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.

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 Land Use and Development** discusses development that has occurred since the last plan update and any increased or decreased risk that resulted. This section also discusses areas of planned future development and any implications on risk/vulnerability;
- **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 Strength/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 hazards 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 in 2016 and Marion County, Hannibal, and Palmyra School District participated in the multi-jurisdictional county wideplan. The 2016 Hazard Mitigation Plan was consulted in development of the risk assessment and information included and updated where appropriate.

The MPC decided to include only natural hazards, as only natural hazards are required by federal regulation 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

Disaster 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 3.1. FEMA Disaster Declarations that included Marion County, Missouri, 1965-Present

Disaster Number	Description	Declaration Date Incident Period	Individual Assistance (IA) Public Assistance (PA)
198	Flooding	June 14, 1965	Public Assistance, Individual Assistance
372	Heavy Rains, Tornadoes, Flooding	April 19, 1973	Public Assistance, Individual Assistance
989	Severe Storms, Flooding	May 11, 1993 April 15 to May 29, 1993	Individual Assistance
995	Severe Storms, Flooding	July 9, 1993 June 10 to October 25, 1993	Public Assistance, Individual Assistance

1403	Severe Winter Ice Storm	February 6, 2002 January 29 to February 13, 2002	Public Assistance, Individual Assistance
1412	Severe Storms, Tornadoes, Flooding	May 6, 2002 April 24 to June 10, 2002	Public Assistance
1463	Severe Storms, Tornadoes, Flooding	May 6, 2003 May 4 to May 30, 2003	Public Assistance, Individual Assistance
1673	Severe Winter Storms	December 29, 2006 November 30 to December 2, 2006	Public Assistance
1773	Severe Storms, Flooding	June 25, 2008 June 1 to August 13, 2008	Public Assistance, Individual Assistance
1809	Severe Storms, Flooding, Tornado	November 13, 2008 September 11 to September 24, 2008	Public Assistance
1847	Severe Storms, Tornadoes, Flooding	June 19, 2009 May 8 to May 16, 2009	Public Assistance
1934	Severe Storms, Flooding, Tornadoes	August 17, 2010 June 12 to July 31, 2010	Public Assistance
1961	Severe Winter Storm, Snow Storm	March 23, 2011 January 31 to February 5, 2011	Public Assistance
3017	Drought	September 24, 1976	Public Assistance
3232	Hurricane Katrina Evacuation	September 10, 2005 August 29 to October 1, 2005	Public Assistance
3281	Severe Winter Storms	December 12, 2007 December 8 to December 15, 2007	Public Assistance
3303	Severe Winter Storm	January 30, 2009 January 26 to January 28, 2009	Public Assistance
3317	Severe Winter Storm	February 3, 2011 January 31 to February 5, 2011	Public Assistance
3374	Severe Storms, Tornadoes, Straight-Line Winds, Flooding	January 2, 2016 December 22, 2015 to January 9, 2016	Public Assistance
3482	COVID-19	March 13, 2020 January 20, 2020 to Present	Public Assistance
4130	Severe Storms, Tornadoes, Straight-Line Winds, Flooding	July 18, 2013 May 29 to June 10, 2013	Public Assistance
4238	Severe Storms, Tornadoes, Straight-Line Winds, Flooding	August 7, 2015 May 15 to July 27, 2015	Public Assistance
4451	Severe Storms, Tornadoes, Flooding	July 9, 2019 April 29 to July 5, 2019	Public Assistance
4490	COVID-19	March 26, 2020 January 20, 2020 to Present	Public Assistance

Source: FEMA, https://www.fema.gov/data-visualization-summary-disaster-declarations-and-grants

3.1.3 Research Additional Sources

The list below is additional sources of data on locations and past impacts of hazards in the planning area:

- Missouri Hazard Mitigation Plans (2010, 2013, and 2018)
- Previously approved planning area Hazard Mitigation Plan (2016)
- Federal Emergency Management Agency (FEMA)
- Missouri Department of Natural Resources

- 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 Centers for Environmental Information (NCEI);
- 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 (citations to the sources are provided in the body of the plan)

Note that the only centralized source of data for many of the weather-related hazards is the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI). Although it is usually the best and most current source, there are limitations to the data which should be noted. The NCEI 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 NCEI 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 NCEI should be cautious as the NWS does not guarantee the accuracy or validity of the information.

The NCEI 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 NCEI 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

Table 3.2. Hazards Identified for Each Jurisdiction

Jurisdiction	Dam Failure	Drought	Earthquake	Extreme Temperatures	Flooding (River and Flash)	Land Subsidence/Sinkholes	Levee Failure	Severe Winter Weather	Thunderstorm/Lightning/Hail/ High Wind	Tornado	Wildfire	
Marion County	x	x	x	x	x	x	x	x	x	x	x	
Hannibal	-	x	x	x	x	x	x	x	-	x	x	
Palmyra	x	x	x	x	x	x	-	x	-	x	x	

3.1.5 Multi-Jurisdictional Risk Assessment

For this multi-jurisdictional plan, the risks are assessed for each jurisdiction where they deviate from the risks facing the entire planning area. The planning area is fairly uniform in terms of climate and topography, as well as building construction characteristics. Accordingly, the geographic areas of occurrence for weather-related hazards do not vary greatly across the planning area for most hazards. The City of Hannibal is slightly more urbanized within the planning area and have more assets that are vulnerable to the weather-related hazards and varied development trends impact the future vulnerability. These differences are discussed in greater detail in the vulnerability sections of each hazard.

The hazards that vary across the planning area in terms of risk include dam failure, flash flood, grass or wildland fire, and sinkholes/land subsidence. The difference in hazards is explained in each hazard profile under a separate heading.

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

Unincorporated County and Incorporated Cities

In the following three tables, population data is based on 2010 Census Bureau data. Building counts and building exposure values are based on parcel data developed by the State of Missouri Geographic Information Systems (GIS) database. This data, organized by County, is available on Google Drive through the link provided on the previous page. Contents exposure values were calculated by factoring a multiplier to the building exposure values based on usage type. The multipliers were derived from the Hazus and are defined below in **Table 3.3**. Land values have been purposely excluded from consideration because land remains following disasters, and subsequent market devaluations are frequently short term and difficult to quantify. Another reason for excluding land values is that state and federal disaster assistance programs generally do not address loss of land (other than crop insurance). It should be noted that the total valuation of buildings is based on county assessors' data which may not be current. In addition, government owned properties are usually taxed differently or not at all, and so may not be an accurate representation of true value. Note that public school district assets and special districts assets are included in the total exposure tables assets by community and county.

Table 3.3 shows the total population, building count, estimated value of buildings, estimated value of contents and estimated total exposure to parcels for the unincorporated county and each incorporated city. For multi-county communities, the population and building data may include data on assets located outside the planning area. **T a b l e 3 . 4** that follows provides the building value exposures for the county and each city in the planning area broken down by usage type. Finally, **Table 3.5** provides the building count total for the county and each city in the planning area broken out by building usage types (residential, commercial, industrial, and agricultural).

Table 3.3. Maximum Population and Building Exposure by Jurisdiction

Jurisdiction	2019 Annual Population Estimate	Building Count	Building Exposure ($)	Contents Exposure ($)	Total Exposure ($)
Hannibal	17,320	7,059	$1,133,750	$522,012	$1,755,762
Palmyra	3,612	1,567	$250,988	$149,897	$400,885
Marion County	28,530	7,953	$591,510	$350,019	$941,529
Totals	49,462	16,579	$1,976,248	$1,021,928	$3,098,176

Source: U.S. Bureau of the Census, Annual population estimates/ 5-Year American Community Survey 2019; Building Count and Building Exposure, Missouri GIS Database from SEMA Mitigation Management; Contents Exposure derived by applying multiplier to Building Exposure based on Hazus MH 2.1 standard contents multipliers per usage type as follows: Residential (50%), Commercial (100%), Industrial (150%), Agricultural (100%). For purposes of these calculations, government, school, and utility were calculated at the commercial contents rate.

Table 3.4. Building Values/Exposure by Usage Type

Jurisdiction	Residential	Commercial	Industrial	Agricultural	Total
Hannibal	$943,573	$135,496	$4,802	$144	$1,084,015
Palmyra	$194,594	$45,401	$4,312	$66	$244,373
Marion County	$471,404	$47,344	$43,215	$26,416	$588,379
Totals	$1,609,571	$228,241	$52,329	$26,626	$1,916,767

Source: Missouri GIS Database, SEMA Mitigation Management Section

Table 3.5. Building Counts by Usage Type

Jurisdiction	Residential Counts	Commercial Counts	Industrial Counts	Agricultural Counts	Total
Hannibal	6,163	767	20	24	6,974
Palmyra	1,271	257	18	11	1,557
Marion County	3,079	268	180	4,413	7,940
Totals	10,513	1,292	218	4,448	16,471

Source: Missouri GIS Database, SEMA Mitigation Management Section; Public School Districts and Special Districts

Even though schools and special districts' total assets are included in the tables above, additional discussion is needed, based on the data that is available from the districts' completion of the Data Collection Questionnaire and district-maintained websites. The number of enrolled students at the participating public school districts is provided in **Table 3.6** below. Additional information includes the number of buildings, building values (building exposure) and contents value (contents exposure). These numbers will represent the total enrollment and building count for the public school districts regardless of the county in which they are located.

Table 3.6. Population and Building Exposure by Jurisdiction-Public School Districts

Public School District	Enrollment	Building Count
Hannibal School District	3,606	8
Palmyra R-I	1,123	3
Marion County R-II	206	2

Source: http://mcds.dese.mo.gov/quickfacts/Pages/District-and-School-Information.aspx.

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 3.7 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:

- 2018 Missouri State Hazard Mitigation Plan and Hazard Mitigation Viewer http://bit.ly/MoHazardMitigationPlanViewer2018
- List other sources used to assemble critical facility inventory
- Chemical Facilities (Tier II Facilities) information (if included in the list of hazards identified by the participants) can be obtained by contacting the county LEPC. The LEPC will then request information (name, address, purpose for asking, etc.) and then provide the
  information. In order to find out who the LEPC contact is for your planning areas, see
- https://sema.dps.mo.gov/docs/programs/executive/MERC/LEPC_Manual/LEPCaddresses.pdf
- Hazus contains an inventory of critical facilities that can be exported for each jurisdiction.
- The Homeland Security Infrastructure Protection Program (HSIPP) is another source. But access may be restricted.

Table 3.7. 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	Stormwater Pump Stations	Tier II Chemical Facility	Wastewater Facility	Total
Hannibal			X	X	X	X	X	X	X		X	X		X	X	X	X	X	X	X			X	**17**
Palmyra			X	X	X		X	X	X		X	X			X	X	X	X	X	X			X	**15**
Marion County	X		X	X			X	X			X			X			X	X	X	X		X		**12**
Total	**1**	**0**	**3**	**3**	**2**	**1**	**3**	**3**	**2**	**0**	**3**	**2**	**0**	**2**	**2**	**2**	**3**	**3**	**3**	**3**	**0**	**1**	**2**	**44**

Source: Missouri 2018 State Hazard Mitigation Plan and Hazard Mitigation Viewer; Data Collection Questionnaires; Hazus, etc.

Bridges: The term “scour critical” 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.

Figure 3.1. Marion County Bridges

County	Bridge Counts				Bridge Area (Square Meters)			
	All	Good	Fair	Poor	All	Good	Fair	Poor
Marion County (127)	188	80	90	18	134,374	77,675	41,922	14,777

Figure 3.2. Marion County Structurally Deficient Bridges

Source: https://www.modot.org/sites/default/files/documents/Statewide_Poor_Bridges_2018_with_insets%5B1%5D.pdf

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.

Threatened and Endangered Species: Table 3.8 shows Federally Threatened, Endangered, Proposed and Candidate Species in Marion County.

Table 3.8. Threatened and Endangered Species in Marion County

Common Name	Scientific Name	Status
Gray Bat	Myotis grisescens	Endangered
Indiana Bat	Myotis sodalis	Endangered
Northern Long-Eared Bat	Myotis septentrionalis	Threatended
Pallud Sturgeon	Scaphirhynchus albus	Endangered
Higgins Eye	Lampsilis higginsil	Endangered
Sheepnose Mussel	Plethobasus cyphyus	Endangered
Spectaclecase	Cumberlandia monodonta	Endangered

Source: U.S. Fish and Wildlife Service, https://ecos.fws.gov/ipac/

Natural Resources: Marion County has ten conservation and recreation areas. The Missouri Department of Conservation (MDC) provides a database of lands the MDC owns, leases or manages for public use. Table 3.9 provides the names and location of parks and conservation areas in the planning area owned by Missouri Department of Conservation and owed by the jurisdictions.

Table 3.9. Parks in Marion County

Park / Conservation Area	Address	City
Akerson Access	Main St to W West New St to N Breck	Palmyra
Black Hawk Access	Route M to S CR 159 to E CR 134	Emerson
Callahan Mound Access	W Highway 168 to S County Road 197	Philadelphia
Dunn Ford Access	N Rt D to W Rt J, N County Road 123	Philadelphia
Elmslie Memorial Conservation Area	E Route C to S County Road 229	Warren
Fabius Chute Access	N Hwy 61 to E CR 332 to NE CR 342	Palmyra
J. Thad Ray Memorial Wildlife Area	Jct of Route W/Hwy 61 to W Route W	Hannibal
Julian Steyermark Woods Conservation Area	N Highway 168 to E County Road 410	Hannibal
McPike Access	Route M to County Road 137	Emerson
Soulard Access	N Highway 61 to E County Road 344	Palmyra

Source: http://mdc7.mdc.mo.gov/applications/moatlas/AreaList.aspx?txtUserID=guest&txtAreaNm=s

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 3.10. Marion County Properties on the National Register of Historic Places

Property	Address	City	Date Listed
Levi Barkley House	T57 R5W Sec. 18 and 19	Hannibal	03/02/1984
Broadway District	Bounded by S Main, Broadway, S 3rd St	Hannibal	08/01/1986
Buildings at 207-209 S Main Street	207-209 S Main Street	Hannibal	08/01/1986
Central Park Historic District	Bounded by 4th 7th North and Lyons St	Hannibal	10/07/1982
Clemens Field	401 Collier	Hannibal	08/26/2008
Culberston-Head Farmstead	7178 County Road 402	Palmyra	09/04/2008
Davidson Building	106 S Main Street	Hannibal	08/01/1986
Digel Block	218-222 S Main Street	Hannibal	08/01/1986
Dryden-Louthan House	402 E Ross	Palmyra	01/18/1985
Ebert-Dulany House	1000 Center Street	Hannibal	02/17/1983
Eighth and Center Streets Baptist Church	722 Center Street	Hannibal	09/04/1980
Elliott's, Robert, Wholesale Grocery	116-120 S Third Street	Hannibal	08/01/1986
Federal Building	600 Broadway	Hannibal	10/15/1980
Gardner House	421 Hamilton and Main Streets	Palmyra	03/04/1971
Green Double House	113-115 S 3rd Street	Hannibal	08/01/1986
Hafner Grocery Warehouse	101 E Church Street	Hannibal	08/01/1986
Hannibal Lime Company Office	623 Collier Street	Hannibal	09/06/1984
Hannibal Old Police Station and Jail	4th and Church Streets	Hannibal	07/17/1979
Hendren Farm	Off US 61	Hannibal	08/22/1984
Hock Building	312 Center Street	Hannibal	12/02/1986
Holmes-Dakin Building	120-122 S Main Street	Hannibal	08/01/1986
Benjamin Horr House	308 Central Street	Hannibal	12/02/1986
Maple Avenue Historic District	Bounded by Broadway and Center, Alley to North, Dulany to Section	Hannibal	11/21/2002
Marion County Courthouse	906 Broadway	Hannibal	10/22/2002
Marion County Jail and Jailor's House	210 W Lafayette Street	Palmyra	10/04/2002
Mark Twain Historic District	Bounded by Bird, Main, Hill Sts, US 36 and Mississippi River	Hannibal	01/04/1978
Mark Twain Hotel	200 S Main Street	Hannibal	08/01/1986
Robert Masterson House	NW of Hannibal	Hannibal	04/05/1984
North Main Street Historic District	Bounded by Bird, N Main, and Hill Sts	Hannibal	08/01/1986
Osterhout Mound Park	Wauneta Place	Hannibal	04/11/1973
Riverview Park	200 Harrison Hill	Hannibal	09/06/2005
Rockcliffe Mansion	1000 Bird Street	Hannibal	09/18/1980
St. Elizabeth Hospital	109 Virginia Street	Hannibal	08/14/2012
Peter J Sowers House	221 Home Street	Palmyra	01/18/1985
Speigle House	406 S Dickerson	Palmyra	02/14/1985
Standard Printing Company	210 N 3rd Street	Hannibal	08/01/1986
Mark Twain Boyhood Home	206-208 Hill Street	Hannibal	12/29/1962
Walker-Woodward Schaffer House	1425 S Main Street	Palmyra	02/16/1984
Ephriam J Wilson Farm Complex	E of Palmyra off MO 168	Palmyra	12/28/1982

Source: Missouri Department of Natural Resources – Missouri National Register Listing http://dnr.mo.gov/shpo/mnrlist.htm

Economic Resources: Table 3.11 shows major non-government employers in Marion County.

Table 3.11. Major Non-Government Employers in Marion County

Employer Name	Main Locations	Product or Service	Employees
Hannibal Regional Hospital	Hannibal	Medical	850
Hannibal 60 School District	Hannibal	School	640
BASF Corporation	Palmyra	Chemicals	390
Wal-Mart Supercenter	Hannibal	Retail	375
Emery Sapp and Sons	Hannibal	Construction	350
Waltow Electric Manufacturing	Hannibal	Industry	300
SC Data Call Center	Hannibal	Retail	250
Hannibal LaGrange Univ.	Hannibal	Higher Education	250
Continental Cement	Hannibal	Industry	230
Levering Regional Healthcare	Hannibal	Medical	215
Hannibal Clinic	Hannibal	Medical	200
Palmyra R-I School	Palmyra	School	170
Northeast Power Cooperative	Palmyra	Utilities	58

Source: Data Collection Questionnaires; local Economic Development Commissions

Agriculture: Agriculture plays an important role in the planning area's economy. Table 3.12 provides a summary of the agriculture-related jobs in Marion County.

Table 3.12. Agriculture-Related Jobs in Marion County

		Marion
Hired farm labor	farms	119
	workers	300
	$1,000 payroll	2,956
Farms with-		
1 worker	farms	45
	workers	45
2 workers	farms	30
	workers	60
3 or 4 workers	farms	28
	workers	(D)
5 to 9 workers	farms	15
	workers	99
10 workers or more	farms	1
	workers	(D)
Workers by days worked:		
150 days or more	farms	61
	workers	107
Farms with-		
1 worker	farms	28
	workers	28
2 workers	farms	26
	workers	52
3 or 4 workers	farms	6
	workers	(D)
5 to 9 workers	farms	1
	workers	(D)
10 workers or more	farms	-
	workers	-
Less than 150 days	farms	95
	workers	193
Farms with-		
1 worker	farms	55
	workers	55
2 workers	farms	15
	workers	30
3 or 4 workers	farms	19
	workers	63
5 to 9 workers	farms	6
	workers	45
10 workers or more	farms	-
	workers	-
Reported only workers working 150 days or more	farms	24
	workers	41
	$1,000 payroll	1,247
Reported only workers working less than 150 days	farms	58
	workers	119
	$1,000 payroll	376
Reported both - workers working 150 days or more and workers working less than 150 days	farms	37
	150 days or more, workers	66
	less than 150 days, workers	74
	$1,000 payroll	1,333
Total migrant workers	farms	1
	workers	(D)
Migrant farm labor on farms with hired labor	farms	1
	workers	(D)
Migrant farm labor on farms reporting only contract labor	farms	-
	workers	-
Unpaid workers	farms	230
	workers	533

Source:
https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/Missouri/st29_2_0007_0007.pdf

3.3 LAND USE AND DEVELOPMENT

3.3.1 Development Since Previous Plan Update

According to the building permit data that was obtained through the U.S. Census Bureau, there has been growth in Marion County, Hannibal, and Palmyra since the last plan update. Growth in an area increases risk for the planning area as there can be more structural damage to the planning area.

The U.S. Census Bureau shows Marion County is expected to have decreased by 0.87% since the last census was performed. Table 3.13 provides the population growth statistics for all the cities in Marion County, as well as the county as a whole. Population statistics represent the 2010 U.S. Census and American Community Survey 5-year estimates.

Table 3.13. County Population Growth, 2010-2019

Jurisdiction	Total Population 2010	Total Population 2019	2010-2019 # Change	2000-2019 % Change
Marion County	28,781	28,530	-251	-0.87%
Hannibal	17,916	17,320	-596	-3.33%
Palmyra	3,565	3,612	47	1.32%

Source: U.S. Bureau of the Census, Decennial Census, Annual Population Estimates, American Community Survey 5-year Estimates; Population Statistics are for entire incorporated areas as reported by the Census bureau

Population growth or decline is generally accompanied by increases or decreases in the number of housing units. Marion County and Palmyra have shown an increase in housing, with Hannibal reflecting a decline.

Table 3.14. Change in Housing Units, 2010-2019

Jurisdiction	Housing Units 2010	Housing Units 2019	2010-2019 # Change	2000-2019 % Change
Marion County	12,826	13,036	210	1.64%
Hannibal	8,021	7,771	-250	-3.12%
Palmyra	1,542	1,718	176	11.4%

Source: U.S. Bureau of the Census, Decennial Census, American Community Survey 5-year Estimates; Population Statistics are for entire incorporated areas as reported by the U.S. Census Bureau

U.S. Census information is compiled every 10 years, with the last Census completed in 2010 estimates were used for the above data. 2020 Census data was not available at the time of this update. According to American Fact Finder, estimates show that in 2019 the number of housing units are expected to increase in all jurisdictions within Marion County, with the exception of Hannibal. Vulnerability to hazards will be affected based on population, and where new housing units have been built. Due to city ordinances, vulnerability is not expected to increase as ordinances for new builds have been set to protect citizens.

3.3.2 Future Land Use and Development

According to the Data Questionnaire's no participating jurisdictions anticipated future development within the planning area.

School District's Future Development

According to the Data Collection Questionnaire, safe rooms/storms shelters will be constructed if funding became available.

Special District's Future Development

According to the Data Collection Questionnaire, there is no anticipated future development.

3.4 HAZARD PROFILES, VULNERABILITY, AND PROBLEM STATEMENTS

Each hazard will be analyzed individually in a hazard profile. The profile will consist of a general hazard description, location, strength/magnitude/extent, previous events, future probability, a discussion of risk variations between jurisdictions, and how anticipated development could impact risk. At the end of each hazard profile will be a vulnerability assessment, followed by a summary problem statement.

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 3.1.4** will be profiled individually in this section in alphabetical order. 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 areas in the planning area that are affected by the hazard. 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.
- **Strength/Magnitude/Extent:** This includes information about the strength, 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. This section should also include information on the typical or expected strength/magnitude/extent of the hazard in the planning area. Strength, magnitude,

and extent can also include the speed of onset and the duration of hazard events. Describing the strength/magnitude/extent of a hazard is not the same as describing its potential impacts on a community. Strength/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 can be determined by dividing the number of recorded events by the number of years of available data 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 should be reported as 100% in any given year, with a statement of the average number of events annually. For hazards such as drought that may have gradual onset and extended duration, probability can be based on the number of months in drought in a given time-period and expressed as the probability for any given month to be in drought.
- **Changing Future Conditions Considerations**: In addition to the probability of future occurrence, changing future conditions should also be considered, including the effects of long-term changes in weather patterns and climate on the identified hazards.

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 should be based on the best available data. The vulnerability assessments can also be based on data that was collected for the 2018 State Hazard Mitigation Plan Update. With the 2018 Hazard Mitigation

Plan Update, SEMA is pleased to provide online access to the risk assessment data and associated mapping for the 114 counties in the State, including the independent City of St. Louis. Through the web-based Missouri Hazard Mitigation Viewer, local planners or other interested parties can obtain all State Plan datasets. This effort removes from local mitigation planners a barrier to performing all the needed local risk assessments by providing the data developed during the 2018 State Plan Update.

The Missouri Hazard Mitigation Viewer includes a Map Viewer with a legend of clearly labeled features, a north arrow, a base map that is either aerial imagery or a street map, risk assessment data symbolized the same as in the 2018 State Plan for easy reference, search and query capabilities, ability to zoom to county level data and capability to download PDF format maps. The Missouri Hazard Mitigation Viewer can be found at this link: http://bit.ly/MoHazardMitigationPlanViewer2018.

The vulnerability assessments in the County A 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.

Within the Vulnerability Assessment, the following sub-headings will be addressed:

- **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, 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 to existing development. Where data is available, this section provides estimated financial losses as well as the methodology used. For hazards with an overall "Low" rating, potential losses may not be discussed.

- **Previous and Future Development:** This section provides information on how vulnerability to this hazard will be impacted by planned future development as well as information for jurisdictions to consider in planning future development.

- **Hazard Summary by Jurisdiction:** For hazard risks that vary by jurisdiction, this section will provide an overview how the hazard varies, followed by a table indicating the probability, magnitude, warning time, and duration rankings for each jurisdiction with the resulting hazard score and level.

Problem Statements

Each hazard analysis will conclude with a brief summary of the problems created by the hazard in the planning area, and possible ways to resolve those problems.

3.4.1 Flooding (Riverine and Flash)

Hazard Profile

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 3.4.3 and Section 3.4.2 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.

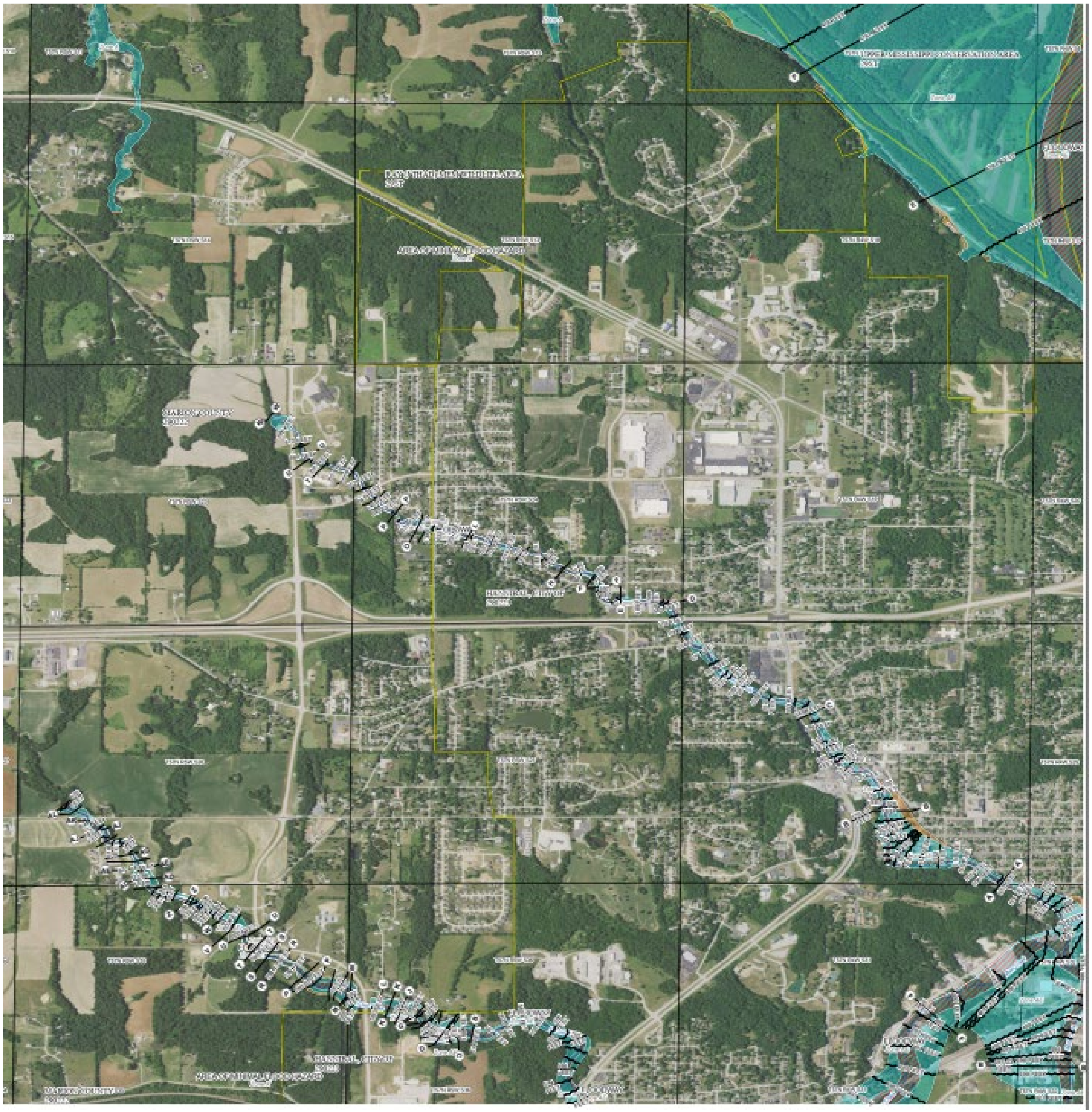
Although flash floods are somewhat unpredictable, there are factors that can point to the likelihood of flash floods occurring. Weather surveillance radar is being used to improve monitoring capabilities of intense rainfall. This, along with knowledge of the watershed characteristics, modeling techniques,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

Geographic Location

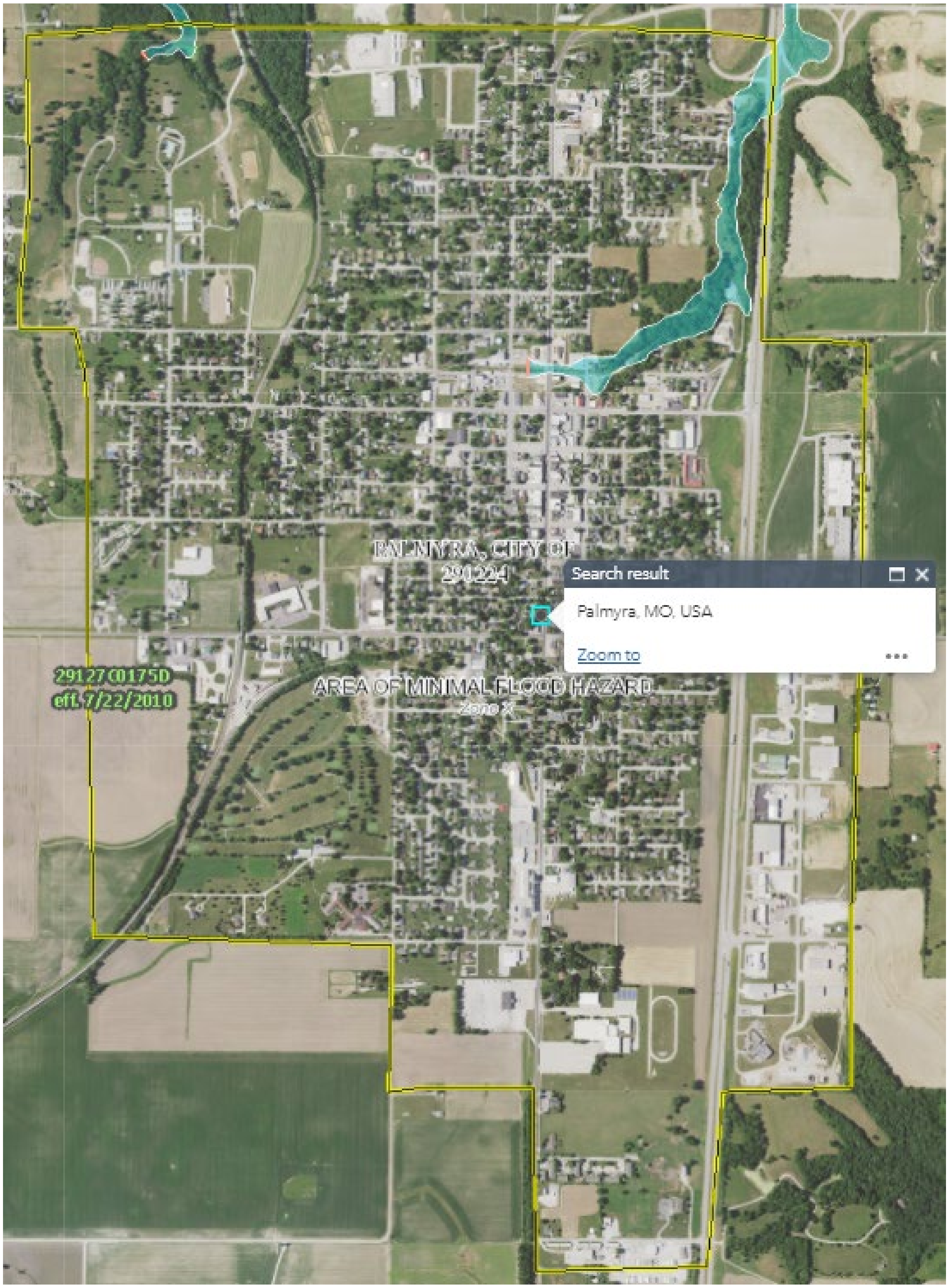
Riverine flooding is most likely to occur in (Special Flood Hazard Areas) SFHAs.

