3 RISK ASSESSMENT

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

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

Changes in this version:
The risk assessment in this plan consolidates, updates, and streamlines content from the 2015 approved plan. Content has been restructured to cover a broad range of emerging hazards, vulnerabilities, and risk issues. Significant changes have been made that include standardized terminology, new GIS-based ranking methodology which assess hazard risk by jurisdiction, new analysis for all major hazards, and development of annualized loss by jurisdiction and review of local risk assessments, land use planning and development.

This chapter is divided into four main parts:

- **Section 3.1 Hazard Identification** identifies the hazards that threaten the planning area and provides a factual basis for elimination of hazards from further consideration;
- **Section 3.2 Assets at Risk** provides the planning area's total exposure to natural hazards, considering critical facilities and other community assets at risk;
- **Section 3.3 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-jurisdictional Hazard Mitigation Plan dated 2015 and Randolph County, Cairo, Clark, Clifton Hill, Higbee, Huntsville, Jacksonville, Moberly, Renick, Higbee R-III, Moberly School District, Renick R-V, Northeast R-IV School, Westran R-I School, MACC College and CCCB College participated in the multi-jurisdictional county wide-plan. The 2015 Randolph County Multi-Jurisdictional Hazard Mitigation Plan was consulted in development of the risk assessment and information was 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

Disasters 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 Randolph County, Missouri, 1965-Present

Disaster Number	Description	Declaration Date Incident Period	Individual Assistance (IA) Public Assistance (PA)
372	Heavy Rains, Tornadoes & Flooding	April 19,1973 April 19, 1973	-
3017	Drought	September 24, 1976 September 24, 1976	-
995	Severe Storms & Flooding	July 9,1993 June 10, 1993 to Oct. 25, 1993	-
1403	Severe Winter Ice Storm	February 6, 2002 Jan. 1, 2002 to Feb. 13, 2002	PA
1463	Severe Storms, Tornadoes & Flooding	May 6, 2003 May 4, 2003 to May 30, 2003	IA, PA
1524	Severe Storms, Tornadoes & Flooding	June 11, 2004 May 18, 2004 to May 31, 2004	IA
3232	Hurricane Katrina Evacuation	September 10, 2005 Aug. 29, 2005 to Oct. 1, 2005	PA
1631	Severe Storms, Tornadoes & Flooding	March 16, 2006 March 8, 2006 to March 13, 2006	IA, PA
3281	Severe Winter Storms	December 12,2007 Dec. 8, 2007 to Dec. 15, 2007	PA
1809	Severe Storms, Flooding & a Tornado	November 13, 2008 Sept. 11, 2008 to Sept. 24, 2008	IA, PA
1773	Severe Storms and Flooding	June 25, 2008 June 1, 2008 to Aug. 13, 2008	IA, PA
3303	Severe Winter Storm	January 30, 2009 Jan. 26, 2009 to Jan. 28, 2009	-
3317	Severe Winter Storm	February 3, 2011 Jan. 31, 2011 to Feb. 5, 2011	PA
1961	Severe Winter Storm & Snowstorm	March 23, 2011 Jan. 31, 2011 to Feb. 5, 2011	PA

Source: Federal Emergency Management Agency, https://www.fema.gov/data-visualization-summary-disaster-declarations-and-grants

3.1.3 Research Additional Sources

Additional sources of data and past impacts of hazards in the planning area:

- Missouri Hazard Mitigation Plans (2010, 2013, and 2018)
- Previously approved planning area Hazard Mitigation Plan
- 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 Public Service Commission

- National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI);
- Randolph County and local Comprehensive Plans to the extent available
- County Emergency Management
- County Flood Insurance Rate Map, FEMA
- Flood Insurance Study, FEMA
- SILVIS Lab, Department of Forest Ecology and Management, University of Wisconsin
- U.S. Army Corps of Engineers
- U.S. Department of Transportation
- United States Geological Survey (USGS)
- Various articles and publications available on the internet (you should state that you will give citations to the sources in the body of the plan)

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

The jurisdictions in Randolph County differ in their susceptibilities to certain hazards. The hazards identified were based on the input from the planning team members, available historical data and the hazard modeling results described with the hazard mitigation plans. The jurisdictions and hazards chosen that significantly impact the planning area is listed in Table 3.2. The chart includes an “x” to indicate the jurisdiction is impacted by the hazard and a “- “indicates the hazard is not applicable to that jurisdiction.

Table 3.2. Hazards Identified for Each Jurisdiction

Jurisdiction	Dam Failure	Drought	Earthquake	Extreme Temperatures	Flooding (River and Flash)	Land Subsidence/Sinkholes	Severe Winter Weather	Thunderstorm/Lightning/Hail/ High Wind	Tornado	Wildfire	Levee
Randolph County	-	X	X	X	X	X	X	X	X	X	X
Cairo	-	X	X	X	X	-	X	X	X	-	-
Clark	-	X	X	X	X	-	X	X	X	-	-
Higbee	-	X	X	X	X	-	X	X	X	-	-
Huntsville	-	X	X	X	X	-	X	X	X	-	-
Moberly	X	X	X	X	X	-	X	X	X	-	-
Renick	-	X	X	X	-	-	X	X	X	-	-
Higbee R-VIII School District	-	-	X	X	-	-	X	X	X	-	-
Moberly School District	-	-	X	X	-	-	X	X	X	-	-
Renick School District	-	-	X	X	-	-	X	X	X	-	-
Westran School District	-	-	X	X	-	-	X	X	X	-	-
Special Road District			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. Moberly is the most 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. Similarly, more rural areas have more assets (crops/livestock) that are vulnerable to animal/plant/crop/disease. 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, levee failure, 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 and the following information was not available for the plan: 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 Randolph County and Incorporated Cities

Table 3.3 shows the total population and the following was not, building count, estimated value of buildings, estimated value of contents and estimated total exposure to parcels for the unincorporated Randolph County and each incorporated city. **Table 3.3** the annual population estimate and building exposures was not available for Randolph County and each city in the planning area by usage type. Finally, **Table 3.4** provides the building count total and building exposures for the schools in Randolph County.

Table 3.3. Maximum Population and Building Exposure by Jurisdiction

Jurisdiction	2017 Annual Population Estimate	Building Count	Building Exposure ($)	Contents Exposure ($)	Total Exposure ($)
Cairo	326	167	$5,490	$2,681	$8,171
Clark	249	163	$5,013	$2,652	$7,665
Higbee	586	315	$10,836	$5,671	$16,507
Huntsville	1,618	695	$23,945	$12,687	$36,632
Moberly	13,775	5,758	$208,191	$114,076	$322,266
Renick	190	89	$3,265	$1,596	$4,862
Randolph County	24,987	16,796	$161,183	$90,940	$252,123

Source: U.S. Bureau of the Census, Annual population estimates/ 5-Year American Community Survey 2017; 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. Population and Building Exposure by Jurisdiction-Public School Districts

Public School District	Enrolment	Building Count	Building Exposure ($)	Contents Exposure ($)	Total Exposure ($)
Higbee R-VIII	204	11	$7,329,287	$1,458,804	$8,788,091
Moberly School District	2,431	18	$65,865,936	$17,038,454	$82,904,390
Renick	98	4	$6,054,430	$1,510,000	$7,564,430
Westran	584	7	$19,910,082	$3,460,151	$23,370,233

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 3.5 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
- Mark Twain Regional Council of Governments list of 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/LEPC-addresses.pdf
- Hazus contains an inventory of critical facilities that can be exported for each jurisdiction.

Table 3.5. 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
Cairo	-	-	X	-	-	X	X	X	X	-	-	-	-	-	-	-	-	-	-	X	-	-	X	7
Clark	-	-	-	-	-	X	X	X	-	-	-	-	-	-	-	-	-	X	-	-	-	-	X	5
Higbee	-	-	-	-	-	X	X	X	X	-	-	-	-	-	-	-	-	X	-	X	-	-	X	7
Huntsville	-	-	X	-	-	X	X	X	X	X	X	-	-	-	X	X	-	X	-	X	-	-	X	12
Moberly	X	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-	-	X	20
Renick	-	-	X	-	-	X	X	X	-	-	-	-	-	-	-	-	-	X	-	X	-	-	X	7
Randolph County	-	-	-	X	X	X	X	X	-	X	X	-	-	X	-	X	-	X	-	-	-	-	-	10
Totals	1	0	4	2	2	7	7	7	4	3	3	1	1	2	2	3	1	6	1	5	0	0	6	68

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

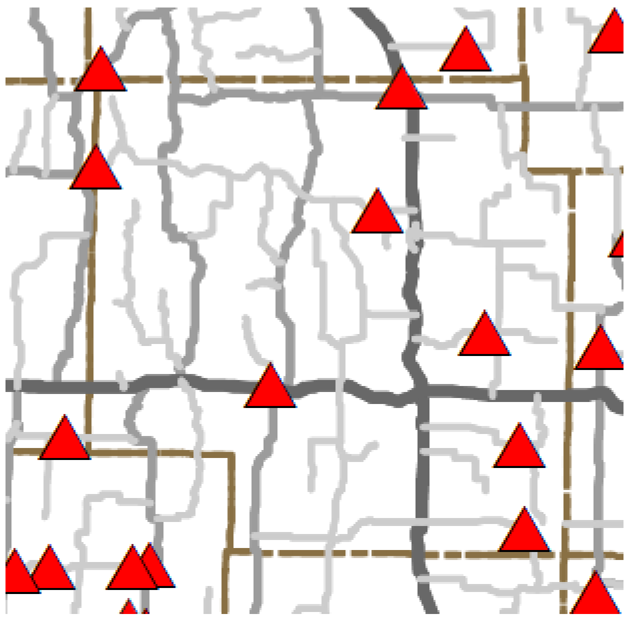
Bridges: This term refers to one of the database elements in the National Bridge Inventory. This element is quantified using a "scour index", which is a number indicating the vulnerability of a bridge to scour during a flood. Bridges with a scour index between 1 and 3 are considered "scour critical", or a bridge with a foundation determined to be unstable for the observed or evaluated scour condition. Randolph County has 8 bridges in the scour index. The map below shows structurally deficient bridges within Randolph County.

Figure 3.1. Randolph County Bridges

County	Bridge Counts				Bridge Area (Square Meters)			
	All	Good	Fair	Poor	All	Good	Fair	Poor
RANDOLPH (175)	163	98	60	5	46,143	32,293	12,983	868

Source: https://www.fhwa.dot.gov/bridge/nbi/no10/county18b.cfm#mo

Figure 3.2. Randolph 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 3.6) shows Federally Threatened, Endangered, Proposed and Candidate Species in Randolph County.

Table 3.6. Threatened and Endangered Species in Randolph County

Common Name	Scientific Name	Status
Topeka shiner	Notropis topeka= tristis	Endangered
Indiana Bat	Myotis sodalist	Endangered
Gray Bat	Myotis grisescens	Endangered
Northern Long-Eared Bat	Myotis septentrionalis	Threatened

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

Natural Resources: Randolph County has five 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 3.7 provides the names and location of parks and conservation areas in the planning area owned by Missouri Department of Conservation and within the jurisdictions.

Table 3.7. Parks in Randolph County

Park / Conservation Area	Address	City
Bee Hallow	From Macon take Highway 63 South 8 miles, then Jackpot Road west 2 miles.	Jacksonville
Bennitt Rudolf	From Columbia take Highway 63 north 19 miles, then Route F west 5 miles, then Route T 2.75 miles, then County Road 2930 west .50 mile to the area.	Clark
Beuth Park Lake	From the Junction of Bus. Highway 63 and Highway 24, take Business Highway 63 south 2.20 miles, then McKinsey Street west 1 mile.	Moberly
Sugar Creek Lake	From Moberly take Highway 24 west 1 mile, then Route DD north 2 miles, and County Road 1310 north 1.50 miles.	Moberly
Water Works Lake	Rothwell City Park	Moberly

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 3.8. Randolph County Properties on the National Register of Historic Places

Property	Address	City	Date Listed
Burkholder- O'Keefe House	605 S. 5th Street	Moberly	9/25/189
Mitchell Petroglyph Archaeological Site	Address Restricted		06/23/1969
Moberly Commercial Historic District	W. Coates, W. Rollins, N. Clark & Johnson Streets	Moberly	09/04/2012
Moberly Junior High School	101 Johnson Street	Moberly	01/04/2008

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

Economic Resources: Table 3.9 provides major non-governmental employers in the planning area.

Table 3.9. Major Non-Government Employers in Randolph County

Employer Name	Main Locations	Product or Service	Employees
DURA Automotive	Moberly	Automotive Parts	97
Cardinal Health	Moberly	Medical Supplies	170
Wilson Trailer	Moberly	Agriculture Trailers	63
Everlast	Moberly	Gym Equipment	81
Orscheln Products	Moberly	Automotive Cables	318
Mack Pro	Moberly	Automotive parts	105
Mid-Am Building Supply	Moberly	Building Supply	148
MFA	Moberly	Distribution Service	72
Orscheln Farm & Home Stores	Moberly	Distribution Service	383
Walmart Perishable Food	Moberly	Distribution Service	288
Wells Fargo	Moberly	Financial Services	103
Leaf Financial	Moberly	Financial Services	70
Associated Electric	Huntsville	Electric Power	251
Norfolk and Southern	Moberly	Railroad	189

Source: Data Collection Questionnaires;

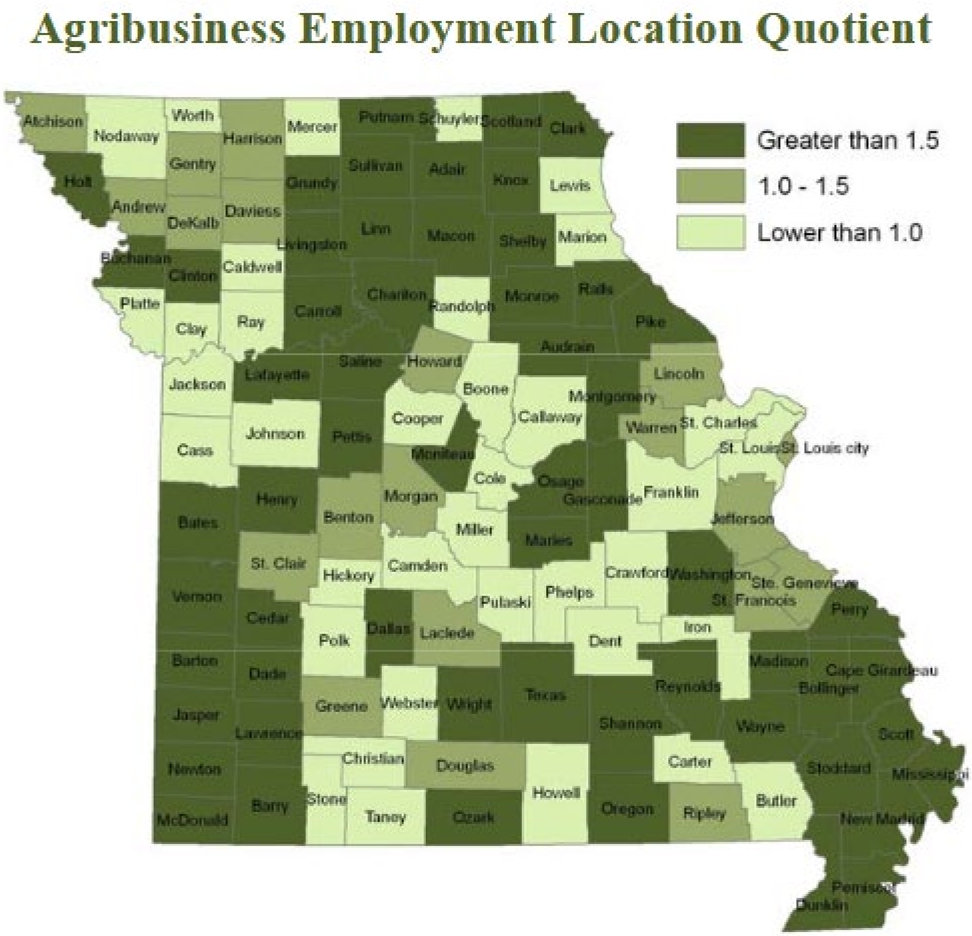
Agriculture: Agriculture plays an important role in the Randolph County economy. **Table 3.10** shows the Agriculture –Related Jobs in Randolph County. **Figure 3.3** shows Randolph County is lower than 1.0 in Agribusiness Employment.

Table 3.10. Agriculture-Related Jobs in Randolph County

Item		Randolph
Hired farm labor	farms	152
	workers	318
	$1,000 payroll	1,191
Farms with-		
1 worker	farms	73
	workers	73
2 workers	farms	41
	workers	82
3 or 4 workers	farms	29
	workers	95
5 to 9 workers	farms	6
	workers	35
10 workers or more	farms	3
	workers	30
Workers by days worked:		
150 days or more	farms	43
	workers	77
Farms with-		
1 worker	farms	23
	workers	23
2 workers	farms	13
	workers	26
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	122
	workers	241
Farms with-		
1 worker	farms	63
	workers	63
2 workers	farms	28
	workers	56
3 or 4 workers	farms	27
	workers	91
5 to 9 workers	farms	2
	workers	(D)
10 workers or more	farms	2
	workers	(D)
Reported only workers working 150 days or more	farms	30
	workers	45
	$1,000 payroll	715
Reported only workers working less than 150 days	farms	109
	workers	210
	$1,000 payroll	206
Reported both - workers working 150 days or more and workers working less than 150 days	farms	13
	150 days or more, workers	29
	less than 150 days, workers	31
	$1,000 payroll	270
Total migrant workers (see text)	farms	3
	workers	5
Migrant farm labor on farms with hired labor	farms	3
	workers	5
Migrant farm labor on farms reporting only contract labor	farms	-
	workers	-
Unpaid workers (see text)	farms	328
	workers	725

Source: https://www.nass.usda.gov/Publications/AgCensus/2012/Full_Report/Volume_1,_Chapter_2_County_Level/Missouri/st29_2_007_007.pdf

Figure 3.3. Agribusiness Employment Location Quotient



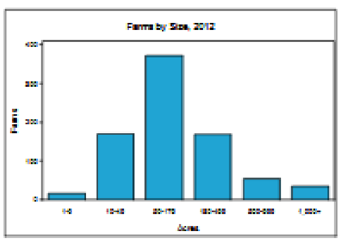
Source: https://www.missourieconomy.org/pdfs/missouri_farms_and_agribusiness.pdf

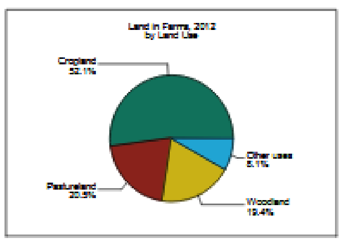
Figure 3.4. 2012 Census of Agriculture, Randolph County

2012 CENSUS OF AGRICULTURE
COUNTY PROFILE

Randolph County
Missouri

	2012	2007	% change
Number of Farms	818	1,000	- 18
Land in Farms	209,491 acres	221,647 acres	- 5
Average Size of Farm	256 acres	222 acres	+ 15
Market Value of Products Sold	$36,706,000	$36,064,000	+ 2
Crop Sales $21,478,000 (59 percent)			
Livestock Sales $15,228,000 (41 percent)			
Average Per Farm	$44,873	$36,064	+ 24
Government Payments	$2,820,000	$2,849,000	- 1
Average Per Farm Receiving Payments	$6,294	$5,016	+ 25





Source: https://www.nass.usda.gov/Publications/AgCensus/2012/Online_Resources/County_Profiles/Missouri/cp29175.pdf

Figure 3.5. Randolph County Agriculture Data

Randolph County – Missouri

Ranked items among the 114 state counties and 3,079 U.S. counties, 2012

Item	Quantity	State Rank	Universe [1]	U.S. Rank	Universe [1]
MARKET VALUE OF AGRICULTURAL PRODUCTS SOLD ($1,000)					
Total value of agricultural products sold	36,706	52	114	1,995	3,077
Value of crops including nursery and greenhouse	21,478	60	114	1,665	3,072
Value of livestock, poultry, and their products	15,228	53	114	1,542	3,076
VALUE OF SALES BY COMMODITY GROUP ($1,000)					
Grains, oilseeds, dry beans, and dry peas	18,148	60	114	1,274	2,926
Tobacco	-	-	12	-	436
Cotton and cottonseed	-	-	7	-	635
Vegetables, melons, potatoes, and sweet potatoes	(D)	(D)	109	(D)	2,802
Fruits, tree nuts, and berries	(D)	14	107	(D)	2,724
Nursery, greenhouse, floriculture, and sod	354	41	107	1,520	2,678
Cut Christmas trees and short rotation woody crops	(D)	35	55	(D)	1,530
Other crops and hay	2,540	29	113	1,125	3,049
Poultry and eggs	28	70	113	1,927	3,013
Cattle and calves	13,074	70	114	1,120	3,056
Milk from cows	(D)	(D)	96	(D)	2,036
Hogs and pigs	(D)	54	109	(D)	2,827
Sheep, goats, wool, mohair, and milk	80	69	110	1,547	2,988
Horses, ponies, mules, burros, and donkeys	113	66	114	1,723	3,011
Aquaculture	-	-	48	-	1,366
Other animals and other animal products	2	101	114	2,703	2,924
TOP CROP ITEMS (acres)					
Soybeans for beans	44,163	54	111	651	2,162
Forage-land used for all hay and haylage, grass silage, and greenchop	25,656	60	114	744	3,057
Corn for grain	12,536	65	105	1,121	2,636
Wheat for grain, all	4,758	42	105	1,000	2,537
Winter wheat for grain	4,758	42	105	922	2,480
TOP LIVESTOCK INVENTORY ITEMS (number)					
Cattle and calves	22,188	74	114	1,298	3,063
Hogs and pigs	(D)	(D)	105	(D)	2,559
Layers	1,573	58	113	1,496	3,040
Horses and ponies	912	30	114	1,310	3,072
Sheep and lambs	865	42	109	1,010	2,897

Other County Highlights, 2012

Economic Characteristics	Quantity
Farms by value of sales:	
Less than $1,000	258
$1,000 to $2,499	81
$2,500 to $4,999	70
$5,000 to $9,999	91
$10,000 to $19,999	78
$20,000 to $24,999	27
$25,000 to $39,999	47
$40,000 to $49,999	33
$50,000 to $99,999	54
$100,000 to $249,999	28
$250,000 to $499,999	11
$500,000 or more	14
Total farm production expenses ($1,000)	39,558
Average per farm ($)	48,358
Net cash farm income of operation ($1,000)	5,764
Average per farm ($)	7,047

Operator Characteristics	Quantity
Principal operators by primary occupation:	
Farming	330
Other	488
Principal operators by sex:	
Male	717
Female	101
Average age of principal operator (years)	60.3
All operators by race [2]:	
American Indian or Alaska Native	5
Asian	1
Black or African American	1
Native Hawaiian or Other Pacific Islander	-
White	1,219
More than one race	4
All operators of Spanish, Hispanic, or Latino Origin [2]	4

See "Census of Agriculture, Volume 1, Geographic Area Series" for complete footnotes, explanations, definitions, and methodology.
- Represents zero. (D) Withheld to avoid disclosing data for individual operations.
[1] Universe is number of counties in state or U.S. with item. [2] Data were collected for a maximum of three operators per farm.

Source: https://www.nass.usda.gov/Publications/AgCensus/2012/Online_Resources/County_Profiles/Missouri/cp29175.pdf

3.3 LAND USE AND DEVELOPMENT

3.3.1 Development Since Previous Plan Update

The U.S. Census Bureau shows Randolph County is expected to have decreased by 2.09% since the last census was performed. Table 3.11 provides the population growth statistics for all the cities in Randolph as well as Randolph County as a whole. Population statistics represent the 2010 U.S. Census and American Community Survey 5-year estimates.

Table 3.11. Randolph County Population Growth, 2010-2017

Jurisdiction	Total Population 2010	Total Population 2017	2010-2017 # Change	2000-2017 % Change
Randolph County	25,414	24,945	-531	-2.09%
Cairo	292	285	-7	-2.39%
Clark	298	291	-7	-2.34%
Clifton Hill	114	111	-3	-2.63%
Higbee	568	552	-16	-2.82%
Huntsville	1,564	1,519	-45	-2.88%
Jacksonville	151	146	-5	-3.31%
Moberly	13,974	13,786	-188	-1.37%
Renick	172	168	-4	-2.33%

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. Randolph County, Higbee, Huntsville and Renick have shown an increase in housing, with Cairo, Clifton Hill, Jacksonville and Moberly reflecting a decline. The community of Clark is showing as remaining the same. When American Factfinder was utilized for this information it shows Higbee as having a significant increase in housing units. After visiting with the community it was verified they did not have a significant increase in housing units.

Table 3.12. Change in Housing Units, 2010-2017

Jurisdiction	Housing Units 2010	Housing Units 2017	2010-2017 # Change	2000-2017 % Change
Randolph County	10,739	10,758	+19	.18%
Cairo	125	121	-4	-3.20%
Clark	115	115	0	0
Clifton Hill	51	32	-19	-37.25%
Higbee	273	380	+107	39.19%
Huntsville	690	694	+4	.58%
Jacksonville	65	64	-1	-1.54%
Moberly	5.687	5,595	-92	-1.62%
Renick	75	107	+32	42.67%

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. According to the American Fact Finder estimates show that in 2017 the number of housing units were expected to increase in all jurisdictions within Randolph County. 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

Randolph County

Randolph County has no plans for future development.

City of Moberly

Development is occurring throughout the community and residential development includes Southridge Subdivision, Ellis Place and Angels Landing Plat 3.

City of Huntsville

Huntsville has no plans for future land use or development.

City of Renick

City of Renick has no plans for future land use or development.

School District's Future Development

The Higbee R-VIII is in the process of adding a preschool/multipurpose facility, maintenance shop and freezer and remodeling classrooms from the 1913.

Special District's Future Development

The Special Road District does not have any plans for 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 **3.4** 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. NOAA has the NOAA Climate Explorer, https://toolkit.climate.gov/tools/climate-explorer

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 Randolph County plan will also be based on:

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

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 must conclude with a brief summary of the problems created by the hazard in the planning area, and possible ways to resolve those problems. Jurisdiction-specific information in those cases where the risk varies across the planning area will be included.

