of the identified hazards include information categorized as follows:

Hazard Description: This section consists of a general description of the hazard and the types of impacts it may have on a community or school/special district.

Geographic Location: This section describes the geographic location of the hazard in the planning area. Where available, use maps to indicate the specific locations of the planning area that are vulnerable to the subject hazard. For some hazards, the entire planning area is at risk.

Severity/Magnitude/Extent: This includes information about the severity, magnitude, and extent of a hazard. For some hazards, this is accomplished with description of a value on an established scientific scale or measurement system, such as an EF2 tornado on the Enhanced Fujita Scale. Severity, magnitude, and extent can also include the speed of onset and the duration of hazard events. Describing the severity/magnitude/extent of a hazard is not the same as describing its potential impacts on a community. Severity/magnitude/extent defines the characteristics of the hazard regardless of the people and property it affects.

Previous Occurrences: This section includes available information on historic incidents and their impacts. Historic event records form a solid basis for probability calculations.

Probability of Future Occurrence: The frequency of recorded past events is used to estimate the likelihood of future occurrences. Probability was determined by dividing the number of recorded events by the number of years and multiplying by 100. This gives the percent chance of the event happening in any given year. For events occurring more than once annually, the probability will be reported 100% in any given year, with a statement of the average number of events annually.

Vulnerability Assessments

Requirement §201.6(c)(2)(ii) :[The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community.

Requirement §201.6(c)(2)(ii)(A) :The plan should describe vulnerability in terms of the types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas.

Requirement §201.6(c)(2)(ii)(B) :[The plan should describe vulnerability in terms of an] estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(i)(A) of this section and a description of the methodology used to prepare the estimate.

Requirement §201.6(c)(2)(ii)(C): [The plan should describe vulnerability in terms of] providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.

Requirement §201.6(c)(2)(ii): (As of October 1, 2008) [The risk assessment] must also address National Flood Insurance Program (NFIP) insured structures that have been repetitively damaged in floods.

Following the hazard profile for each hazard will be the vulnerability assessment. The vulnerability assessment further defines and quantifies populations, buildings, critical facilities, and other community assets at risk to damages from natural hazards. The vulnerability assessments will be based on the best available county-level data, which is in the Missouri Hazard Mitigation Plan (2010). The county-level assessments in the State Plan were based on the following sources:

- Statewide GIS data sets compiled by state and federal agencies; and
- FEMA's HAZUS-MH loss estimation software.

The vulnerability assessments in the Pike County plan will also be based on:

- Written descriptions of assets and risks provided by participating jurisdictions;
- Existing plans and reports;
- Personal interviews with planning committee members and other stakeholders; and
- Other sources as cited.

:

Vulnerability Overview

This section consists of a general overview narrative of the planning area's vulnerability to the hazard. Within this section, the magnitude/severity of the hazard is discussed. The magnitude of the impact of a hazard event (past and perceived) is related directly to the vulnerability of the people, property, and the environment it affects. This is a function of when the event occurs, the location affected by the resilience of the community, and the effectiveness of the emergency response and disaster recovery efforts.

Potential Losses to Existing Development: This section provides the potential losses existing development.

Previous and Future Development: This section will include information on anticipated future development in the county, and how that would impact hazard risk in the planning area.

Hazard Summary by Jurisdiction: For hazard risks that vary by jurisdiction, this section will provide an overview of the variation and the factual basis for that variation.

Problem Statements

Each hazard analysis must conclude with a summary of the problems created by the hazard in the planning area, and possible ways to resolve those problems. If the risk varies across the planning area jurisdiction-specific information will be included.

3.4.1 Dam Failure

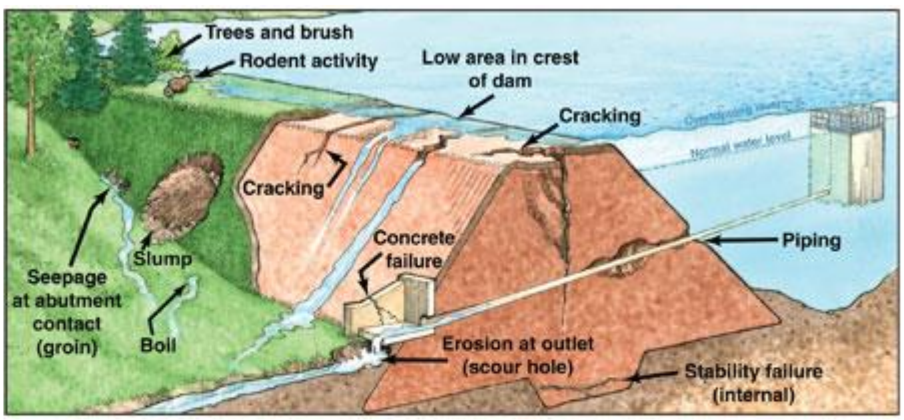
Hazard Description

A dam is defined as a barrier constructed across a watercourse for the purpose of storage, control, or diversion of water. Dams are typically constructed of earth, rock, concrete, or mine tailings. Dam failure is the uncontrolled release of impounded water resulting in downstream flooding, affecting both life and property. Dam failure can be caused by any of the following:

1. Overtopping - inadequate spillway design, debris blockage of spillways or settlement of the dam crest.
2. Piping: internal erosion caused by embankment leakage, foundation leakage and deterioration of pertinent structures appended to the dam.
3. Erosion: inadequate spillway capacity causing overtopping of the dam, flow erosion, and inadequate slope protection.
4. Structural Failure: caused by an earthquake, slope instability or faulty construction.

Data on dams in Pike County has been collected from two sources; a listing maintained by the Missouri Department of Natural Resources (MoDNR) and the National Inventory of Dams (NID). Each has its own system of classifying dams. For the purpose of planning, the NID information was used. Neither the MoDNR nor the NID hazard potential classification references the condition of the dam.

Table 3.8. Causes of Dam Failure



Source: United States Forest Service http://www.fs.fed.us/eng/pubs/htmlpubs/htm12732805/page02.htm

Dams in Pike County are subject to classification by the State of Missouri and by the federal government. Table 3.9 shows the system of classification used by the Missouri Department of Natural Resources. A hazard classification is assigned to each dam during the initial permit process.

Table 3.9. MDNR Dam Hazard Classification Definitions

Hazard Class	Definition
Class I	Contains 10 or more permanent dwellings or any public building
Class II	Contains 1 to 9 permanent dwellings or 1 or more campgrounds with permanent water, sewer, and electrical services or 1 or more industrial buildings
Class III	Everything else

Source: Missouri Department of Natural Resources, http://dnr.mo.gov/env/wrc/docs/rules_reg_94.pdf

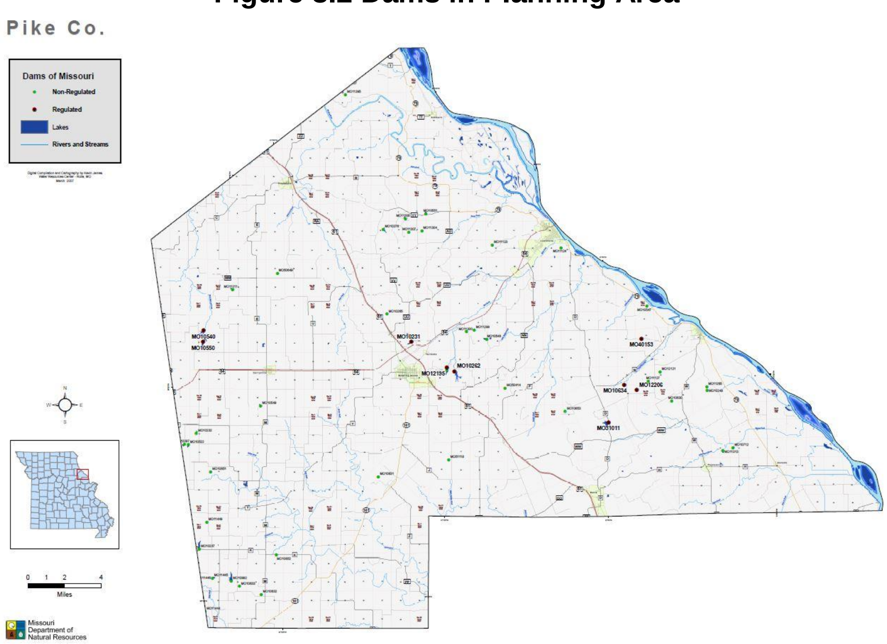
Table 3.10. NID Dam Hazard Classification Definitions

Hazard Class	Definition
Low Hazard	A dam located in an area where failure could damage only farm or other uninhabited buildings, agricultural or undeveloped land including hiking trails, or traffic on low volume roads that meet the requirements for low hazard dams.
Significant Hazard	A dam located in an area where failure could endanger a few lives, damage an isolated home, damage traffic on moderate volume roads that meet certain requirements, damage low-volume railroad tracks, interrupt the use or service of a utility serving a small number of customers, or inundate recreation facilities, including campground areas intermittently used for sleeping and serving a relatively small number of persons.
High Hazard	A dam located in an area where failure could result in any of the following: extensive loss of life, damage to more than one home, damage to industrial or commercial facilities, interruption of a public utility serving a large number of customers, damage to traffic on high-volume roads that meet the requirements for hazard class C dams or a high-volume railroad line, inundation of a frequently used recreation facility serving a relatively large number of persons, or two or more individual hazards described for significant hazard dams.

Source: National Inventory of Dams

Geographic Location

Figure 3.2 Dams in Planning Area



Pike County has nine state-regulated dams inside the county boundaries. Within the State of Missouri, the Department of Natural Resources maintains a Dam and Safety Program overseen by the Division of Geology and Land Survey. Chapter 236 Revised Statutes of Missouri state that a dam must be 35 feet or higher to be state regulated. The United States Army Corps of Engineers regulates the Lock and Dam #24 on the Mississippi River and the Clarence Cannon Dam located in Ralls County.

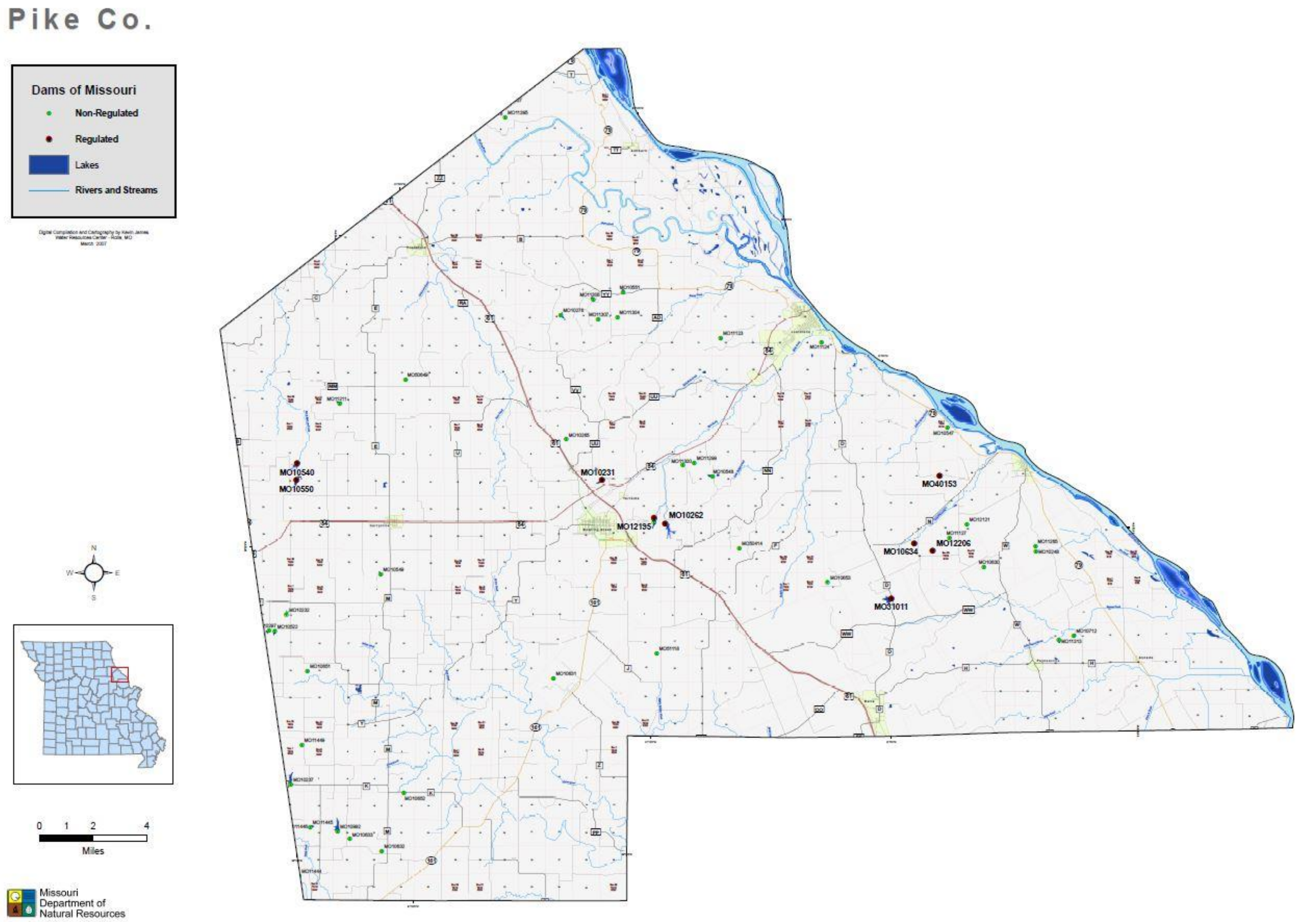
The NID Dam data for Pike County includes 41 dams: Miller Dam, Bibb Lake Dam, Station, Kohl Lake Dam-East, Charles Morris Dam, Lock and Dam #24, Bowling Green Dam #1, WL Morris Dam, Camerer Dam, Thiel Lake Dam-East, Clithero Lake Dam, Kohl Lake Dam-West, Love Lake Dam, Old Bowling Green Reservoir Dam, Morris Lake Dam, Harris Lake Dam, Bachman Lake Dam, Magee Lake Dam, Berra Lake Dam, Thiel Lake Dam-West, Lewis Lake Dam, IMR Corp-SEC 11, White Lake Dam, Vandalia Lake Dam, Ripple Lake Dam, Smith Lake Dam, Love Lake Dam, Joseph Keeven Dam, Tievoli Hills Lake #1 Dam, Vera Lake Dam, Wilhite Dam, Paul Williams Dam, Daniels Lake Dam, Pfautch Lake Dam, Clithero Lake Dam, Bowling Green Dam #2, Niemeyer Dam, Evans and Wertz's Dam, Stormwater Management Dam and Epperson Dam.

Table 3.11. High Hazard Dams in the Pike County Planning Area

Dam Name	Other Dam Name	NIDID	Hazard Potential *	NID Height (Ft.)	River	Nearest City *	Distance To City (Mi.) *	County	State	Enforcement Authority
SMITH LAKE DAM	-	MO11124	High	31	TR MISSISSIPPI RIVER	LOUISIANA	1	PIKE	MO	N
VERA LAKE DAM	-	MO11300	High	25	TR-NOIX CREEK	LOUISIANA	6	PIKE	MO	N
WILLIAMS,PAUL DAM	-	MO11299	High	28	TR-NOIX CREEK	LOUISIANA	7	PIKE	MO	N
WILHITE DAM	-	MO11307	High	30	CAINS CREEK	LOUISIANA	8	PIKE	MO	N
PFAUTCH LAKE DAM	-	MO11304	High	30	TR-CAINS CREEK	LOUISIANA	7	PIKE	MO	N
BIBB LAKE DAM	-	MO10231	High	46	TRIBUTARY TO NOIX CREEK	BOWLING GREEN	1.6	PIKE	MO	Y
LOVE LAKE DAM	-	MO10276	High	30	TR-SUGAR CREEK	LOUISIANA	14	PIKE	MO	N
MORRIS W L DAM	-	MO10651	High	25	TR-SHADY CREEK	NEW HARTFORD	9	PIKE	MO	N
WHITE LAKE DAM	-	MO10551	High	25	TR-CAINS CREEK	LOUISIANA	8	PIKE	MO	N
BOWLING GREEN DAM #1	-	MO10262	High	73	TRIBUTARY TO NOIX CREEK	BOWLING GREEN	2.2	PIKE	MO	Y
OLD BOWLING GREEN RESERVOIR DAM	-	MO10263	High	23	TR-BUCKNER HOLLOW-NOIX CREEK	LOUISIANA	-	PIKE	MO	N
MAGEE LAKE DAM	LOCKHARD LAKE DAM	MO31011	High	42	MUD CREEK	EOLIA	8.7	PIKE	MO	Y
BOWLING GREEN DAM #2	-	MO12195	High	61	TR BUCKNER HOLLOW	BOWLING GREEN	1.8	PIKE	MO	Y
EVANS & WERTZ'S DAM	-	MO50414	High	27	TR-GOOSE CREEK	CLARKSVILLE	20	PIKE	MO	N

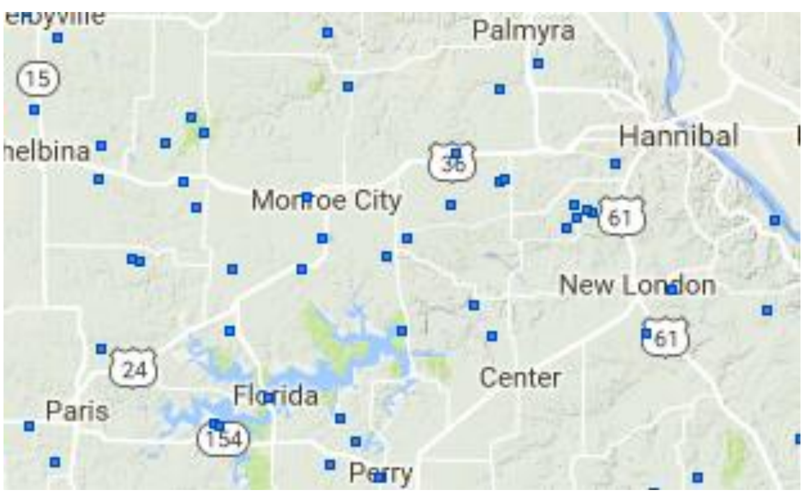
Sources: Missouri Department of Natural Resources, http://dnr.mo.gov/env/wrc/dam-safety/statemap.htm and National Inventory of Dams, http://nid.usace.army.mil/cm_apex/f?p=838:12By the end of 2015, the Missouri DNR anticipates having Emergency Action Plans, including inundation maps for all state-regulated Class 1 and Class 2 dams. Contact the DNR Dam and Reservoir Safety Program at 800-361-4827 to request the inundation maps for your county to show geographic locations at risk, extent of failure and to perform GIS analysis of those assets at risk to dam failure.

Figure 3.2. High Hazard Dam Locations in Pike County and Areas Impacted in the Event of Breach.



Source: Missouri Department of Natural Resources

Figure 3.3. Upstream Dams Outside Pike County



Source: U.S. Army Corps of Engineers, Missouri Department of Natural Resources

Most of the dams upstream from Pike County are located in Pike and Pike Counties and lie in

the Salt River watershed. Any failure in those counties would affect assets located near those rivers. The Clarence Cannon Dam in Ralls County flows into the Salt River in northern Pike county. Failure of the Clarence Cannon Dam would have a catastrophic ***impact on rural Pike county. A failure of any dams located in the Mississippi River valley could directly impact cities and rural properties located along the Mississippi River in Pike County.***

Severity/Magnitude/Extent

It can be stated that the severity/magnitude of dam failure would be similar in some cases to the impacts associated with flood events (see the flood hazard vulnerability analysis and discussion). Based on the hazard class definitions, failure of any of the High Hazard/Class I dams could result in a serious threat of loss of human life, serious damage to residential, industrial or commercial areas, public utilities, public buildings, or major transportation facilities. Catastrophic failure of any high hazard dams has the potential to result in greater destruction due to the potential speed of onset and greater depth, extent, and velocity of flooding. Note that for this reason, dam failures could flood areas outside of mapped flood hazards. Inundation data, however, is not currently available for any of the county's dams or the surrounding areas from DNR. The future probable severity of a dam failure in Pike County is shown below according to DNR's hazard potential levels.

Hazard Level	Probable Risk
High	catastrophic
Significant	critical
low	negligible

Previous Occurrences

Thousands of people have been injured, many killed, and billions of dollars in property damaged by dam failures in the United States. The problem of unsafe dams in Missouri was underscored by dam failures at Lawrenceton in 1968, Washington County in 1975, Fredericktown in 1977, Taum Sauk in 2005, and a near failure in Franklin County in 1978. There have been 26 recorded dam failures in Missouri over the last 100 years. One drowning is recorded among all of these disasters.

To determine previous occurrences of dam failure within the Pike County, the Pike County Missouri Natural Hazard Mitigation Plan was consulted as well as the Missouri State Hazard Mitigation Plan and the Stanford University's National Performance of Dams Program (http://npdp.stanford.edu/). One dam in Pike County previously had an incident. Bowling Green Dam #1 had an issue with seepage and piping on 6-26-1995.

Probability of Future Occurrence

Dam failure and its associated impacts is a possibility for disaster in Pike County. Pike County has fourteen high hazard dams. There is a small chance of dam failure happening based on past occurrences. However, the effects of a failure would be horrific.

Vulnerability

Vulnerability Overview

Most of Pike County's vulnerability in the event of a dam failure is loss of agriculture assets. Without inundation maps available it is hard to predict how far downstream the effects of a dam breech would be. Several communities have dams located upstream from them but again it is not easy to ascertain how many lives or how much property would be affected in a dam failure. Some of the dams are located close enough to major highways that it appears that a compromise in the integrity of a dam could threaten to close or damage roadways.

Impact of Previous and Future Development

Future development in the City of Louisiana could impact the amount of damages caused by a failure in the Smith Lake Dam. The location of remaining high hazard dams in the planning area are located in rural areas and future development would have very little impact.

Hazard Summary by Jurisdiction

Vulnerability to dam failure is very minimal with the exception to the City of Louisiana. The remaining participating jurisdictions including school districts would be affected very minimally.

Problem Statement

Pike County residents with a dam on their property do not properly inspect the dams to ensure the safety of the dam not failing. Residents need to be informed of the proper way to inspect a dam and look for initial problems.

3.4.2 Drought

Hazard Profile

Hazard Description

Drought is generally defined as a condition of moisture levels significantly below normal for an extended period of time over a large area that adversely affects plants, animal life, and humans. A drought period can last for months, years, or even decades. There are four types of drought conditions relevant to Missouri, according to the State Plan, which are as follows.

- Meteorological drought is defined in terms of the basis of the degree of dryness (in comparison to some "normal" or average amount) and the duration of the dry period. A meteorological drought must be considered as region-specific since the atmospheric conditions that result in deficiencies of precipitation are highly variable from region to region.

- Hydrological drought is associated with the effects of periods of precipitation (including snowfall) shortfalls on surface or subsurface water supply (e.g., streamflow, reservoir and lake levels, ground water). The frequency and severity of hydrological drought is often defined on a watershed or river basin scale. Although all droughts originate with a deficiency of precipitation, hydrologists are more concerned with how this deficiency plays out through the hydrologic system. Hydrological droughts are usually out of phase with or lag the occurrence of meteorological and agricultural droughts. It takes longer for precipitation deficiencies to show up in components of the hydrological system such as soil moisture, streamflow, and ground water and reservoir levels. As a result, these impacts also are out of phase with impacts in other economic sectors.

- Agricultural drought focus is on soil moisture deficiencies, differences between actual and potential evaporation, reduced ground water or reservoir levels, etc. Plant demand for water depends on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and the physical and biological properties of the soil.

- Socioeconomic drought refers to when physical water shortage begins to affect people.

Data sources: http://www.drought.unl.edu/

Geographic Location

Droughts are regional in nature. All areas of the United States are vulnerable to the risk of drought and extreme heat. Droughts can be widespread or localized events. The extent of the droughts varies both in terms of the extent of the heat and range of precipitation. The severity of a drought depends on locations, duration, and geographical extent. Additionally, drought severity depends on the water supply, usage demands made by human activities, vegetation and agricultural operations. Drought brings several different problems that must be addressed. The quality and quantity of crops, livestock, and other agricultural assets will be affected during a drought. Drought can adversely impact forested areas leading to an increased potential for extremely destructive forest and woodland fires that could threaten residential, commercial, and recreational structures.

As of 2012, 84% of Pike County consisted of land in farms which left 67,415 acres of developed land. Farming is concentrated in the north, west, south and southeast areas of the county leaving the Eastern and Central part of the county as the most developed.

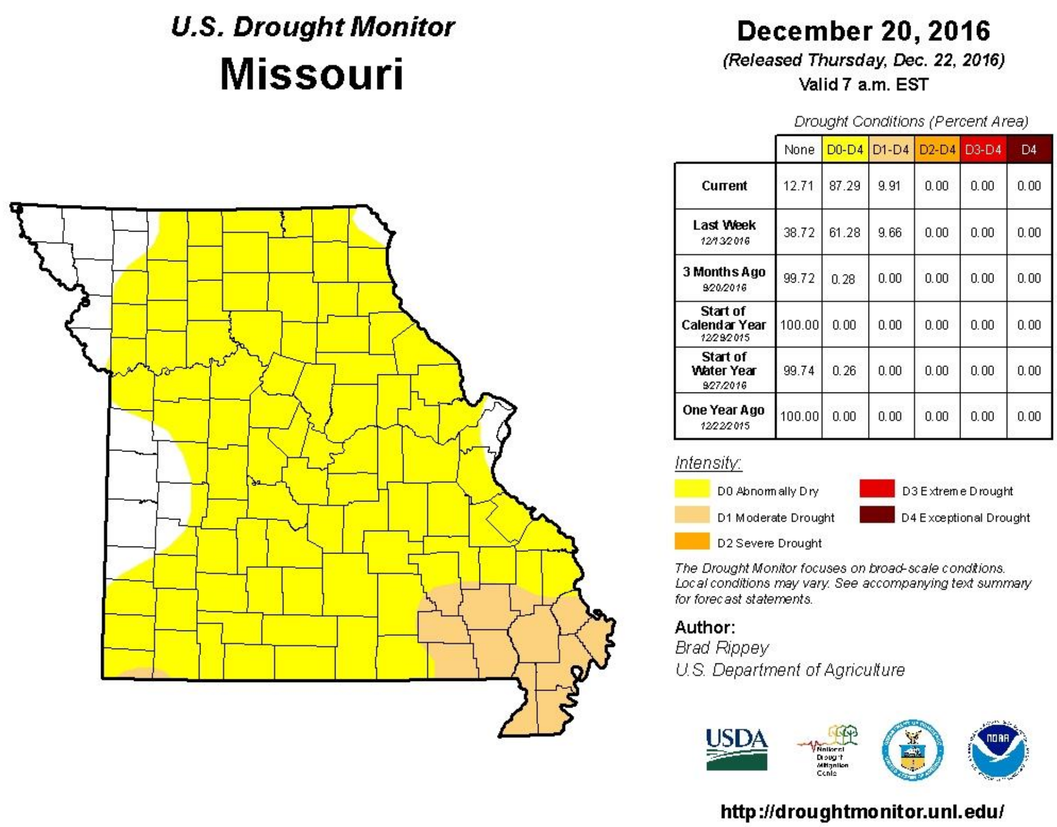
Source:
https://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/Missouri/st29_2_008_008.pdf

Severity/Magnitude/Extent

The National Drought Monitor Center at the University of Nebraska at Lincoln summarized the potential severity of drought as follows. Drought can create economic impacts on agriculture and related sectors, including forestry and fisheries, because of the reliance of these sectors on surface and subsurface water supplies. In addition to losses in yields in crop and livestock production, drought is associated with increases in insect infestations, plant disease, and wind erosion. Droughts also bring increased problems with insects and disease to forests and reduce growth. The incidence of forest and range fires increases substantially during extended droughts, which in turn place both human and wildlife populations at higher levels of risk. Income loss is another indicator used in assessing the impacts of drought because so many sectors are affected. Finally, while drought is rarely a direct cause of death, the associated heat, dust and stress can all contribute to increased mortality.

A recent map from the U.S. Drought Monitor can be inserted as an example of the geographic area that could be in drought at any given moment in time. Remember that it is only a snapshot of conditions at a given moment in time. Either use an arrow to indicate the location of the planning area on the map, or use narrative to explain what the map illustrates in terms of the planning area.

Figure 3.4. U.S. Drought Monitor Map of Missouri on December 27, 2016



Source: U.S. Drought Monitor, http://droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?MO

USDA Risk Management Insurance Payments Due to Drought in Pike County, 1996-Present

Year	Indemnity Amount	Year	Indemnity Amount
2015	$ 0.00	2005	$ 3,503,334.00
2014	$ 0.00	2004	$ 0.00
2013	$ 985,175.00	2003	$ 1,452,576.00
2012	$ 29,053,436.00	2002	$ 1,378,418.00
2011	$ 2,793,021.00	2001	$ 516,849.00
2010	$ 0.00	2000	$ 32,571.00
2009	$ 0.00	1999	$ 2,135,391.00
2008	$ 7,801.00	1998	$ 10,365.00
2007	$ 2,929,638.00	1997	$ 134,711.00
2006	$ 293,835.00	1996	$ 3,740.00

The Palmer Drought Indices measure dryness based on recent precipitation and temperature. The indices are based on a “supply-and-demand model” of soil moisture. Calculation of supply is relatively straightforward, using temperature and the amount of moisture in the soil. However, demand is more complicated as it depends on a variety of factors, such as evapotranspiration and recharge rates. These rates are harder to calculate. Palmer tried to overcome these difficulties by developing an algorithm that approximated these rates, and based the algorithm on the most readily available data — precipitation and temperature.