<u>Marion County</u>

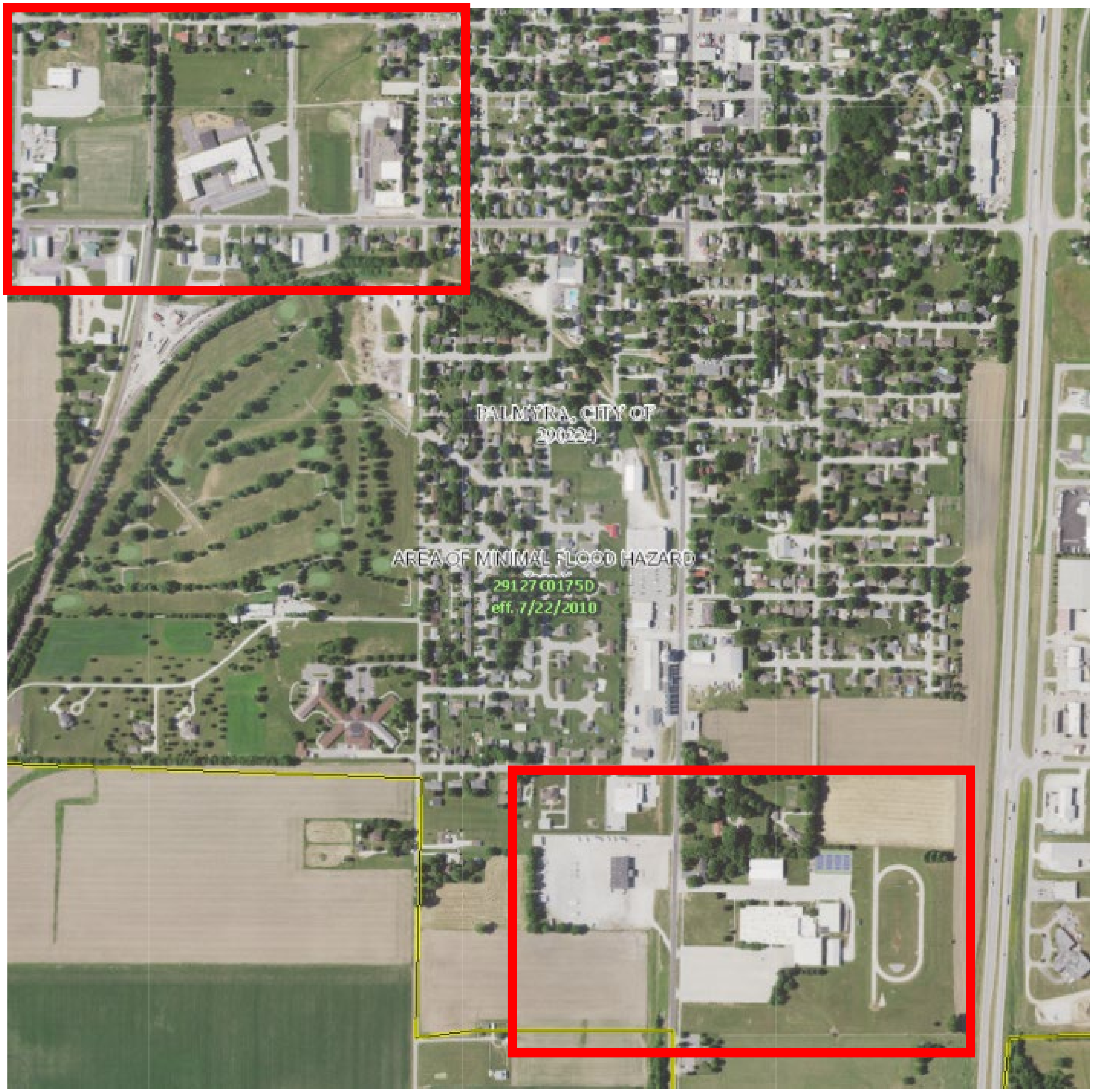
City of Hannibal



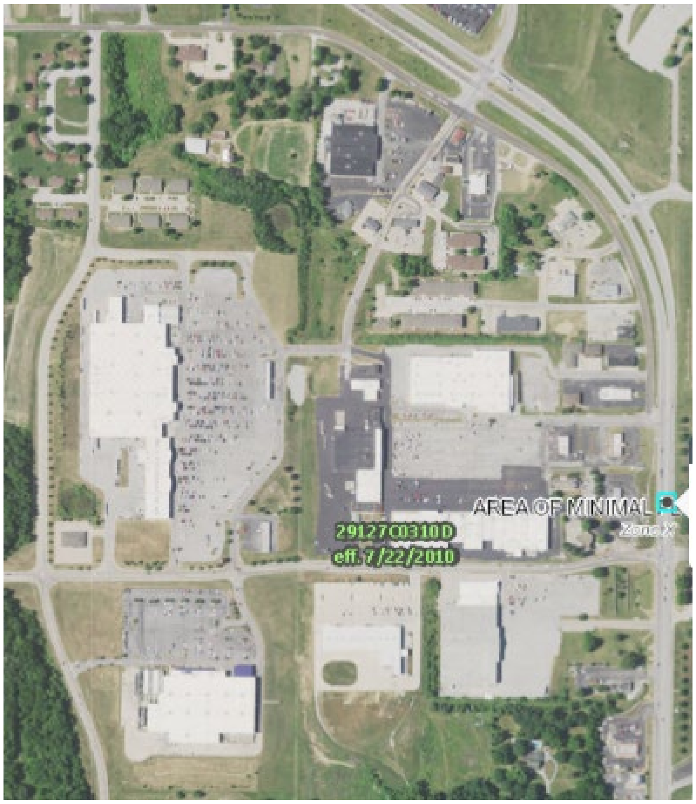
City of Palmyra



Palmyra School District

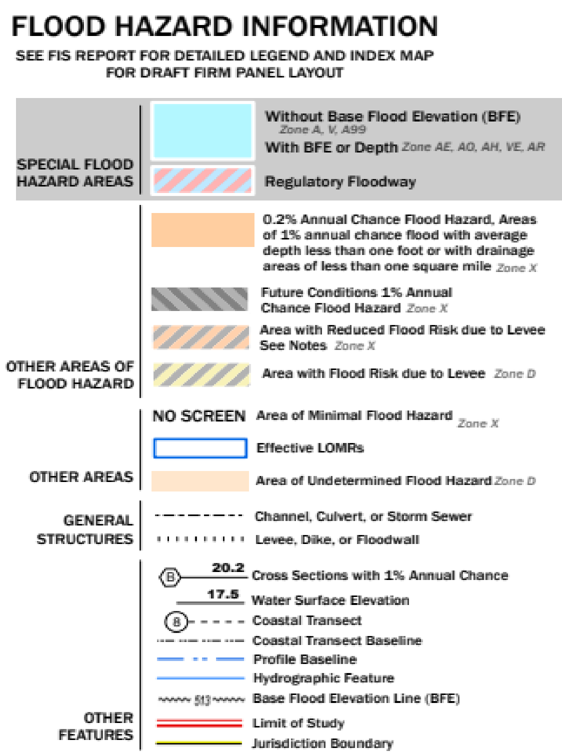


Hannibal School District



Marion County School District

Legend



Source: FEMA's National Flood Hazard Layer (NFHL) Viewer

Table 3.15. Marion County NCEI Flood Events by Location, 2001-2021

Location	# of Events
Unincorporated Marion County	14
-Unincorporated County (unspecified) – 8 flood events	
-Woodland – 1 flood events	
-Taylor - 2 flood events	
-West Quincy – 3 flood events	
Hannibal	4
-Hannibal – 4 flood events	

Source: National Centers for Environmental Information, 03/05/21

Flash flooding occurs in SFHAs and low-lying locations in the planning area. They also occur in areas without adequate drainage to carry away the amount of water that falls during intense rainfall events. NCEI database was used to determine which jurisdictions are most prone to flash flooding during a 20-year time period. Table 3.16 shows the number of flash flood events by location recorded in NCEI for the 20-year period.

Table 3.16. Marion County NCEI Flash Flood Events by Location, 2001-2021

Location	# of Events
Unincorporated County	13
-Unincorporated County (unspecified) - 4 flood events	
-White Bear - 1 flood events	
-Cherrydell-Route J - 2 flood events	
-West Quincy - 4 flood events	
-Hwy 61 and Hwy 168 - 1 flood events	
-Taylor - 1 flood events	
Hannibal	2
-Hannibal – 2 flood events	
Palmyra	1
-Palmyra – 1 flood events	

Source: National Centers for Environmental Information, 03/05/21

Strength/Magnitude/Extent

Missouri has a long and active history of flooding over the past century, according to the 2018 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.

According to the U.S. Geological Survey, two critical factors affect flooding due to rainfall: rainfall duration and rainfall intensity – the rate at which it rains. These factors contribute to a flood's height, water velocity and other properties that reveal its magnitude.

National Flood Insurance Program (NFIP) Participation

Table 3.17 provides details on NFIP participation for the communities in the planning area. Table 3.18 provides information on the number of policies in force, amount of insurance in force, number of closed losses, and total payments for each jurisdiction in Marion County.

Table 3.17. NFIP Participation in Marion County

Community ID #	Community Name	NFIP Participant (Y/N/Sanctioned)	Current Effective Map Date	Regular-Emergency Program Entry Date
290223	Hannibal, City of	Yes	07/22/10	08/01/78
290222	Marion County	Yes	07/20/16	05/16/77
290224	Palmyra, City of	Yes	07/22/10	03/04/09

Source: NFIP Community Status Book, 03/05/21; BureauNet, http://www.fema.gov/national-flood-insurance-program/national-floodinsurance-program-community-status-book; M= No elevation determined – all Zone A, C, and X: NSFHA = No Special Flood Hazard Area; E=Emergency Program

Table 3.18. NFIP Policy and Claim Statistics as of Date

Community Name	Policies in Force	Insurance in Force	Closed Losses	Total Payments
Marion County	72	15,190,900	196	6,760,107.01
Hannibal, City of	58	12,572,300	311	4,064,588.48
Palmyra, City of	1	42,000	2	3,375.16

Source: NFIP Community Status Book, 5/26/21; BureauNet, http://bsa.nfipstat.fema.gov/reports/reports.html; *Closed Losses are those flood insurance claims that resulted in payment. Loss statistics as of 5/26/21.

The City of Hannibal is significantly higher in insurance payments with over $4 million, in comparison to the City of Palmyra with only $3,375.16.

Repetitive Loss/Severe Repetitive Loss Properties

Repetitive Loss Properties are those properties with at least two flood insurance payments of $1,000 or more in a 10-year period. According to the Flood Insurance Administration, jurisdictions included in the planning area have a combined total of 40 repetitive loss properties. As of 03/15/2021, 22 properties have been mitigated, leaving 18 un-mitigated repetitive loss properties.

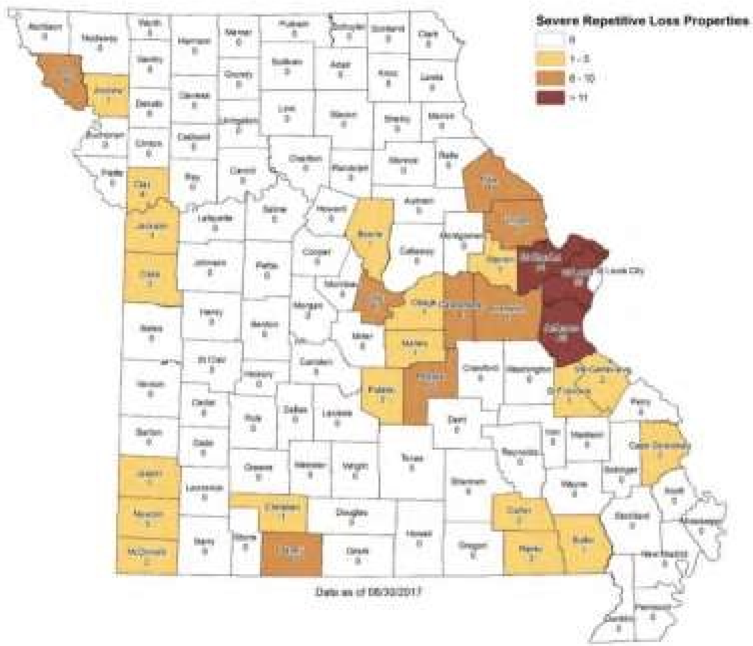
Table 3.19. Marion County Repetitive Loss Properties

Jurisdiction	# of Properties	Type of Property	# Mitigated	Building Payments	Content Payments	Total Payments	Average Payment	# of Losses
Marion County	11	-	2	$536,220.74	$59,835.09	$596,055.83	$54,186.89	34
Hannibal, City of	29	-	20	$1,121,998.97	$1,412,403.51	$2,534,402.48	$87,393.19	72

Source: Flood Insurance Administration as of 03/15/21

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 $1,000 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.

Due to Federal restrictions on data sharing, the state was unable to provide full Repetitive Loss data or current Severe Repetitive Loss data. However, according to the 2018 Missouri Hazard Mitigation Plan, Marion County has zero (0) severe repetitive loss properties reported.



Source: 2018 Missouri Hazard Mitigation Plan

Previous Occurrences

Disaster 4451 – 6/03/19
On June 3, Governor Parson toured the flood damage in Hannibal, Canton, and Clarksville. Twenty-eight levees were reported as breached across the state. In Hannibal, the Mississippi River crested at 30.15 feet on June 1, as the second highest record in history. In Canton, the Mississippi River crested at 27.11 feet on June 1, as the third highest record in history. According to the Missouri Department of Transportation, approximately 382 roads closed in 56 counties due to flooding. The Missouri National Guard assisted Brunswick, Canton, Clarksville, Hannibal, Hardin, and Norborne with flood fighting.

Disaster 4238 – 07/21/15
Beginning in mid-May, a series of severe storms moved across Missouri, generating tornadoes, straight line winds, heavy rain, hail, flooding and flash flooding across the state. The prolonged pattern of recurring severe storm systems brought record rainfall to many parts of the state, extensively damaging roads, bridges and other public infrastructure and resulted in at least 10 deaths. The Missouri Department of Transportation reported an estimated 870 total road closures.

On June 18, Gov. Nixon declared a state of emergency in response to the severe storms that were causing wind damage and widespread flooding across Missouri. The order activated the State Emergency Operations Center (SEOC), which enables the state to mobilize its resources, including the State Emergency Management Agency, to assist local authorities.

The counties included in the federal public assistance disaster declaration are: Adair, Andrew, Atchison, Audrain, Barry, Bates, Benton, Buchanan, Caldwell, Chariton, Christian, Clark, Clay, Clinton, Cole, Crawford, Dade, Dallas, Daviess, DeKalb, Douglas, Gentry, Harrison, Henry, Hickory, Holt, Jefferson, Johnson, Knox, Laclede, Lafayette, Lewis, Lincoln, Linn, Livingston, McDonald, Macon, Maries, Marion, Miller, Moniteau, Monroe, Montgomery, Morgan, Osage, Ozark, Perry, Pettis, Pike, Platte, Polk, Putnam, Ralls, Ray, Ste. Genevieve, Saline, Schuyler, Scotland, Shannon, Shelby, Stone, Sullivan, Taney, Texas, Washington, Webster, Worth and Wright.

Disaster 4130 – 05/31/13

In May and June 2013, Missouri was impacted by a widespread storm system that brought heavy rain, straight-line winds, hail, flooding and tornadoes. The severe weather system and flooding caused extensive damage to homes, businesses and farmland in the affected communities.

On May 31, Gov. Nixon declared a state of emergency, activating the State Emergency Operations Center and enabled the state to mobilize its resources to assist local authorities.

On July 3, Gov. Nixon requested a major disaster declaration by President Barack Obama, requesting individual and public assistance for the affected areas.

On July 17, a major disaster declaration was granted by President Obama for public assistance in 27 Missouri counties. The following counties were included in the federal disaster declaration: Barton, Callaway, Cape Girardeau, Chariton, Clark, Howard, Iron, Knox, Lewis, Lincoln, Maries, Marion, Miller, Montgomery, Osage, Perry, Pike, Putnam, Ralls, Shelby, St. Charles, St. Louis, Ste. Genevieve, Stoddard, Sullivan, Texas and Webster.

Disaster 1934 – 08/17/10

During June and July 2010, northern Missouri experienced severe storms, tornadoes and flooding. With many parts of the state along the Missouri River and its tributaries experiencing high water, flooded farmland and closed roads, and with the possibility that the situation would become worse, on June 15, Gov. Jay Nixon ordered the activation of the State Emergency Operations Center. The center helps coordinate the response of state agencies in assisting local jurisdictions with their emergency protective actions. On June 21, Gov. Nixon declared a State of Emergency in Missouri.

On June 22, the Governor authorized the use of offenders from the Department of Corrections to assist in sandbagging efforts. Thirty-seven offenders from the Western Reception and Diagnostic Correctional Center in St. Joseph were utilized by the Missouri Department of Transportation in the effort to protect Interstate 29 from rising flood waters near the Mound City exit.

On June 23, Gov. Nixon activated the Missouri National Guard to provide emergency assistance to residents of northwest Missouri communities that could be affected by continued flooding along the Missouri River. The Missouri State Highway Patrol and Missouri State Water Patrol also stepped-up patrols and extended shifts in the affected areas. The State Emergency Management Agency arranged for thousands of sandbags and two sandbagging machines.

On July 20, Gov. Nixon extended the state of emergency, which was set to expire that day.

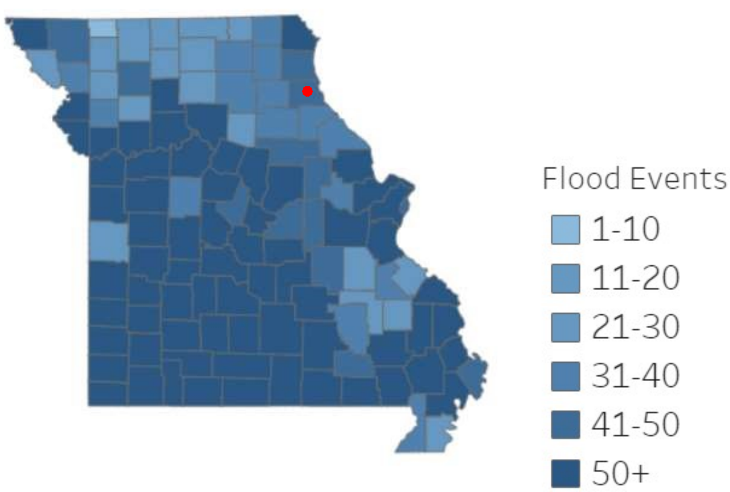
On July 27, Missouri requested a major disaster declaration, which President Barack Obama granted on Aug. 17, 2010. The 29 counties initially granted assistance in the major disaster declaration were Adair, Andrew, Atchison, Buchanan, Caldwell, Carroll, Cass, Chariton, Clark, Clinton, Daviess, DeKalb, Gentry, Grundy, Harrison, Holt, Howard, Jackson, Lafayette, Lewis, Livingston, Mercer, Nodaway, Putnam, Ray, Schuyler, Scotland, Sullivan and Worth.

On Aug. 27 Knox, Linn, Marion, Monroe, Pike, Ralls, and Shelby counties were added on Sept. 24, bringing the total number of counties in Missouri affected to 37.

Table 3.20. NCEI Marion County Flash Flood Events Summary, 2001 to 2021.

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
2002	2	0	0	0	0
2004	2	0	0	0	0
2008	3	0	0	0	0
2009	1	0	0	0	0
2010	3	0	0	$200,000	0
2013	1	0	0	0	0
2015	2	0	0	0	0
2017	1	0	0	0	0
2020	1	0	0	0	0

Source: NCEI, data accessed [03/16/21]



Source: https://www.fema.gov/data-visualization-floods-data-visualization *Red star indicates Marion County

The FEMA Data Visualization Tool as shown above, indicates Marion County had between 31-40 events of flood impact.

Table 3.21. NCEI County A Riverine Flood Events Summary, 2001 to 2021

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
2001	4	0	0	0	0

2002	4	0	0	0	0
2007	1	0	0	0	0
2008	3	0	0	7.1M	13.3M
2010	1	0	0	0	0
2013	5	0	0	0	0

Source: NCEI, 03/16/21

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-

The bulk of the flooding occurred in agricultural lowlands. In Marion County at Hannibal, the crest was 5 feet below the top of the flood wall. A couple of businesses along Bear Creek south of the flood wall did suffer flood damage. In Pike County, the story was similar. Agricultural lowlands flooded, the riverfront park in Louisiana was flooded, a couple of businesses in Clarksville and Louisiana were flooded, and Highway 79 had to be closed in several places from Louisiana to Clarksville, and Clarksville to Annada. In Lincoln County, an agricultural levee in the Old Monroe area failed on May 18, flooding approximately 1000 acres of farmland. From St. Charles County south to St. Louis damage was minimal with only agricultural lowlands flooded.

August 2007-

Heavy rain upstream caused minor flooding on the Mississippi River. At Hannibal, the river peaked about 2.5 feet over flood stage and was still in flood when the month ended.

June 2008-

The Mississippi River at Hannibal, MO crested at 29.54 feet on 6/18/2008. This is the second highest crest ever recorded. The City of Hannibal escaped relatively unscathed as the flood wall and most levees north and south of town held due to work by the National Guard and volunteers. Plastic and sandbags were used to raise and cover about 60% of the levees in the County. The Mark Bottoms levee was over topped resulting in 19 homes being flooded. Highway 79 in the south part of Hannibal was closed. No other towns in the county were affected as the remainder of the land along the river is used for agriculture or conservation purposes. County Extension Service personnel estimated agricultural losses at $13.3 million. Emergency management personnel reported $7.1 million in infrastructure damages.

July 2008-

The Mississippi River crested at Hannibal, MO on July 1 at 25.49 feet. The river fell below flood stage on July 14. For additional information on the flooding consult the June report.

September 2008-

Four to five inches of rain fell onto already saturated soils causing flooding. Some of the rainfall was from the remnants of Hurricane Ike. Numerous secondary roads were flooded. The heavy rains loosened up soils in the area causing several trees to fall. A large mudslide occurred on Ely Street in Hannibal. Up to ten dump trucks full of mud had to be hauled away from the slide. No structures were affected by the mudslide.

Flash Flood Events

August 2004-
Another evening of heavy rain caused flash flooding across parts of Northeast Missouri. Numerous county roads were flooded and damaged by the runoff. Several roads, including Highway 6, and County roads 150, 408, 168, 410 and 320 in the Taylor, Palmyra, and Hannibal areas were impassable most of the night of the 27th. Bear Creek in south Hannibal flooded with water getting into several homes. In Shelby County, Highway W was closed due to water from the North River. Highway AA southeast of Shelbyville was closed by flood water from the North Fork River.

July 2008-
Three to four inches of rain fell onto already saturated soils in about a 40-minute time frame causing flash flooding. In the southern sections of Hannibal, water was 3 to 4 feet deep in the area of Irwin Street and Bowling Avenue as the nearby creek overflowed its banks. A couple of cars were destroyed in the flood and a couple of mobile homes had some water damage.

April 2009-
Between 2 and 3 inches of rain fell in a short amount of time causing flash flooding. There were areas of flash flooding around Bear Creek, Munger Lane Bridge was washed out and many county roads were closed due to high water.

July 2010-
Up to 6 inches of rain fell in a short amount of time causing flash flooding. Numerous roads were flooded including several in Hannibal. Also, Bear Creek in Hannibal overflowed its banks flooding a nearby parking lot with two feet of water and 35 to 40 residents along the creek had to be rescued from their homes by boat due to the flooding.

September 2010-
Up to four inches of rain fell in a short amount of time causing flash flooding. Numerous roads were flooded including outer roads along U.S. Highway 61 near Taylor.

May 2013-
Up to three inches of rain fell in a short amount of time causing flash flooding in the Hannibal and Palmyra areas. Several roads were flooded including the intersection of U.S. Highway 61 and Highway 168.

July 2015-
Up to five inches of rain fell onto already saturated soils causing flash flooding. Numerous roads were flooded including Highway MM at Bear Creek, County Roads 425 and 403. Several homes in Hannibal had up to 17 inches of water in their basements.

July 2015-
Up to three inches of rain fell in a short amount of time causing flash flooding. Numerous roads were flooded. In Hannibal, water was high enough on some streets to get into vehicles. No injuries or deaths were reported.

July 2017-
Up to three inches of rain fell in less than an hour causing flash flooding. County Road 306 near Taylor had 6 to 8 inches of fast flowing water over it.

June 2020-
Up to five inches fell in about a 3-hour period causing flash flooding. Numerous roads were flooded including County Road 195 near North River. Also, County Road 230 bridge over Big Branch Creek was washed out.

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 95%. Flash floods occur often in the planning area and have a 75% probability of occurring in any given year.

Changing Future Conditions Considerations

According to the National Climate Assessment, extreme rainfall events and flooding have increased during the last century, and these trends are expected to continue.

Vulnerability

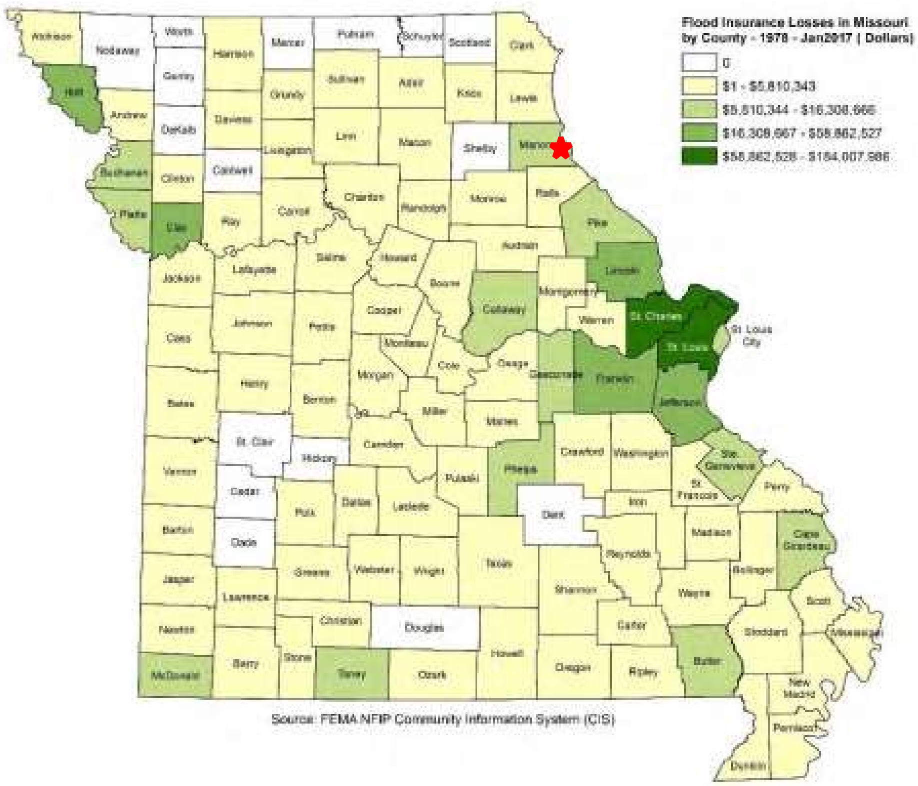
Vulnerability Overview

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.

Figure 3.57. Map of Dollars Paid Historically for Flood Insurance Losses in Missouri by County, 1978-January 2017



Source: 2018 Missouri State Hazard Mitigation Plan, *Red star indicates Marion County

According to the 2018 Missouri State Hazard Mitigation Plan, Marion County ranged in the middle of Flood Insurance Losses between $5,810,344-$16,306,666.

Potential Losses to Existing Development

An estimate for the potential loss to existing development was not able to be obtained and included in this plan for Marion County.

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.

EMAP Consequence Analysis

Table 3.22. EMAP Impact Analysis: Flooding

Subject	Detrimental Impacts
Public	Localized impact expected to be severe for incident areas and moderate to light for other adversely affected areas.
Responders	Localized impact expected to limit damage to personnel in the flood areas at the time of the incident.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations. Localized disruption of roads, facilities, and/or utilities caused by incident may postpone delivery of some services.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Environment	Localized impact expected to be severe for incident areas and moderate to light for other areas affected by the flood or HazMat spills.
Economic Condition of Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

Vulnerability to flood varies by jurisdiction. Tables 3.15 and 3.16 shows 34 flood events occurring during the last 20 years of data.

Hannibal- The floodplain map in the geographic location section shows the greatest risk to be within the City of Hannibal.

Palmyra- There is a risk of flooding within the City of Palmyra, but at a lesser level.

No school buildings are located within the SFHA.

Problem Statement

Flooding or flash flooding has affected every community in Marion County which has impacted homes and business, not everyone utilizes social media or texting, Hannibal 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 are to increase the education to residents, promote the use of social media or texting and work with officials to identify flood prone areas.

