Section 4: Hazard Identification and Risk Assessment

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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.*

4.1 Overview and Changes from 2020 Plan

For the 2025 Plan Update, the Planning Team continued to focus on five natural hazards in the region. The selected hazards are consolidated into five main categories: tornadoes, severe thunderstorms, severe winter weather, heat, and flooding. The heat category includes a profile on drought and heat waves. The flooding category includes a profile on flooding, levee failures, and dam failures. Focusing the Plan on natural disasters was done to narrow each jurisdiction's focus and simplify the selection of, and implementation for, mitigation efforts. The identification of these priority natural hazards was made by the project steering committee and was informed by a survey of jurisdiction representatives and the public.

Each hazard profile includes:

- **Description**
- **Historical Occurrences**
- **Probable Location**
    - Magnitude
- **Impact**
- **Probability of Future Occurrence**
- **Extent**
    - Probable Duration
- **Vulnerability Analysis**
- **Problem Statements**

Each profile may differ slightly due to the characteristics of the hazard.

The areas that may be affected by weather-related natural hazards are very difficult to identify. Where possible, the locations or geographic areas that may be affected are mapped. Tornadoes, for example, may affect any part of the Kansas City metropolitan area. Severe thunderstorms, severe winter weather, drought, and heat waves are usually widespread weather events that affect parts of the region or the entire region. In the *Probable Locations* section of each hazard profile, a magnitude rating was given to the five-county area estimating the percent of a county that could be affected during a hazard event. The methodology is explained in ***Section 4.2***.

Certain locations — because of specific characteristics of the built environment, socio-economic conditions or a combination of these elements — may be more susceptible to these natural hazards. The Vulnerability Analysis in **Section 4.5** highlights these areas and populations.

Many sources were researched for data and information relating to hazards in the Kansas City metropolitan area. Principal sources of all-hazard information include FEMA and SEMA. The National Climate Data Center (NCDC), National Oceanic and Atmospheric Administration (NOAA) and the National Weather Service (NWS) were primary sources of information and statistics on weather and/or climate-related hazards.

Hazard-specific databases were also researched for this Plan. For instance, the National Drought Mitigation Center at University Nebraska Lincoln was used for the drought profile. The primary sources of information on dams and dam safety were the Missouri Department of Natural Resources (MDNR) Dam Safety Division and the U.S. Army Corps of Engineers' (USACE) National Inventory of Dams (NID). The primary source for information on levees was the National Levee Database.

Other sources of information include MARC Research Services Department; city and county Web sites and officials; existing county, regional and state plans, reports and documents; newspaper and news organization Web sites, articles and accounts of natural disasters; other state and federal agencies, such as the U.S. Census Bureau and Missouri Census Data Center (MCDC); and colleges and universities, especially the University of Missouri and University of Missouri Extension. References are noted at the end of each hazard profile with a bibliography of research sources in **Appendix C: Maps and References**.

Several data deficiencies noted in the 2020 Plan have been corrected or new sources of information identified. These are noted where applicable.

4.1.1 Hazards Not Included and Reasons for Elimination

While the Plan was consolidated to only include natural hazards, there are two natural hazards that were removed from the Plan. Wildland fires and earthquakes are not included in this Plan due to low probabilities. In the 2015 Plan, earthquakes rated 'low' in all modified Mercalli levels for future probable severity. The maximum percentage of any portion of any county affected by wildfires, was 7.5 percent. The majority of every county in the planning area was 0%-1% affected by wildland fires.

All man-made hazards were removed from this Plan to help jurisdictions narrow their mitigation efforts. The following hazards may be of concern to one or more local jurisdictions but were not included in the 2020 plan: emerging infectious disease, transboundary animal disease, hazardous materials incidents, mass transportation accidents, cyber disruption, public mass shooter incidents, civil disorder, and terrorism.

4.2 Community-Driven Risk Assessment

As part of the 2025 Plan Community Profile Survey, each jurisdiction was asked to reassess its risks for the natural hazards identified in the Plan. "Cascading hazards," those hazards resulting from a natural disaster, were listed to be considered when reassessing risk. **Table 4.1** shows the relationship between the region's identified disasters and categories of possible cascading hazards. Any of these cascading hazards alone or in combination with the direct adverse effects of a disaster can potentially impact emergency response operations in affected communities.

Table 4.1: Cascading Hazards Resulting from Disasters

Natural Disaster	Power and Communications Interruption	Water Supply Interruption	Business Interruption	Computer Failure and/or Loss of Records	Transportation Interruption	Health and/or Environmental Hazards
Tornado	X	X	X	X	X	X
Severe Thunderstorms	X		X	X		
Severe Winter Weather	X	X	X	X	X	X
Drought		X	X			X
Heat Wave		X	X			X
Flood	X	X	X	X	X	X
Levee Failure	X	X	X	X	X	X
Dam Failure	X	X	X	X	X	X

X = 50 percent or greater chance of cascading effect resulting from disaster

As each county noted the risk each hazard poses to their governance, hazards were re-prioritized or deleted. If a hazard was not of concern, the jurisdiction was asked to describe why it was eliminated. Risk is "the potential for damage, loss, or other impacts created by the interaction of natural hazards with community assets."[i]

4.3 Hazard Identification

Requirement §201.6(c)(2)(i): *[The risk assessment shall include a] description of the type, 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.*

Description of the eight sections describing each hazard:

- **Description** section explains the hazard.
- **Historical Occurrences** section offers a description of all hazard events occurring in the region.
- **Probable Location** section describes the geographic areas that may be affected. Along with the magnitude, or percent, of the county that can be affected during a hazard event.
- **Impact** section describes the effects a hazard can have on property and people.

- **Probability of Future Occurrence** section describes the likelihood of a hazard occurring in the future.
- **Extent** section describes classification methods and advisories commonly used to describe the severity of a hazard.
    - **Probable Duration** subsection describes the hazard duration and the potential speed of onset.
- **Vulnerability Analysis** section describes areas and populations in the region that are most susceptible to the hazard.
- **Problem Statements** section outlines concerns and vulnerabilities identified by jurisdictions in relation to the hazard.

Tables 4.3 through 4.8 contain a summary analysis of the identified priority hazards that could potentially affect Cass, Clay, Jackson, Platte, and Ray counties. The summaries include values for magnitude, impact, and probability of future occurrence. The metrics in the summary tables differ from the previous plan due to the omission of the statistical risk assessment. Now, the values are shown as unique, county percentages instead of 'high, medium, or low' rankings. Each hazard is profiled in detail starting in Section 4.6.

4.4 Hazard Analysis Summary and Calculations

Magnitude is the potential percentage range of the land area of the county that can be affected by a hazard. The ranking was given to the counties based on the characteristics of the hazard. Magnitude is ranked on a scale of four levels:

1. Less than 10 percent
2. 10 to 25 percent
3. 25 to 50 percent
4. More than 50 percent

Impact includes the damage totals (crop and property), injuries, and deaths of historical occurrences, where applicable.

Probability of Future Occurrence is the percent chance that the hazard will occur in a given year. Variables used to calculate the probability are listed in the summary charts. Many hazards have events occurring more than once a year. The total events are noted in the chart, however only the number of years with one or more events were used to find the probability. For example, 40 tornadoes have struck Cass County over the past 73 years. However, in the 73 years there were only 29 years experiencing one or more tornado events. Thus, Cass County has a 40 percent chance of having a tornado event in any given year (29 divided by 73 times 100). **Table 4.2** shows the layout of the hazard summary tables.

Table 4.2: Cass County Hazard Summary			
	Magnitude	**Impact**	**Probability of Future Occurrence**

Hazard (period with data on record)			Total Events	Years with 1+ Events	Years with data on record	Probability
Tornadoes (1950-2024)	>50%	Damages: $31.45M Deaths: 3 Injuries: 26	40	29	73	40%

The data contained in **Tables 4.3-4.7** is aggregated for Cass, Clay, Jackson, Platte and Ray counties because every jurisdiction and unincorporated part of each county did not fully participate in this plan. To compensate for data lost due to lack of response, the information below is summarized at the county level to provide a more concise regional assessment. All information was collected from the National Weather Service's NCDC online database. Each hazard is profiled in detail starting in Section 4.6.

Table 4.3: Cass County Hazard Summary

Hazard (period with data on record)	Magnitude	Impact	Probability of Future Occurrence			
			Total Events	Years with 1+ Events	Years with data on record	Probability
Tornadoes (1950-2024)	>50%[1]	Damages: $31.45M Deaths: 3 Injuries: 26	40	29	73	40%
Severe Thunderstorms (including lightning and hail events) (1955-2024)	10%-25%	Damages: $4.48M Deaths: 1 Injuries: 7	498	62	65	95%
Severe Winter Weather (1996-2024)	>50%	Damages: $7.3M[2] Deaths: 0 Injuries: 0	61	22	28	79%
Heat Wave* (1998-2024)	>50%	Deaths: 2 Injuries: 0	15	7	26	27%
Drought (2000-2024)	>50%	Total Reports: 118[3] Total Impacts: 36[3]	21	6	24	25%
Flooding (1996-2024)	25%-50%	Damages: $728K Deaths: 0 Injuries: 0	68	24	28	86%
Levee Failures	0	Not in the Hazard Area	Not in the Hazard Area	Not in the Hazard Area	Not in the Hazard Area	0%
Dam Failures (No known events on record)	<10%	Damage Likely	0	0	0	Unknown

[1] Although it is highly unlikely that a single tornado event will cause damage to more than 50 percent of the county, a magnitude of 4 is assigned here to account for the random nature of tornadoes, in that the entire region is vulnerable to a tornado strike.

[2] Damage estimates aggregated for all counties affected by winter storms.

[3] Report and Impact data covers 2009-2024 only

*Heat wave data is aggregated for multiple Missouri NWS Forecast Zones affected by heat wave events, which included Cass, Clay, Jackson, Platte and Cass counties. County-specific data is unavailable.

Table 4.4: Clay County Hazard Summary						
Hazard (period with data on record)	**Magnitude**	**Impact**	**Probability of Future Occurrence**			
			Total Events	**Years with 1+ Events**	**Years with data on record**	**Probability**
Tornadoes (1950-2024)	>50%[1]	Damages: $114.21M Deaths: 0 Injuries: 30	34	30	73	41%
Severe Thunderstorms (including lightning and hail events) (1955-2024)	10%-25%	Damages: $7.31M Deaths: 0 Injuries: 4	620	65	69	94%
Severe Winter Weather (1996-2024)	>50%	Damages: $272K[2] Deaths: 0 Injuries: 0	49	24	28	86%
Heat Wave* (1998-2024)	>50%	Deaths: 2 Injuries: 0	18	7	26	27%
Drought (2000-2024)	>50%	Total Reports: 108[3] Total Impacts: 32[3]	18	5	24	21%
Flooding (1996-2024)	25%-50%	Damages: $4.82M Deaths: 0 Injuries: 0	125	22	28	79%
Levee Failures	10%-15%	N/A	N/A	N/A	N/A	N/A
Dam Failures (No known events on record)	<10%	Damage Likely	0	0	0	Unknown

[1] Although it is highly unlikely that a single tornado event will cause damage to more than 50 percent of the county, a magnitude of 4 is assigned here to account for the random nature of tornadoes, in that the entire region is vulnerable to a tornado strike.
[2] Damage estimates aggregated for all counties affected by winter storms.
[3] Report and Impact data covers 2009-2024 only
*Heat wave data is aggregated for multiple Missouri NWS Forecast Zones affected by heat wave events, which included Cass, Clay, Jackson, Platte and Cass counties. County-specific data is unavailable.

Table 4.5: Jackson County Hazard Summary						
Hazard (period with data on record)	**Magnitude**	**Impact**	**Probability of Future Occurrence**			
			Total Events	**Years with 1+ Events**	**Years with data on record**	**Probability**
Tornadoes (1950-2024)	>50%[1]	Damages: $11.58M Deaths: 37 Injuries: 193	48	36	73	49%
Severe Thunderstorms (including lightning and hail events) (1955-2024)	10%-25%	Damages: $28.86M Deaths: 1 Injuries: 13	548	67	69	97%
Severe Winter Weather (1996-2024)	>50%	Damages: $17.02M[2] Deaths: 3 Injuries: 0	77	24	28	86%
Heat Wave* (1998-2024)	>50%	Deaths: 48 Injuries: 0	28	12	26	46%
Drought (2000-2024)	>50%	Total Reports: 113[3] Total Impacts: 70[3]	24	6	24	25%
Flooding (1996-2024)	25%-50%	Damages: $22.68M Deaths: 1 Injuries: 0	206	27	28	96%
Levee Failures	10%-15%	N/A	N/A	N/A	N/A	N/A
Dam Failures (No known events on record)	<10%	Damage Likely	0	0	0	Unknown

[1] Although it is highly unlikely that a single tornado event will cause damage to more than 50 percent of the county, a magnitude of 4 is assigned here to account for the random nature of tornadoes, in that the entire region is vulnerable to a tornado strike.

[2] Damage estimates aggregated for all counties affected by winter storms.

[3] Report and Impact data covers 2009-2024 only

*Heat wave data is aggregated for multiple Missouri NWS Forecast Zones affected by heat wave events, which included Cass, Clay, Jackson, Platte and Cass counties. County-specific data is unavailable.