The Palmer Index has proven most effective in identifying long-term drought of more than several months. However, the Palmer Index has been less effective in determining conditions over a matter of weeks. It uses a “0” as normal, and drought is shown in terms of negative numbers; for example, negative 2 is moderate drought, negative 3 is severe drought, and negative 4 is extreme drought. Palmer's algorithm also is used to describe wet spells, using corresponding positive numbers.

Palmer also developed a formula for standardizing drought calculations for each individual location based on the variability of precipitation and temperature at that location. The Palmer index can therefore be applied to any site for which sufficient precipitation and temperature data is available.

The participating communities use water from a water source other than a well. The communities may face difficulties during a drought that will not be as severe as a community utilizing only well water.

Previous Occurrences

Drought occurs periodically in Missouri with the most severe in historical times occurring in 2012. Other major droughts, usually characterized by deficient rainfall combined with unusually high summer temperatures, occurred in 2013, 2005, and 1999. Although droughts are not the spectacular weather events that floods, blizzards or tornadoes can be, historically they produce more economic damage to the State than all other weather events combined.

According to the National Drought Mitigation Center’s Drought Impact Reporter, during the 10-year period from January 2007 to December 2016, Pike County had 303 reported drought impacts. The following are the categories and reported number of impacts:

- Agriculture - 213
- Business & Industry - 7
- Energy - 3
- Fire – 39
- Plants & Wildlife - 79
- Relief, Response, & Restrictions - 44
- Society & Public Health - 20
- Tourism & Recreation - 4
- Water Supply & Quality – 75

Impacts of recent drought periods in Missouri that affected Pike County are provided below. Unless otherwise indicated, these impacts are from the Drought Impact Reporter:

• Growing belief in Global Warming: October 31, 2015 - Some Americans, witnessing ongoing drought in parts of the U.S., have come to believe that global warming is real. Seven out of 10 people say that solid evidence for global warming exists. This is an uptick of 10 percent since fall 2014 and was nearing the record 72 percent in 2008. More than 60 percent of those acknowledging global warming say that severe drought had a “very large effect” on their view of the matter.

• Grass Growth Hampered, Hay Feeding Underway in Missouri: October 22, 2015 - Dry weather has hampered grass growth in Missouri, forcing farmers to begin feeding hay earlier than usual, which will add to farmers’ winter feed bills. Fall grass often supports beef cattle into December. Spring grass production may also be affected by the fall drought.

• Water Restrictions Due to Drought Conditions: August 3, 2015 – Limited water supply due to recent drought conditions is causing governments to restrict the amount of water used by residents and businesses. Agricultural needs are a top priority with residential needs coming in second during drought conditions and water restrictions.

• US Cattle Herd Numbers: February 6, 2015 - Drought reduced the national cattle herd in recent years, but the number of cattle in the country climbed over the last year from 87.7 million to 89.8 million on Jan. 1, 2015, for an increase of one percent. This is the first uptick in cattle numbers since 2007 and shows that herds are being rebuilt faster than expected, say some meat industry publications. Beef prices continued to set new highs.

Information on droughts is very limited since the 1950’s according to Missouri State Plan 2013.
The table below provides detailed drought information from MO DNR since 1999 taken out of the Missouri State Plan 2013.

DATE	DESCRIPTION
July 1999 to November 1999	In September 1999, a Phase I Drought Advisory was declared for the state of Missouri. Governor Carnahan declared an agricultural emergency for the entire state. Agricultural reporting showed a 50 percent crop loss from the drought in 50 counties, with severe damage to pastures for livestock, corn crops, and Missouri’s top cash crop—soybeans. On October 13, 1999, Dan Glickman, USDA secretary declared all Missouri counties agricultural disaster areas, making low-interest loans available to farmers in Missouri and contiguous states. The drought intensity increased through autumn and peaked at the end of November 1999. In fact, the five-month span between July and November became the second driest July-November period in Missouri since 1895, averaging only 9.38 inches of rain.
March 2000 to May 2000	A wetter-than-normal winter diminished dry conditions in central and southern Missouri, but longterm moisture deficits continued to exist. At the same time, the remainder of the State (roughly north of the Missouri River) continued under drought conditions. Overall dry conditions returned through much of the State in March 2000, and costly wildfires and brush fires (70) erupted in many counties. By May, the entire state was under a Phase II Drought Alert level, and

	on May 23, Governor Carnahan announced activation of the Missouri Drought Assessment Committee (DAC), made up of state and federal agencies and chaired by Jeff Staake the DNR deputy director.
May 2000 to July 2000	At a May 25, 2000, meeting, the DAC selected a subcommittee (guided by the Missouri Drought Plan) to determine the drought status of each county. In June, based on observations across the State and projections of future rainfall, the committee upgraded the drought status for 27 northern Missouri counties to Phase III Conservation. This was based on concerns for water supplies and agricultural impacts. The City of Milan in Sullivan County was among the most severely affected in terms of water supplies. In June, a total of 80 Missouri counties remained under the Phase II Alert level, while 7 counties in southeast Missouri (Butler, Dunklin, Mississippi, New Madrid, Pemiscot, Scott, and Stoddard) remained under Phase I Advisory conditions. By mid-July 2000, some areas of northern Missouri benefited from additional rainfall, while drier conditions prevailed in other areas. At its July 12 meeting, the DAC revised its assessment, placing 30 counties under Phase III Conservation conditions, including 10 counties in the south-central area. The remaining 84 counties in the State were under Phase II Drought Alert conditions. This included seven counties in northern Missouri, which were downgraded from Phase III Conservation, and seven counties in Southeast Missouri, which were previously assessed as Phase I Advisory. To ease the agricultural impact of the drought during the summer months, Governor Carnahan gained release of over one million acres from the Conservation Reserve Program (CRP) to provide farmers and ranchers in 21 counties additional sources to cut hay for livestock feed. Also, livestock producers in 16 counties were released from CRP contracts to allow cattle grazing on certain idle lands.
2002 to June 2004	The drought of 2002 caused tremendous financial hardships to many Missouri crop and livestock producers. The financial impact of the drought on producers in turn impacted the local communities and the State in terms of reduced economic activity. This drought cost an estimated $46 million in 2002 and $575 million for 2003 in terms of Missouri's agricultural and economic productivity. Drought conditions encompassed most of the northwestern quarter of Missouri. Severe drought conditions affected the northwest, west-central, and some portions of southwest Missouri, causing water conservation measures to be taken and restrictions to be imposed. For some areas, this was the second driest year since 1914. The only drier year was in 1988. 2002 had the driest November– December period on record for northwestern and north-central Missouri. The drought continued through 2003 and 2004 with conditions improving in 2004. As of March 3, 2004, drought conditions still encompassed most of the northwestern quarter of Missouri with 18 counties designated as being in Phase III Conservation. The drought conditions improved due to an increase in precipitation between March and June 2004. In June 2004, Missouri was considered drought-free for the first time in three years.
July 2005 to September 2005	The drought of 2005, as in the previous drought of 2003-2004, caused tremendous hardships to many Missouri crop and livestock producers. According to the University of Missouri's Food and Agriculture Institute, the estimated losses to the corn and hay crops alone will likely top $370 million. For some Missouri farmers, this will be a drier year than 1988. By late July, the drought conditions encompassed all but nine counties in the northwestern corner of the State. Severe drought conditions affected counties in the southwest through the northeast part of the State. Effective August 23, 2005, due to the secretarial disaster designation, 114 Missouri counties and St. Louis City were designated as natural disasters for physical and/or production-loss loan assistance from Farm Service Agency (FSA). The drought conditions began to improve by late August and into September.
September 2006 to December 2006	The drought of 2006 has had a tremendous agricultural impact on Missouri farmers. As of September 2006, FSA reported that 26 counties had requested Emergency Conservation Program (ECP) funds with two additional counties pending. The livestock industry is feeling severe effects from the current drought. Hay supplies are short, and water supplies for livestock continue to decline. USDA reported that the new $50 million program for livestock producers, called the Livestock Assistance Grant Program, will provide this money in Section 32 to states in block grant form. The drought has also had an impact on local water supplies with several communities issuing mandatory conservation measures. On September 19, 2006, only 10 counties in the southeastern portion of the State were free of drought. By November 28, 2006, 5 more counties were drought-free and 11 more had entered Phase III for a total of 49 counties in the Conservation Phase. In October 2006, the USDA designated 85 Missouri counties as a primary natural disaster area (and extended assistance eligibility to 20 contiguous counties) due to losses caused by the drought beginning January 1, 2006. Only the southeast corner and the extreme northwest corner were not eligible for assistance. According to Pat Guinan, University of Missouri

	climatologist, a snowstorm in late November/early December put a dent in the drought, but more rain and snow are needed for conditions to return to normal.
February 2007 to October 2007	No serious drought conditions have been reported since 2006. The Interim Drought Status map (February 13, 2007) indicates that there were 76 counties in Phase I—Advisory Phase, and 38 counties with no drought. The U.S. Drought Monitor map (July 31, 2007) indicates that several counties north of I-70 and all counties along the Mississippi River to the south had abnormally dry conditions. The Palmer Drought Severity Index map for October 16, 2007, forecasts moderate to extreme drought for most of the counties in Missouri. On October 23, 2007 (see Figure 3.22) shows that there were 61 counties with no drought, 33 counties in Phase I—Advisory Phase, and 20 counties Phase II—Drought Alert.
June 2010 to March 2011	Starting in July 2010, precipitation levels dropped as temperatures remained high, stressing crops in southeast Missouri. Rainfall in late July and August and Tropical Storm Hermine in September gave little relief as water shortage continued. Continued lack of rainfall led to severe (D2) drought conditions in September and extreme (D3) conditions in October the Bootheel region of Missouri. The drought expanded north and west during October and wildfire risk increased due to the dry conditions. Several wildfires occurred in November in Wayne and Carter counties. Precipitation in February provided some relief from the drought and reduced conditions back to severe, then additional rainfall in March further improved the drought status in Missouri.
May 2012 to January 2013 and beyond	May of 2012 brought below average rainfall and resulted in crop damage, low soil moisture levels, and reduced stream flows. By the end of the month, the southern and Bootheel regions of Missouri reached a severe (D2) level drought. In June the drought worsened, meriting an upgrade to an extreme (D3) drought. Fire warnings were high, soybean, corn, and sorghum crops became stressed, and soils moisture levels continued to drop. The drought expanded further into the Ozarks, East Central, Northeast, and Southeast Missouri by the end of June. During July, the drought level was heightened to exceptional (D4) conditions. Crops continued to decline and more livestock had to switch to hay bales for feed. Fourth of July fireworks were canceled due to the dangerously dry conditions. The drought continued for the remainder of 2012 and into 2013. The majority of the state has remained at a severe (D2) drought condition as of January 2013. All counties in Missouri have been declared disaster areas due to the drought.

Probability of Future Occurrence

In the 20-year period there was 74 months with drought recorded. The annual average percentage probability of drought of 31% was calculated by multiplying 20 (years) times 12 (months) equals 240. The number of months in drought of 74 was divided by the 240 to obtain the annual average percentage probability of drought in the planning area. Although drought is not predictable, long-range outlooks and predicted impacts of climate change could indicate an increased chance of drought.

Vulnerability

Vulnerability Overview

The best and most recent data available is from the Missouri State Plan 2013. Data is not available to quantify vulnerability or estimate losses as a result of drought on State owned facilities. A research investigation was conducted to determine if there was additional non-quantifiable data that could add information or provide a better understanding of the vulnerability of facilities. This information is provided for review purposes only and has not been incorporated into the mitigation analysis however any information of significance has been included below.

Drought has had a significant impact on the planning area and the State has taken an active role in addressing the issue. The Governor, Jay Nixon, took an active role in 2012 in addressing drought conditions and supporting programs that improved conditions for crop and livestock production. The State of Missouri Drought Plan from 2002 provides information on the State’s drought response plan. Designed to work in conjunction with the State Consolidated Plan and the State Emergency

Operations Plan, the Drought Plan looks at the strategic and tactical measures designed to better prepare Missouri for drought.

The State Department of Natural Resources has a website devoted to addressing drought issue and water management which provides current information on conditions in the State. While not quantifiably vulnerable to drought alone, structures of all kinds are vulnerable to the shrink-swell cycle that occurs as soils swell during wet periods and shrink during dry periods. Of concern are MoDOT roads and bridges. Concrete structures like these are not able to expand and contract with the movement of soil and can be damaged or broken as a result. Most of the impacts associated with drought are to crop land, not facilities however there are conservation areas owned and operated by the Missouri Department of Conservation that may be impacted by drought. Many of these are in recreational areas, areas such as are streams, lakes, reservoirs, and ponds that can shrink in size or completely dry up causing the death of fish and other wildlife as well as a potential loss of recreation-based revenue and negatively impact municipal water supply.

Potential Losses to Existing Development

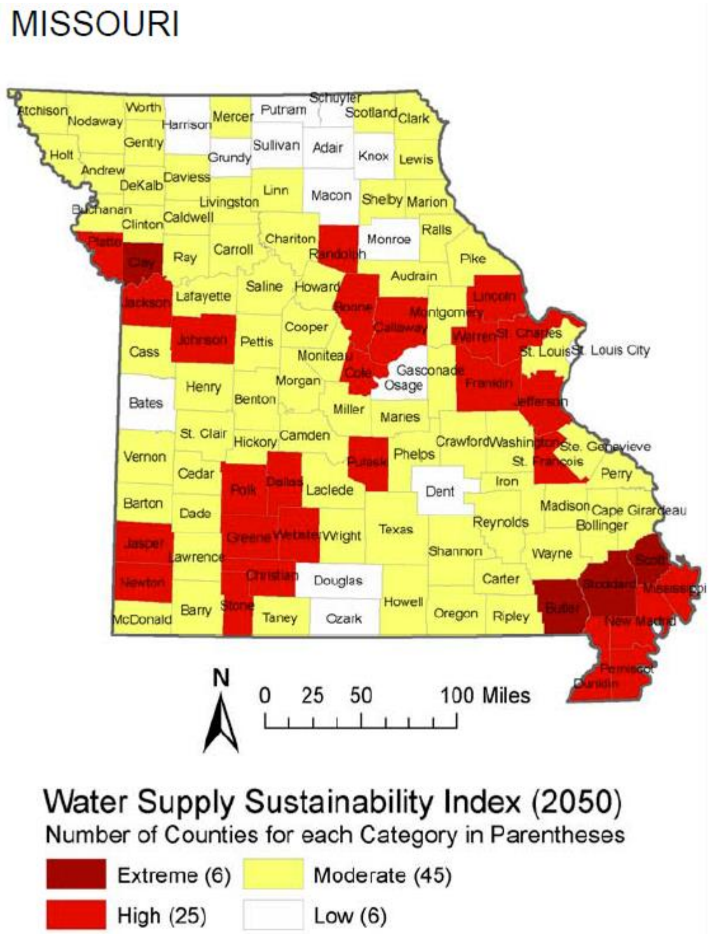
In northeast Missouri moderate drought is likely in any given year. The annualized losses of near 1 million dollars shown in the above chart leads to the conclusion that drought is a serious concern for farmers in Pike County. Drought is not a hazard that can be predicted and there are no easy solutions to supply needed water to croplands. The rolling hills, terraced farmland commonly does not have access to irrigation wells. By contrast, some of the river bottom farmlands do have access to irrigation water because of the high water table allows shallow wells to provide irrigation. But as the water table drops during a drought this water source would likely be affected.

Impact of Previous and Future Development

Future development will remain vulnerable to drought. Typically, some urban and rural areas are more susceptible than others. For example, urban areas are subject to water shortages during periods of drought. Excessive demands of the populated area place a limit on water resources. As population increases this will cause an increased demand for treated water, adding additional strain on water supply systems. In rural areas, crops and livestock may suffer from extended periods of heat and drought. As the size of farms increase more crops will be exposed to drought-related agricultural losses. Dry conditions can lead to the ignition of wildfires that could threaten residential, commercial and recreational areas.

Impact of Climate Change

A new analysis, performed for the Natural Resources Defense Council, examined the effects of climate change on water supply and demand in the contiguous United States. The study found that more than 1,100 counties will face higher risks of water shortages by mid-century as a result of climate change. Two of the principal reasons for the projected water constraints are shifts in precipitation and potential evapotranspiration (PET). Climate models project decreases in precipitation in many regions of the U.S., including areas that may currently be described as experiencing water shortages of some degree. Go to



http://www.nrdc.org/globalWarming/watersustainability/ , click for Kansas – Montana, click on Missouri to view maps with climate change and without climate change to show the anticipated impacts to your county.

Hazard Summary by Jurisdiction

The entire planning area will be affected by drought of some degree. The unincorporated agricultural areas of Pike County are the most vulnerable to drought while the drought condition will also affect the cities except the magnitude would be different with only lawns and local gardens will be impacted. In addition damage to crops, produce, livestock, soil and building foundations could be weakened due to shrinking and expanding soils.

<u>Problem Statement</u>

Pike County residents are not informed on water conservation, not all citizens comply with warnings, water use would be greatly affected, businesses and residents have continual problems with water shortages.

Education needs to occur on water conservation and insure all citizens comply with water shortage warnings and establish plans for businesses and residents on how to survive a drought.

3.4.3 Earthquakes

Hazard Profile

Hazard Description

An earthquake is a sudden motion or trembling that is caused by a release of energy accumulated within or along the edge of the earth’s tectonic plates. Earthquakes occur primarily along fault zones and tears in the earth's crust. Along these faults and tears in the crust, stresses can build until one side of the fault slips, generating compressive and shear energy that produces the shaking and damage to the built environment. Heaviest damage generally occurs nearest the earthquake epicenter, which is that point on the earth's surface directly above the point of fault movement. The composition of geologic materials between these points is a major factor in transmitting the energy to buildings and other structures on the earth's surface.

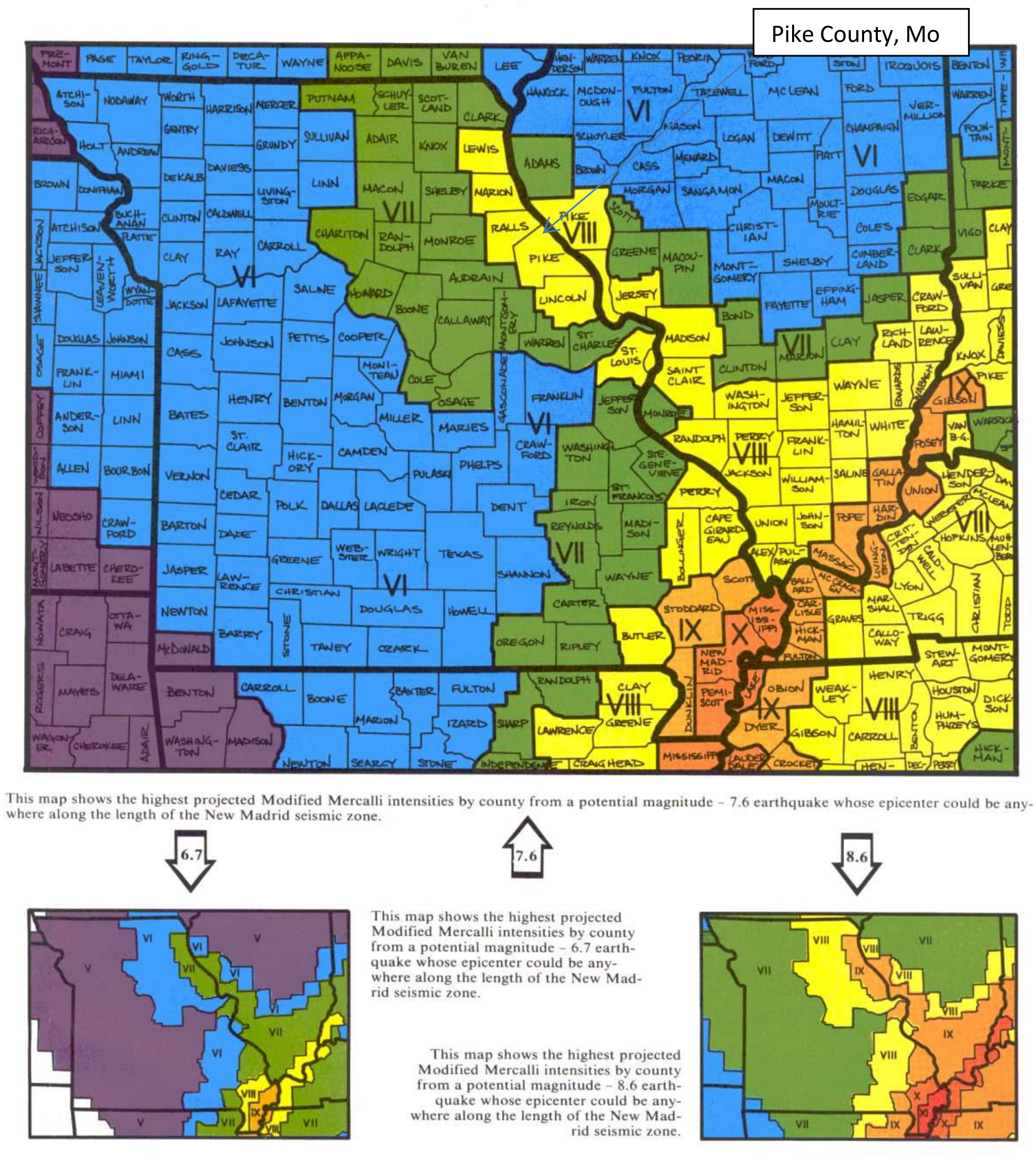
Some earthquakes occur in the middle of plates, as is the case for seismic zones in the Midwestern United States. The most seismically active area in the Midwest is the New Madrid Seismic Zone. The possibility of the occurrence of a catastrophic earthquake in the central and Eastern United States is real as evidenced by history. The impacts of significant earthquakes affect large areas, terminating public services and systems needed to aid the suffering and displaced. As with hurricanes, mass relocation may be necessary, but the residents who are suffering from the earthquake can neither leave the heavily impacted areas nor receive aid or even communication in the aftermath of a significant event.

Geographic Location

Seismic activity on the New Madrid Seismic Zone of Southeastern Missouri is very significant both historically and at present. On December 16, 1811 and January 23 and February 7 of 1812, three earthquakes struck the central U.S. with magnitudes estimated to be 7.5-8.0. These earthquakes caused violent ground cracking and volcano-like eruptions of sediment (sand blows) over an area of >10,500 km2 , and uplift of a 50 km by 23 km zone (the Lake County uplift). The shaking was felt over a total area of over 10 million km2 (the largest felt area of any historical earthquake). Of all the historical earthquakes that have the U.S., an 1811- style event would do the most damage if it recurred today. If an 1811 earthquake occurred in Pike County the earthquake intensity would not vary within the county. Damage would be to buildings of good design and construction, slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures and some chimneys broken.

The following SEMA map (**Figure 3.5**) shows the highest projected Modified Mercalli intensities by county from a potential magnitude 7.6 earthquake whose epicenter could be anywhere along the length of the New Madrid Seismic Zone. The arrow indicates Pike County and the affects that would be felt from an earthquake.

Figure 3.5. **Impact Zones for Earthquake Along the New Madrid Fault**



Source:
http://sema.dps.mo.gov/docs/programs/Planning,%20Disaster%20&%20Recovery/State%20of%20Missouri%20Hazard%20Analysis/2012-State-Hazard-Analysis/Annex_F_Earthquakes.pdf

PROJECTED EARTHQUAKE INTENSITIES

MODIFIED MERCALLI INTENSITY SCALE

I People do not feel any Earth movement.

II A few people might notice movement.

III Many people indoors feel movement. Hanging objects swing.

IV Most people indoors feel movement. Dishes, windows, and doors rattle. Walls and frames of structures creak. Liquids in open vessels are slightly disturbed. Parked cars rock.

V Almost everyone feels movement. Most people are awakened. Doors swing open or closed. Dishes are broken. Pictures on the wall move. Windows crack in some cases. Small objects move or are turned over. Liquids might spill out of open containers.

VI Everyone feels movement. Poorly built buildings are damaged slightly. Considerable quantities of dishes and glassware, and some windows are broken. People have trouble walking. Pictures fall off walls. Objects fall from shelves. Plaster in walls might crack. Some furniture is overturned. Small bells in churches, chapels and schools ring.

VII People have difficulty standing. Considerable damage in poorly built or badly designed buildings, adobe houses, old walls, spires and others. Damage is slight to moderate in well-built buildings. Numerous windows are broken. Weak chimneys break at roof lines. Cornices from towers and high buildings fall. Loose bricks fall from buildings. Heavy furniture is overturned and damaged. Some sand and gravel stream banks cave in.

VIII Drivers have trouble steering. Poorly built structures suffer severe damage. Ordinary substantial buildings partially collapse. Damage slight in structures especially built to withstand earthquakes. Tree branches break. Houses not bolted down might shift on their foundations. Tall structures such as towers and chimneys might twist and fall. Temporary or permanent changes in springs and wells. Sand and mud is ejected in small amounts.

IX Most buildings suffer damage. Houses that are not bolted down move off their foundations. Some underground pipes are broken. The ground cracks conspicuously. Reservoirs suffer severe damage.

X Well-built wooden structures are severely damaged and some destroyed. Most masonry and frame structures are destroyed, including their foundations. Some bridges are destroyed. Dams are seriously damaged. Large landslides occur. Water is thrown on the banks of canals, rivers, and lakes. Railroad tracks are bent slightly. Cracks are opened in cement pavements and asphalt road surfaces.

XI Few if any masonry structures remain standing. Large, well-built bridges are destroyed. Wood frame structures are severely damaged, especially near epicenters. Buried pipelines are rendered completely useless. Railroad tracks are badly bent. Water mixed with sand, and mud is ejected in large amounts.

XII Damage is total, and nearly all works of construction are damaged greatly or destroyed. Objects are thrown into the air. The ground moves in waves or ripples. Large amounts of rock may move. Lakes are dammed, waterfalls formed and rivers are deflected.

Intensity is a numerical index describing the effects of an earthquake on the surface of the Earth, on man, and on structures built by man. The intensities shown in these maps are the highest likely under the most adverse geologic conditions. There will actually be a range in intensities within any small area such as a town or county, with the highest intensity generally occurring at only a few sites. Earthquakes of all three magnitudes represented in these maps occurred during the 1811 - 1812 "New Madrid earthquakes." The isoseismal patterns shown here, however, were simulated based on actual patterns of somewhat smaller but damaging earthquakes that occurred in the New Madrid seismic zone in 1843 and 1895.

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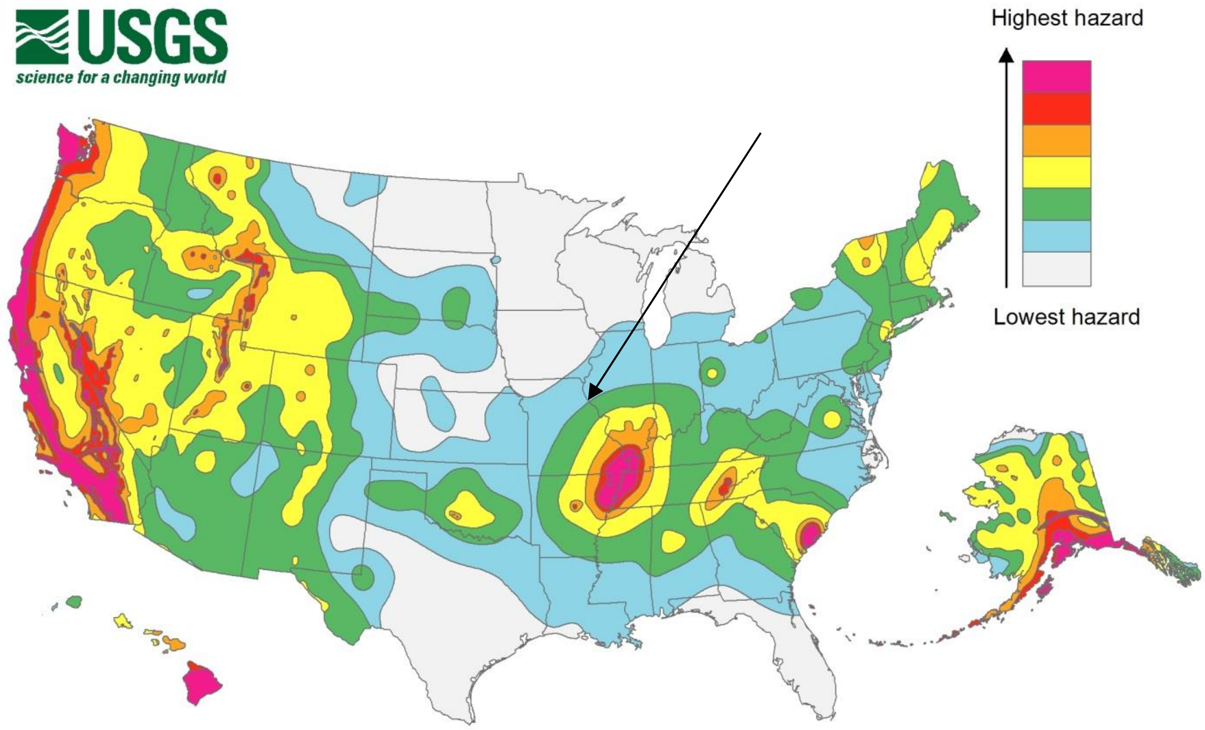
P.O. BOX 116
JEFFERSON CITY, MO 65102
Telephone: 573-526-9100

Figure 3.6. United States Seismic Hazard Map



Source: United States Geological Survey at http://earthquake.usgs.gov/hazards/products/conterminous/2014/HazardMap2014_lg.jpg

Severity/Magnitude/Extent

The extent or severity of earthquakes is generally measured in two ways: 1) the Richter Magnitude Scale is a measure of earthquake magnitude; and 2) the Modified Mercalli Intensity Scale is a measure of earthquake severity. The two scales are defined a follows.