3.4.2 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://mrcc.isws.illinois.edu/1913Flood/awareness/materials/SoYouLiveBehindLevee.pdf).

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),

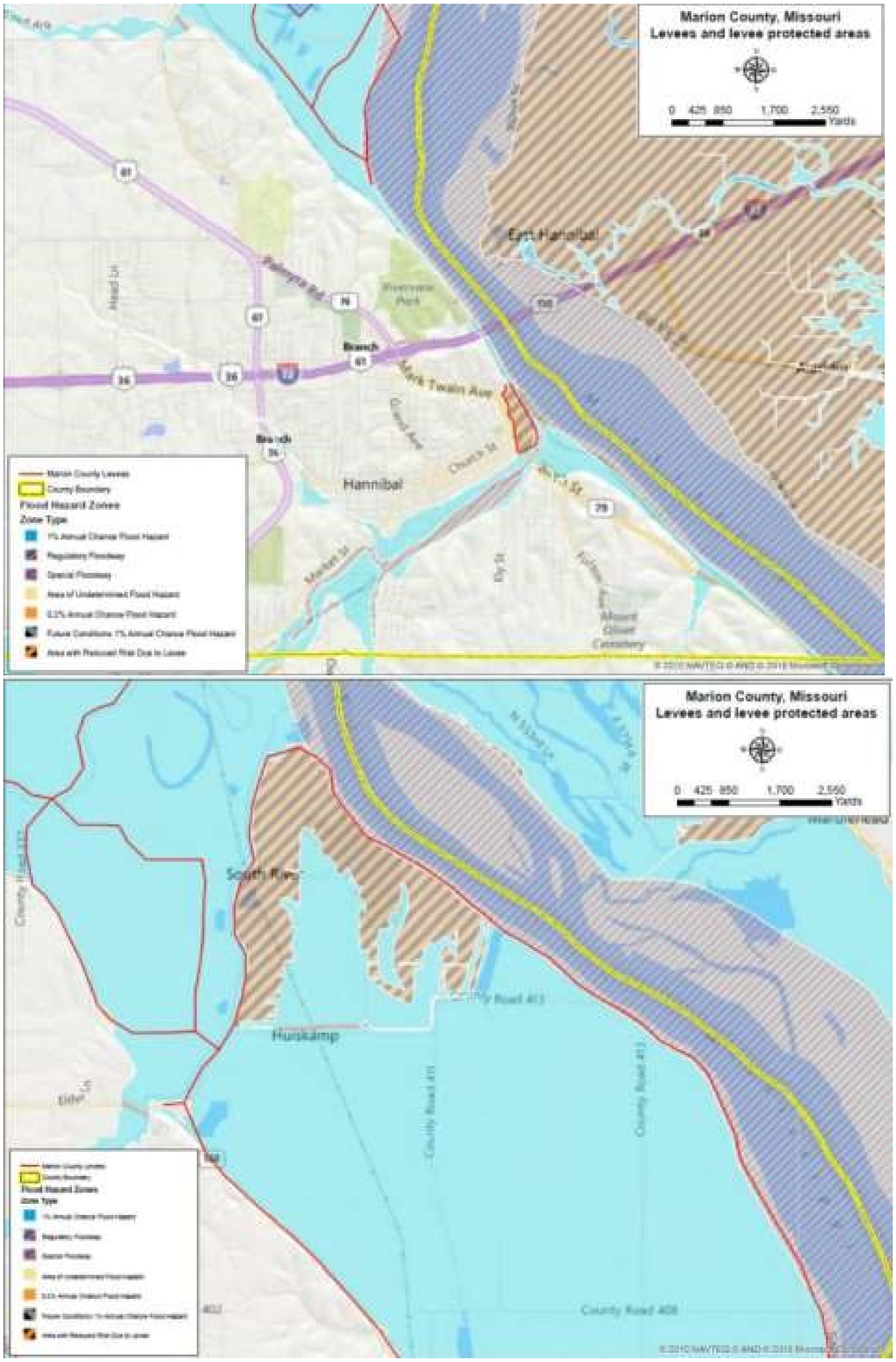
developed by FEMA, captures all levee data (USACE and non-USACE) but primarily focuses on levees that provide 1% annual-chance flood protection on FEMA Flood Insurance Rate Maps (FIRMs).
It is likely that agricultural levees and other non-regulated levees within the planning area exist that are not inventoried or inspected. These levees that are not designed to provide protection from the 1percent annual chance flood would overtop or fail in the 1-percent annual chance flood scenario. Therefore, any associated losses would be taken into account in the loss estimates provided in the Flood Hazard Section.

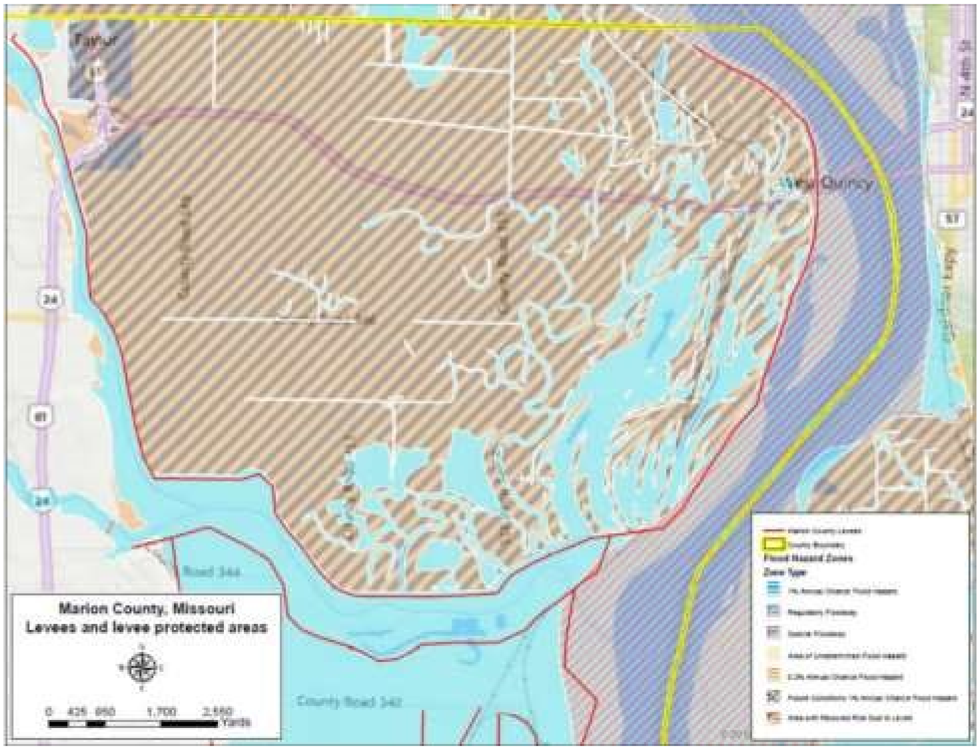
For purposes of the levee failure profile and risk assessment, those levees indicated on the Preliminary DFIRM as providing protection from at least the 1-percent annual chance flood will be discussed and further analyzed. It is noted that increased discharges are being taken into account in revision of the flood maps as part of the RiskMap efforts. This may result in changes to the flood protection level that existing levees are certified as providing. According to the National Levee Database, there are sixteen identified levees in the planning area.

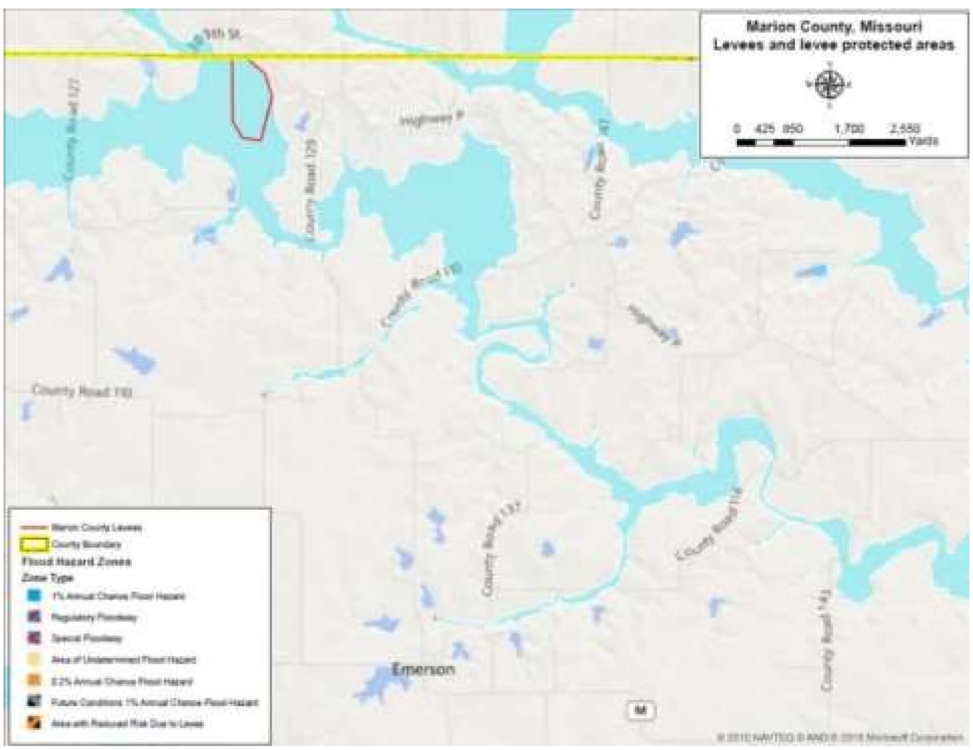
Figure 3.3. Marion County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood

Source: https://levees.sec.usace.army.mil/#

Figure 3.4. County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood







Source: FEMA Flood Insurance Rate Map, 03/08/21

Strength/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.

Previous Occurrences

According to the US Army Corps of Engineers the Fabius River Levee in the far northeast corner of Marion County broke during the flood of 1993 resulting in the inundation of floodwater. The loss in farm production, homes and business in the West Quincy and Taylor areas was substantial. Over fifty homes, businesses and 14,000 acres of valuable farmland were totally inundated. In addition, the loss of commerce with Quincy and the impact on 1800 Marion County residents who could no longer cross the bridge to their jobs in Illinois (commutes of 100 miles via Keokuk, Iowa became the norm) caused serious hardship. The loss of an entire planting season to the farmers in the West Quincy and Taylor areas the Flood of 1993 was financially devastating. However, according to the National Levee Database, the levees in Marion County are at low risk for being overtopped in the next year and within the next 30 years.

Probability of Future Occurrence

According to the data researched during the last 27 years Marion County has only had one levee breach resulting in a low probability Marion County will have a levee breach in any given year. Due to a lack of a centralized database for Missouri levees the ability to obtain levee breach data is very limited. Changing Future Conditions Considerations

Changing Future Considerations

The impact of changing future conditions on levee failure will most likely be related to changes in precipitation and flood likelihood. Climate change projections suggest that precipitation may increase and occur in more extreme events, which may increase risk of flooding, putting stress on levees and increasing likelihood of levee failure.

Vulnerability

Vulnerability Overview

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.

Both Routine and Periodic Inspections result in a rating for operation and maintenance. Each levee segment receives an overall segment inspection rating of Acceptable, Minimally Acceptable, or Unacceptable. **Figure 3.5** below defines the three ratings.

Figure 3.5. Definitions of the Three Levee System Ratings

Levee System Inspection Ratings

Acceptable	All inspection items are rated as Acceptable.
Minimally Accept	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 two (2) of the three (3) dams listed for Marion County as minimally acceptable and one (1) as acceptable.

Potential Losses to Existing Development

To determine the population and building count vulnerable to damage if these levee segments were to fail, the “Area Protected by Levees” feature class from the FEMA Midterm Levee Inventory was overlaid on census block –level buildings and population data from US Census 2010. As the vulnerability analysis of levee failure in this plan is limited to levees indicated as providing protection from 100-year or higher base flood level, protected area polygons were extracted for levees with a stated level of protection for the 100-year flood or greater. The overlay was performed using proportional division (so that if the levee protected area covers a fraction of a census block, that fraction of the building or population data is counted in the exposure), the building and contents value, building count and population exposure was calculated. While the levee program has made extraordinary progress, there are still limitation and gaps in the data available. The study information for MO did not have inland levee protection information other than those listed on the major rivers. From this analysis, it was determined that the population at risk in the levee protected area is approximately 566 people. The residential building exposure count in the levee protected area is 221 and the building loss is $221,517,950.37.

Impact of Previous and Future Development

Impact on future development in the planning area is directly related to the floodplain management and regulations set forth by Marion County and individuals through levee management and regulations which are not clearly defined. It is difficult to predict the impact on future development due to most private levees are not regulated or inspected by one agency or on a regular basis. Any new construction that falls in the floodplain will have to adhere to Marion County's construction and zoning regulations and must adhere to those regulations.

EMAP Consequence Analysis

Table 3.23. EMAP Impact Analysis: Levee Failure

Subject	Detrimental Impacts
Public	Localized impact expected to be severe for inundation area and moderate to light for other adversely affected areas.
Responders	Localized impact expected to limit damage to personnel in the inundation area at the time of the incident.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations. Localized disruption of roads and/or utilities may postpone delivery of some services.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the inundation area of the incident. Some severe damage possible.
Environment	Localized impact expected to be severe for inundation area and moderate to light for other adversely affected areas.
Economic Condition of Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time, depending on damage and length of investigation.
Public Confidence in the Jurisdiction's Governance	Localized impact expected to adversely affect confidence in local, state, and federal government, regardless of the levee owner.

Hazard Summary by Jurisdiction

Structures located in the downtown Hannibal area would be vulnerable to the effects of a levee failure along the Mississippi River. The downtown area would experience devastating flooding, substantial business losses and residents in the immediate area would be highly impacted. The City of Taylor is protected by a levee the breached during the 1993 and if this occurred again the same devastating flooding would be experienced.

Problem Statement

Low-head agricultural levees are not regulated or inspected on a regular basis. Residents need to be informed on how to perform inspections on low-head agricultural levees.

3.4.3 Dam Failure

Hazard Profile

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.

Table 3.24. MoDNR 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 3.25. NID Dam Hazard Classification Definitions

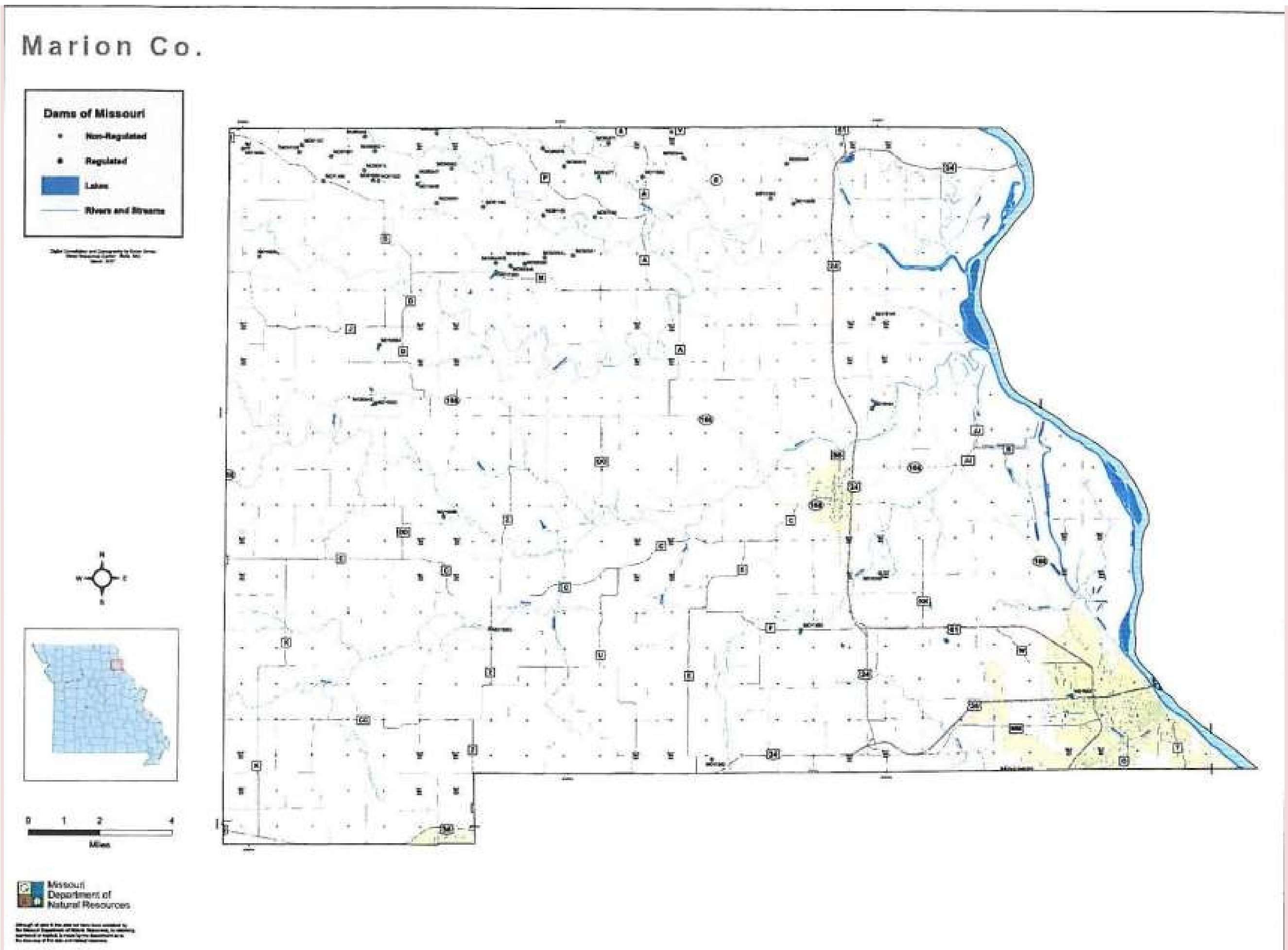
Hazard Class	Definition
Low Hazard	A dam located in an area where failure could damage only farm or other uninhabited buildings, agricultural or undeveloped land including hiking trails or traffic on low volume roads that meet the requirements for low hazard dams.
Significant Hazard	A dam located in 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

Dams Located Within the Planning Area



Marion County has no 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 #21 on the Mississippi River.

The NID Dam data for Marion County includes the following 47 dams: Frankenbach Brothers Lake, Sutter Dam, Stevens Lake Dam, Russel Sandifer Dam, Tallent Lake Dam, Gentry Dam, Lavingon Dam, Sparrow Lake Dam, Bridgeman Dam, Well Dr. JW Dam, Keller Lake Dam, Disckson Lake Dam, Mononame 12, Gard Lake Dam, Gottman Dam, Bevill Dam, Moser Dam, Bevill Dam, Lesser Lake Dam ,Troublesome Creek Watershed Dams – 96, 31, 43, 37, 32, 91, 92, 35, 42, 40, 97, 28, 95, 38, 59 39, 26, 29, 94, 98, 93, 41, Grassy Creek Watershed Dams-99, 93, 94, Reid Dam and Bimson Dam.

Table 3.26. High Hazard Dams in the Marion County Planning Area

Dam Name	Other Dam Name	NIDID	Hazard Potential*	NID Height (Ft.)	River	Nearest City*	Distance To City (Mi.)*	County	State
FRANKENBACH BROS LAKE DAM	-	MO11353	High	30	TR-SOUTH RIVER	HANNIBAL	23	MARION	MO
SUTTER DAM	-	MO11283	High	27	TR TROUBLESOME CREEK	EMERSON	-	MARION	MO
STEVENS LAKE DAM	-	MO10107	High	36	TR SOUTH RIVER	HANNIBAL	20	MARION	MO
RUSSEL SANDIFER DAM	-	MO10259	High	28	TR-NORTH RIVER	PALMYRA	10	MARION	MO
TALLENT LAKE DAM	-	MO10553	Low	25	TR-SOUTH FABIUS RIVER	EMERSON	7	MARION	MO
GENTRY DAM	-	MO11352	Low	24	TR SOUTH RIVER	WEST ELY	3	MARION	MO
LAVINGON DAM	-	MO11350	Low	26	TR GRASSY CREEK	HANNIBAL	28	MARION	MO
SPARROW LAKE DAM	-	MO11489	Low	25	TR-ALLEN BRANCH	NELSONVILLE	4	MARION	MO
BRIDGMAN DAM	-	MO11490	Low	25	TR-SOUTH FABIUS RIVER	NELSONVILLE	35	MARION	MO
WELL,DR J W DAM	DR JW WELL DAM -1974 DAM INV	MO10054	Low	20	TR SOUTH FABIUS RIVER	PHILADELPHIA	2	MARION	MO
KELLER LAKE DAM	CB KELLER DAM - 1974 DAM INV	MO10565	Low	29	TR-SOUTH FABIUS RIVER	HANNIBAL	20	MARION	MO
DICKSON LAKE DAM	-	MO10254	Low	25	TR SOUTH FABIUS RIVER	NELSONVILLE	3	MARION	MO
MONONAME 12	-	MO10164	Low	20	TR NORTH RIVER	WEST QUINCY	-	MARION	MO
GARD LAKE DAM	-	MO10104	Low	10	TR-NORTH RIVER	HANNIBAL	20	MARION	MO
GOTTMAN DAM	-	MO10251	Low	30	TR-SOUTH FORK NORTH RIVER	HANNIBAL	30	MARION	MO
BEVILL DAM	-	MO10252	Low	25	TR NORTH RIVER	PHILADELPHIA	1	MARION	MO
TROUBLESOME CREEK WATERSHED DAM S- 96	STR S-96	MO50352	Low	26	TR-TROUBLESOME CREEK	NELSONVILLE	2	MARION	MO
MOSER DAM	-	MO50534	Low	27	TR-NORTH FABIUS RIVER	TSYLOR	2	MARION	MO
BEVILL DAM	-	MO50343	Low	26	TR-NORTH RIVER	HANNIBAL	27	MARION	MO
LEESER LAKE DAM	-	MO12352	Low	29	TRIB SO FARIUS CREEK	HANNIBAL	25	MARION	MO
TROUBLESOME CREEK WATERSHED DAM R- 31	-	MO50951	Low	28	TROUBLESOME CREEK	NONE	-	MARION	MO
GRASSY CREEK WATERSHED DAM G- 96	-	MO50877	Low	31	GRASSY CREEK	DURHAM	4	MARION	MO
TROUBLESOME CREEK WATERSHED DAM R- 43	-	MO51156	Low	26	TR-TROUBLESOME CREEK	EMERSON	1.5	MARION	MO
TROUBLESOME CREEK WATERSHED DAM R- 37	-	MO51155	Low	30	TR-TROUBLESOME CREEK	PHILADELPHIA	3.5	MARION	MO
TROUBLESOME CREEK WATERSHED DAM R- 32	-	MO51153	Low	31	TR-TROUBLESOME CREEK	EMERSON	2	MARION	MO
TROUBLESOME CREEK WATERSHED DAM S- 91	-	MO51157	Low	27	TR-TROUBLESOME CREEK	STEFFENVILLE	4.5	MARION	MO
TROUBLESOME CREEK WATERSHED DAM S- 92	-	MO51158	Low	31	TR-TROUBLESOME CREEK	STEFFENVILLE	4.5	MARION	MO
TROUBLESOME CREEK WATERSHED DAM R- 35	-	MO51154	Low	27	TR-TROUBLESOME CREEK	EMERSON	1.4	MARION	MO
TROUBLESOME CREEK WATERSHED DAM R- 42	STR R-42	MO50351	Low	25	TR-TROUBLESOME CREEK	NONE	-	MARION	MO
TROUBLESOME CREEK WATERSHED DAM R- 40	STR R-40	MO50350	Low	33	TR-TROUBLESOME CREEK	NONE	-	MARION	MO
TROUBLESOME CREEK WATERSHED DAM S- 97	-	MO51030	Low	38	TR-TROUBLESOME CREEK	NAOMI	5	MARION	MO
TROUBLESOME CREEK WATERSHED DAM R- 28	STR R-28	MO50347	Low	27	TR-TROUBLESOME CREEK	NONE	-	MARION	MO
TROUBLESOME CREEK WATERSHED DAM S- 95	STR S-95	MO50346	Low	26	TR-TROUBLESOME CREEK	NELSONVILLE	2	MARION	MO
TROUBLESOME CREEK WATERSHED DAM R- 38	STR R-38	MO50348	Low	28	TR-TROUBLESOME CREEK	NONE	-	MARION	MO
TROUBLESOME CREEK WATERSHED DAM R- 39	STR R-39	MO50349	Low	32	TR-TROUBLESOME CREEK	NONE	-	MARION	MO
TROUBLESOME CREEK WATERSHED DAM R- 26	-	MO50954	Low	34	TROUBLESOME CREEK	NONE	-	MARION	MO
TROUBLESOME CREEK WATERSHED DAM R- 29	-	MO50952	Low	34	TR-TROUBLESOME	NONE	-	MARION	MO
GRASSY CREEK WATERSHED DAM G- 99	-	MO50871	Low	27	GRASSY CREEK	DURHAM	2.5	MARION	MO
REID DAM	-	MO50628	Low	36	TR-MIDDLE FABIUS RIVER	MAYWOOD	1	MARION	MO
GRASSY CREEK WATERSHED DAM G- 93	-	MO50878	Low	34	GRASSY CREEK	DURHAM	-	MARION	MO
TROUBLESOME CREEK WATERSHED DAM S- 94	-	MO50913	Low	41	TROUBLESOME CREEK	EWING	8	MARION	MO
BIMSON DAM	-	MO50344	Low	26	TR-SOUTH FABIUS RIVER	HANNIBAL	27	MARION	MO
TROUBLESOME CREEK WATERSHED DAM S- 98	-	MO51029	Low	36	TR-TROUBLESOME CREEK	NAOMI	5	MARION	MO
GRASSY CREEK WATERSHED DAM G- 94	-	MO50872	Low	34	GRASSY CREEK	DURHAM	3	MARION	MO
TROUBLESOME CREEK WATERSHED DAM S- 93	-	MO51031	Low	29	TR-TROUBLESOME CREEK	NONE	-	MARION	MO
TROUBLESOME CREEK WATERSHED DAM R- 41	-	MO50953	Significant	37	TR-TROUBLESOME	EMERSON	-	MARION	MO

Sources: National Inventory of Dams, http://nid.usace.army.mil/cm_apex/f?p=838:12

Figure 3.5 High Hazard Dams Locations in Marion County

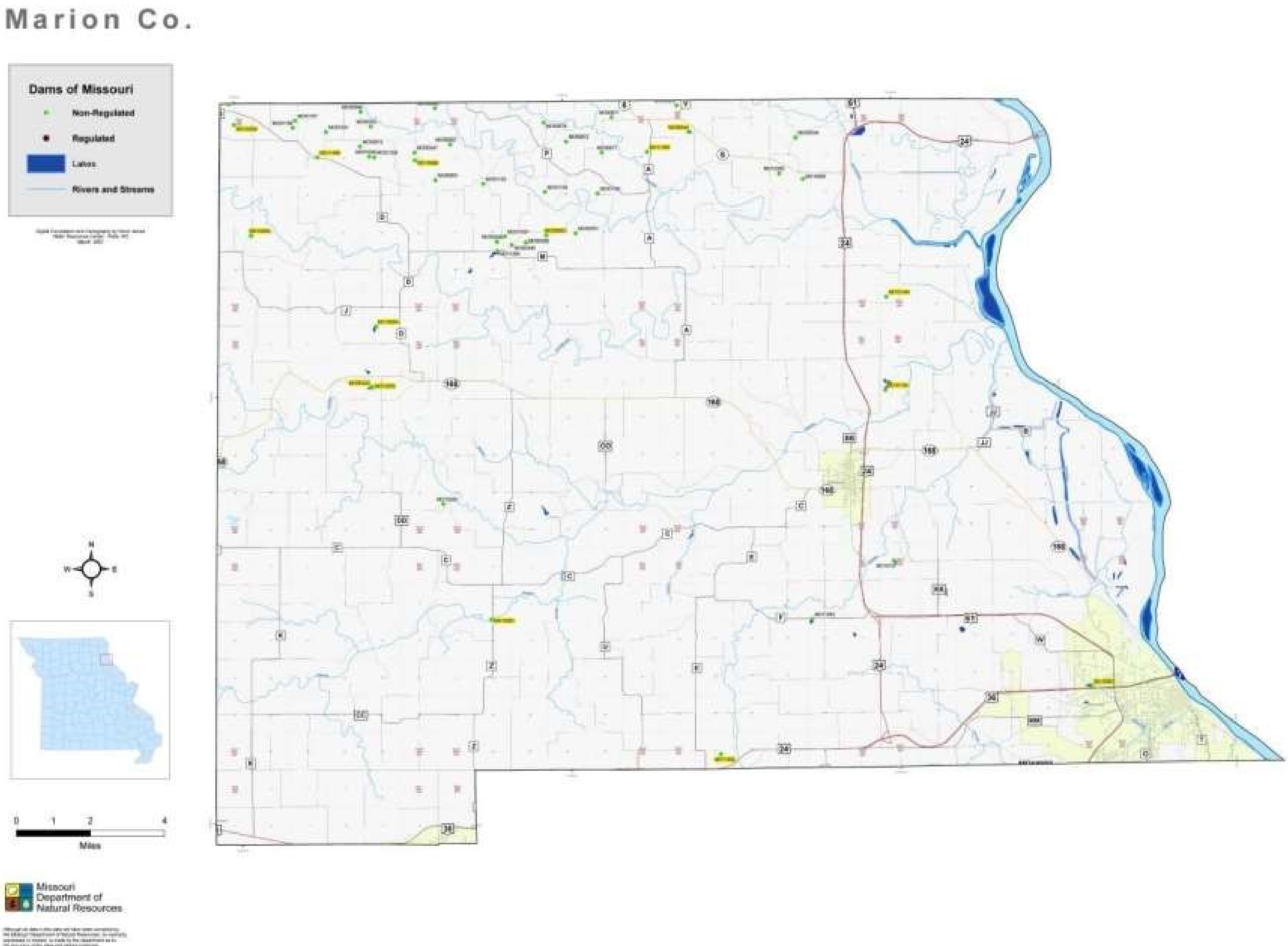
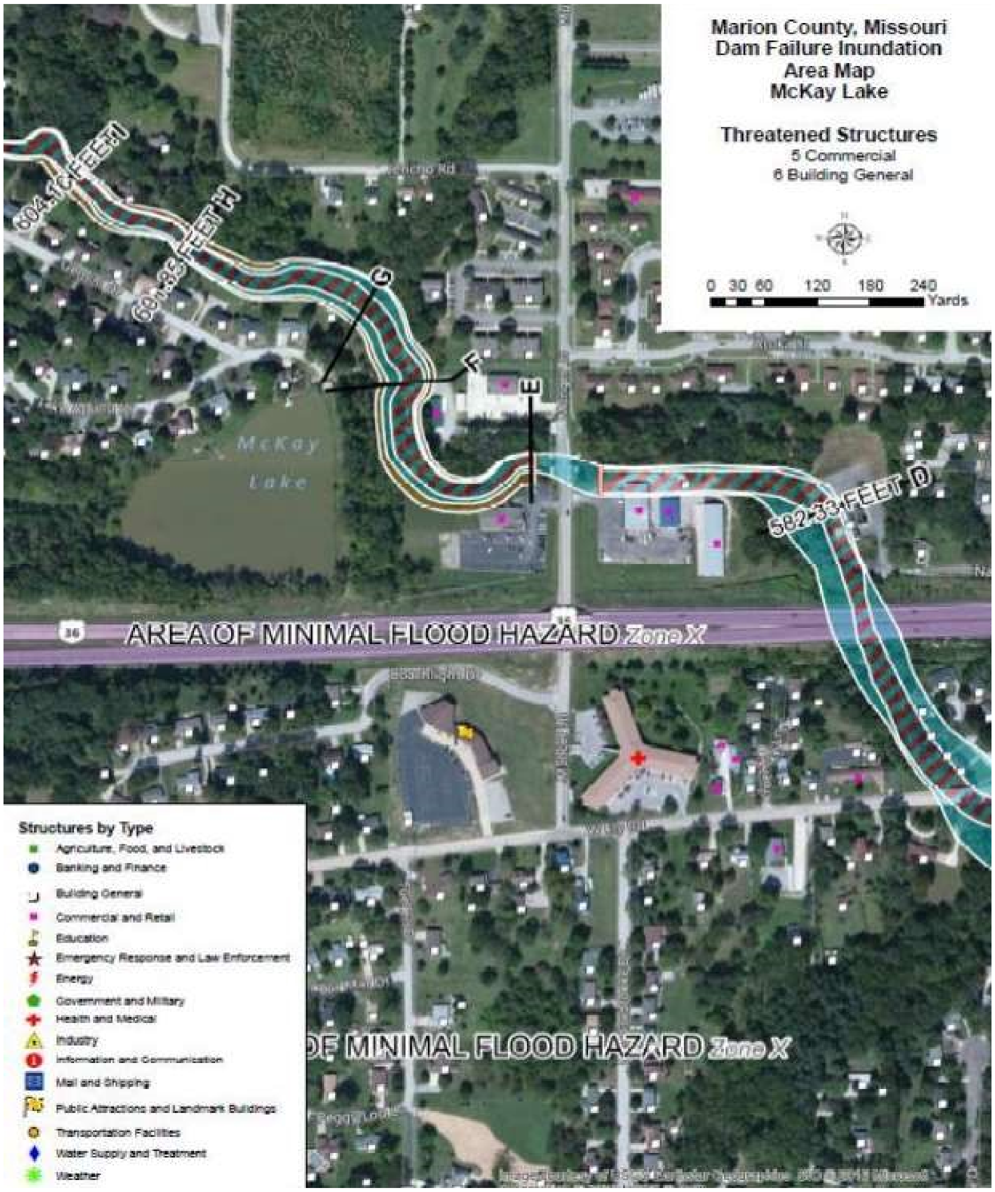


Figure 3.6. High Hazard Dam Locations in Marion County and Areas Impacted in the Event of Breach.