Table 4.6: Platte County Hazard Summary						
Hazard (period with data on record)	**Magnitude**	**Impact**	**Probability of Future Occurrence**			
			Total Events	**Years with 1+ Events**	**Years with data on record**	**Probability**
Tornadoes (1950-2024)	>50%[1]	Damages: $35.61M Deaths: 0 Injuries: 17	19	16	73	22%
Severe Thunderstorms (including lightning and hail events) (1955-2024)	10%-25%	Damages: $2.05M Deaths: 0 Injuries: 1	425	58	69	84%
Severe Winter Weather (1996-2024)	>50%	Damages: $5.272M[2] Deaths: 0 Injuries: 0	64	26	28	93%
Heat Wave (1998-2024)	>50%	Deaths: 1 Injuries: 0	19	7	26	27%
Drought (2000-2024)	>50%	Total Reports: 143[3] Total Impacts: 40[3]	18	5	24	21%
Flooding (1996-2024)	25%-50%	Damages: $45.4M Deaths: 0 Injuries: 0	107	19	28	68%
Levee Failures	10%-15%	N/A	N/A	N/A	N/A	N/A
Dam Failures (No known events on record)	<10%	Damage Likely	0	0	0	Unknown

[1] Although it is highly unlikely that a single tornado event will cause damage to more than 50 percent of the county, a magnitude of 4 is assigned here to account for the random nature of tornadoes, in that the entire region is vulnerable to a tornado strike.

[2] Damage estimates aggregated for all counties affected by winter storms.

[3] Report and Impact data covers 2009-2024 only

*Heat wave data is aggregated for multiple Missouri NWS Forecast Zones affected by heat wave events, which included Cass, Clay, Jackson, Platte and Cass counties. County-specific data is unavailable.

Table 4.7: Ray County Hazard Summary						
Hazard (period with data on record)	**Magnitude**	**Impact**	**Probability of Future Occurrence**			
			Total Events	**Years with 1+ Events**	**Years with data on record**	**Probability**
Tornadoes (1950-2024)	>50%[1]	Damages: $6.45M Deaths: 2 Injuries: 21	33	28	73	38%
Severe Thunderstorms (including lightning and hail events) (1955-2024)	10%-25%	Damages: $1M Deaths: 0 Injuries: 0	172	49	69	71%
Severe Winter Weather (1996-2024)	>50%	Damages: $300K[2] Deaths: 0 Injuries: 0	47	20	28	71%
Heat Wave* (1998-2024)	>50%	Deaths: 0 Injuries: 0	12	6	26	23%
Drought (2000-2024)	>50%	**Total Reports: 100[3] Total Impacts: 27[3]	19	6	24	25%
Flooding (1996-2024)	25%-50%	Damages: $101K Deaths: 1 Injuries: 0	54	16	28	57%
Levee Failures	10%-15%	N/A	N/A	N/A	N/A	N/A
Dam Failures (No known events on record)	<10%	Damage Likely	0	0	0	Unknown

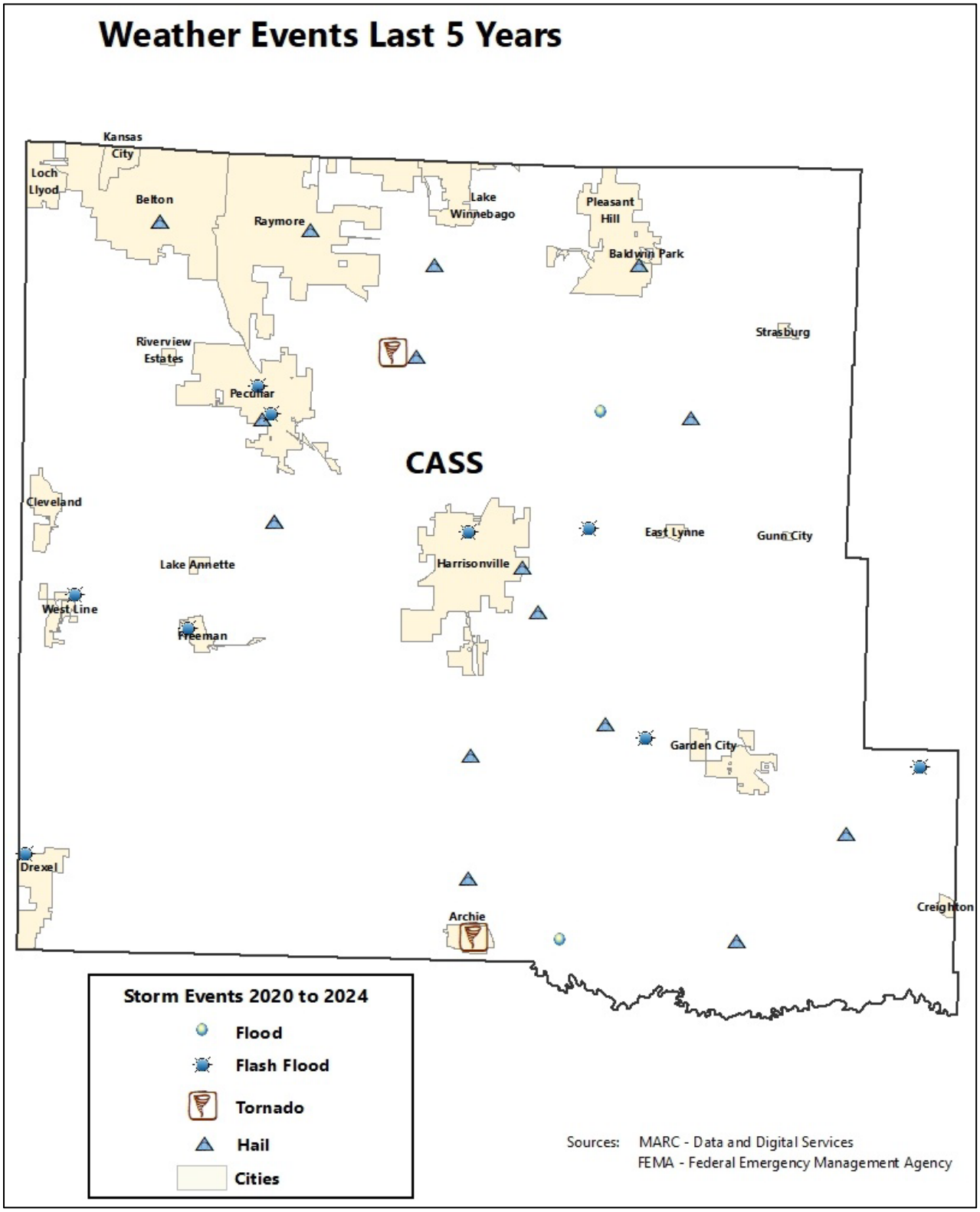
[1] Although it is highly unlikely that a single tornado event will cause damage to more than 50 percent of the county, a magnitude of 4 is assigned here to account for the random nature of tornadoes, in that the entire region is vulnerable to a tornado strike.

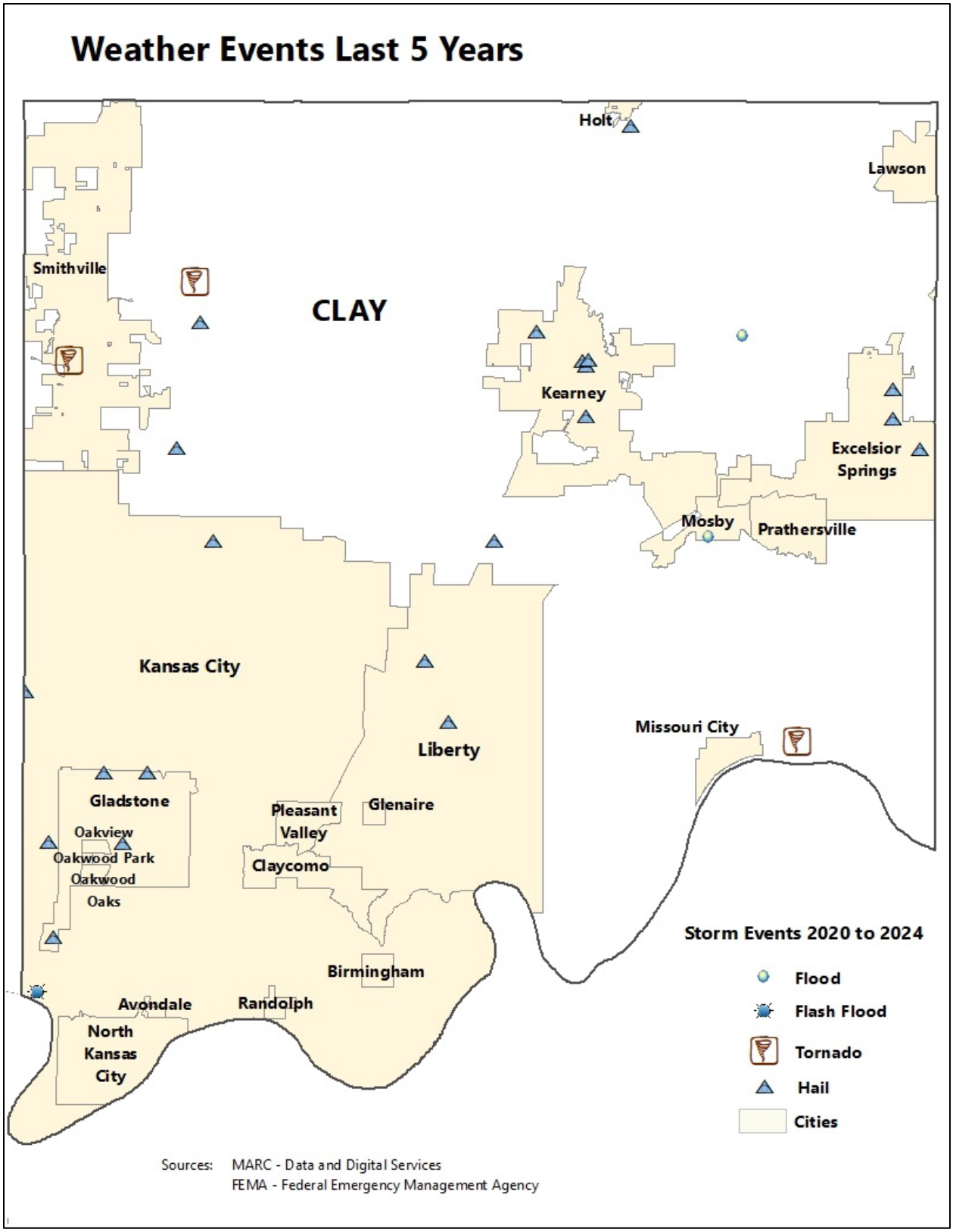
[2] Damage estimates aggregated for all counties affected by winter storms.

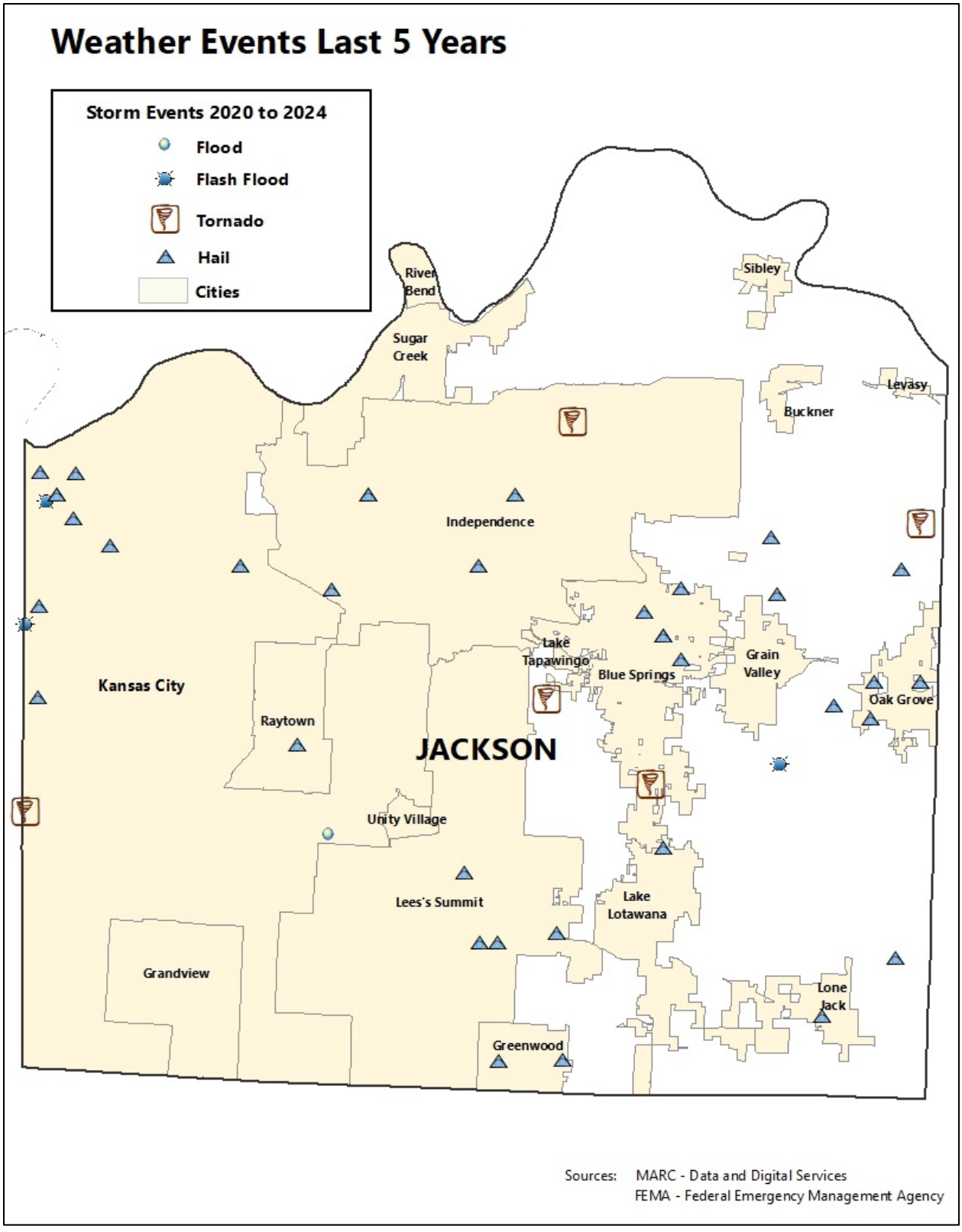
[3] Report and Impact data covers 2009-2024 only