Richter Magnitude Scale

The Richter Magnitude Scale was developed in 1935 as a device to compare the size of earthquakes. The magnitude of an earthquake is measured using a logarithm of the maximum extent of waves recorded by seismographs. Adjustments are made to reflect the variation in the distance between the various seismographs and the epicenter of the earthquakes. On the Richter Scale, magnitude is expressed in whole numbers and decimal fractions. For example, comparing a 5.3 and a 6.3 earthquake shows that the 6.3 quake is ten times bigger in magnitude. Each whole number increase in magnitude represents a tenfold increase in measured amplitude because of the logarithm. Each whole number step in the magnitude scale represents a release of approximately 31 times more energy.

Modified Mercalli Intensity Scale

The intensity of an earthquake is measured by the effect of the earthquake on the earth's surface. The intensity scale is based on the responses to the quake, such as people awakening, movement of furniture, damage to chimneys, etc. The intensity scale currently used in the United States is the Modified Mercalli (MM) Intensity Scale. It was developed in 1931 and is composed of 12 increasing levels of intensity. They range from imperceptible shaking to catastrophic destruction, and each of the twelve levels is denoted by a Roman numeral. The scale does not have a mathematical basis, but is based on observed effects. Its use gives the laymen a more meaningful idea of the severity.

Previous Occurrences

There have been 0 earthquakes recorded in Pike County since 1931.
http://www.homefacts.com/earthquakes/Missouri/Pike-County.html

Probability of Future Occurrence

Figure 3.6 demonstrates the probability of an earthquake with a magnitude greater than 5.0 in Pike County in a 50-year time frame. The arrow shows the approximate Pike County boundary. As shown in this graphic, the probability of a 5.0 Magnitude or greater earthquake in the next 50 years is .03 percent. The probability converts to an estimated maximum recurrence interval of 5,000 years. The probability of a significant earthquake in any given year is unlikely. Reference the previous map (**Figure 3.6).**

Hazard Summary by Jurisdiction

Since the earthquake intensity is not likely to vary greatly throughout Pike County, the risk will be the same throughout. However, damages could differ if there are structural variations in the planning area built environment. For example, older structures and those structures which are not in prime condition are likely to experience higher damages.

Impact of Previous and Future Development

Future development is not expected to increase the risk other than contributing to the overall exposure of what could become damaged as a result of an event.

<u>Vulnerability</u>

Vulnerability Overview

<u>Missouri State Hazard Mitigation Plan (2013) Analysis:</u> Specific modeling of damage and loss from earthquake scenarios has been conducted for the state using HAZUS 2.1 software; the findings are included in the Missouri State Hazard Mitigation Plan (2013). HAZUS software is used by FEMA to compare relative risk from earthquakes and other natural hazards.
The earthquake vulnerability analysis in the MO State Hazard Mitigation Plan (2013) used demographic data based on the 2010 Census; site specific essential facility data was based on the 2011 HSIP inventory data. Two types of analysis were done:

Annualized Loss Scenario based on eight earthquake return periods (100, 200, 500, 750, 1000, 1500, 2000 and 2500 years)- a “worst case scenario”

<u>*Annualized Loss Scenario*</u>

The MO State Hazard Mitigation Plan (2013) explains the annualized loss scenario as follows*: HAZUS defines annualized loss as the expected value of loss in any year. The software develops annualized loss estimates by aggregating the losses and their exceedance probabilities from the eight return periods. Annualized loss is the maximum potential annual dollar loss resulting from various return periods averaged on a 'per year' basis. It is the summation of all HAZUS- supplied return periods multiplied by the return period probability (as a weighted calculation).*

Potential Losses to Existing Development

The HAZUS building inventory counts are based on the 2000 census data adjusted to 2006 numbers using the Dun & Bradstreet Business Population Report. Inventory values reflect 2006 valuations, based on RSMeans (a supplier of construction cost information) replacement costs. Population counts are 2008 estimates from the U.S. Census Bureau.

HAZUS-MH Earthquake Loss Estimation 2% Probability of Exceedance in 50 Years Scenario for Pike County						
Structural Damage	**Non-Structural Damage**	**Contents Damage and Inventory Loss**	**Loss Ratio %***	**Income Loss**	**Total Economic Loss to Buildings****	**Loss Ratio Rank*****
$10,939,000	$34,560,000	$12,181,000	2.68	$16,520,000	$75,200,000	51
* Loss ratio equals the sum of structural and nonstructural damage divided by the entire building inventory value within the county.						
**Total economic loss includes inventory loss, relocation loss, capital-related loss, wages loss, and rental income loss						
***Out of 115 (114 counties and the City of St. Louis)						
Source: MO State Hazard Mitigation Plan (2013)						

Impact of Previous and Future Development

Overall the planning area has a low vulnerability to earthquake risk. Future development is not expected to increase the risk other than contributing to the overall exposure of what could become damaged as a result of the unlikely event.

Hazard Summary by Jurisdiction

The earthquake intensity is not likely to vary greatly throughout the planning area and all jurisdictions within the planning area will be the same throughout. However, the City of Louisiana could see a greater amount of structural damage due to having a higher percentage (35.2%) of residences built prior to 1939 than other jurisdictions in the planning area. The City of Bowling Green has a low percentage (18.5) of residences built prior to 1939 putting them at a lower risk.

See http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

Problem Statement

Although Pike County is not located in an area that will likely see catastrophic damage from an earthquake, the County will be impacted by the loss of communications, transportation, the disruption of roads, rail and pipelines, water transportation, and the area will see a significant amount of refugees fleeing from Southern Missouri if a quake hits that area. Education is minimal for earthquakes do to the low likely hood of impact. Clarksville, Louisiana and Bowling Green consist of a few older tall buildings that are not able to withstand an earthquake event. There is one Emergency Management Director for the County that knows where all the generators and emergency buildings are. Not all citizens utilize social media and texting.

An emergency plan for earthquakes need to be made available to all residents and stated what would happen in the event of an earthquake with details for communications and transportation. Downtown building owners need to know plan in case damage is done to their building. Residents need to be made aware of where the generators and emergency buildings are located. Utilization of social media and texting needs to encouraged.

3.4.4 Extreme Heat

Hazard Profile

Hazard Description

Extreme temperature events, both hot and cold, can impact human health and mortality, natural ecosystems, agriculture and other economic sectors. The remainder of this section profiles extreme heat. Extreme cold events are profiled in combination with Winter Storm in **Section 3.4.11.** According to information provided by FEMA, extreme heat is defined as temperatures that hover 10 degrees or more above the average high temperature for the region and last for several weeks. Ambient air temperature is one component of heat conditions, with relative humidity being the other. The relationship of these factors creates what is known as the apparent temperature. The Heat Index chart shown in Figure **3.7** uses both of these factors to produce a guide for the apparent temperature or relative intensity of heat conditions.

Figure 3.7. Heat Index (HI) Chart

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

Source: National Weather Service (NWS)

Note: Exposure to direct sun can increase Heat Index values by as much as 15°F. The shaded zone above 105°F corresponds to a HI that may cause increasingly severe heat disorders with continued exposure and/or physical activity.

Geographic Location

The entire planning area is subject to extreme heat and all participating jurisdictions are affected.

Severity/Magnitude/Extent

Extreme heat can cause stress to crops and animals. According to USDA Risk Management Agency, losses to insurable crops during the 10-year time period from 2005 to 2015 were $1,799,659. Extreme heat can also strain electricity delivery infrastructure overloaded during peak use of air conditioning during extreme heat events. Another type of infrastructure damage from extreme heat is road damage. When asphalt is exposed to prolonged extreme heat, it can cause buckling of asphalt-paved roads, driveways, and parking lots.

From 1988-2011, there were 3,496 fatalities in the U.S. attributed to summer heat. This translates to an annual national average of 146 deaths. During the same period, 2 deaths were recorded in the planning area, according to NCDC data. The National Weather Service stated that among natural hazards, no other natural disaster—not lightning, hurricanes, tornadoes, floods, or earthquakes—causes more deaths.

Those at greatest risk for heat-related illness include infants and children up to five years of age, people

65 years of age and older, people who are overweight, and people who are ill or on certain medications. However, even young and healthy individuals are susceptible if they participate in strenuous physical activities during hot weather. In agricultural areas, the exposure of farm workers, as well as livestock, to extreme temperatures is a major concern.

Table 3.12. Typical Health Impacts of Extreme Heat

Heat Index (HI)	Disorder
80-90° F (HI)	Fatigue possible with prolonged exposure and/or physical activity
90-105° F (HI)	Sunstroke, heat cramps, and heat exhaustion possible with prolonged exposure and/or physical activity
105-130° F (HI)	Heatstroke/sunstroke highly likely with continued exposure

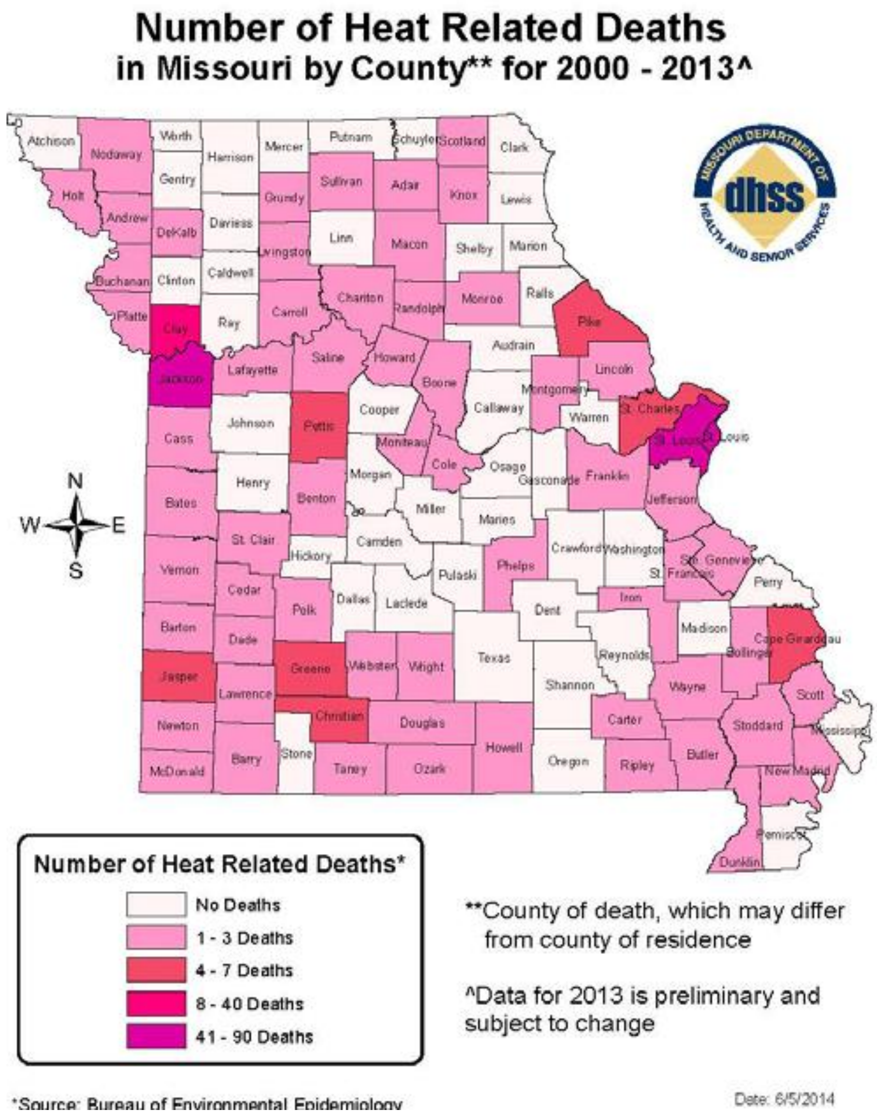
Source: National Weather Service Heat Index Program, www.weather.gov/os/heat/index.shtml

The National Weather Service has an alert system in place (advisories or warnings) when the Heat Index is expected to have a significant impact on public safety. The expected severity of the heat determines whether advisories or warnings are issued. A common guideline for issuing excessive heat alerts is when for two or more consecutive days : (1) when the maximum daytime Heat Index is expected to equal or exceed 105 degrees Fahrenheit (°F); and the night time minimum Heat Index is 80°F or above. A heat advisory is issued when temperatures reach 105 degrees and a warning is issued at 115 degrees.

Previous Occurrences

According to information obtained from the National Climate Data Center (NCDC) and the Spatial Hazard Events and Losses Database for the United States (SHELDUS) there have been 16 recorded extreme heat events from 1995 to 2015. Additional research was conducted through Google and Yahoo searches and no injury or deaths were reported.

Figure 3.8. Heat Related Deaths in Missouri 2000 - 2013



Probability of Future Occurrence

NOAA dating back to 1995 indicates 15 years without extreme heat events (1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2008, 2013 and 2015). In three years there were multiple extreme heat events. Based on this historical data, the calculated probability of an extreme heat event in any given year is 25%.

Vulnerability

Vulnerability Overview

Based on the most recent data available from the 2013 Missouri State Plan the entire planning area is vulnerable to the impacts of extreme heat. However, counties with a higher percentage of elderly may be more at risk due to the heightened vulnerability of this segment of population. According to the data presented in the State Plan Pike County has 12.6% to 15.8% elderly population which is not considered to be a high percentage of elderly residents in Pike County. The figures for the State Plan were based on the US Census 2010 information.

Potential Losses to Existing Development

During the ten year period from 2005 to 2015 there were $1,799,659 in crop insurance claims paid as a result of losses to extreme temperatures. Pike County is considered to be one of the highest counties in insurance payments for extreme heat. The anticipated loss in any given year can be expected to be the annual average of $179,965.90. Illness and loss of life are the most concern with extreme heat however there has not been any injury or deaths related to extreme heat reported in the 10 year period reviewed.

Impact of Previous and Future Development

Population growth can result in increases in the age-groups that are most vulnerable to extreme heat. Population growth also increases the strain on electricity infrastructure, as more electricity is needed to accommodate the growing population.

Hazard Summary by Jurisdiction

Those at greatest risk for heat-related illness and deaths include children up to five years of age, people 65 years of age and older, people who are overweight, and people who are ill or on certain medications. To determine jurisdictions within the planning area with populations more vulnerable to extreme heat, demographic data was obtained from the 2010 census on population percentages in each jurisdiction comprised of those under age 5 and over age 65. Data was not available for overweight individuals and those on medications vulnerable to extreme heat. **Table 3.19** below summarizes vulnerable populations in the participating jurisdictions. Note that school and special districts are not included in the table because students and those working for the special districts are not customarily in these age groups.

Table 3.13. Pike County Population Under Age 5 and Over Age 65, 2010 Census Data

Jurisdiction	Population Under 5 yrs	Population 65 yrs and over
*Pike County	1,131	2,883
Louisiana	226	170
Clarksville	29	93
Paynesville	10	15
Annada	0	3
Bowling Green	290	590
Frankford	18	50

Source: U.S. Census Bureau, (*) includes entire population of each city or county

All of the schools in Pike County have air conditioning which does not put school age children at risk during extreme temperatures due to this the schools do not have a policy in affect to close if there are extreme heat occurrences.

Problem Statement

Not everyone in Pike County utilizes social media and texting, elderly and young children are most vulnerable to a heat wave. Cooling locations in the County need to be identified and open to everyone for extended hours. Utilization of social media and texting needs to be promoted. Special attention needs to be paid to insuring the elderly and young children are kept cool and notified of the cooling locations. Education of the cooling locations needs to occur throughout the County.

3.4.5 Wild Fires

Hazard Profile

Hazard Description

The incident types considered for wild fires include: 1) natural vegetation fire, 2) outside rubbish fire, 3) special outside fire, and 4) cultivated vegetation, crop fire.

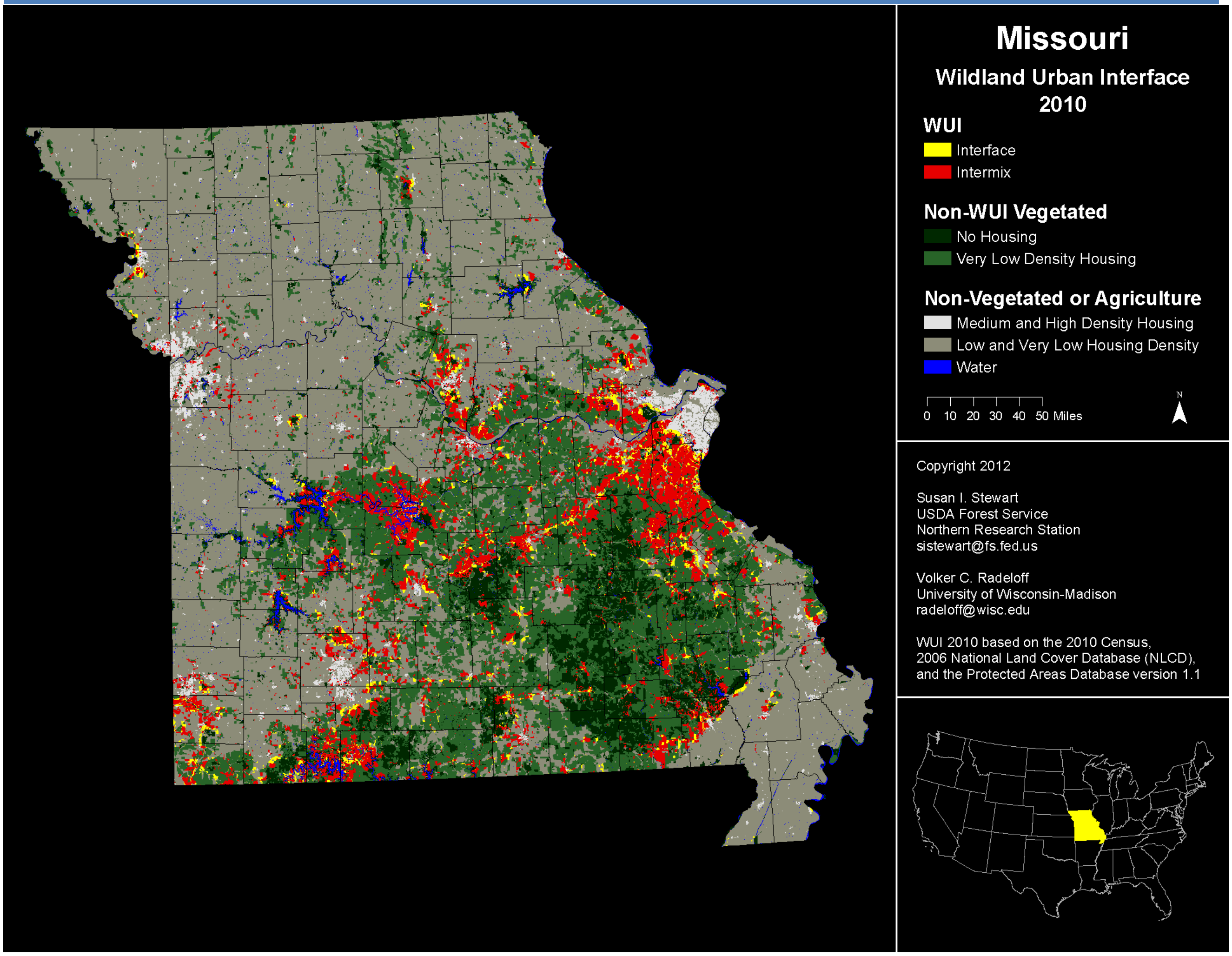
The Forestry Division of the Missouri Department of Conservation (MDC) is responsible for protecting privately owned and state-owned forests and grasslands from wildfires. To accomplish this task, eight forestry regions have been established in Missouri for fire suppression. The Forestry Division works closely with volunteer fire departments and federal partners to assist with fire suppression activities. Currently, more than 900 rural fire departments in Missouri have mutual aid agreements with the Forestry Division to obtain assistance in wildfire protection if needed.

Most of Missouri fires occur during the spring season between February and May. The length and severity of both structural and wildland fires depend largely on weather conditions. Spring in Missouri is usually characterized by low humidity and high winds. These conditions result in higher fire danger. In addition, due to the recent lack of moisture throughout many areas of the state, conditions are likely to increase the risk of wildfires. Drought conditions can also hamper firefighting efforts, as decreasing water supplies may not prove adequate for firefighting. It is common for rural residents burn their garden spots, brush piles, and other areas in the spring. Some landowners also believe it is necessary to burn their forests in the spring to promote grass growth, kill ticks, and reduce brush. Therefore, spring months are the most dangerous for wildfires. The second most critical period of the year is fall. Depending on the weather conditions, a sizeable number of fires may occur between mid-October and late November.

Geographic Location

The term refers to the zone of transition between unoccupied land and human development and needs to be defined in the plan. Within the WUI, there are two specific areas identified: 1) Interface and 2) Intermix. The interface areas are those areas that abut wildland vegetation and the Intermix areas are those areas that intermingle with wildland areas.

The map below shows the Wildland-Urban Interface for the State of Missouri. The entire Northeast Region is comparable to Pike County with very low risk for damages to any of the cities in the area. Wildfires are included in the plan because like most other natural hazards there is always a possibility. When there are periods of extreme heat and drought the risk of wildfire increases



http://silvis.forest.wisc.edu/maps/wui_main

Severity/Magnitude/Extent

Wildfires damage the environment, killing some plants and occasionally animals. Firefighters have been injured or killed, and structures can be damaged or destroyed. The loss of plants can heighten the risk of soil erosion and landslides. Although Missouri wildfires are not the size and intensity of those in the Western United States, they could impact recreation and tourism in and near the fires.

Wildland fires in Missouri have been mostly a result of human activity rather than lightning or some other natural event. Wildfires in Missouri are usually surface fires, burning the dead leaves on the ground or dried grasses. They do sometimes “torch” or “crown” out in certain dense evergreen stands like eastern red cedar and shortleaf pine. However, Missouri does not have the extensive stands of evergreens found in the western US that fuel the large fire storms seen on television news stories.

While very unusual, crown fires can and do occur in Missouri native hardwood forests during prolonged periods of drought combined with extreme heat, low relative humidity, and high wind. Tornadoes, high winds, wet snow and ice storms in recent years have placed a large amount of woody material on the forest floor that causes wildfires to burn hotter and longer. These conditions also make it more difficult for fire fighters suppress fires safely. See ***http://www.firewisemissouri.org/wildfire-in-missouri.html***

Often wildfires in Missouri go unnoticed by the general public because the sensational fire behavior that captures the attention of television viewers is rare in the state. Yet, from the standpoint of destroying homes and other property, Missouri wildfires can be quite destructive.

At this time, no information is available on the severity of damages from the notable planning area on wildland fires.

Previous Occurrences

According to information obtained from the Missouri Division of Fire Safety (MDFS) Website as well as the Missouri Department of Conversation Wildfire Data Search there were 191 reported wildland or grass fires in Pike County from 2005 to 2016. In total, these 191 fires burned 2,386.81 acres and no injuries were reported. Forty-one of the fires had an unknown cause for starting and burning 690.2 acres and 35 were started by a debris. These 76 fires burned 1,320.21 acres during the eleven year reporting period. http://mdc4.mdc.mo.gov./applications/FireReporting/Report.aspx .

At this time no information is available from school districts and special districts about previous fire events and the damages resulting from them.

Probability of Future Occurrence

When analyzing the wildland fires, there has been an average of 17.36 fires burning 216.98 acres per year. However, it was reported these fires did not result in major damages. The probability score to be likely in any given year that a wildfire could occur in the planning area.

Vulnerability

Vulnerability Overview

Wildfires in the planning area are most likely to occur every year with minor damage resulting. The wildfires occur in the unincorporated areas and are limited to undeveloped land. The jurisdictions and school districts are largely surrounded by undeveloped land but have not been affected by wildfires. In years of significant drought or excessive heat the potential for a wildfire in planning area increases.

As outlined in the Missouri 2013 State Plan Pike County was given a medium vulnerability rating being based on housing, density, likelihood, building exposure, annualized property loss ratio and death/injury factor. The data for wildfires are insufficient due to only 57% of fire departments in Missouri reporting to the National Fire Incident Reporting System. The majority of the fire departments in the planning area are comprised of volunteers and are limited on the time spent to report information.

Potential Losses to Existing Development

The potential loss to existing development due to wildfire is difficult to determine due to lack of sufficient historical data. An average number of fires per year has been determined however there are no losses reported associated with the data. Information on historical losses was sought after through various sources including the Missouri Division of Fire Safety and The Missouri Department of Conservation.

Impact of Previous and Future Development

Future and previous development in the wildland-urban interface would increase vulnerability to the hazard.

Hazard Summary by Jurisdiction

The rural jurisdictions in the planning area are all surrounded by undeveloped agricultural land and face the possibility of a wildfire. The school districts located in a rural area do not face danger of wildfire due to barriers in place around the school.

Problem Statement

Residents do not comply with burn bans, education is not available for the levels of burn bans, many residents lack education in fire safety and not all residents utilize social media and texting.

Education needs to occur on the dangers associated with not complying with the burn bans, more education for fire safety and encourage utilization of social media and texting.

3.4.6 Flooding (Flash and River)

Hazard Description

A flood is partial or complete inundation of normally dry land areas. Riverine flooding is defined as the overflow of rivers, streams, drains, and lakes due to excessive rainfall, rapid snowmelt, or ice. There are several types of riverine floods, including headwater, backwater, interior drainage, and flash flooding. Riverine flooding is defined as the overflow of rivers, streams, drains, and lakes due to excessive rainfall, rapid snowmelt or ice melt. The areas adjacent to rivers and stream banks that carry excess floodwater during rapid runoff are called floodplains. A floodplain is defined as the lowland and relatively flat area adjoining a river or stream. The terms “base flood” and “100- year flood” refer to the area in the floodplain that is subject to a one percent or greater chance of flooding in any given year. Floodplains are part of a larger entity called a basin, which is defined as all the land drained by a river and its branches.

Flooding caused by dam and levee failure is discussed in Section 3.4.1 and Section 3.4.8 respectively. It will not be addressed in this section.

A flash flood occurs when water levels rise at an extremely fast rate as a result of intense rainfall over a brief period, sometimes combined with rapid snowmelt, ice jam release, frozen ground, saturated soil, or impermeable surfaces. Flash flooding can happen in Special Flood Hazard Areas (SFHAs) as delineated by the National Flood Insurance Program (NFIP), and can also happen in areas not associated with floodplains.

Ice jam flooding is a form of flash flooding that occurs when ice breaks up in moving waterways, and then stacks on itself where channels narrow. This creates a natural dam, often causing flooding within minutes of the dam formation.

In some cases, flooding may not be directly attributable to a river, stream, or lake overflowing its banks. Rather, it may simply be the combination of excessive rainfall or snowmelt, saturated ground, and inadequate drainage. With no place to go, the water will find the lowest elevations – areas that are often not in a floodplain. This type of flooding, often referred to as sheet flooding, is becoming increasingly prevalent as development outstrips the ability of the drainage infrastructure to properly carry and disburse the water flow.

Most flash flooding is caused by slow-moving thunderstorms or thunderstorms repeatedly moving over the same area. Flash flooding is a dangerous form of flooding which can reach full peak in only a few minutes. Rapid onset allows little or no time for protective measures. Flash flood waters move at very fast speeds and can move boulders, tear out trees, scour channels, destroy buildings, and obliterate bridges. Flash flooding can result in higher loss of life, both human and animal, than slower developing river and stream flooding.

In certain areas, aging storm sewer systems are not designed to carry the capacity currently needed to handle the increased storm runoff. Typically, the result is water backing into basements, which damages mechanical systems and can create serious public health and safety concerns. This combined with rainfall trends and rainfall extremes all demonstrate the high probability, yet generally unpredictable nature of flash flooding in the planning area.

Although flash floods are somewhat unpredictable, there are factors that can point to the likelihood of flash floods occurring. Weather surveillance radar is being used to improve monitoring capabilities of intense rainfall. This, along with knowledge of the watershed characteristics, modeling techniques, monitoring, and advanced warning systems has increased the warning time for flash floods.