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

In the event of a breach of the McKay Dam located in the City of Hannibal could be detrimental to the area protected by the dam. The location of the 16 remaining high hazard dams in the planning are located in the rural area and future development would have very little impact.

Upstream Dams Outside the Planning Area

The Missouri Department of Natural Resources was consulted and Lewis County north of Marion County has four dams: Deerridge, Ewing Lake Dame, LaBelle and Bellview Lake Dam. None of the dams listed would affect Marion County. At the time of plan development, an inundation map was under development. However, it was not yet available for incorporation in the risk assessment. If this, or other inundation maps become available, they will be incorporated in the update to this plan.

Strength/Magnitude/Extent

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.

Previous Occurrences

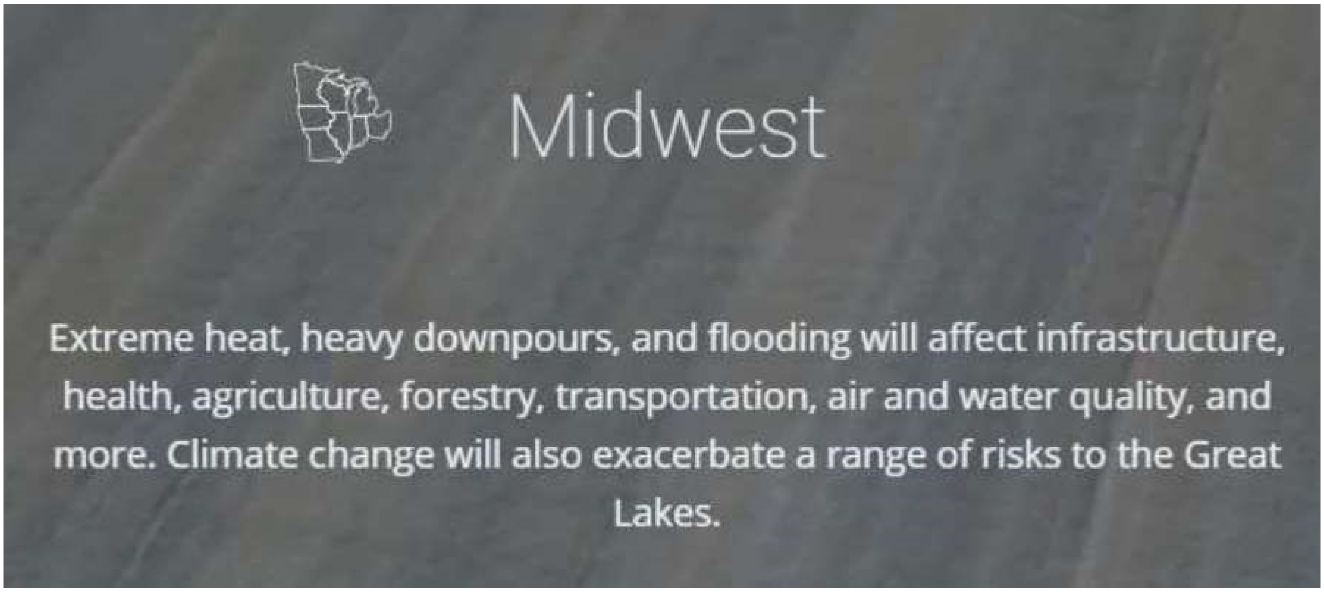
To determine previous occurrences of dam failure within the Marion County, the Marion County Missouri Natural Hazard Mitigation Plan was consulted as well as the Missouri State Hazard Mitigation Plan and the Stanford University's National Performance of Dams Program (http://npdp.stanford.edu/). No record of dam failure within Marion County boundaries was found.

Probability of Future Occurrence

Due to the number of high hazard dams (17 in Marion County) dam failure and its associated impacts is a possibility for disaster. Sixteen of the 17 dams are located in rural areas and would not have a major effect. The McKay Dam located within the limits of Hannibal could have a significant impact on the businesses and residents in the inundation area.

Changing Future Conditions Considerations

Source: US Climate Resilience Toolkit; https://toolkit.climate.gov/tools/climate-explorer



Source: National Climate Assessment; https://nca2014.globalchange.gov/

Vulnerability

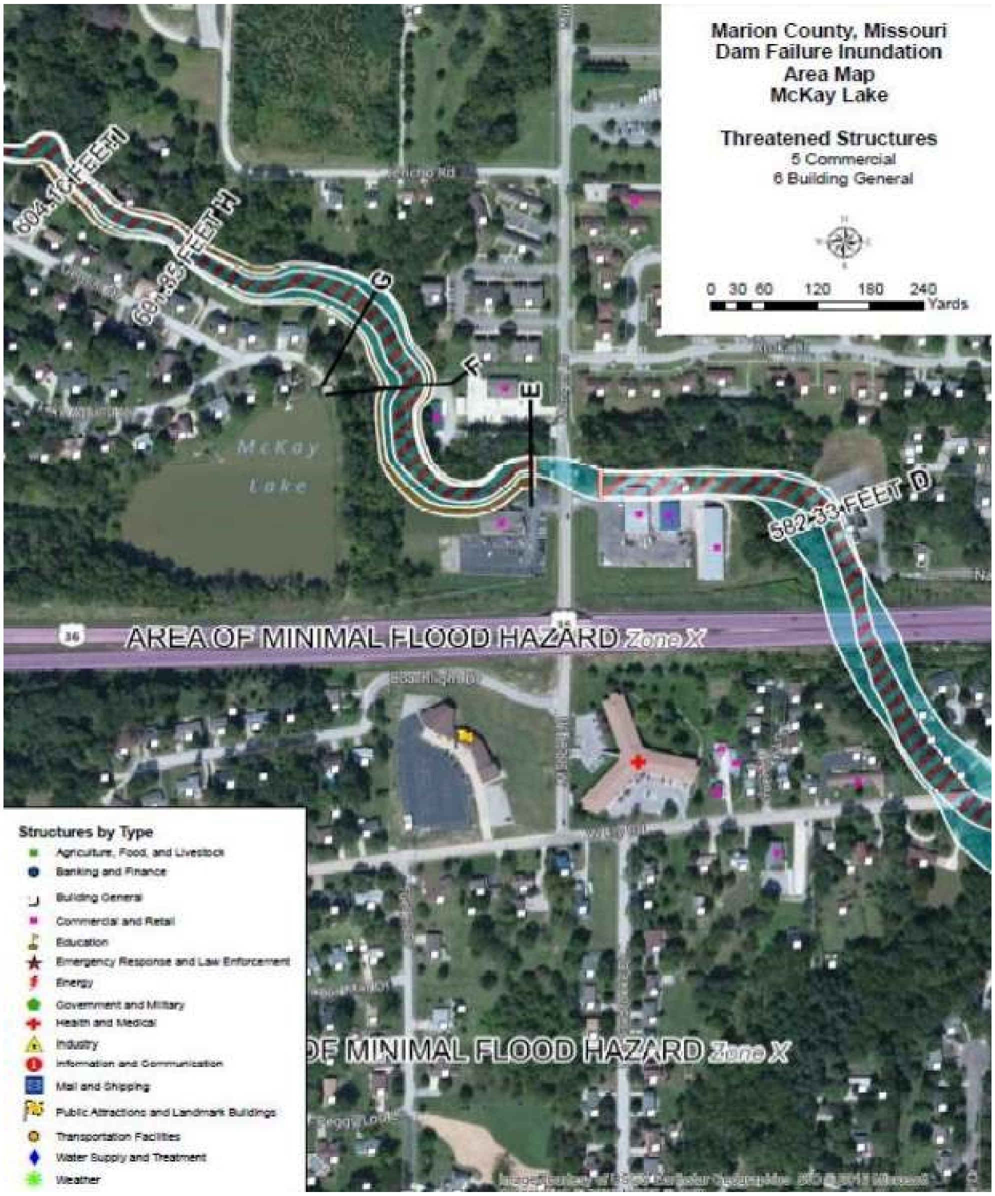
Vulnerability Overview

Vulnerability to dam failure is limited to a very few areas in Marion County, primarily within the city of Hannibal where one of the high hazard dams are located.

Potential Losses to Existing Development:
(including types and numbers, of buildings, critical facilities, etc.)

Figure 3.6 shows the lost to existing development if the McKay Dam would fail. The existing development impacted includes business, residential, roadways, and would be catastrophic for the city of Hannibal.

Figure 3.6 McKay Lake Dam



Impact of Previous and Future Development

Future development in the City of Hannibal could impact the number of damages caused by a failure in the McKay Dam. The location of the 16 remaining high hazard dams in the planning are located in the rural area and future development would have very little impact.

EMAP Consequence Analysis

Table 3.27. EMAP Impact Analysis: Dam Failure

Subject	Detrimental Impacts
Public	Localized impact expected to be severe for inundation area and moderate to light for other adversely affected areas.
Responders	Localized impact expected to limit damage to personnel in the inundation area at the time of the incident.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations. Localized disruption of roads and/or utilities may postpone delivery of some services. Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. Impact may reduce deliveries.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the inundation area of the incident. Some severe damage possible.
Environment	Localized impact expected to be severe for inundation area and moderate to light for other adversely affected areas.
Economic Condition of Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time, depending on damage and length of investigation.
Public Confidence in the Jurisdiction's Governance	Localized impact expected to primarily adversely affect dam owner and local entities.

Hazard Summary by Jurisdiction

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

Problem Statement

A lack of regular inspection/maintenance of un-regulated high hazard dams was noted by the Mitigation Planning Committee. Possible solutions include the development of a regular maintenance schedule, identification of qualified staff and/or consultant to assist, and maintenance report submittal requirements.

3.4.4 Earthquakes

<u>Hazard Profile</u>

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.

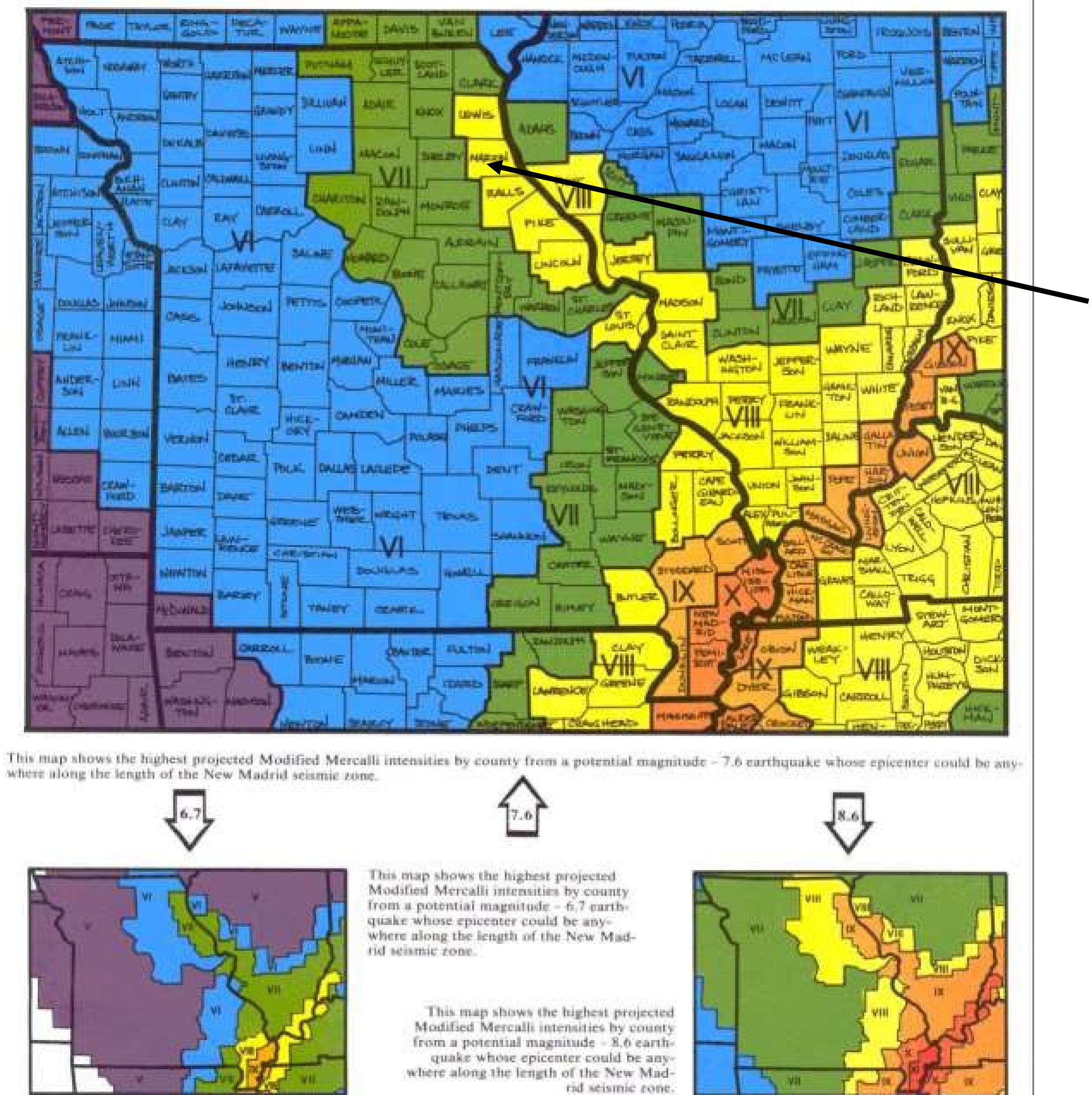
Some earthquakes occur in the middle of plates, as is the case for seismic zones in the Midwestern United States. The most seismically active area in the Midwest is the New Madrid Seismic Zone. The possibility of the occurrence of a catastrophic earthquake in the Central and Eastern United States is 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 earthquakes 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 50km 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 Marion 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 3.7) 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 Marion County and the affects that could be felt from the earthquake.

Figure 3.7. Impact Zones for Earthquake Along the New Madrid Fault



Source: https://sema.dps.mo.gov/docs/EQ_Map.pdf *Arrow indicates Marion County

Figure 3.8. 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.

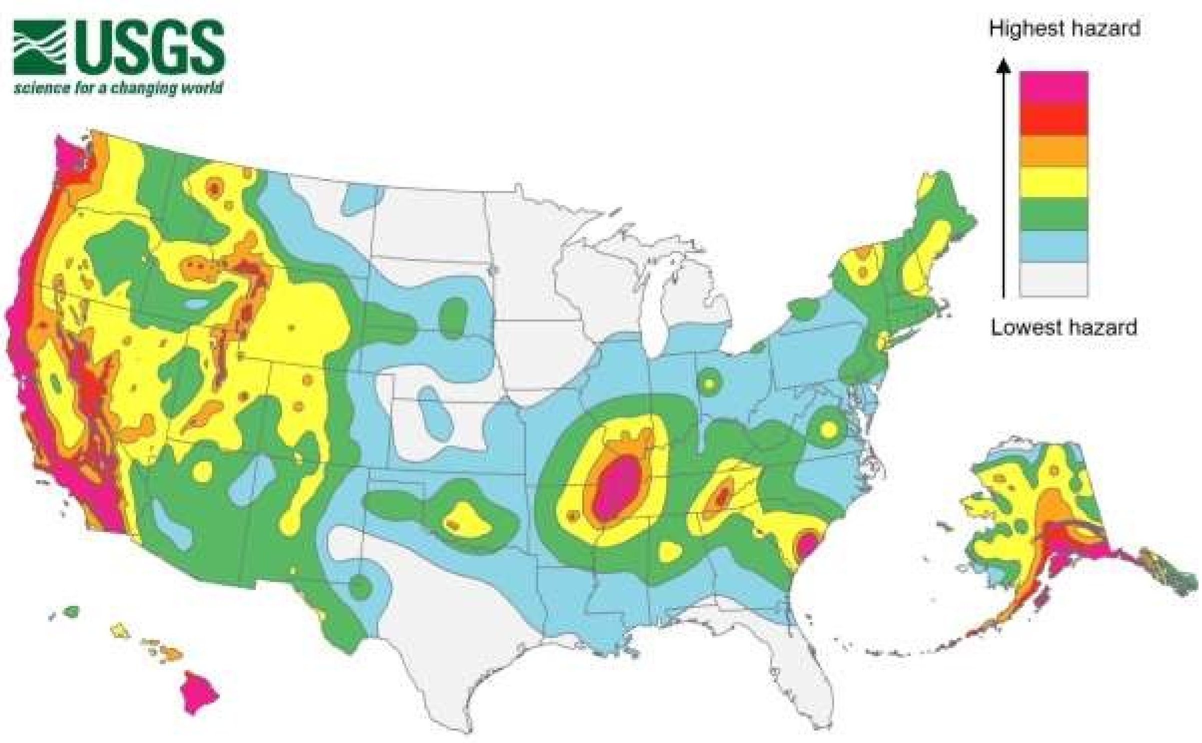
XI Few if any masonry structures remain standing. Large, well-built bridges are destroyed. Wood frame structures are severely damaged, especially near epicenters. Buried pipelines are rendered completely useless. Railroad tracks are badly bent. Water mixed with sand, and mud is ejected in large amounts.

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.

Prepared and distributed by
THE MISSOURI STATE
EMERGENCY MANAGEMENT AGENCY
P.O. BOX 116
JEFFERSON CITY, MO 65102
Telephone: 573-526-9100

Figure 3.9. United States Seismic Hazard Map



Source: United States Geological Survey at
https://earthquake.usgs.gov/hazards/hazmaps/conterminous/2014/images/HazardMap2014_lg.jpg

Strength/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 as 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

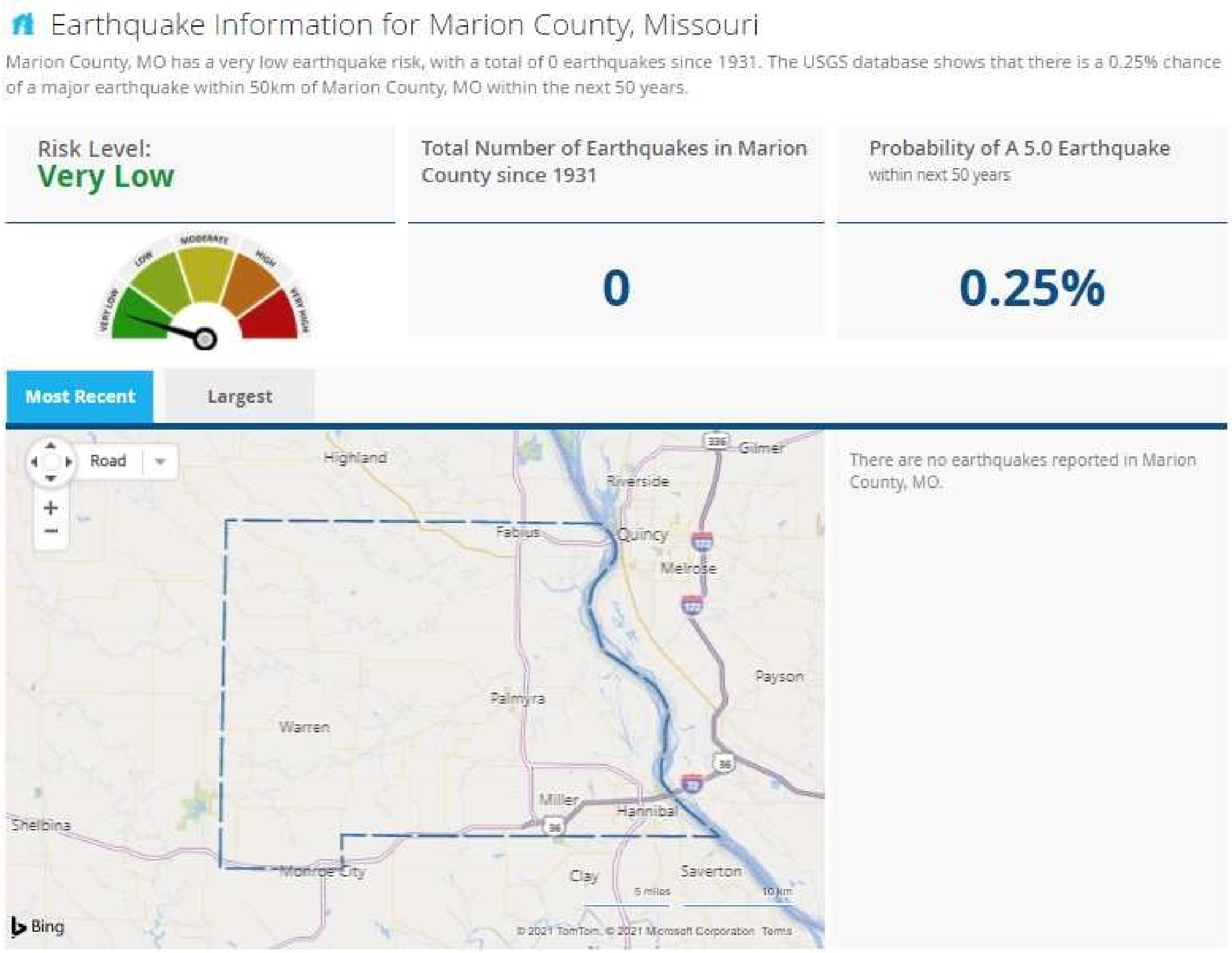
The intensity of an earthquake is measured by the effect of the earthquake on the earth's surface. The intensity scale is based on the responses to the quake, such as people awakening, movement of furniture, damage to chimneys, etc. The intensity scale currently used in the United States is the

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 within 30 miles of Marion County since 1931.

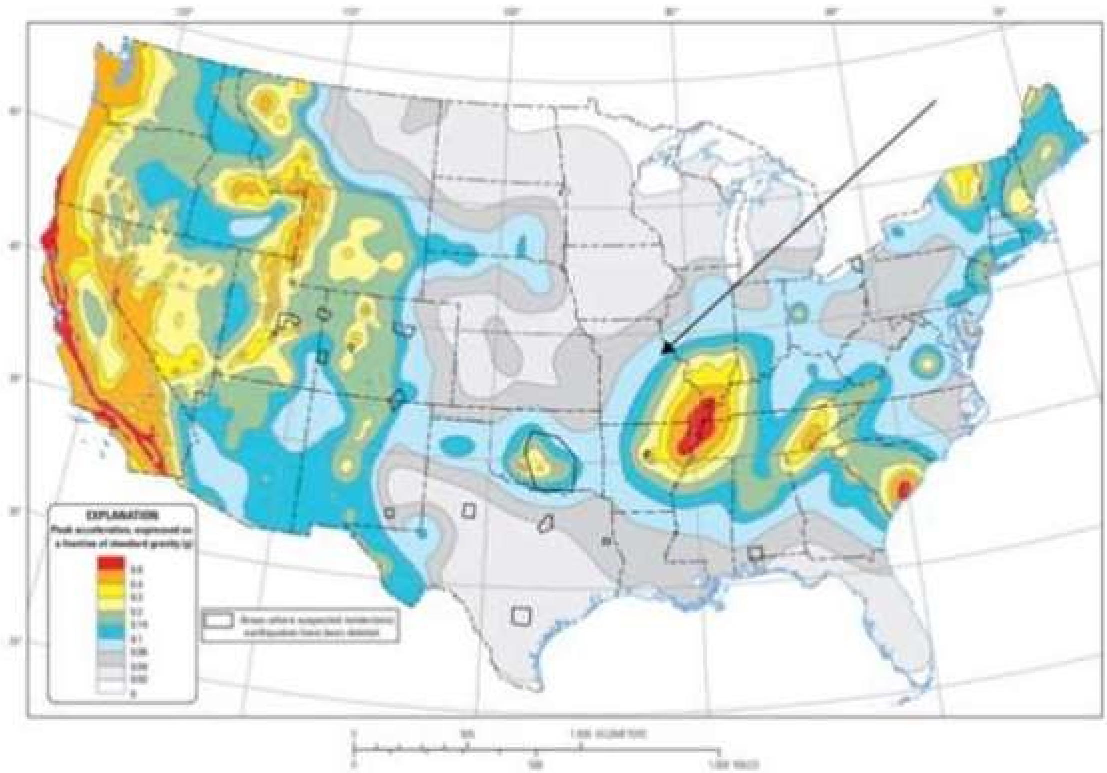
Probability of Future Occurrence



Source: https://www.homefacts.com/earthquakes/Missouri/Marion-County.html

Marion County has a very low earthquake risk, with 0 earthquakes since 1931 within 30 miles of the planning area. The USGS database shows that there is a 0.25% chance of a major earthquake within 50 km of Marion County within the next 50 years. There are no earthquakes reported in the planning area.

Figure 3.10. **United States Seismic Hazard Map**



Two-percent probability of exceedance in 50 years map of peak ground acceleration

Source: https://earthquake.usgs.gov/hazards/hazmaps/conterminous/index.php#2014

Changing Future Conditions Considerations

Scientists are beginning to believe there may be a connection between changing climate conditions and earthquakes. Changing ice caps and sea-level redistribute weight over fault lines, which could potentially have an influence on earthquake occurrences. However, currently no studies quantify the relationship to a high level of detail, so recent earthquakes should not be linked with climate change. While not conclusive, early research suggests that more intense earthquakes and tsunamis may eventually be added to the adverse consequences which are caused by changing future conditions

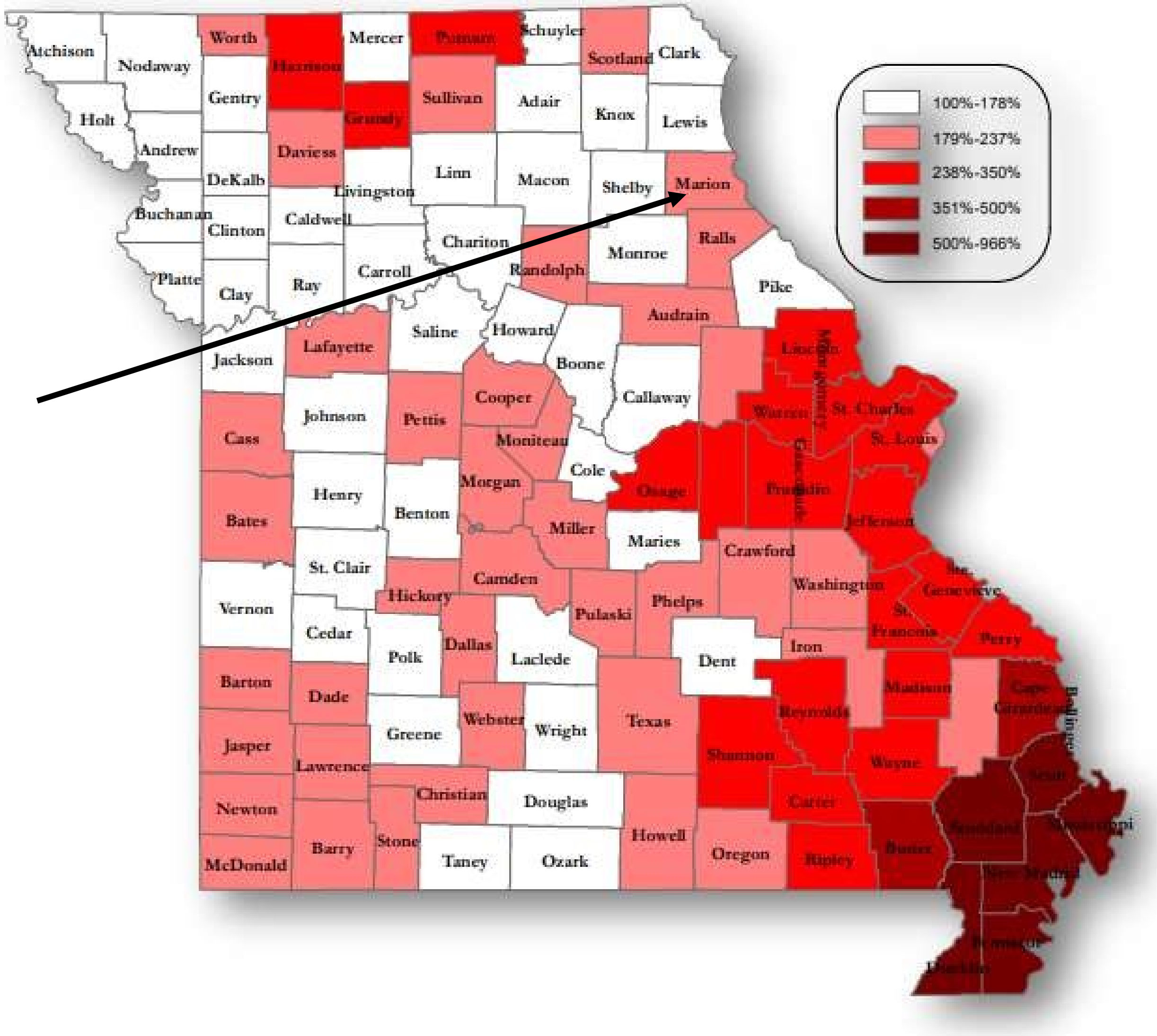
Vulnerability

Vulnerability Overview

According to the data obtained from the 2018 State Plan, Marion County was listed as N/A for Hazard Ranking.