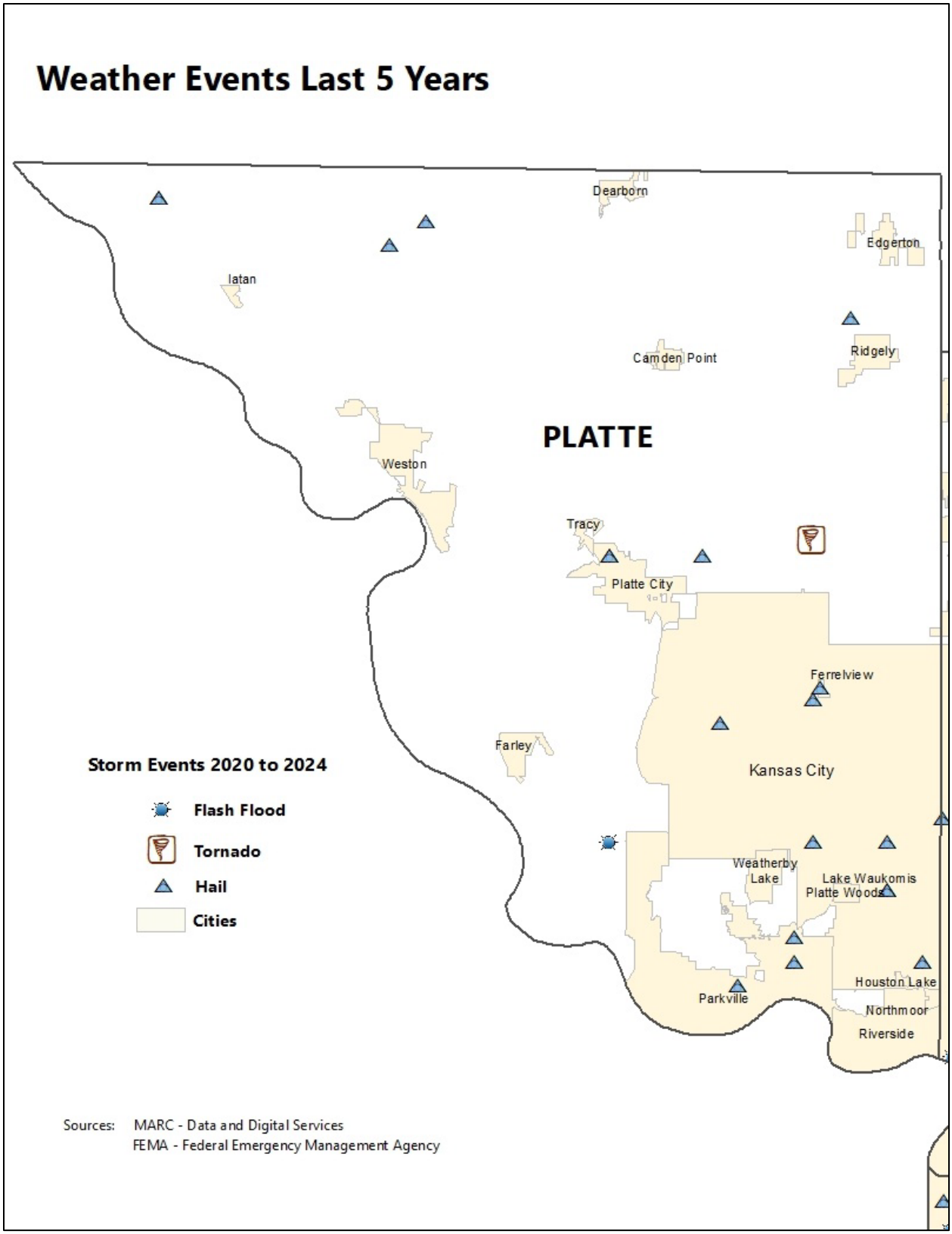
*Heat wave data is aggregated for multiple Missouri NWS Forecast Zones affected by heat wave events, which included Cass, Clay, Jackson, Platte and Cass counties. County-specific data is unavailable.

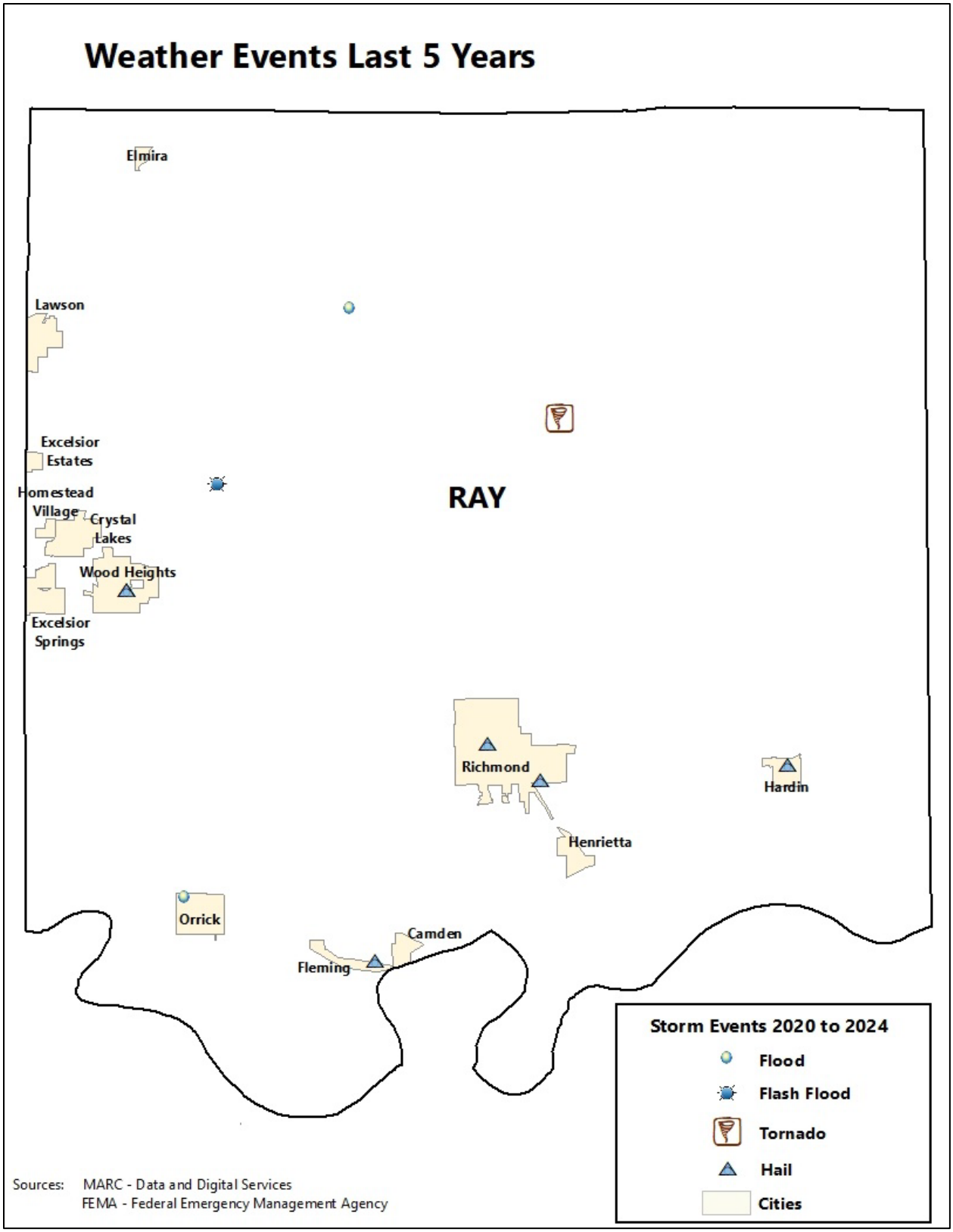
The following maps below illustrate the significant natural hazard events that have occurred over the past 5 years in each of the participating counties.




Weather Events Last 5 Years
Holt
Lawson
Smithville
CLAY
Kearney
Excelsior Springs
Mosby
Prathersville
Kansas City
Liberty
Missouri City
Gladstone
Oakview
Oakwood Park
Oakwood
Oaks
Pleasant Valley
Glenaire
Claycomo
Birmingham
Avondale
Randolph
North Kansas City
Storm Events 2020 to 2024
Flood
Flash Flood
Tornado
Hail
Cities
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency


Weather Events Last 5 Years
Storm Events 2020 to 2024
Flood
Flash Flood
Tornado
Hail
Cities
River Bend
Sugar Creek
Sibley
Levasy
Buckner
Independence
Lake Tapawingo
Blue Springs
Grain Valley
Oak Grove
Kansas City
Raytown
JACKSON
Unity Village
Lees's Summit
Lake Lotawana
Grandview
Lone Jack
Greenwood
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency


Weather Events Last 5 Years
Dearborn
Edgerton
Iatan
Camden Point
Ridgely
PLATTE
Weston
Tracy
Platte City
Ferrelview
Farley
Kansas City
Storm Events 2020 to 2024
Flash Flood
Tornado
Hail
Cities
Weatherby Lake
Lake Waukomis
Platte Woods
Houston Lake
Parkville
Northmoor
Riverside
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency


Weather Events Last 5 Years
Elmira
Lawson
Excelsior Estates
Homestead Village
Crystal Lakes
Wood Heights
Excelsior Springs
RAY
Richmond
Hardin
Henrietta
Orrick
Camden
Fleming
Storm Events 2020 to 2024
Flood
Flash Flood
Tornado
Hail
Cities
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency

Data limitations:
The NCDC database does not contain information on events prior to 1950, and for some hazards there is no information prior to 1996 or 1998; this relatively short data set lends itself to the possibility of skewed probability of occurrence outcomes. To compensate for this, only the years in which events occurred, and not the total number of events, were factored when determining probability—as demonstrated in the preceding Cass County tornado example. If the total number of events is divided by the years in question, then the possibility exists for achieving a greater than a 100 percent probability of an event occurring. For instance, taking Cass County again, but this time using floods, there have been 54 floods in Cass County since 1996 (the earliest data is available). If these numbers were used to determine probability, then 54 events divided by 28 years equals an over 200 percent probability of a flood event occurring. But, if only the years in which at least one flood occurred are used rather than the total number of floods, then the probability becomes more realistic. In this case, 21 of the 28 years on record had flood events, thus there is a 75 percent probability of at least one flood occurring a year.

Severe winter weather damage estimates are calculated for the total area affected by the storm, which generally includes a group of counties. Therefore, each county's exact loss estimate is unknown. It is likely that damage estimates from each winter storm overlap from county to county. To compensate for this, the total damage costs for all storms that included the selected county are described here to provide a comprehensive understanding of damages from winter storms.

The future probability of occurrence for drought is calculated using historic events but due to the complexity of determining drought conditions the percentage lacks credibility. An additional measure of drought future probability is discussed in ***Section 4.12***.

Where other data limitations exist, they are explained separately in each hazard.

4.5 Vulnerability Assessment

"Vulnerability" describes an asset's level of exposure or susceptibility to damage from natural hazards. The vulnerability of an asset—such as residential and commercial property, critical facilities or infrastructure—depends on a variety of factors, including its construction, contents and/or economic value of its functions. A vulnerability assessment provides policymakers, emergency managers and planners with information on the extent or severity of loss of life, injuries and/or property damage that may result from a hazard event of a given intensity in a given area. The vulnerability assessment attempts to combine information related to hazard identification with an inventory of commercial property, residential property, public facilities (including critical facilities) and infrastructure. Information detailed in **Section 2: Regional Profile** was used to approximate value of buildings and infrastructure and identify likely affected populations. Because hazards have different impact areas and characteristics, varying methodologies were used to estimate vulnerability and are described below.

Additionally, the last section of each hazard profile includes a series of *problem statements*, which are statements identified by each county to describe its greatest vulnerabilities to specific hazards and to be addressed in the mitigation strategy. When appropriate, specific jurisdictions are highlighted.

4.5.1 Vulnerability Assessment for "Non-Area Specific" Hazards

Tornadoes, severe thunderstorms, severe winter weather, drought, and heat waves are identified in this Plan and are best characterized as "non-area specific" hazards, meaning the hazard is not confined to a defined geographic area and has an equal chance of occurring (and impacting) any given portion of the planning area versus another. This presents serious challenges when attempting to describe a jurisdiction's vulnerability in realistic terms, as the totality of its assets could be considered vulnerable and offers little definitive guidance as to where jurisdictions should direct limited resources for mitigation efforts.

The vulnerability analysis for non-area specific hazards remain broad estimates when outlining areas and population that could be most affected in a hazard event. Each profile includes different information based on the specific hazard. The Vulnerability Analysis section will include one or more of the following topics:

- **Critical Facility** information in the form of maps or tables.
- **Vulnerable Population** information in the form of maps or graphs.
- **Vulnerable Asset** descriptions including population, structures, and other community assets determined to have value and susceptible to damage and loss from hazard events.