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. Below is a Hazus Vs DFIRM Grid for Randolph County.

Figure 3.6. RiskMAP, DFIRM and Hazus based Depth Grids used in Hazus Analysis

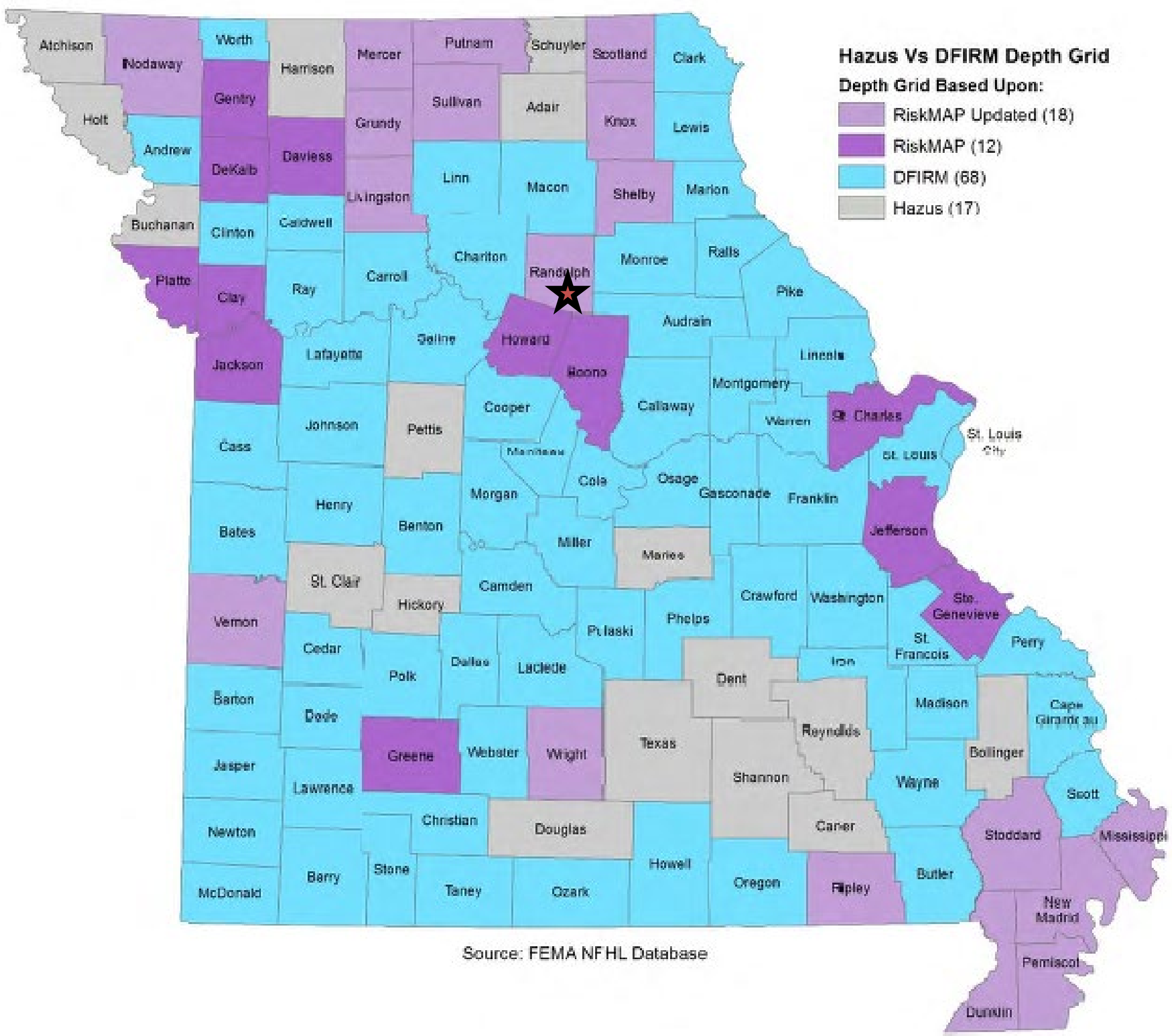


Table 3.13. Randolph County NCEI Flood Events by Location, 1998-2018

Location	# of Events
Unincorporated Randolph County	0
Huntsville	1
Water over road at Route D	

Source: National Centers for Environmental Information, August 11, 2019 https://www.ncdc.noaa.gov/stormevents

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 3.14 shows the number of flash flood events by location recorded in NCEI for the 20-year period.

Table 3.14. Randolph County NCEI Flash Flood Events by Location, 1998-2018

Location	# of Events
Unincorporated Randolph County	1
-Unincorporated Randolph County (unspecified)- 0 flood events	
-Unincorporated Randolph County Road 1150-1 flood events	
City of Moberly	9
-City of Moberly- Highway 24 and JJ- 1 flood event	
-City of Moberly- Throughout the City- 2 flood events	
-City of Moberly- S. Morley & Rollins- 1 flood event	
-City of Moberly- Morley & Woodland- 1 flood event	
-City of Moberly- Bradley Omar Airport- 1 flood event	
-City of Moberly- Franklin & Rollins- 1 flood event	
-City of Moberly- Rail Bridge & Highway 63- 1 flood event	
City of Clark	1
-City of Clark – Highway NN and 63- 1 flood events	

Source: National Centers for Environmental Information, August 11,2019 https://www.ncdc.noaa.gov/stormevents

Strength/Magnitude/Extent

Missouri has a long and active history of flooding over the past century, according to the current State Hazard Mitigation Plan. Flooding along Missouri 's major rivers generally result 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 extract 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 3.15 provides details on NFIP participation for the communities in the planning area. Table 3.16 provides information on the number of policies in force, amount of insurance in force, number of closed losses, and total payments for each jurisdiction, where applicable.

Table 3.15. NFIP Participation in Randolph County

Community ID #	Community Name	NFIP Participant (Y/N/Sanctioned)	Current Effective Map Date	Regular-Emergency Program Entry Date
29082	Randolph County	Y	04/01/2010 (L)	04/01/2010
	Cairo	N		
	Clark	N		
	Higbee	N		
290718	Huntsville	Y	NSFHA	08/24/1984
290305	Moberly	Y	11/09/1982	06/01/1977
	Renick	N		

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

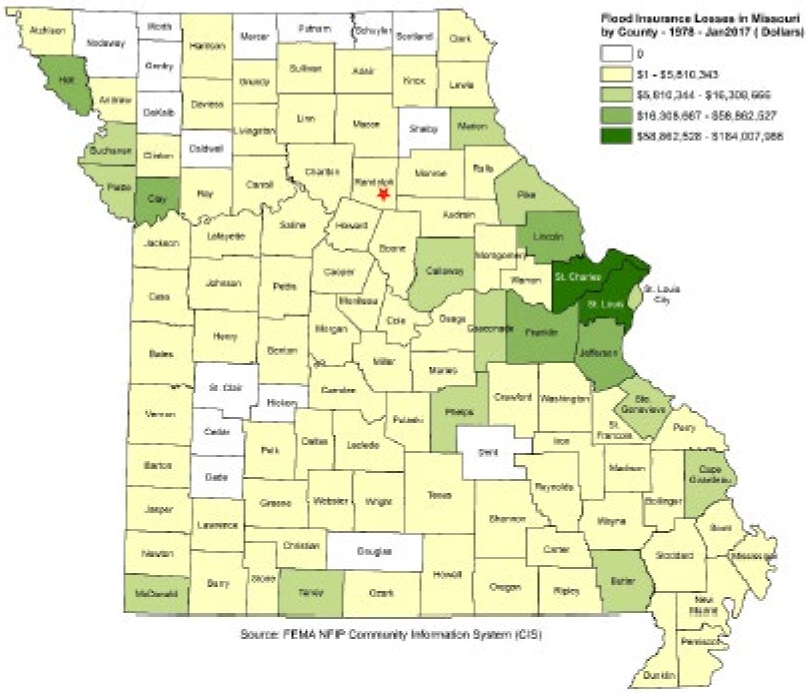
Table 3.16. NFIP Policy and Claim Statistics as of Date

Community Name	Policies in Force	Insurance in Force	Closed Losses	Total Payments
Moberly	11	$1,095,900	0	0
Randolph County	4	$272,500	0	$1 to $5,810,343

Source: NFIP Community Status Book, August 11, 2019 ; BureauNet, http://bsa.nfipstat.fema.gov/reports/reports.html; *Closed Losses are those flood insurance claims that resulted in payment. Loss statistics are for the period as of September 2018.

According to Table 3.16 the City of Moberly had zero claims resulting in zero payments and unincorporated Randolph County had total payments of between $1 to $5,810,343.

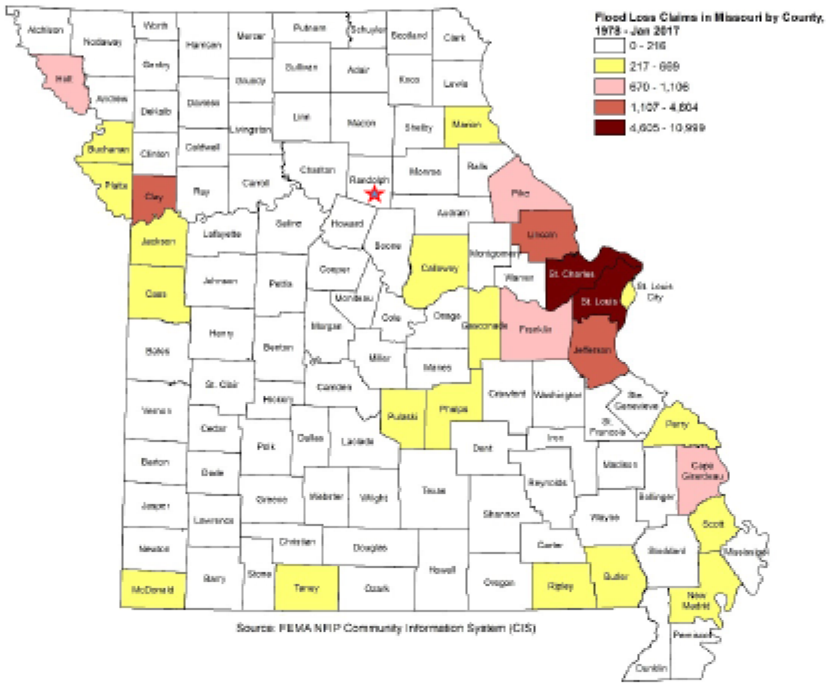
Figure 3.7. Map of Dollars Paid Historically for Flood Insurance Losses in Missouri by County, 1978 - January 2017



Source: 2018 Missouri State Hazard Mitigation Plan, * Red star shows Randolph County

Figure 3.7 shows during the period of 1978 – January 2017, Randolph County received between $1 and $5,810,343 in Flood Insurance payments.

Figure 3.8. **Flood Loss Claims in Missouri by County, 1978 - January 2017**



Source: 2018 Missouri State Hazard Mitigation Plan *Red Star shows Randolph County

Figure 3.8 demonstrates between the period of 1978 and January 2017, Randolph County had between 0 and 216 Flood Loss Claims.

According to the 2018 Missouri State Hazard Mitigation Plan, Randolph County was not one of the top ten counties in the state to receive payments due to flooding.

Repetitive Loss/Severe Repetitive Loss Properties

Repetitive Loss Properties are those properties with at least two flood insurance payments of $1,000 each have been paid under the National Flood Insurance Program (NFIP) within any 10-year period since 1978. According to the Flood Insurance Administration, jurisdictions included in the planning area have a combined total of zero repetitive loss properties.

According to the Flood Insurance Administration, jurisdictions included in the planning area have no repetitive loss properties.

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

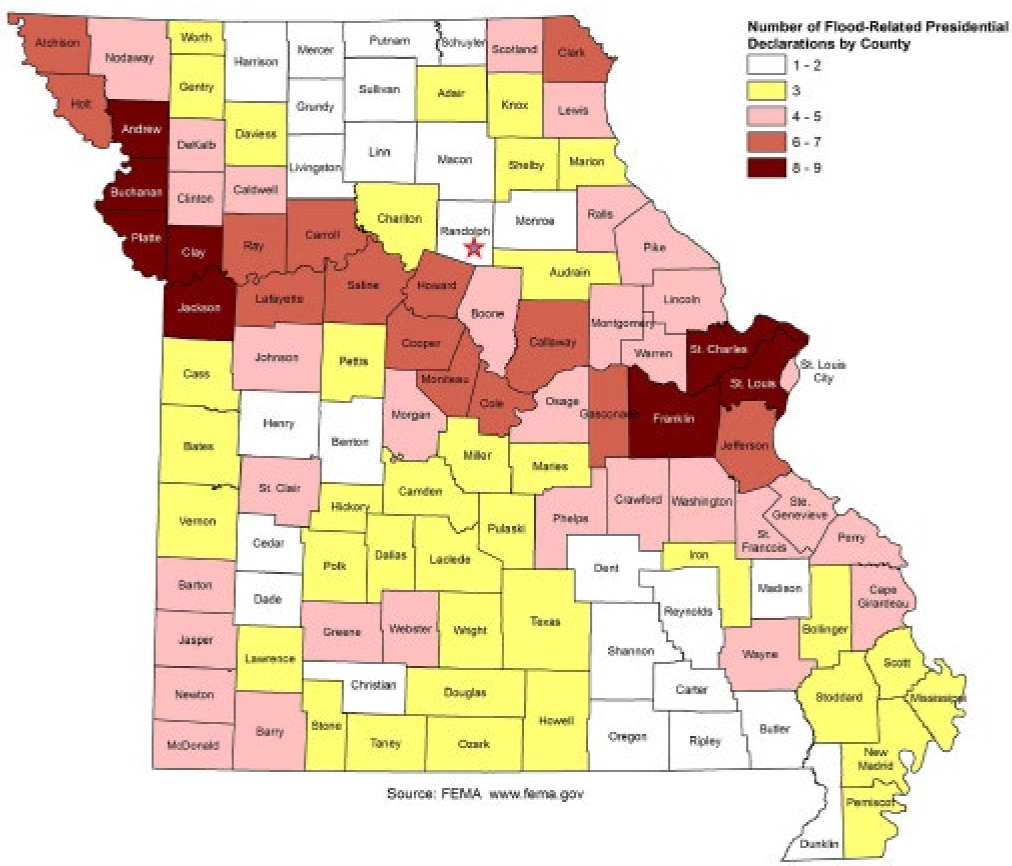
There are no validated Severe Repetitive Loss Properties in Randolph County.

Previous Occurrences

Table 3.17. Presidential Flooding Disaster Declarations Including Randolph County

Disaster Number	Description	Declaration Date Incident Period	Individual Assistance (IA) Public Assistance (PA)
995	Severe Storms & Flooding	July 9,1993 June 10, 1993 to Oct. 25, 1993	-
1773	Severe Storms and Flooding	June 25, 2008 June 1, 2008 to Aug. 13, 2008	IA, PA

Figure 3.9. Number of Flood-Related Presidential Declarations by County



Source: 2018 Missouri State Hazard Mitigation Plan, *Red star shows Randolph County

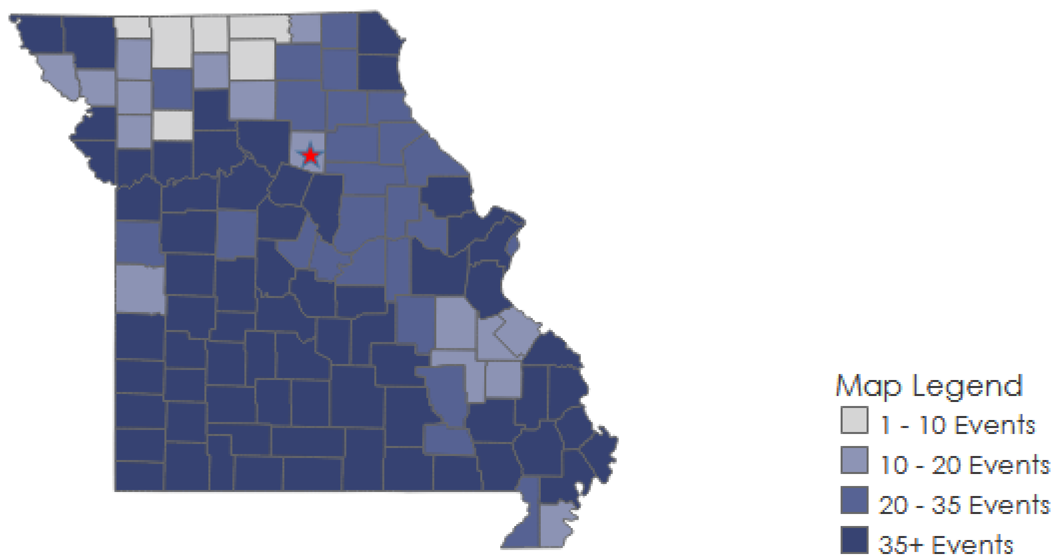
NCEI information for the last 20 years for flash flood and riverine events are shown in (Table 3.18 and Table 3.19).

Table 3.18. NCEI Randolph County Flash Flood Events Summary, 1998 to 2018

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
2003	2	0	0	$0	$0
2004	1	0	0	$0	$0
2005	1	0	0	$0	$0
2008	3	0	0	$0	$0
2010	3	0	0	$0	$0
2014	1	0	0	$0	$0
2016	1	0	0	$0	$0
2018	1	0	0	$0	$0

Source: NCEI, data accessed August 11, 2019

Figure 3.10. Historical Flood Impact for Randolph County



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

The FEMA Data Visualization Tool as shown above in Figure 3.10, Randolph County had between 10 – 20 events of flood impact.

Table 3.19. NCEI Randolph County Riverine Flood Events Summary, 1998 to 2018

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
2010	1	0	0	$0	$0

Source: NCEI, August 11, 2019

Probability of Future Occurrence

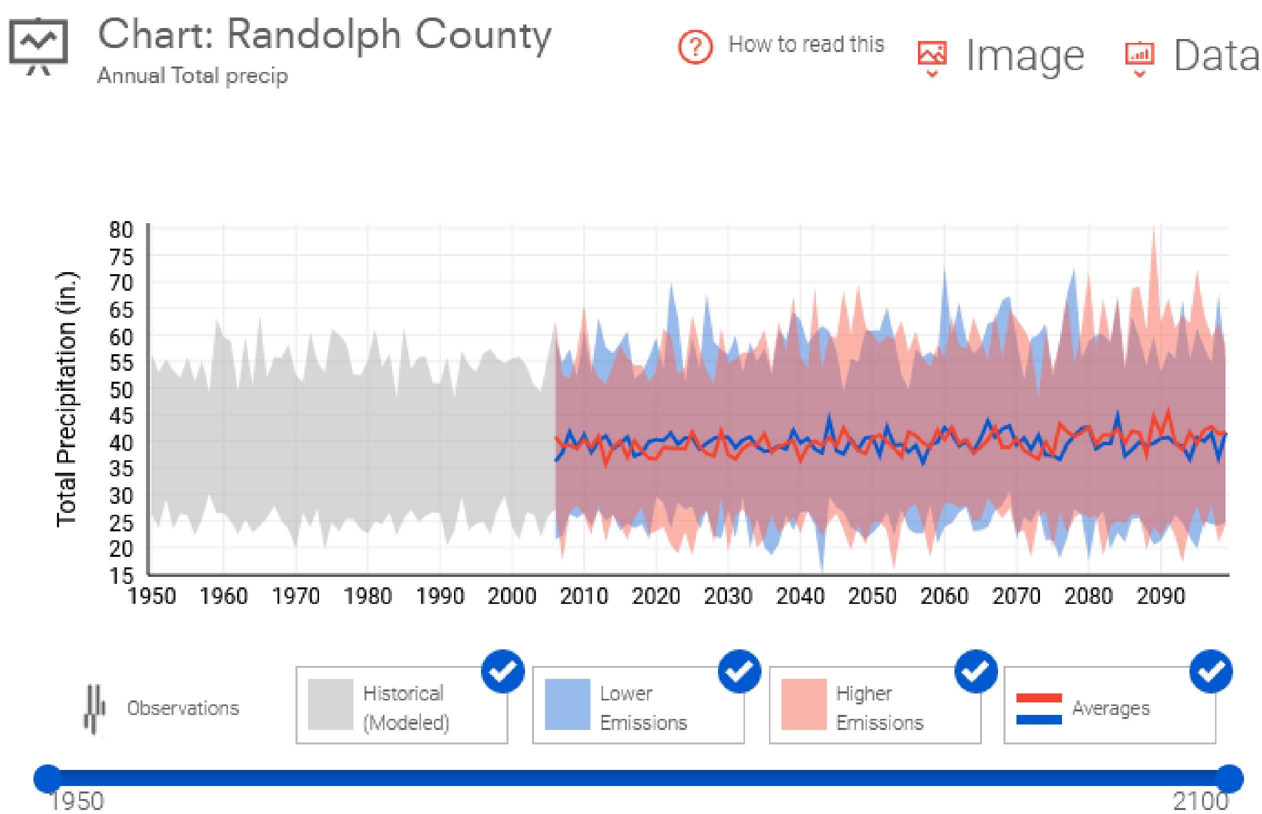
Flash flooding in the planning area has occurred 8 out of 21 years making flash flooding a 38% probability flash flooding will occur in any given year.

Riverine Flooding in the planning area has occurred once in the last 21 years making riverine flooding a 4.7% probability flooding will occur 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.

Figure 3.11. U. S. Climate Resilience Toolkit- Annual Total Precipitation for Randolph County

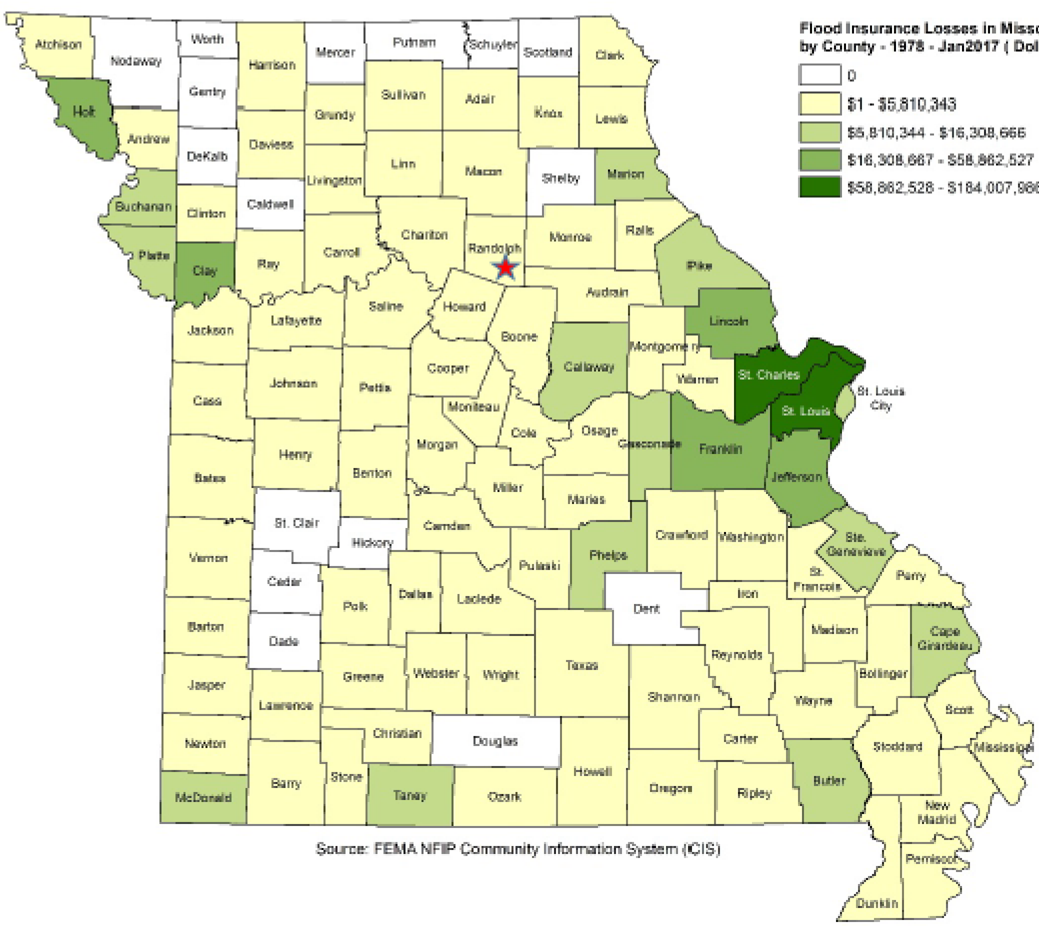


Source: US Climate Resilience Toolkit, https://toolkit.climate.gov/tools/climate-explorer

Vulnerability

Vulnerability Overview

Figure 3.12. Map of Dollars Paid Historically for Flood Insurance Losses in Missouri by County, 1978 to January 2017



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

According to the 2018 Missouri State Hazard Mitigation Plan, Randolph County flood losses were at the lower end which is between $1 and $5,810,343.

The 2018 Missouri State Hazard Mitigation Plan demonstrates Randolph County's loss ratio at .17%. This ratio represents a total direct building loss and income loss.

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.

Potential Losses to Existing Development

Using the data obtained from the Flood Insurance Administration it showed the City of Moberly has a history of flood and flash flood events and are the most vulnerable to have another event occur. Due to the flood events the City of Moberly experiences they have repeatedly damaged roads and infrastructure.

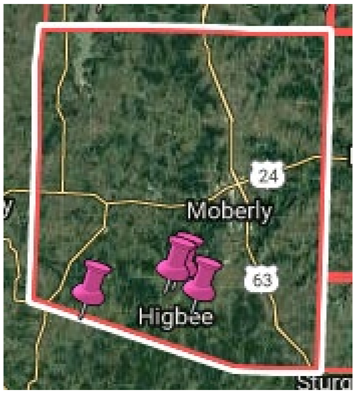
Impact of Previous and Future Development

Any future development in floodplains would increase risk in those areas. For the three communities participating 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 be necessary due to rising waters. In addition, floods that exceed mitigated levels may still cause damages.