The State of Earthquake Coverage Report states that the average premium for earthquake coverage in Marion County in 2018 was $81.

Figure 3.11. Change in Average Premium for Earthquake Coverage, 2000-2018

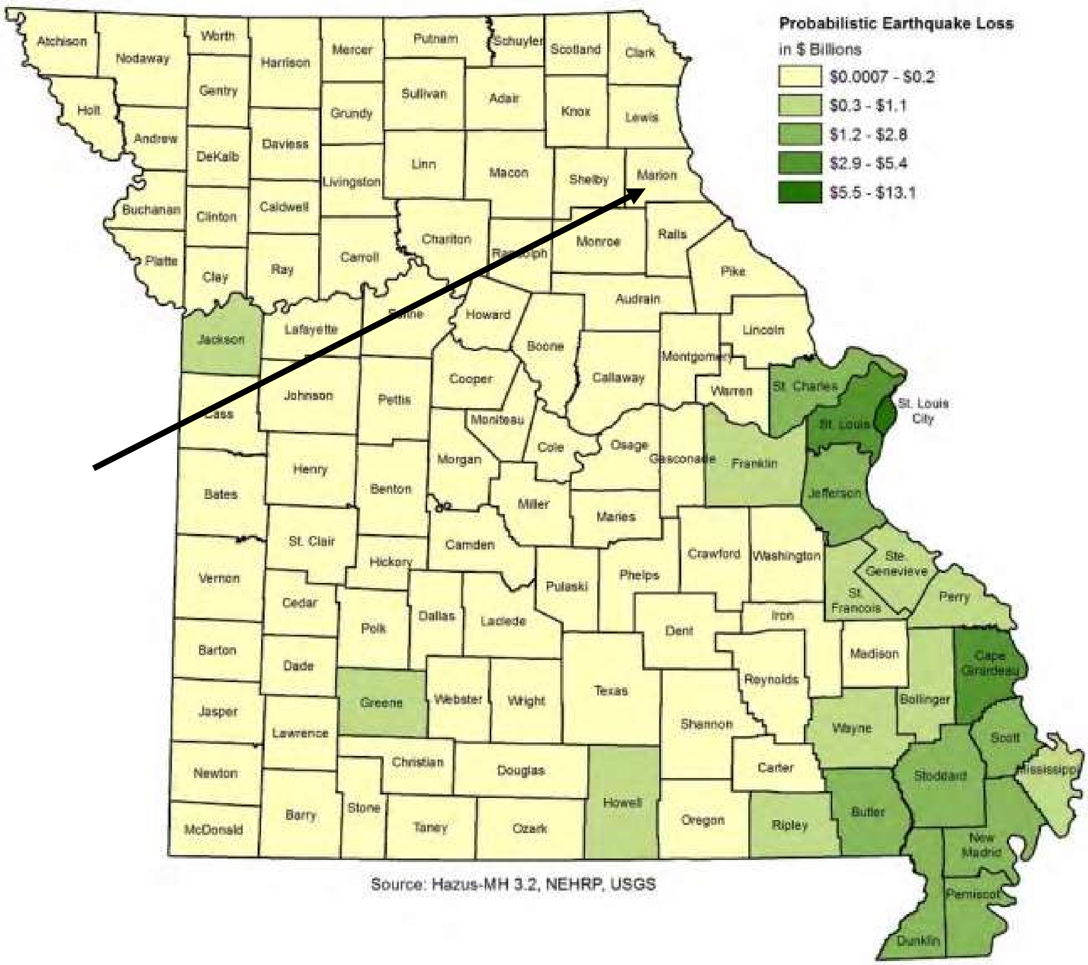


Source: https://insurance.mo.gov/earthquake/documents/EarthquakeInsuranceMarketsInMissouriReport20197-8-2019_000.pdf
*Arrow indicates Marion County

Potential Losses to Existing Development

The Hazus building inventory counts are based on the 2010 census data adjusted to 2014 numbers using the Dun & Bradstreet Business Population Report. Inventory values reflect 2014 valuations, based on RSMeans (a supplier of construction cost information) replacement costs. Population counts are 2010 estimates from the U.S. Census Bureau.

Figure 3.12. HAZUS-MH Earthquake Loss Estimation: Annualized Loss Scenario-Direct Economic Losses to Buildings



Source: 2018 Missouri State Hazard Mitigation Plan *Arrow indicates Marion County

Figure 3.13. HAZUS-MH Earthquake Loss Estimation: Annualized Loss Scenario

County	Total Losses, in $ Thousands	Loss Per Capita, in $ Thousands	Loss Ratio, in $ per Million
Marion	$37	$0.0013	$12

Figure 3.14. Housing Density, Building Exposure, SOVI, and Mobile Home Data

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Ranking Rating	Percent Mobile Homes	Percent Mobile Homes Rating
Marion	$3,224,641,000	1	29.49	1	Medium High	4	5.3	2

Figure 3.15. Number of High Wind, Hail, and Lightning Events, Likelihood of Occurrence, and Associated Ratings

County	HIGH WIND			HAIL			LIGHTNING		
	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating
Marion	64	3.048	2	77	3.667	2	4	0.190	3

Figure 3.16. Annualized Property Loss and Associated Ratings

COUNTY	HIGH WIND		HAIL		LIGHTNING	
	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating
Marion	$5,238	1	$47,619	2	$1,200	2

Sources: Missouri State Hazard Mitigation Plan, 2018
https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan2018.pdf

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.

EMAP Consequence Analysis

For communities with emergency management programs seeking EMAP accreditation, complete Table 3.28 to summarize the detrimental impacts from earthquakes.

Table 3.28. EMAP Impact Analysis: Earthquakes

Subject	Detrimental Impacts
Public	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Responders	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.

Continuity of Operations	Damage to facilities/personnel in the area of the incident may require relocation of operations and lines of succession
	execution. Disruption of lines of communication and destruction of facilities may extensively postpone delivery of services.
Property, Facilities, and Infrastructure	Damage to facilities and infrastructure in the area of the incident may be extensive for facilities, people, infrastructure, and HazMat.
Environment	May cause extensive damage, creating denial or delays in the use of some areas. Remediation needed.
Economic Condition of Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

Since the earthquake intensity is not likely to vary greatly throughout the planning area, the risk will be the same throughout. Marion County is not near the New Madrid Shock Zone, but it will likely endure mild effects from the earthquake such as structure damage environmental impacts and economic disruption/losses. However, damages could vary due to structural variations in the planning area's built environment. For example, the City of Hannibal could see a greater amount of structural damage due to having a higher percentage (34.8%) of residential properties built prior to 1939. The City of Palmyra has a lower percentage (16.3) of residences built before 1939 putting them at a lower risk. Marion County would likely be impacted by the number of refugees traveling through the area seeking safety and assistance.

Problem Statement

Although Marion 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 due to the low likely hood of impact. 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 needs 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 be encouraged.

3.4.5 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.

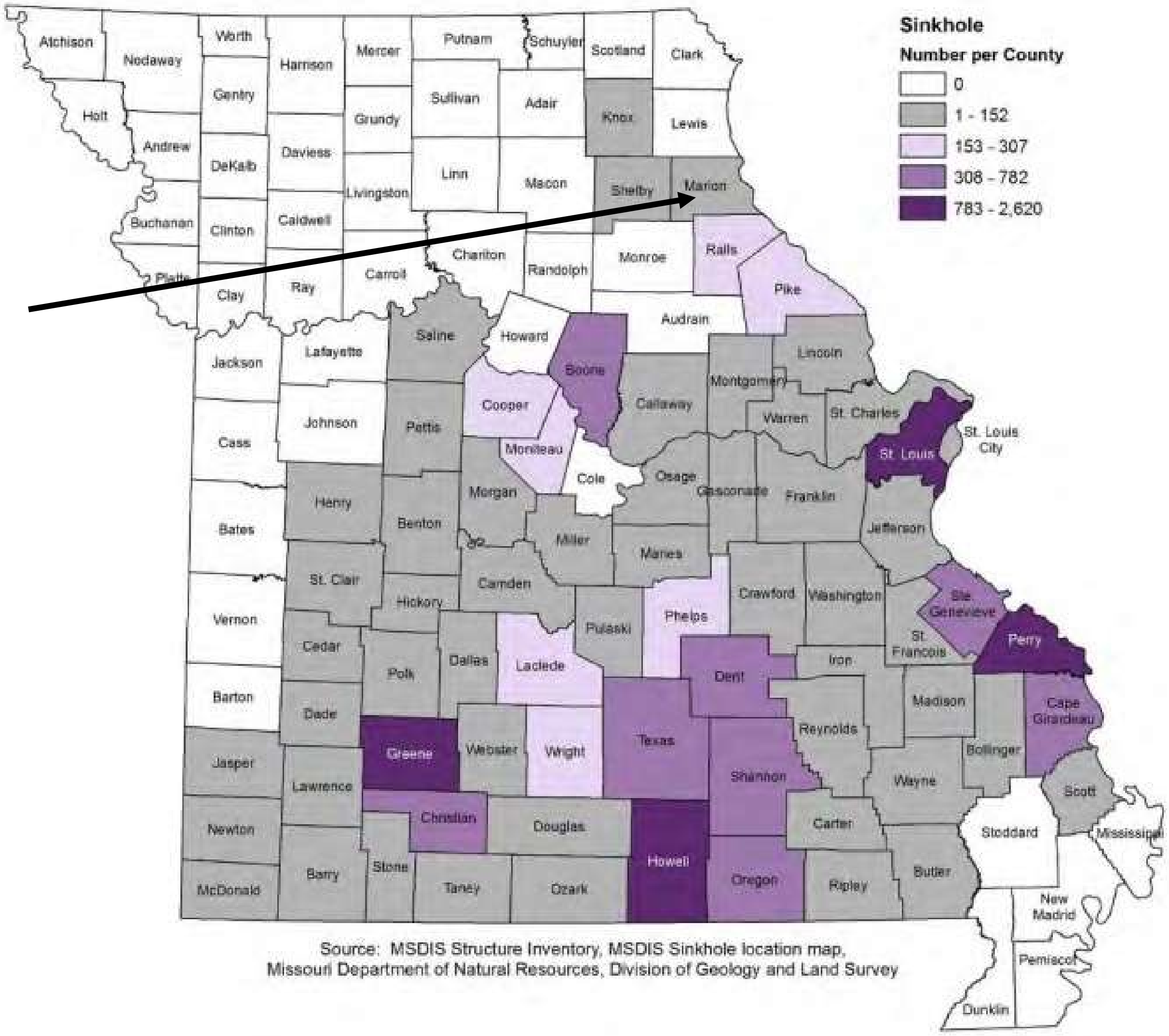
In the case of sinkholes, the rock below the surface is rock that has been dissolving by circulating groundwater. As the rock dissolves, spaces and caverns form, and ultimately the land above the spaces collapse. In Missouri, sinkhole problems are usually a result of surface materials above openings 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 the 2018 Missouri State Hazard Mitigation Plan, there are 46 mines in Marion County and 44 sinkholes.

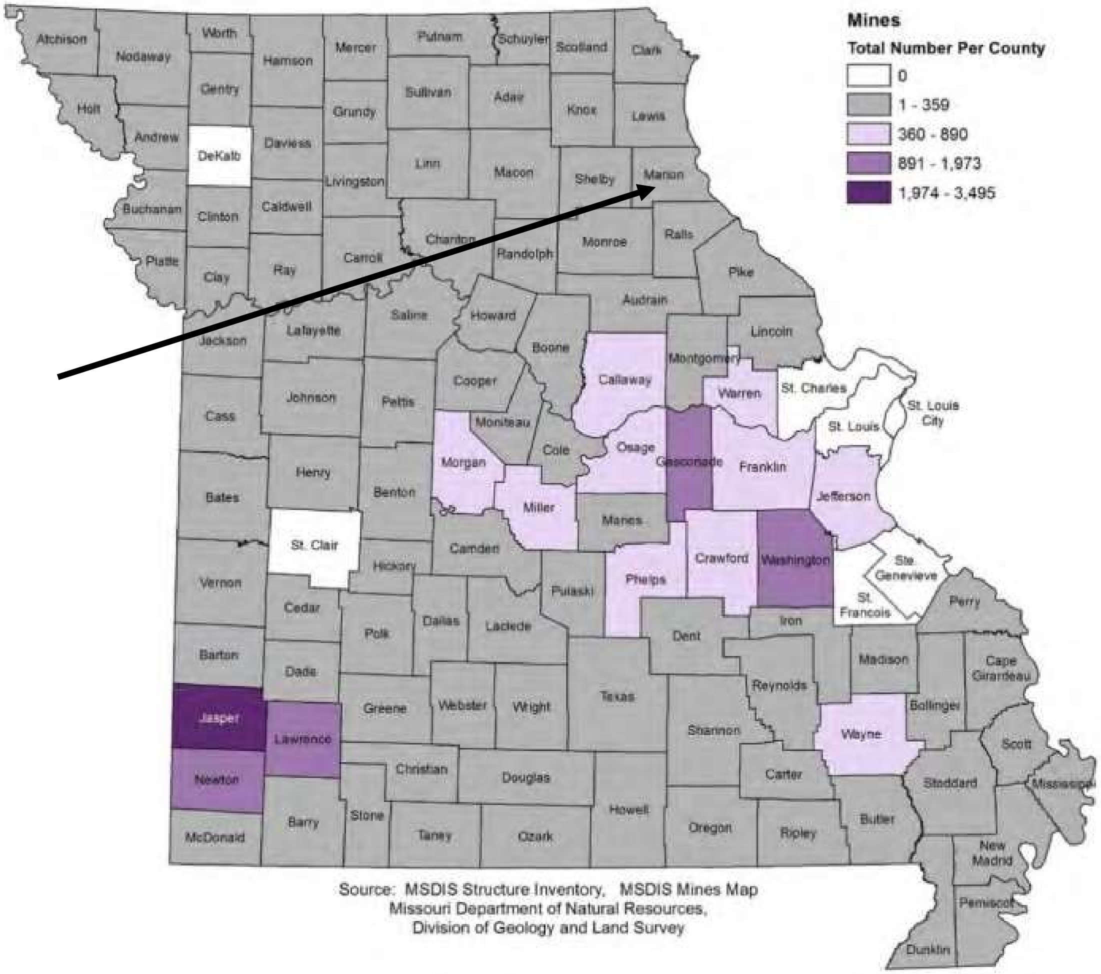
Geographic Location

Figure 3.17. Sinkholes in Marion County



Source: Missouri State Hazard Mitigation Plan, 2018
https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan2018.pdf

Figure 3.18. Mines in Marion County



Source: Missouri State Hazard Mitigation Plan, 2018
https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan2018.pdf

Figure 3.19. Sinkhole and Mine Counts in Marion County

County	Number of Sinkholes Per County	Number of Mines Per County
Marion	44	46

Source: Missouri State Hazard Mitigation Plan, 2018
https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan2018.pdf

Strength/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.

Previous Occurrences

As noted in the 2018 State Plan, sinkholes are a regular occurrence in Missouri, but rarely are they events of any significance. However, not only have flood waters taken their toll on residents, but the streets of Hannibal have also taken a beating. A sinkhole opened near the intersection of South Ninth and Lyon Streets in May 2019. A sinkhole collapsed on February 2, 2020 on Union Street in Hannibal, under the feet of resident taking a walk which resulted in injury.

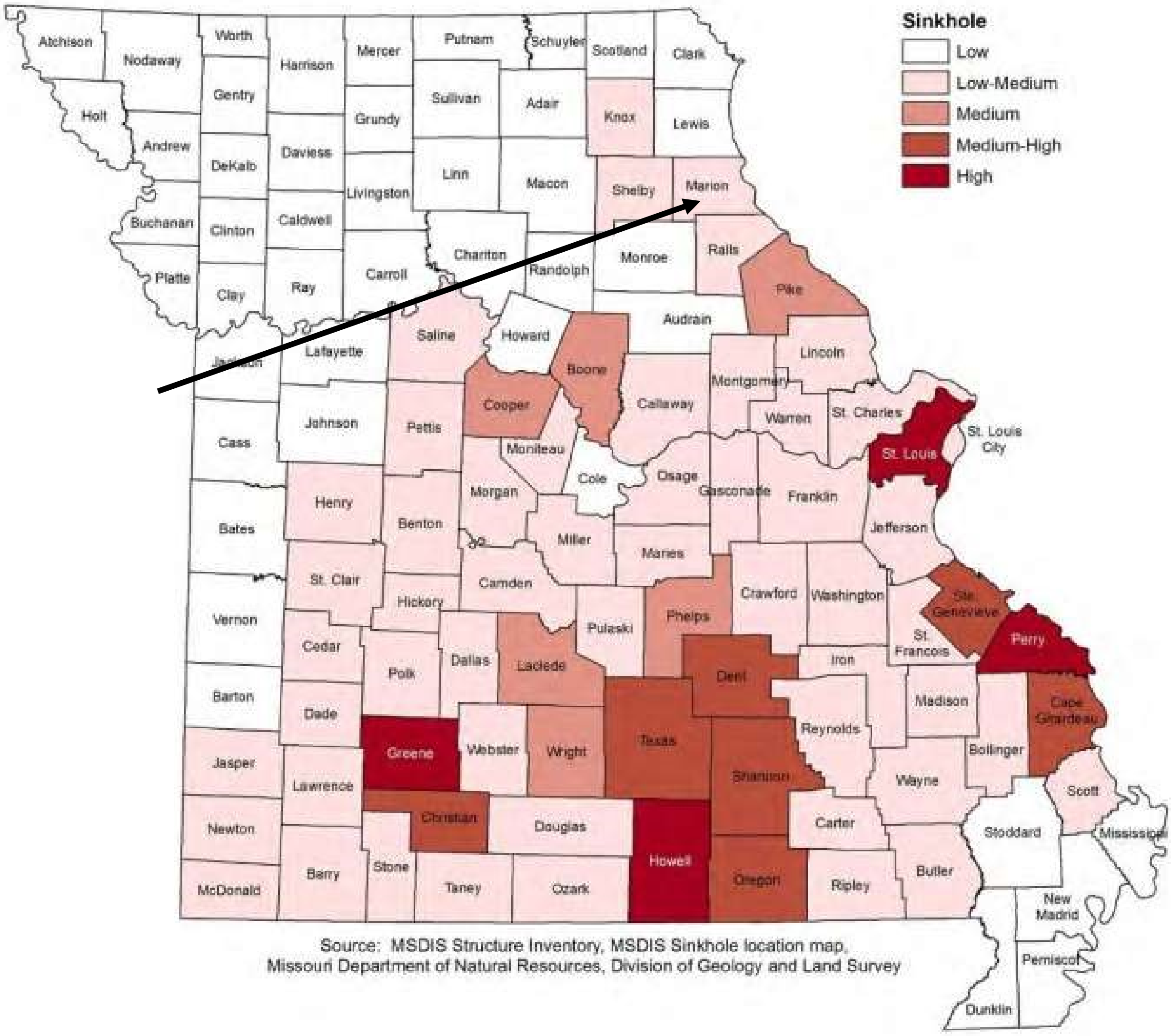
Probability of Future Occurrence

Probability of future occurrence cannot be calculated due to insufficient records of every sinkhole event. Sinkholes have a greater reputation of being a dangerous nuisance in Southern Missouri, but Marion County is still susceptible to collapses due to recent flooding events and general human activities. As represented in the figures below, the sinkholes located in Marion County have been rated Low-Medium risk with mines being rated Low risk.

Figure 3.20. Sinkhole Rating Values

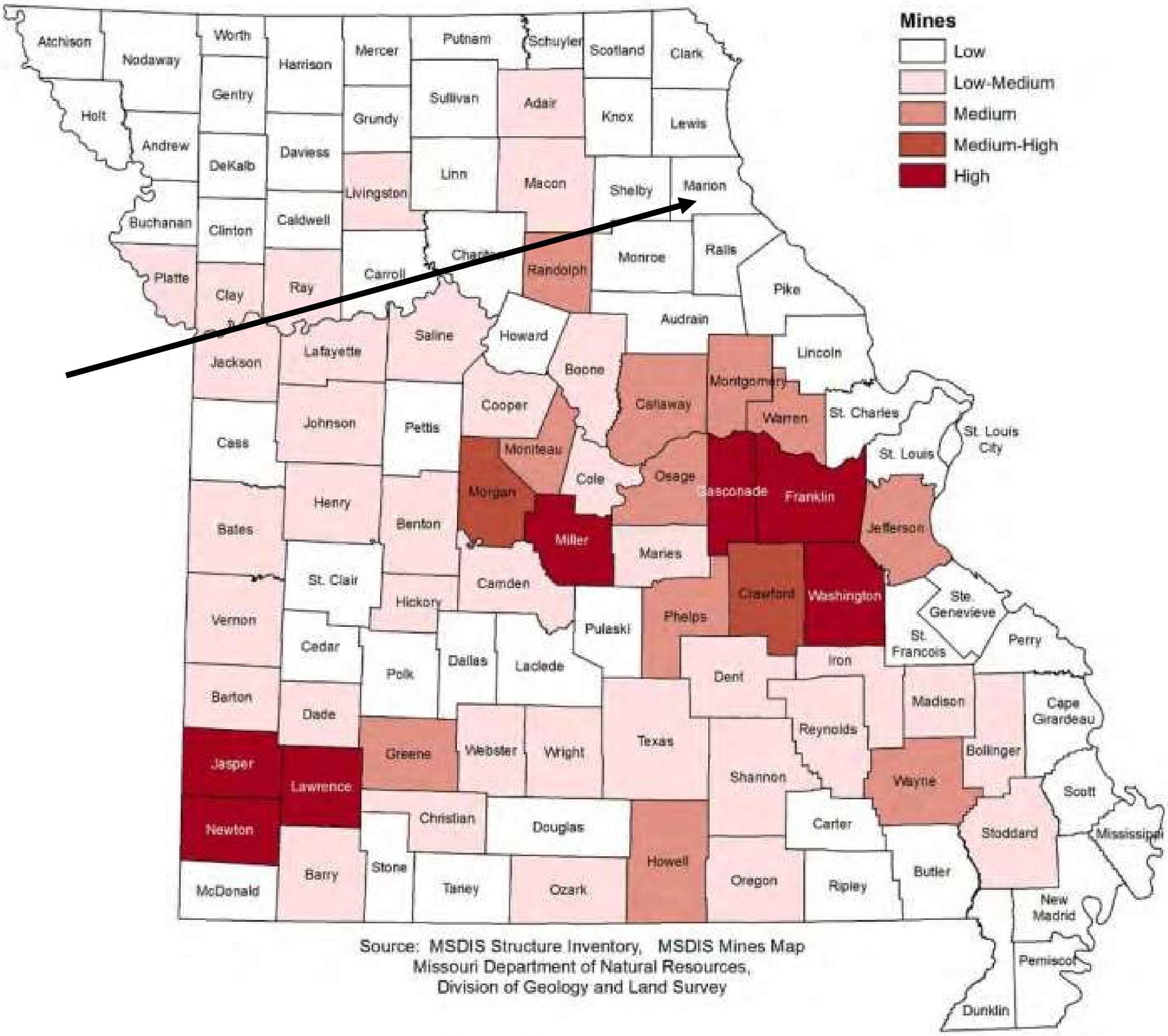
Factor	1 (Low)	2 (Low-medium)	3 (Medium)	4 (Medium-high)	5 (High)
Sinkholes per county	0	1 – 200	201 – 400	401 – 800	801+
Mines per county	0 - 100	101 - 250	251 – 500	501 – 750	751 +

Figure 3.21. Sinkhole Rating Value by County



Source: Missouri State Hazard Mitigation Plan, 2018
https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan2018.pdf

Figure 3.22. Mine Rating Value by County



Source: Missouri State Hazard Mitigation Plan, 2018
https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan2018.pdf

Changing Future Conditions Considerations

According to the 2018 Missouri State Hazard Mitigation Plan, direct effects from changing climate conditions such as an increase in droughts and could contribute to an increase in sinkholes. These changes raise the likelihood of extreme weather, meaning the torrential rain and flooding conditions which often lead to the exposure of sinkholes are likely to become increasingly common. Certain events such as a heavy precipitation following a period of drought can trigger a sinkhole due to low levels of groundwater combined with a heavy influx of rain.

Vulnerability

Vulnerability Overview

Sinkholes in the planning area are not a common occurrence due to composition of the land. However, recent flooding events has made Marion County more vulnerable. 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.

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 the mapping of potential sinkholes 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 not 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

Marion County is documented to have a large number of caves and the 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.

EMAP Consequence Analysis

For communities with emergency management programs seeking EMAP accreditation, complete Table 3.29 to summarize the detrimental impacts from land subsidence/sinkholes.

Table 3.29. EMAP Impact Analysis: Land Subsidence/Sinkholes

Subject	Detrimental Impacts
Public	Localized impact expected to be moderate to light for incident areas and light for other adversely affected areas.
Responders	Localized impact expected to limit damage to personnel in the areas at the time of the incident.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations. Localized disruption of roads, facilities, and/or utilities caused by incident may postpone delivery of some services.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Environment	Localized impact expected to be moderate to light for incident areas and moderate to light for other areas affected by the sinkhole.
Economic Condition of Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time.

Public Confidence in the Jurisdiction’s Governance	Ability to respond and recover may be questioned and challenged if planning, response and recovery not timely and effective.

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

3.4.6 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.

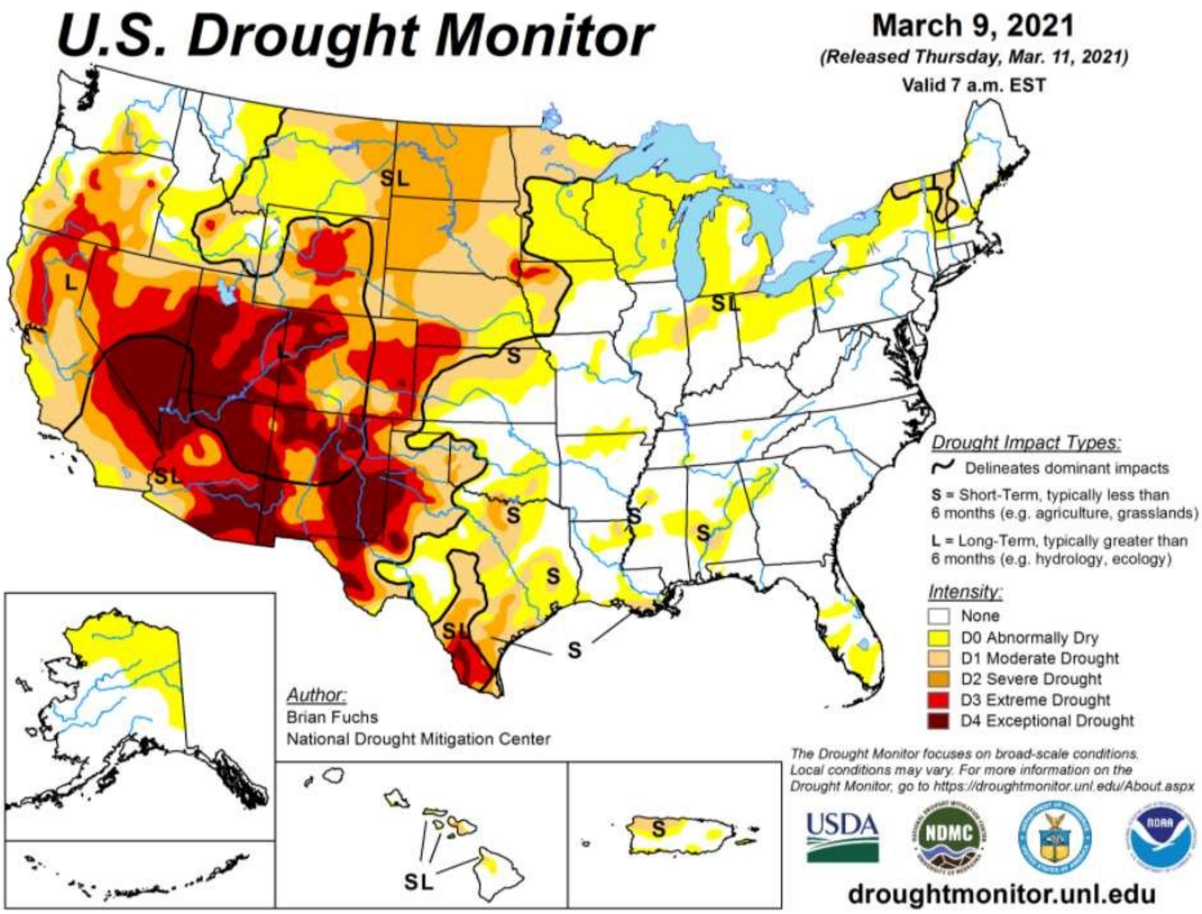
- Agricultural drought focus is on soil moisture deficiencies, differences between actual and potential evaporation, reduced ground water or reservoir levels, etc. Plant demand for water depends on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and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

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

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. According to the 2017 Census of Agriculture, Marion County consist of 232,558 acres land in farms, crop sales generate $75,999,000 and livestock sales generate $23,118,000. A drought would directly impact livestock production and the agriculture economy in Marion County.

Figure 3.23. U.S. Drought Monitor Map of Missouri on Date



Source: U.S. Drought Monitor, https://droughtmonitor.unl.edu/Maps/MapArchive.aspx

Strength/Magnitude/Extent

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.

Previous Occurrences

Drought occurs periodically in Missouri with the most severe and costly time occurring in 2018. 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 NCEI's storm database, 6 drought events have occurred in Marion County between 2000 to 2020.