4.5.2 Vulnerability Assessment for "Area Specific" Hazards

The three remaining hazards – flooding, levee failure, and dam failure are considered "area specific" hazards, in that they have generally known geographic boundaries and can impact specific portions of the planning area. Because more is known about these hazards, detailed loss estimates can be conducted for each. For flooding, HAZUS-MH was used to calculate potential losses by jurisdiction (see flooding hazard profile for more information). For levee failures, building parcel data was overlaid on a GIS layer for areas protected by levees to estimate the potential loss of buildings within the protected area by impacted jurisdiction (see levee failure hazard profile). For dam failure, jurisdictions and buildings in wildland/urban interface areas susceptible to fire were identified and mapped. These vulnerability assessments estimate losses to people, buildings and infrastructure potentially at risk from hazards in each county.

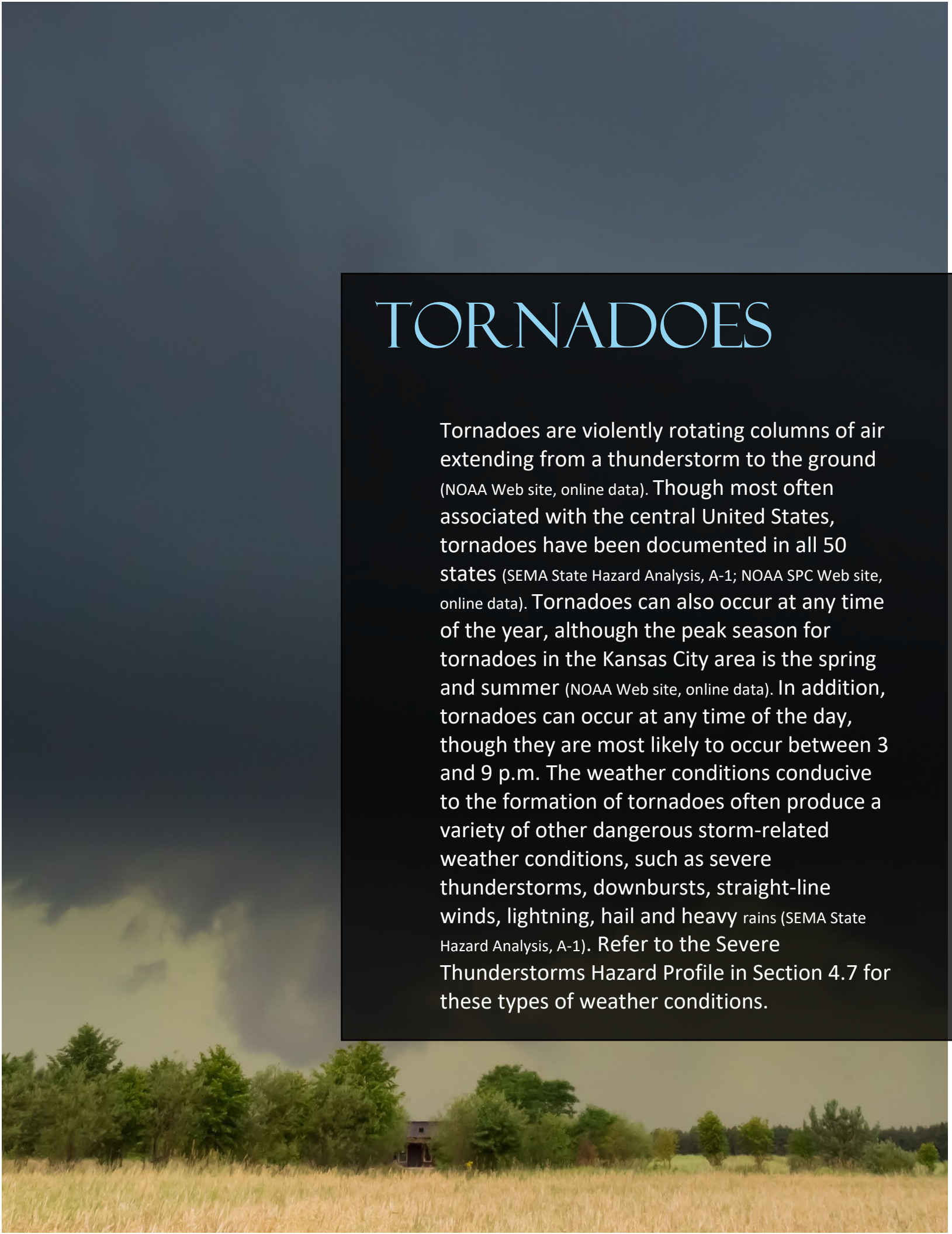
Building and income loss:

- **Potential Impacts** identified as consequences or effects on a community and its vulnerable assets
- **Loss Estimates** based on a jurisdiction's building stock or other hazard-specific disaster impacts

Attachments

Attachment 4-1: Summary Assessment of Risks (Cass, Clay, Jackson, Platte & Ray Counties and Kansas City)

[i] FEMA *Local Mitigation Planning Handbook,* May 2023



TORNADOES

Tornadoes are violently rotating columns of air extending from a thunderstorm to the ground (NOAA Web site, online data). Though most often associated with the central United States, tornadoes have been documented in all 50 states (SEMA State Hazard Analysis, A-1; NOAA SPC Web site, online data). Tornadoes can also occur at any time of the year, although the peak season for tornadoes in the Kansas City area is the spring and summer (NOAA Web site, online data). In addition, tornadoes can occur at any time of the day, though they are most likely to occur between 3 and 9 p.m. The weather conditions conducive to the formation of tornadoes often produce a variety of other dangerous storm-related weather conditions, such as severe thunderstorms, downbursts, straight-line winds, lightning, hail and heavy rains (SEMA State Hazard Analysis, A-1). Refer to the Severe Thunderstorms Hazard Profile in Section 4.7 for these types of weather conditions.

4.6 Tornadoes

Tornadoes are formed from the largest thunderstorms, and the most destructive tornadoes are formed by "supercells," which are, according to NOAA's Storm Prediction Center (SPC), "rotating thunderstorms with a well-defined radar circulation called a mesocyclone."[i] SEMA Hazard Analysis provides a vivid description of the formation of a tornado:

> [The] cumulonimbus clouds [in a thunderstorm] can reach heights of up to 55,000 feet above ground level, and are commonly formed when warm, 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. Adding to all this is the deflection of the earth's surface, and the air masses will 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.[ii]

The average period of a tornado's ground contact is 30 minutes, covering an average distance of 15 miles a review of Missouri tornadoes occurring between 1950 and 1996, the National Weather Service calculated a mean path length of 2.27 miles and a mean path area of 0.14 square miles.[iii]

The damage associated with tornadoes is primarily caused by wind speed; in general, the greater the wind speed, the greater the potential for damage. The violently rotating winds of a tornado can break branches and uproot trees, tear roofs off houses, lift vehicles off the ground, remove walls from houses and topple well-constructed homes and other structures. In addition, a large amount of debris can be generated by a tornado's destructive winds and objects can become "missiles," indirectly damaging structures and injuring or killing people through the force of their impact.

Tornadoes are classified according to the Enhanced Fujita Tornado Damage Scale, commonly referred to as the EF-Scale. The Enhanced Fujita scale, which became standard in 2007, replaced the replaced Fujita scale.[iv] The NWS is the only federal agency with authority to provide 'official' tornado EF Scale ratings. The National Weather Service explains, "the goal is to assign an EF Scale category based on the highest wind speed that occurred within the damage path. First, trained NWS personnel will identify the appropriate damage indicator (DI) [see list below] from more than one of the 28 used in rating the damage. The construction or description of a building should match the DI being considered, and the observed damage should match one of the 8 degrees of damage (DOD) used by the scale. The tornado evaluator will then make a judgment within the range of upper and lower bound wind speeds, as to whether the wind speed to cause the damage is higher or lower than the expected value for the

particular DOD. This is done for several structures not just one, before a final EF rating is determined."[v] **(See Table 4.6.1)**

Table 4.6.1 below compares the F-scale to the EF-scale:

Table 4.6.1 Enhanced Fujita Scale			
Derived EF Scale		**Operation EF Scale**	
EF Number	**Three-Second Gust (mph)**	**EF Number**	**Three-Second Gust (mph)**
0	65-85	0	65-85
1	86-109	1	86-110
2	110-137	2	111-135
3	138-167	3	136-165
4	168-199	4	166-200
5	200-234	5	Over 200

Source: NOAA Web site, online data

4.6.1

Historical Occurrences

According to the National Climatic Data Center (NCDC), the Kansas City area has been struck by 160 tornadoes of varying degrees of intensity since January 1, 1950.[vi] These tornadoes in Cass, Clay, Jackson, Platte and Ray counties have caused 42 deaths and 289 injuries. Most notably, the Ruskin Heights Tornado of May 20, 1957 was the deadliest and most destructive tornado to ever strike the Kansas City metro area. The track of this F5 tornado was 71 miles long and averaged 400 yards wide.[vii] This massive tornado was responsible for 44 deaths in the bistate Kansas City area, including 37 people killed in Jackson County alone and 531 injuries.[viii] Damages were estimated at $40 million. When adjusted for inflation (in 1997 dollars), the damage from this tornado was $228 million, making it the fourteenth most damaging tornado in United States history.[ix] The current costliest tornado on record, according to NOAA, is the EF5 tornado devastating Joplin, Missouri on May 22, 2011, with estimated $2.8 billion in damage (2011 dollars).[x]

Data Limitation: One limitation to this data is that many tornadoes that might have occurred in uninhabited areas, as well as some inhabited areas, have not been reported. NOAA Storm Data and the Storm Events Database report tornadoes in segments.[xi] Event data may show that a tornado contains multiple segments if it crosses a county or state line. Also, tornadoes that lift off the ground in less than five minutes or 2.5 miles are considered separate tornadoes. The NOAA data for tornadoes is adjusted for inflation and other economic effects.

Table 4.6.2 below lists the number of tornadoes by EF-Scale rating in Cass, Clay, Jackson, Platte and Ray counties. No additional deaths caused by tornadoes have occurred since the last plan update; however, 12 injuries occurred in Tarsney Lakes on March 6, 2017 due to an EF3 tornado.

Table 4.6.2: Kansas City Area Tornadoes by EF-Scale (1950-2018)						
EF-Scale	**Cass**	**Clay**	**Jackson**	**Platte**	**Ray**	**Total**
F0	20	9	17	4	9	**59**
F1	11	12	10	4	11	**48**
F2	2	6	7	2	8	**25**
F3	5	2	4	4	2	**17**
F4	0	3	1	4	2	**10**
F5	0	0	1	0	0	**1**
Total	**38**	**32**	**40**	**18**	**32**	**160**

Source: NOAA Web site, online data

Table 4.6.3 provides the locations, dates, magnitude, number of deaths, number of injuries, property damage and crop damage for tornadoes occurring in Cass, Clay, Jackson, Platte and Ray counties between January 1, 2015, and December 31, 2018. The data for these tables is from the storm event database on the NCDC Web site.[xii] A total of 18 tornado events since the last plan update occurred on eight specific dates in March, May, June, July, September, and October: May 16, 2015; July 1, 2015; September 18, 2015; March 6, 2017; June 26, 2018; July 6, 2017; May 2, 2018; and October 9, 2018.

Table 4.6.3: Kansas City Area Tornadoes (2015-2018)							
County	**Location**	**Date**	**Magnitude**	**Deaths**	**Injuries**	**Property Damage***	**Crop Damage***
CASS	GOWDY	7/1/2015	EF0	0	0	$0	$0
CASS	WEST LINE	9/18/2015	EF1	0	0	$0	$0
CASS	HARRISONVILLE ARPT	9/18/2015	EF0	0	0	$0	$0
CASS	BELTON	5/2/2018	EF0	0	0	$0	$0
CLAY	GLENAIRE	7/6/2015	EF0	0	0	$0	$0
CLAY	SMITHVILLE	3/6/2017	EF2	0	0	$0	$0
JACKSON	BUCKNER	5/16/2015	EF1	0	0	$0	$0
JACKSON	UNITY VLG	7/1/2015	EF1	0	0	$0	$0
JACKSON	LAKE LOTAWANA	7/1/2015	EF0	0	0	$0	$0
JACKSON	VALE	3/6/2017	EF0	0	0	$0	$0
JACKSON	TARSNEY LAKES	3/6/2017	EF3	0	12	$0	$0
JACKSON	DODSON	5/2/2018	EF0	0	0	$0	$0
JACKSON	RAYTOWN	5/2/2018	EF0	0	0	$0	$0
JACKSON	LAKE LOTAWANA	6/26/2018	EF0	0	0	$150,000	$0
RAY	LAWSON	5/16/2015	EF0	0	0	$0	$0
RAY	ORRICK	5/16/2015	EF2	0	0	$0	$0
RAY	TAITSVILLE	5/16/2015	EF1	0	0	$0	$0
RAY	KNOXVILLE	10/9/2018	EF0	0	0	$0	$0

Source: NOAA NCDC Web site

*the dollar values assigned in storm data are a basic estimate

Table 4.6.4 provides the locations, dates, magnitude, number of deaths, number of injuries, property damage and crop damage for tornadoes occurring in Cass, Clay, Jackson, Platte and Ray counties between May 2019 and November 2024. The data for this table is from the storm event database on the NCDC Web site.