Hazard Summary by Jurisdiction

Vulnerability to flooding varies by jurisdiction as each community has a different layout, as described above the City of Moberly has a history of flash flood events and would be more vulnerable to another loss in the future. Cairo, Clark, Higbee and Huntsville also experience minor flash flooding of streets and low-lying areas in the communities. Table 3.14 reflects the NCEI Flash Flood Events in Unincorporated Randolph County at 1 event, City of Moberly at 9 events, and Clark at 1event with a total of 13 events in the planning area.

Figure 3.13. Low Water Crossings in Randolph County



Problem Statement

Flooding or flash flooding affects the rural areas of Randolph County and the City of Moberly. 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. The City of Moberly could mitigate the damage caused to the roads by improving the infrastructure including the drainage system and creating water basins to hold the water so flooding does not occur.

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

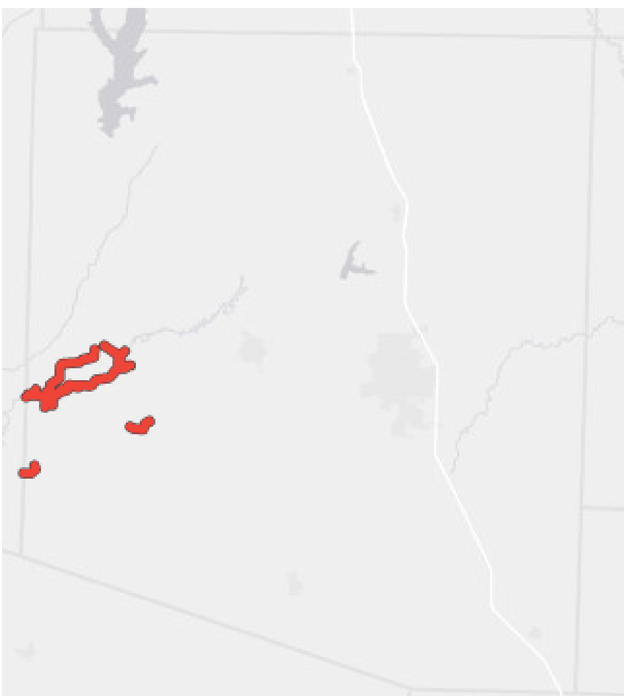
Missouri is a state with many levees. Currently, there is no single comprehensive inventory of levee systems in the state. Levees have been constructed across the state by public entities and private entities with varying levels of protection, inspection oversight, and maintenance. The lack of a comprehensive 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 1-percent 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, Randolph County does not have a DFIRM issued for the county. The seven levees in Randolph County are agriculture levees and protect farmland. One of the seven levees protects farmland comprised of mature pecan trees and holds significant commercial value. There are no residential properties being directly protected by the 7 levees in the County. The Chariton River flows through the western part of the county and the levees protect farmland against the flooding of the river. The 7 levees are considered low risk and only protecting farmland.

Figure 3.14. Levees of Randolph County



7 System(s) Found

EAST FORK LITTLE CHARITON RIVER LEVEE 1
Location: Chariton, Randolph , Missouri

EAST FORK LITTLE CHARITON RIVER LEVEE 2
Location: Randolph , Missouri

EAST FORK LITTLE CHARITON RIVER LEVEE 3
Location: Randolph , Missouri

EAST FORK LITTLE CHARITON RIVER LEVEE 4
Location: Randolph , Missouri

EAST FORK LITTLE CHARITON RIVER LEVEE 5
Location: Chariton, Randolph , Missouri

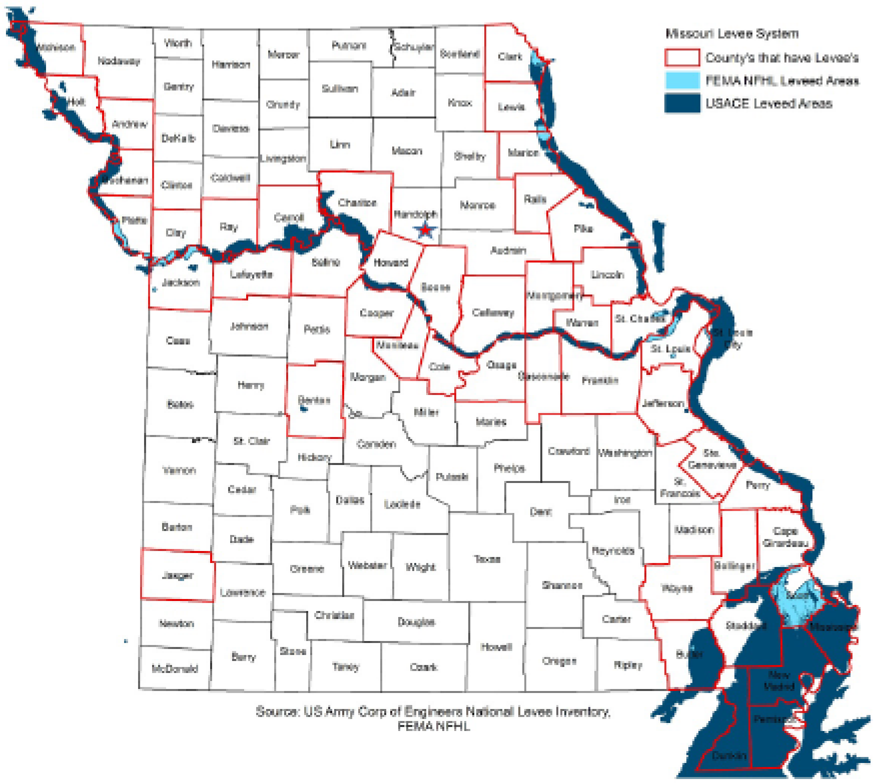
SILVER CREEK LEVEE
Location: Chariton, Randolph , Missouri

SWEET SPRING CREEK LEVEE
Location: Randolph , Missouri

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

According to the Missouri 2018 Hazard Mitigation Plan Randolph County is not impacted by Levees as Figure 3.15 shows.

Figure 3.15. Missouri Counties Impacted by Levees



Source: 2018 Missouri State Hazard Mitigation Plan: * Red Star Indicates Randolph County

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

Levees in the planning area are not high-risk levees.

Probability of Future Occurrence

It is the responsibility of the individual landowners to inspect and maintain the levees. Landowners need to take into consideration the age and condition of the levee when inspecting. All the levees are agriculture levees and are not a threat to significant population areas or critical facilities. Based on the number of levees in the planning area, and no record of previous occurrences the probability of a future occurrence cannot be calculated.

Changing Future Conditions Considerations

The planning area should be aware of how surrounding levees in neighboring counties could affect Randolph County in the event of a breech.

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 3.16 below defines the three ratings.

Located in western Randolph County are seven Levees with one protecting a large grove of pecan trees with a high commercial value.

Figure 3.16. Definitions of the Three Levee System Ratings

Levee System Inspection Ratings

Acceptable	All inspection items are rated as Acceptable.
Minimally Acceptable	One or more levee segment inspection items are rated as Minimally Acceptable or one or more items are rated as Unacceptable and an engineering determination concludes that the Unacceptable inspection items would not prevent the segment/system from performing as intended during the next flood event.
Unacceptable	One or more levee segment inspection items are rated as Unacceptable and would prevent the segment/system from performing as intended, or a serious deficiency noted in past inspections (previous Unacceptable items in a

	Minimally Acceptable overall rating) has not been corrected within the established timeframe, not to exceed two years.

Potential Losses to Existing Development

The seven levees are located in the western part of the planning area along the Chariton Riven. The seven levees protect farmland and there is no potential loss to existing development.

Impact of Previous and Future Development

The seven levees in the planning area protect farmland and there is no impact to previous and future development.

Hazard Summary by Jurisdiction

The seven levees in Western Randolph County along the Chariton River are agriculture levees and protect farmland. One of the seven levees protects farmland comprised of mature pecan trees and holds significant commercial value. There are no residential properties being directly protected by the 7 levees in the County. The Chariton River flows through the western part of the county and the levees protect farmland against the flooding of the river. The 7 levees are considered low risk and only protecting farmland.

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.

The following tables included information about the dam classification systems under both the Missouri Department of Natural Resources and the National Inventory of Dams.

Table 3.20. 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 3.21. 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

Figure 3.17. Dams in Randolph County – MoDNR Data

DAMS IN MISSOURI AS OF 7/20/2017 – MISSOURI DEPARTMENT OF NATURAL RESOURCES

Although this data set has been compiled by the Missouri Department of Natural Resources, no warranty, expressed or implied, is made by the Department as to the accuracy of the data. The act of distribution shall not constitute any such warranty, and n

COUNTY	LOCATION	ID_NO	NAME	YEAR COMPLETE	LENGTH	DAMHT	RESAREA	DRAINAGE AREA (acres)	STATE REGULATED	HAZARD CLASS
RANDOLP	S33, T52 N, R13W	MO10775	MILNES LAKE DAM	1963	0	25	8	156	N	3
RANDOLP	S30, T54 N, R14W	MO10787	KELLEY LAKE DAM (DRY)	0000	0	20	16	235	N	2
RANDOLP	S25, T55 N, R15W	MO11416	KOHL LAKE DAM	0000	0	20	45	202	N	3
RANDOLP	S16, T54 N, R14W	MO10005	SUGAR CREEK LAKE DAM	1957	1030	49	323	6750	Y	3
RANDOLP	S03, T53 N, R14W	MO10006	WATER WORKS LAKE DAM	1870	0	30	21	418	N	1
RANDOLP	S03, T53 N, R14W	MO10004	ROTHWELL LAKE DAM	1902	0	29	26	458	N	1
RANDOLP	S18, T52 N, R14W	MO10125	SHADY OAKS LAKE DAM	1957	0	20	9	818	N	3
RANDOLP	S24, T55 N, R16W	MO10134	THOMAS HILL RESERVOIR DAM	1966	2450	70	3500	4000	Y	1
RANDOLP	S17, T55 N, R14W	MO10135	HOLIDAY ACRES LAKE DAM	1962	1400	45	218	2291	Y	3
RANDOLP	S21, T52 N, R13W	MO10148	BACKUES LAKE DAM	1959	0	30	20	228	N	3
RANDOLP	S17, T52 N, R14W	MO10222	HIGBEE LAKE DAM	1963	750	30	107	13	N	2
RANDOLP	S10, T54 N, R15W	MO10628	MILLERS LAKE DAM	1941	0	20	15	126	N	3
RANDOLP	S23, T55 N, R15W	MO10629	RILEY LAKE DAM	1944	0	25	17	235	N	2
RANDOLP	S09, T55 N, R14W	MO10637	HOLIDAY ACRES LAKE UPSTREAM DAM	1966	0	25	40	829	N	3
RANDOLP	S22, T55 N, R15W	MO10638	STUCK LAKE DAM	1936	0	25	4	20	N	3
RANDOLP	S26, T55 N, R15W	MO10639	THOMAS BROS LAKE DAM	1942	0	25	14	220	N	2
RANDOLP	S09, T52 N, R14W	MO10660	HIGBEE CITY LAKE DAM	1963	750	45	13	107	Y	3
RANDOLP	S07, T53 N, R14W	MO10671	LAKE WATA DAM	1960	1270	37	22	76	Y	3
RANDOLP	S21, T53 N, R15W	MO10752	VANDERBACK SECT-21 LAKE DAM	1967	0	30	8	76	N	3
RANDOLP	S19, T54 N, R15W	MO10753	J P RYALS LAKE DAM	1962	0	30	8	40	N	3
RANDOLP	S23, T55 N, R13W	MO10754	THUNDERBIRD LAKE DAM	1960	0	33	22	18	N	3
RANDOLP	S01, T55 N, R15W	MO10755	SOLITUDE LAKE DAM	1959	0	25	20	180	N	3
RANDOLP	S05, T53 N, R13W	MO11179	O'HARA LAKE DAM	0000	0	25	15	153	N	2
RANDOLP	S10, T52 N, R13W	MO11182	MARTIN LAKE DAM	1977	0	18	37	313	N	2
RANDOLP	S13, T55 N, R15W	MO11200	ADAMS LAKE DAM	1974	0	25	14	180	N	3
RANDOLP	S29, T54 N, R15W	MO11202	WALLACE RYALS LAKE DAM	0000	0	25	25	265	N	3
RANDOLP	S11, T53 N, R16W	MO11207	QUINN&FITZGERALD LAKE DAM	1973	0	25	10	80	N	2
RANDOLP	S08, T53 N, R14W	MO11486	FRENCH CREEK FARMS LAKE DAM	1970	0	25	8	36	N	3
RANDOLP	S13, T53 N, R16W	MO11517	BROWN LAKE DAM	1977	0	12	15	590	N	2
RANDOLP	S03, T52 N, R16W	MO11523	HELMICH LAKE DAM	0000	0	30	5	41	N	2
RANDOLP	S01, T54 N, R13W	MO11565	JOHNSON LAKE DAM	1975	0	25	10	464	N	3
RANDOLP	S13, T54 N, R13W	MO11566	MALLORY LAKE DAM	1974	0	20	9	160	N	3
RANDOLP	S22, T54 N, R13W	MO11567	ANDERSON LAKE DAM	0000	0	25	3	34	N	2
RANDOLP	S14, T52 N, R14W	MO11652	GONYEA LAKE DAM	0000	0	30	5	30	N	3
RANDOLP	S27, T54 N, R14W	MO11654	VANDERBECK LAKE DAM	1980	390	50	4	47	Y	3
RANDOLP	S33, T54 N, R14W	MO11655	HILS LAKE DAM	0000	0	34	5	70	N	3
RANDOLP	S07, T53 N, R13W	MO11656	CAMP LAKE DAM	1970	0	25	8	169	N	3
RANDOLP	S11, T53 N, R14W	MO11657	WHITE OAK CAMP LAKE DAM	0000	0	25	3	70	N	3
RANDOLP	S17, T55 N, R14W	MO11660	HISLE LAKE DAM	1960	0	20	10	69	N	3
RANDOLP	S09, T55 N, R14W	MO11661	PASTROVICH LAKE DAM	1977	610	25	9	393	N	3
RANDOLP	S15, T53 N, R14W	MO12200	ROBB FARM DAM	1980	0	30	2	14	N	3
RANDOLP	S16, T54 N, R14W	MO12227	NEMO RECLAMATION POND	1950	0	16	3	69	N	3
RANDOLP	S25, T55 N, R15W	MO12232	CRUTCHFIELD RECLAMATION DAM	1989	1200	42	39	738	Y	3
RANDOLP	S23,T54N,R14W	MO50982	ROLLS DAM	1999	800	25	6	294	N	3
RANDOLP	S09,T52N,R14W	MO51032	MONITEAU CREEK WS DAM M- 92	2001	420	27	4	215	N	3
RANDOLP	S15,T52N,R14W	MO51033	MONITEAU CREEK WS DAM M- 88	2001	600	27	1	90	N	3
RANDOLP	S27,T52N,R14W	MO51034	MONITEAU CREEK WS DAM M- 84	2001	390	31	7	166	N	3
RANDOLP	S22,T52N,R14W	MO51035	MONITEAU CREEK WS DAM M- 80	2001	360	32	5	243	N	3
RANDOLP	S35,T53N,R14W	MO50993	MONITEAU CREEK WS DAM M-100	2000	840	27	4	145	N	3
RANDOLP	S27,T53N,R14W	MO51268	MONITEAU CREEK WS DAM M-101	2001	820	17	10	425	N	3
RANDOLP	S33,T53N,R14W	MO51269	MONITEAU CREEK WS DAM M- 94	2001	560	17	4	165	N	3
RANDOLP	S21,T52N,R14W	MO51271	MONITEAU CREEK WS DAM M- 85	2001	360	21	16	1075	N	3
RANDOLP	S17,T52N,R14W	MO51433	MONITEAU CREEK WS DAM M- 89	2006	630	26	1	173	N	3
RANDOLP	S04,T52N,R14W	MO51434	MONITEAU CREEK WS DAM M- 93A	2006	380	24	4	160	N	3
RANDOLP	S02,T52N,R14W	MO51435	MONITEAU CREEK WS DAM M- 97A	2006	480	22	4	302	N	3
RANDOLP	S16,T52N,R14W	MO51436	MONITEAU CREEK WS DAM M- 86C	2006	390	26	18	349	N	3
RANDOLP	S16,T52N,R14W	MO51437	MONITEAU CREEK WS DAM M- 86D	2007	410	29	1	19	N	3

Source: Missouri Department of Natural Resources, Dam and Reservoir Safety, https://dnr.mo.gov/geology/wrc/dam-safety/damsinmissouri.htm

Figure 3.18. Dams Located within Randolph County-NID Data

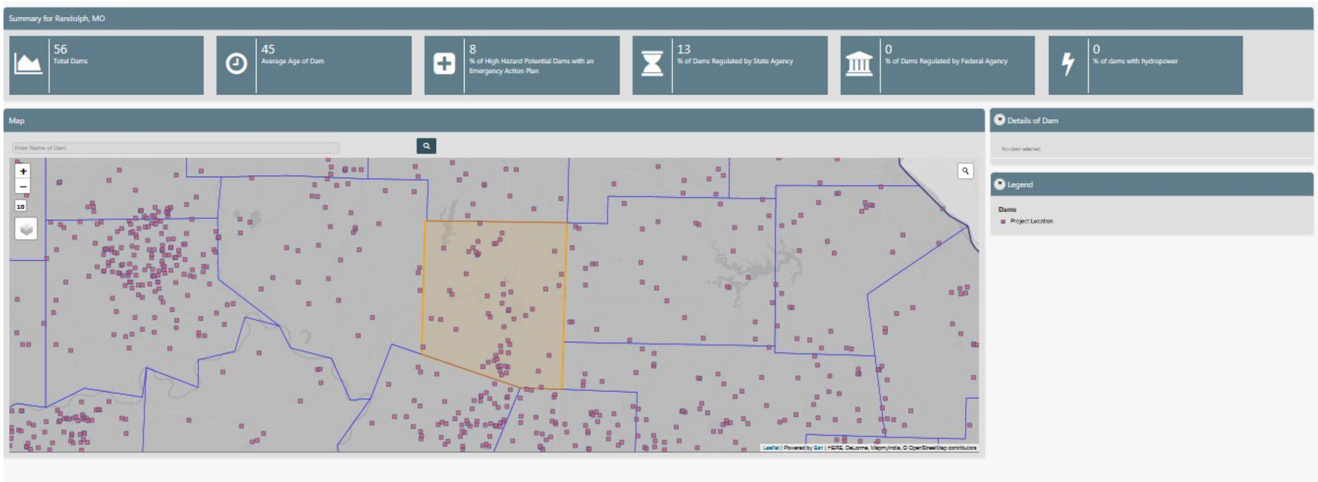
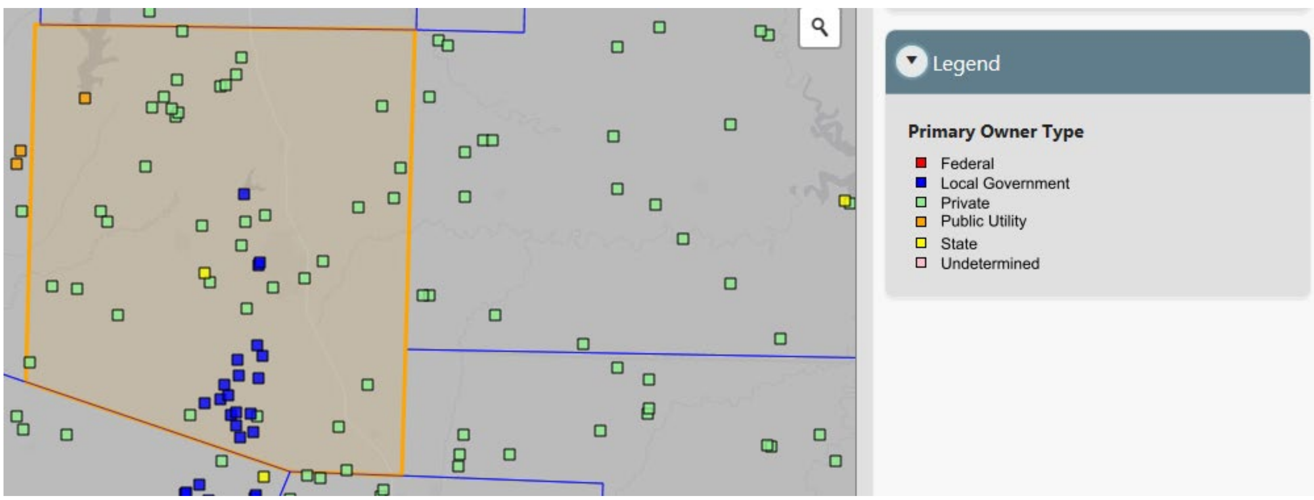


Figure 3.19. Randolph County Dams by Owner Type



Geographic Location

There are 56 dams located inside the county boundaries, and 13 high hazard dams using both the NID and the Mo DNR data.

The table below list the names, locations and other pertinent information for all high hazard dams in the planning area.

Figure 3.20. High Hazard Dams in the Randolph County Planning Area

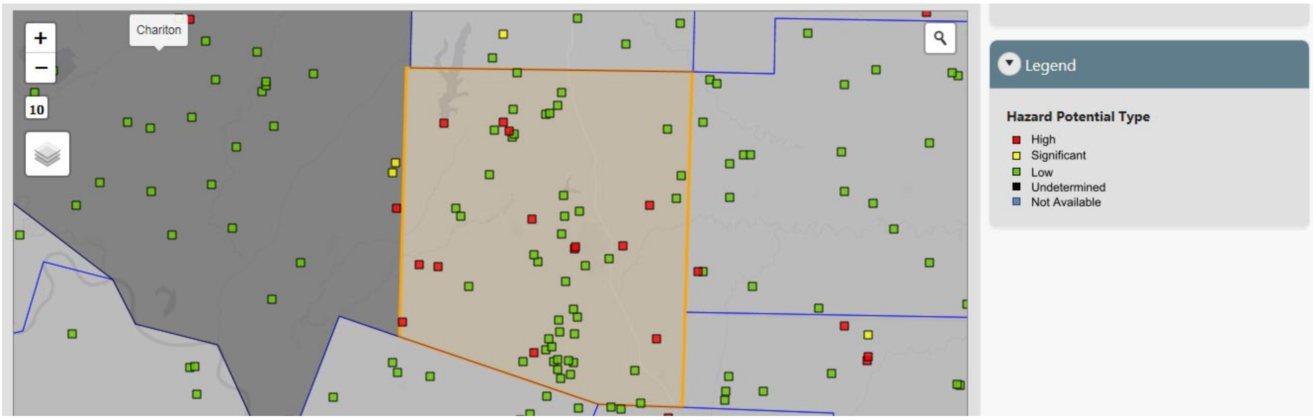


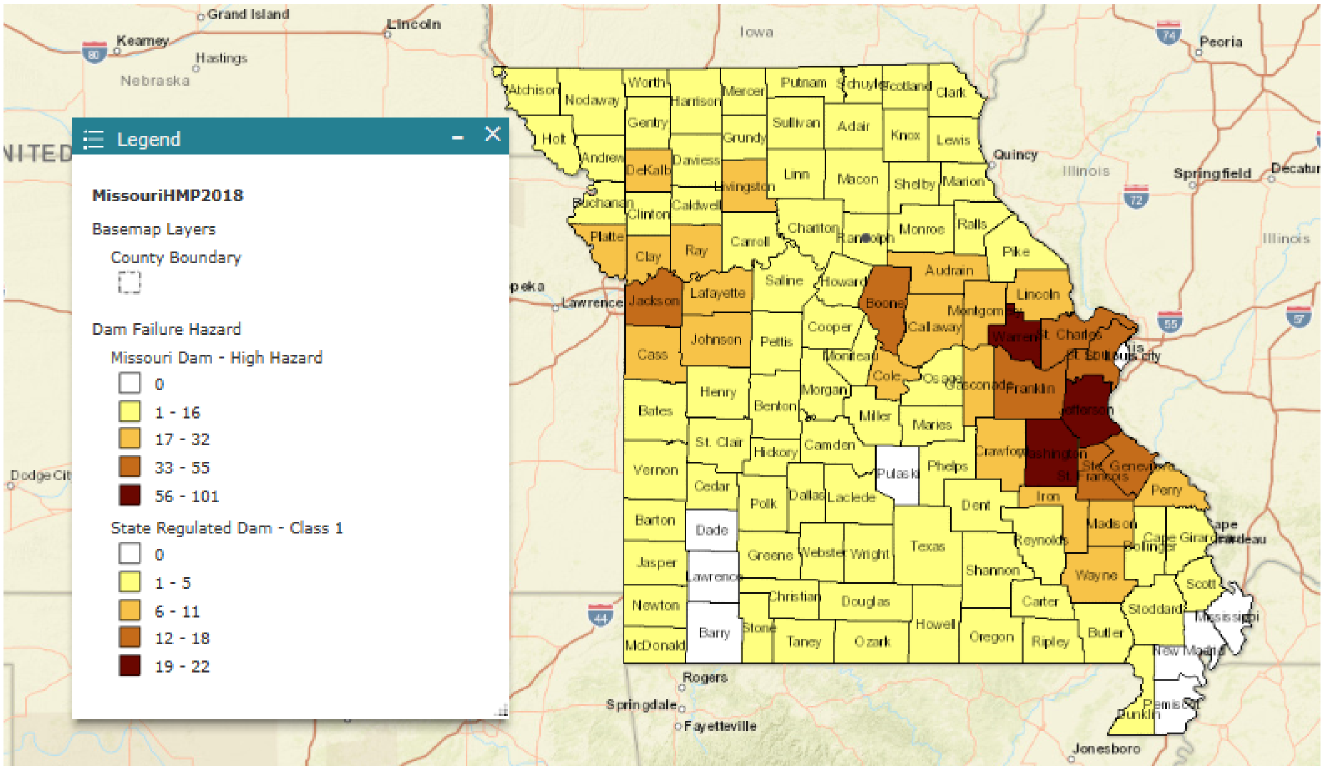
Table 3.22. High Hazard Dams in the Randolph County Planning Area

Dam Name	Emergency Action Plan (EAP)AP	Dam Height (Ft)	Normal Storage (Acre-Ft)	Last Inspection Date	River	Nearest Downstream City	Distance to Nearest City (Miles)	Dam Owner
Kelley Lake Dam	Not Required	20	128	-	Sugar Creek	Moberly	3	Hazel Kelley
Water Works Lake Dam	Not Required	30	337	6/13/79	Sweet Spring Creek	Moberly	0	City of Moberly
Rothwell Lake Dam	Not Required	29	403	6/14/79	Sweet Spring Creek	Moberly	0	City of Moberly
Thomas Hill Reservoir Dam	Yes	70	260,488	2/17/17	Middle Fork	Cairo	10	Associated Electric
Higbee Lake Dam	Not Required	30	171	12/20/88	Salt Fork	Higbee	.50	Marshall Baker
Riley Lake Dam	Not Required	25	227	-	E. Fork/Chariton	Cairo	6	Floyd Riley
Thomas Bros Lake Dame	Not Required	25	187	-	Chariton River	Cairo	5	Thomas Bros.
Brown Lake Dam	Not Required	12	96	-	Sweet Spring Creek	Roanoke	3.5	Aubrey Brown
O'Hara Lake Dam	Not Required	25	201	-	Coon Creek	Moberly	1	Rex O'Hara
Martin Lake Dam	Not Required	18	356	-	Hardin Creek	Clark	3.88	Earl Martin
Helmich Lake Dam	Not Required	30	80	-	Mott Creek	Roanoke	1.41	Billie Helmich
Anderson Lake Dam	Not Required	25	40	-	Elk Fork River	Moberly	3.9	Ronald Anderson
Quinn & Fitzgerald	Not Required	25	134	-	Chariton River	Roanoke	3.75	Quinn & Fitzgerald Inc.