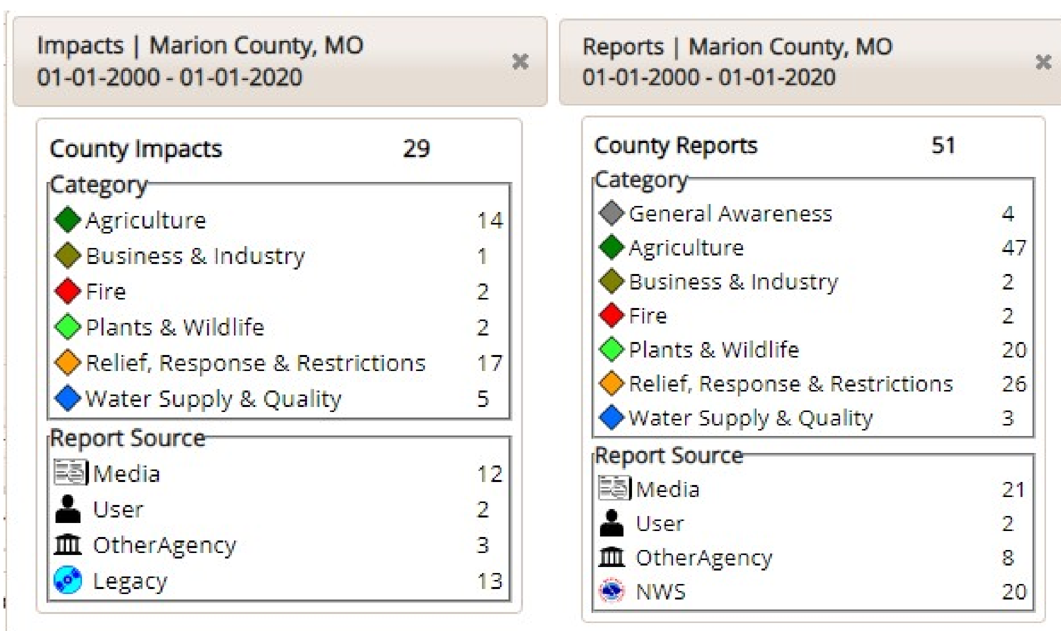
Table 3.30. Missouri Insurance Payments Due to Drought from 2016 to 2020

Drought Year	Insurance Payment
2016	$11,477.50
2017	$560,045.92
2018	$105,523.49
2019	$43,754.00
2020	$49,761.40
Total	**$770,562.31**

Source: http://www.rma.usda.gov/data/cause.html

According to the National Drought Mitigation Center's Drought Impact Reporter, during the 20-year period from January 2000 to January 2020 Marion County had 29 drought impacts and 51 reports.

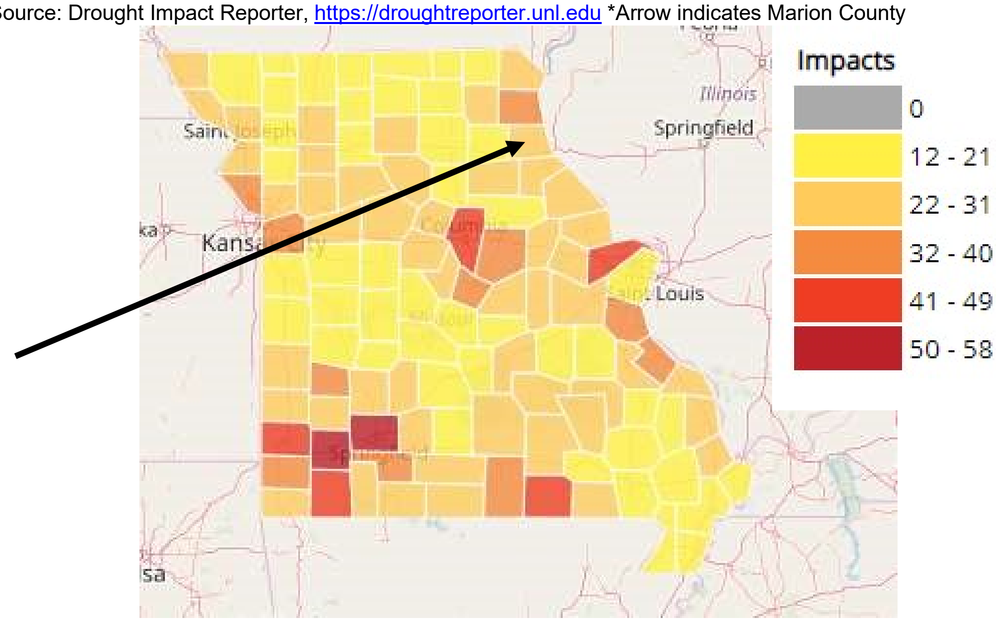
Figure 3.24. Drought Impacts in Marion County



Source: https://droughtreporter.unl.edu/map/

Figure 3.25. Missouri Drought Impact Map (January 2000 to December 2019)

Source: Drought Impact Reporter, https://droughtreporter.unl.edu *Arrow indicates Marion County



Probability of Future Occurrence

According to the 2018 State Plan, Marion County has a High total rating for droughts and is very likely to experience droughts in the future, with a 10.72% chance likelihood of a severe drought.

Figure 3.26. Vulnerability of Marion County to Drought

County	SOVI Index Rating	USDA RMA Total Drought Crop Claims	Average Annualized Crop Claims	USDA Claims Rating	2012 Crop Exposure	Crop Exposure Rating	Likeli-hood of Severe Drought (%)	Drought Occurrence Rating	Total Rating	Total Rating (Text) Drought
Marion	3	$26,387,111	$2,931,901	4	$53,674,000	3	10.72	5	15	High

Source: Missouri State Hazard Mitigation Plan, 2018

Figure 3.27. Ranges for Drought Vulnerability Factor Ratings

Factors Considered	Low (1)	Low-medium (2)	Medium (3)	Medium-high-4	High (5)
Social Vulnerability Index	1	2	3	4	5
Crop Exposure Ratio Rating	$886,000 - $10,669,000	$10,669,001 - $33,252,000	$33,252,001 - $73,277,000	$73,277,001 - $155,369,000	$155,369,001 - $256,080,000
Annualized USDA Crop Claims Paid	< $340,000	$670,000- $669,999	$670,000- $999,999	$1M-$1,299,999	> $1,300,000
Likelihood of Occurrence of severe or extreme drought	1-1.9%	2-3.9%	4-5.9%	6-8.9%	9-10.72%
Total Drought Vulnerability Rating	7-8	9-10	11-12	13-14	15-17

Source: Missouri State Hazard Mitigation Plan, 2018

Although drought is not predictable, long-range outlooks and predicted impacts of climate change could indicate an increased chance of drought.

Changing Future Conditions Considerations

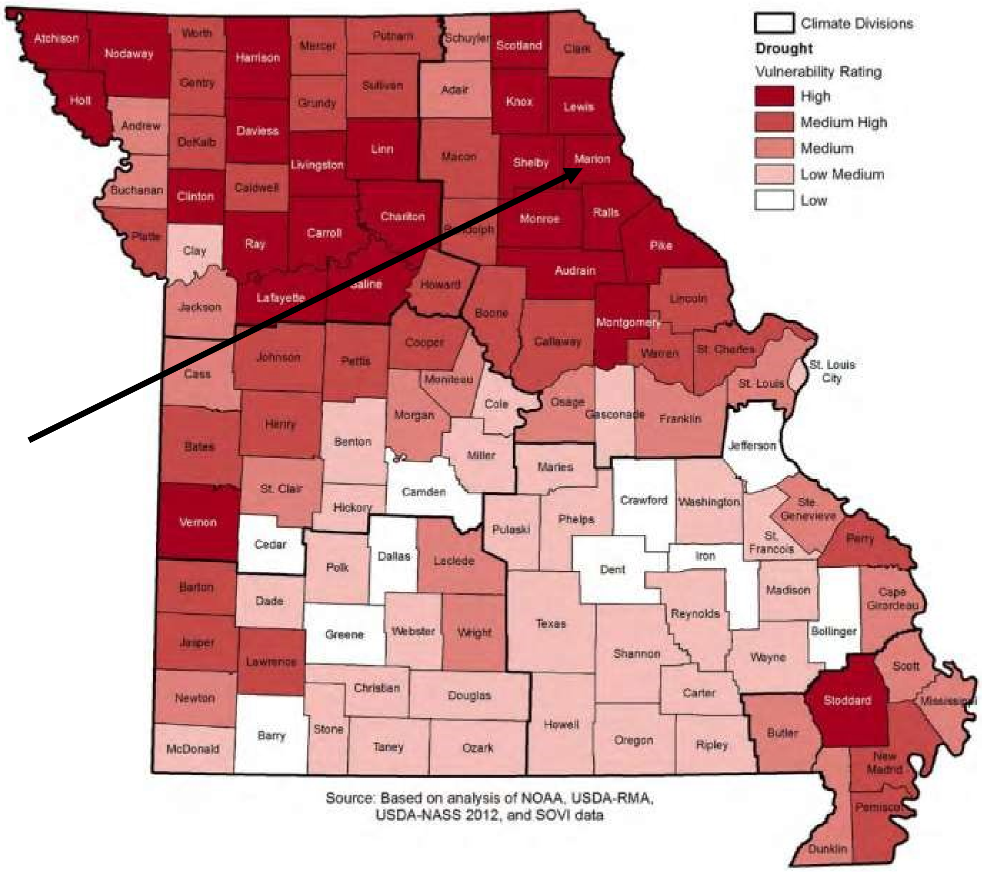
The 2018 State Plan, Severe drought, a natural part of Missouri's climate, is at risk to this agriculturedependent state. Future increases in evaporation rates due to higher temperatures may increase the intensity of naturally-occurring droughts. The number of heavy rainfall events is predicted to increase, yet researchers currently expect little change in total rainfall amounts, indicating the periods between heavy rainfalls will be marked by an increasing number of dry days. Higher temperatures and increased evapotranspiration increase the likelihood of a drought. This could lead to agricultural drought and suppressed crop yields.

Vulnerability

Vulnerability Overview

According to the analysis from the 2018 State Plan, Marion County is a High vulnerability County for droughts.

Figure 3.28. Missouri Drought Vulnerability by County



Source: Missouri State Hazard Mitigation Plan, 2018 *Arrow indicates Marion County

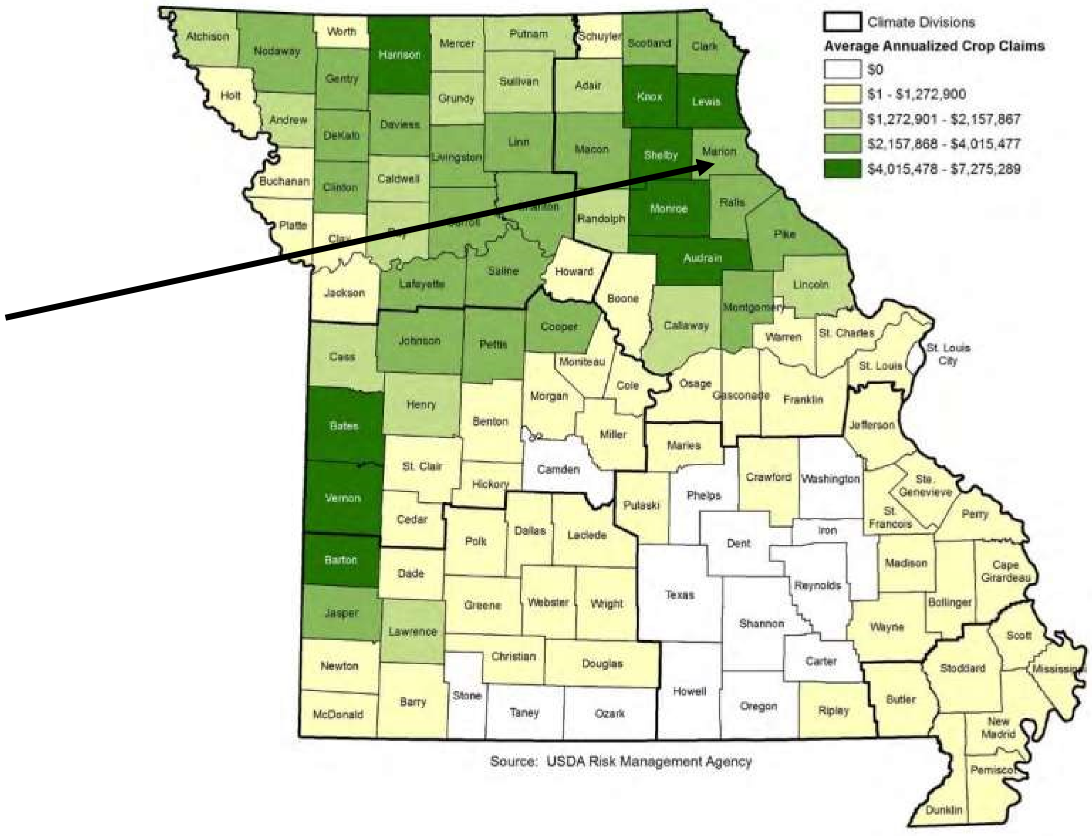
Potential Losses to Existing Development

The National Drought Monitor Center at the University of Nebraska summarized the potential impacts 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.

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. 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.

Figure 3.29. Annualized Drought Crop Insurance Claims Paid from 2007-2016

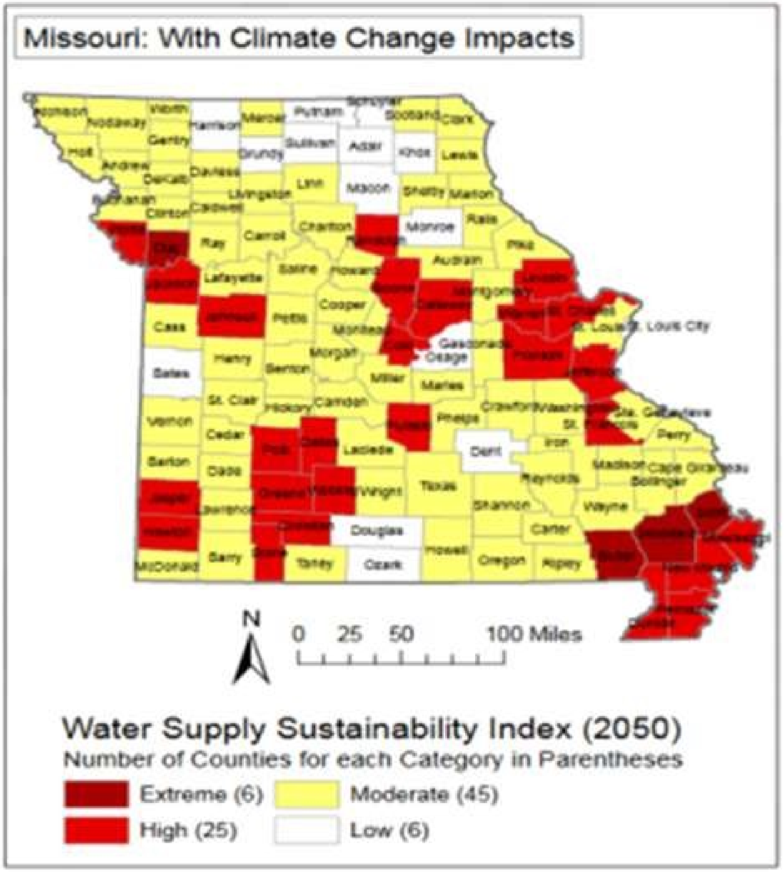


Source: Missouri State Hazard Mitigation Plan, 2018 *Arrow indicates Marion County

Changing Future Conditions Considerations

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 3.61 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.

Figure 3.30. Climate Change Impacts



Source: http://www.nrdc.org/globalWarming/watersustainability/

EMAP Consequence Analysis

For communities with emergency management programs seeking EMAP accreditation, complete Table 3.31 to summarize the detrimental impacts from drought.

Table 3.31. EMAP Impact Analysis: Drought

Subject	Detrimental Impacts
Public	Most damage expected to be agricultural in nature. However, water supply disruptions may adversely affect people.
Responders	Nature of hazard expected to minimize any serious damage to properly equipped and trained personnel.
Continuity of Operations	Unlikely to necessitate execution of the Continuity of Operations Plan. Nature of hazard expected to minimize serious damage to services, except for moderate impact on water utilities.

Property, Facilities, and Infrastructure	Nature of hazard expected to minimize any serious damage to facilities.
Environment	May cause disruptions in wildlife habitat, increasing interface with people, and reducing numbers of animals.
Economic Condition of Jurisdiction	Local economy and finances dependent on abundant water supply adversely affected for duration of drought.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

The entire planning area will be affected by drought to some degree. The unincorporated agricultural areas of Marion 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, local garden and possibly infrastructure impacted. In addition, damage to crops, produce, livestock, soils and building foundations could be weakened due to shrinking and expanding soil.

Problem Statement

Marion County is at a High risk for a severe drought which is an extra strain placed on the water supply system. Possible solutions include the development of agreements with neighboring communities for a secondary water source and review of local ordinances/regulation for inclusion of water-use restrictions during periods of drought.

3.4.7 Extreme Temperatures

Hazard Profile

Hazard Description

Extreme temperature events, both hot and cold, can impact human health and mortality, natural ecosystems, agriculture and other economic sectors. 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 3.31** uses both of these factors to produce a guide for the apparent temperature or relative intensity of heat conditions.

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.

Geographic Location

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

Strength/Magnitude/Extent

The National Weather Service (NWS) 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.

Figure 3.31. Heat Index (HI) Chart

NWS Heat Index — 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										

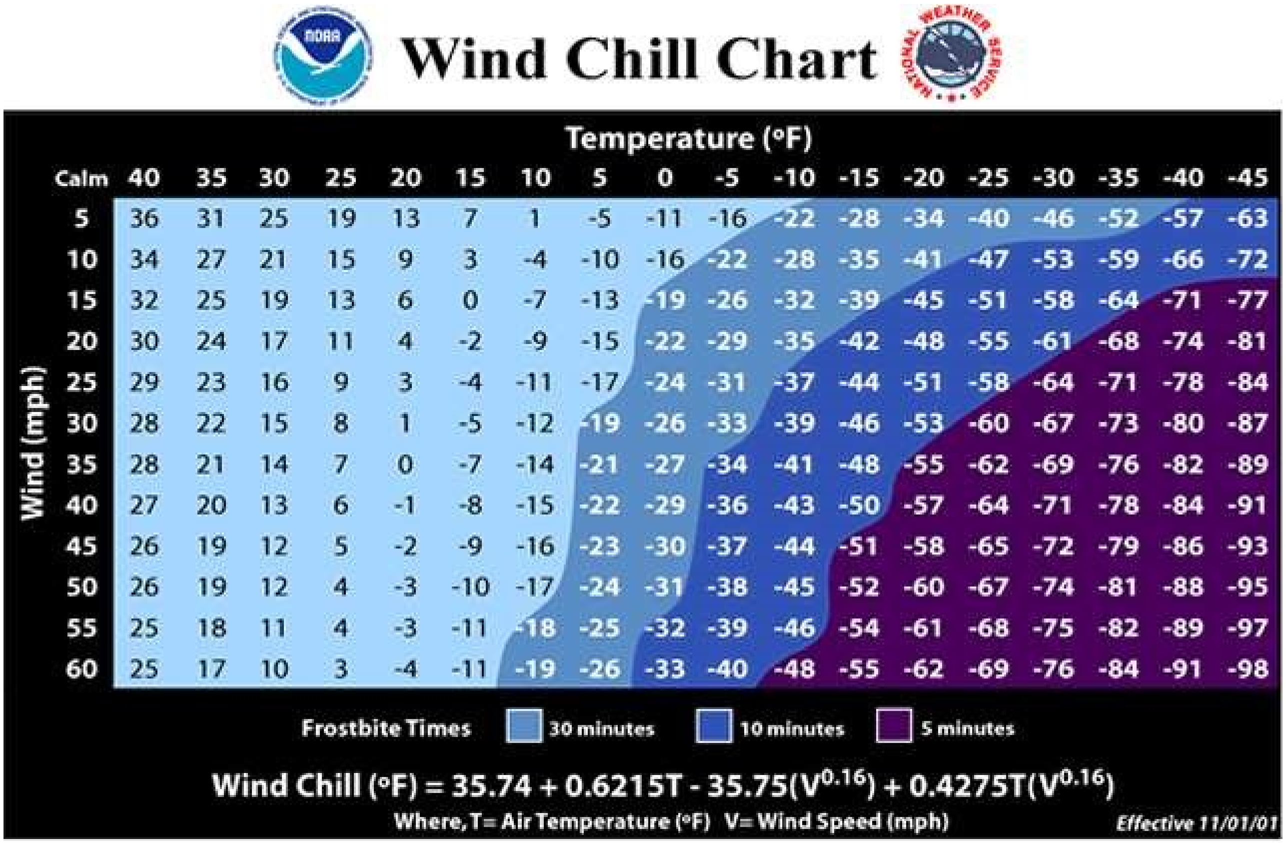
Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution — Extreme Caution — Danger — Extreme Danger

Source: National Weather Service (NWS); https://www.weather.gov/safety/heat-index
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.

The NWS Wind Chill Temperature (WCT) index uses advances in science, technology, and computer modeling to provide an accurate, understandable, and useful formula for calculating the dangers from winter winds and freezing temperatures. The figure below presents wind chill temperatures which are based on the rate of heat loss from exposed skin caused by wind and cold. As the wind increases, it draws heat from the body, driving down skin temperature and eventually the internal body temperature.

Figure 3.32. Wind Chill Chart



Wind Chill Chart

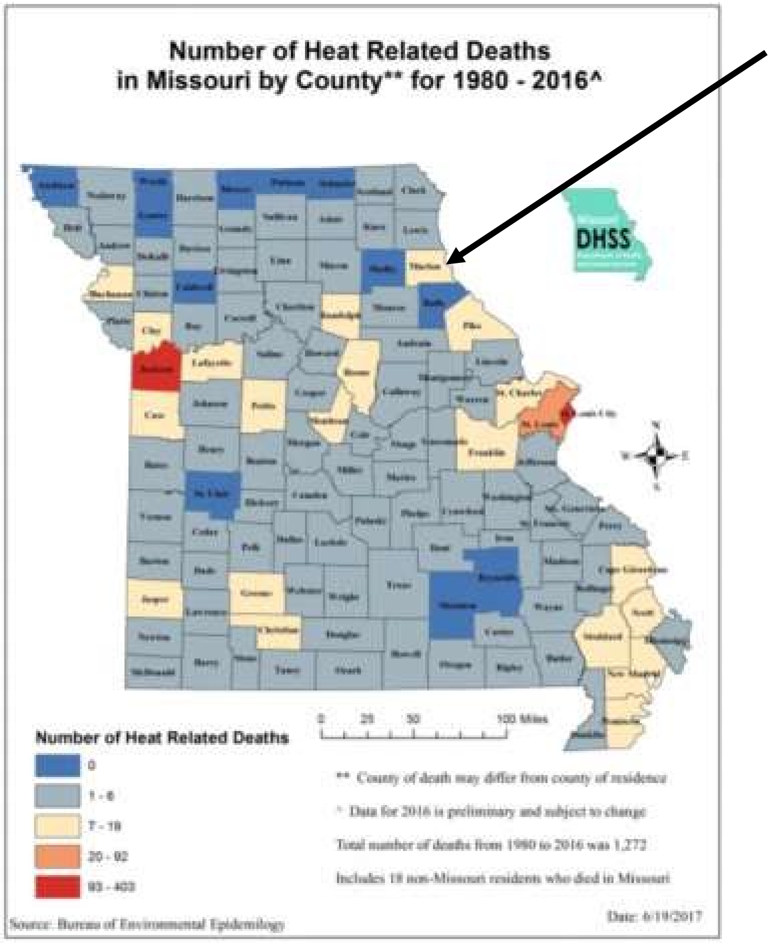
Wind (mph) \ Temperature (°F)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	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

Source: https://www.weather.gov/safety/cold-wind-chill-chart

Previous Occurrences

The recorded events in the National Centers for Environmental Information (NCEI) database state there have been 21 recorded events of excessive heat in the 20-year period of 2001-2021. There was 0 deaths or injuries associated with these events. The NCEI database shows 1 recorded events of extreme cold/wind chill, with 0 deaths or injuries associated with this event. Figure 3.34 illustrates between 7-19 heat related deaths in Marion County between the time of 1980-2016, no supporting documentation could be found to include in this plan.

Figure 3.33. Heat Related Deaths in Missouri 2000 - 2016



Source: https://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/stat-report.pdf

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 2011 to 2021 were $553,459.70. 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, __ deaths were recorded in the planning area, according to NCEI data. The National Weather Service stated that among natural hazards, no other natural disaster—not lightning, hurricanes, tornadoes, floods, or earthquakes—causes more deaths.

Probability of Future Occurrence

NOAA dating back to 2011 indicates 6 years with extreme heat events (2011, 2012, 2014, 2015, 2016, 2017). Based on this historical data, the calculated probability of an extreme heat event in any given year is 60%.

Changing Future Conditions Considerations

According to the 2018 Missouri State Plan, average annual temperatures are projected to most likely exceed historical record levels by the middle of the 21st century. The impacts of extreme heat events are experienced most acutely by the elderly and other vulnerable populations. High temperatures are exacerbated in urban environments, a phenomenon known as the urban heat island effect, which in turn tend to have higher concentrations of vulnerable populations. Higher demand for electricity as people tries to keep cool amplifies stress on power systems and may lead to an increase in the number of power outages. Atmospheric concentrations of ozone occur at higher air temperatures, resulting in poorer air quality, while harmful algal blooms flourish in warmer water temperatures, resulting in poorer water quality.

Vulnerability

Vulnerability Overview

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 3.32 lists typical symptoms and health impacts due to exposure to extreme heat.

Table 3.32. 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

Figure 3.118. Average Annual Occurrence for Extreme Heat

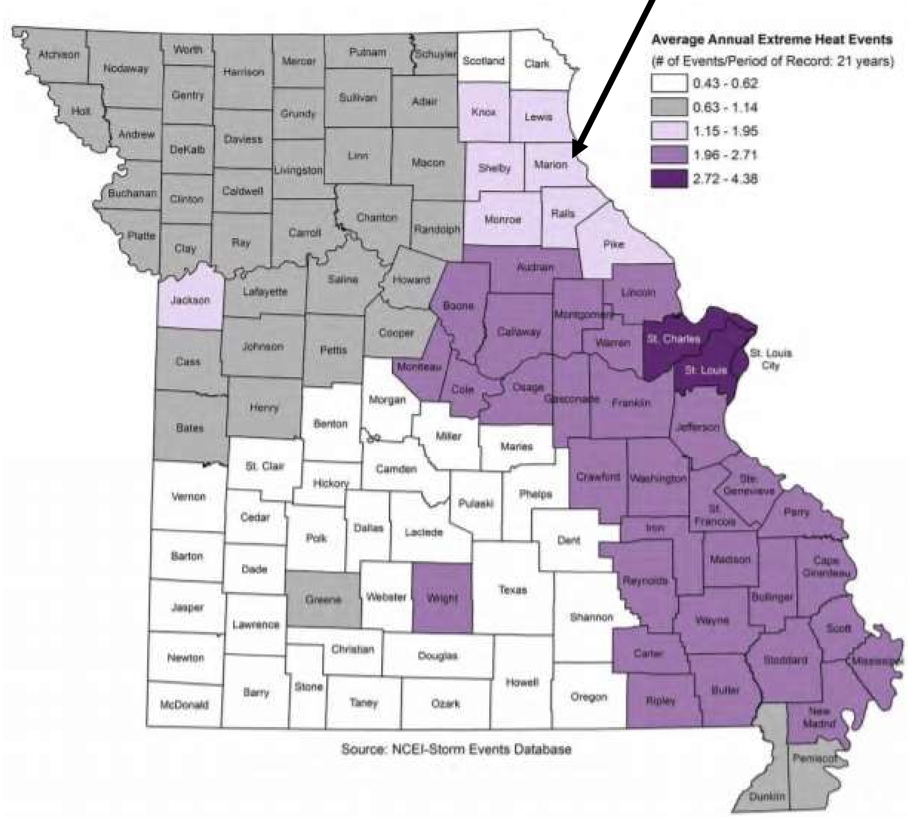


Figure 3.119. Vulnerability Summary for Extreme Heat

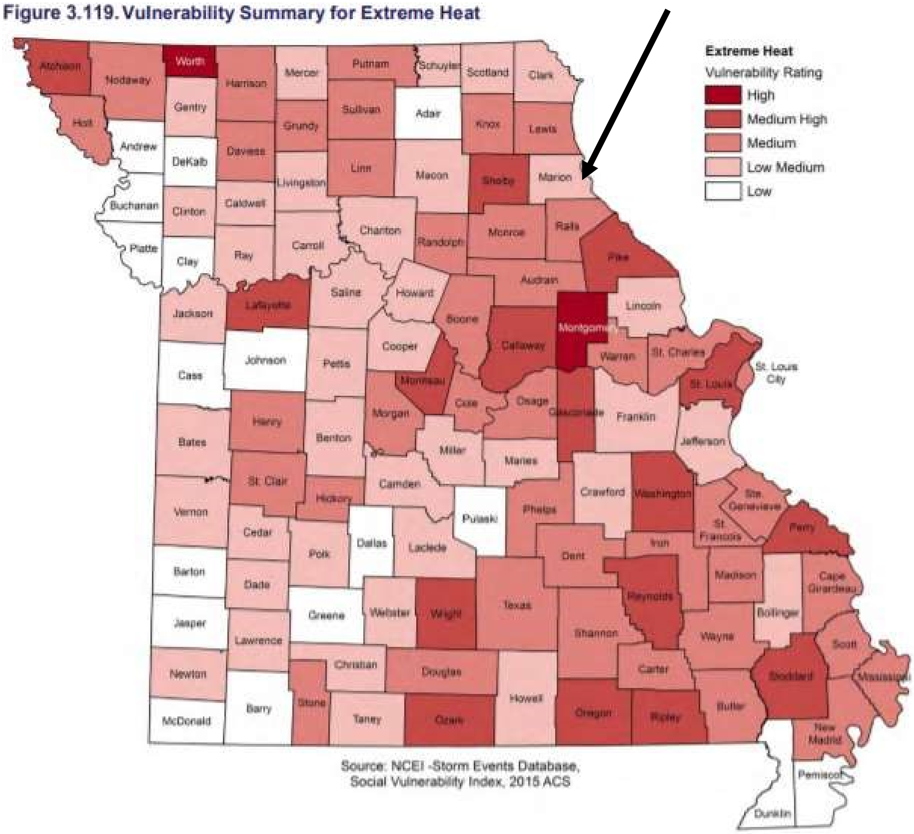


Figure 3.120. Average Annual Occurrence for Extreme Cold

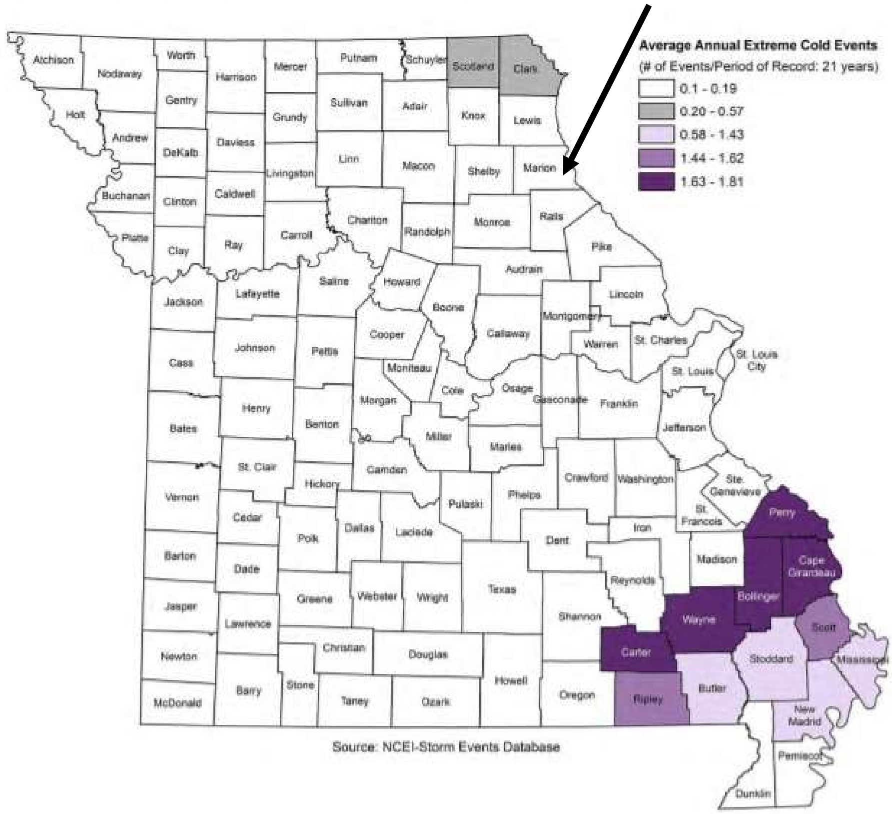
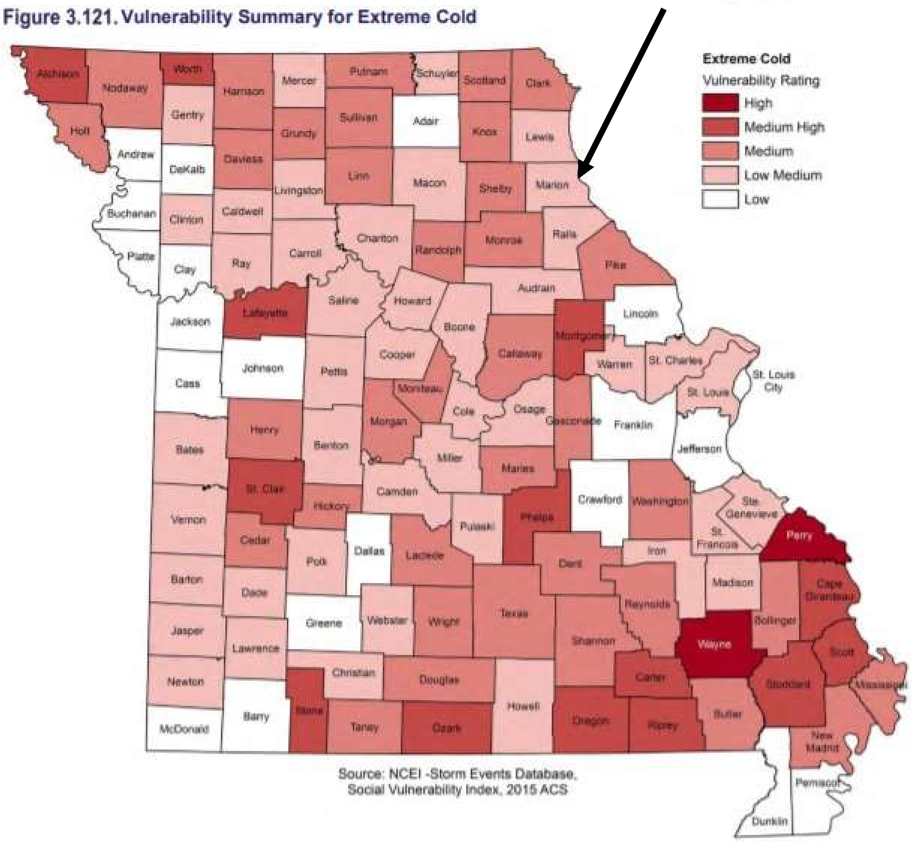


Figure 3.121. Vulnerability Summary for Extreme Cold



Potential Losses to Existing Development

During the ten-year period from 2011 to 2021 there were $553,459.70 in crop insurance claims paid as a result of losses to extreme temperatures. The anticipated loss in any given year can be expected to be the annual average of $55,345.97. 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 ten-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. Of the participating jurisdictions that have the highest concentrations of populations vulnerable to extreme heat all saw a decrease in population over the last 10 years. Population growth also increases the strain on electricity infrastructure, as more electricity is needed to accommodate the growing population.