Geographic Location

Riverine flooding is most likely to occur in SFHAs. Note that NCDC data includes events for flooding and for flash flooding. In order to obtain information for the following tables, consult event narratives. Those events without location-specific information will be tabulated under “unspecified” locations in the table. Generally, using a 20-year time frame for previous events is adequate. However, where flooding records are scanty, use as many years needed for a solid probability calculation.

Table 3.14. Pike County” NCDC Flood Events by Location, 1995-2015

Location	# of Events
Pike County	14
Louisiana	1
Clarksville	1
Hope	4
Busch	3

Source: National Climatic Data Center

Flash flooding occurs in those locations in the planning area that are low-lying and/or do not have adequate drainage to carry away the amount of water that falls during intense rainfall events. Table 3.15 shows the number of flash flood events by location recorded in NCDC for the 20-year period.

Table 3.15. Pike County NCDC Flash Flood Events by Location, 1995-2015

Location	# of Events
Pike County	12
Annada	1
Estes	1
Spencerburg	1
Stark	1
Busch	1

Source: National Climatic Data Center

Severity/Magnitude/Extent

Missouri has a long and active history of flooding over the past century, according to the 2010 State Hazard Mitigation Plan. Flooding along Missouri's major rivers generally results in slow-moving disasters. River crest levels are forecast several days in advance, allowing communities downstream sufficient time to take protective measures, such as sandbagging and evacuations. Nevertheless, floods exact a heavy toll in terms of human suffering and losses to public and private property. By contrast, flash flood events in recent years have caused a higher number of deaths and major property damage in many areas of Missouri.

Flooding presents a danger to life and property, often resulting in injuries, and in some cases, fatalities. Floodwaters themselves can interact with hazardous materials. Hazardous materials stored in large containers could break loose or puncture as a result of flood activity. Examples are bulk propane tanks. When this happens, evacuation of citizens is necessary.

Public health concerns may result from flooding, requiring disease and injury surveillance. Community sanitation to evaluate flood-affected food supplies may also be necessary. Private water and sewage sanitation could be impacted, and vector control (for mosquitoes and other entomology concerns) may be necessary.

When roads and bridges are inundated by water, damage can occur as the water scours materials around bridge abutments and gravel roads. Floodwaters can also cause erosion undermining road beds. In some instances, steep slopes that are saturated with water may cause mud or rock slides onto roadways. These damages can cause costly repairs for state, county, and city road and bridge maintenance departments. When sewer back-up occurs, this can result in costly clean-up for home and business owners as well as present a health hazard.

National Flood Insurance Program (NFIP) Participation

Provide a table (**Table 3.16**) with details on NFIP participation for the communities in the planning area. Provide another table (**Table 3.17**) with the number of policies in force, amount of insurance in force, number of closed losses, and total payments for each jurisdiction, where applicable. Identify the time period represented by the data.

Table 3.16. NFIP Participation in Pike County

Community ID #	Community Name	NFIP Participant (Y/N)	Current Effective Map Date	Regular-Emergency Program Entry Date
290287	Annanda	Yes	04/19/10	11/19/1986
290288	Bowling Green	Yes	04/19/10	05/02/1977
290289	Clarksville	Yes	04/19/10	04/01/1977
290290	Louisiana	Yes	04/19/10	04/03/1978
290286	County of Pike	Yes	04/19/10	05/01/1989
290588	Eolia	Yes	04/19/10	03/26/77
290593A	Frankford	Yes	04/19/10	01/07/1978
290233	Paynesville	Yes	04/19/10	04/19/2011

Source: NFIP Community Status Book, 9/26/2013; BureauNet, http://www.fema.gov/national-flood-insurance-program/national-flood-insurance-program-community-status-book; M= No elevation determined – all Zone A, C, and X: NSFHA = No Special Flood Hazard Area; E=Emergency Program

Table 3.17. NFIP Policy and Claim Statistics as of January 2, 2017

Community Name	Policies in Force	Insurance in Force	Closed Losses	Total Payments
Annanda	10	$474,100	56	$574,789.51
Bowling Green	2	$195,000	2	$3,312.61
Clarksville	34	$4,127,200	146	$1,311,385.66
Louisiana	31	$2,649,900	149	$1,877,175.30
County of Pike	61	$6,189,100	462	$4,348,869.13

Source: NFIP Community Status Book, [January 2017]; BureauNet, http://bsa.nfipstat.fema.gov/reports/reports.html; *Closed Losses are those flood insurance claims that resulted in payment. Loss statistics as of January 2017.

Louisiana had the most insurance payments with those payments totaling $1,877,175.30

Repetitive Loss/Severe Repetitive Loss Properties

Repetitive Loss Properties are those properties with at least two flood insurance payments of $5,000 or more in a 10-year period. According to the Flood Insurance Administration, jurisdictions included in the planning area have a combined total of 91 repetitive loss properties.

Table 3.18. Pike County Repetitive Loss Properties

Jurisdiction	# of Propertie	Type of Property	Building Payments	Content Payments	Total Payments	Average Payment	# of Losses
Annada	40	Single Family	1,091,395.24	$100,926.18	1,192,321.42	29,808.03	91
Clarksville	29	Single Family	$2,182,790.48	$201,852.33	2,384,642.81	$36,130.95	66
Clarksville	4	Other-Non	$116,817.27	$647.27	$117,464.54	$39,391.98	11
Louisiana	8	Single Family	$118,150.55	$0.00	$118,150.55	$29,985.56	16
Louisiana	6	Non-Residence	$610,784.74	$239,548.75	$850,333.49	$136,424.54	43
Louisiana	1	Condo	$15,272,99	$15,800.33	31,073.27	$15,536.63	2
Pike County	2	Single Family	$88,575.31	$1,370.23	$89,945.54	$12,849.36	7
Pike County	1	Other-Non Res	$49,141.17	12,800	$61,941.17	$30,970.58	3

Source: Flood Insurance Administration as of 02/29/16

Severe Repetitive Loss (SRL): A SRL property is defined it as a single family property (consisting of one-to-four residences) that is covered under flood insurance by the NFIP; and has (1) incurred flood-related damage for which four or more separate claims payments have been paid under flood insurance coverage with the amount of each claim payment exceeding $5,000 and with cumulative amounts of such claims payments exceeding $20,000; or (2) for which at least two separate claims payments have been made with the cumulative amount of such claims exceeding the reported value of the property.

There are no severe repetitive loss properties in Pike County.

Previous Occurrences

June 1974- (DR-439) Federal Disaster declaration was issued for Pike County for flooding.

May 11, 1993- (DR-989) A Federal Disaster declaration was issued for Pike County for flooding from April 15, 1993 to May 29, 1993.

July 9, 1993- (DR-995) A Federal Disaster declaration was issued for Pike County for flooding from June 10, 1993 to October 25, 1993.

January 2, 2016- (DR-3374) A Federal Disaster declaration was issued for Pike County and other counties in Missouri for flooding from December 22, 2015 to January 9, 2016.

Table 3.19. NCDC Pike County Flash Flood Events Summary, 1995 to 2015

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
1997	1	0	0	0	0
1998	1	0	0	0	0
2002	1	0	0	0	0
2003	2	0	0	0	0
2004	2	0	0	0	0
2008	3	0	0	$100,000	0
2010	1	1	0	0	0
2015	1	0	0	0	0

Source: NCDC, data accessed January 5, 2017

Table 3.20. NCDC Pike County Riverine Flood Events Summary, 1995 to 2015

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
1996	1	0	0	0	0
2001	2	0	0	0	0
2002	2	0	0	0	0
2007	1	0	0	0	0
2008	4	0	0	$285,000	$11, 200,000
2010	1	0	0	0	0
2013	3	0	0	$25,000	$23,000

Source: NCDC, data accessed January 5, 2017

Flood Events

May, 1996 - The Mississippi and Missouri Rivers, and several smaller rivers in the area, flooded during much of May due to heavy spring rains. The heavy rain primarily fell from late April through early May. Rainfall for the month average from 1 to 7 inches above normal with measurable rain falling in the hydrologic service area 16 days during the month. Following are some of the crests reached along the major rivers during month. Most crests ranged from 3 to 7 feet over flood stage. Many of the rises in late April and early May were very rapid, considering the size of the rivers. On the Missouri River at Hermann, the river at one point rose 10 feet in about 24 hours.

April, 2001 - Rainfall in the upper Mississippi River Basin hastened the snowmelt in Minnesota and Iowa. Although the flood wave attenuated significantly by the time it reached the St. Louis Hydrologic Service Area (HSA), the flooding was still significant. Hannibal, MO reached the 9th highest stage on record, hitting 23.3 feet (flood stage 16) on April 28. Despite the fact that the stages were fairly high, damage was limited. Only 4 businesses sit outside Hannibal's flood levee. The rest were bought out and removed after the flood of record in 1993. Most land flooded was either agricultural or land that was reverted back to natural floodplain after previous floods.

May, 2001 - Continued rainfall in the upper Mississippi River Basin worsened the conditions along the already swollen river. Although the flood wave along the Mississippi River attenuated significantly by the time it reached the St. Louis Hydrological Service Area, upstream of Grafton, IL major flooding occurred. Canton, MO Lock and Dam 20 Tail water down through Winfield, MO Lock and Dam 25 Tail water reached the 3rd highest crests of record.

April, 2002 - Heavy rain during the last week of April pushed the Mississippi River over its banks. The flooding was relatively minor but continued and worsened into May.

May, 2002 - The Mississippi River started the month in flood at most locations, dropped below flood stage briefly early in the month, then rose again for most of the remainder of May due to several heavy rain events. Flooding along the river ranged from about 5 feet to about 12 feet over flood stage. The primary problem caused by the flooding was inconveniences created by closed roads. The west bound lanes of Highway 67 in St. Charles County had to be closed by high water. This created a 1 hour detour for people in Illinois wanting to travel into Missouri. In Crystal City, in Jefferson County, a couple of business had to be sand bagged to keep the river out. A new levee is planned for this area which should prevent flooding in the future. The main businesses affected by the flooding was tourism. Riverfront attractions in many cities had to shut down for a while due to the flooding. Damage to homes was virtually nonexistent due to relocations and buyouts after the Great Flood of 1993.

August, 2007 - Heavy rain upstream caused minor flooding on the Mississippi River. At Clarksville and Louisiana, the river peaked about 2 feet over flood stage and was still in flood when the month ended.

August, 2008 - The Mississippi River at Louisiana crested at 26.96 feet on 6/23/2008. This is the third highest crest ever recorded. The Highway 54 bridge had to be closed due to flooding on the Illinois side. Highway 79 was also closed in town. Eighteen homes and eight businesses were flooded but many others were saved by sand bagging efforts. A boil order was in effect for a while due to a water main break. The Mississippi River at Clarksville crested at 36.70 feet on 6/24/2008. This is the third highest crest ever recorded. A huge sand bagging effort saved much of the downtown area, but 10 homes were still flooded. Fifteen homes lost water service due to a water line break. Damage to public infrastructure was estimated at $285,000. The Farm Service Agency estimated agricultural losses in the County to be about $11.2 million.

July, 2007 - The Mississippi River crested at Louisiana, MO on July 1 at 23.95 feet. It fell below flood stage on July 16. The river crested at Clarksville, MO on July 1 at 34.60 feet. It fell below flood stage on July 17. For additional information about the flooding consult the June report.

July, 2008 - Rainfall of 7 - 10 inches in North Central Missouri caused flooding along the Salt River below Mark Twain Lake. This represented the first flooding of the Salt River since the completion of Clarence Cannon Dam which created Mark Twain Lake in 1984. The flooding was limited to agricultural and conservation lowlands along the river. Several roads were flooded and had to be closed, including Highway 79.

September, 2008 - Between 4 and 5 inches of rain fell onto already saturated soils as the remnants of Hurricane Ike moved through the region causing flooding. Numerous roads were flooded including Highway 79 north of Louisiana.

June, 2010 - Moderate flooding affected areas along the Mississippi River from mid-June through the end of the month. There was little damage other than some roads near the river being closed and some low-land farm fields flooded.

April, 2013 - The Mississippi River rose to major flood levels along the border of Pike County. The river crested on the 22nd but remained above flood stage into May. The City of Clarksville, with the help of the Missouri National Guard and many volunteers, was able to build a sandbag wall to protect the downtown business district. Thus damage was limited to some flooded roads, a few outbuilding in the flood plain, and agricultural lowlands.

May, 2013 - The Mississippi River remained in flood through May along the border of Pike County.

The river started at major flood levels, dropped some into the middle of the month, then rose again to major levels at the end of May. The town most affected was Clarksville. Sandbagging efforts by the National Guard and volunteers were successful in keeping the downtown area mostly dry.

June, 2013 - The Mississippi River started June in flood and hit major flood levels cresting on the 1st. The river fell the rest of the month but remained in flood into July. Damage was mainly limited to some flooded roads and flooded farmland. Residents of Clarksville once again used the National Guard and volunteers to build a sandbag wall to keep the downtown business district dry.

Flash Flood Events

June, 1997 - 2 to 3 inches of rain flooded roads across the county. Highway 79 was flooded in places as was Route D., Route NN south of Louisiana was also flooded.

July, 1998 - Rainfall of 2 to 4 inches caused flooding of some roads across the west portion of the area.

May, 2002 - The first heavy rain event of the month brought 2-4 inches of rain and widespread flash flooding. Most creeks and small streams flooded closing some roads and flooding farmland. In cities, flooded basements was a major problem.

May, 2003 - Rainfall of 4 to 6 inches caused flash flooding across much of Pike County. Flooding was reported on Highway 61 near Bowling Green, on Route D south of Louisiana, and on Route K east of Gazette. Part of the pavement was washed away on Highway 61.

June, 2003 - Heavy rain caused flash flooding across much of Pike County. Several county roads were flooded and damaged by the flood water. Highways 79 and UU in the Louisiana area flooded and were closed by high water.

May, 2004 - Two to four inches of rain caused flash flooding across the area. Flooding was reported in Paris, Center, and Bowling Green. Two bridges in the Bowling Green area were damaged by debris and had to be closed.

August, 2004 - Rainfall of 4 to 5 inches caused flash flooding across Northeast Missouri. Numerous county roads were flooded with some damaged by the runoff.

June, 2008 - A levee broke just north of Highway M in Lincoln county and near Kickapoo Road. It flooded portions of the Elsberry Levee District in extreme southeastern Pike county east of Highway 79 and from Annada southward.

July, 2008 - Between 3 and 5 inches of rain fell in a short amount of time on already saturated soils causing flash flooding. Numerous roads were flooded and closed for a time including...Highway 154 west of Curryville, Route M south of Curryville, Route V and Route Y.

August, 2008 - Very heavy rain fell in a short amount of time on already saturated soils causing flash flooding. Highway E east of Spencerburg was closed due to water flowing over the road.

July, 2010 - Up to five inches of rain fell in a short amount of time causing flash flooding. Numerous roads were flooded including Highway 79 north of Louisiana, U.S. Highways 54 and 61 in spots, and Highway UU northeast of Bowling Green. Also, one woman drowned when she slipped at a low-water crossing and became trapped in a culvert. It occurred at a popular swimming area call The Slabs on Pike County Road 252 along Buffalo Creek, about five miles south of Louisiana. She had been swimming in the rain-swollen creek with her son and his friend. The boys were uninjured in the incident. In Louisiana, several streets downtown were flooded for a time due to a creek flooding out of its banks. Several businesses and homes sustained flooding damage.

June, 2015 - Up to 5 inches of rain fell onto already saturated soils causing flash flooding. Several roads were flooded including Highway 79 at Pike Street in Annada and Highway N west of Clarksville.

Probability of Future Occurrence

With the extensive history of flooding in the planning area, it is highly likely that flooding of various levels will continue to occur frequently. The probability of a flood event occurring in the planning area in any given year if 70%. Flash floods occur often in the planning area and have a 60% probability of occurring in any given year.

Vulnerability

Vulnerability Overview

Flooding in the planning area has caused significant damage throughout with 12 documented flood events in the last 20 years making flooding a 70% probability flooding will occur in any given year.

Potential Losses to Existing Development

The existing development along the Mississippi River in Pike County includes the towns of Louisiana, Clarksville and Annada. The potential losses could include businesses, government buildings, homes. In un-incorporated Pike County, there is a potential loss of cropland, farms and homes.

Impact of Previous and Future Development

Any future development in floodplains would increase risk in those areas. For those communities that participate in the National Flood Insurance Program, enforcement of the floodplain management regulations will ensure mitigation of future construction in those areas. However, even if structures are mitigated, evacuation may still be necessary due to rising waters. In, addition, floods that exceed mitigated levels may still cause damages.

Hazard Summary by Jurisdiction

All of the communities can be impacted by flooding of major roads and low water crossings in the areas proximate to their corporate limits. Several incorporated areas in the county are susceptible to street flooding during periods of heavy rain as evidenced by the previous occurrences by location. The floodplain map in the geographic section shows the greatest risk to be along the Mississippi River and Salt River. The Salt River is flood controlled, but if a disaster at Clarence Cannon Dam ever happened a tragic event would take place along the Salt River with loss of life, damage to homes, businesses and cropland. The jurisdictions of Louisiana, Annada and Clarksville are at the greatest risk of damage from flooding due to their location along the Mississippi River. Businesses, government buildings and residential properties and lives would be impacted in a high flood event.

Problem Statement

Flooding or flash flooding has effected every community in Pike County which has impacted homes and business, not everyone utilizes social media or texting, Louisiana and Clarksville sits along the Mississippi river which is prone to flooding and education is deficient in what to do in the event of a flood. Possible solutions is to increase the education to residents, promote the use of social media or texting and work with officials to identify flood prone areas.

3.4.7 Land Subsidence/Sinkholes

Hazard Profile

Hazard Description

Sinkholes are common where the rock below the land surface is limestone, carbonate rock, salt beds, or rocks that naturally can be dissolved by ground water circulating through them. As the rock dissolves, spaces and caverns develop underground. The sudden collapse of the land surface above them can be dramatic and range in size from broad, regional lowering of the land surface to localized collapse. However, the primary causes of most subsidence are human activities: underground mining of coal, groundwater or petroleum withdrawal, and drainage of organic soils. In addition, sinkholes can develop as a result of subsurface void spaces created over time due to the erosion of subsurface limestone (karst).

Land subsidence occurs slowly and continuously over time, as a general rule. On occasion, it can occur abruptly, as in the sudden formation of sinkholes. Sinkhole formation can be aggravated by flooding.

In the case of sinkholes, the rock below the surface is rock that has been dissolving by circulating groundwater. As the rock dissolves, spaces and caverns form, and ultimately the land above the spaces collapse. In Missouri, sinkhole problems are usually a result of surface materials above openings into bedrock caves eroding and collapsing into the cave opening. These collapses are called “cover collapses” and geologic information can be applied to predict the general regions where collapse will occur. Sinkholes range in size from several square yards to hundreds of acres and may be quite shallow or hundreds of feet deep.

According to the U.S. Geological Survey (USGS), the most damage from sinkholes tends to occur in Florida, Texas, Alabama, Missouri, Kentucky, Tennessee, and Pennsylvania. Fifty-nine percent of Missouri is underlain by thick, carbonate rock that makes Missouri vulnerable to sinkholes. Sinkholes occur in Missouri on a fairly frequent basis. Most of Missouri‘s sinkholes occur naturally in the State‘s karst regions (areas with soluble bedrock). They are a common geologic hazard in southern Missouri, but also occur in the central and northeastern parts of the State. Missouri sinkholes have varied from a few feet to hundreds of acres and from less than one to more than 100 feet deep. The largest known sinkhole in Missouri encompasses about 700 acres in western Boone County southeast of where Interstate 70 crosses the Missouri River. Sinkholes can also vary is shape like shallow bowls or saucers whereas other have vertical walls. Some hold water and form natural ponds.

According to US Mines.com there is 38 mines in the planning area. Thirty-five of the mines conduct mining activities for crushed stone, 2 mines sand and gravel and 1 mine for clay.

Geographic Location

The Missouri Department of Natural Resources documented 134 sinkholes in the planning area. The sinkholes are throughout the county and not located in one distinct area of the county.

The majority of the sinkholes are located in areas of the county where mining has occurred.

Source:http://www.dnr.mo.gov/geology/geosrv/envgeo/sinkholes.htm

Severity/Magnitude/Extent

Sinkholes vary in size and location, and these variances will determine the impact of the hazard. A sinkhole could result in the loss of a personal vehicle, a building collapse, or damage to infrastructure such as roads, water, or sewer lines. Groundwater contamination is also possible from a sinkhole. Because of the relationship of sinkholes to groundwater, pollutants captured or dumped in sinkholes could affect a community's groundwater system. Sinkhole collapse could be triggered by large earthquakes. Sinkholes located in floodplains can absorb floodwaters but make detailed flood hazard studies difficult to model.

The 2013 State Plan included only seven documented sinkhole "notable events". The plan stated that sinkholes are common to Missouri and the probability is high that they will occur in the future. To date, Missouri sinkholes have historically not had major impacts on development nor have they caused serious damage. Thus, the severity of future events is likely to be low.

Previous Occurrences

According to the Missouri 2010 State Plan sinkholes are a regular occurrence in Missouri, but are rarely the events of any significance. The Missouri State Hazard Mitigation Plan lists seven notable sinkhole events with none of them occurring in the planning area.

Although Pike County has over 134 sinkholes they have not been a problem and the likeliness of a future occurrence would be considered negligible. However, the potential for this type of hazard to occur in Pike County exists. There are portions of the county where sinkholes and underground caverns exist and can increase the likely hood of a sinkhole occurring.

Probability of Future Occurrence

The likely hood of a sinkhole occurring of any significance is low based on the past history of the sinkholes recorded. Due to data limitations precluding a probability calculation, such as the lack of a centralized database for sinkhole occurrences in the state.

Vulnerability

Vulnerability Overview

Sinkholes in the planning area are not common occurrence due to composition of the land. While some sinkholes may be considered a slow changing nuisance; other more sudden, catastrophic collapses can destroy property, delay construction projects and contaminate ground water resources.
Sinkholes

The Missouri Department of Natural Resources shows the location of 134 sinkholes for the planning area. These sinkholes can vary from a few feet to hundreds of acres and from less than one to more than 100 feet deep. They can also vary is shape like shallow bowls or saucers whereas other have vertical walls, some hold water and form natural ponds. There are no statics on the number of voids present in the subsurface that will collapse in the future to form new surface sinkholes, however, areas have been identified that have the greatest potential for future sinkholes and land subsidence.

Mines

The Missouri Mine Map Repository maintained by the Missouri Department of Natural Resources did not include any mines in Pike County although the previously discussed website did show mines in Pike County. The Missouri Department of Natural Resources Division of Geology and Land Survey shows there is production of construction crushed stone occurring Pike County. http://dnr.mo.gov/geology/adm/publications/docs/map-MinRes.pdf

Potential Losses to Existing Development

The potential impact of sinkholes on existing structures is difficult to determine due to the lack of data on historic damages caused by sinkholes and even either the mapping of potential sinkholes it is difficult if not impossible to predict where a sinkhole will collapse and how significant the collapse will be.

Because sinkhole collapse is not predictable and previous events have occurred in the rural area there is not significant data to estimate the future losses due to a sinkhole.

Impact of Previous and Future Development

As more development occurs on unmapped rural areas the vulnerability to the hazard will increase; however, sinkholes are unpredictable and the development in rural areas is difficult to limit due to the lack of occurrence.

Pike County is documented to have a large number of caves and future development over existing caves can have an impact on this hazard. The installation of residential services such as septic tanks, lagoons, and structures can cause shifts in the karst deposit located in the planning area and allow the formation of a sinkhole.

Hazard Summary by Jurisdiction

The risk for the development is uniform throughout the planning and has not affected one jurisdiction specifically.

Problem Statement

Sinkholes can occur at any time and without warning and vary by size. There can be a disruption of transportation services and not residents in the dangerous areas are not educated on what to do if a sinkhole occurs.

Education needs to occur on the danger areas of a sinkhole occurring and what to do if a sinkhole does occur.

3.4.8 Levee Failure

Hazard Profile

Hazard Description

Levees are earth embankments constructed along rivers and coastlines to protect adjacent lands from flooding. Floodwalls are concrete structures, often components of levee systems, designed for urban areas where there is insufficient room for earthen levees. When levees and floodwalls and their appurtenant structures are stressed beyond their capabilities to withstand floods, levee failure can result in injuries and loss of life, as well as damages to property, the environment, and the economy.

Levees can be small agricultural levees that protect farmland from high-frequency flooding. Levees can also be larger, designed to protect people and property in larger urban areas from less frequent flooding events such as the 100-year and 500-year flood levels. For purposes of this discussion, levee failure will refer to both overtopping and breach as defined in FEMA's Publication "So You Live Behind a Levee" (http://content.asce.org/ASCELeveeGuide.html). Following are the FEMA publication descriptions of different kinds of levee failure.

> **Overtopping: When a Flood Is Too Big**
> Overtopping occurs when floodwaters exceed the height of a levee and flow over its crown. As the water passes over the top, it may erode the levee, worsening the flooding and potentially causing an opening, or breach, in the levee.
>
> **Breaching: When a Levee Gives Way**
> A levee breach occurs when part of a levee gives way, creating an opening through which floodwaters may pass. A breach may occur gradually or suddenly. The most dangerous breaches happen quickly during periods of high water. The resulting torrent can quickly swamp a large area behind the failed levee with little or no warning.

Earthen levees can be damaged in several ways. For instance, strong river currents and waves can erode the surface. Debris and ice carried by floodwaters—and even large objects such as boats or barges—can collide with and gouge the levee. Trees growing on a levee can blow over, leaving a hole where the root wad and soil used to be. Burrowing animals can create holes that enable water to pass through a levee. If severe enough, any of these situations can lead to a zone of weakness that could cause a levee breach. In seismically active areas, earthquakes and ground shaking can cause a loss of soil strength, weakening a levee and possibly resulting in failure. Seismic activity can also cause levees to slide or slump, both of which can lead to failure.

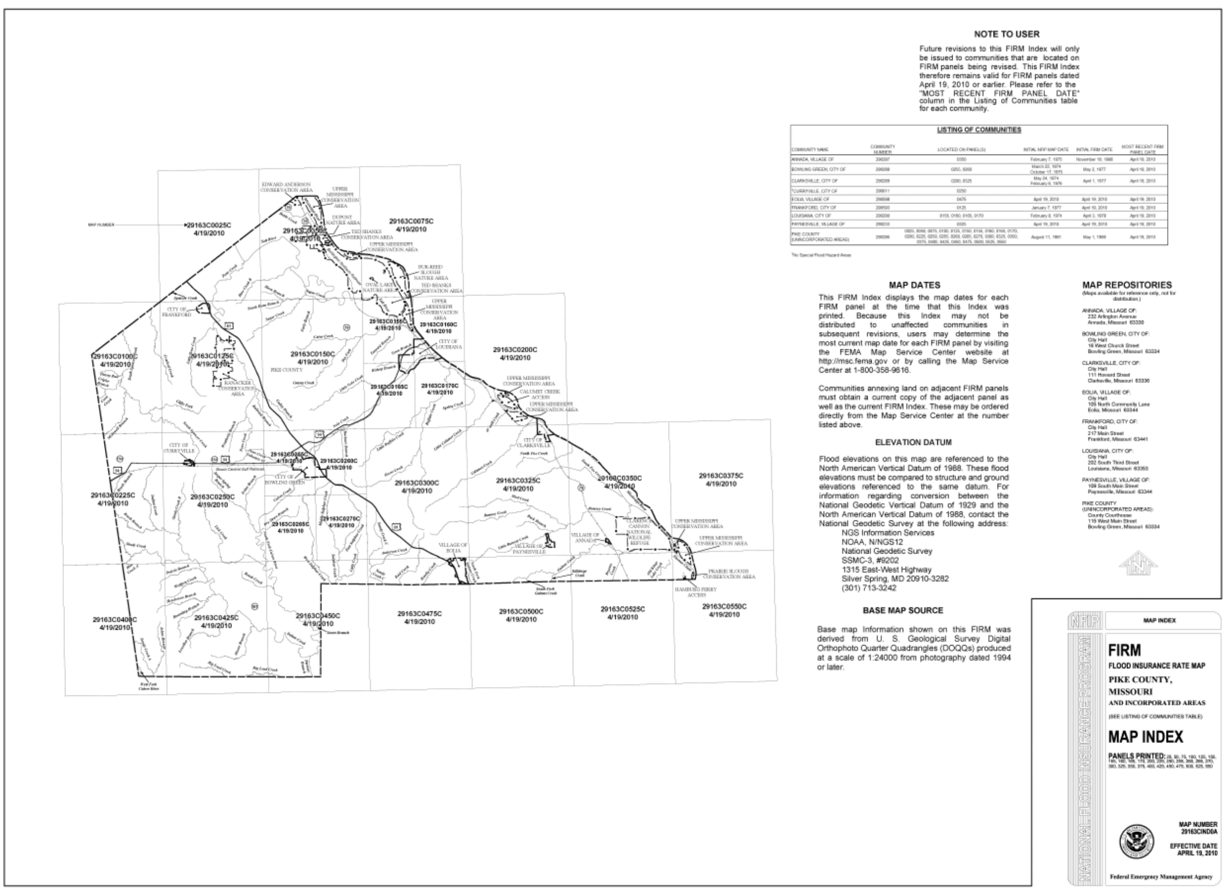
Geographic Location

Missouri is a state with many levees. Currently, there is no single comprehensive inventory of levee systems in the state. Levees have been constructed across the state by public entities and private entities with varying levels of protection, inspection oversight, and maintenance. The lack of a comprehensive levee inventory is not unique to Missouri.