Sources: Missouri Department of Natural Resources, https://dnr.mo.gov/geology/wrc/dam-safety/damsinmissouri.htm and National Inventory of Dams, http://nid.usace.army.mil/cm_apex/f?p=838:12

Figure 3.21 provides the number of high hazard dams and state regulated dams.

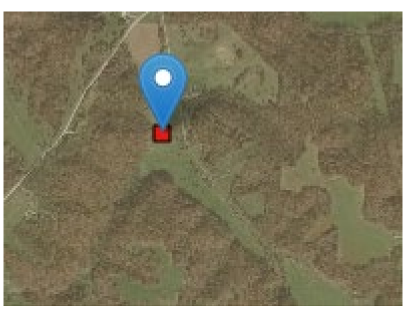
Figure 3.21. High Hazard Dam and State Regulated Dams



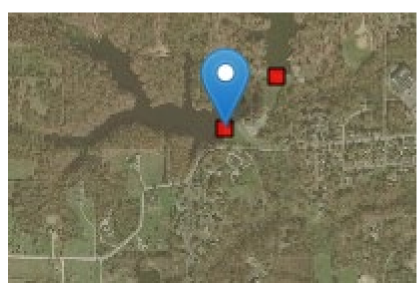
Source: Missouri Hazard Mitigation Viewer;
http://amecei.maps.arcgis.com/apps/webappviewer/index.html?id=d97d80d5cff04996bff54b2250e47d83

Figure 3.22. High Hazard Dams in Randolph County

Kelley Lake Dam

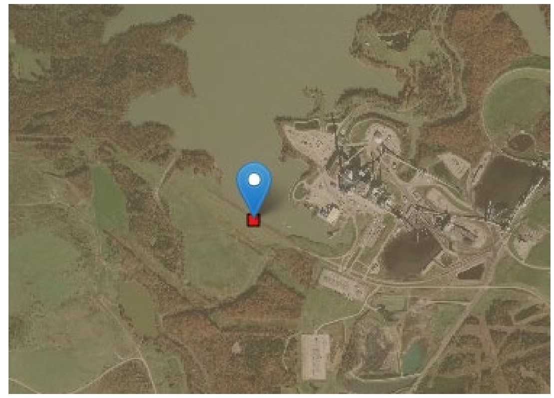


Water Works Lake Dam

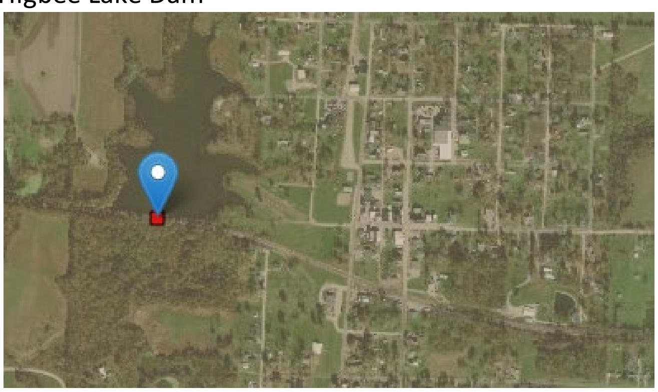


Rothwell Lake Dam

Thomas Hill Reservoir Dam

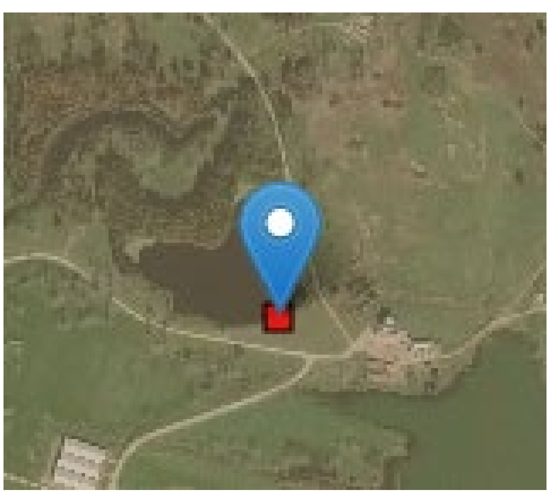


Higbee Lake Dam



Riley Lake Dam

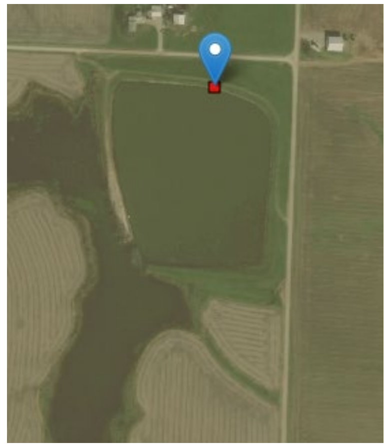
Thomas Bros Lake Dam



Brown Lake Dam

O'Hara Lake Dam

Martin Lake Dam



Helmich Lake Dam

Anderson Lake Dam

Quinn & Fitzgerald Lake Dam

Strength/Magnitude/Extent

The strength/magnitude of dam failure would be similar in some cases to flood events (see the flood hazard vulnerability analysis and discussion). The strength/magnitude/extent of dam failure is related to the volume of water behind the dam as well as the potential speed of onset, depth, and velocity. Note that for this reason, dam failures could flood areas outside of mapped flood hazards.

Inundation data, however, is not currently available for any of the county's dams or the surrounding areas. The future probable severity of a dam failure in Randolph County is shown below according to DNR's hazard potential levels.

Hazard Level	Probable Risk
High	Catastrophic
Significant	Critical
Low	Negligible

Previous Occurrences

To determine previous occurrences of dam failure within Randolph County, previously approved county hazard mitigation plans, the 2018 Missouri State Hazard Mitigation Plan, and the Stanford University's National Performance of Dams Program was consulted. There are no records of dam failure within the county boundaries.

Probability of Future Occurrence

It is the responsibility of the individual landowners to inspect and maintain the dams. Landowners need to take into consideration the age and condition of the dam when inspecting. All the dams with the exception of one are small in terms of dam height and storage area and are not a threat to significant population areas or critical facilities. Based on the number of high hazard dams in the planning area, and no record of previous occurrences the probability of a future occurrence cannot be calculated.

Figure 3.23. Climate Changing Future Considerations

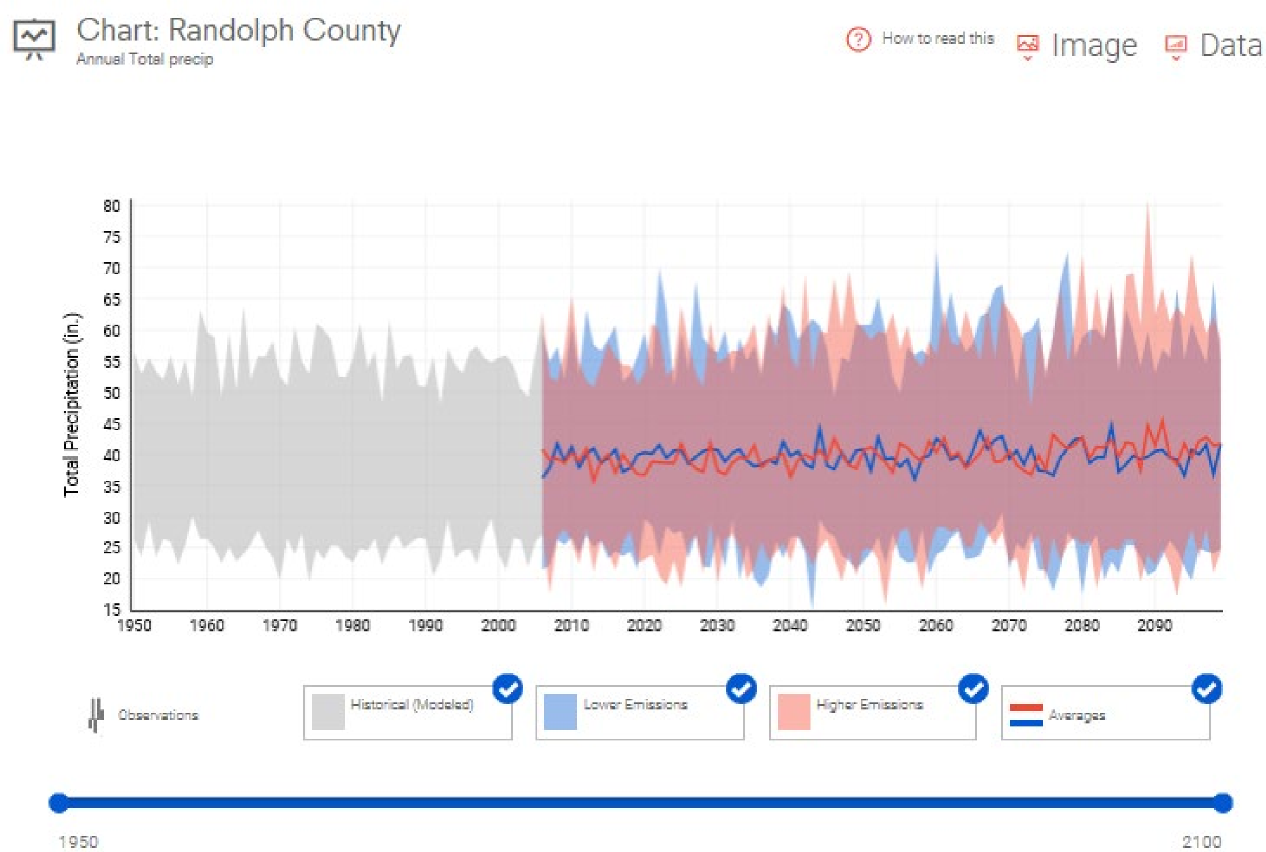
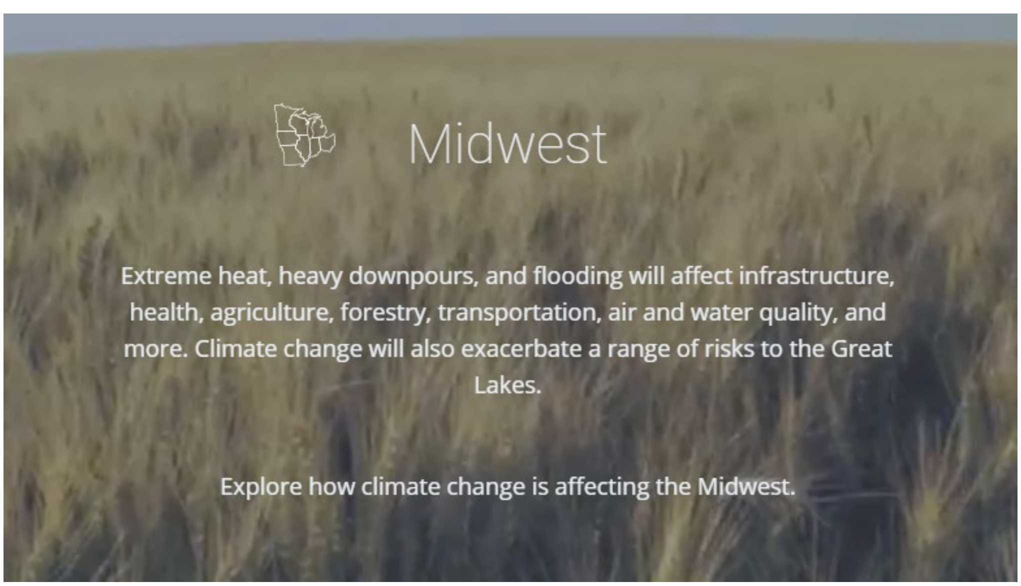


Figure 3.24. Climate Change Affecting the Midwest



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

Vulnerability

Vulnerability Overview

Vulnerability to dam failure is a factor due to the multiple dams in the planning area, including several High Hazard Dams, indicating the loss of life is possible in the event of a failure. Neighboring communities are also at risk if they are downstream from a dam. Should the Thomas Hill Reservoir Dam be comprised, damage and loss of life would be less due to the rural area of the dam. The planning committee chose only to address the high hazard dams within the planning area due to the pre-determined risk associated by these dams.

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

The only dam located within Randolph County regulated by the State of Missouri is the Thomas Hill Reservoir. The Thomas Hill Reservoir is a height of 70 feet.

An inundation map for the Thomas Hill Reservoir could not be located prior to plan submission.

Impact of Previous and Future Development

There are 13 high hazard dams within the planning area, none of which are state regulated. Prior to future development in those areas, the jurisdiction should be contacted and a review of impact of new development in the event of a breach in dam should be reviewed.

Hazard Summary by Jurisdiction

Of the 56 dams in Randolph County, 13 dams have been classified as high hazard dams. All dams with the exception of one are small in terms of height and storage area which does not pose a significant threat to the population. One dam in the planning area is 70 feet high and holds a significant amount of water (260,488) however the location of the dam is in a rural area and is not relatively close to any significant population area or critical facilities. Jurisdictions and Schools in the planning area are unlikely to be affected by a compromised dam due to the rural location of the 70 feet high dam and the low water capacity of the remaining dams. Located within the City of Moberly is a dam that would affect the City of a breach occurred.

Problem Statement

A lack of regular inspection/maintenance of un-regulated high hazard dams was noted by the Mitigation Planning Committee. Possible solutions include training landowners how to properly inspect dams, and encourage dams to be inspected on a regular schedule.

3.4.4 Earthquakes

Hazard Profile

Hazard Description

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

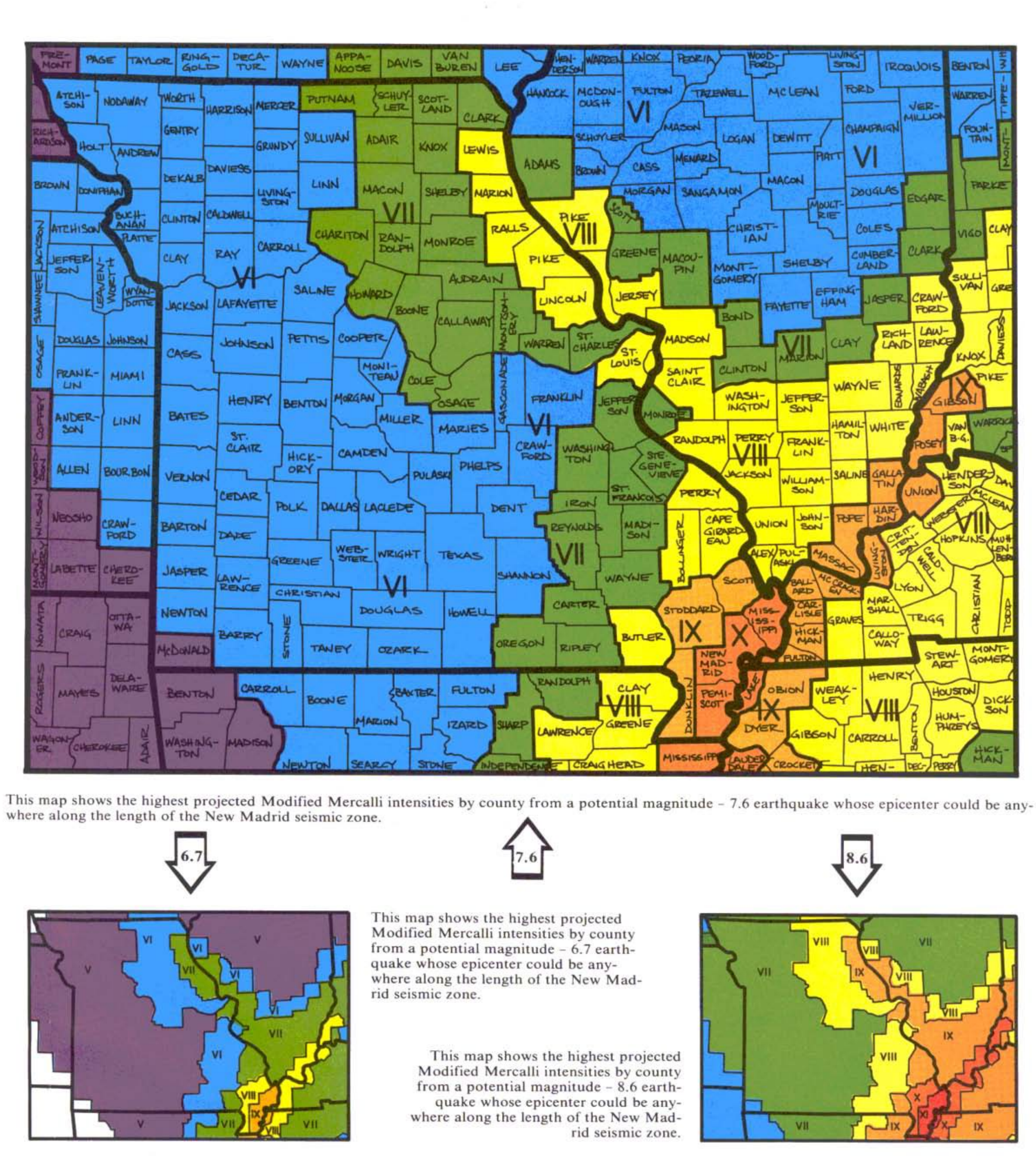
Some earthquakes occur in the middle of plates, as is the case for seismic zones in the Midwestern United States. The most seismically active area in the Midwest is the New Madrid Seismic Zone. The possibility of the occurrence of a catastrophic earthquake in the Central and Eastern United States is real as evidenced by history. The impacts of significant earthquakes affect large areas, terminating public services and systems needed to aid the suffering and displaced. As with hurricanes, mass relocation may be necessary, but the residents who are suffering from the 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 km^2, 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 km^2 (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 Randolph 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 3.25) 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 below figure indicates Randolph County and the affects that could be felt from the earthquake.

Figure 3.25. Impact Zones for Earthquake Along the New Madrid Fault



Source: https://sema.dps.mo.gov/docs/EQ_Map.pdf

Figure 3.26. 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.

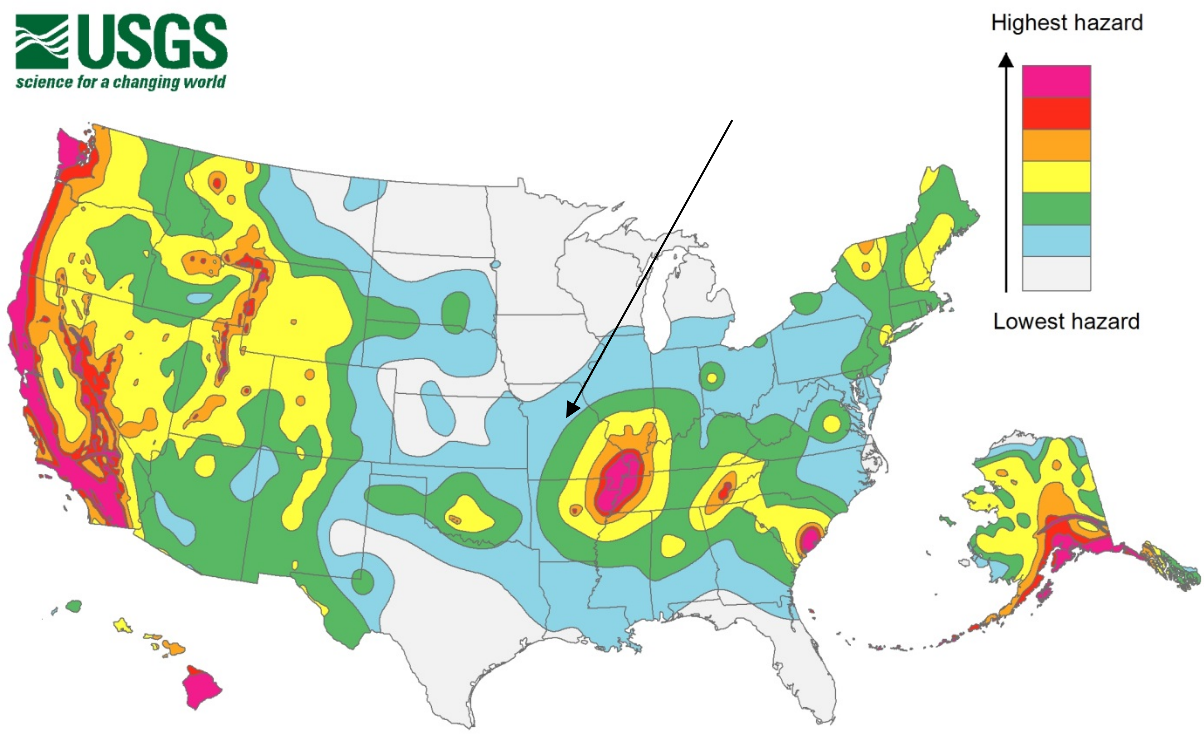
XI Few if any masonry structures remain standing. Large, well-built bridges are destroyed. Wood frame structures are severely damaged, especially near epicenters. Buried pipelines are rendered completely useless. Railroad tracks are badly bent. Water mixed with sand, and mud is ejected in large amounts.

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 3.27. 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.

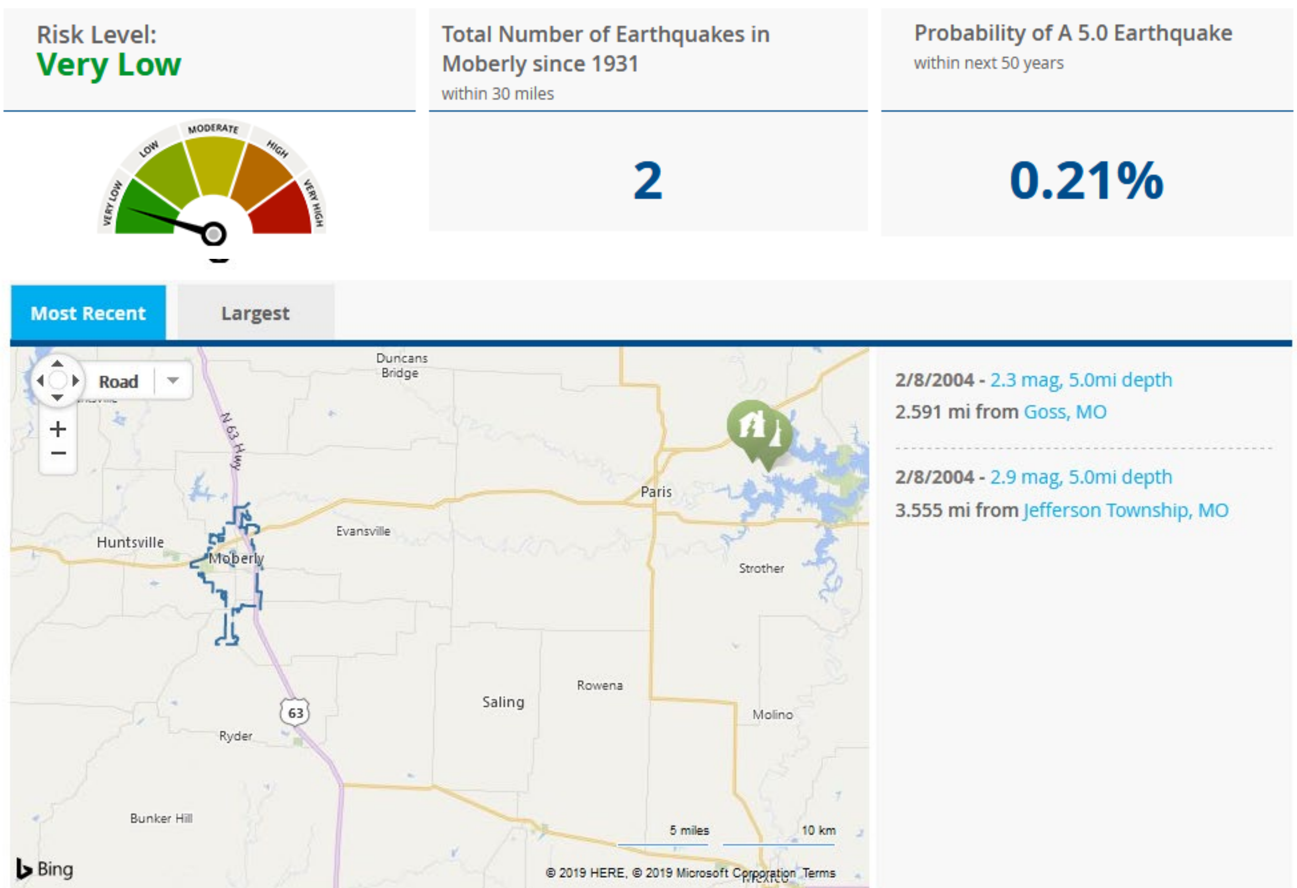
Modified Mercalli Intensity Scale

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 2 earthquakes within 30 miles of Randolph County since 1931 according to the information obtained from homefacts.com as shown in Figure 3.28.