Table 4.6.4: Kansas City Area Tornadoes (2019- November 2024)

County	Location	Date	Magnitude	Deaths	Injuries	Property Damage*	Crop Damage*
Cass	ARCHIE	06/04/2020	EF0	0	0	$0	$0
Cass	PECULIAR ARPT	03/15/2021	EF0	0	0	$0	$0
Clay	MOSBY	05/28/2019	EF2	0	0	$0	$0
Clay	SMITHVILLE	07/29/2020	EF0	0	0	$0	$0
Clay	MISSOURI CITY	06/11/2021	EF0	0	0	$0	$0
Clay	PARADISE	04/16/2024	EF1	0	0	$0	$0
Jackson	VALE	05/24/2019	EF0	0	0	$0	$0
Jackson	COCKRELL	05/24/2019	EF0	0	0	$0	$0
Jackson	COCKRELL	09/22/2019	EF0	0	0	$0	$0
Jackson	LAKE TAPAWINGO	06/04/2020	EF0	0	0	$0	$0
Jackson	RED BRIDGE	06/08/2022	EF1	0	0	$0	$0
Jackson	RIPLEY	06/08/2022	EF2	0	0	$0	$0
Jackson	BLUE SPGS	05/06/2024	EF1	0	0	$0	$0
Jackson	LEVASY	05/06/2024	EF0	0	0	$0	$0
Platte	HOOVER	05/06/2024	EF0	0	0	$0	$0
Ray	MILLVILLE	08/04/2023	EF0	0	0	$0	$0

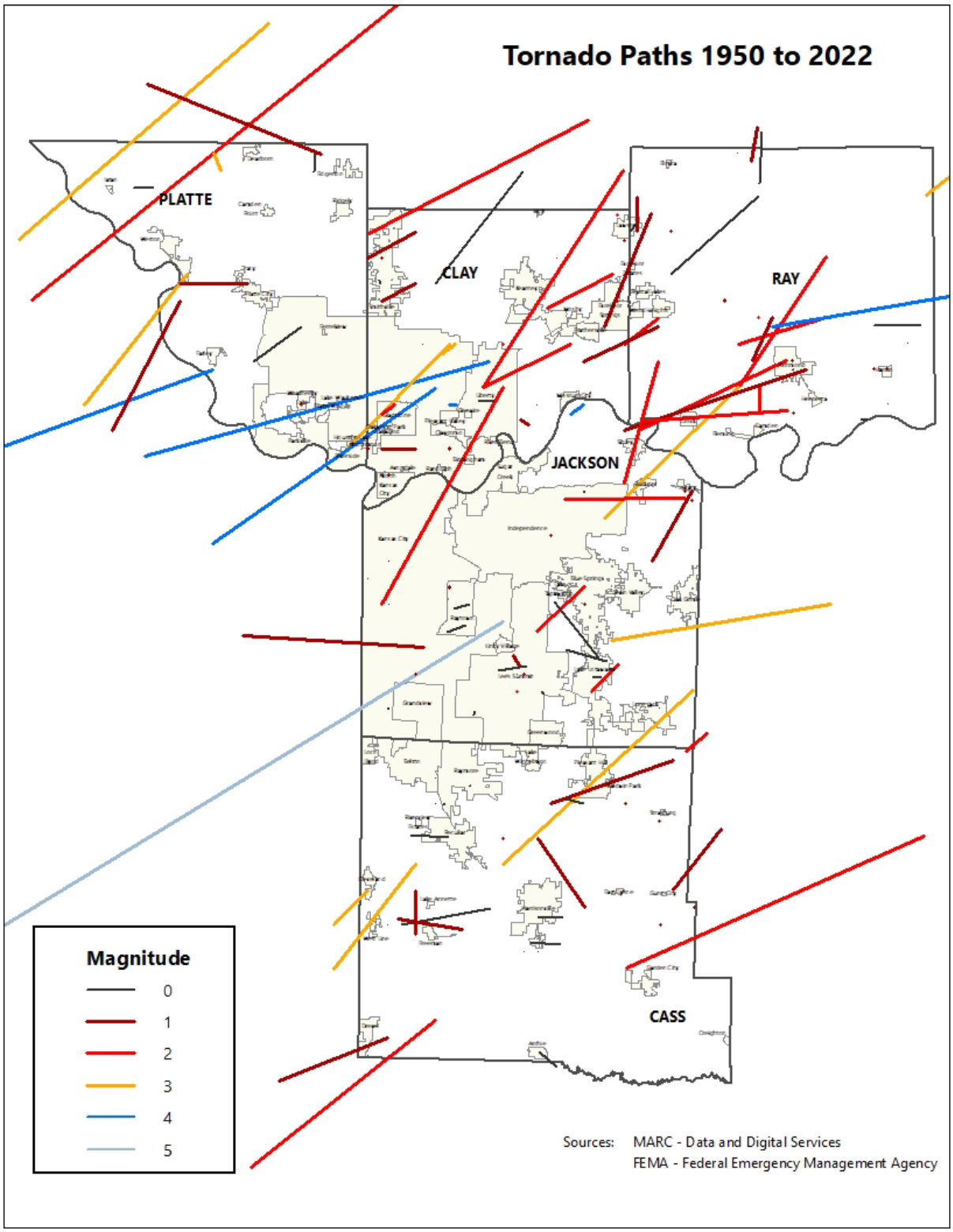
Source: NOAA NCDC Web site

*the dollar values assigned in storm data are a basic estimate

Map 4.6.1 illustrates the history of tornadoes hitting in and around the Kansas City region since 1996. The figure presents paths of destruction.

Historical narratives of the region's prior deadly tornadoes prior to 2010 are available in the 2010 Plan update. Narratives were removed from the 2015 Plan update as well as the 2020 Plan update to streamline information. The 2020 Plan update and 2025 Plan update focus on events occurring in the

last five years or those in the recent past that give context to the region's vulnerability and demonstrate potential impact to the region.

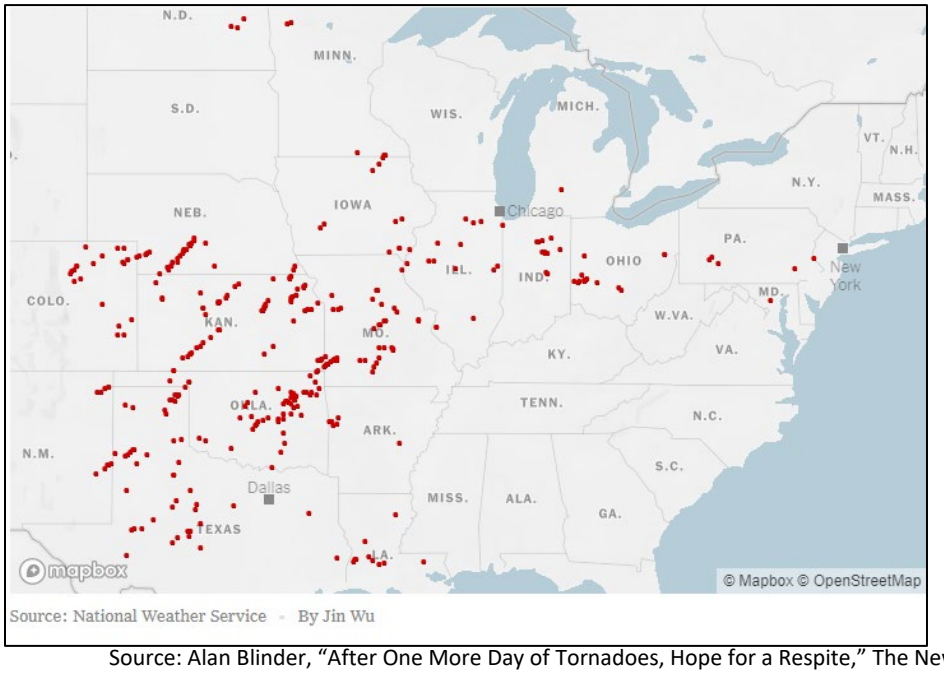


Map 4.6.1 Kansas City Metropolitan Area Tornadoes 1996-2019)

4.6.1a Tornado Outbreak of May 2019

A major tornado outbreak occurred across the central region of the United States during the month of May 2019. Damage was reported in multiple Midwest states as well as states outside the Midwest. As of June 2019, tornado events from 2019 are not logged in the NOAA Storm Events Database. Information from a New York Times article called, "After One More Day of Tornadoes, Hope for a Respite," cited The National Weather Service saying:

> "Powered by a high-pressure system in the South and a trough that hung atop the West, the burst of storms pushed the United States to a total of 38 tornado-linked deaths so far this year, the highest count since 2014. Wednesday was the 13th consecutive day when the National Oceanic and Atmospheric Administration received at least eight preliminary reports of tornadoes.
>
> And of the roughly 300 tornado or severe thunderstorm watches that forecasters have issued this year [2019], more than 40 percent have come since May 17, when this pernicious round of bad weather began."



Source: Alan Blinder, "After One More Day of Tornadoes, Hope for a Respite," The New York Times[xiii]

Map 4.6.2: Locations of Tornadoes Reported from May 17-29, 2019

While damage to the planning area was not as severe as the last tornado outbreak of May 4, 2003, Cass, Clay, Jackson, Platte, and Ray counties were in or close to many catastrophic tornado events. This was the second major tornado outbreak in the Kansas City area in the past 10 years. The only other recorded outbreak happened in 1977.

Jackson County, MO – June 8, 2022

Strong to Severe thunderstorms across Kansas and Missouri the evening of June 7th, 2022, continued to evolve into a complex of strong to severe thunderstorms as they moved into the Kansas City Metro area between 12:30 and 1 AM CDT. These storms resulted in numerous reports of wind damage across the region as well as four confirmed tornadoes, one through the southern side of the Kansas City Metro, one

in northeastern Jackson County Missouri and two near Louisburg, KS. The tornado developed within a larger bowing line segment of thunderstorms moving across the region. In addition to the tornado, a large swath of wind damage was noted south of the tornado track. In this area, downed tree limbs and other indicators were noted to be blown in the same west to east direction.

Clay County, MO – May 28, 2019 [xiv]
Kearney, Missouri experienced an EF- 2 tornado that had a maximum width of 400 yards and traveled a length of 5.84 miles. The estimated peak winds were 115 miles per hour. The tornado began about 2 or 3 miles south and southeast of Kearney, MO, traveling east and northeast, ending about 2 miles north of Excelsior Springs, Damage to several homes and trees occurred.

Douglas and Leavenworth County, KS – May 28, 2019[xv]
Douglas and Leavenworth County are not in the Hazard Planning area; however, Leavenworth County is included in the Mid-America Regional Council's planning profile. These counties are part of the Kansas City area or very close. The tornado these counties experienced had a maximum width of one mile and traveled 31.82 miles. This tornado is the same one that reached Kearney, MO in the prior narrative. The tornado was rated EF-4. It developed in southwestern Douglas County Kansas and tracked to the east-northeast while strengthening. EF-3 damage occurred in northeastern Douglas County, then the storm gained strength and produced EF-4 damage in southern Leavenworth County Kansas.

4.6.2 Probable Locations

Magnitude: >50%

Tornadoes can occur anywhere in the Kansas City area. A common myth about tornadoes is that they do not cross over rivers or hit big cities.[xvi] The Orrick tornado of May 10, 2014, started in Jackson County south of Sibley and crossed the Missouri River into Ray County. The Orrick tornado of January 24, 1967 took a similar path. Additionally, one of the tornadoes spawned during the May 4, 2003, tornado outbreak in the northern Kansas City area swept across the Missouri River from Leavenworth County, Kansas, into Platte County, Missouri. The Ruskin Heights area of south Kansas City, a densely populated area, was struck by an F5 tornado on May 20, 1957, resulting in 37 deaths, hundreds of injuries and catastrophic damage to the area. More recently, the Joplin EF5 tornado of May 22, 2011, devastated a large portion of the city, resulting in 161 fatalities, over 1,000 injured and damage to 7,500 residential dwellings. Over 500 businesses were affected, affecting 4,500 to 5,000 employees.

The threat of tornadoes is not limited to any specific part of the Kansas City area; both rural and urban areas can be affected. Although greater in the spring and early summer, the possibility exists for destructive tornadoes to occur at any time of the year. Likewise, tornadoes may occur at any time of the day or night. Finally, tornadoes of all magnitudes can and have occurred in the Kansas City area, from F0 tornadoes that causing little or no damage to F5 tornadoes causing enormous death and destruction.

Each county was given a >50% magnitude rating. Although it is highly unlikely that a single tornado event will cause damage to more than 50 percent of the county, the highest magnitude rating was assigned to account for the random nature of tornadoes, in that the entire region is vulnerable to a tornado strike.

4.6.3 Impact

Tornadoes can cause tremendous damage in the places it touches down, as well as the surrounding areas. **Table 4.6.4 – Table 4.6.8**[xvii] summarizes all tornado events by EF Scale and their impact for each of the five counties. Information was retrieved from the NOAA NCDC Storm Event Database as of December 13, 2024. The property and crop damage values are the sum of reported values only. The NCDC labels these values as a 'basic estimate'. Damage values are most likely higher than the values due to unreported impacts. This information is used to determine severity, magnitude and probability of occurrence.