There are two concurrent nation-wide levee inventory development efforts, one led by the United State Army Corps of Engineers (USACE) and one led by Federal Emergency Management Agency (FEMA). The National Levee Database (NLD), developed by USACE, captures all USACE related levee projects, regardless of design levels of protection. The Midterm Levee Inventory (MLI), developed by FEMA, captures all levee data (USACE and non-USACE) but primarily focuses on levees that provide 1% annual-chance flood protection on FEMA Flood Insurance Rate Maps (FIRMs).

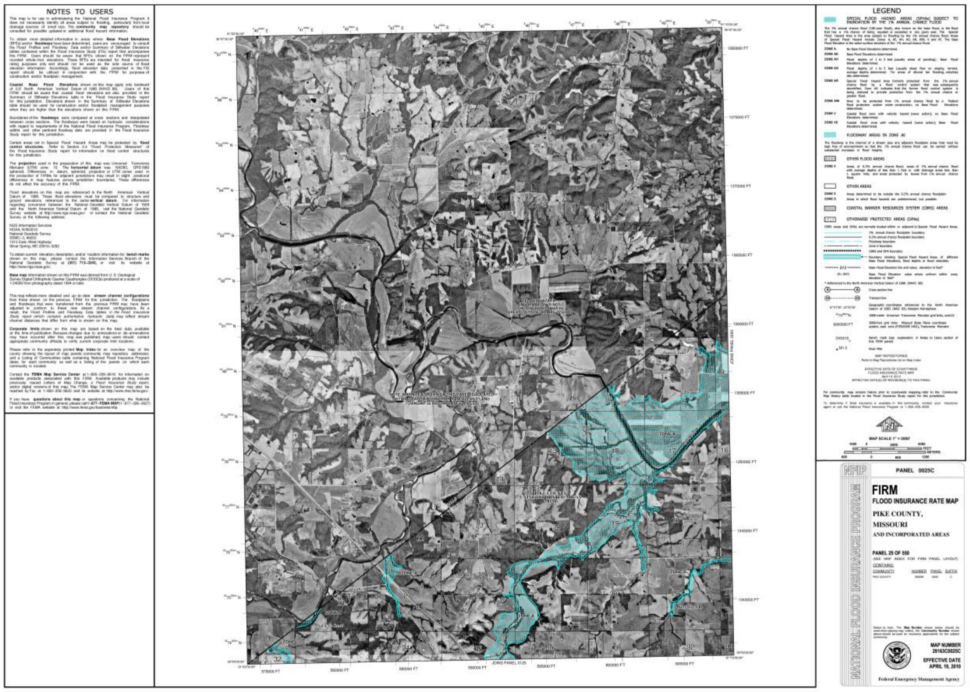
It is likely that agricultural levees and other non-regulated levees within the planning area exist that are not inventoried or inspected. These levees that are not designed to provide protection from the 1-percent annual chance flood would overtop or fail in the 1-percent annual chance flood scenario. Therefore, any associated losses would be considered in the loss estimates provided in the Flood Hazard Section.

Figure 3.9. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



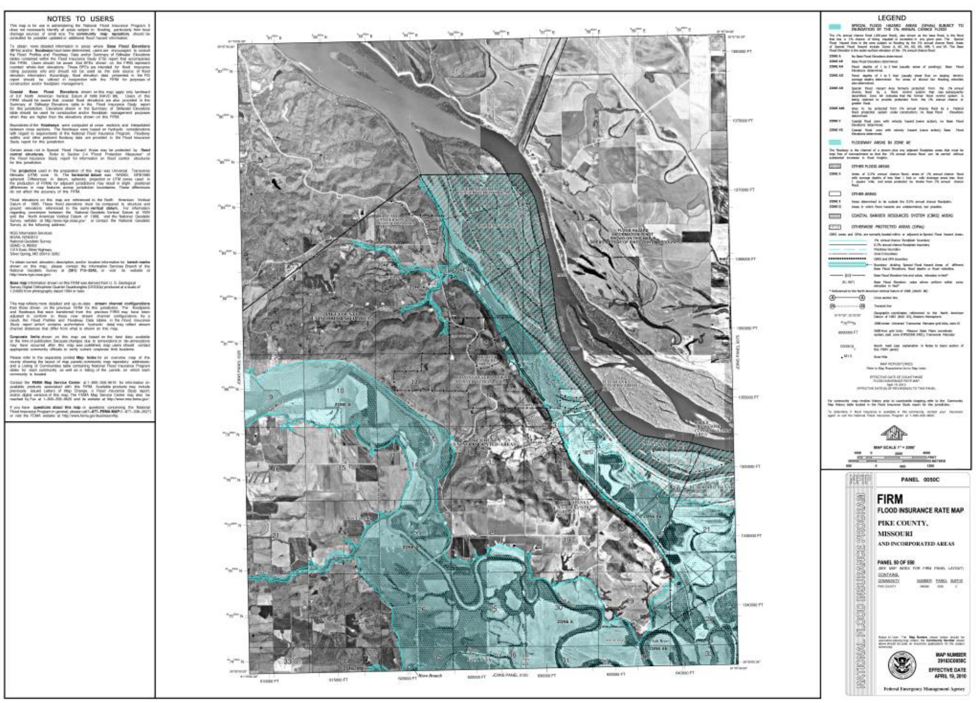
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.10. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



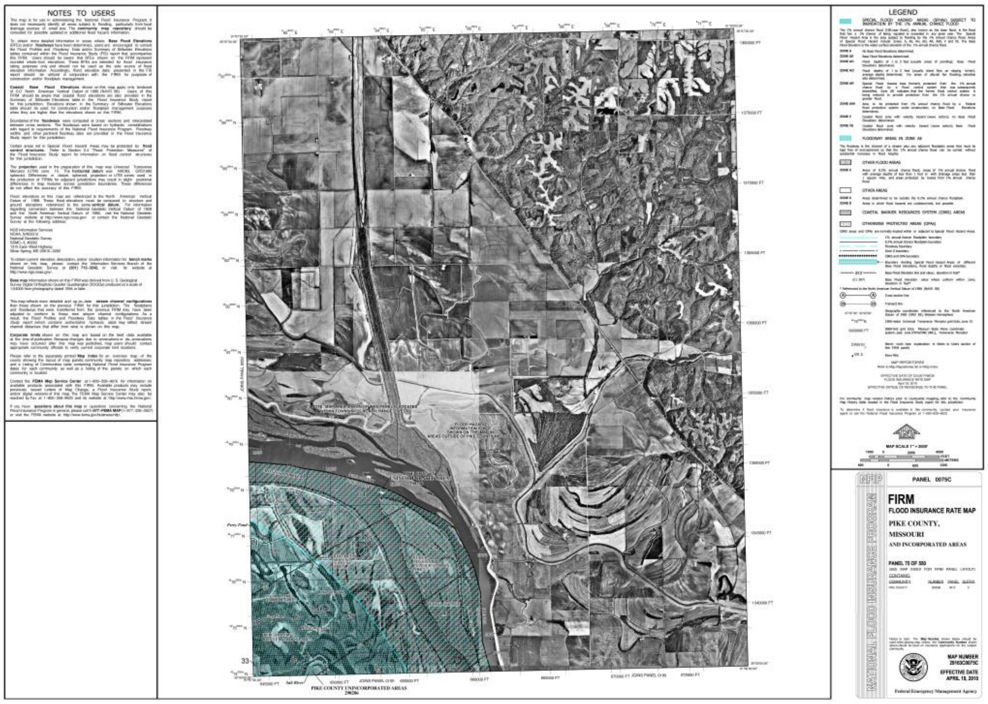
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.11. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



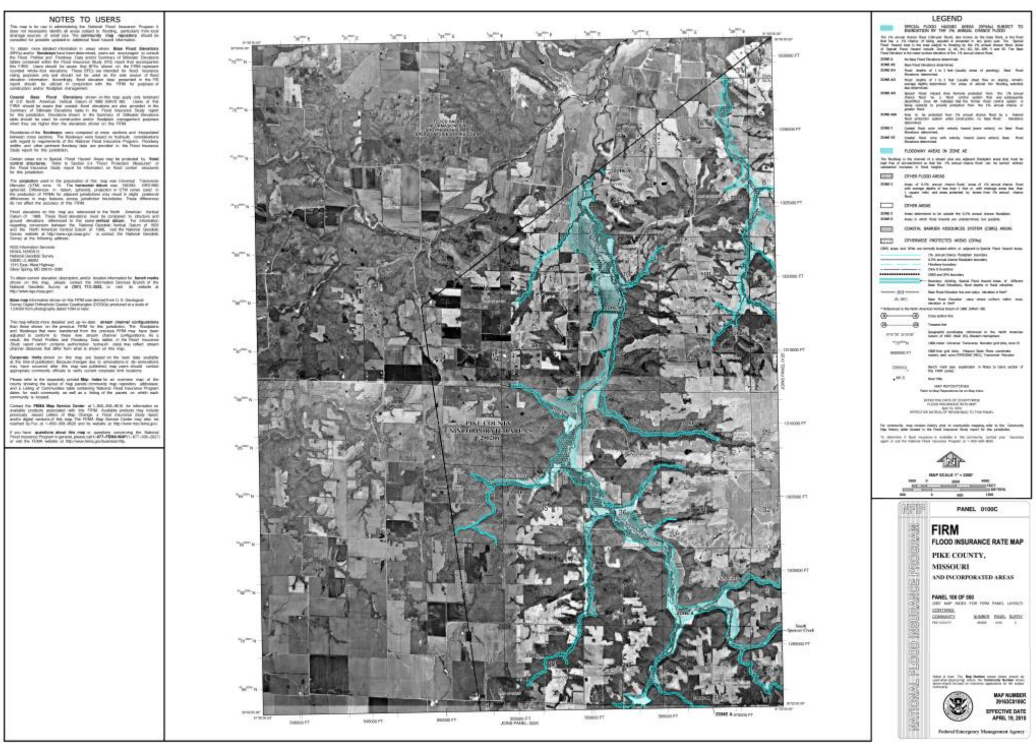
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.12. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



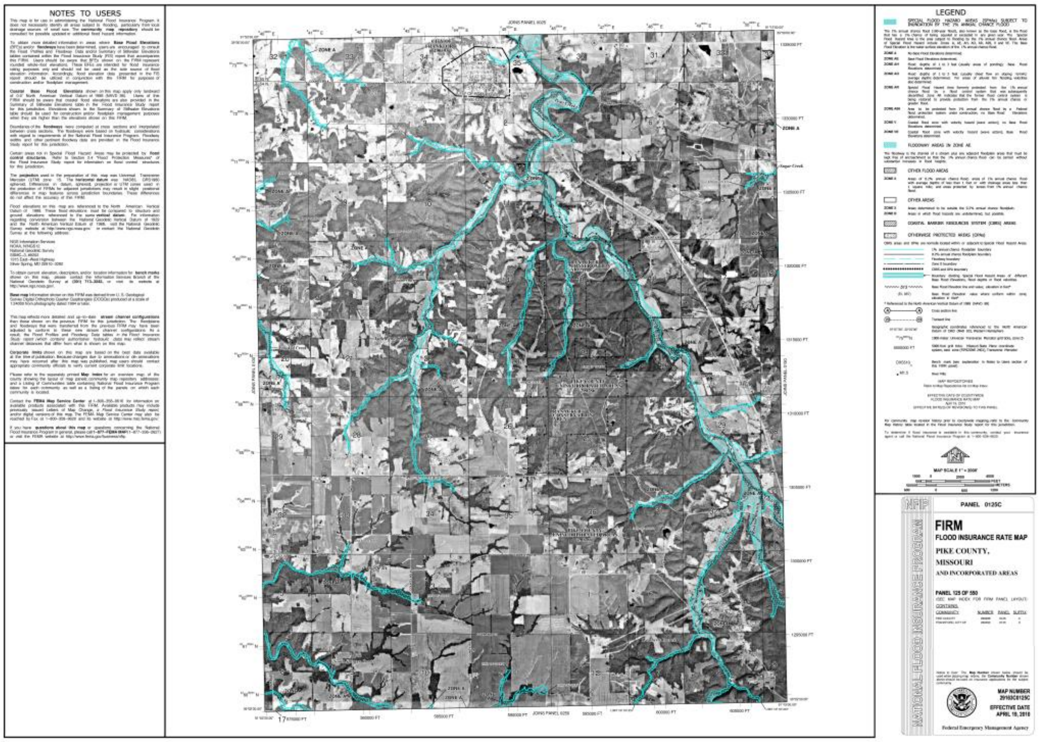
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.13. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



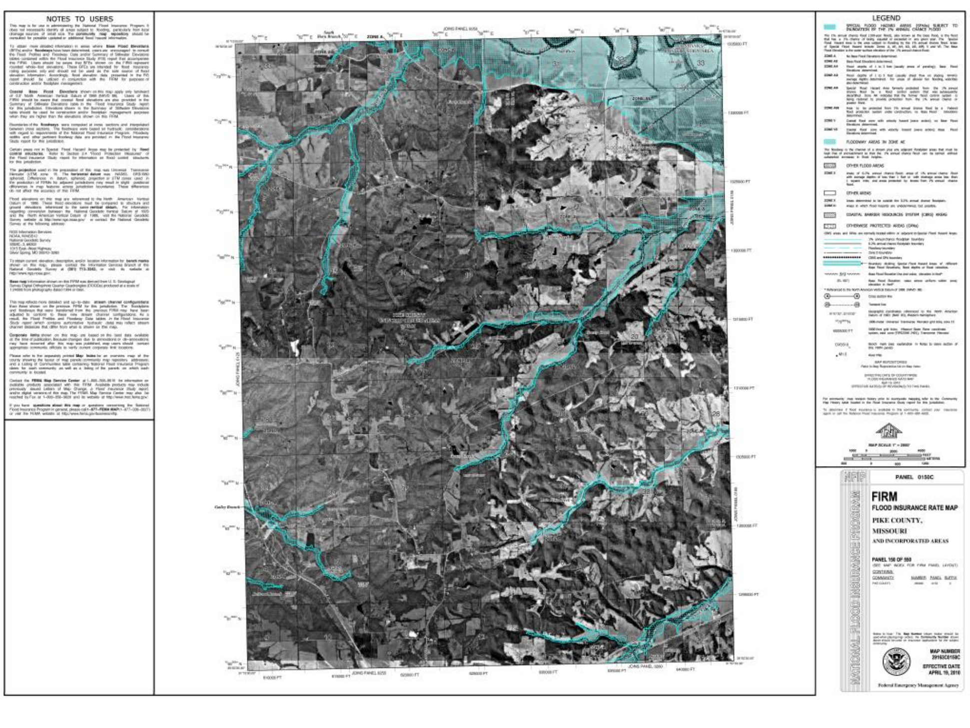
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.14. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



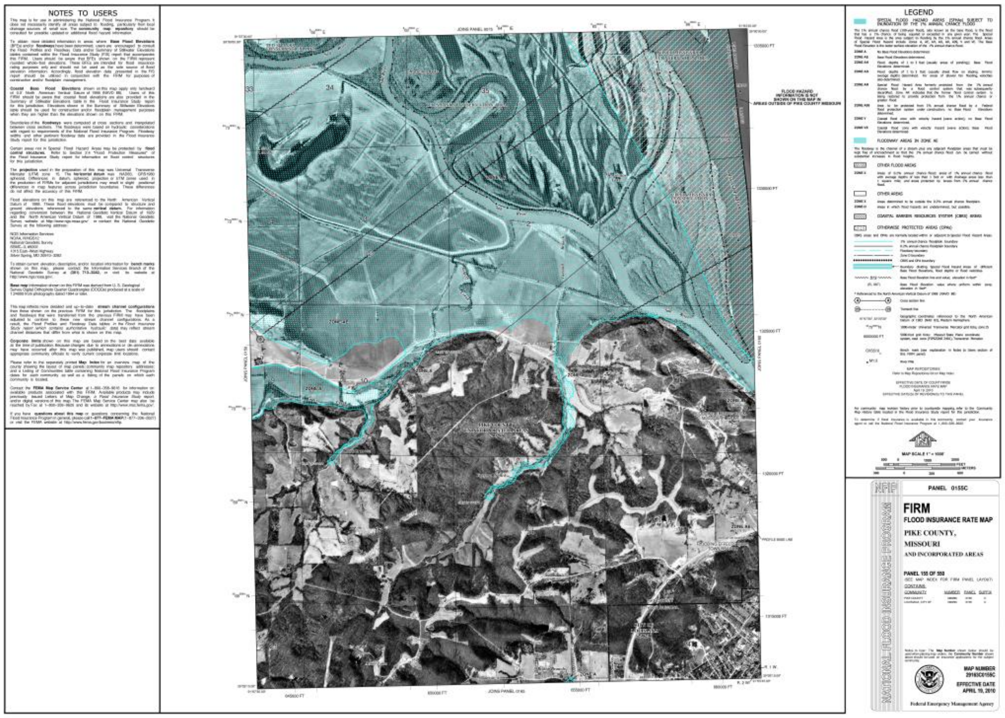
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.15. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



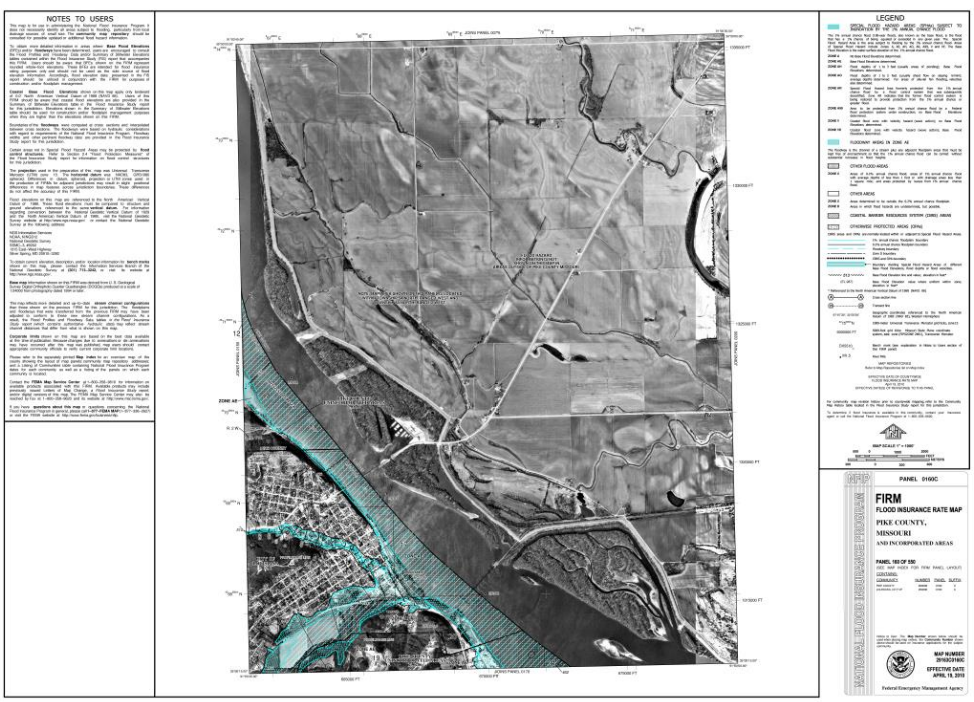
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.16. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



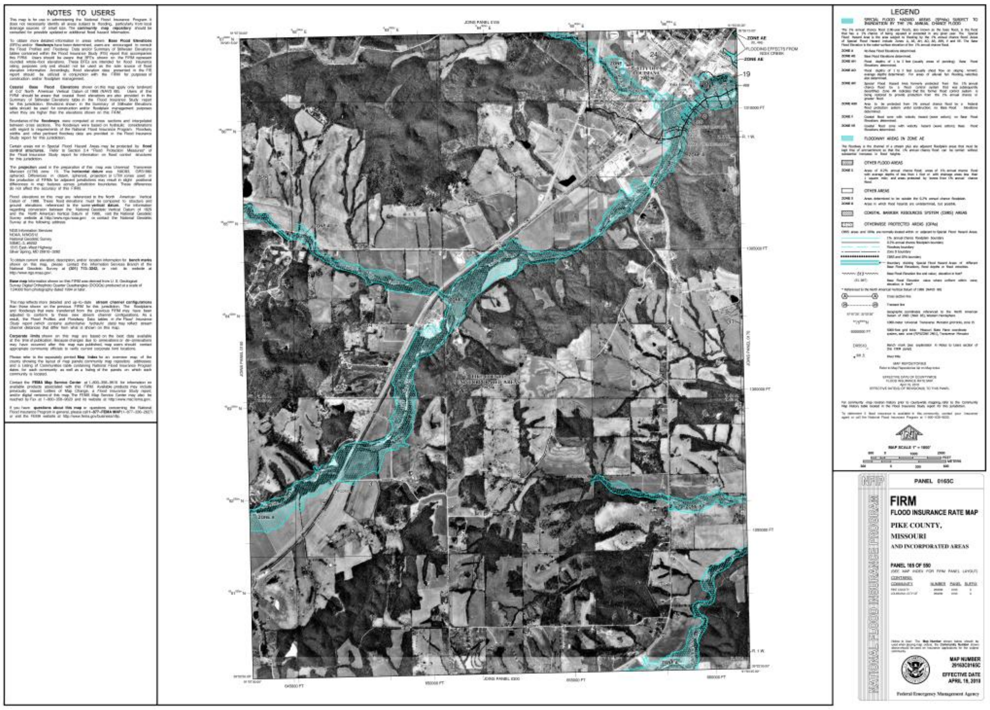
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.17. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



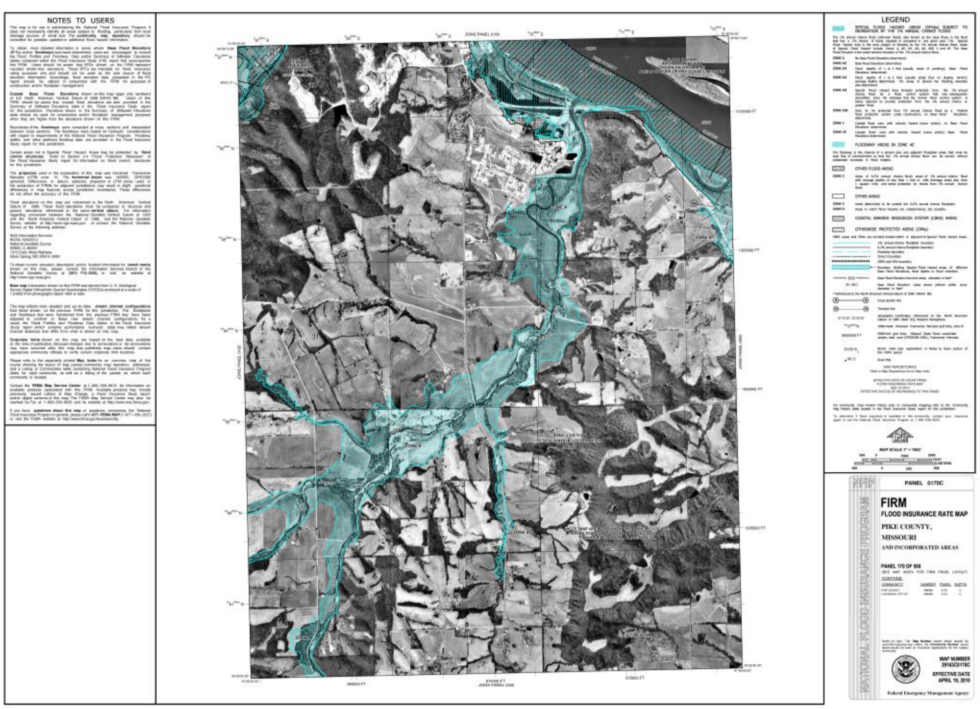
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.18. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



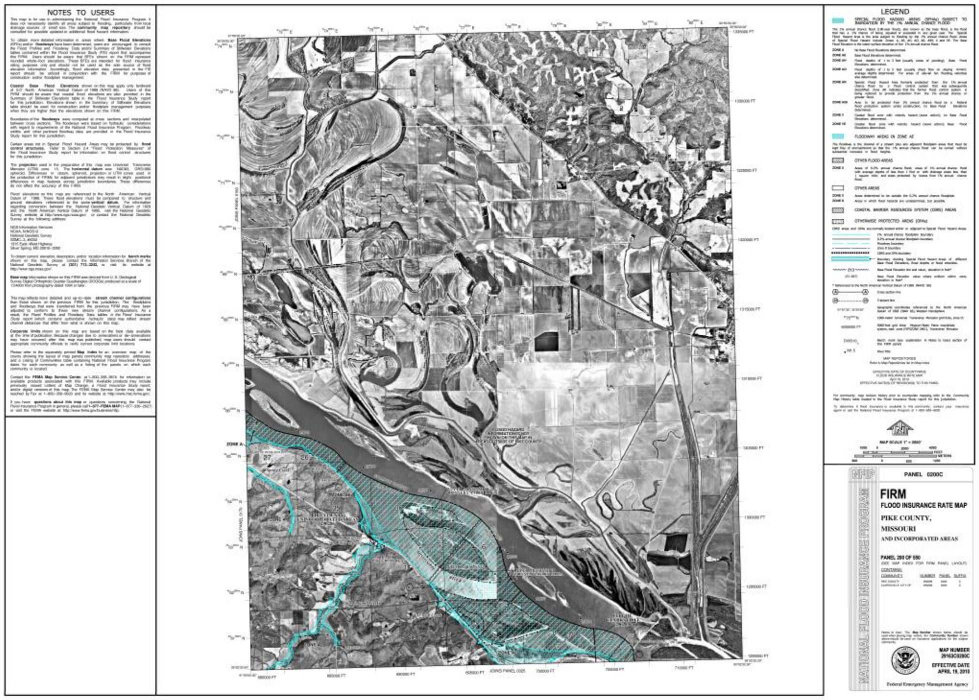
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.19. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



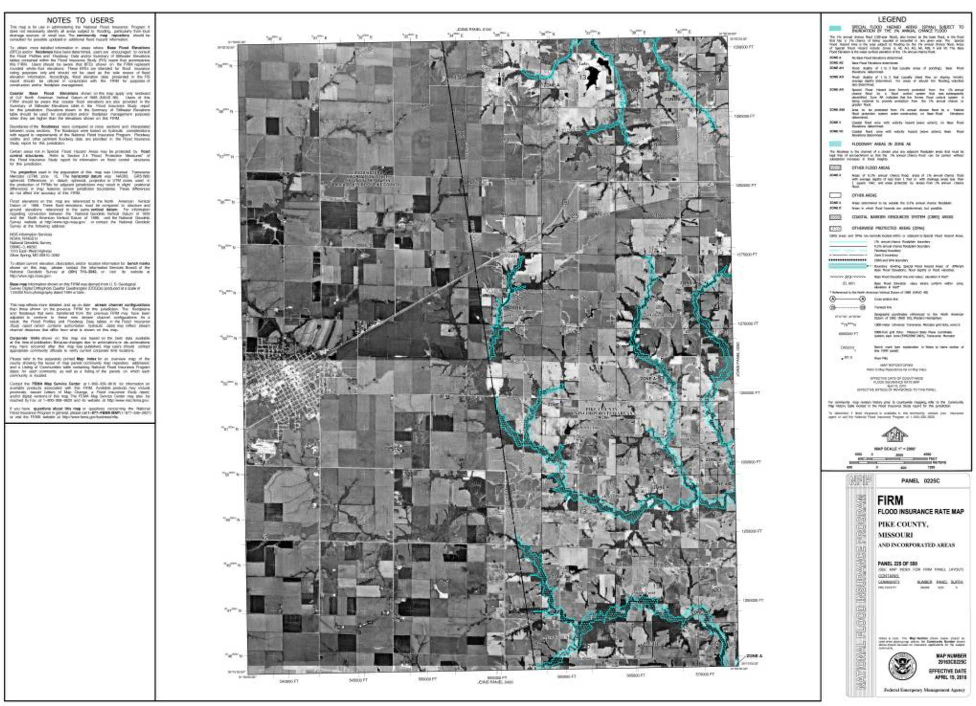
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.20. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



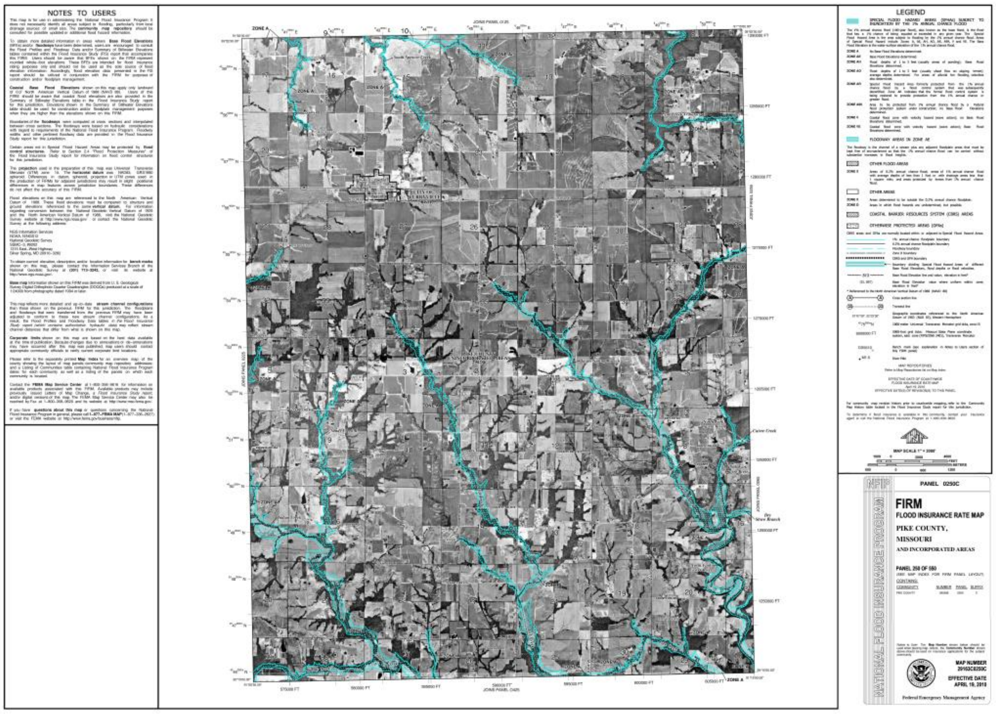
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.21. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.22. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



Source: FEMA Flood Insurance Rate Map, January 2017.