Figure 3.28. Probability of Earthquake in Randolph County

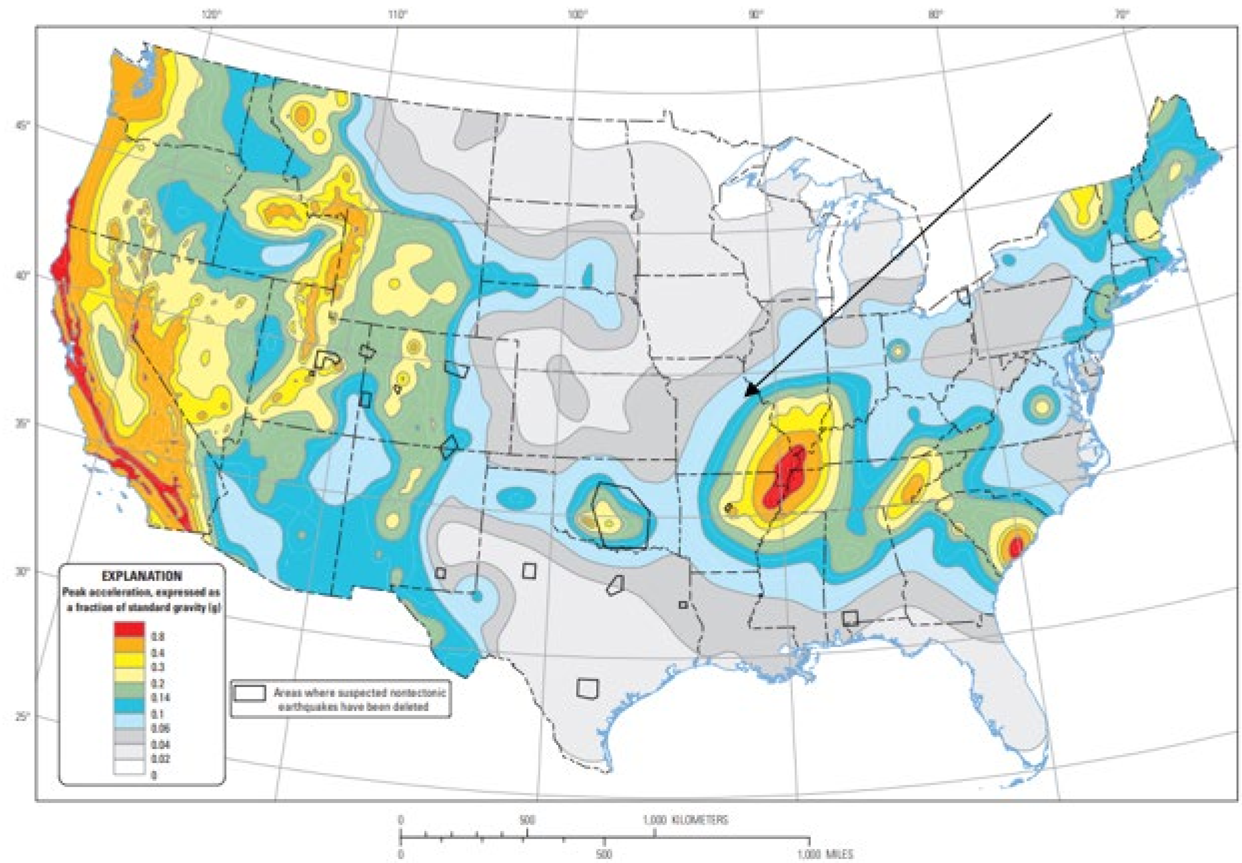


Source: www.homefacts.com

Probability of Future Occurrence

As described in Figure 3.28 Randolph County, MO has a very low earthquake risk, with a total of 2 earthquakes since 1931 within 30 miles of Randolph County. The USGS database shows that there is a 0.21% chance of a major earthquake within 50 km of Randolph County, MO within the next 50 years. The largest earthquake within 30 miles of Randolph County, MO was a 2.9 magnitude in 2004.

Figure 3.29. Two-Percent Probability of Exceedance in 50 Years Map of Peak Ground Acceleration



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.

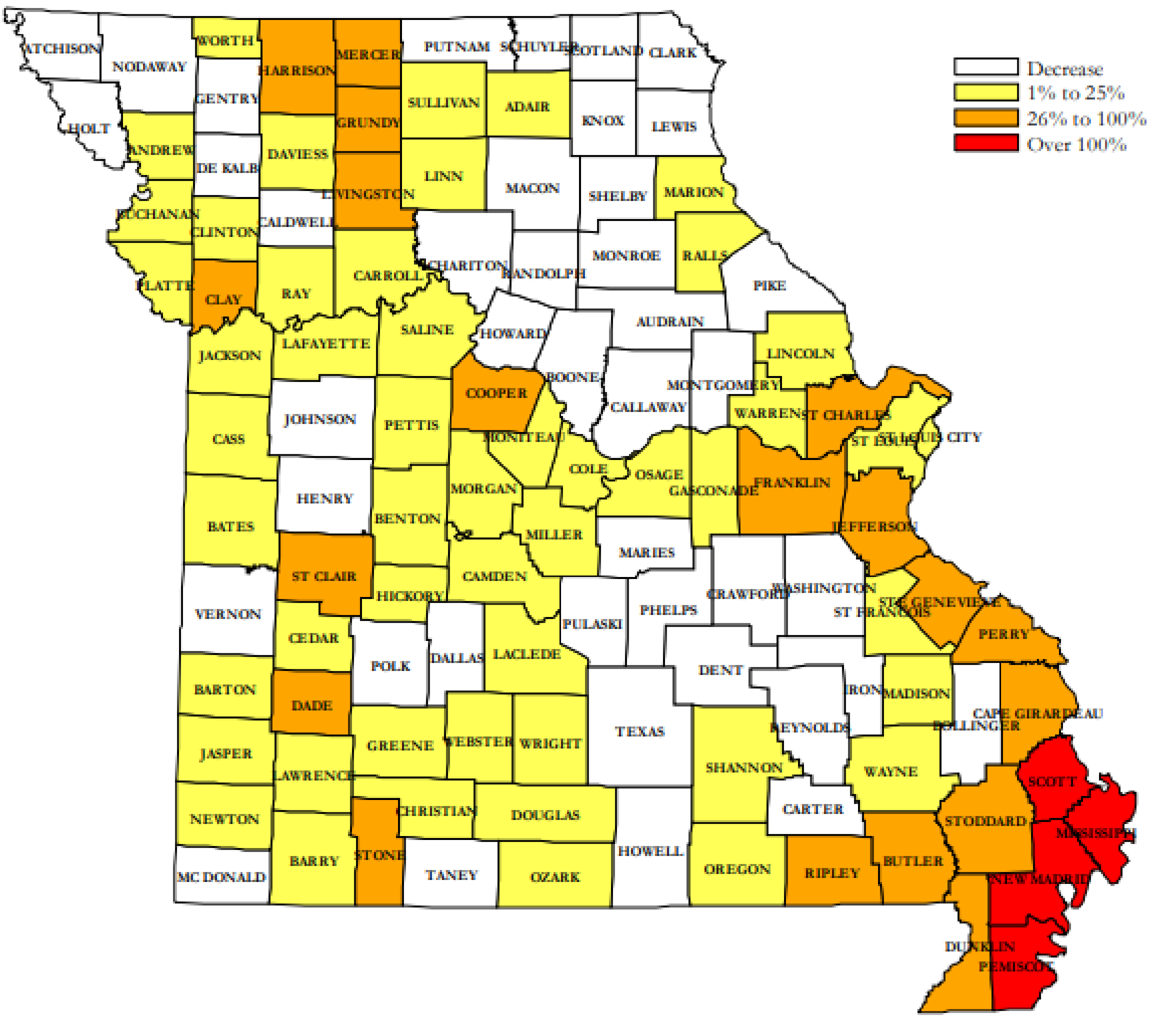
Vulnerability

Vulnerability Overview

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

The State of Earthquake Coverage Report states the average premium for earthquake coverage in Randolph County during 2017 was $65, with the average premium $110k- $140k coverage at $37.

Figure 3.30. Percent Change in Cost of Earthquake Coverage between 2009- 2017, $110 - $140k Coverage Limits



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.

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 the result of an event.

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. However, damages could differ due to structural variations in the planning area built-environment. The downtown area of the City of Moberly is made up of buildings built prior to 1939 and could see significant damage from an earthquake.

Problem Statement

Randolph County is not located in an area which will likely see catastrophic damage from an earthquake, the County could 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 the southern area.

The downtown area of the City of Moberly would be at a high risk to see structural damage due to the age of the buildings.

Building owners in Moberly's downtown area needs to be educated on the proper insurance to maintain and the earthquake risk for the community. Downtown building owners need to have a plan in case damage is done to their building.

Figure 3.31. Moberly's Downtown District

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.

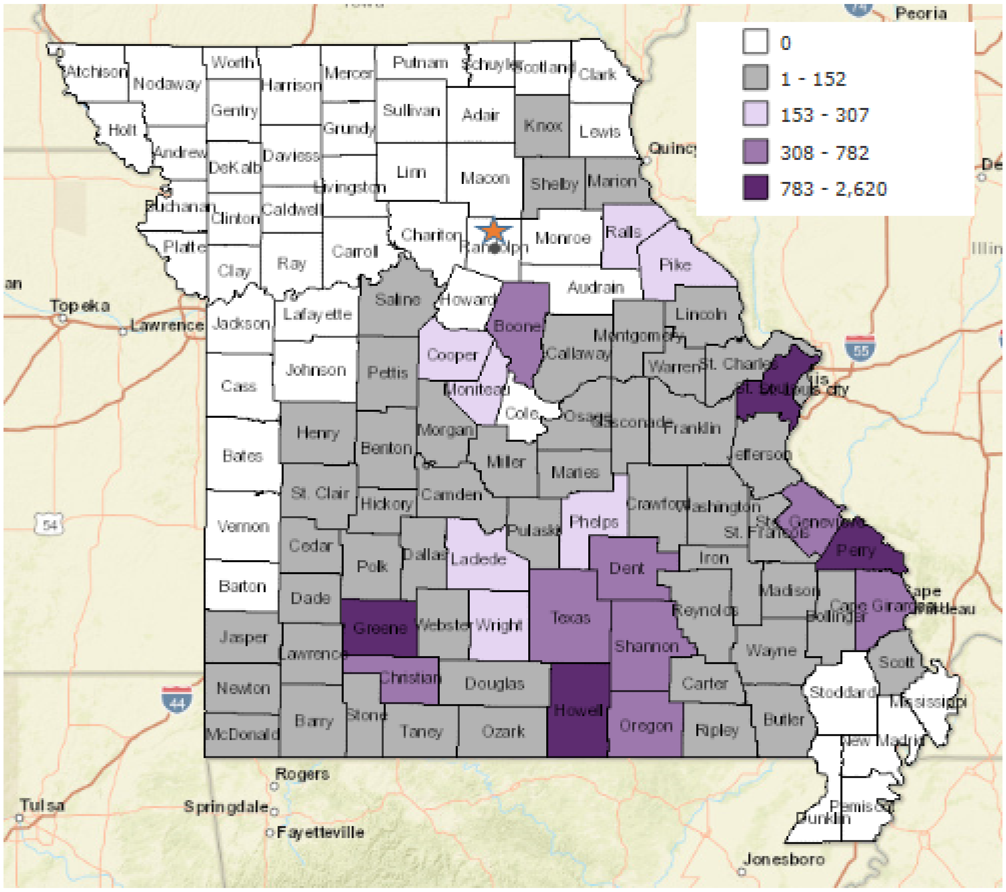
In the case of sinkholes, the rock below the surface is rock that has been dissolving by circulating groundwater. As the rock dissolves, spaces and caverns form, and ultimately the land above the spaces collapse. In Missouri, sinkhole problems are usually a result of surface materials above openings 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 255 mines in Randolph County and 0 sinkholes.

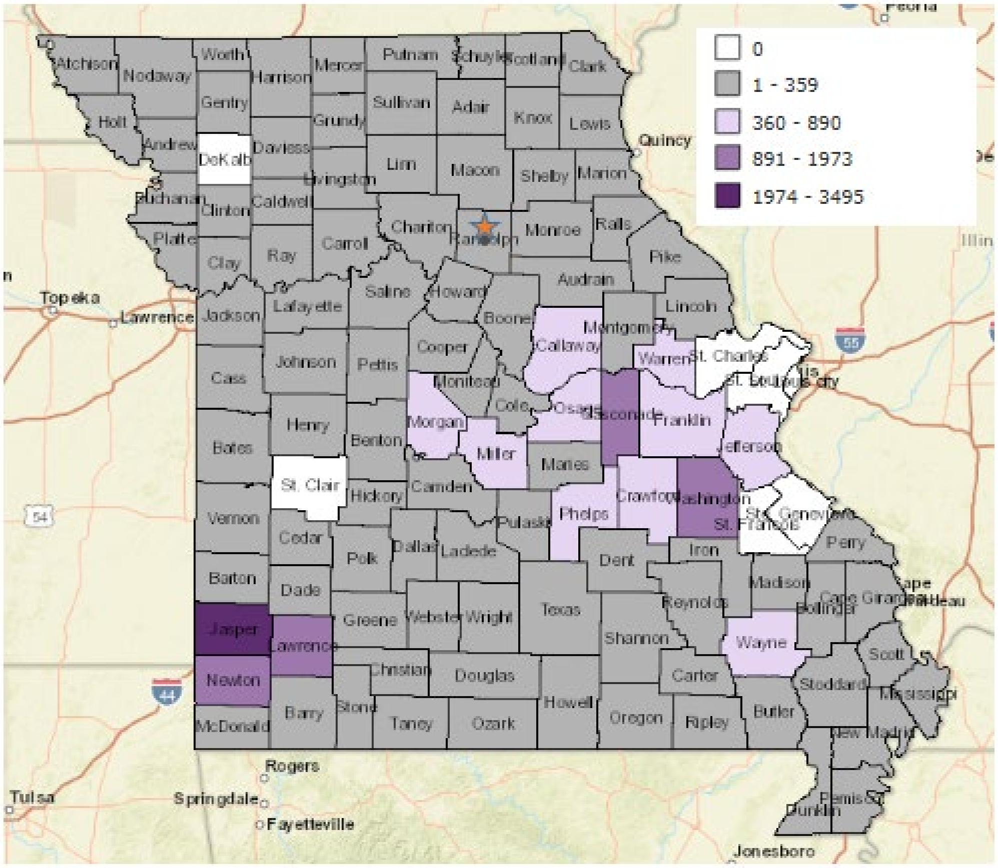
Geographic Location

Figure 3.32. **Sinkholes in Randolph County**



Source: 2018 Missouri State Hazard Mitigation Plan; * Star shows Randolph County

Figure 3.33. Mine Count in Randolph County



Source: 2018 Missouri State Hazard Mitigation Plan: * Star indicates Randolph County

Table 3.23. Randolph County Sinkhole and Mine Counts

County	Number of Sinkholes Per County	Number of Mines Per County
Randolph	0	255

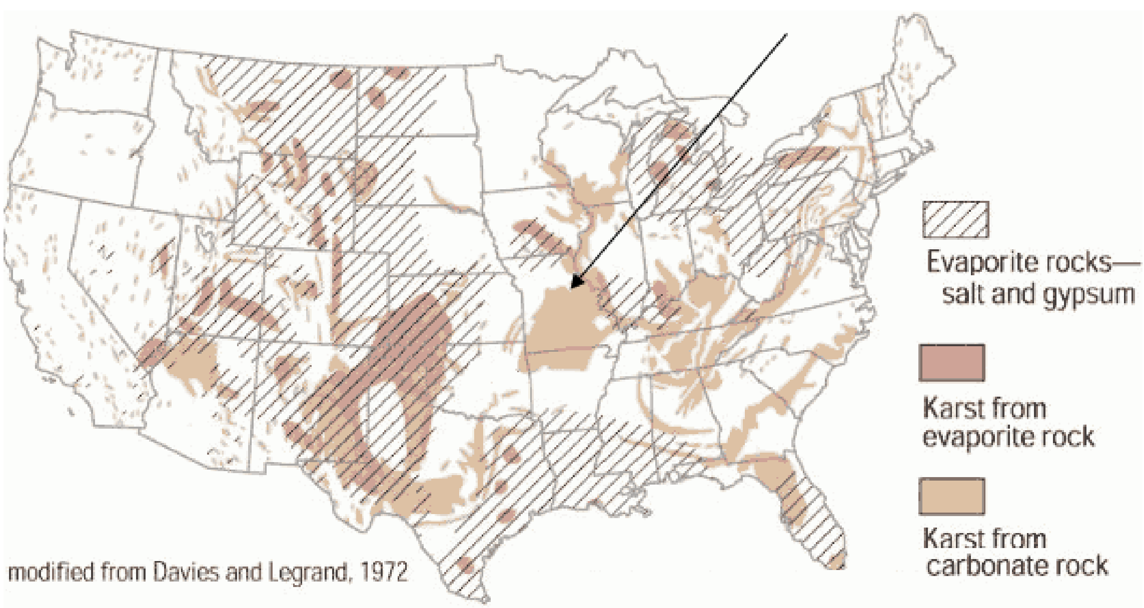
Source: 2018 Missouri State Hazard Mitigation Plan

255 Mines in Randolph County

Figure 3.34. Sinkholes in Missouri

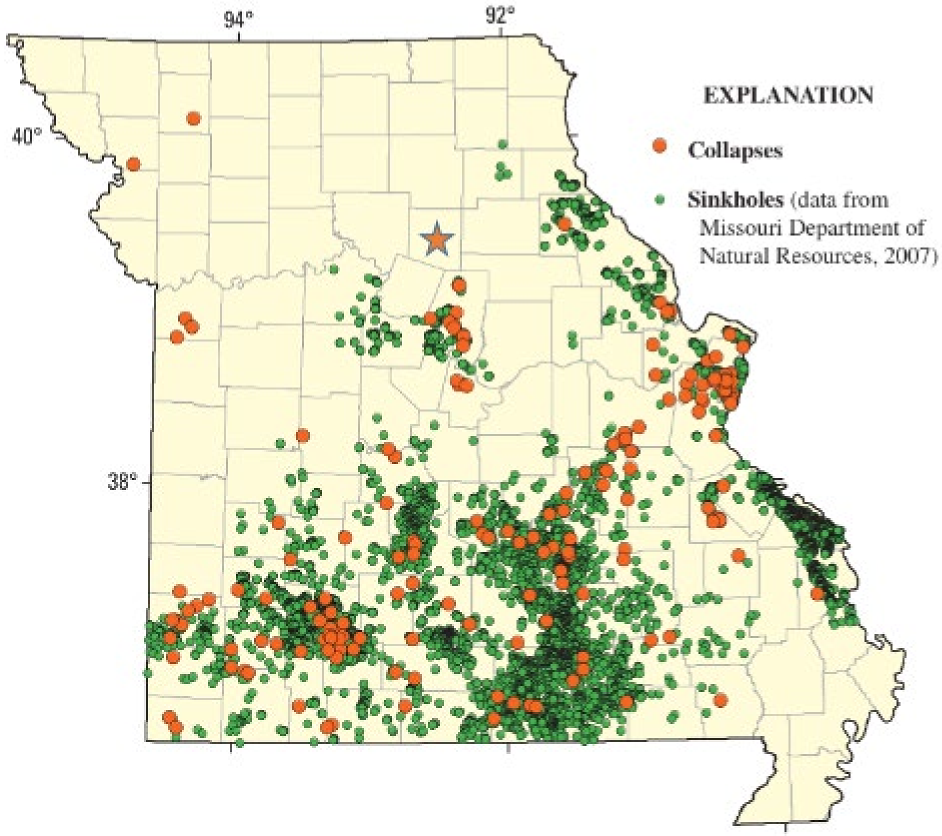
Source: Missouri Department of Natural Resources: https://dnr.mo.gov/geology/geosrv/envgeo/images/sinkholesinmissouri.jpg

Figure 3.35. Karst in Missouri



Source: http://strangesounds.org/2013/07/us-sinkhole-map-these-maps-show-that-around-40-of-the-u-s-lies-in-areas-prone-to-sinkholes.html

Figure 3.36. Collapses and Sinkholes in Randolph County



Source: http://www.businessinsider.com/where-youll-be-swallowed-by-a-sinkhole-2013-3 : * Star indicates Randolph County

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 the events of any significance. There is no record of previous occurrences in Randolph County.

Probability of Future Occurrence

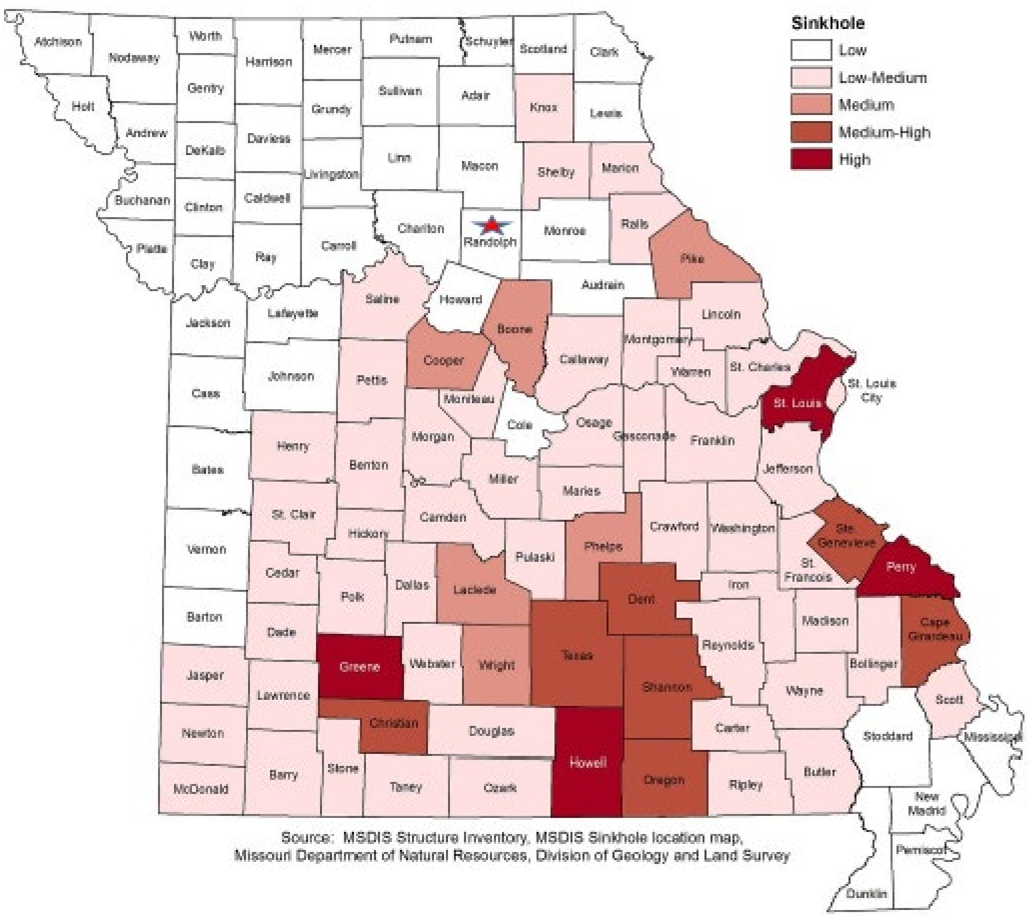
Table 3.24. Sinkhole Rating Values

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 +

Source: 2018 Missouri State Hazard Mitigation Plan

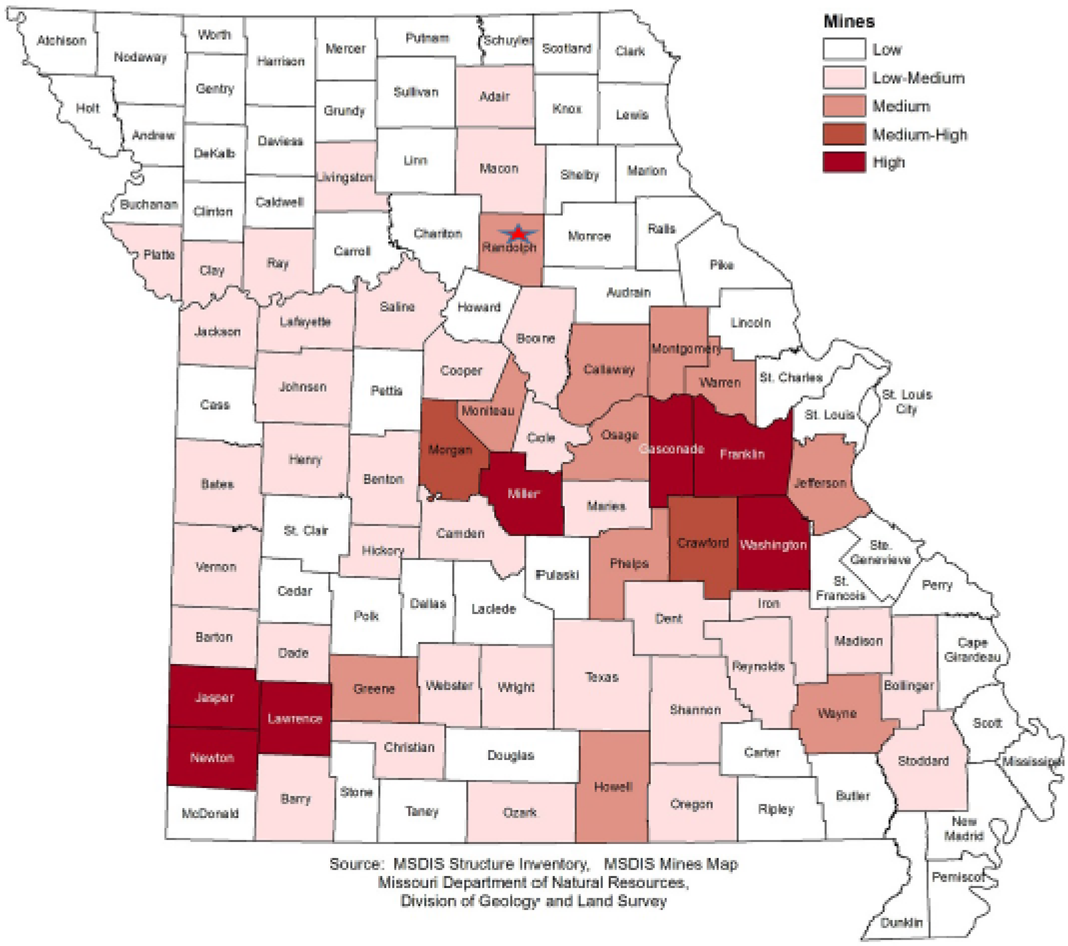
Randolph County has zero sinkholes with a low rating and 255 mines for a medium rating.