Table 4.6.4: Cass County Tornadoes (1950-2024)

Magnitude	Years with +1 Events	No.	Deaths	Injuries	Property Damage	Crop Damage
F0	16	22	0	0	$11,340	$0
F1	7	11	0	1	$1,135,250	$0
F2	2	2	0	0	$275,000	$0
F3	4	5	3	25	$30,025,250	$0
F4	0	0	0	0	$0	$0
F5	0	0	0	0	$0	$0
Overall	**29**	**40**	**3**	**26**	**$31,446,840**	**$0**

Table 4.6.5: Clay County Tornadoes (1950-2024)

Magnitude	Years with +1 Events	No.	Deaths	Injuries	Property Damage	Crop Damage
F0	8	9	0	0	$7,780	$0
F1	11	13	0	0	$6,325,780	$0
F2	7	7	0	9	$70,300,000	$0
F3	2	2	0	3	$4,025,000	$0
F4	2	3	0	18	$33,550,000	$0
F5	0	0	0	0	$0	$0
Overall	**30**	**34**	**0**	**30**	**$114,208,560**	**$0**

Table 4.6.6: Jackson County Tornadoes (1950-2024)						
Magnitude	**Years with +1 Events**	**No.**	**Deaths**	**Injuries**	**Property Damage**	**Crop Damage**
F0	15	22	0	0	$192,280	$0
F1	10	12	0	0	$580,000	$0
F2	6	8	0	5	$800,250	$0
F3	3	4	0	12	$7,500,000	$0
F4	1	1	0	0	$2,500	$0
F5	1	1	37	176	$2,500,000	$0
Overall	**36**	**48**	**37**	**193**	**$11,575,030**	**$0**

Table 4.6.7: Platte County Tornadoes (1950-2024)						
Magnitude	**Years with +1 Events**	**No.**	**Deaths**	**Injuries**	**Property Damage**	**Crop Damage**
F0	4	5	0	0	$60	$0
F1	4	4	0	2	$2,250,000	$0
F2	2	2	0	4	$275,000	$0
F3	4	4	0	11	$330,000	$0
F4	2	4	0	0	$32,750,000	$0
F5	0	0	0	0	$0	$0
Overall	**16**	**19**	**0**	**17**	**$35,605,060**	**$0**

Table 4.6.8: Ray County Tornadoes (1950-2024)						
Magnitude	**Years with +1 Events**	**No.**	**Deaths**	**Injuries**	**Property Damage**	**Crop Damage**
F0	9	10	0	0	$295,000	$0
F1	11	11	0	0	$507,750	$0
F2	6	8	0	2	$375,000	$0
F3	1	2	2	18	$2,750,000	$0
F4	1	2	0	1	$2,525,000	$0
F5	0	0	0	0	$0	$0
Overall	**28**	**33**	**2**	**21**	**$6,452,750**	**$0**

4.6.4 Probability of Future Occurrence: 61%

Based on historical occurrences from 1950, there is a 61 percent chance of a tornado occurring in a given year in the five-county planning area. Table 4.6.9 shows the probability of a tornado in a given year specific to each county. The probability was calculated by dividing the number of years with one or more tornado events in that county, by the total number of years the data was available. The data from the NOAA Storm Events database begins in 1951 and is current through 2024, a total of 73 years.

Table 4.6.9: Probability of Future Tornado Occurrence by County		
County	**Years with 1+ Events**	**Probability (%)**
Cass	29	40%
Clay	30	41%
Jackson	36	49%
Platte	16	22%
Ray	28	38%

The central United States has a repeatable annual tornado cycle, with the highest probability of tornadoes occurring in the spring.[xviii] With its location in the central plains, the Kansas City area experiences a tornado season each year. Figure 4.6.1 depicts the annual cycle of probability of tornadoes in the Kansas City area (NOAA NSSL, online data). The lines on the graph correspond to the states of Kansas and Missouri, indicated in the legend. As the graph shows, the period with the greatest probability of tornado activity is approximately late March through July. Although an update to this chart is not available past 2010, all of the tornadoes occurring in the last five years in the five county area happened in May and June.

Source: U.S. NOAA Tornado Climatology Website, monthly Tornado Occurrence Maps

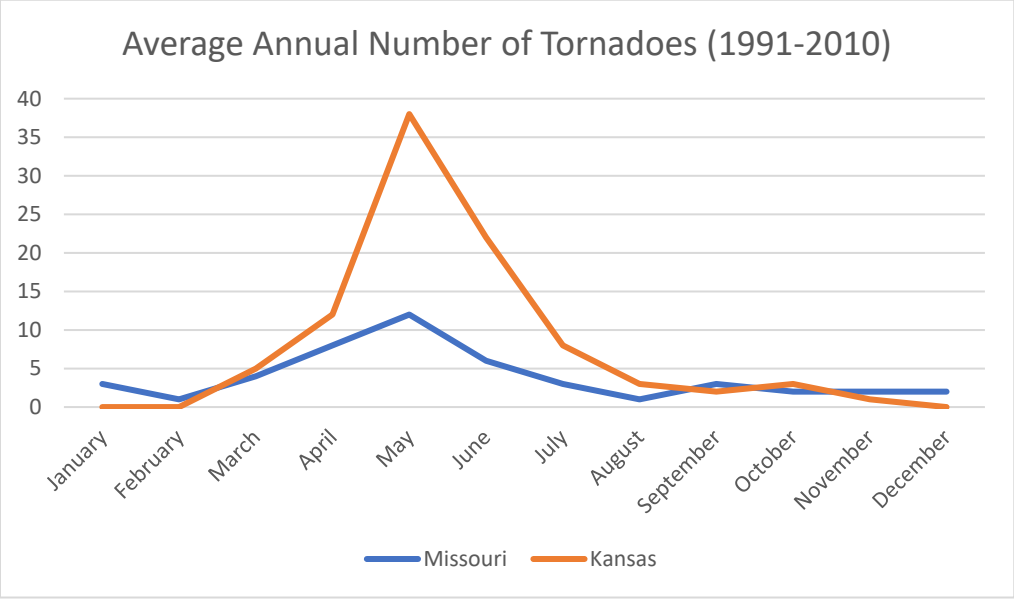


Figure 4.6.1: Tornado Annual Cycle in Missouri and Kansas (1991-2010)

Although, the likelihood of tornadoes is greatest during the spring and early summer — the "tornado season" — tornadoes can occur anywhere in the region, at any time of the year and at any hour of the day or night. For example, the deadly Blue Valley (Jackson County) tornado of 1941 occurred on Oct. 6, while an F3 tornado struck Orrick (Ray County) on Jan. 24, 1967. The entire region is at risk from tornadoes year-round.

4.6.5 Extent

Historical statistics associated with the occurrence of tornadoes in the region, presented in Table 4.6.10. indicates the likelihood, or risk, by magnitude (EF-Scale) of a tornado occurring anywhere in the Kansas City region. The probable risk percentages are the likelihood of a tornado with a given EF occurring in a given year. For example, based on the 69-year history of tornadoes, there is a 60 percent chance of an EF0 tornado occurring in the Kansas City area.

Table 4.6.10: Risk of Future Tornado Occurrence

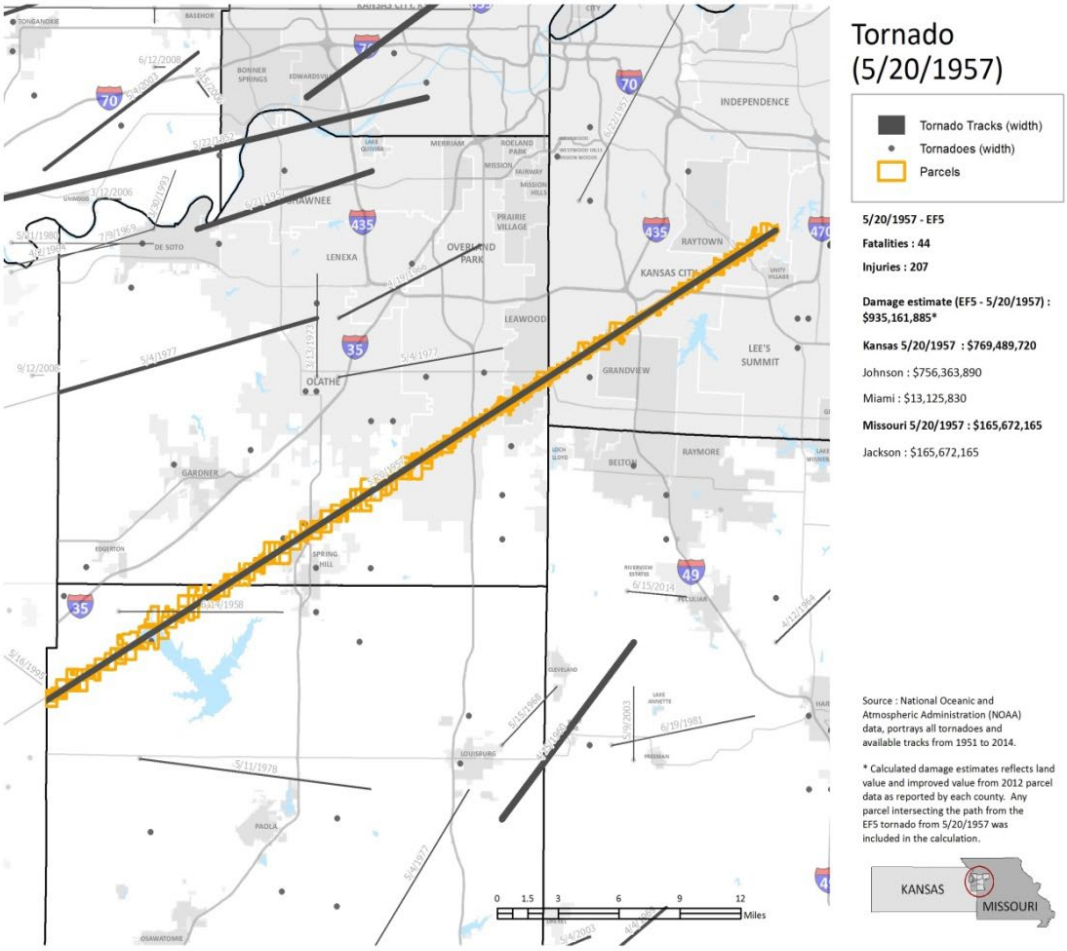
EF-Scale	Speed (mph)	Probable Risk (Highly Likely, Likely, Possible or Unlikely)
0	65-85	60% — Highly Likely
1	86-109	64% — Highly Likely
2	110-137	43% — Likely
3	138-167	24% — Possible
4	168-199	7% — Unlikely
5	200-234	2% — Unlikely

Using the same probability calculation, Table 4.6.11, indicates the risk of a specific EF-Scale tornado occurring anywhere in the Kansas City region. For example, over the last 73 years, 2% of tornadoes were rated EF5. Although this percentage is low, an EF5 tornado poses catastrophic risk to people and property.

Table 4.6.11: Probable Future Tornado Severity by EF-Scale

EF-Scale	Speed (mph)	Probable Risk (Limited, Critical, or Catastrophic)
0	65-85	60% — Limited
1	86-109	64% — Limited
2	110-137	43% — Critical
3	138-167	24% — Critical
4	168-199	7% — Catastrophic
5	200-234	2% — Catastrophic

Map 4.6.4 demonstrates the path of destruction and potential losses of an EF5 tornado based on the Ruskin Heights Tornado of May 20, 1957, if a similar event occurred in Jackson County today.



Map 4.6.3 Potential Impact of EF-5 Tornado on the Kansas City Region

Because of larger populations and greater concentration of homes, commercial structures, public facilities, utilities and infrastructure, the urban and suburban areas of Cass, Clay, Jackson, Platte and Ray counties are more susceptible to the damaging effects of tornadoes than the rural portions of these jurisdictions. Nevertheless, rural portions of the Kansas City metropolitan area can still suffer the effects of tornadoes. People may be injured or killed, just as in urban areas, though in lesser numbers due to lower population density. Outdoor warning systems may not be present in rural areas, increasing the need for other methods of warning, such as NOAA weather radios and television and radio broadcasts. Alternatively, urban areas may have more redundancy in warning systems. In addition, livestock may be killed, and crops damaged in rural areas. The costs associated with losses in rural areas may be significant. However, they will generally be lower than damage costs in urban areas.

Based on a 69-year history of tornado events in Cass, Clay, Jackson, Platte and Ray counties, Table 4.6.12 presents the likely adverse impact of future Kansas City region tornado events.

Table 4.6.12: Estimated Categories of Impact				
Effects of Tornadoes	**Life**	**Property**	**Emotional**	**Financial**
Without mitigation measures	Limited	Critical	Critical	Critical
With mitigation measures	Negligible	Limited	Limited	Limited

The potential severity of effects from tornadoes will continue to be high.[xix] Although the region will continue to experience deaths, injuries and property damages from tornadoes, mitigation measures can dramatically reduce adverse impacts of a tornado by helping to save lives, prevent injuries and lessen property damage.[xx] These measures include public education and awareness programs, public use of enhanced warning and communications systems (e.g., NOAA weather radios, mass notification systems and alerts), and the construction and use of "safe rooms" or "safe areas" in public and private structures.