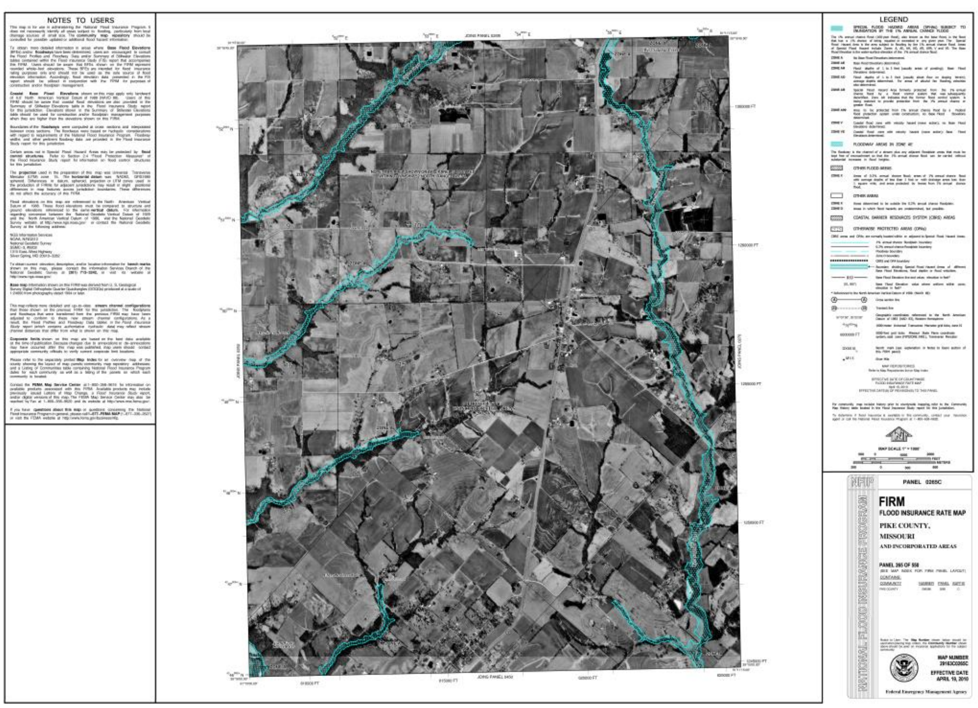
Figure 3.23. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood

Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.24. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood

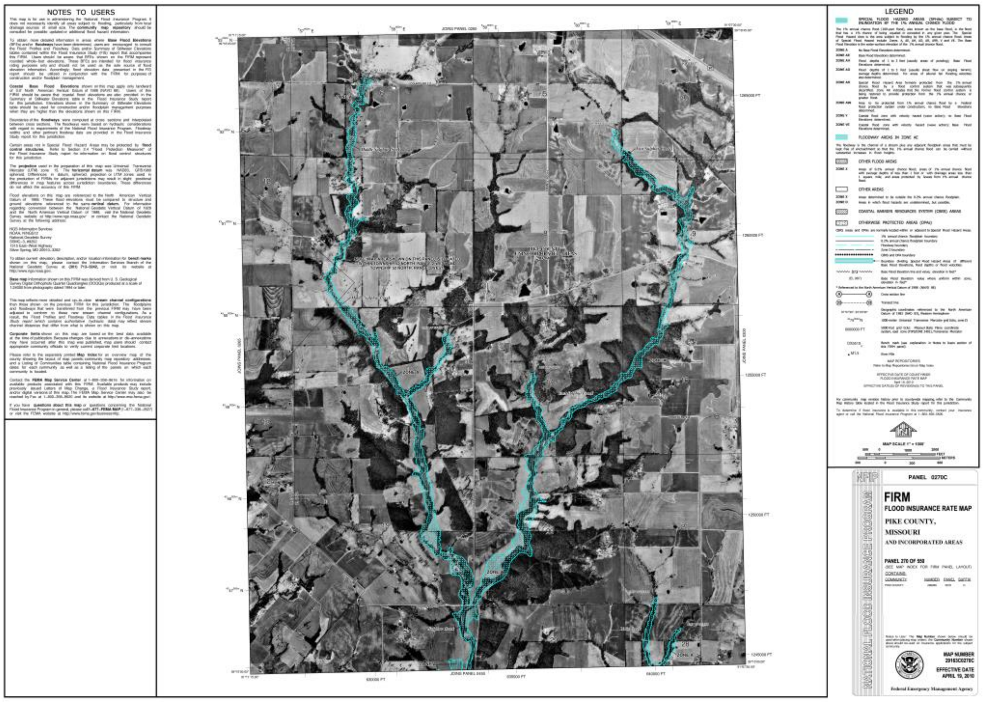
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.25. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



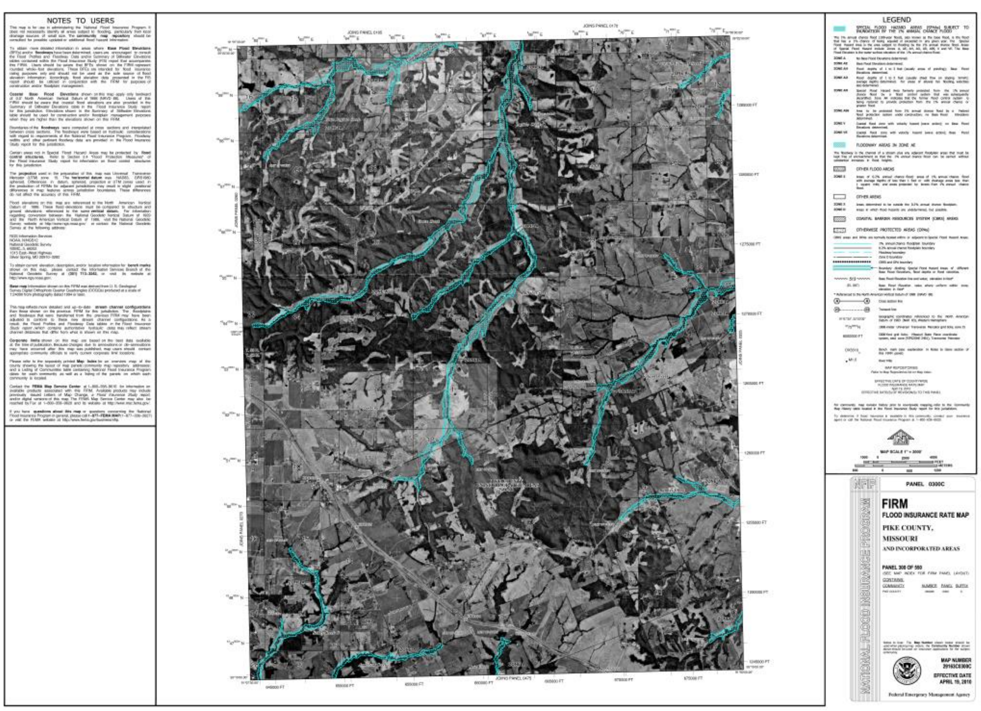
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.26. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



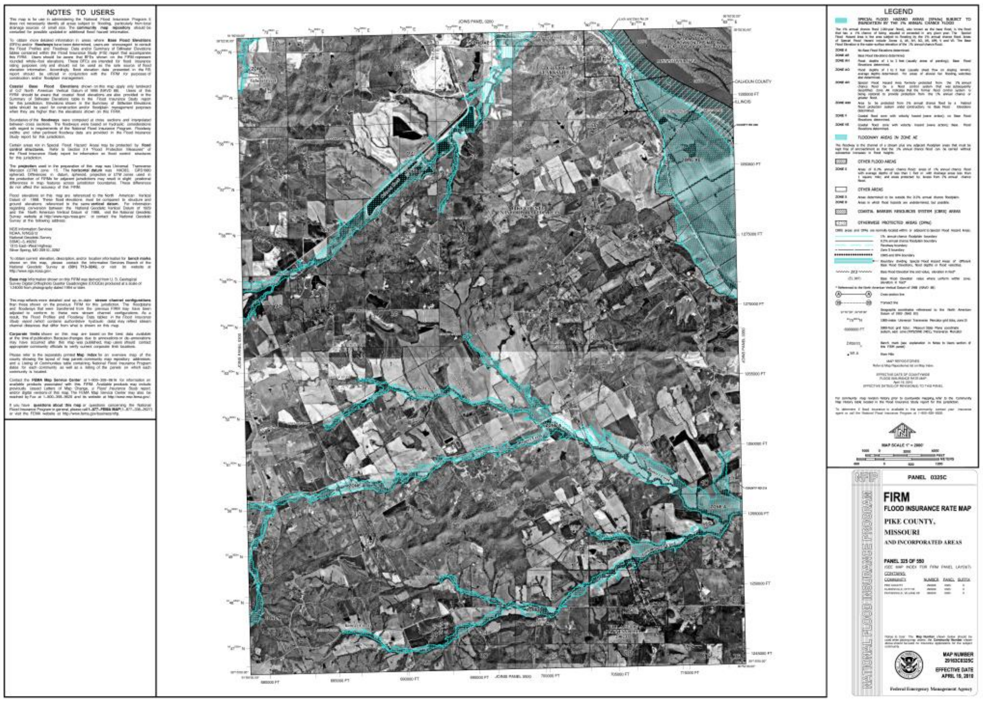
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.27. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



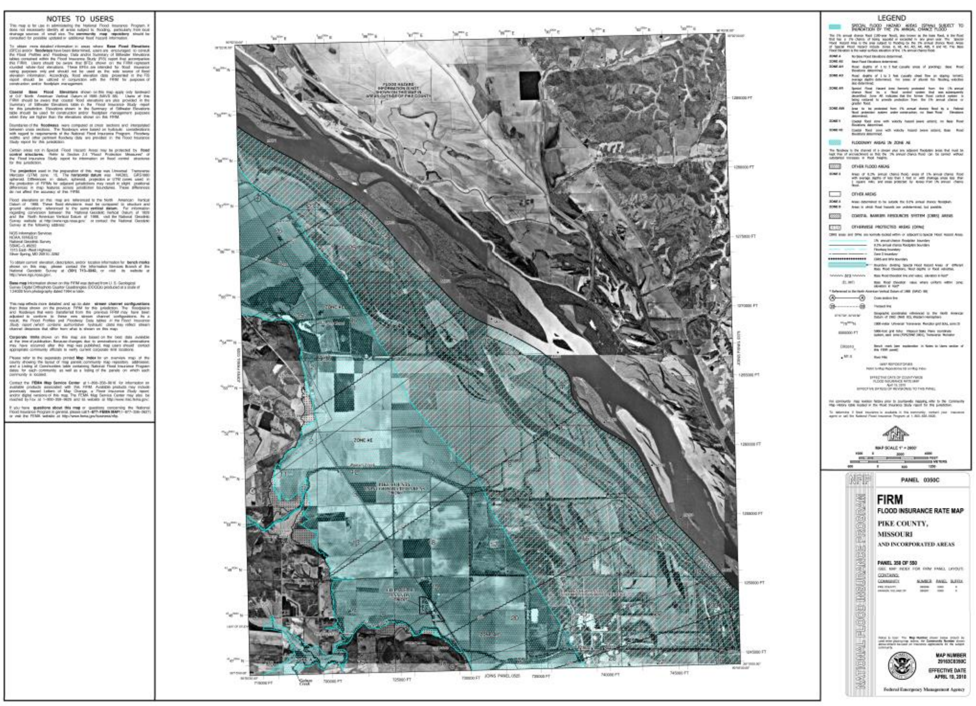
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.28. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



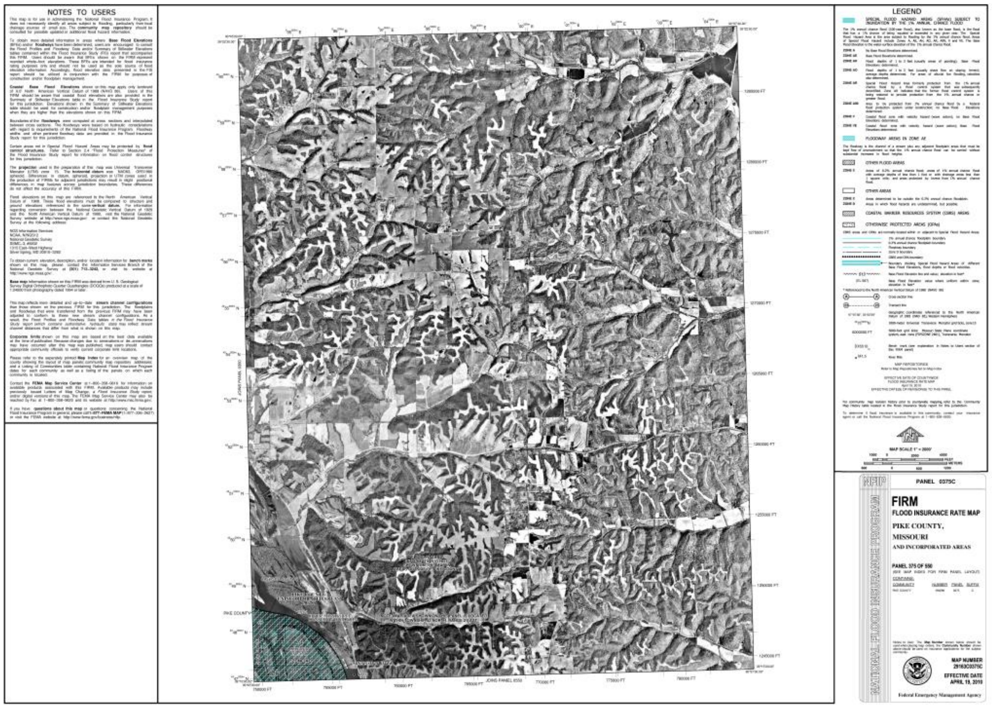
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.29. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



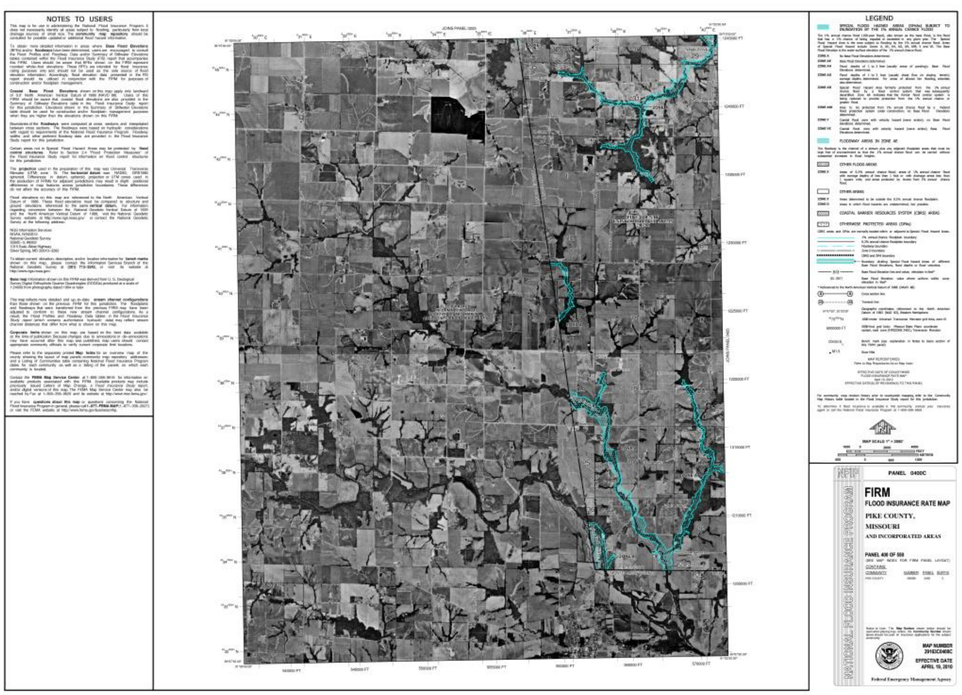
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.30. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



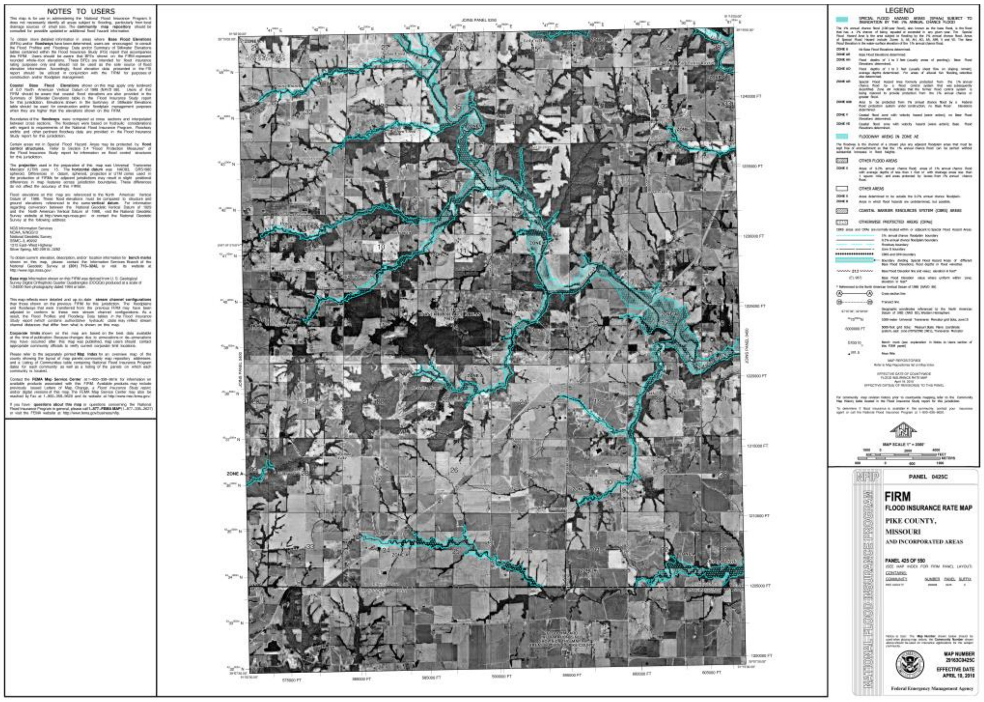
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.31. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



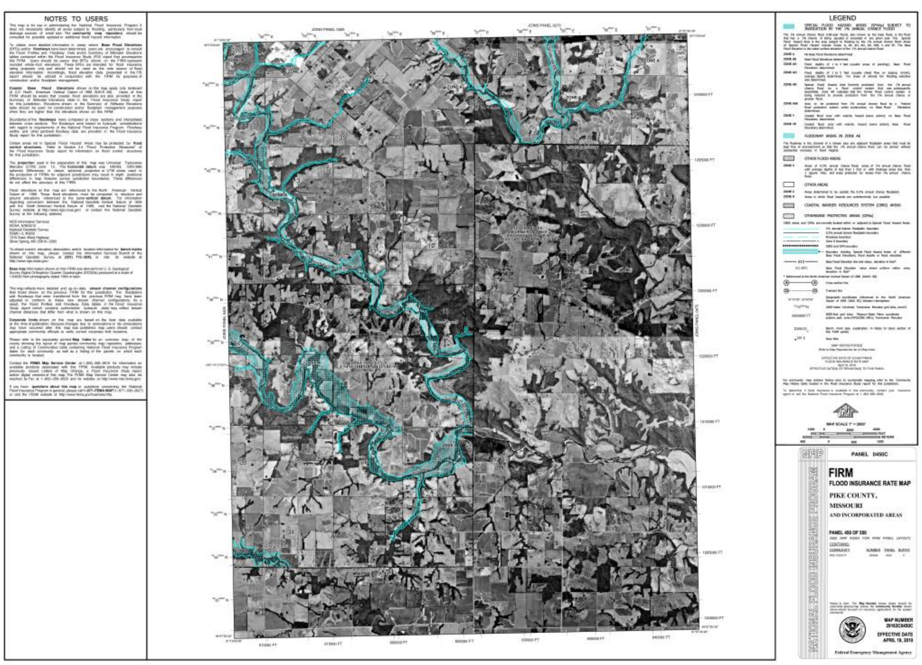
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.32. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



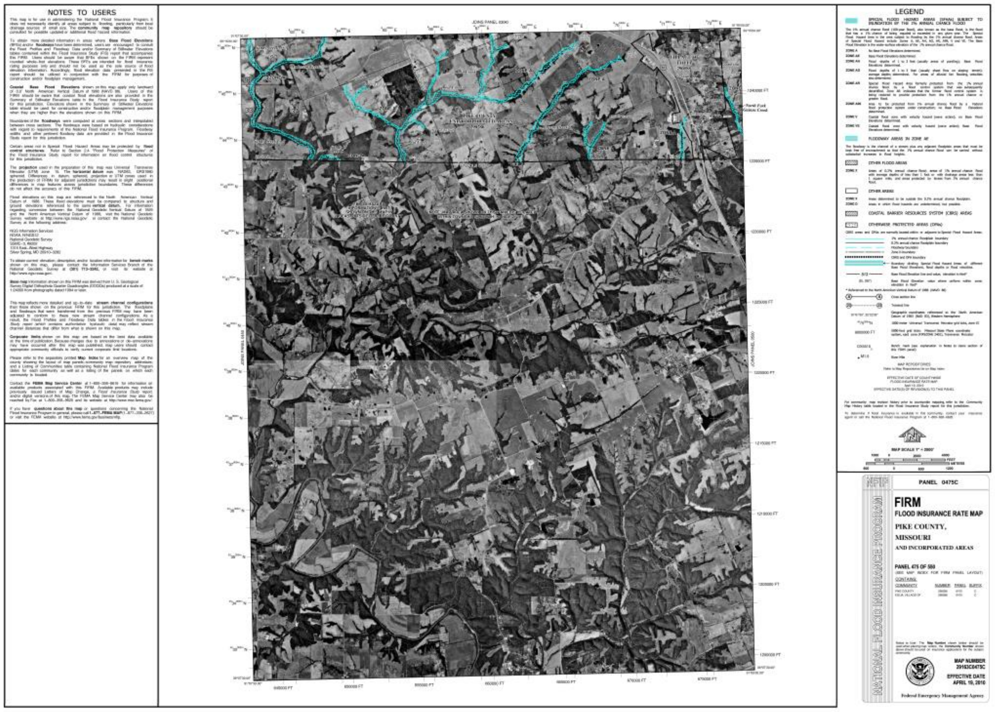
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.33. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



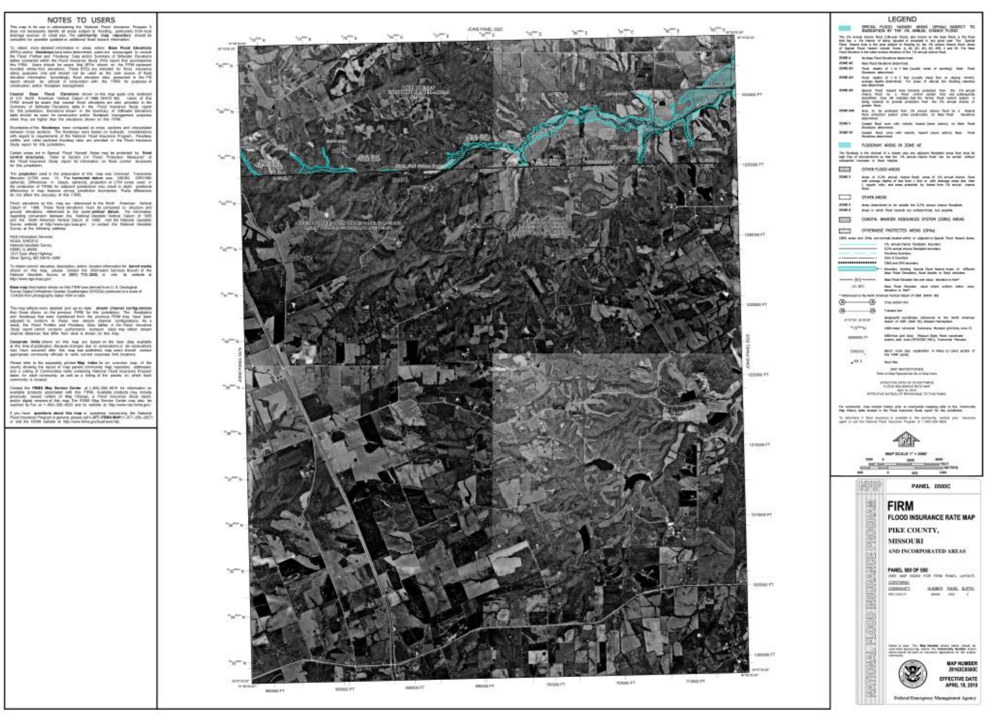
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.34. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



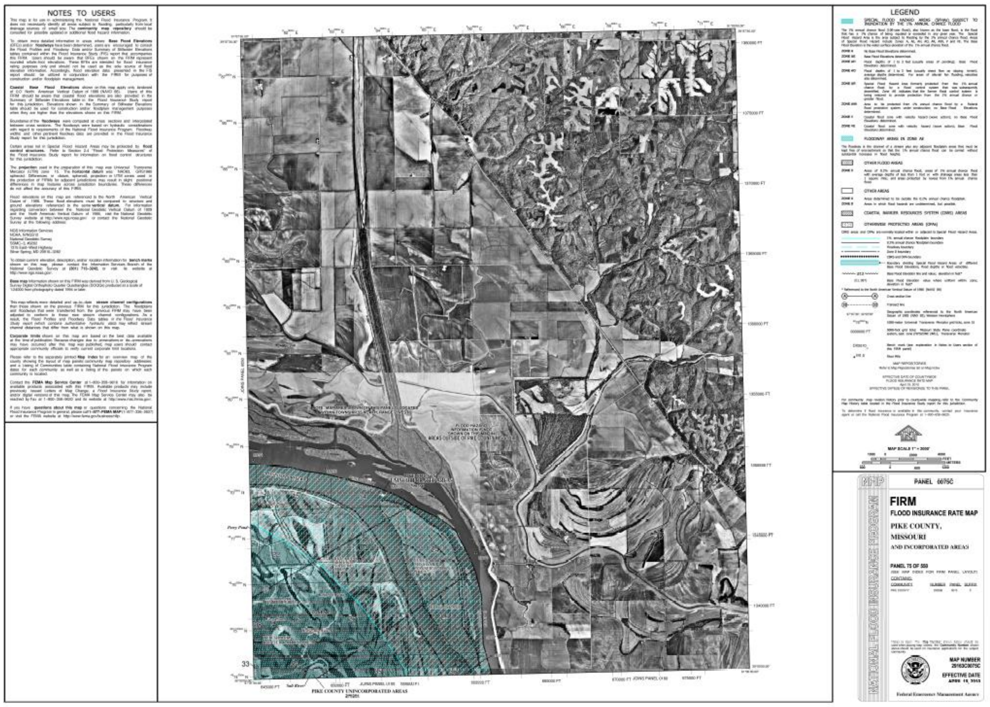
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.35. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



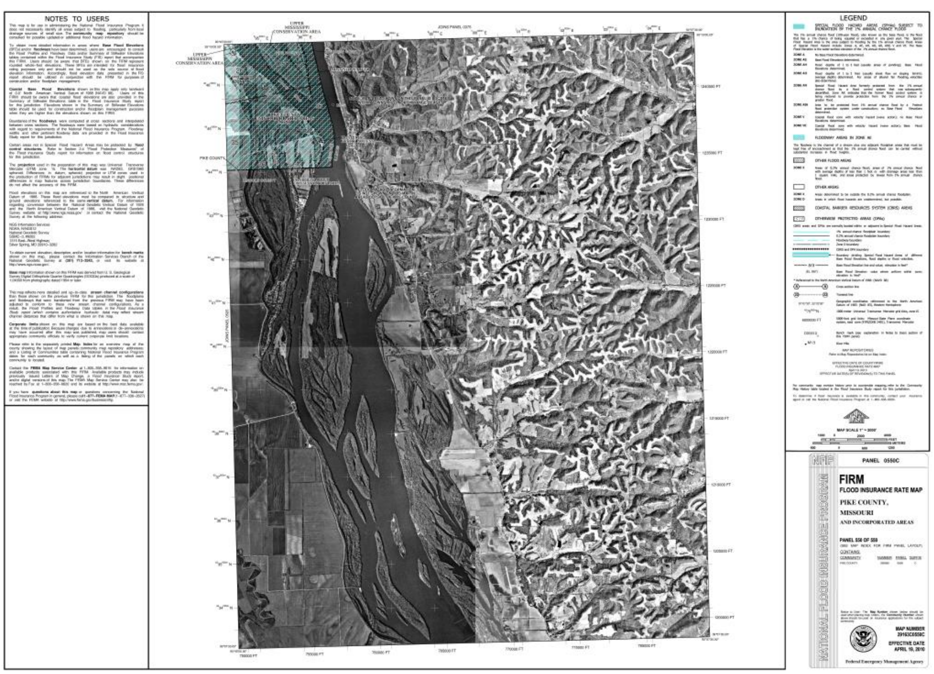
Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.36. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



Source: FEMA Flood Insurance Rate Map, January 2017.