Figure 3.37. Sinkhole Rating by County



Source: 2018 Missouri State Hazard Mitigation Plan; * Star indicates Randolph county

Figure 3.38. Mine Rating Value by County



Source: 2018 Missouri State Hazard Mitigation Plan; * Star indicates Randolph County

There are no records of previous events in the planning area, the probabilities cannot be calculated due to the limited information. As represented in the figures above, the sinkholes located in Randolph County is a low risk and mines in Randolph County are a medium risk.

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 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 common occurrence due to composition of the land. While sinkholes may be considered a slow changing nuisance; other more sudden, catastrophic collapses can destroy property, delay construction projects and contaminate ground water resources.

The Missouri Department of Natural Resources shows no sinkholes for the planning area.

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. Due to sinkholes collapsing not being predictable and previous events have occurred in the rural area there is not significant data to estimate the future losses due to a sinkhole.

Impact of Previous and Future Development

As more development occurs on unmapped rural areas the vulnerability to the hazard will increase; however, sinkholes are unpredictable and the development in rural areas is difficult to limit due to the lack of occurrence. There are currently no sinkholes in the planning area, and the Randolph County participating jurisdictions have no plans to limit construction due to sinkholes.

Hazard Summary by Jurisdiction

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

Problem Statement

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

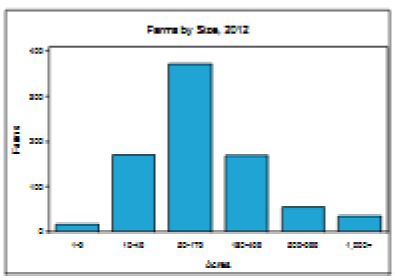
Droughts are regional in nature. All areas of the United States are vulnerable to the risk of drought and extreme heat. Droughts can be widespread or localized events. The extent of the droughts varies both in terms of the extent of the heat and range of precipitation. The severity of a drought depends 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 2012 Census of Agriculture, Randolph County consists of 209,491 acres of land in farms, crop sales generate $21,478,000 and livestock sales generate $15,228,000. A drought would directly impact livestock production and the agriculture economy in Randolph County.

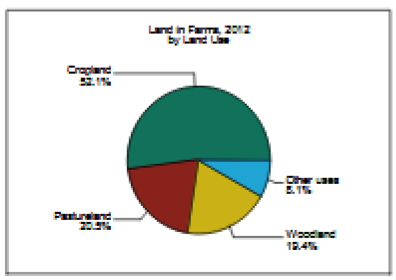
Figure 3.39. 2012 Census of Agriculture, Randolph County

2012 CENSUS OF AGRICULTURE
COUNTY PROFILE

Randolph County
Missouri

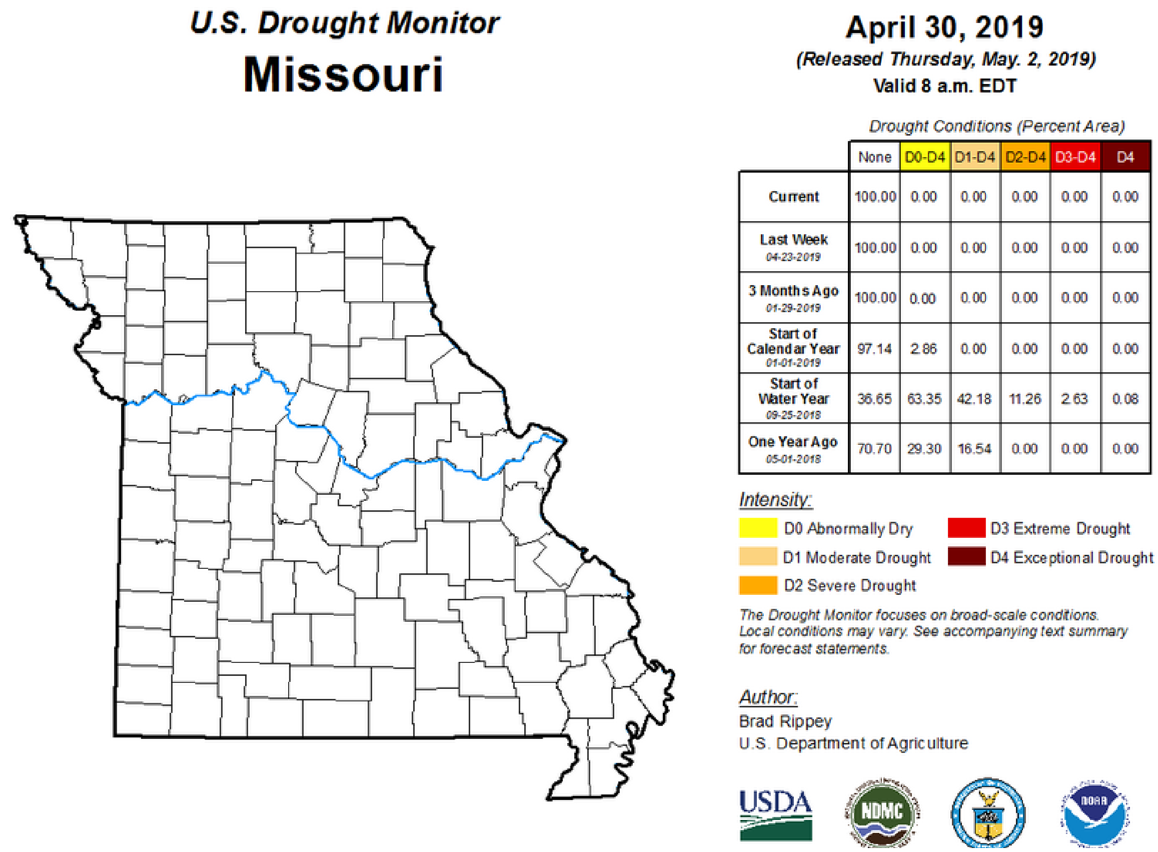
	2012	2007	% change
Number of Farms	818	1,000	- 18
Land in Farms	209,491 acres	221,647 acres	- 5
Average Size of Farm	256 acres	222 acres	+ 15
Market Value of Products Sold	$36,706,000	$36,064,000	+ 2
Crop Sales $21,478,000 (59 percent) Livestock Sales $15,228,000 (41 percent)			
Average Per Farm	$44,873	$36,064	+ 24
Government Payments	$2,820,000	$2,849,000	- 1
Average Per Farm Receiving Payments	$6,294	$5,016	+ 25





Source: https://www.nass.usda.gov/Publications/AgCensus/2012/Online_Resources/County_Profiles/Missouri/cp29175.pdf

Figure 3.40. U.S. Drought Monitor Map of Missouri on April 30, 2019



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	100.00	0.00	0.00	0.00	0.00	0.00
Last Week 04-23-2019	100.00	0.00	0.00	0.00	0.00	0.00
3 Months Ago 01-29-2019	100.00	0.00	0.00	0.00	0.00	0.00
Start of Calendar Year 01-01-2019	97.14	2.86	0.00	0.00	0.00	0.00
Start of Water Year 09-25-2018	36.65	63.35	42.18	11.26	2.63	0.08
One Year Ago 05-01-2018	70.70	29.30	16.54	0.00	0.00	0.00

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 times 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.

Table 3.25. Missouri Insurance Payments Due to Drought from 2014 to 2018

Drought Year	Insurance Payment
2014	$4,826.80
2015	$401,419.90
2016	$9,058.00
2017	$94,969.00
2018	$2,742,063.22
Total	**$3,252,336.92**

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 1998 to December 2018, Randolph County had 16 drought reports and 21 impacts.

Figure 3.41. Randolph County Drought Reports from January 1998 to December 2018

The Drought Report Reporter found **16** Reports matching your query.

Category/ies

14 in Agriculture
1 in Business & Industry
1 in Fire
1 in General Awareness
2 in Plants & Wildlife
12 in Relief, Response & Restrictions
2 in Society & Public Health
7 in Water Supply & Quality

Sources

4 in User
1 in CoCoRaHS
8 in Media
0 in National Weather Service
3 in Other Agency
0 in Hawaii

Source: https://droughtreporter.unl.edu

Figure 3.42. Randolph County Drought Impacts from January 1998 to December 2018

The Drought Impact Reporter found **21** Impacts matching your query.

Category/ies

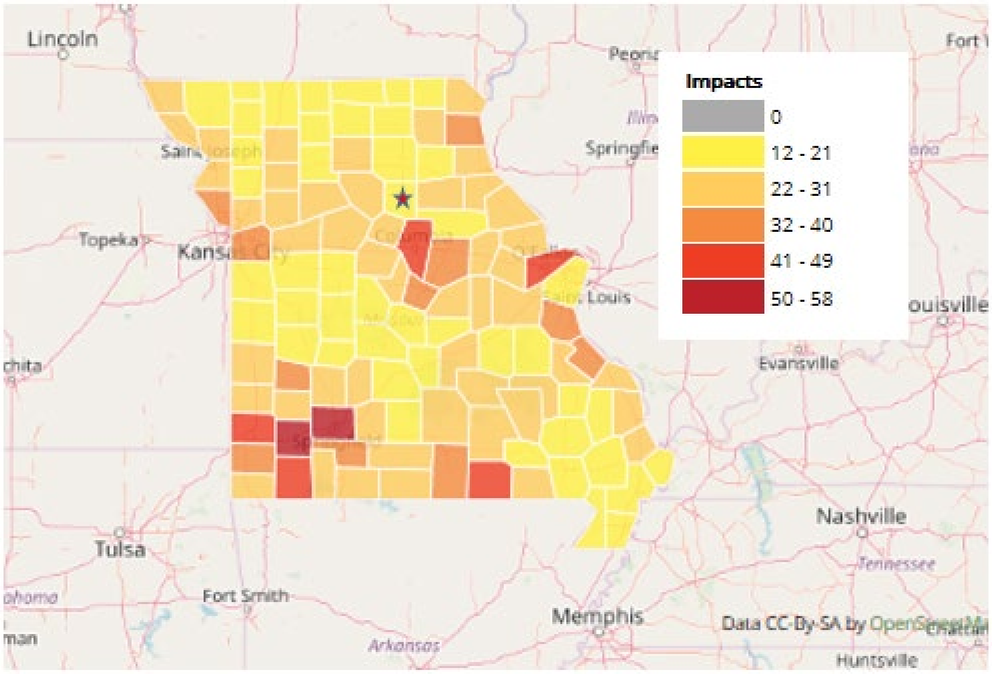
15 in Agriculture
1 in Business & Industry
0 in Energy
2 in Fire
5 in Plants & Wildlife
12 in Relief, Response & Restrictions
1 in Society & Public Health
0 in Tourism & Recreation
6 in Water Supply & Quality

Sources

4 in User
0 in CoCoRaHS
13 in Media
0 in National Weather Service
2 in Other Agency
0 in Hawaii
3 in Legacy

Source: https://droughtreporter.unl.edu

Figure 3.43. Randolph County Impact (January 1999 to December 2018)



Source: Drought Impact Reporter; http://droughtreporter.uni.edu/; *Star indicates Randolph County

Probability of Future Occurrence

According to the 2018 State Plan Randolph County has a medium-high total rate for droughts and is very likely to experience droughts in the future, with a 10.72% chance likelihood of a severe drought.

Table 3.26. Vulnerability of Randolph 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
Randolph	4	$14,450,278	$1,605,586	3	$21,478,000	2	10.72	5	14	Medium-High

Source: 2018 Missouri State Hazard Mitigation Plan

Table 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: 2018 Missouri State Hazard Mitigation Plan

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

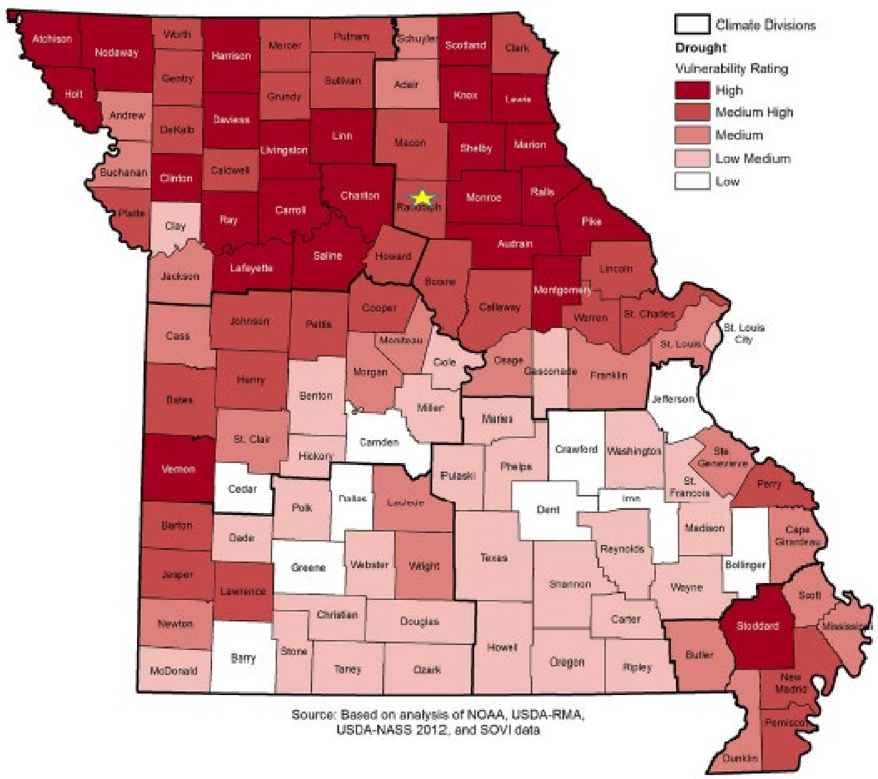
Changing Future Conditions Considerations

The 2018 State Plan, Severe drought, a natural part of Missouri's climate, is at risk to this agriculture-dependent 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 evapo- transpiration increase the likelihood of a drought. This could lead to agricultural drought and suppressed crop yields.

Vulnerability

Vulnerability Overview

Figure 3.44. Missouri Drought Vulnerability by County



Source: 2018 Missouri State Hazard Mitigation Plan

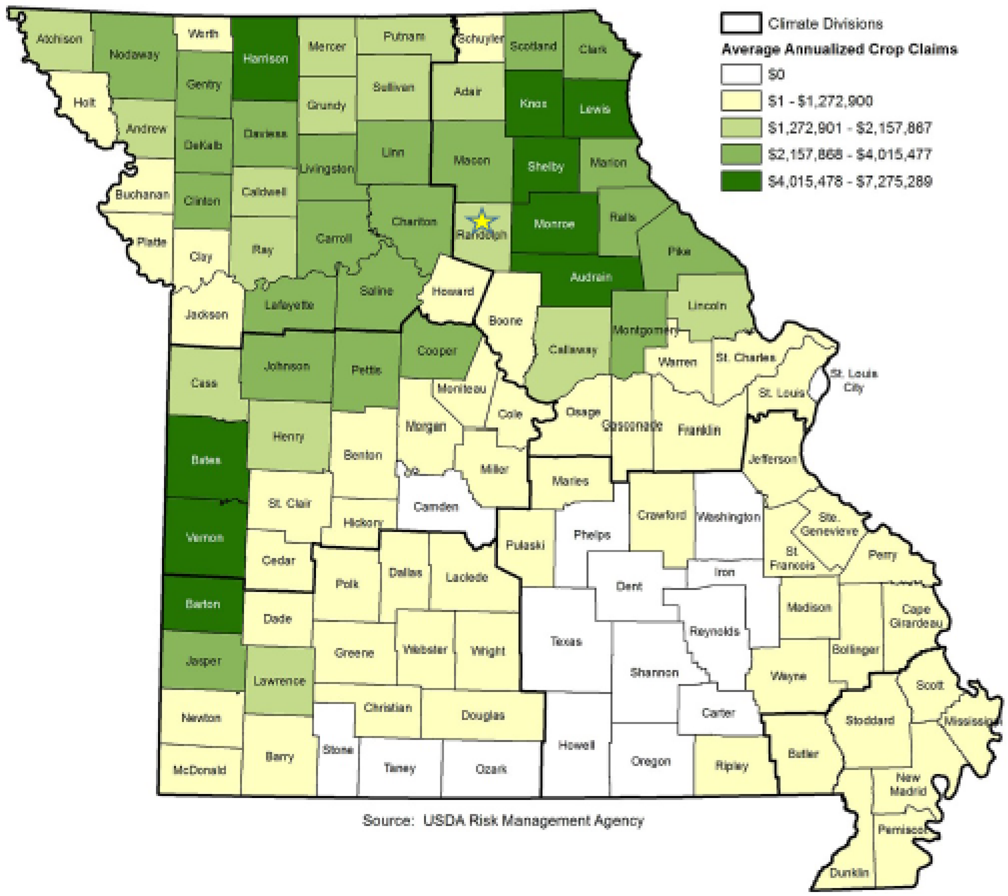
According to the analysis from the 2018 State Plan, Randolph County is a medium- high vulnerability for droughts.

Potential Losses to Existing Development

The National Drought Monitor Center at the University of Nebraska at Lincoln 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

Figure 3.45. Annualized Drought Crop Insurance Claims Paid from 2007- 2016

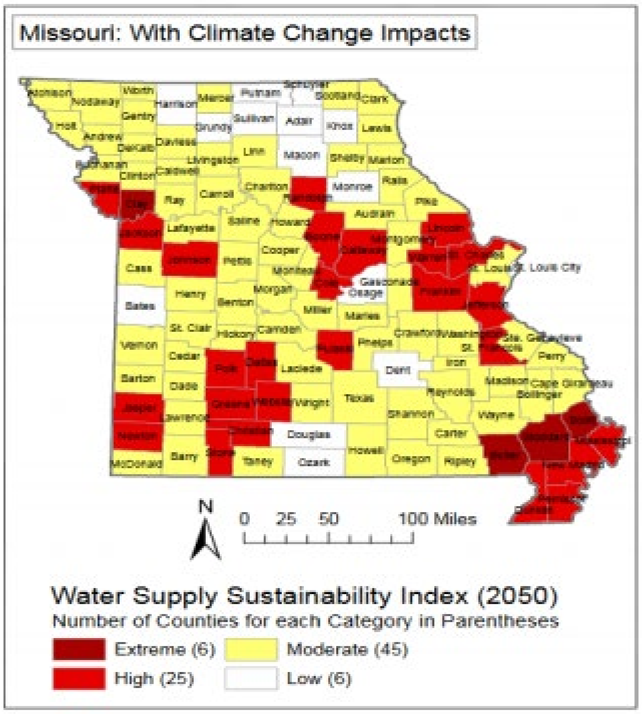


Source: 2018 Missouri State Hazard Mitigation Plan; *Star indicates Randolph County

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 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 3.46. Missouri with Climate Change Impacts



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

Hazard Summary by Jurisdiction

The entire planning area will be affected by drought to some degree. The unincorporated agricultural areas of Randolph 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.

<u>Problem Statement</u>

Randolph County is at a medium- 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.

Clark has a well owned by the City that needs the pump fixed that would mitigate drought in the City.

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 3.47 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 3.47. 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 3.48. Wind Chill Chart

Wind Chill Chart

Temperature (°F)

Wind (mph) Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

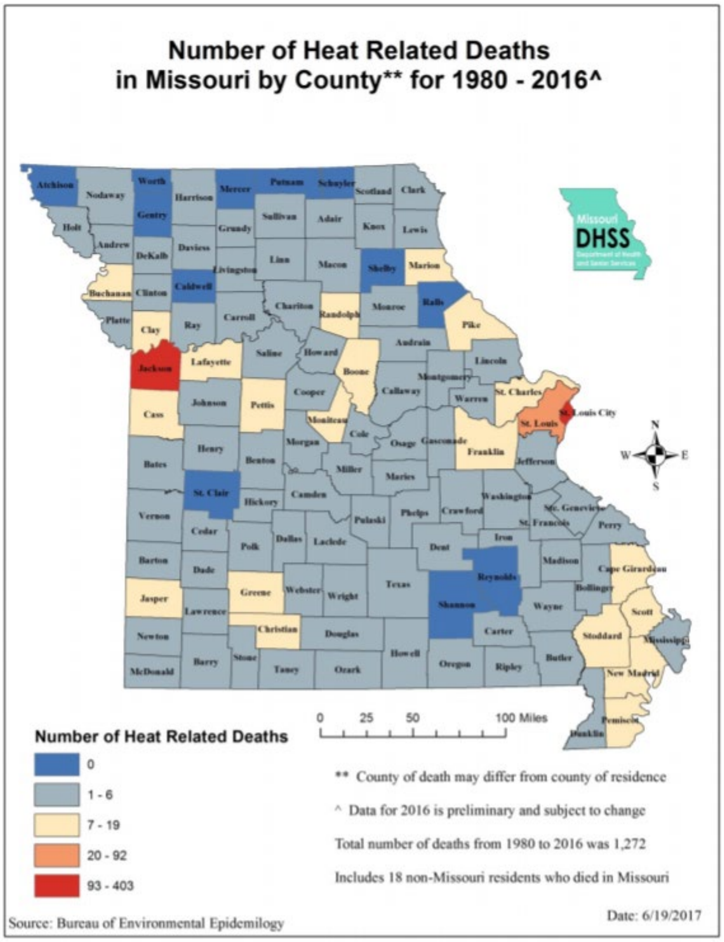
Effective 11/01/01

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

Previous Occurrences

The recorded events in the National Centers for Environmental Information (NCEI) database and state there have been 2 recorded events of excessive heat in the 20-year period of 1999-2018. There were no deaths or injuries associated with these events. The NCEI database show 1 recorded event of extreme cold/wind chill, with 0 deaths or injuries associated with this event. Figure 3.49 illustrates between 7 – 19 heat related deaths in Randolph County between the time of 1980 – 2016, no supporting documentation could be found to include in this plan.

Figure 3.49. Heat Related Deaths in Missouri 1980 - 2016



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

Table 3.28. Randolph County Agricultural Insurance Claims Due to Extreme Temperature-Heat

2007	$	0
2008	$	0
2009	$	0
2010	$	0
2011	$	183,641.00
2012	$	292,489.00
2013	$	46,144.00
2014	$	0
2015	$	0
2016	$	0
Total	$	522,274.00

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 2007 to 2016 were $522,274. 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, 0 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

NCEI information was obtained for 1997 through 2018. When the data was evaluated it was determined there was 3 years without an extreme heat event (1998, 2013 and 2018). The data indicated there were multiple extreme heat events in eight years.

Based on this historical data, the calculated probability of an extreme heat event in any given year is 85.71%. The probability was determined by taking the number of years with an extreme heat event (18) divided by the number of years (21) data was obtained for.

NCEI, dating back to 1999 to 2018 indicates 1 extreme cold/wind chill event. Based on this historical data, the calculated probability of an extreme cold event in any given year is 5%.

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.

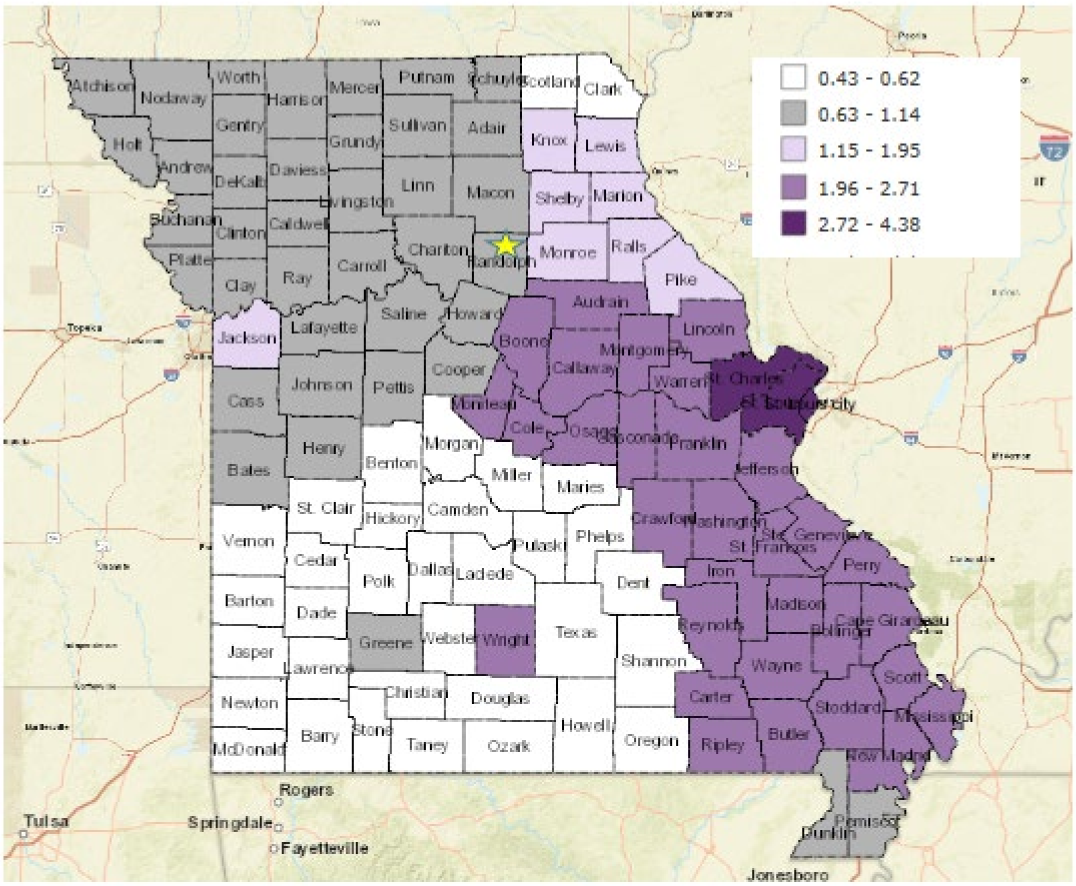
Table 3.29 lists typical symptoms and health impacts due to exposure to extreme heat.