4.6.5a Probable Duration

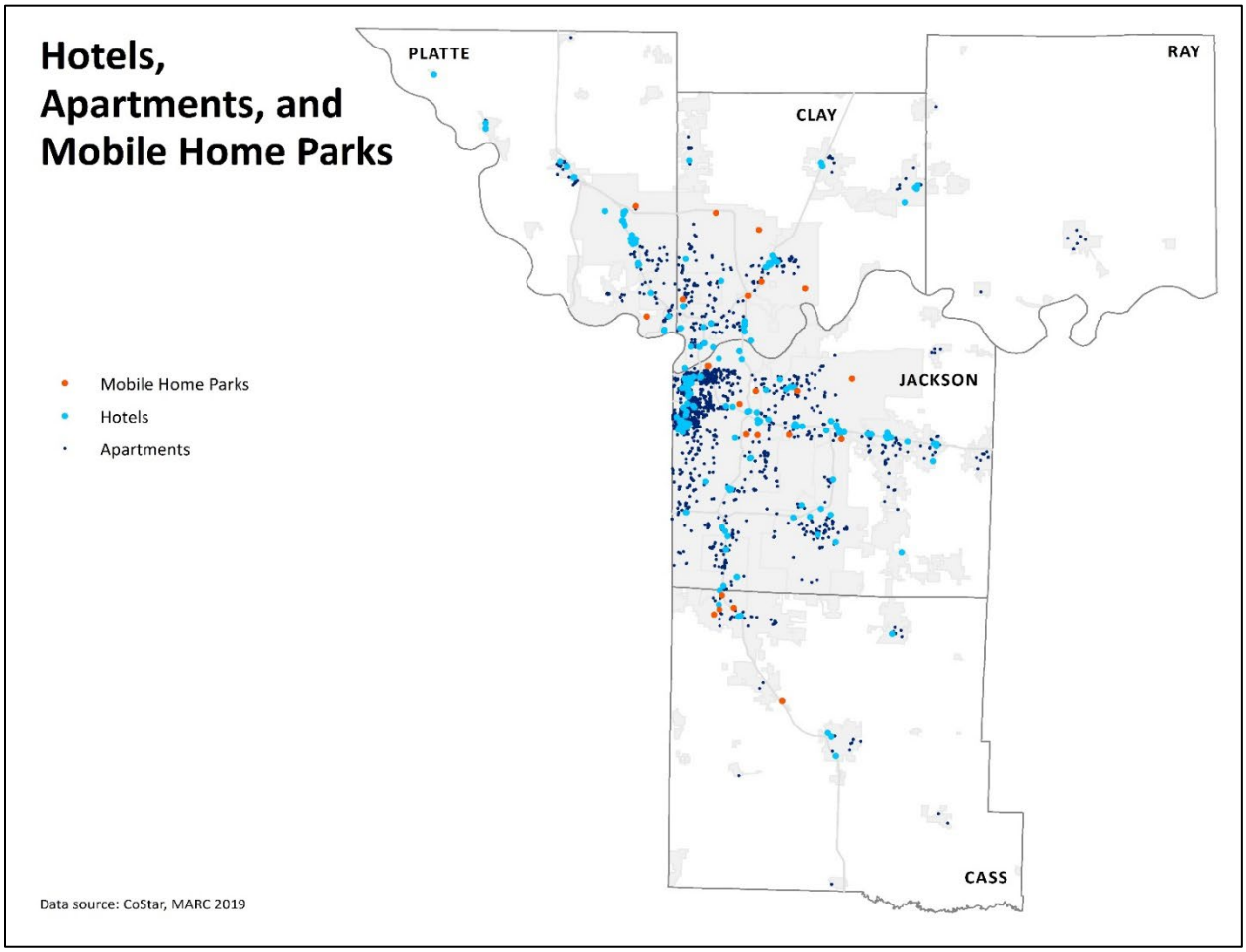
Tornadoes affecting the greater Kansas City metropolitan area have ranged from F0 to F5. The vast majority of tornadoes have been F0 to F1, although several F4 tornadoes and an F5 tornado have affected the Kansas City metropolitan area. Tornadoes of this magnitude are normally only on the ground for a few minutes.

Potential speed of onset (probable amount of warning time):

- ■ Minimal (or no) warning
- ☐ 6 to 12 hours warning
- ☐ 12 to 24 hours warning
- ☐ More than 24 hours warning

4.6.6 Vulnerability Analysis

While tornados can occur anywhere in the planning area, those most exposed when a tornado does occur are individuals who may not have access to some sort of safe shelter which may include individuals living in mobile homes or apartments or people living in homes without basements or those who may have difficulty getting to a safe location. Studies have indicated 45 percent of all fatalities during tornadoes occur in mobile homes, compared to 26 percent in traditional site-built houses.[xxi] Additionally, individuals who do not know where to go in the event of a tornado are also at greater risk in an event. Public venues and large outdoor gatherings are of special concern. **Map 4.6.4** and **Table 4.6.13** illustrate the number and type of particularly vulnerable sites in the planning area.

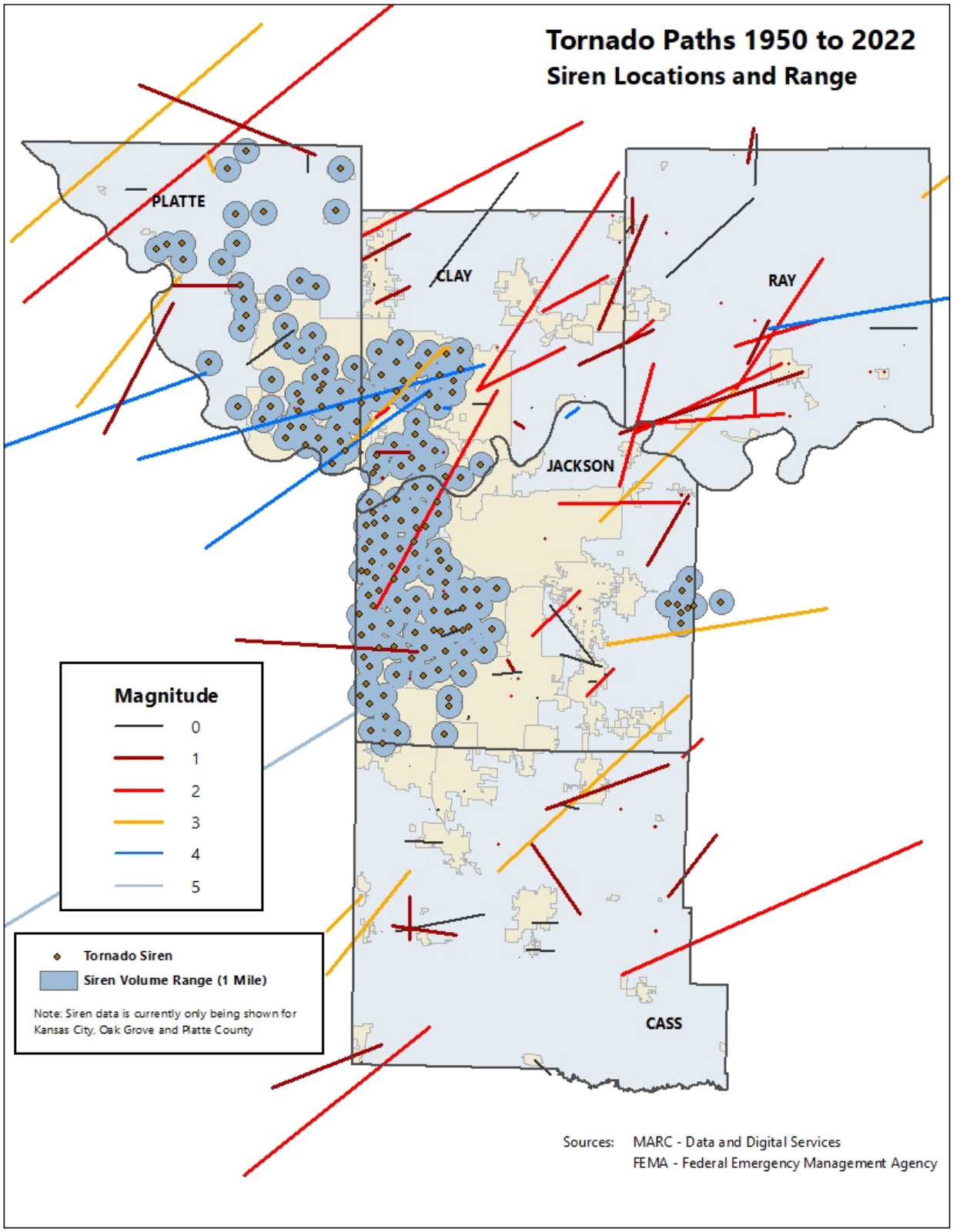


Map 4.6.4 High Risk Assets to Tornado in the Planning Area

Table 4.6.13 High Risk Locations during Tornadic Activity							
Asset (critical facility)	**Cass**	**Clay**	**Jackson**	**Platte**	**Ray**	**Planning Area**	**Kansas City**
Day Care	41	91	350	29	8	511	238
Nursing Home	10	21	85	12	2	128	52
Public Housing	36	53	365	14	13	481	326
School	39	80	260	36	11	415	191
College	1	5	40	3	0	49	32
Hospital	2	4	13	1	1	21	8
Health Facilities	5	4	41	5	1	56	36
Police	15	16	25	17	9	82	15
Fire	17	27	67	17	6	128	38
PSAP	5	6	13	2	1	27	4
Local (city, county, other) Government	13	15	13	12	4	53	1
Hotels	8	40	133	39	0	220	136
Apartments	83	248	1950	110	11	2391	1678

Trailer Parks	5	6	10	2	0	23	8
Professional Sports Stadiums	0	0	3	0	0	3	3
Arena or Convention Center	0	0	3	0	0	3	2

Tornado sirens typically have an audible range of one to two miles, but coverage can vary depending on factors like sound level and storm conditions. While sirens are the only universal warning protocol for severe weather in areas with adequate coverage, ubiquitous coverage is rare and should not be relied on from the public as the sole warning source for severe weather. As technological improvements occur, some areas have replaced sirens with more specific warnings, like the Emergency Alert System and Wireless Emergency Alerts. It should also be noted that sirens are an outdoor warning system designed only to alert those who are outside that something dangerous is approaching. The map below illustrates siren coverage in relation to historical tornado incidents.



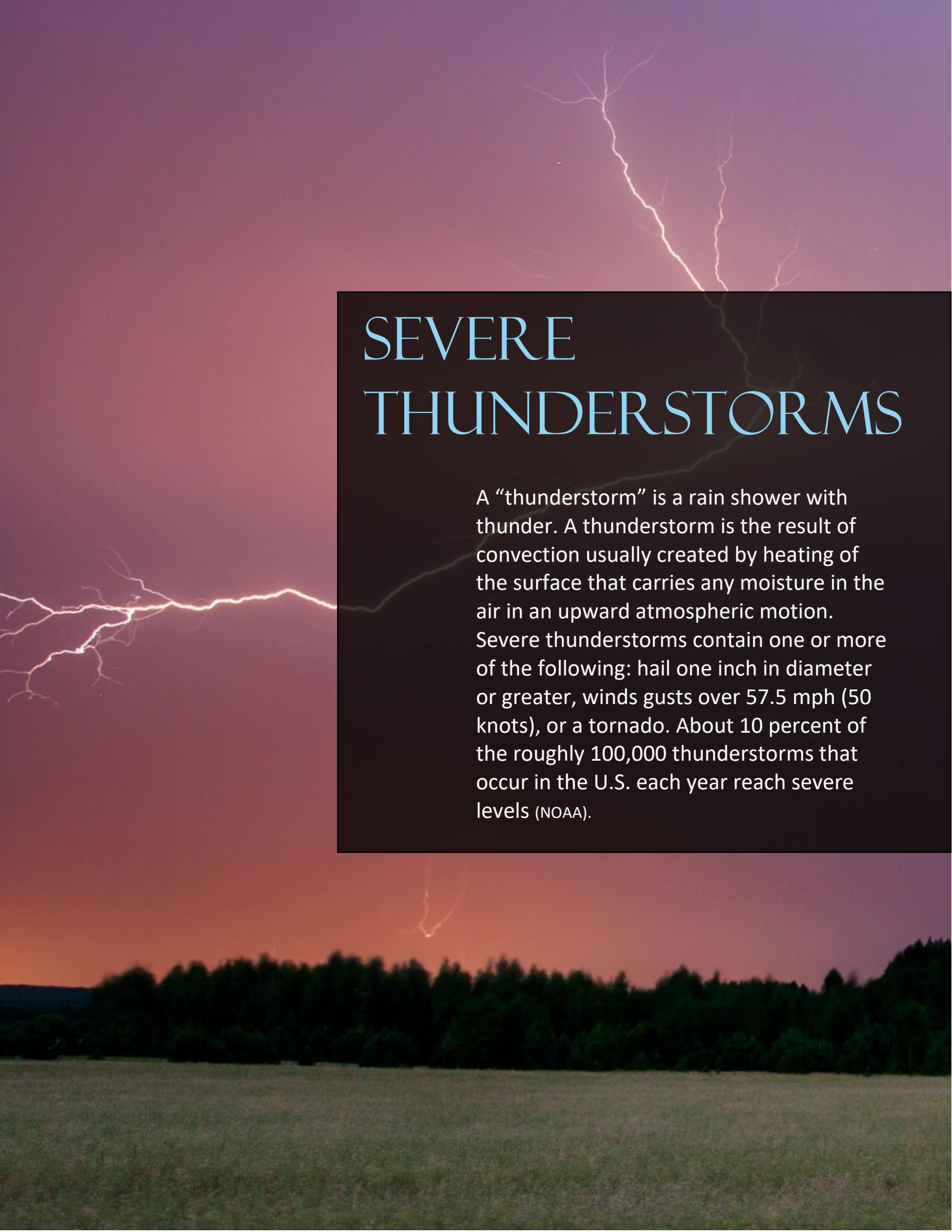
Map 4.6.5 Siren Coverage in Relation to Historical Tornadoes in the Planning Area

4.6.7 Problem Statements

Tornadoes are random events and can equally impact any jurisdiction within the region. While the maximum and minimum loss estimates were removed from this Plan, jurisdictions have provided problem statements outlining their concerns related to tornadoes. Problem statements, such as those below, can help highlight struggling areas to help support development of mitigation strategies for tornadoes:

- New tornado warning technologies have created the potential for uncoordinated warnings (or conversely, oversaturation) leading to residents not taking appropriate protective actions.
- High population centers (apartment buildings, trailer parks, shopping centers, hotels, etc.) often lack storm shelters.
- Current public information efforts have likely plateaued in their effectiveness.