EMAP Consequence Analysis

For communities with emergency management programs seeking EMAP accreditation, complete Table 3.33 to summarize the detrimental impacts from extreme temperatures.

Table 3.33. EMAP Impact Analysis: Extreme Temperatures

Subject	Detrimental Impacts
Public	Localized impact expected to be severe for incident areas and moderate to light for other adversely affected areas.
Responders	Localized impact expected to limit damage to personnel in the areas at the time of the incident.
Continuity of Operations	Unlikely to necessitate execution of the Continuity of Operations Plan. Extent of agricultural damage depends on duration. Water supplies and electricity may be disrupted.
Property, Facilities, and Infrastructure	Nature of hazard expected to minimize any serious damage to facilities. Asphalt parking lots and roads are routinely damaged during periods of extreme heat as the hot asphalt becomes less rigid and can be displaced by heavy equipment or automobiles.
Environment	Potential for crop damage; May cause disruptions in wildlife habitat, increase interface with people, and reduce numbers of animals.
Economic Condition of Jurisdiction	Local economy and finances dependent on stable electricity and water supply adversely affected for duration of heat wave.
Public Confidence in the Jurisdiction’s Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

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 3.33 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 3.34. Marion County Population Under Age 5 and Over Age 65, 2010 Census Data

Jurisdiction	Population Under 5 yrs	Population 65 yrs and over
Marion County	1,985	4,507
Hannibal	1,343	2,669

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

All of the schools in Marion County have air conditioning which does not put any school age children at risk during extreme temperatures due to the schools not having a policy in place to close if there are extreme temperatures.

Problem Statement

Marion County has a growing population of residents over 65 years, who are at a greater risk for extreme-temperature related illnesses, injuries, and death. Possible solutions include organizing outreach to the vulnerable elderly populations, including establishing and promoting accessible heating or cooling centers in the community and creating a database in coordination with the Health Department to track those individuals at high risk.

3.4.8 Severe Thunderstorms Including High Winds, Hail, and Lightning

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 (discussed separately in **Section 3.4.1)** and tornadoes (discussed separately in **Section 3.4.10**).

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

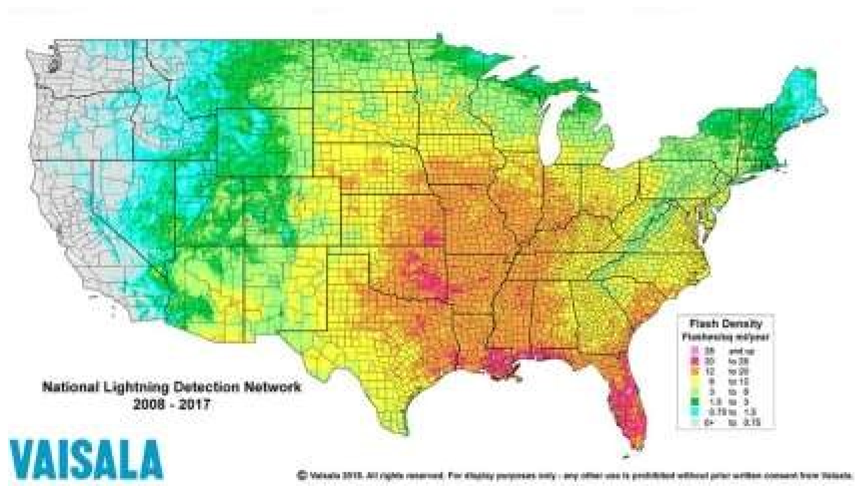
According to the National Oceanic and Atmospheric Administration (NOAA), hail is precipitation that is formed when thunderstorm updrafts carry raindrops upward into extremely cold atmosphere causing them to freeze. The raindrops form into small frozen droplets. They continue to grow as they come into 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

Thunderstorms/high winds/hail/lightning events are an area-wide hazard that can happen anywhere in the county. 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 3.14. Location and Frequency of Lightning in Missouri



Source: National Weather Service, http://www.vaisala.com/en/products/thunderstormandlightningdetectionsystems/Pages/NLDN.aspx . Note: indicate location of planning area with a colored square or arrow.

Figure 3.34. Wind Zones in the United States

Source: FEMA 320, Taking Shelter from the Storm, 3rd edition, https://www.fema.gov/pdf/library/ism2_s1.pdf

Strength/Magnitude/Extent

Based on information provided by the Tornado and Storm Research Organization (TORRO), **Table 3.35** below describes typical damage impacts of the various sizes of hail.

Table 3.35. 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 3.0-3.5	Tennis ball > cricket ball	Severe roof damage, risk of serious injuries

Destructive	76-90		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 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

The tables below (**Table 3.36 through Table 3.39**) 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 3.36. Crop Insurance Claims Paid in Marion County from Thunderstorms, [2011-2021].

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
	No Reports		
Total			

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

Table 3.37. Crop Insurance Claims Paid in Marion County from High Winds, [2011-21]

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2011	Corn	Hot Wind	$5,201.00

2011	Corn	Wind/Excess Wind	$10,452.00
2013	Corn	Wind/Excess Wind	$14,320.00
2013	Corn	Wind/Excess Wind	$11,447.00
Total			$41,420.00

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

Table 3.38. Crop Insurance Claims Paid in Marion County from Lightning, [2011-2021].

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2012	Soybeans	Other Possible Lightning	$2,033.00
Total			$2,033.00

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

Table 3.39. Crop Insurance Claims Paid in Marion County from Hail, [2011-2021].

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2011	Wheat	Hail	$5,198.00
2011	Wheat	Hail	$575.00
2011	Wheat	Hail	$1,637.00
2011	Corn	Hail	$1,102.00
2011	Soybeans	Hail	$4,827.00
2013	Corn	Hail	$14,320.0
2013	Corn	Hail	$11,447.00
Total			$39,107.00

USDA Risk Management Agency, Insurance Claims, https://www.rma.usda.gov/data/caus e

Probability of Future Occurrence

Thunderstorms

Due to no reports, adequate calculations cannot be configured at this time.

High Winds

Based on this data, there have been 4 events in a 10-year period, producing an average of 0.4 high wind events each year in Marion County. Based on history, the probability of a high wind event in any given year is 100 percent. Thus, making the probability as likely in any given year.

Lightning

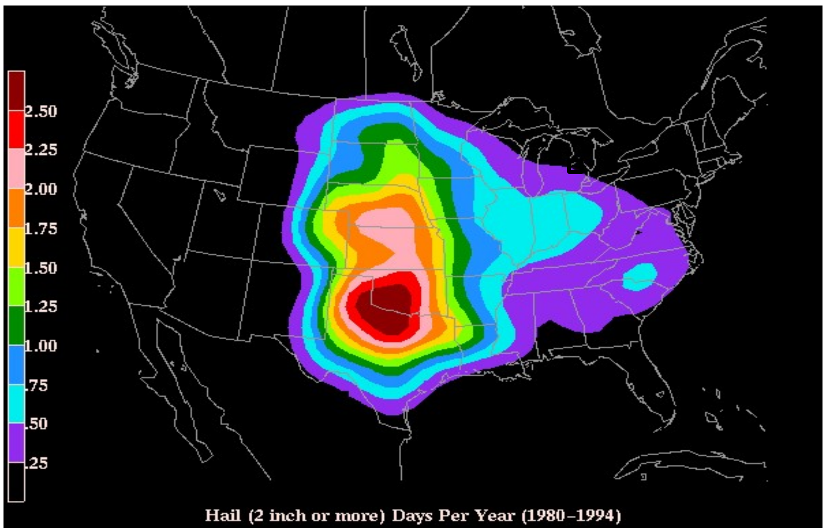
Based on this data, there has been 1 event in a 10-year period, producing an average of 0.1 lightning events each year in Marion County. Based on history, the probability of a lightning event in any given year is 100 percent. Thus, making the probability as likely in any given year.

Hail

Based on this data, there have been 7 events in a 10-year period, producing an average of .7 hail events each year in Marion County. Based on history, the probability of a hail event in any given year is 100 percent. Thus, making the probability as likely in any given year.

Figure 3.35 is based on hailstorm data from 1980-1994. It shows the probability of hailstorm occurrence (2" diameter or larger) based on number of days per year. Marion County is located in the region to receive between .75 and 1 hailstorm annually.

Figure 3.35. Annual Hailstorm Probability (2″ diameter or larger), U 1980- 1994



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

Changing Future Conditions Considerations

According to the 2018 Missouri State Plan, predicted increases in temperature could help create atmospheric conditions that are fertile breeding grounds for severe thunderstorms and tornadoes in Missouri. Possible impacts include an increased risk to life and property in both the public and private sectors. Public utilities and manufactured housing developments will be especially prone to damages. Jurisdictions already affected should be prepared for more of these events, and should thus prioritize mitigation actions such as construction of safe rooms for vulnerable populations, retrofitting and/or hardening existing structures, improving warning systems and public education, and reinforcing utilities and additional critical infrastructure.

Vulnerability

Vulnerability Overview

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.vaisala.com/en/products/thunderstormandlightningdetectionsystems/Pages/NLDN.aspx and http://www.lightningsafety.noaa.gov/

Potential Losses to Existing Development

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 have not been any fatalities and only 1 injury due to lightning in Marion County during the 10-year period reviewed. Thunderstorms and lightning contributed to approximately $125,000 in damages with an annualize cost of $12,500.00.

Hail

The estimated annualized property damages resulting from hail is $100,000. 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 still no reported damage due to high winds reported for Marion County.

Previous and Future Development

Marion County's 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 the hazards.

EMAP Consequence Analysis

Table 3.40. EMAP Impact Analysis: Severe Thunderstorms

Subject	Detrimental Impacts
Public	Localized impact expected to be severe for incident areas and moderate to light for other adversely affected areas.
Responders	Localized impact expected to limit damage to personnel in the areas at the time of the incident.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations. Localized disruption of roads, facilities, and/or utilities caused by incident may postpone delivery of some services.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Environment	Localized impact expected to be severe for incident areas and moderate to light for other areas affected by the storm or HazMat spills.
Economic Condition of Jurisdiction	Losses to private structures covered, for the most part, by private insurance.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

Thunderstorms/high winds/ lightning/hail events are area-wide, NCEI 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, communities would benefit from updated sirens. Possible solutions include review of local ordinance and building codes to address high winds and/or construction techniques to include structural bracing, straps and clips, or anchor bolts.

3.4.9 Severe Winter Weather

Hazard Profile

Hazard Description

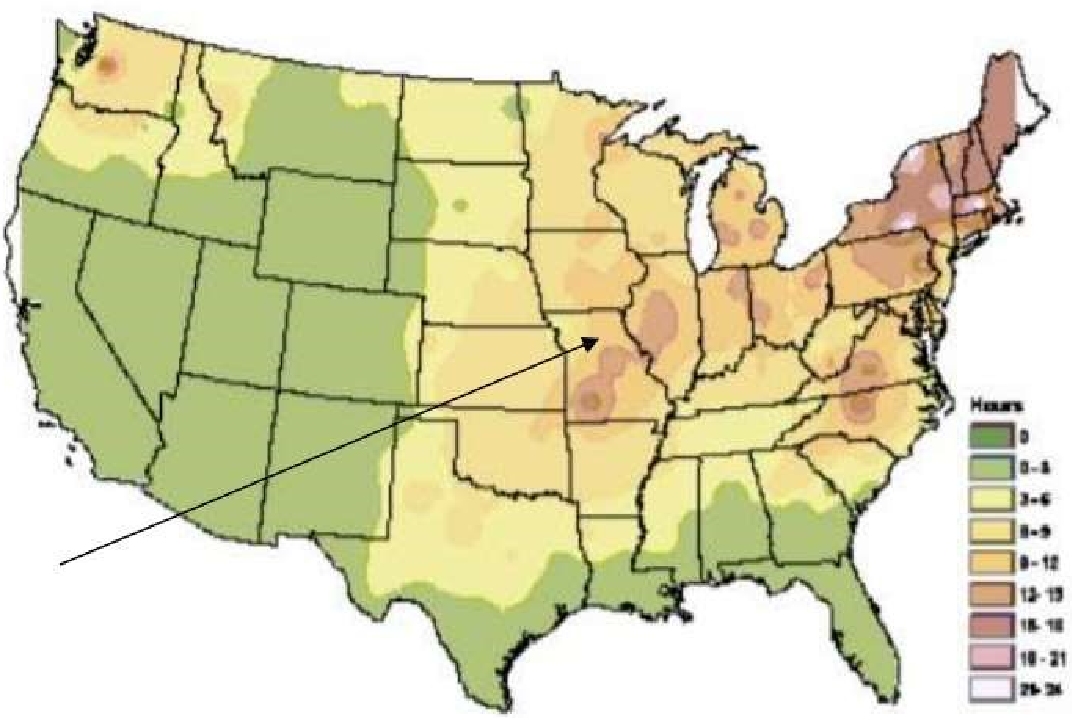
A major winter storm can last for several days and be accompanied by high winds, freezing rain or sleet, heavy snowfall, and cold temperatures. The National Weather Service describes different types of winter storm events as follows.

- **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 Marion County is vulnerable to heavy snow, ice, extreme cold temperatures and freezing rain. Insert a map (Figure 3.36) and either show the county graphically or include narrative indicating the zone in which the county located, and how many hours of freezing rain is indicated annually.

Figure 3.36. 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

Strength/Magnitude/Extent

Severe winter storms include heavy snowfall, ice, and strong winds which can push the wind chill well below zero degrees in the planning area.

For severe weather conditions, the National Weather Service issues some or all of the following products as conditions warrant across the State of Missouri. NWS local offices in Missouri may collaborate with local partners to determine when an alert should be issued for a local area.

- Winter Weather Advisory — Winter weather conditions are expected to cause significant inconveniences and may be hazardous. If caution is exercised, these situations should not become life threatening. Often the greatest hazard is to motorists.
- Winter Storm Watch — Severe winter conditions, such as heavy snow and/or ice are possible within the next day or two.
- Winter Storm Warning — Severe winter conditions have begun or are about to begin.

- Blizzard Warning — Snow and strong winds will combine to produce a blinding snow (near zero visibility), deep drifts, and life-threatening wind chill.
- Ice Storm Warning -- Dangerous accumulations of ice are expected with generally over one quarter inch of ice on exposed surfaces. Travel is impacted, and widespread downed trees and power lines often result.
- Wind Chill Advisory -- Combination of low temperatures and strong winds will result in wind chill readings of -20 degrees F or lower.
- Wind Chill Warning -- Wind chill temperatures of -35 degrees F or lower are expected. This is a life-threatening situation.

Previous Occurrences

Table 3.41. NCEI Marion County Winter Weather Events Summary, [01/01/2011-11/30/2020]

Type of Event	Inclusive Dates	Magnitude	# of Injuries	Property Damages	Crop Damages
Winter Storm	01/31/2011	-	0	0	0
Winter Storm/Blizzard	02/01/2011	-	0	0	0
Winter Storm	02/21/2011	-	0	0	0
Heavy Snow	03/24/2011	-	0	0	0
Winter Storm	12/21/2013	-	0	0	0
Cold/Wind Chill	01/06/2014	-	0	0	0
Winter Storm	02/04/2014	-	0	0	0
Heavy Snow	02/20/2015	-	0	0	0
Ice Storm	01/14/2017	-	0	0	0
Blizzard	11/25/2018	-	0	0	0
Heavy Snow	01/11/2019	-	0	0	0

Source: NCEI, data accessed [03/15/21]

Presidential Disaster Declaration for Winter Storms

In January 2011, Missouri was impacted by a severe winter storm system that produced ice, heavy snowfall and blizzard and white-out conditions in much of the state. Due to the storm, which deposited up to 23 inches of snow in the state, Gov. Nixon closed I-70 between St. Louis and Kansas City, and I-44 from Springfield to Oklahoma. The storm saddled local and state governments with eligible costs estimated at more than $14 million for removal of the record or near-record snowfall in many areas of the state.

On Jan. 31, Gov. Jay Nixon ordered activation of the State Emergency Operations Plan in preparation of the storm. On the same day, Gov. Nixon also declared a State of Emergency for the entire state of Missouri and activated over 600 members of the Missouri National Guard to position around the state for assistance.

On Feb. 2, Gov. Nixon requested that a state of emergency be declared in Missouri by President Barack Obama.

On Feb. 4, because many county and local roads were still impassable, Gov. Nixon ordered the Missouri Department of Transportation to assist with clearing snow from county and local roadways.

On March 1, Gov. Nixon requested that a major disaster declaration be declared by President Obama, requesting Public Assistance for the affected areas. On March 23, a disaster declaration was granted by President Obama for Public Assistance to the 59 counties of Adair, Andrew, Audrain, Barton, Bates, Benton, Boone, Caldwell, Callaway, Carroll, Cass, Cedar, Chariton, Clark, Clinton, Cole, Cooper, Dade, Dallas, DeKalb, Grundy, Henry, Hickory, Howard, Johnson, Knox, Laclede, Lafayette, Lewis, Linn, Livingston, Macon, Madison, Maries, Marion, McDonald, Miller, Moniteau, Monroe, Montgomery, Morgan, Newton, Osage, Pettis, Platte, Polk, Pulaski, Putnam, Ralls, Randolph, Ray, St. Clair, Saline, Schuyler, Scotland, Shelby, Sullivan, Vernon and Worth.

Winter storms, cold, frost and freeze take a toll on crop production in the planning area. **Table 3.42** shows the USDA's Risk Management Agency payments for insured crop losses in the planning area as a result of cold conditions and snow for the past 10 years.

Table 3.42. Crop Insurance Claims Paid in Marion County as a Result of Cold Conditions and Snow [2011-2021]

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid ($)
2011	Wheat	Cold Winter	$4,816.00
2011	Wheat	Cold Wet Weather	$8,871.00
2011	Corn	Cold Wet Weather	$832.00
2011	Corn	Cold Wet Weather	$49,063.00
2012	Wheat	Cold Wet Weather	$870.00
2013	Corn	Cold Wet Weather	$11,904.00
2013	Soybeans	Cold Wet Weather	$167.00
2014	Wheat	Freeze	$11,056.00
2014	Wheat	Freeze	$7,590.00
2014	Wheat	Cold Winter	$159,414.00
2014	Wheat	Cold Winter	$24,346.00
2014	Wheat	Cold Winter	$1,002.00
2014	Wheat	Cold Winter	$27,395.00
2014	Wheat	Cold Wet Weather	$28,683.00
2014	Wheat	Cold Wet Weather	$19,721.00
2014	Soybeans	Frost	$8,670.00
2014	Soybeans	Cold Wet Weather	$7,043.00
2014	Soybeans	Cold Wet Weather	$4,090.00
2015	Wheat	Cold Winter	$8,745.00
2015	Wheat	Cold Wet Weather	$4,881.00
2015	Corn	Cold Wet Weather	$72,569.00
2015	Soybeans	Cold Wet Weather	$8,573.00
2015	Soybeans	Cold Wet Weather	$4,947.00
2016	Wheat	Cold Winter	$7,540.00
2016	Wheat	Cold Winter	$1,049.00
2016	Wheat	Cold Wet Weather	$5,225.00

2016	Wheat	Cold Wet Weather	$137.00
2016	Corn	Cold Wet Weather	$21,665.00
2016	Soybeans	Cold Wet Weather	$62,046.00
2016	Soybeans	Cold Wet Weather	$5,975.00
2016	Soybeans	Cold Wet Weather	$1,741.00
2017	Corn	Cold Wet Weather	$19,120.50
2017	Corn	Cold Wet Weather	$16,667.00
2017	Soybeans	Cold Wet Weather	$62,013.00
2018	Wheat	Cold Winter	$698.00
2018	Wheat	Cold Winter	$1,885.00
2018	Corn	Cold Wet Weather	$3,027.50
2018	Soybeans	Cold Wet Weather	$79.00
2019	Wheat	Cold Winter	$10,539.50
2019	Wheat	Cold Winter	$1,774.50
2019	Wheat	Cold Wet Weather	$649.00
2020	Wheat	Cold Wet Weather	$2,375.00
2020	Wheat	Cold Wet Weather	$354.00
2020	Corn	Cold Wet Weather	$66,597.00
2020	Corn	Cold Wet Weather	$37,108.50
2020	Soybeans	Cold Wet Weather	$4,448.00
2020	Soybeans	Cold Wet Weather	$33,138.00
Total			$841,099.50

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

Probability of Future Occurrence

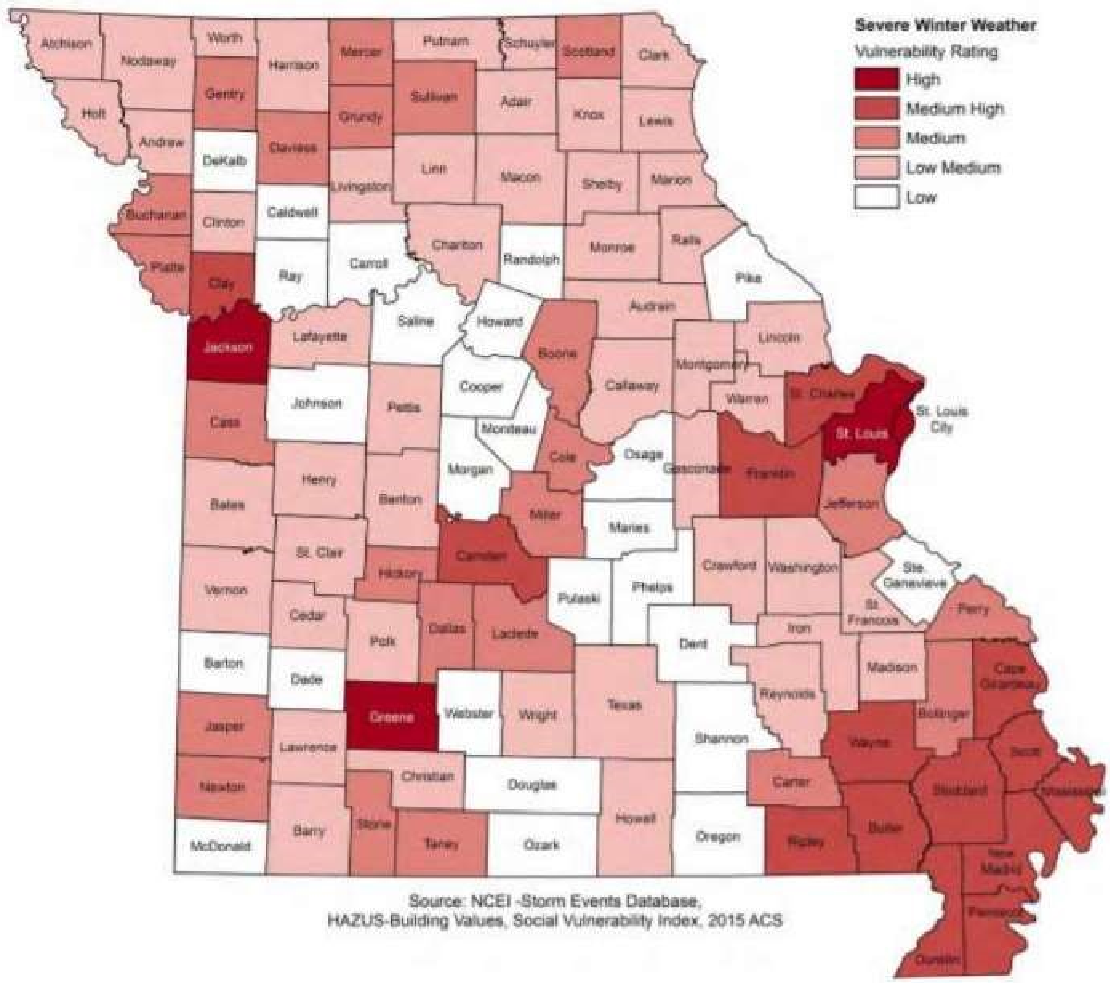
The entire planning area is vulnerable to the effects of winter storm/blizzard, ice storms, winter weather, cold/wind chill and heavy snow. All effects of winters tend to make driving more treacherous and can impact the response of emergency vehicles. The probability of utility and infrastructure failure 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.

Changing Future Conditions Considerations

According to the 2018 Missouri State Plan, a shorter overall winter season and fewer days of extreme cold may have both positive and negative indirect impacts. Warmer winter temperatures may result in changing distributions of native plant and animal species and/or an increase in pests and non-native species. Warmer winter temperatures will result in a reduction of lake ice cover. Reduced lake ice cover impacts aquatic ecosystems by raising water temperatures. Water temperature is linked to dissolved oxygen levels and many other environmental parameters that affect fish, plant, and other animal populations. A lack of ice cover also leaves lakes exposed to wind and evaporation during a time of year when they are normally protected. As both temperature and precipitation increase during the winter months, freezing rain will be more likely. Additional wintertime precipitation in any form will contribute to saturation and increase the risk and/or severity of spring flooding. A greater proportion of wintertime precipitation may fall as rain rather than snow.

Vulnerability

Vulnerability Overview



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.

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.

Potential Losses to Existing Development

The next severe winter storm will most likely close schools and businesses for multiple days, and make roadways hazardous for travel. Heavy ice accumulation may damage electrical infrastructures causing prolonged power outages for large portions of the region. In addition, freezing temperatures make water lines vulnerable to freeze/thaw. Fallen tree limbs also pose a threat to various structures/infrastructures across the county.

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.

EMAP Consequence Analysis

Table 3.43. EMAP Impact Analysis: Severe Winter Weather

Subject	Detrimental Impacts
Public	Localized impact expected to be severe for affected areas and moderate to light for other less affected areas.
Responders	Adverse impact expected to be severe for unprotected personnel and moderate to light for trained, equipped, and protected personnel.
Continuity of Operations	Unlikely to necessitate execution of the Continuity of Operations Plan. Localized disruption of roads and/or utilities caused by incident may postpone delivery of some services.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the areas of the incident. Power lines and roads most adversely affected.
Environment	Environmental damage to trees, bushes, etc.
Economic Condition of Jurisdiction	Local economy and finances may be adversely affected, depending on damage.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

Although crop loss as a result 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. 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.

Problem Statement

Marion County is expected to experience at least one severe winter weather events annually; the county has a low-medium vulnerability rating. Jurisdictions should enhance their weather monitoring to be better prepared for sever weather hazards. If jurisdictions monitor winter weather, they can dispatch road crews to prepare for the hazard. County and city crews can also trim trees along power lines to minimize the potential for outages due to snow and ice. Citizens should also be educated about the benefits of being proactive to alleviate property damage as well as preparing for power outages. 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.

3.4.10 Tornado

Hazard Profile

Hazard Description

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. The unique geography of the central United States allows for the development of thunderstorms that spawn tornadoes. The jet stream, which is a high-velocity stream of air, determines which area of the central United States will be prone to tornado development. The jet stream normally 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.