Table 3.29. 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 3.50. Randolph County Average Annual Occurrence for Extreme Heat



Source: 2018 Missouri State Hazard Mitigation Plan; *Star indicates Randolph County

Figure 3.51. Randolph County Average Annual Occurrence for Extreme Cold Events

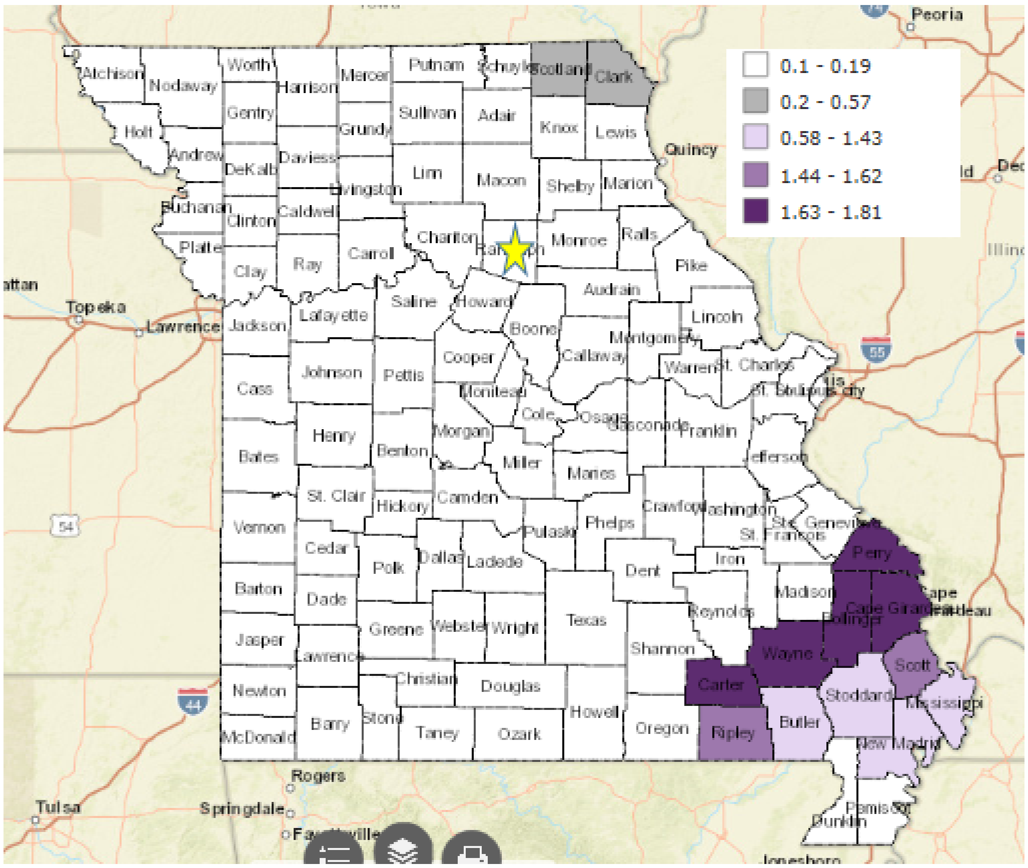
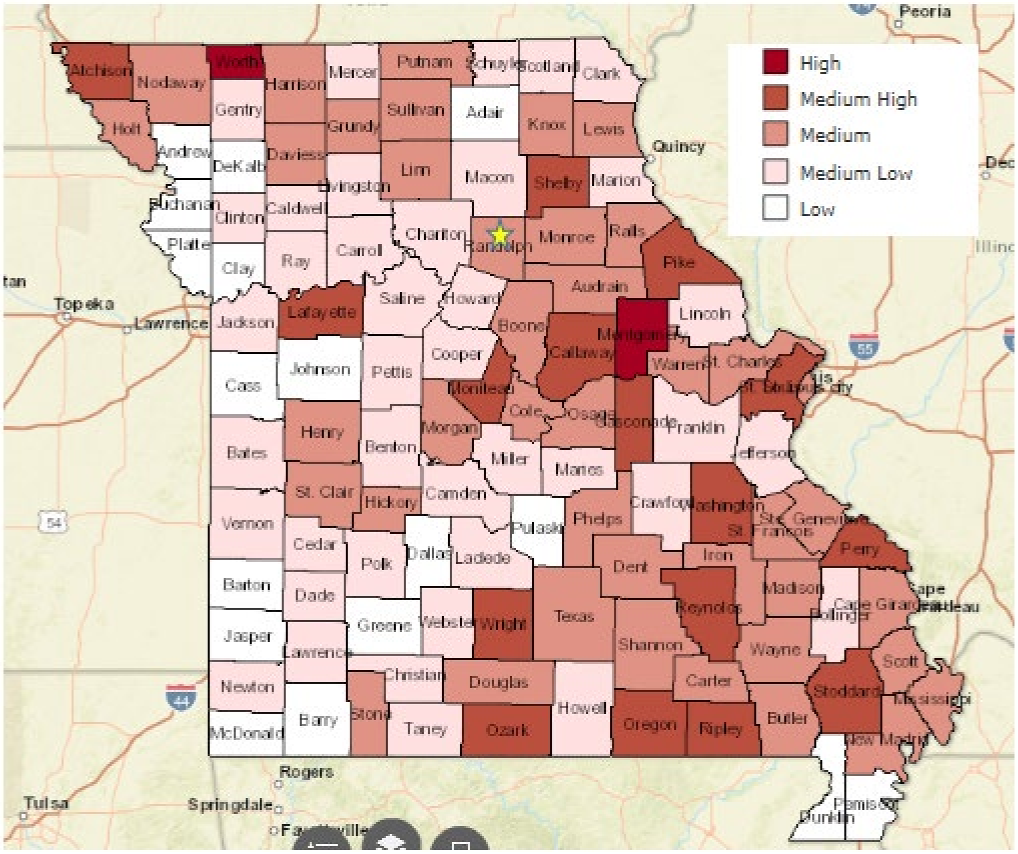
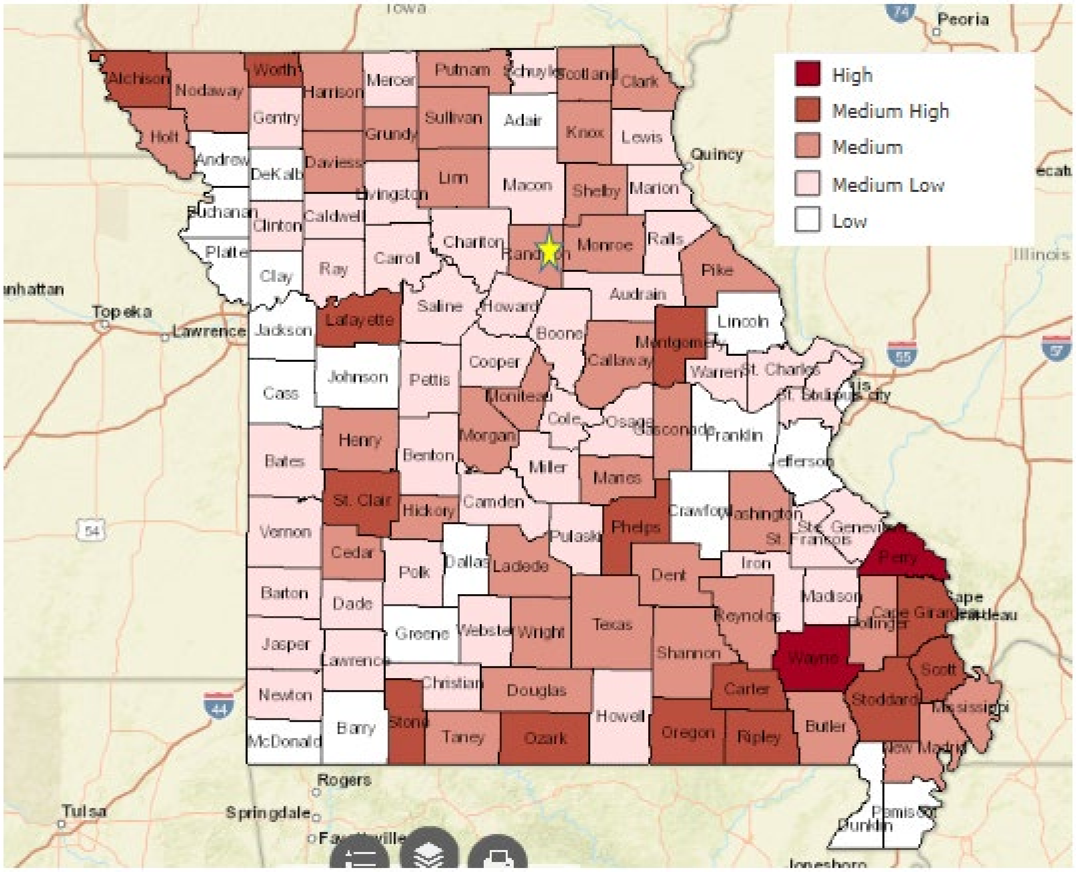


Figure 3.52. Randolph County Vulnerability Rating-Extreme Heat



Source: 2018 Missouri State Hazard Mitigation Plan; *Star indicates Randolph County

Figure 3.53. **Randolph County Vulnerability Rating-Extreme Cold**



Source: 2018 Missouri State Hazard Mitigation Plan; *Star indicates Randolph County

Potential Losses to Existing Development

During the ten-year period from 2007 -2016 there was $522,274 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 $52,227.40. Illness and loss of life are the most concern with extreme heat.

Impact of Previous and Future Development

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

According to the 2017 American Community Survey 5-Year estimates, Randolph County, Cairo, Clark, Clifton Hill, Higbee, Huntsville, Jacksonville and Renick will have a decrease of population under 5 years and Randolph County, Cairo, Clark, Higbee, Huntsville, Jacksonville and Renick will have an increase in population of 65 years and over.

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 3.30 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 3.30. Randolph County Population Under Age 5 and Over Age 65, 2010 Census Data

Jurisdiction	Population Under 5 yrs	Population 65 yrs and over
*Randolph County	1.596	3,605
Cairo	21	46
Clark	27	27
Clifton Hill	8	17
Higbee	35	90
Huntsville	101	219
Jacksonville	13	18
Moberly	901	1,945
Renick	11	29

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

Problem Statement

Randolph 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 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

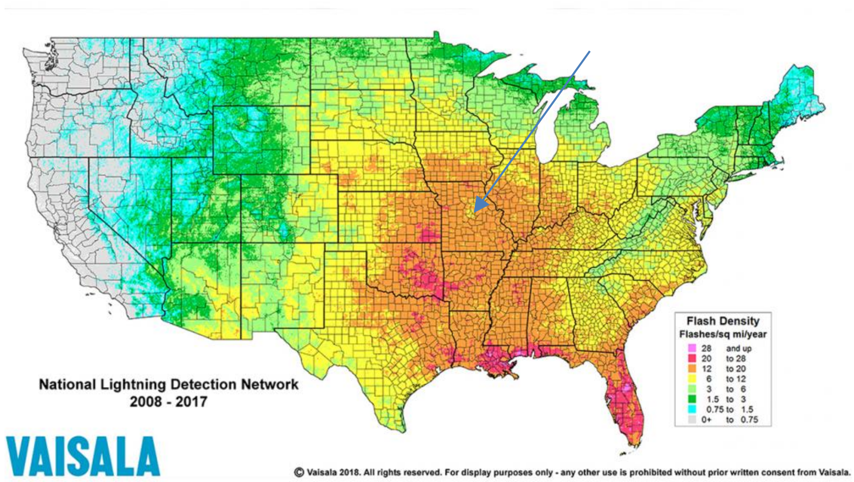
According to the National Oceanic and Atmospheric Administration (NOAA), hail is precipitation that is formed when thunderstorm updrafts carry raindrops upward into extremely cold atmosphere causing them to freeze. The raindrops form into small frozen droplets. They continue to grow as they come into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

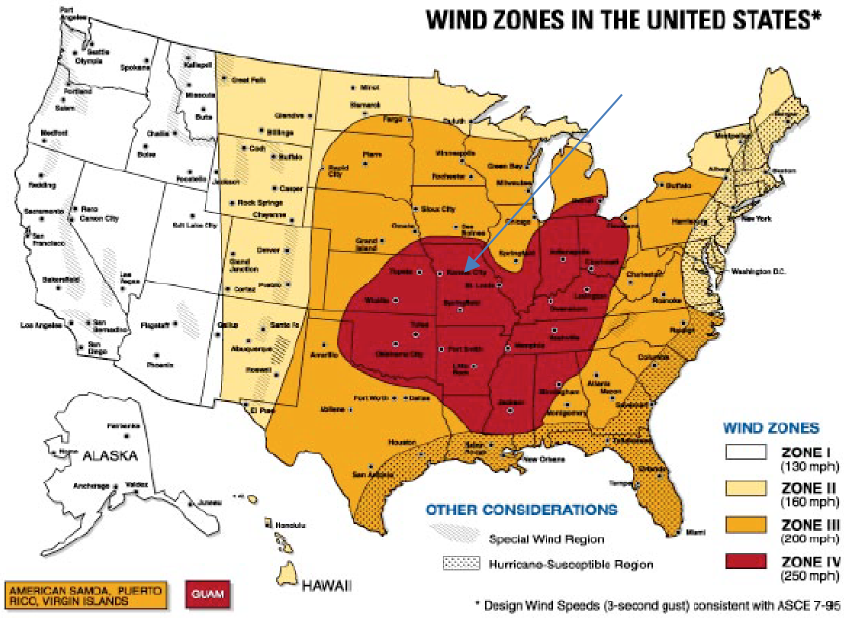
Thunderstorms/high winds/hail/lightning events are an area-wide hazard that can happen anywhere in the county. Although these events occur similarly throughout the planning area, they are more frequently reported in more urbanized areas. In addition, damages are more likely to occur in more densely developed urban areas.

Figure 3.54. Location and Frequency of Lightning in Missouri



Source: National Weather Service, http://www.vaisala.com/en/products/thunderstormandlightningdetectionsystems/Pages/NLDN.aspx . Location of planning area indicated with arrow.

Figure 3.55.   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 3.31 below describes typical damage impacts of the various sizes of hail.

Table 3.31.   Tornado and Storm Research Organization Hailstorm Intensity Scale

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

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

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

The 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 3.32 through Table 3.34**) 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 3.32. Crop Insurance Claims Paid in Randolph County from High Winds, 2007 - 2016

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2013	Corn	Wind	$477.00
Total			$477.00

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

Table 3.33. Crop Insurance Claims Paid in Randolph County from Lightning, 2007 - 2016

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2015	Soybeans	Lightning	$1,157.00
Total			$1,157.00

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

Table 3.34. Crop Insurance Claims Paid in Randolph County from Hail, 2007 - 2016

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2011	Wheat	Hail	$918.00
2011	Soybeans	Hail	$6,189.00
Total			$7,107.00

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

Probability of Future Occurrence

Thunderstorms

Based on the data provided, there has been 0 events in a 10-year period. Based on history, the probability of a thunderstorm in any given year is zero. Thus, making the probability low a thunderstorm evert is likely in any given year.

High Winds

Based on the data provided, there has been 1 event in a 10-year period, producing an average of .10

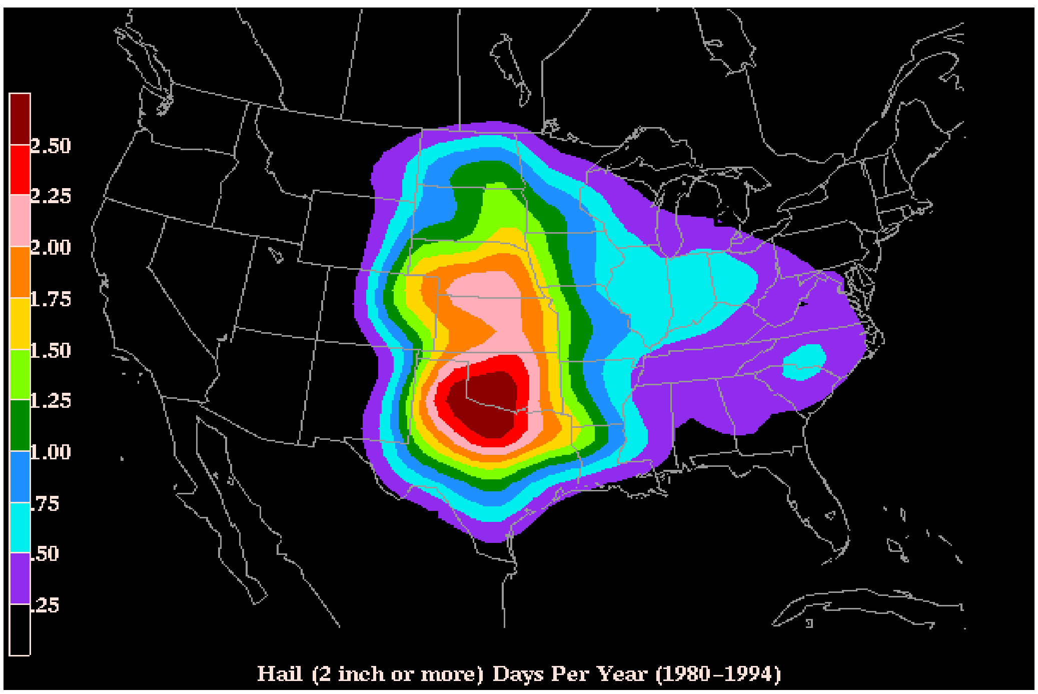
wind events each year in Randolph County. Based on history, the probability of a wind event in any given year is 10 percent. Thus, making the probability low a wind event is likely in any given year.

Lightning
Based on the data provided, there has been 1 event in a 10-year period, producing an average of .10 lightning events each year in Randolph County. Based on history, the probability of a lightning event in any given year is 10 percent. Thus, making the probability low a lightning event is likely in any given year.

Hail
Based on the data provided, there have been 2 events in a 10-year period, producing an average of .20 hail events each year in Randolph County. Based on history, the probability of a hail event in any given year is 20 percent. Thus, making the probability low a hail event is likely in any given year.

Figure 3.56 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. Randolph County is located in the region to receive between .75 to 1" hailstorm annually.

Figure 3.56. Annual Hailstorm Probability (2" diameter or larger), U 1980- 1994



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

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 for 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.

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 has not been any fatalities or injuries due to lightning in Randolph County during the 10-year period reviewed. When the review period was extended to 20 years there was 0 reported lightning events where individuals reported injury. There have been four insurance claims due to wind, lightning and hail due to loss of property.

Hail

There were 2 reported crop insurance claims for a 10-year period resulting in $7,107.00 in insurance payments.

High Winds

There were 1 reported crop insurance claims for a 10-year period resulting in $477.00 in insurance payments.

Lightning

There were 1 reported crop insurance claims for a 10-year period resulting in $1,157.00 in insurance payments.

Previous and Future Development

Randolph 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.

Hazard Summary by Jurisdiction

Thunderstorms/high winds/ lightning/hail events are area-wide, NCEI data did not indicate 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

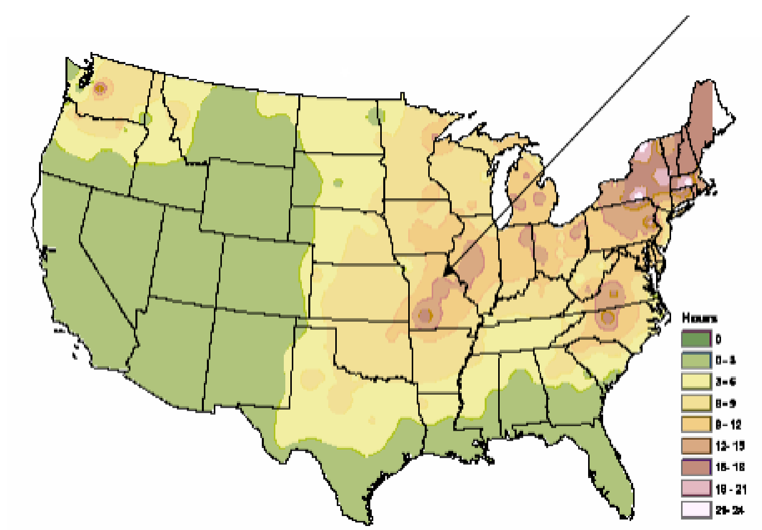
A major winter storm can last for several days and be accompanied by high winds, freezing rain or sleet, heavy snowfall, and cold temperatures. The National Weather Service describes different types of winter storm events as follows.

- **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 Randolph County is vulnerable to heavy snow, ice, extreme cold temperatures and freezing rain.

Figure 3.57. 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 3.35 includes NCEI reported events and damages for at least the past 10 years. Events include blizzard, cold/wind chill, extreme cold/wind chill, heavy snow, ice storm, sleet, winter storm, and winter weather (events happening on the same day has been combined).

Table 3.35. NCEI Randolph County Winter Weather Events Summary, 2009 - 2018

Type of Event	Inclusive Dates	Magnitude	# of Injuries	Property Damages	Crop Damages
Blizzard	2/1/2011		0	$0.00	$0.00
Blizzard	11/25/2018		0	$0.00	$0.00
Cold/Wind Chill	1/06/2014		0	$0.00	$0.00
Heavy Snow	2/4/2014	1 to 2 feet of snow	0	$0.00	$0.00
Extreme Cold	No Reports				
Ice Storm	No Reports				
Sleet	No Reports				
Winter Storm	1/6/2010	3 to 6 inches of snow	0	$0.00	$0.00
Winter Storm	1/19/2011	5 to 8 inches of snow	0	$0.00	$0.00
Winter Storm	2/24/2011	5 to 7 inches of snow	0	$0.00	$0.00
Winter Storm	2/21/2013	Up to a foot of snow	0	$0.00	$0.00
Winter Storm	2/25/2013	Up to 2 inches an hour	0	$0.00	$0.00
Winter Storm	3/23/2013	6 to 10 inches of snow	0	$0.00	$0.00
Winter Storm	12/21/2013	6 to 8 inches of snow	0	$0.00	$0.00
Winter Storm	3/01/2014	½ Sleet, 5 inches snow	0	$0.00	$0.00
Winter Weather	1/10/2011		0	$0.00	$0.00
Winter Weather	12/8/2011		0	$0.00	$0.00
Winter Weather	2/13/2012		0	$0.00	$0.00

Source: NCEI, data accessed May 27, 2019

Blizzard

February 2011 - A historic winter storm impacted a wide swath of the central and eastern United States on Tuesday, February 1st into Wednesday, February 2nd. This was one of the strongest blizzards ever to impact the region. Locally, cooperative and community weather observers in Warrensburg, Clinton, Sedalia, Calhoun, Boonville, and Brookfield, Missouri, each reported daily record snowfall totals near or exceeding 20 inches. Nearby, an equally impressive snowfall of 12-18 inches fell along the Interstate 70 corridor, causing the first ever state-wide closure of Interstate 70, from Tuesday night into early Wednesday. Snowfall rates of 2-3 inches per hour, also resulted in the temporary closure of Kansas City International Airport, Tuesday afternoon and evening. These snow rates also brought travel in the Kansas City metropolitan area to a grinding halt, causing temporary closures of many of the urban expressways. Some schools were closed for several days. In addition to the heavy snow, this event also brought very rare blizzard conditions to the region. Strong northwest winds frequently gusted between 35 and 45 mph across the region, reducing visibilities to near zero at times in white out conditions, and drifting snow 3 to 4 feet deep in many areas. Outside of the record snowfall of central Missouri, significant snowfall also was observed across the bulk of western and northeast Missouri, with 9-12 inches of snow falling across the Kansas City metropolitan area. Amounts tapered off to 3 to 6 inches in the extreme northwest corner of Missouri. However, blowing and drifting snow caused very hazardous driving conditions in that area as well.