Figure 3.37. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



Source: FEMA Flood Insurance Rate Map, January 2017.

Severity/Magnitude/Extent

Levee failure is typically an additional or secondary impact of another disaster such as flooding or earthquake. The main difference between levee failure and losses associated with riverine flooding is magnitude. Levee failure often occurs during a flood event, causing destruction in addition to what would have been caused by flooding alone. In addition, there would be an increased potential for loss of life due to the speed of onset and greater depth, extent, and velocity of flooding due to levee breach.

As previously mentioned, agricultural levees and levees that are not designed to provide flood protection from at least the 1-percent annual chance flood likely do exist in the planning area. However, none of these levees are shown on the Preliminary DFIRM, nor are they enrolled in the USACE Levee Safety Program. As a result, an inventory of these types of levees is not available for analysis. Additionally, since these types of levees do not provide protection from the 1-percent annual chance flood, losses associated with overtopping or failure are captured in the Flood Section of this plan.

The USACE regularly inspects levees within its Levee Safety Program to monitor their overall condition, identify deficiencies, verify that maintenance is taking place, determine eligibility for federal rehabilitation assistance (in accordance with P.L. 84-99), and provide information about the levees on which the public relies. Inspection information also contributes to effective risk assessments and supports levee accreditation decisions for the National Flood Insurance Program administered by the Federal Emergency Management Agency (FEMA).

The USACE now conducts two types of levee inspections. Routine Inspection is a visual inspection to verify and rate levee system operation and maintenance. It is typically conducted each year for all levees in the USACE Levee Safety Program. Periodic Inspection is a comprehensive inspection led by a professional engineer and conducted by a USACE multidisciplinary team that includes the levee sponsor. The USACE typically conducts this inspection every five years on the federally authorized levees in the USACE Levee Safety Program.

Figure 3.38. Definitions of the Three Levee System Ratings

Levee System Inspection Ratings

Acceptable	All inspection items are rated as Acceptable.
Minimally Acceptable	One or more levee segment inspection items are rated as Minimally Acceptable or one or more items are rated as Unacceptable and an engineering determination concludes that the Unacceptable inspection items would not prevent the segment/system from performing as intended during the next flood event.
Unacceptable	One or more levee segment inspection items are rated as Unacceptable and would prevent the segment/system from performing as intended, or a serious deficiency noted in past inspections (previous Unacceptable items in a Minimally Acceptable overall rating) has not been corrected within the established timeframe, not to exceed two years.

The U.S. Army Corp of Engineers rated one (1) levee in Pike County as unacceptable.

Previous Occurrences

There were no breaches to U.S. Army Corps of Engineers levees operated or built in the planning area.

Probability of Future Occurrence

Due to the lack of information on low-head agricultural levees information on levee failure is unobtainable.

Vulnerability

Vulnerability Overview

The Mississippi River Floodplain remains agricultural in nature with family farms sparely distributed within them. The Cities of Louisiana, Paynesville, Annada and Clarksville lie within the Mississippi's Floodplain and are frequently at risk of flooding due to levee failure or overtopping. Some areas are un-protected from levees, including the City of Clarksville. Critical facilities at risk include Missouri Highway 79 as well as infrastructure associated with the above towns.

Potential Losses to Existing Development

Levees have been constructed across the planning area by public entities and private entities with varying levels of protection, inspection oversight and maintenance. Levee failure would create devastating losses to existing development including businesses, government buildings, homes, and farms.

Impact of Previous and Future Development

Development upstream, in the form of additional levees, creates the greatest impact to Mississippi River flooding in Pike County due to channeling additional water into waterways. Flash floods and levee failures will continue to impact residents choosing to live in rural areas where low water crossings are required to access their homes. There is anticipated to be little or no increase in run off created by potential development; however, that could change within 15 years due to the potential development

Hazard Summary by Jurisdiction

As stated above, the agricultural areas, along with the cities of eastern Pike County depend on levees to hold back flood waters.

Problem Statement

The risk of levee failure is usually a secondary effect of flooding or some other natural disaster. The Eastern portion of the county is directly affected by flooding of the Mississippi River and consequential levee failures. Cropland production is decreased, transportation systems effected and the economy as a whole suffers. There is a lack of participation in hazard mitigation planning by property owners, businesses, and occupants of flood-prone areas, and outreach could be improved so they better understand they consequences of living in these areas. As well, transportation systems along highway 79 is highly susceptible to flooding due to levee failure, and are typically closed when an event occurs. Unfortunately, there is not an effective method in place to alert residents of specifically a flash flooding issue. Levee Districts are unable to keep the existing levees in good condition, and find it hard to keep up with the U.S. Corps of Engineers' regulations.

3.4.9 Thunderstorm/High Winds/Lightning/Hail

Hazard Profile

Hazard Description

Thunderstorms

A thunderstorm is defined as a storm that contains lightning and thunder which is caused by unstable atmospheric conditions. When cold upper air sinks and warm moist air rises, storm clouds or 'thunderheads' develop resulting in thunderstorms. This can occur singularly, as well as in clusters or lines. The National Weather Service defines a thunderstorm as "severe" if it includes hail that is one inch or more, or wind gusts that are at 58 miles per hour or higher. At any given moment across the world, there are about 1,800 thunderstorms occurring. Severe thunderstorms most often occur in Missouri in the spring and summer, during the afternoon and evenings, but can occur at any time. Other hazards associated with thunderstorms are heavy rains resulting in flooding.

High Winds

A severe thunderstorm can produce winds causing as much damage as a weak tornado. The damaging winds of thunderstorms include downbursts, microbursts, and straight-line winds. Downbursts are localized currents of air blasting down from a thunderstorm, which induce an outward burst of damaging wind on or near the ground. Microbursts are minimized downbursts covering an area of less than 2.5 miles across. They include a strong wind shear (a rapid change in the direction of wind over a short distance) near the surface. Microbursts may or may not include precipitation and can produce winds at speeds of more than 150 miles per hour. Damaging straight-line winds are high winds across a wide area that can reach speeds of 140 miles per hour.

Lightning

All thunderstorms produce lightning which can strike outside of the area where it is raining and is has been known to fall more than 10 miles away from the rainfall area. Thunder is simply the sound that lightning makes. Lightning is a huge discharge of electricity that shoots through the air causing vibrations and creating the sound of thunder.

Hail

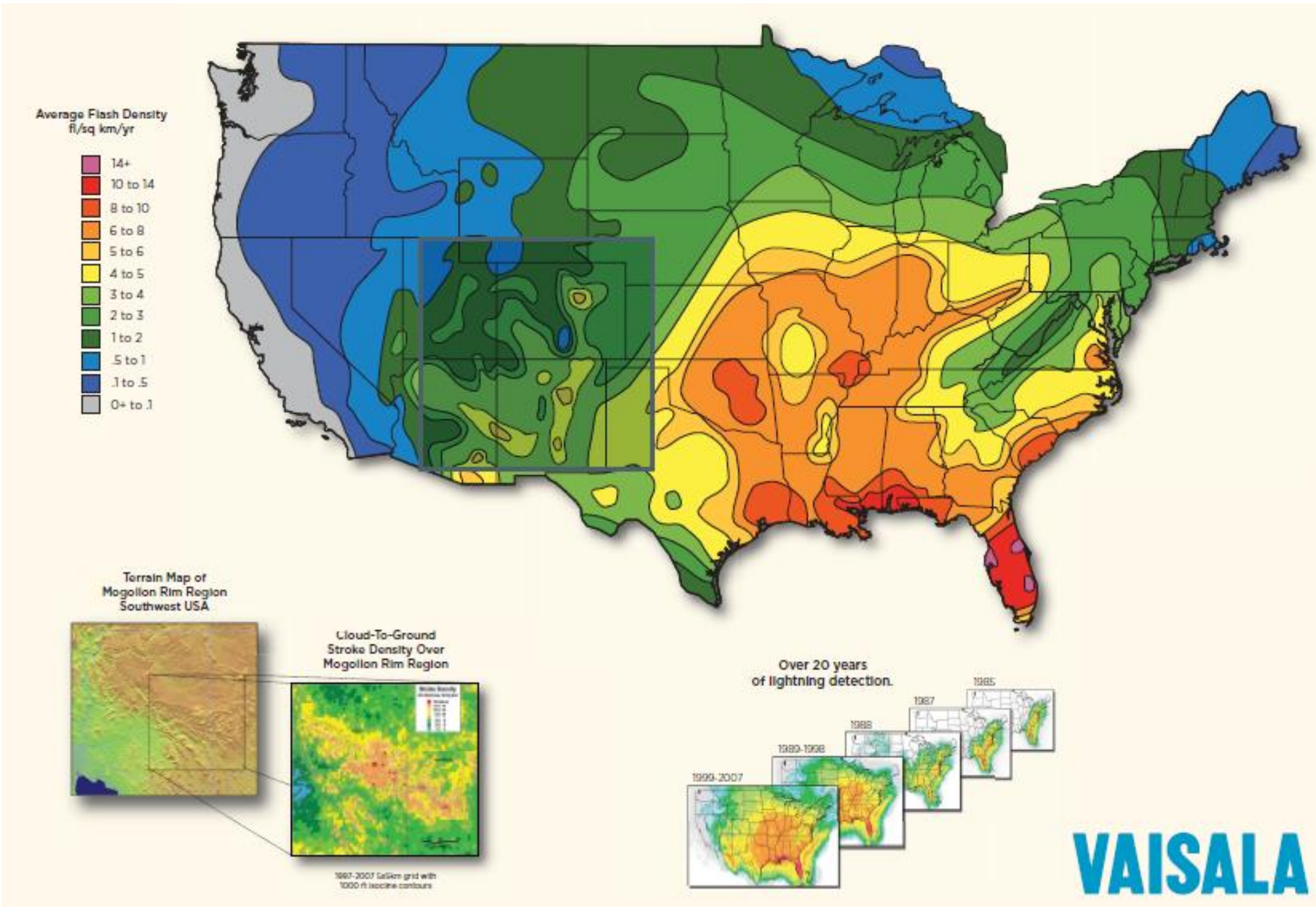
According to the National Oceanic and Atmospheric Administration (NOAA), hail is precipitation that is formed when thunderstorm updrafts carry raindrops upward into extremely cold atmosphere causing them to freeze. The raindrops form into small frozen droplets. They continue to grow as they come into contact with super-cooled water which will freeze on contact with the frozen rain droplet. This frozen droplet can continue to grow and form hail. As long as the updraft forces can support or suspend the weight of the hailstone, hail can continue to grow before it hits the earth.

At the time when the updraft can no longer support the hailstone, it will fall down to the earth. For example, a ¼" diameter or pea sized hail requires updrafts of 24 miles per hour, while a 2 ¾" diameter or baseball sized hail requires an updraft of 81 miles per hour. According to the NOAA, the largest hailstone in diameter recorded in the United States was found in Vivian, South Dakota on July 23, 2010. It was eight inches in diameter, almost the size of a soccer ball. Soccer-ball-sized hail is the exception, but even small pea-sized hail can do damage.

Geographic Location

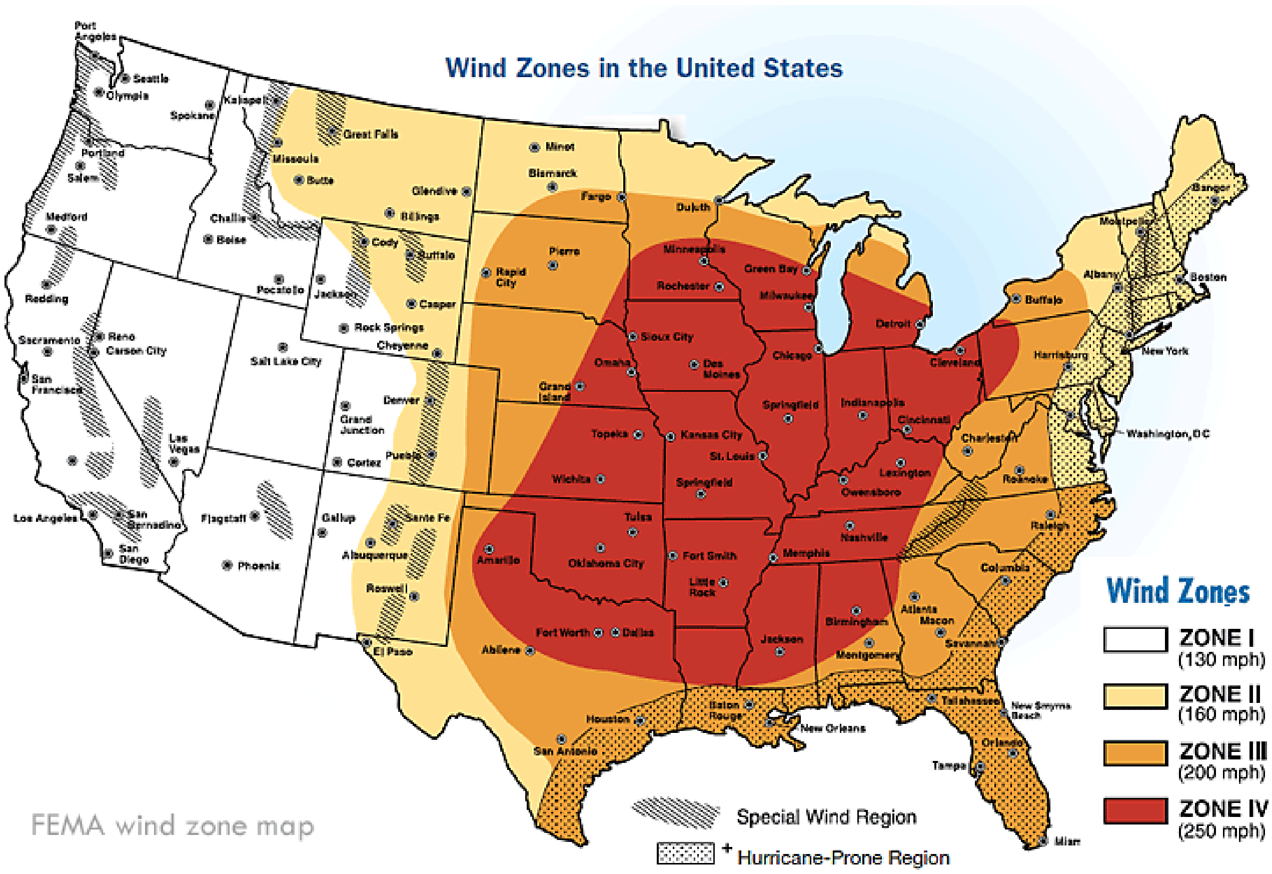
All of Pike County is susceptible to thunderstorms/high winds/hail and lighting events. Although these events occur similarly throughout the planning area, they are more frequently reported in more urbanized areas. In addition, damages are more likely to occur in more densely developed urban areas.

Figure 3.39. Location and Frequency of Lightning in Missouri



Source: National Weather Service, http://www.lightningsafety.noaa.gov/stats/08_Vaisala_NLDN_Poster.pdf. Note: indicate location of planning area with a colored square or arro

Figure 3.40. Wind Zones in the United States



Source: FEMA 320, Taking Shelter from the Storm, 3rd edition, http://www.weather.gov/media/bis/FEMA_SafeRoom.pdf

Severity/Magnitude/Extent

Severe thunderstorm losses are usually attributed to the associated hazards of hail, downburst winds, lightning and heavy rains. Losses due to hail and high wind are typically insured losses that are localized and do not result in presidential disaster declarations. However, in some cases, impacts are severe and widespread and assistance outside state capabilities is necessary. Hail and wind also can have devastating impacts on crops. Severe thunderstorms/heavy rains that lead to flooding are discussed in the flooding hazard profile. Hailstorms cause damage to property, crops, and the environment, and can injure and even kill livestock. In the United States, hail causes more than $1 billion in damage to property and crops each year. Even relatively small hail can shred plants to ribbons in a matter of minutes. Vehicles, roofs of buildings and homes, and landscaping are also commonly damaged by hail. Hail has been known to cause injury to humans, occasionally fatal injury.

In general, assets in the County vulnerable to thunderstorms with lightning, high winds, and hail include people, crops, vehicles, and built structures. Although this hazard results in high annual losses, private property insurance and crop insurance usually cover the majority of losses. Considering insurance coverage as a recovery capability, the overall impact on jurisdictions is reduced.

Most lightning damages occur to electronic equipment located inside buildings. But structural damage can also occur when a lightning strike causes a building fire. In addition, lightning strikes can cause damages to crops if fields or forested lands are set on fire. Communications equipment and warning transmitters and receivers can also be knocked out by lightning strikes. http://www.lightningsafety.noaa.gov/stats/08_Vaisala_NLDN_Poster.pdf and http://www.lightningsafety.noaa.gov/

Based on information provided by the Tornado and Storm Research Organization (TORRO), below describes typical damage impacts of the various sizes of hail.

Table 3.21. Tornado and Storm Research Organization Hailstorm Intensity Scale

Intensity Category	Diameter (mm)	Diameter (inches)	Size Description	Typical Damage Impacts
Hard Hail	5-9	0.2-0.4	Pea	No damage
Potentially Damaging	10-15	0.4-0.6	Mothball	Slight general damage to plants, crops
Significant	16-20	0.6-0.8	Marble, grape	Significant damage to fruit, crops, vegetation
Severe	21-30	0.8-1.2	Walnut	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored
Severe	31-40	1.2-1.6	Pigeon's egg > squash ball	Widespread glass damage, vehicle bodywork damage
Destructive	41-50	1.6-2.0	Golf ball > Pullet's egg	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries
Destructive	51-60	2.0-2.4	Hen's egg	Bodywork of grounded aircraft dented, brick walls pitted
Destructive	61-75	2.4-3.0	Tennis ball > cricket ball	Severe roof damage, risk of serious injuries
Destructive	76-90	3.0-3.5	Large orange > Soft ball	Severe damage to aircraft bodywork
Super Hailstorms	91-100	3.6-3.9	Grapefruit	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open
Super Hailstorms	>100	4.0+	Melon	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open

Source: Tornado and Storm Research Organization (TORRO), Department of Geography, Oxford Brookes University
Notes: In addition to hail diameter, factors including number and density of hailstones, hail fall speed and surface wind speeds affect severity. http://www.torro.org.uk/site/hscale.php

Straight-line winds are defined as any thunderstorm wind that is not associated with rotation (i.e., is not a tornado). It is these winds, which can exceed 100 miles per hour, which represent the most common type of severe weather. They are responsible for most wind damage related to thunderstorms. Since thunderstorms do not have narrow tracks like tornadoes, the associated wind damage can be extensive and affect entire (and multiple) counties. Objects like trees, barns, outbuildings, high-profile vehicles, and power lines/poles can be toppled or destroyed, and roofs, windows, and homes can be damaged as wind speeds increase.

The tables below (**Tables 3.22** through **Table 3.24**) summarize past crop damages as indicated by crop insurance claims. The tables illustrate the magnitude of the impact on the planning area's agricultural economy.

Table 3.22. Crop Insurance Claims Paid in Pike County from high Winds, 01/2005 – 12/2015

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2005	Corn	Wind/Excess Wind	$43,485
2006	Corn	Wind/Excess Wind	$5,470
2011	Corn	Wind/Excess Wind	$4,784
2014	Corn	Wind/Excess Wind	$6,440
		Total:	$60,179

Source: USDA Risk Management Agency, Insurance Claims, http://www.rma.usda.gov/data/cause.htm

Table 3.23. Crop Insurance Claims Paid in Pike County from Lightning, 01/2005 – 12/2015

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2006	Corn	Lightning	$4,478
2006	Corn	Lightning	$2,741
2009	Soybeans	Lightning	$6,364
2013	Soybeans	Lightning	$7,768
2014	Soybeans	Lightning	$2,140
2015	Corn	Lightning	$7,917
		Total:	$31,408

USDA Risk Management Agency, Insurance Claims, http://www.rma.usda.gov/data/cause.htm

Table 3.24. Crop Insurance Claims Paid in Pike County from Hail, 01/2005 – 12/2015

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2006	Soybeans	Hail	$973
2006	Soybeans	Hail	$4,621
2006	Corn	Hail	$2,426
2011	Wheat	Hail	$7,524
2011	Wheat	Hail	$650
2012	Corn	Hail	$1,617
2015	Wheat	Hail	$12,994
2015	Wheat	Hail	$25,363
		Total:	$56,168

USDA Risk Management Agency, Insurance Claims, http://www.rma.usda.gov/data/cause.htm

The onset of thunderstorms with lightning, high wind, and hail is generally rapid. Duration is less than six hours and warning time is generally six to twelve hours. Nationwide, lightning kills 75 to 100 people each year. Lightning strikes can also start structural and wildland fires, as well as damage electrical systems and equipment.

Previous Occurrences

Table 3.23 Reported Events and Damages in Pike County from Thunderstorms from 2005 to 2015, Events Summarized by Magnitude

Wind Magnitude	Number of Events	Property Damages	Crop Damages
50 -55	21	$20,000	$0
56- 60	10	$0	$0
61- 65	4	$0	$0
66- 70	3	$0	$0
71 – 75	0	$0	$0
76 +	0	$0	$0

August 8, 2006 - Thunderstorm winds blew the roof off of the concession stand at the Pike County Fairgrounds, as well as a portion of the roof of a barn.

December 27, 2008 - Thunderstorm winds blew the roof off of the concession stand at the Pike County Fairgrounds, as well as a portion of the roof of a barn.

June 27, 2011 – An intense bow echo moved through Pike County. Several large trees, numerous tree limbs and power lines were blown down in Bowling Green. Part of one fallen tree landed on an unoccupied vehicle and destroying it. No injuries were reported.

Table 3.24 Reported Events and Damages in Pike County from Hail from 2005 to 2015, Events Summarized by Magnitude

Hail Size (inches)	Number of Events	Property Damages	Crop Damages
.75	14	$0	$0
.88	6	$0	$0
1.00	8	$0	$0
1.25	3	$0	$0
1.50	0	$0	$0
1.75 +	10	$0	$0

April 19, 2011 – warm front was lifting northward through the region, triggering numerous showers and thunderstorms. Some of the storms produced tornadoes as well as a lot of large hail. There were 6 tornadoes with this event, including an EF3 in southern Pike County.

Table 3.25 Reported Events and Damages in Pike County from High Wind from 2005 to 2015, Events Summarized by Magnitude

Wind Magnitude	Number of Events	Property Damages	Crop Damages
50 -55	0	$0	$0
56- 60	1	$0	$0
61- 65	0	$0	$0
66- 70	0	$0	$0
71 – 75	0	$0	$0
76 +	0	$0	$0

Table 3.26 Reported Events and Damages in Pike County from Lightning from 2005 to 2015,

Events Summarized by Magnitude

There were no lightning events within the planning area from 2005 – 2015.

Probability of Future Occurrence

Thunderstorms

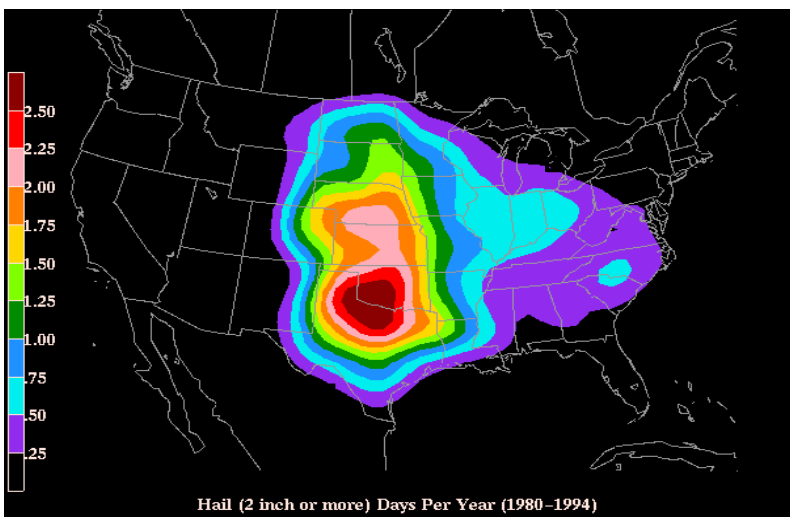
Thunderstorm wind events 50 knots and greater have a probability of occurring 3.8 times per year in the planning area in any given year. These rates occurrence are expected to continue in the future.

Hail

Based on this data, there have been 41 events in a 10-year period, producing an average of 4.1 hail events each year in Pike County. When limiting probability analysis to hail events producing hail 1.50 inches and larger, there have been 10 events in a 10-year period. Based on history, the probability of a destructive hail event in any given year is 100 percent. Thus making the probability as likely in any given year.

Figure 3.14 is based on hailstorm data from 1980 -1994. The figure shows the probability of hailstorm occurrence (2" diameter or larger) based on number of days per year. Pike County is located in the region to receive between .75 and 1 hailstorms annually.

Figure 3.41. Annual Hailstorm Probability (2" diameter or larger), U 1980- 1994



Source: NSSL, http://www.nssl.noaa.gov/users/brooks/public_html/bighail.gif Note:

Vulnerability

Vulnerability Overview

In general, assets in the planning area that are vulnerable to hail (.75 inches in diameter or larger), thunderstorm and lightning damages include people, crops, vehicles and built structures. According to the 2013 Missouri State Plan the Pike County annualized hail damages are $3,087.75, thunderstorm damages are $14,805.00 and $666.67 in lightning damages.

Potential Losses to Existing Development
Thunderstorms and Lightning

Most damages occur to electronic equipment located inside buildings, but structural damage can also occur when a lightning strike causes a building fire. Communications equipment and warning transmitters and receivers can also be knocked out by lightning strikes. There has not been any fatalities or injuries due to lightning in Pike County during the 10-year period reviewed. No property or crop damage was reported during the 10-year reporting period. When the review period was extended to 19 years there was 1 reported lightning events will individuals injured.

Hail

No property or crop damage was reported during the 10-year reporting period. This amount does not take in account most buildings and structures that are privately insured thus insurance would help the building owner recover from hail damage.

High Winds

During the 10-year period reviewed there was no damage contributed to high winds. When the review period is extended to the last 65 years there is 6 events that occurred in Pike County.

Previous and Future Development

Pike County's current trend in increased development will likely increase vulnerability to thunderstorms, high winds, hail and lightning. With more development of housing neighborhoods and businesses, the increased population will be vulnerable to all of the hazards.

Hazard Summary by Jurisdiction

Thunderstorms/high winds/ lightning/hail events are area-wide, NCDC data did not seem to indicate that any particular community had higher losses as compared to another.

Problem Statement

Thunderstorms can damage power lines with the high winds or fallen debris such as tree limbs. Not everyone in the county utilizes social media, texting or have access to a weather radio, smaller communities do not have warning sirens, rural areas do not have warning sirens.

Possible solutions could be the installation of warning sirens in smaller communities, rural citizens are educated on how to utilize social media and texting, warning sirens are installed in campgrounds and weather radios are accessed by residents more than what is currently being used.

3.4.10 Tornado

Hazard Profile

Hazard Description

The NWS defines a tornado as "a violently rotating column of air extending from a thunderstorm to the ground." It is usually spawned by a thunderstorm and produced when cool air overrides a layer of warm air, forcing the warm air to rise rapidly. Often, vortices remain suspended in the atmosphere as funnel clouds. When the lower tip of a vortex touches the ground, it becomes a tornado.

High winds not associated with tornadoes are profiled separately in this document in **Section 3.4.9,** Thunderstorm/High Wind/Hail/Lightning.

Essentially, tornadoes are a vortex storm with two components of winds. The first is the rotational winds that can measure up to 500 miles per hour, and the second is an uplifting current of great strength. The dynamic strength of both these currents can cause vacuums that can overpressure structures from the inside.