Tornadoes spawn from the largest thunderstorms. The associated cumulonimbus clouds can reach heights of up to 55,000 feet above ground level and are commonly formed when Gulf air is warmed by solar heating. The moist, warm air is overridden by the dry cool air provided by the jet stream. This cold air presses down on the warm air, preventing it from rising, but only temporarily. Soon, the warm air forces its way through the cool air and the cool air moves downward past the rising warm air. This air movement, along with the deflection of the earth's surface, can cause the air masses to start rotating. This rotational movement around the location of the breakthrough forms a vortex, or funnel. If the newly created funnel stays in the sky, it is referred to as a funnel cloud. However, if it touches the ground, the funnel officially becomes a tornado.

A typical tornado can be described as a funnel-shaped cloud that is "anchored" to a cloud, usually a cumulonimbus that is also in contact with the earth's surface. 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

Tornadoes can occur in the entire planning area and no area is immune from tornado damage.

Strength/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 3.44**) 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 3.44. 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	mb 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 3.45**. 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/efscale.html.

Table 3.45. 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
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 NCEI 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 NCEI. 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.

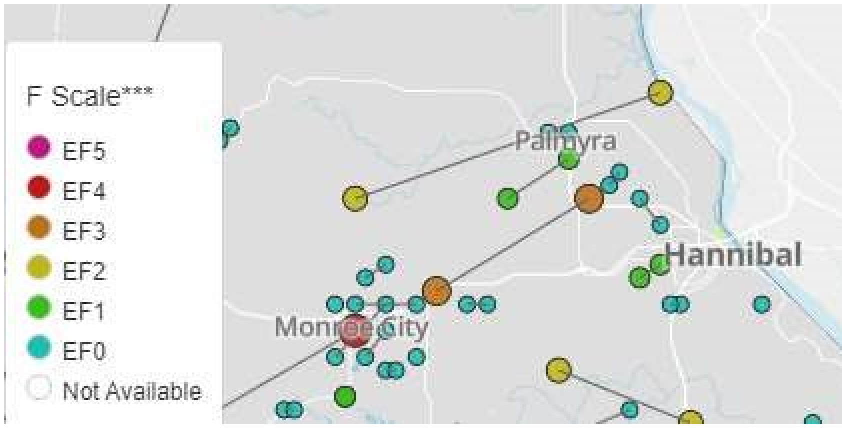
Table 3.46. Recorded Tornadoes in Marion, 1993 – Present

Date	Beginning Location	Ending Location	Length (miles)	Width (yards)	F/EF Rating	Death	Injury	Property Damage	Crop Damages
05/10/2003	6SW Ely	5SW Ely	1	40	F0	0	0	$0	$0
5/10/2003	1SW Ely	4S SE Palmyra	9.5	200	F3	0	0	$0	$0
5/24/2004	6NW Hannibal	4NW Hannibal	2	50	F0	0	0	$0	$0
10/02/2007	5W Ely	4W Ely	1.2	50	EF0	0	0	$0	$0
10/02/2007	1E Woodland	2S SE Palmyra	3.79	100	EF1	0	1	$100,000	$0
10/02/2007	0SW Palmyra	E Palmyra	.7	60	EF0	0	0	$50,000	$0
10/02/2007	3NNW Hannibal	2WSW Helton	.51	40	EF0	0	0	$0	$0
05/20/2013	2ENE White Bear	2S SE Hannibal	1.16	50	EF1	0	0	$0	$0
	Total					0	1	$150,000	$0

Source: National Centers for Environmental Information, http://www.NCEI.noaa.gov/stormevents/

The figure below shows historic tornado paths in the planning area.

Figure 3.37. Marion County Map Historic Tornado Events



Source: Missouri Tornado History Project, https://data.news-leader.com/tornado-archive/missouri/

Data from the USDA Risk Management Agency showed Marion County received no insurance payments as a result of tornados.

Probability of Future Occurrence

The National Centers for Environmental Information reported 8 tornadoes in Marion County in a 28year time period, which calculates to a 29 percent chance of tornado in any given year. Therefore, it is a low probability that some portion of Marion County will experience tornado activity in any given year

Changing Future Conditions Considerations

According to the 2018 Missouri State Hazard Mitigation Plan, Scientists do not know how the frequency and severity of tornadoes will change. Research published in 2015 suggests that changes in heat and moisture content in the atmosphere, brought on by a warming world, could be playing a role in making tornado outbreaks more common and severe in the U.S. The research concluded that the number of days with large outbreaks have been increasing since the 1950s and that densely concentrated tornado outbreaks are on the rise. It is notable that the research shows that the area of tornado activity is not expanding, but rather the areas already subject to tornado activity are seeing the more densely packed tornadoes. Because Missouri experiences on average around 39.6 tornadoes a year, such research is closely followed by meteorologists in the state.

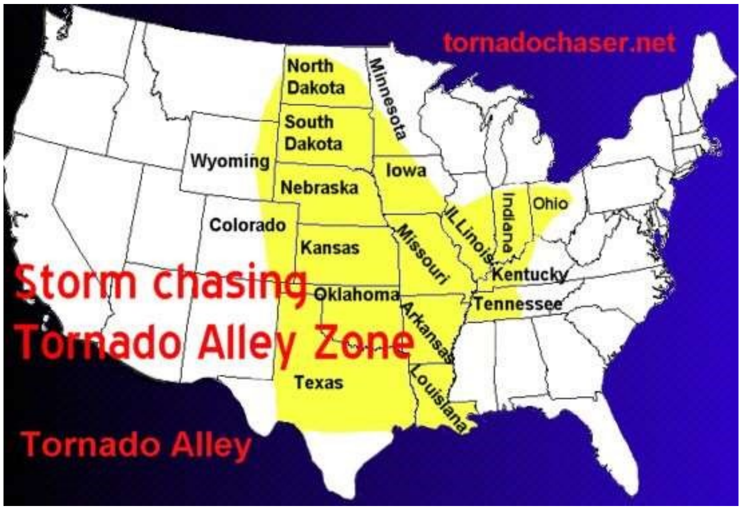
Vulnerability

Vulnerability Overview

Marion County is located in a region of the U.S. with high frequency of dangerous and destructive tornadoes referred to as "Tornado Alley". Figure 3.38 illustrates areas where dangerous tornadoes historically have occurred.

From the statistical data collected, six factors were considered in determining overall vulnerability to tornadoes as follows: building exposure, population density, social vulnerability, percentage of mobile homes, likelihood of occurrence, and annual property loss. Based on natural breaks in the statistical data, a rating value of 1 through 5 was assigned to each factor. These rating values correspond to the following descriptive terms: 1) Low 2) Low-medium 3) Medium 4) Medium-high 5) High.

Figure 3.38. Tornado Alley in the U.S.



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

Table 3.47. Ranges for Tornado Vulnerability Factor Ratings

Factors Considered	Low (1)	Low-medium (2)	Medium (3)	Medium-High (4)	High (5)
Common Factors					
Building Exposure ($)	$269,532-$3,224,641	$3,224,642-$8,792,829	$8,792,830-$22,249,768	$22,249,769-$46,880,213	$46,880,214-$138,887,850
Population Density (#per sq. mile)	4.11-44.23	44.24-134.91	134.92-259.98	259.99-862.69	862.70-2,836.23
Social Vulnerability	1	2	3	4	5
Percent Mobile Homes	0.2-4.5%	4.51-8.8%	8.81-14%	14.01-21.2%	21.21-33.2%
Likelihood of Occurrence (# of events/ yrs. of data)	0.119 - 0.208	0.209 - 0.313	0.314 - 0.417	0.418 - 0.552	0.553 - 0.791
Total Annualized Property Loss ($ / yrs. of data)	$974 - $281,874	$281,875 - $991,825	$991,826 - $2,099,000	$2,099,001 - $5,047,474	$5,047,475 - $42,467,109

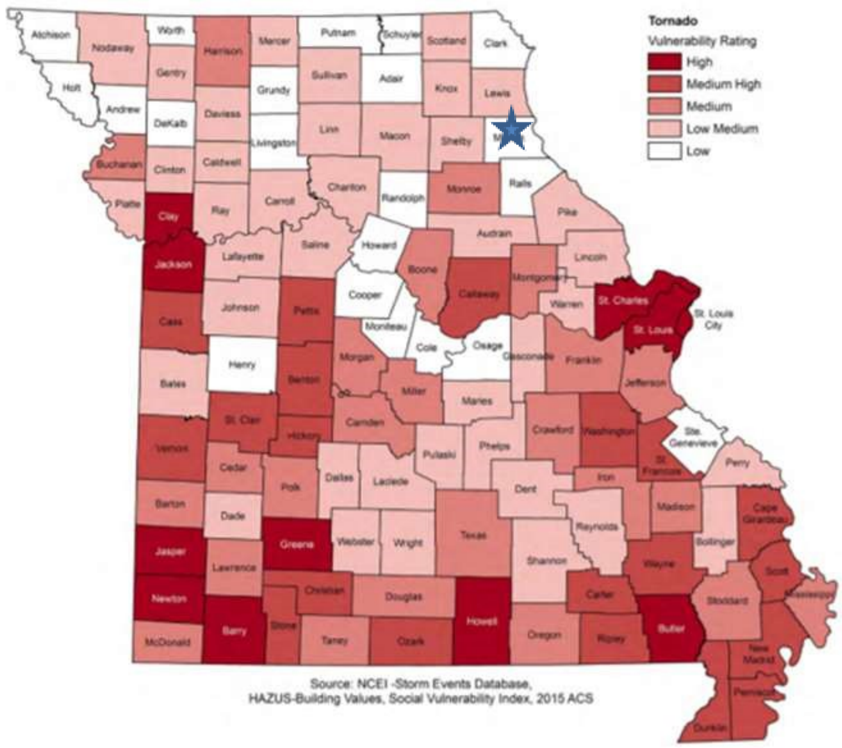
Table 3.48. Ranges for Tornado Combined Vulnerability Rating

	Low (1)	Low-medium (2)	Medium (3)	Medium-High (4)	High (5)
Tornado Combined Vulnerability	7-10	11-12	13-14	15-16	17-21

Table 3.49. Building Exposure, Population Density, SOVI and Mobile Home Data

County	Total Building Exposure (Hazus)	Exposure Rating	Population Density	Population Rating	SOVI Index Ranking	SOVI Rating	Percent Mobile Homes	Mobile Home Rating
Marion	$3,224,641,000	1	66.10	1	Medium High	4	5.3	2

Figure 3.39. Vulnerability to Tornadoes

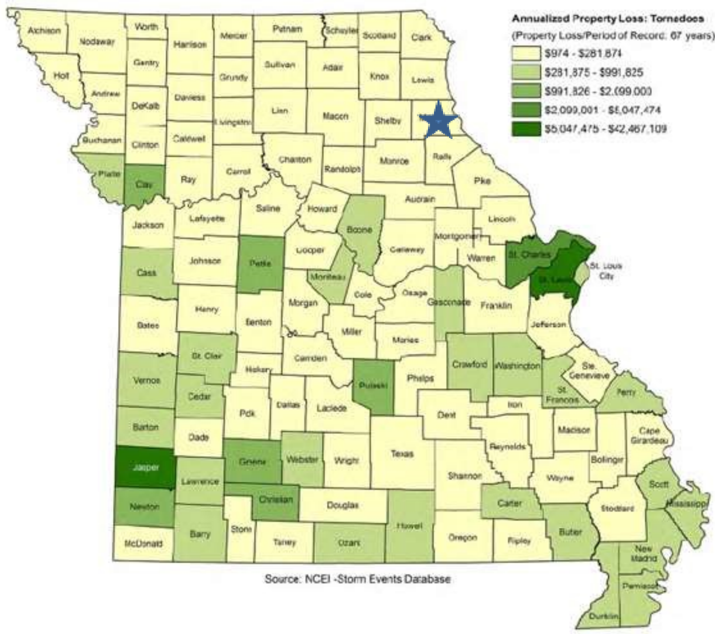


Source : 2018 State Hazard Mitigation Plan, Star indicates Marion County

Potential Losses to Existing Development

In the past 67 years, Marion County has had minimal property ($974 -$821,874) loss from tornadoes.

Figure 3.40. Annualized Property Loss for tornadoes



Source : 2018 Missouri State Hazard Mitigation Plan, Star indicates Marion County.

Previous and Future Development

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 safe room to protect occupants in the event of a tornado.

Hazard Summary by Jurisdiction

Tornado events could occur anywhere in the planning area, but some jurisdictions would suffer heavier damages because of the age of the housing or the high concentration of mobile homes. Communities that have adopted building codes may also be less vulnerable to damages.

Problem Statement

Marion County has inadequate tornado shelters throughout the county, not everyone utilizes social media and/or texting, the rural areas do not have warning sirens, lack of awareness for available shelters and more education needs to occur. Possible solutions include promoting the use of NOAA weather radios and conducting public education and outreach activities to increase awareness of tornado risk. Another solution of funding becomes available would be the construction of a safe room.

3.4.11 Wildfire

Hazard Profile

Hazard Description

The fire incident types for wildfires 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.

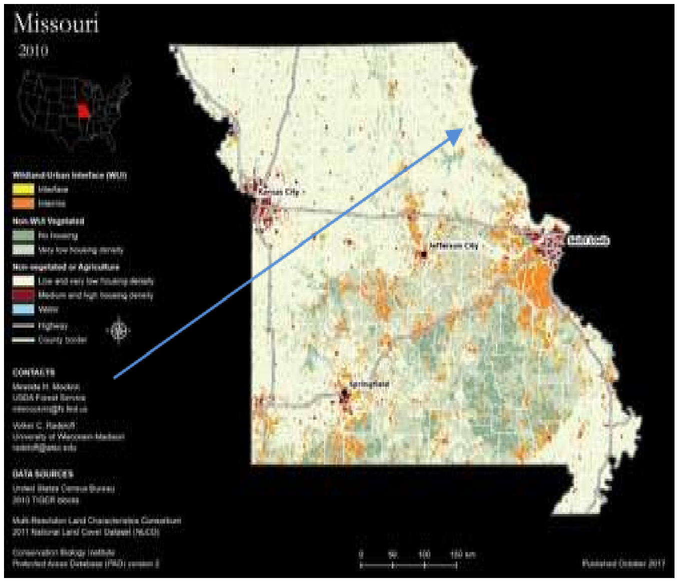
Most of Missouri fires occur during the spring season between February and May. The length and severity of wildland fires depend largely on weather conditions. Spring in Missouri is usually characterized by low humidity and high winds. These conditions result in higher fire danger. In addition, due to 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.

At this time, Wildland-Urban Interface area has information not specifically identified for Marion County. If this information become available prior to the next update of this plan, it will be incorporated.

Figure 3.41. Wildland-Urban Interface



Source: http://silvis.forest.wisc.edu/data/wui-change/ *Arrow indicates approximate location of Marion County

Strength/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.

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.

Previous Occurrences

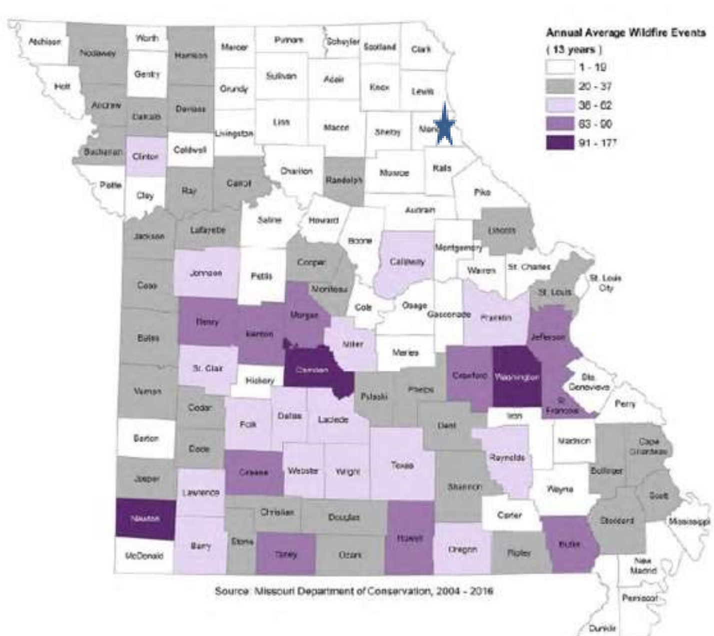
According to the Missouri Division of Fire Safety (MDFS) website, as well as the Missouri Department of Conversation Wildfire Data Search, there were 111 reported wildland or grass fires in Marion County from 2009-2019. In total, these 111 fires burned 1,021 acres and no injuries were reported. During the eleven-year reporting period, 51 of the fires had an unknown cause for starting and burning 326 acres, 14 were started by debris and burnt 493 acres, 6 of the fires were started by equipment and burnt 39 acres. 2 of the fires were started by smoking and burnt 1 acre.

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

Wildfires in the planning area are most likely to occur every year with very little resulting damage. 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.

Figure 3.42. Likelihood of Wildfire Events within Marion County Indicated



Source: 2018 Missouri State Hazard Mitigation Plan, Star indicates Marion County

Changing Future Conditions Considerations

According to the 2018 State Plan, higher temperatures and changes in rainfall are unlikely to substantially reduce forest cover in Missouri, although the composition of trees in the forests may change. More droughts would reduce forest productivity, and changing future conditions are also likely to increase the damage from insects and diseases. But longer growing seasons and increased carbon dioxide concentrations could more than offset the losses from those factors. Forests cover about one-third of the state, dominated by oak and hickory trees. As the climate changes, the abundance of pines in Missouri's forests is likely to increase, while the population of hickory trees is likely to decrease 0.

Additionally, stated in the 2018 State Plan, higher temperatures will also reduce the number of days prescribed burning can be performed. Reduction of prescribed burning will allow for growth of understory vegetation – providing fuel for destructive wildfires. Drought is also anticipated to increase in frequency and intensity during summer months under projected future scenarios. Drought can lead to dead or dying vegetation and landscaping material close to structures which creates fodder for wildfires within both the urban and rural settings.

Vulnerability

Vulnerability Overview

With over 14 million acres, Missouri ranks seventh in the northeast region of the U.S. in forest land area. From the data obtained from the Department of Conservation, the likelihood of occurrence and the annualized acres burned were determined for Marion County and listed in the section below.

Potential Losses to Existing Development

Table 3.50. Statistical Data for Wildfire Vulnerability for Marion County

County	Number of Wildfires 2004-2016	Likelihood of Occurrence (#/year)	Total Acres Burned	Average Annual Acreage Burned
Marion	95	7.31	1,367.45	105

Table 3.51. Estimated Numbers and Values of Structures and Population Vulnerable to Wildfire for Marion County

County	Number of Structures	Value of Structures	Population
Marion	**580**	**$148,765,167**	**1,147**
Agriculture	70	$15,552,250	
Commercial	28	$17,309,211	
Education	6	$10,154,483	
Government	2	$1,433,677	
Residential	474	$104,315,546	

Table 3.52. Wildfire Potential Loss Estimates for Marion County

County	Total WUI Acreage	Total Structure Value Within WUI	Average Value/Acre within WUI	Average Annual Acreage Burned	Potential Loss
Marion	6,056.84	$148,765,167	$24,562	105	$2,578,960

According to the 2018 Missouri State Hazard Mitigation Plan, Marion County is estimated to have on average 105 acres burned with a potential loss of $2,578,960.

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 are located inside city limits and do not face danger of wildfire due to barriers in place around the school. As long as drought conditions are not seriously inflamed, future wildfires in Marion County should have a negligible adverse impact on the community, as it would affect a small percentage of the population. Nonetheless, homes and businesses located in unincorporated areas are at higher risk from wildfires due to proximity to wood and distance from fire services. Variations in both structural/urban and wildfires are not able to be determined at this time due to lack of data. However, both fire types are expected to occur on an annual basis across the county.

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. Due to Marion County's drought rating, they may be more susceptible to fires.

3.4.12 Pandemic

Hazard Profile

Hazard Description

According to the Center for Disease Control, a pandemic is a global outbreak of disease. Pandemics happen when a new virus emerges to infect people and can spread between people sustainably. Because there is little to no pre-existing immunity against the new virus, it spreads worldwide.

Geographic Location

All of Marion County is susceptible to a pandemic outbreak due to its main characteristic of being on a global level.

Strength/Magnitude/Extent

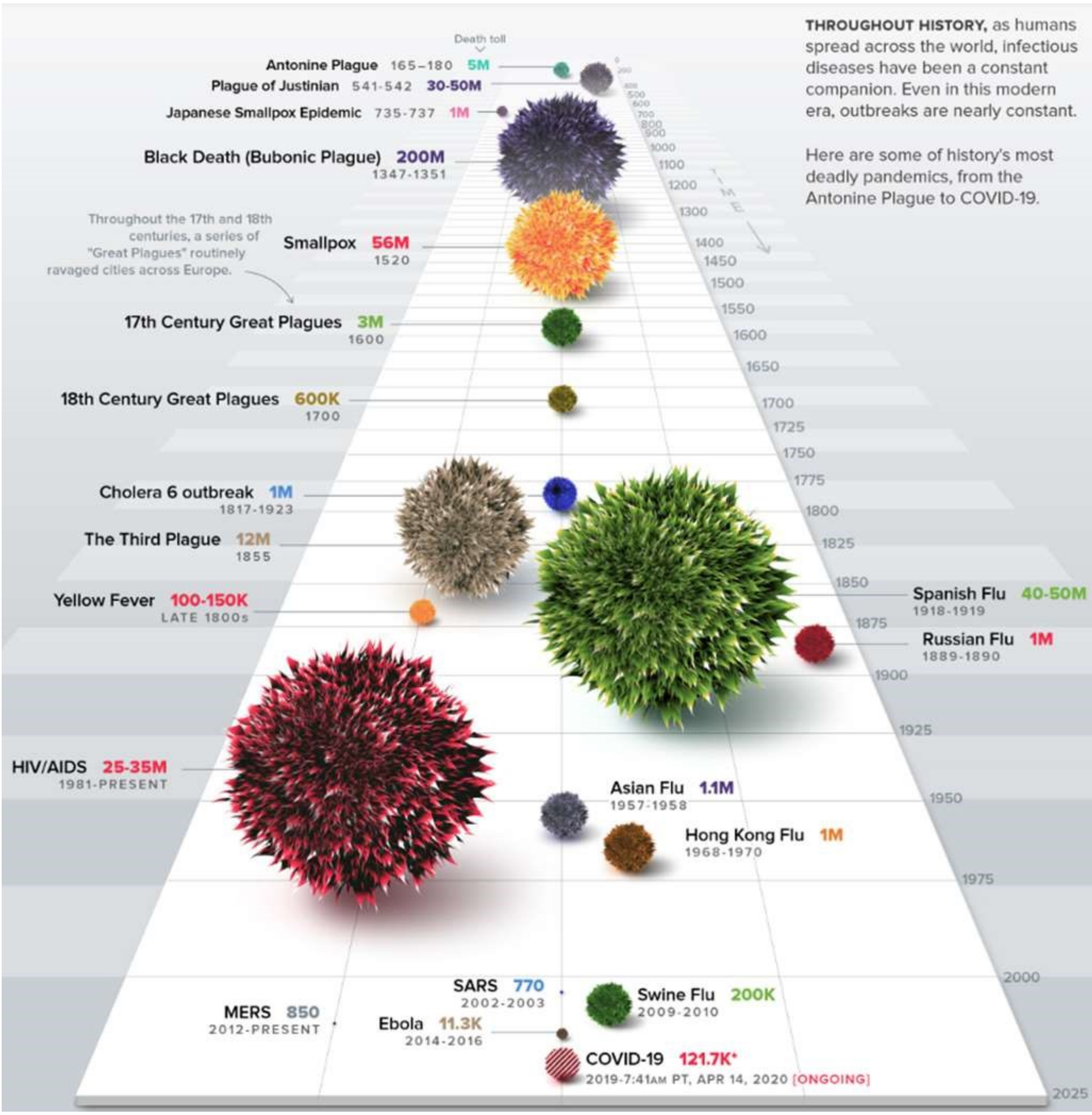
Risk depends on characteristics of the virus, including how well it spreads between people; the severity of resulting illness; and the medical or other measures available to control the impact of the virus (for example, vaccines or medications that can treat the illness) and the relative success of these. In the absence of vaccine or treatment medications, nonpharmaceutical interventions become the most important response strategy. These are community interventions that can reduce the impact of disease.

Previous Occurrences

The planning area, in addition to others across the globe, is currently in the midst of a pandemic. The virus that causes COVID-19 is infecting people and spreading easily from person-to-person. On March 11, 2020 the COVID-19 outbreak was characterized as a pandemic by the World Health Organization. According to the Center for Disease Control, this is the first pandemic known to be caused by a new coronavirus. In the past century, there have been four pandemics caused by the emergence of new influenza viruses. As a result, most research and guidance around pandemics is specific to influenza, but the same premises can be applied to the current COVID-19 pandemic. Pandemics of respiratory disease follow a certain progression outlined in a "Pandemic Intervals Framework." Pandemics begin with an investigation phase, followed by recognition, initiation, and acceleration phases. The peak of illnesses occurs at the end of the acceleration phase, which is followed by a deceleration phase, during which there is a decrease in illnesses. Different countries can be in different phases of the pandemic at any point in time and different parts of the same country can also be in different phases of a pandemic.

As humans have spread across the world, so have infectious diseases. Even in this modern era, outbreaks are nearly constant, though not every outbreak reaches pandemic level. Figure 3.43 below outlines the history of pandemics dating back to 165.

Figure 3.43. History of Pandemics



Source: https://www.visualcapitalist.com/history-of-pandemics-deadliest/

Probability of Future Occurrence

The threat of pandemics in the planning area, and across the globe, remains a concern.

Changing Future Conditions Considerations

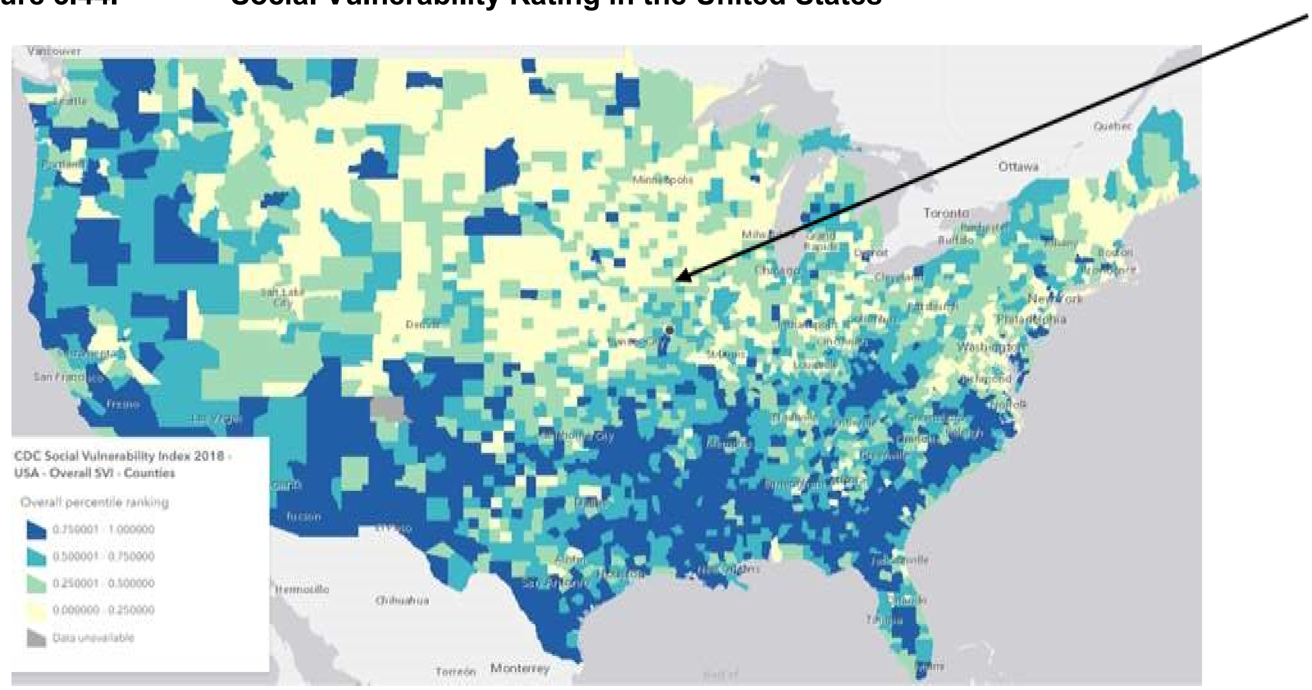
Climate change and weather patterns are widely thought to have direct impacts on the probability and severity of future pandemic outbreaks. Habitat loss due to climate is bringing animals that can transmit disease in contact with humans more often. Floods can enhance the spread of infectious agents like insects, bacteria, and viruses. Increasing temperatures and humidity affect the development, survival and spread of not only pathogens, but also their hosts (often animals).

Vulnerability

Vulnerability Overview

Each jurisdiction and its population, businesses, and school districts are vulnerable to a pandemic outbreak. Due to an increasing elderly population throughout the planning area, an outbreak of an infectious or viral disease could have major impacts on the communities and the assets each possess.

Figure 3.44. Social Vulnerability Rating in the United States



Source: https://livingatlas.arcgis.com/policy/browse/?loc=-94.542,39.439,5&col=88f17b4580e846609f92c9f75a9d9eee,2c8fdc6267e4439e968837020e7618f3,48638a1be455429287d6756985013910,02a82293e2dd475391cb3699b5e82d61,d89c527f2e6b4d658db0948ea9d49cd9,48a70b524601428ba297e3106b751401,be559110b5c34591b1a767fbb807bcbf,e0427fbc472f4a45b7d94d182a5e9591,142e65436bed4063973380feae6ed248&viz=2c8fdc6267e4439e968837020e7618f3&hs=1 *Arrow indicates Marion County

Potential Losses to Existing Development

During a pandemic, COVID-19 for example, people have been ordered to stay home, schools adjourned the remainder of the year, restaurants and bars are forced to close their doors. It is very likely the livelihood of the population and some of the planning area's most beloved assets and businesses will not be able to recover the pandemic due to extreme economic loss and health threats.

Impact of Previous and Future Development

Pandemics create unprecedented disruption for global health and the development of communities. Urbanization in the developing world is bringing more and more rural residents into denser neighborhoods, while population increases are putting greater pressure on the environment. In conjunction, air traffic nearly doubled in the past decade. These macro trends are having major impacts on the spread of infectious disease.

Hazard Summary by Jurisdiction

The planning area is largely rural and many have a sense of "safeness" when it comes to an infectious or viral pandemic, in the sense that most of the population can securely distance themselves from one another, whereas larger cities do not have that luxury. Unfortunately, pandemics happen on a global level and no community is immune.

Problem Statement

In order to keep transmission rates low during a pandemic outbreak, residents need to safely distance themselves as best as possible and follow the numerous Center for Disease Control guidelines. Due to the lack of accessibility to ongoing public health information and broadband connectivity, it is especially challenging to inform residents about current and upcoming pandemic updates. It is an issue in rural America to convey the severity of pandemic outbreaks and provide preparedness instruction because social media, website posts, podcasts, etc. are not an option for every resident in the planning area.