Table 3.36. Presidential Disaster Declarations for Winter Storms in Randolph County

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
January 30, 2009	DR-3303	Severe Winter Storms	Emergency Declaration for all counties in Missouri	PA
March 23, 2011	DR-1961	Severe Winter Storms	Adair, Andrew, Audrain, Barton, Bates, Benton, Boone, Buchanan, Caldwell, Callaway, Camden, 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, Pike, Platte, Polk, Pulaski, Putnam, Ralls, Randolph, Ray, Saint Clair, Saline, Schuyler, Scotland, Shelby, Sullivan, Vernon and Worth.	PA

Winter Storms, cold, frost and freeze take a toll on crop production in the planning area. Table 3.37 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 3.37. Crop Insurance Claims Paid in Randolph County as a Result of Cold Conditions

and Snow 2007 – 2018

Crop Year	Crop Name	Cause of Loss/ Description	Insurance Paid
2007	WHEAT	Freeze	$ (103.00)
2007	WHEAT	Freeze	$ 168.00
2007	WHEAT	Freeze	$ 385.00
2008	WHEAT	Cold Wet Weather	$ 2,203.00
2008	WHEAT	Cold Wet Weather	$ 8,449.00
2009	CORN	Cold Wet Weather	$ 478.00
2009	CORN	Cold Wet Weather	$ 8,242.00
2009	GRAIN SORGHUM	Frost	$ 25,159.00
2010	WHEAT	Cold Winter	$ 6,435.00
2010	WHEAT	Cold Wet Weather	$ 9,498.00
2010	WHEAT	Cold Wet Weather	$ 14,543.00
2010	CORN	Cold Wet Weather	$ 7,612.00
2010	CORN	Cold Wet Weather	$ 21,027.00
2010	CORN	Cold Wet Weather	$ 13,891.00
2010	CORN	Cold Wet Weather	$ 27,370.00
2010	SOYBEANS	Cold Wet Weather	$ 3,770.00
2011	WHEAT	Cold Winter	$ (1,248.00)
2011	WHEAT	Cold Winter	$ 2,964.00
2011	CORN	Cold Wet Weather	$ 25,692.00
2013	WHEAT	Freeze	$ 38,107.00
2013	WHEAT	Cold Wet Weather	$ 4,587.00
2014	WHEAT	Freeze	$ 28,078.00
2014	WHEAT	Cold Winter	$ 6,341.00
2014	WHEAT	Cold Winter	$ 5,461.48
2014	WHEAT	Cold Winter	$ 20,926.00
2014	WHEAT	Cold Wet Weather	$ 1,109.50
2014	CORN	Cold Wet Weather	$ 9,188.00
2015	WHEAT	Cold Winter	$ 32,319.00
2015	WHEAT	Cold Winter	$ 3,544.00
2016	GRAIN SORGHUM	Cold Wet Weather	$ 2,961.00
2016	SOYBEANS	Cold Wet Weather	$ 9,158.00
		Total	$ 338,314.98

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.

Based on the data provided, there has been 9 events in a 11-year period. Based on history, the probability of a severe winter weather event in any given year is 81.81% percent. Thus, making the probability high a winter event is likely in any given year.

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 pets and non-native species. Warmer winter temperatures will result in a reduction of lake ice cover. Reduced 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 ball as rain rather than snow.

Vulnerability

Vulnerability Overview

The method used to determine vulnerability to severe winter weather across Missouri was statistical analysis of data from several sources: National Centers for Environmental Information (NCEI) storm events data (1996 to December 31, 2016), HAZUS Building Exposure Value data, housing density data from U. S. Census (2015 ACS), and the calculated Social Vulnerability Index for Missouri Counties from the Hazards and Vulnerability to severe winter weather as follows: housing density, building exposure, social vulnerability, likelihood of occurrence, and average annual 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

Table 3.38. Ranges for Severe Winter Weather Vulnerability Factor Rating

Factors Considered	Low (1)	Low Medium (2)	Medium (3)	Medium High (4)	High (5)
Common Factors					
Housing Density (# per sq. mile)	4.11-44.23	44.24-134.91	134.92-259.98	259.99-862.69	862.70-2836.23
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
Social Vulnerability	1	2	3	4	5
Likelihood of Occurrence (# of events/ yrs. of data)	1.05-1.43	1.44-1.76	1.77-2.10	2.11-2.67	2.68-4.57
Average Annual Property Loss (annual property loss/ yrs. Of data)	$0-$143,095.24	$143,095.25-$406,666.67	$406,666.68-$1,191,000.95	$1,191,000.96-$3,184,761.90	$3,184,761.91-$5,861,666.67

Source: 2018 Missouri State Hazard Mitigation Plan

Table 3.39. Ranges for Severe Winter Weather Combined Vulnerability Rating

	Low (1)	Low-medium (2)	Medium (3)	Medium-high-4	High (5)
Severe Winter Weather Combined Vulnerability	7-8	8-10	10-12	12-15	15-22

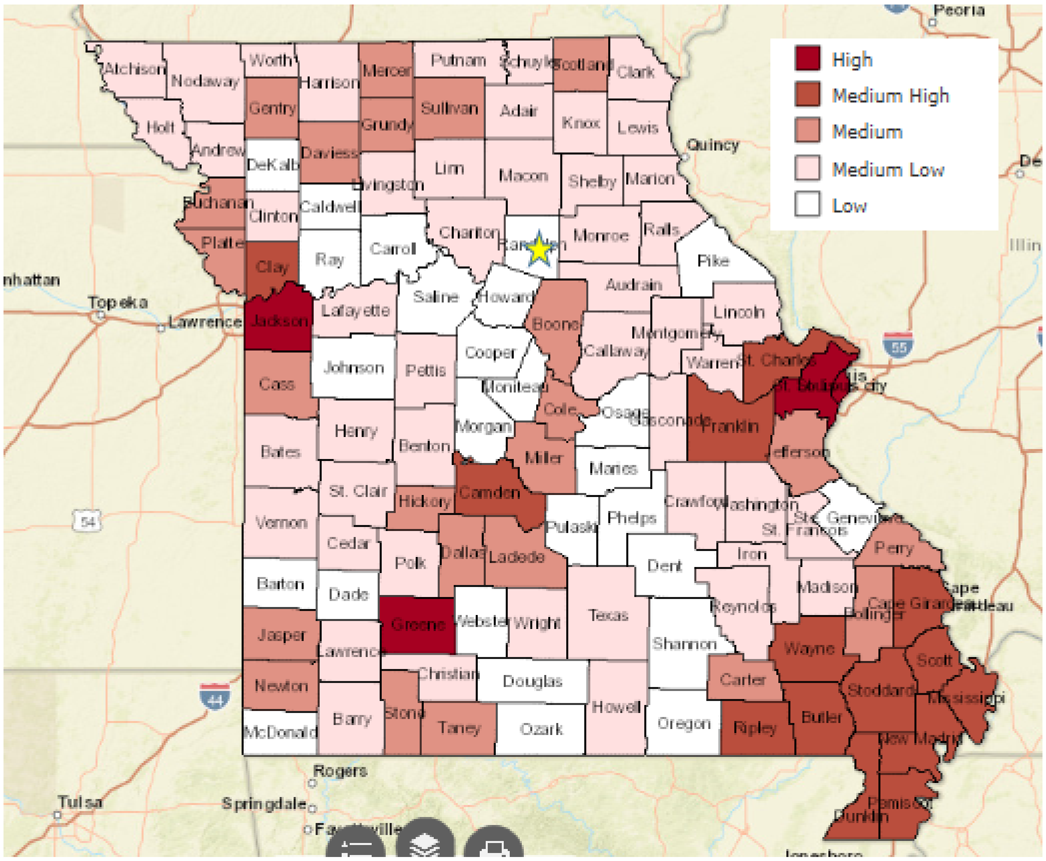
Source: 2018 Missouri State Hazard Mitigation Plan

Table 3.40. Housing Density, Building Exposure, and SOVI Data for Randolph County

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Ranking Rating
Randolph	$2,425,165,000	1	22.11	1	Medium Low	2

Source: 2018 Missouri State Hazard Mitigation Plan

Figure 3.58. Vulnerability Summary for Severe Winter Weather



Source: 2018 Missouri State Hazard Mitigation Plan; *Star indicates Randolph County

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.

Hazard Summary by Jurisdiction

Although crop loss is a result of severe winter storm it 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 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

Randolph County is expected to experience at least one severe winter weather event annually; the county has a low-medium vulnerability rating. Jurisdictions should enhance their weather monitoring to be better prepared for severe 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 in stock and the utilization of social media and texting notices needs to increase.

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

Tornados 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 3.41) 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 3.41. Enhanced F Scale for Tornado Damage

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

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

The wind speeds for the EF scale and damage descriptions are based on information on the NOAA Storm Prediction Center as listed in Table 3.42. The damage descriptions are summaries. For the actual EF scale, it is necessary to look up the damage indicator (type of structure damaged) and refer to the degrees of damage associated with that indicator. Information on the Enhanced Fujita Scale's damage indicators and degrees or damage is located online at www.spc.noaa.gov/efscale/ef-scale.html.

Table 3.42. 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 3.43. Recorded Tornadoes in Randolph County, 1993 – Present

Date	Beginning Location	Ending Location	Length (miles)	Width (yards)	F/EF Rating	Death	Injury	Property Damage	Crop Damages
7/4/1995	39.40	39.80	.1	10	F3	0	0	$400,000	$0.00
3/12/2006	2N NW Huntsville	8NE Moberly	10.5	75	F0	0	0	$0.00	$0.00
3/12/2006	2 E Higbee	8 SE Moberly	10.7	300	F3	4	26	$5 Million	$0.00
4/4/2010	1 S Yates	2E SE Yates	2.41	25	EF0	0	0	$0.00	$0.00
12/4/2017	2E SE Higbee	6E Renick	10	30	EF1	0	2	$200,000	$0.00
	Total							$5.6 Million	$0.00

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

Figure 3.59 shows historic tornado paths in the planning area.

Figure 3.59. Randolph County Map of Historic Tornado Events

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

Data from the USDA Risk Management Agency showed no insurance payment in Randolph County for crop damages as a result of tornadoes within the timeframe of 2009-2018.

Probability of Future Occurrence

The National Centers for Environmental Information reported 5 tornadoes in Randolph County in a 20-year time period, which calculates to a 25 percent chance of tornado in any given year. Therefore, it is a low probability that some portion of Randolph 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 1950's and densely concentrated tornado outbreaks are on the rise. It is notable the research shows the area of tornado activity is not expanding, but rather the areas already subject to tornado activity are seeing the more densely packed tornadoes. Missouri experiences on average 39.6 tornadoes a year, such research is closely followed by meteorologists in the state.

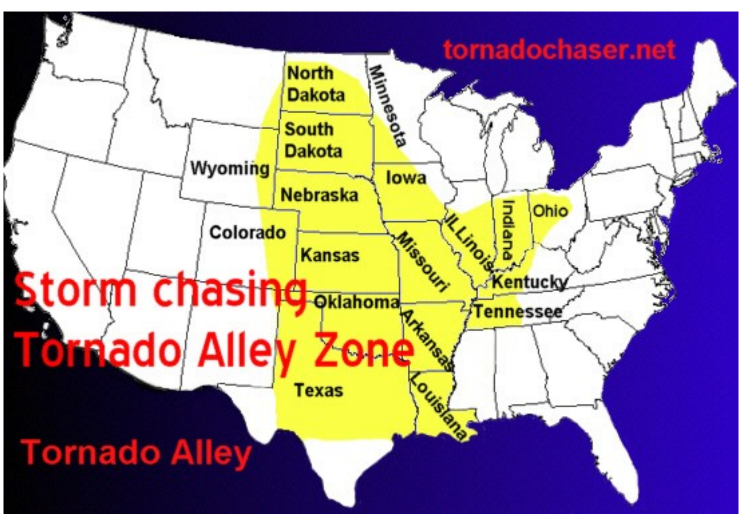
Vulnerability

Vulnerability Overview

Randolph County is located in a region of the U.S. with high frequency of dangerous and destructive tornadoes referred to as "Tornado Alley". Figure 3.60 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 3.60. Tornado Alley in the U.S.



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

Table 3.44. 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

Source: 2018 Missouri State Hazard Mitigation Plan

Table 3.45. Ranges for Tornado Combined Vulnerability Rating

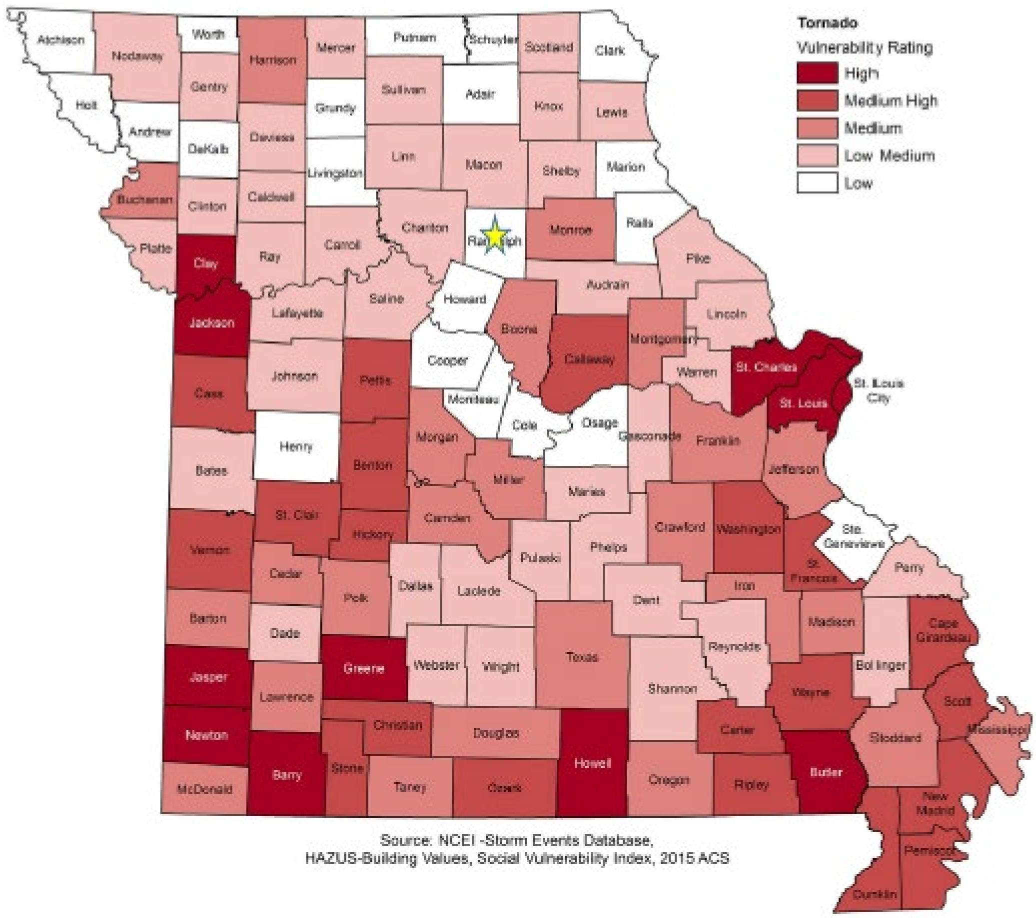
	Low (1)	Low-medium (2)	Medium (3)	Medium-High (4)	High (5)
Tornado Combined Vulnerability	7-10	11-12	13-14	15-16	17-21

Source: 2018 Missouri State Hazard Mitigation Plan

Table 3.46. Building Exposure, Population Density, SOVI and Mobile Home Data for Randolph County

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
Randolph	$2,425,165,000	1	22.11	1	Medium Low	2	13.7	3

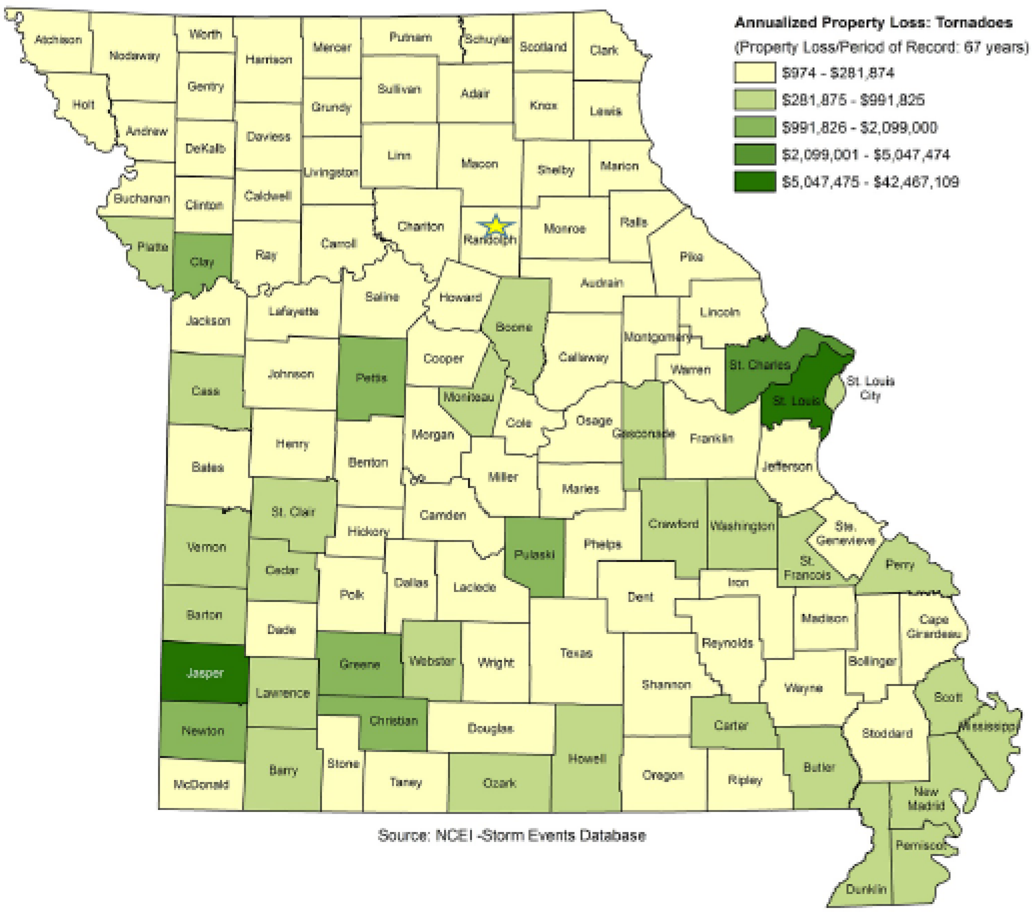
Figure 3.61. Overall Vulnerability for Tornadoes in Randolph County



Source: 2018 Missouri State Hazard Mitigation Plan; * Star indicates Randolph County

Potential Losses to Existing Development

Figure 3.62. Annualized Property Loss for Tornadoes



Source: 2018 Missouri State Hazard Mitigation Plan; * Star indicates Randolph County

The above Figure 3.62 shows in the past 67 years, Randolph County has had minimal annualized property loss ($974 - $281,874) from tornadoes.

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

A tornado event could occur anywhere in the planning area, but some jurisdictions would suffer heavier damages due to 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.

The City of Moberly would suffer heavier damage due to the number of residents living within the city limits and the large number of homes and buildings. Schools in the planning area would also suffer heavy damage due to the number of students and staff located in the school at one time and there is several buildings owned by the schools in the planning area.

Problem Statement

Randolph 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, conducting public education and outreach activities to increase awareness of tornado risk. Schools in the planning area indicated tornado saferooms as a solution against damage from tornados.

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.

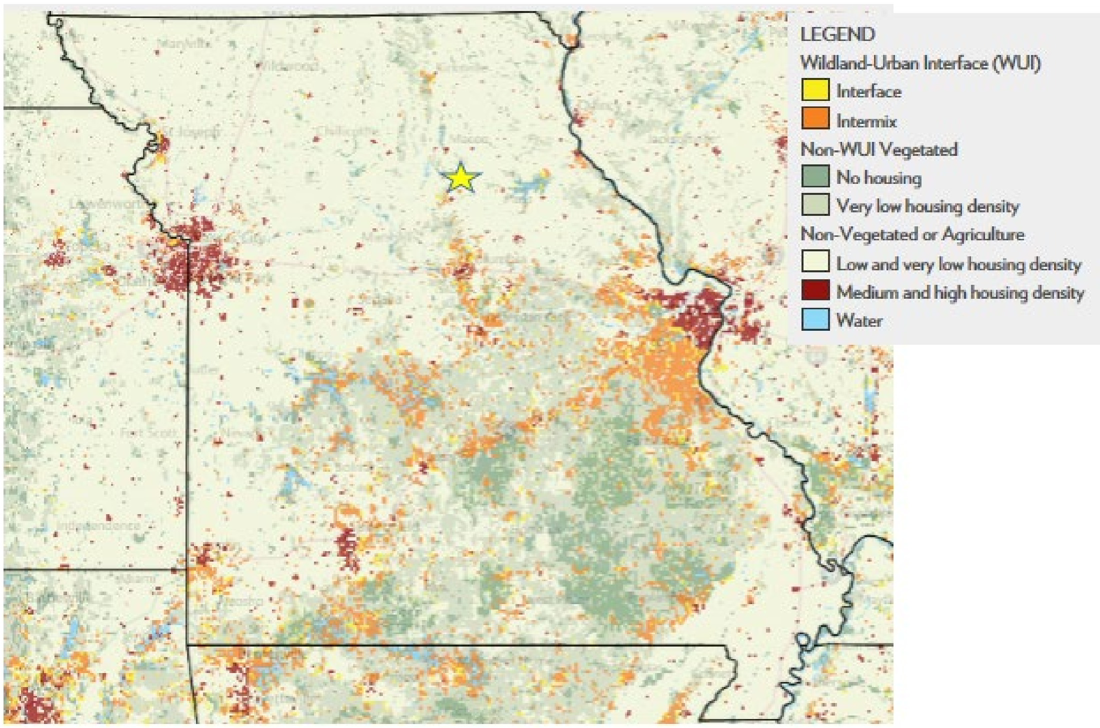
Most of Missouri fires occur during the spring season between February and May. The length and severity of wildland fires depend largely on weather conditions. Spring in Missouri is usually characterized by low humidity and high winds. These conditions result in higher fire danger. In addition, due to 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 Wildland-Urban Interface 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 Randolph County. If this information becomes available prior to the next update of this plan, it will be incorporated.

Figure 3.63. Wildland-Urban Interface



Source: http://silvis.forest.wisc.edu/maps/wui/2010/download ; * Star indicates Randolph 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.

No information was available regarding severity of damages from notable structural fires or wildland fires in the planning area.

Previous Occurrences

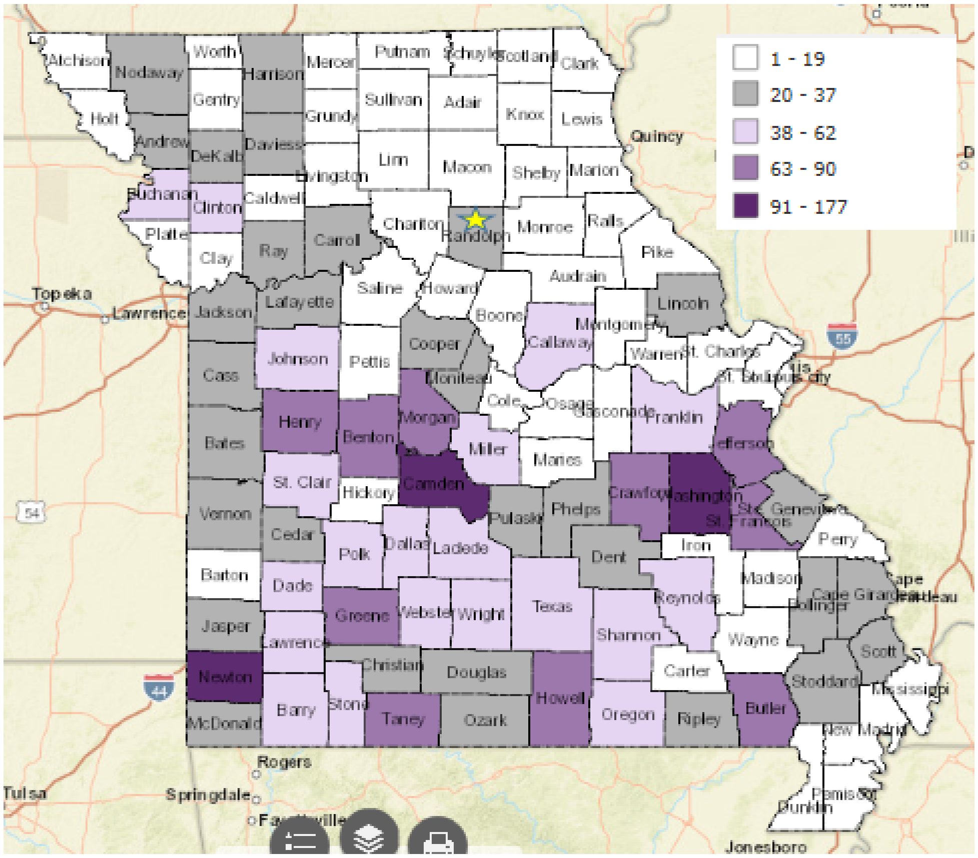
According to the Missouri Division of Fire Safety (MDFS) Website as well as the Missouri Department of Conservation Wildfire Data Search there were over 300 reported wildland or grass fires in Randolph County from 2009 – 2016. In total the over 300 fires burned over 3,000 acres and no injuries were reported. The cause of the over 300 fires included an unknown cause, debris, equipment, smoking and lightning.

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 are most likely to occur every year with very little resulting in damages. 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 3.64. Likelihood of Wildfire events, 2004 – 2016



Source: 2018 Missouri State Hazard Mitigation Plan; *Star indicates Randolph County

Changing Future Conditions Considerations

When analyzing the wildland fires, there has been an average of 42 fires burning per year. However, it was reported these fires did not result in major damages. The probability score to be likely in any given year that a wildfire could occur in the planning area.

Vulnerability

Vulnerability Overview

According to the 2018 Missouri State Hazard Mitigation 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. 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.

Potential Losses to Existing Development

Figure 3.65. Estimated Numbers and Values of Structures and Population Vulnerable to Wildfire in Randolph County

County	Number of Structures	Value of Structures	Population
Randolph	2,303	$540,448,002	5,027
Agriculture	294	$139,703,455	
Commercial	54	$35,545,068	
Education	1	$3,117,286	
Government	11	$7,984,935	
Industrial	2	$2,447,815	
Residential	1,941	$351,649,444	

Source: 2018 Missouri State Hazard Mitigation Plan

Figure 3.66. Wildfire Potential Loss Estimates for Randolph County

County	Total WUI Acreage	Total Structure Value Within WUI	Average Value/Acre within WUI	Average Annual Acreage Burned	Potential Loss
Randolph	15,850.10	$540,448,002	$34,097	262	$8,933,530

Source: 2018 Missouri State Hazard Mitigation Plan

According to the 2018 Missouri State Hazard Mitigation Plan, Randolph County is estimated to have on average 262 acres burned with a potential loss of $8,933,530.

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 in a rural area 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 Randolph 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 Randolph County's high drought rating, the County may be more susceptible to fires.