Although tornadoes have been documented in all 50 states, most of them occur in the central United States due to its unique geography and presence of the jet stream. The jet stream is a high-velocity stream of air that separates the cold air of the north from the warm air of the south. During the winter, the jet stream flows west to east from Texas to the Carolina coast. As the sun moves north, so does the jet stream, which at summer solstice flows from Canada across Lake Superior to Maine. During its move, northward in the spring and its recession south during the fall, the jet stream crosses Missouri, causing the large thunderstorms that breed tornadoes.

A typical tornado can be described as a funnel-shaped cloud in contact with the earth's surface that is "anchored" to a cloud, usually a cumulonimbus. This contact on average lasts 30 minutes and covers an average distance of 15 miles. The width of the tornado (and its path of destruction) is usually about 300 yards. However, tornadoes can stay on the ground for upward of 300 miles and can be up to a mile wide. The National Weather Service, in reviewing tornadoes occurring in Missouri between 1950 and 1996, calculated the mean path length at 2.27 miles and the mean path area at 0.14 square mile.

The average forward speed of a tornado is 30 miles per hour but may vary from nearly stationary to 70 miles per hour. The average tornado moves from southwest to northeast, but tornadoes have been known to move in any direction. Tornadoes are most likely to occur in the afternoon and evening, but have been known to occur at all hours of the day and night.

Geographic Location

Tornados can occur in the entire planning area and no area is immune from suffering from a tornado.

Severity/Magnitude/Extent

Tornadoes are the most violent of all atmospheric storms and are capable of tremendous destruction. Wind speeds can exceed 250 miles per hour and damage paths can be more than one mile wide and 50 miles long. Tornadoes have been known to lift and move objects weighing more than 300 tons a distance of 30 feet, toss homes more than 300 feet from their foundations, and siphon millions of tons of water from water bodies. Tornadoes also can generate a tremendous amount of flying debris or "missiles," which often become airborne shrapnel that causes additional damage. If wind speeds are high enough, missiles can be thrown at a building with enough force to penetrate windows, roofs, and walls. However, the less spectacular damage is much more common.

Tornado magnitude is classified according to the EF- Scale (or the Enhance Fujita Scale, based on the original Fujita Scale developed by Dr. Theodore Fujita, a renowned severe storm researcher). The EF-Scale (see Table 3.23) attempts to rank tornadoes according to wind speed based on the damage caused. This update to the original F Scale was implemented in the U.S. on February 1, 2007.

Table 3.25. Enhanced F Scale for Tornado Damage

FUJITA SCALE			DERIVED EF SCALE		OPERATIONAL EF SCALE	
F Number	Fastest ¼-mile (mph)	3 Second Gust (mph)	EF Nu	3 Second Gust (mph)	EF Number	3 Second Gust (mph)
0	40-72	45-78	0	65-85	0	65-85
1	73-112	79-117	1	86-109	1	86-110
2	113-157	118-161	2	110-137	2	111-135
3	158-207	162-209	3	138-167	3	136-165
4	208-260	210-261	4	168-199	4	166-200
5	261-318	262-317	5	200-234	5	Over 200

Source: The National Weather Service, www.spc.noaa.gov/faq/tornado/ef-scale.html

The wind speeds for the EF scale and damage descriptions are based on information on the NOAA Storm Prediction Center as listed in **Table 3.26**. The damage descriptions are summaries. For the actual EF scale it is necessary to look up the damage indicator (type of structure damaged) and refer to the degrees of damage associated with that indicator. Information on the Enhanced Fujita Scale's damage indicators and degrees or damage is located online at www.spc.noaa.gov/efscale/ef-scale.html.

Table 3.26. Enhanced Fujita Scale with Potential Damage

Enhanced Fujita Scale			
Scale	Wind Speed (mph)	Relative Frequency	Potential Damage
EF0	65-85	53.5%	Light. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Confirmed tornadoes with no reported damage (i.e. those that remain in open fields) are always rated EF0).
EF1	86-110	31.6%	Moderate. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111-135	10.7%	Considerable. Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes complete destroyed; large trees snapped or uprooted; light object missiles generated; cars lifted off ground.
EF3	136-165	3.4%	Severe. Entire stores of well-constructed houses destroyed; severe 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	0.7%	Devastating. Well-constructed houses and whole frame houses completely levelled; cars thrown and small missiles generated.
EF5	>200	<0.1%	Explosive. Strong frame houses levelled off foundations and swept away; automobile-sized missiles fly through the air in excess of 300 ft.; steel reinforced concrete structure badly damaged; high rise buildings have significant structural deformation; incredible phenomena will occur.

Source: NOAA Storm Prediction Center, http://www.spc.noaa.gov/efscale/ef-scale.html

Enhanced weather forecasting has provided the ability to predict severe weather likely to produce tornadoes days in advance. Tornado watches can be delivered to those in the path of these storms several hours in advance. Lead time for actual tornado warnings is about 30 minutes. Tornadoes have been known to change paths very rapidly, thus limiting the time in which to take shelter. Tornadoes may not be visible on the ground if they occur after sundown or due to blowing dust or driving rain and hail.

Previous Occurrences

There are limitations to the use of NCDC tornado data that must be noted. For example, one tornado may contain multiple segments as it moves geographically. A tornado that crosses a county line or state line is considered a separate segment for the purposes of reporting to the NCDC. Also, a tornado that lifts off the ground for less than 5 minutes or 2.5 miles is considered a separate segment. If the tornado lifts off the ground for greater than 5 minutes or 2.5 miles, it is considered a separate tornado. Tornadoes reported in Storm Data and the Storm Events Database are in segments.

Table 3.27. Recorded Tornadoes in Pike County, 1993 – Present

Date	Beginning Location	Ending Location	Length (miles)	Width (yards)	F/EF Rating	Death	Injury	Property Damage	Crop Damages
5/25/1996	BOWLING	BOWLING	3	50	F0	0	0	0	0
6/14/1998	CURRYVILLE	CURRYVILLE	0.2	50	F0	0	0	0	0
2/11/1999	ANNADA	ANNADA	6.4	100	F2	0	0	$200,000	0
4/8/1999	LOUISIANA	LOUISIANA	0.5	75	F0	0	0	0	0
2/29/2000	CURRYVILLE	CURRYVILLE	10	50	F0	0	0	0	0
3/12/2006	NEW	NEW	1	50	F0	0	0	0	0
3/12/2006	NEW	ASHLEY	5	125	F1	0	0	0	0
3/13/2006	ANNADA	ANNADA	8	100	F0	0	0	0	0
6/22/2006	ASHLEY	ASHLEY	0.3	50	F0	0	0	0	0
1/7/2008	STARK	CLARKSVILLE	4.98	40	EF0	0	0	0	0
2/27/2011	READING	READING	2.28	40	EF0	0	0	0	0
2/27/2011	FRANKFORD	FRANKFORD	1.41	40	EF0	0	0	0	0
4/15/2011	VERA	VERA	3.01	50	EF1	0	0	0	0
4/19/2011	FARMER	BOOTH	4.12	150	EF1	0	0	0	0
4/19/2011	CLARKSVILLE	CLARKSVILLE	0.4	50	EF0	0	0	0	0
6/28/2015	EDGEWOOD	EOLIA	2.48	50	EF1	0	0	0	0
6/28/2015	EOLIA	EOLIA	0.65	40	EF0	0	0	0	0

Source: National Climatic Data Center, http://www.ncdc.noaa.gov/stormevents/

Figure 3.42. Pike County Map of Historic Tornado Events

Source: Missouri Tornado History Project, http://www.tornadohistoryproject.com/tornado/Missouri

During the previous 10 years of data from the USDA Risk Management Agency Pike County has not received any insurance payments for crop damages as a result of tornadoes.

Probability of Future Occurrence

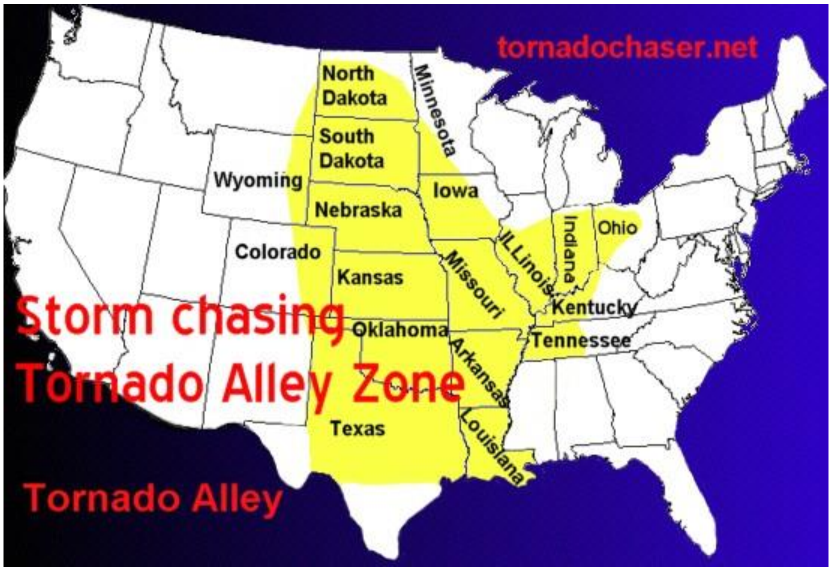
The National Climatic Data Center reported 22 tornadoes in Pike County in a 65-year time period, which calculates to a 34 percent chance of a tornado in any given year. Therefore it is a low probability that some portion of Pike County will experience tornado activity in any given year.

Vulnerability

Vulnerability Overview

Pike County is in a region of the U.S. with high frequency of dangerous and destructive tornadoes referred to as "Tornado Alley". **Figure 3.43** is based on areas where dangerous tornadoes are more likely to occur.

Figure 3.43. Tornado Alley in the U.S.



Source: http://www.tornadochaser.net/tornalley.html

According to the 2013 Missouri Hazard Mitigation Plan, there was 9 reported tornadoes for the same time period as stated in the plan this is due to tornadoes being combined. The likelihood of occurrence is decreased by 2% making a total vulnerability rating of moderate. This vulnerability analysis measured the likelihood of future tornado impacts based on past occurrences value divided by the number of years reviewed to factor out a rating.

Potential Losses to Existing Development

In Pike County, the NCDC estimate for past damages from 1950 to 2015 is $477,530 and the annualized property damage is $7,346 over the 65 years.

To estimate vulnerability to tornadoes, the MPC decided to consider the impacts of an F0 tornado due to this being the most common in the period reviewed tornado with wind speed of approximately 65-85 mph and a length of 3.16 miles and width of 65.29 yards in Pike County. The location chosen is based on medium housing and commercial structure density to show the variance of potential damages. Based on information from the NOAA Storm Prediction Center, a F0/EF0 tornado of this magnitude would create some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged. Several factors impact the severity of damage, including wind speed, time on the ground, length/width of the cell, population density, building density, age and construction of buildings and time of day.

Scenario: Bowling Green . The F0/EF0 tornado starts in a rural area of Pike County approximately 1 mile from the city limits of Bowling Green. The tornado moves in a northeast direction hitting rural properties, Bowling Green schools and moves northeast toward the downtown business district. The City of Bowling Green would have small trees pushed over, broken branches and small amounts of damage to buildings and signs.

City of Bowling Green, Missouri
F0/EF0 Tornado Scenario.

Previous and Future Development

Due to the decrease in population in Pike County, vulnerability to tornadoes is anticipated to remain the same. Future development for public buildings such as schools, government offices, as well as buildings with high occupancy and campgrounds should consider including a tornado saferoom to protect occupants in the event of a tornado.

Hazard Summary by Jurisdiction

Tornadoes can occur in the entire planning area however due to the age of housing, age of commercial structures and a high concentration of mobile homes throughout the county some of the jurisdictions would suffer heavier damages.

Problem Statement

Pike County has inadequate tornado shelters throughout the county, not everyone utilizes social media and/or texting, the rural areas do not have warning sirens, smaller communities do not have warning sirens, lack of awareness for available shelters and more education needs to occur.

Possible solutions could be awareness made of existing tornado shelters, education on what to do in the event of a tornado and smaller communities could install warning sirens. A strong emphasis could be made for everyone in the county to own a weather radio.

3.4.11 Winter Weather/Snow/Ice/Severe Cold

<u>Hazard Profile</u>

Hazard Description

A major winter storm can last for several days and be accompanied by high winds, freezing rain or sleet, heavy snowfall, and cold temperatures. The National Weather Service describes different types of winter storm events as follows.

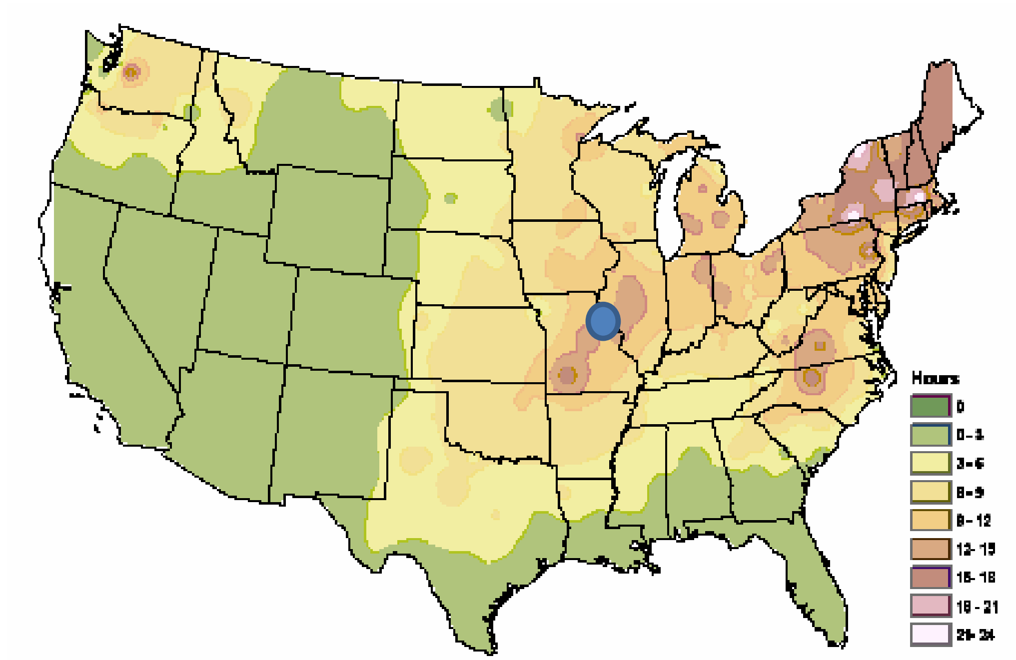
- **Blizzard—**Winds of 35 miles per hour or more with snow and blowing snow reducing visibility to less than ¼ mile for at least three hours.
- **Blowing Snow—**Wind-driven snow that reduces visibility. Blowing snow may be falling snow and/or snow on the ground picked up by the wind.
- **Snow Squalls—**Brief, intense snow showers accompanied by strong, gusty winds. Accumulation may be significant.
- **Snow Showers—**Snow falling at varying intensities for brief periods of time. Some accumulation is possible.
- **Freezing Rain—**Measurable rain that falls onto a surface with a temperature below freezing. This causes it to freeze to surfaces, such as trees, cars, and roads, forming a coating or glaze of ice. Most freezing-rain events are short lived and occur near sunrise between the months of December and March.
- **Sleet—**Rain drops that freeze into ice pellets before reaching the ground. Sleet usually bounces when hitting a surface and does not stick to objects.

Geographic Location

The entire Pike County is vulnerable to heavy snow, extreme temperatures and freezing rain. The snow season normally extends from late November through mid-March but significant snows have fallen as early as November 24, 2004 to as late as April 10, 1997.

Figure 3.17 shows the entire planning area (approximated within the blue circle) is in the orange-shaded area that receives 9-12 hours of freezing rain a year.

Figure 3.44. NWS Statewide Average Number of Hours per Year with Freezing Rain



Source: American Meteorological Society. "Freezing Rain Events in the United States." http://ams.confex.com/ams/pdfpapers/71872.pdf

Severity/Magnitude/Extent

Severe winter storms include extreme cold, heavy snowfall, ice, and strong winds which can push the wind chill well below zero degrees in the planning area. Heavy snow can bring a community to a standstill by inhibiting transportation (in whiteout conditions), weighing down utility lines, and by causing structural collapse in buildings not designed to withstand the weight of the snow. Repair and snow removal costs can be significant. Ice buildup can collapse utility lines and communication towers, as well as make transportation difficult and hazardous. Ice can also become a problem on roadways if the air temperature is high enough that precipitation falls as freezing rain rather than snow.

Extreme cold often accompanies severe winter storms and can lead to hypothermia and frostbite in people without adequate clothing protection. Cold can cause fuel to congeal in storage tanks and supply lines, stopping electric generators. Cold temperatures can also overpower a building's heating system and cause water and sewer pipes to freeze and rupture. Extreme cold also increases the likelihood for ice jams on flat rivers or streams. When combined with high winds from winter storms, extreme cold becomes extreme wind chill, which is hazardous to health and safety.

The National Institute on Aging estimates that more than 2.5 million Americans are elderly and especially vulnerable to hypothermia, with the isolated elders being most at risk. About 10 percent of people over the age of 65 have some kind of bodily temperature-regulating defect, and 3-4 percent of all hospital patients over 65 are hypothermic.

Also at risk are those without shelter, those who are stranded, or who live in a home that is poorly insulated or without heat. Other impacts of extreme cold include asphyxiation (unconsciousness or death from a lack of oxygen) from toxic fumes from emergency heaters; household fires, which can be caused by fireplaces and emergency heaters; and frozen/burst pipes.

Buildings with overhanging tree limbs are more vulnerable to damage during winter storms when limbs fall. Businesses experience loss of income as a result of closure during power outages. In general heavy winter storms increase wear and tear on roadways though the cost of such damages is difficult to determine. Businesses can experience loss of income as a result of closure during winter storms.

Overhead power lines and infrastructure are also vulnerable to damages from winter storms. In particular ice accumulation during winter storm events damage to power lines due to the ice weight on the lines and equipment. Damages also occur to lines and equipment from falling trees and tree limbs weighted down by ice. Potential losses could include cost of repair or replacement of damaged facilities, and lost economic opportunities for businesses.

Secondary effects from loss of power could include burst water pipes in homes without electricity during winter storms. Public safety hazards include risk of electrocution from downed power lines. Specific amounts of estimated losses are not available due to the complexity and multiple variables associated with this hazard. Standard values for loss of service for utilities reported in FEMA's 2009 BCA Reference Guide, the economic impact as a result of loss of power is $126 per person per day of lost service.

Wind can greatly amplify the impact of cold ambient air temperatures. Provided by the National Weather Service**, Figure 3.45** below shows the relationship of wind speed to apparent temperature and typical time periods for the onset of frostbite.

Figure 3.45. Wind Chill Chart

Temperature (°F)

Wind (mph) \ 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

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

Source: National Weather Service, http://www.nws.noaa.gov/om/winter/windchill.shtml

Winter storms, cold, frost and freeze take a toll on crop production in the planning area. According to the USDA's Risk Management Agency, payments for insured crop losses in the planning area as a result of winter storm and cold conditions from 2005 to 2015 totaled $

Table 3.28. Crop Insurance Claims Paid in Pike County as a Result of Cold Conditions and Snow 2005 - 2015

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2005	Wheat	Cold Winter	$1,734
2005	Wheat	Cold Winter	$42
2005	Wheat	Cold Winter	$1,383
2005	Corn	Cold Winter	$313
2005	Corn	Cold Wet Weather	$631
2005	Corn	Cold Wet Weather	$326
2005	Corn	Cold Wet Weather	$2,618
2005	Corn	Cold Wet Weather	$6,453
2006	Corn	Cold Wet Weather	$640
2006	Soybeans	Cold Wet Weather	$3,295
2006	Soybeans	Cold Wet Weather	$1,749
2007	Wheat	Freeze	$1,519
2007	Wheat	Freeze	$1,511
2007	Wheat	Freeze	$3,077
2007	Wheat	Freeze	$8,986
2007	Wheat	Cold Winter	$4,674
2007	Wheat	Cold Wet Weather	$4,223

2008	Wheat	Cold Winter	$4,043
2008	Wheat	Cold Wet Weather	$5,119
2008	Wheat	Cold Wet Weather	$4,624
2008	Corn	Cold Wet Weather	$15,814
2008	Corn	Cold Wet Weather	$35,315
2008	Soybeans	Cold Wet Weather	$8,633
2009	Wheat	Cold Winter	$7,980
2009	Wheat	Cold Winter	$1,612
2009	Wheat	Cold Wet Weather	$8,230
2009	Wheat	Cold Wet Weather	$255,176
2009	Wheat	Cold Wet Weather	$18,291
2009	Wheat	Cold Wet Weather	$29,176
2009	Wheat	Cold Wet Weather	$43,195
2009	Wheat	Cold Wet Weather	$2,842
2009	Corn	Cold Wet Weather	$1,632
2009	Corn	Cold Wet Weather	$614
2009	Corn	Cold Wet Weather	$5,237
2009	Soybeans	Cold Wet Weather	$1,609
2009	Soybeans	Cold Wet Weather	$2,933
2010	Wheat	Cold Winter	$1,132
2010	Wheat	Cold Winter	$13,372
2010	Wheat	Cold Wet Weather	$5,576
2010	Wheat	Cold Wet Weather	$390
2010	Wheat	Cold Wet Weather	$10,749
2010	Wheat	Cold Wet Weather	$39,443
2010	Wheat	Cold Wet Weather	$10,438
2010	Corn	Cold Wet Weather	$3,686
2010	Corn	Cold Wet Weather	$4,234
2010	Soybeans	Cold Wet Weather	$1,661
2011	Wheat	Cold Winter	$248
2011	Wheat	Cold Winter	$15,745
2011	Wheat	Cold Wet Weather	$3,053
2011	Corn	Cold Wet Weather	$2,186
2011	Corn	Cold Wet Weather	$802
2011	Corn	Cold Wet Weather	$9,335
2011	Soybeans	Cold Wet Weather	$6,958
2012	Corn	Cold Wet Weather	$20,675
2012	Corn	Cold Wet Weather	$20,243
2013	Wheat	Cold Wet Weather	$6,996
2013	Wheat	Cold Wet Weather	$8,933
2013	Soybeans	Cold Wet Weather	$1,035
2014	Wheat	Freeze	$12,436
2014	Wheat	Cold Winter	$3,310
2014	Wheat	Cold Winter	$15,044
2014	Wheat	Cold Winter	$19,832
2014	Wheat	Cold Wet Weather	$974
2014	Wheat	Cold Wet Weather	$28,044
2014	Wheat	Cold Wet Weather	$249
2014	Corn	Cold Wet Weather	$3,601

2014	Soybeans	Cold Wet Weather	$4,830
2014	Soybeans	Cold Wet Weather	$4,879
2015	Wheat	Cold Wet Weather	$4,011
2015	Corn	Cold Wet Weather	$750
2015	Soybeans	Cold Wet Weather	$7,111
2015	Soybeans	Cold Wet Weather	$8,860
		Total:	**$794,336**

Source: USDA Risk Management Agency, http://www.rma.usda.gov/data/cause.htm

Previous Occurrences

Table 3.29. NCDC Pike County Winter Weather Events Summary, 2005-2015

Type of Event	Inclusive Dates	# of Injuries	Property Damages	Crop Damages
Blizzard	02/01/2011	0	0	0
Cold/wind Chill	01/01/2010	0	0	0
Cold/wind Chill	01/06/2014	0	0	0
Heavy Snow	02/13/2007	0	0	0
Heavy Snow	12/15/2007	0	0	0
Heavy Snow	03/24/2013	0	0	0
Heavy Snow	02/15/2015	0	0	0
Heavy Snow	02/20/2015	0	0	0
Ice Storm	01/12/2007	0	0	0
Ice Storm	12/08/2007	0	0	0
Winter Storm	12/8/2005	0	$0	$0
Winter Storm	11/29/2006	0	$0	$0
Winter Storm	12/1/2006	0	$0	$0
Winter Storm	1/31/2011	0	$0	$0
Winter Storm	2/1/2011	0	$0	$0
Winter Storm	2/21/2013	0	$0	$0
Winter Storm	12/21/2013	0	$0	$0
Winter Storm	1/5/2014	0	$0	$0
Winter Storm	2/4/2014	0	$0	$0

Source: NCDC, data accessed January 15, 2017.

February 1 & 2, 2011- The first true blizzard in many years hit from Central to Northeast Missouri. Up to 20 inches of snow fell along with winds gusting over 40 mph. For many counties it was a record snowfall event. The National Guard was called out to help clear County roads and assist with emergency transportation. The region was brought to a standstill for several days. A Federal disaster declaration was obtained for many counties in order to assist with the cost of snow removal. Light freezing rain and sleet started to fall on Monday 1/31 with an inch of sleet accumulating by the early morning hours of Tuesday (2/1). By midday Tuesday (2/1) the precipitation had changed to snow and the wind started to increase. I-70 was shut down from Warren County to just east of Kansas City about 8 pm that evening. The snow tapered off to flurries by Wednesday (2/2) morning. The strong wind continued through the day producing very cold wind chill values.

January 1-12, 2010- The first twelve days of January 2010 was one of the coldest outbreaks in many years. For some locations, it was the first time the temperature dropped below zero in about 10 years. For St. Louis, MO, January 1 - 12 was the 7th coldest on record for that time period. Some of the coldest temperatures observed include Rosebud, MO: -16, Freedom, MO; -12, Lake St. Louis, MO: -11, Washington, MO; -10, Fulton, MO; -9, Fredericktown, MO; -9, Hannibal, MO; -7, St. Charles, MO; -6, and University City, MO; -1.

February 13, 2007 - An area of low pressure developed over the Texas Panhandle on February 12th and tracked east across Oklahoma and Arkansas on February 13th. Ahead of the storm system, a strong southerly flow produced widespread rain across the St. Louis NWS warning area. As the storm passed to the south and east of the region the rain transitioned to snow. Snowfall ranged from only a trace across the far southern Missouri counties to as much as 10 inches across West Central Illinois. Amounts from Central into Northeast Missouri ranged from 6 to 9 inches.

January 12 & 13, 2007 - An arctic boundary settled south of the area on the 12th and 13th of January bringing subfreezing temperatures to the northwestern half of the county warning area. Three rounds of precipitation occurred during this period, with the first being the most destructive of all. Significant tree and limb damage was reported because of this storm, together with widespread power outages. More than 100,000 homes and businesses lost power during this storm. About 1.5 inches of sleet fell and a 1/2 inch of ice accumulation hit parts of Central and Northeast Missouri. From 1/4 to 1/2 inch of ice accumulated from freezing rain across Eastern Missouri and parts of Southwest Illinois. Flooding of low lying areas and low water crossings occurred across the eastern Ozarks late Friday night and Saturday morning. One fatality occurred in St. François County when a man attempted to cross a flooded roadway. The damage figures listed for the various counties are for public assistance only.

February 4, 2014 - An early February winter storm dropped from 6 to 13 inches of snow across Central and Northeast Missouri. Travel was very difficult and most schools in rural areas were closed the rest of the week.

Probability of Future Occurrence

According to NCDC, during the 10 – year period from January 2005 to December 2015, the planning area experienced ten winter storm/blizzard events, two ice storm events, two cold/wind chill events and five heavy snow events. This translates to an annual probability of approximately 1.9 per year a winter weather event will occur.

Vulnerability

Vulnerability Overview

The entire planning area is vulnerable to the effects of winter storm/blizzard, ice storms, winter weather, cold/wind chill and heavy snow. All effects of winters tend to make driving more treacherous and can impact the response of emergency vehicles. The probability of utility and infrastructure failure increases during winter weather due to the freezing rain accumulation on utility poles and power lines. Elderly populations are considered particularly vulnerable to the impact of winter weather.

The method used to determine vulnerability to severe winter weather across the planning area was statistical analysis of data from several sources: National Climatic Data Center (NCDC), storm events (1995 to 2015 and Crop Insurance Claims data from USDA's Risk Management Agency (2005 to 2015).

Potential Losses to Existing Development

Pike County including the jurisdictions of Clarksville, Bowling Green, Louisiana have a very old downtown district that is comprised of buildings that suffer from harsh winter weather. The loss of income is experienced by existing businesses due to power outages. In general heavy winter storms increase wear and tear on roadways through the cost of such damages is difficult to determine.

Previous and Future Development

Future development could potentially increase vulnerability to this hazard by increasing demand on the utilities and increasing the exposure of infrastructure networks.

Hazard Summary by Jurisdiction

Although crop loss because of severe winter storm occurs more in the unincorporated portions of the planning area, the density of vulnerable populations is higher in the urban areas of the planning areas. So, it is considered that the magnitude of this hazard is relatively equal. The factors of probability, warning time, and duration are also equal across the planning area. Therefore, the conclusion is the hazard does not substantially vary by jurisdiction. Located in the planning area is a large number of campgrounds that can become isolated during winter weather storms.

Problem Statement

Pike County does not have adequate shelters for residents in the event of a winter storm that is easily accessible with roads that can become hazardous for motorists and emergency responders, power lines can break from ice accumulation and not everyone utilizes social media or texting.

Education needs to occur to ensure all residents are aware of the shelters in the County, residents are educated on emergency supplies to have and the utilization of social media and texting increases.