[i] SEMA State Hazard Analysis, A-1; NOAA SPC Web site, online data
[ii] SEMA State Hazard Analysis, A-1
[iii] SEMA State Hazard Analysis, A-1
[iv] NOAA Web site, online data
[v] NOAA, NWS, The Enhanced Fujita Scale (EF Scale), https://www.weather.gov/oun/efscale
[vi] NOAA
[vii] WDAF TV 4 Web site, online data
[viii] WDAF TV 4 Web site, online data
[ix] Brooks and Doswell, NOAANSSL Web site, online document
[x] Brooks and Doswell, NOAA NSSL Web site, online document
[xi] NOAA Storm Protection Center Web site, http://www.spc.noaa.gov/fqu/tornado/
[xii] NOAA NCDC Web site
[xiii] Alan Blinder, "After One More Day of Tornadoes, Hope for a Respite," The New York Times https://www.nytimes.com/2019/05/29/us/tornadoes-weather.html
[xiv] NOAA NWS 28 May 2019 Tornadoes https://www.weather.gov/eax/28May2019_Tornadoes
[xv] NOAA NWS 28 May 2019 Tornadoes https://www.weather.gov/eax/28May2019_Tornadoes
[xvi] Weather Underground, *Tornadoes*: Fact Vs. Myth, online data
[xvii] NOAA NCDC Web Site, https://www.ncdc.noaa.gov/stormevents
[xviii] Tarp, NOAA OAR Web site, online document
[xix] SEMA State Hazard Analysis, Annex 2, Online
[xx] SEMA State Hazard Analysis, Annex 2, Online
[xxi] Northern Illinois University, "NIU Researchers Say Nighttime Tornadoes are Worst Nightmare," Press Release, November 5, 2008, available at www.Niu.edu/news



SEVERE THUNDERSTORMS

A “thunderstorm” is a rain shower with thunder. A thunderstorm is the result of convection usually created by heating of the surface that carries any moisture in the air in an upward atmospheric motion. Severe thunderstorms contain one or more of the following: hail one inch in diameter or greater, winds gusts over 57.5 mph (50 knots), or a tornado. About 10 percent of the roughly 100,000 thunderstorms that occur in the U.S. each year reach severe levels (NOAA).

4.7 Severe Thunderstorms (Wind, Hail, Lightning)

Many hazardous weather events are associated with thunderstorms. Under the right conditions, rainfall from thunderstorms can cause flash flooding, which kills more people each year than hurricanes, tornadoes or lightning. Lightning is responsible for many fires around the world each year and is also capable of causing fatalities. Hail up to the size of softballs damages cars and windows and can kill livestock caught out in the open. Strong straight-line winds associated with thunderstorms may knock down trees, power lines and mobile homes. Tornadoes (with winds up to about 300 mph) can destroy all but the strongest man-made structures.[i]

All thunderstorms produce lightning, so all thunderstorms can be dangerous. While lightning fatalities have decreased over the past 30 years, lightning continues to be one of the top three storm-related killers in the United States. In 2018, there were 20 fatalities and 82 injuries from lightning.[ii] Although most lightning victims survive, people struck by lightning often report a variety of long-term, debilitating symptoms.[iii]

Other dangers associated with thunderstorms include tornadoes, strong winds, hail and flash flooding. The damaging straight-line winds of thunderstorms can exceed 100 mph. Some thunderstorms produce downbursts — a sudden outrush of damaging wind. Microbursts are smaller scale events that have a damage area less than 2.5 miles wide. Microbursts are larger events where the damage area is wider than 2.5 miles. Downbursts can produce strong wind shears (rapid changes in the speed and/or direction of wind over a short distance) near the surface. These types of winds are especially dangerous to aviation.[iv]

Thunderstorms associated with tornado development also contribute to the number one killer — flash floods.[v] According to the National Weather Service, Preliminary US Flood Fatality Statistics, floods and flash flooding are responsible for more fatalities — 182 fatalities in 2017 and 84 in 2018 — than any other thunderstorm-associated hazard. As of June 2019, there have been 67 flood fatalities in the United States.[vi] Dry thunderstorms, which produce rain that does not reach the ground, are most prevalent in the western United States. Falling raindrops evaporate, but lightning can still reach the ground and can start wildfires.[vii] Large hail can reach the size of grapefruit. Hail causes several hundred millions of dollars in damage annually to property and crops across the nation.

Thunderstorms are most likely to occur in the spring and summer months and during the afternoon and evening hours, but they can occur year-round and at all hours. Thunderstorms frequently form in the late afternoon and at night in the Plains states. The greatest severe weather threat extends from Texas to southern Minnesota, but no place in the U.S. is completely safe from the threat of severe weather.

4.7.1 Historical Occurrences

Historical occurrences described in this hazard profile are based on severe thunderstorm characteristics of winds more than 57 miles per hour and hail at least one inch in diameter. Other associated events were considered, including high winds, heavy rain and lightning; however, those events are fairly limited compared events with hail and damaging winds. Narratives of select storms are included in this discussion.

Table 4.7.1, Table 4.7.2, and Table 4.7.3 provide historical summaries of severe thunderstorms for wind, hail and lightning events between 1950-2018.

Table 4.7.1 Kansas City Area Thunderstorm Wind Events (1950- 2018) (>57mph)					
County	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
Cass	171	1	7	464,500	0
Clay	237	0	2	2,175,000	0
Jackson	392	0	12	13,069,750	7,000
Platte	173	0	1	497,500	0
Ray	65	0	0	486,000	0
Total	**1,038**	**1**	**22**	**$16,692,750**	**$7,000**

Table 4.7.2 Kansas City Area Hail Events (1950- 2018) (>1")					
County	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
Cass	225	0	0	3,554,000	250,000
Clay	259	0	0	5,035,500	55,000
Jackson	339	0	0	15,333,000	0
Platte	159	0	0	1,385,000	0
Ray	67	0	0	5,000	0
Total	**1,049**	**0**	**0**	**$25,312,500**	**$305,000**

Table 4.7.3 Kansas City Area Lightning Events (1950- 2018)					
County	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
Cass	1	0	0	25,000	0
Clay	1	0	0	1,000	0
Jackson	8	1	1	327,000	0
Platte	1	0	0	100,000	0
Ray	2	0	0	10,000	0
Total	**13**	**1**	**1**	**$463,000**	**$0**

Table 4.7.4, **Table 4.7.5, Table 4.7.6** provide historical summaries of severe thunderstorms for wind, hail and lightning events between May 2019 to November 2024.

Table 4.7.4 Kansas City Area Thunderstorm Wind Events (5/19- 11/24) (>57mph)					
County	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
Cass	44	0	0	$120,000	$0
Clay	47	0	0	$30,000	$0
Jackson	108	0	0	$7,000	$0
Platte	32	0	0	$20,000	$0
Ray	12	0	0	$0	$0
Total	**243**	**0**	**0**	**$177,000**	**$0**

Table 4.7.5 Kansas City Area Hail Events (5/19- 11/24) (>1")					
County	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
Cass	17	0	0	$0	$0
Clay	36	0	0	$0	$0
Jackson	48	0	0	$0	$0
Platte	27	0	0	$0	$0
Ray	6	0	0	$0	$0
Total	**134**	**0**	**0**	**$0**	**$0**

Table 4.7.6 Kansas City Area Lightning Events (5/19- 11/24) (>57mph)					
County	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
Cass	0	0	0	$0	$0
Clay	1	0	1	$0	$0
Jackson	0	0	0	$0	$0
Platte	0	0	0	$0	$0
Ray	0	0	0	$0	$0
Total	**1**	**0**	**1**	**$0**	**$0**

Table 4.7.7 and Table 4.7.8 list thunderstorm wind and hail events (causing property damage) between 2014-2018.

Table 4.7.7: Kansas City Area Thunderstorm Events with Damaging Winds (2014-2018) (>57 mph)							
County	**Date**	**Location**	**Wind Speed (mph)**	**Deaths**	**Injuries**	**Property Damage ($)**	**Crop Damage ($)**
Cass	6/12/2016	Harrisonville	60	0	0	1,000	0
Clay	6/17/2017	Claycomo	70	0	0	10,000	0
Jackson	6/2/2018	Lake Lotawana	70	0	0	30,000	0
Jackson	6/2/2018	Cockrell	81	0	0	10,000	0
Jackson	8/28/2018	Kansas City	70	0	0	50,000	0
Platte	6/3/2015	Platte City	60	0	0	5,000	0

Table 4.7.8: Kansas City Severe Thunderstorms with Damaging Hail (2014-2018) (>1")							
County	**Data**	**Location**	**Hail Size (inches)**	**Deaths**	**Injuries**	**Property Damage ($)**	**Crop Damage ($)**
Cass	7/19/2018	Lake Winnebago	1.75	0	0	10,000	0

Table 4.7.9 lists thunderstorm wind events (causing property damage) between May 2019 to November 2024. The Kansas City Area did not record any events with damaging hail (>1”) between 5/2019 and 11/2024 according to NOAA

Table 4.7.9: Kansas City Area Thunderstorm Events with Damaging Winds (5/19- 11/24) (>57 mph)							
County	**Date**	**Location**	**Wind Speed (kts. EG)**	**Deaths**	**Injuries**	**Property Damage ($)**	**Crop Damage ($)**
Cass	05/04/2020	GARDEN CITY	65	0	0	$100,000	$0
Cass	06/11/2021	HARRISONVILLE	70	0	0	$20,000	$0
Clay	07/01/2020	ARLEY	52	0	0	$5,000	$0
Clay	12/15/2021	(MKC)KS CITY DNTN AR	67	0	0	$25,000	$0
Jackson	05/04/2020	SOUTH LEE	52	0	0	$2,000	$0
Jackson	07/01/2020	OAK GROVE	52	0	0	$5,000	$0
Platte	07/01/2020	EDGERTON	52	0	0	$20,000	$0

Table 4.7.10 lists lightning, high wind, and heavy rain events between 2014-2018.

Table 4.7.10: Kansas City Area Lightning, High Wind and Heavy Rain Events 2014-2018								
County	**Data**	**Location**	**Event Type**	**Wind Speed (mph)**	**Deaths**	**Injuries**	**Property Damage ($)**	**Crop Damage ($)**
Ray	11/11/2015	Ray (Zone)	High Wind	52	0	0	0	0
Jackson	11/11/2015	Jackson (Zone)	High Wind	54	0	0	0	0
Platte	11/11/2015	Platte (Zone)	High Wind	52	0	0	0	0
Clay	11/11/2015	Clay (Zone)	High Wind	52	0	0	0	0
Cass	11/11/2015	Cass (Zone)	High Wind	52	0	0	0	0
Jackson	4/29/2017	Jackson (Zone)	High Wind	50	0	0	0	0
Cass	4/29/2017	Cass (Zone)	High Wind	52	0	0	0	0
Jackson	5/17/2017	Jackson (Zone)	High Wind	52	0	0	0	0
Clay	6/16/2017	Paradise	Lightning		0	0	1,000	0
Jackson	6/17/2017	Leeds	Lightning		0	0	50,000	0
Jackson	8/21/2017	Dodson	Heavy Rain		0	0	0	0
Jackson	7/5/2018	Cement City	Lightning		1	0	0	0
Platte	1/28/2019	Platte (Zone)	High Wind	56	0	0	0	0
Clay	1/28/2019	Clay (Zone)	High Wind	56	0	0	0	0

Table 4.7.11 lists lightning, high wind, and heavy rain events between 5/2019 and 11/2024.

Table 4.7.11: Kansas City Area Lightning, High Wind and Heavy Rain Events (5/19- 11/24)								
County	**Date**	**Location**	**Event Type**	**Wind Speed (kts. EG)**	**Deaths**	**Injuries**	**Property Damage ($)**	**Crop Damage ($)**
Cass	05/21/2019	CASS (ZONE)	High Wind	52	0	0	$0	$0
Cass	03/31/2023	CASS (ZONE)	High Wind	52	0	0	$0	$0
Clay	05/18/2019	PARADISE	Lightning		0	1	$0	$0
Clay	05/21/2019	CLAY (ZONE)	High Wind	52	0	0	$0	$0
Clay	12/15/2021	CLAY (ZONE)	High Wind	56	0	0	$0	$0
Jackson	05/21/2019	JACKSON (ZONE)	High Wind	52	0	0	$0	$0
Jackson	12/15/2021	JACKSON (ZONE)	High Wind	56	0	0	$0	$0
Jackson	03/31/2023	JACKSON (ZONE)	High Wind	52	0	0	$0	$0
Platte	05/21/2019	PLATTE (ZONE)	High Wind	51	0	0	$0	$0
Platte	12/15/2021	PLATTE (ZONE)	High Wind	56	0	0	$0	$0
Platte	03/31/2023	PLATTE (ZONE)	High Wind	51	0	0	$0	$0
Ray	12/15/2021	RAY (ZONE)	High Wind	56	0	0	$0	$0

Garden City – May 2020

The morning of May 3, 2020 brought a marginally severe storm into portions of east central Kansas and west central Missouri. This storm was somewhat isolated in the damage it caused, but the worsts of this two day event occurred the next day. The morning of May 4 started out incredibly active across eastern Kansas and western Missouri. In eastern Kansas several supercells formed and moved eastward into western Missouri. The initial round of supercells were generally decaying as they progressed eastward, but one particular supercell formed an enhanced downburst in western Bates County and produced between 70 and 90 mph winds. Upstream of this supercell in eastern Kansas 15-20 power poles were snapped near the intersection known as Jingo, KS. This storm then went on to produce heavy damage to trees and structures between Amsterdam and Butler. It was in this area just west of Passaic that a single fatality occurred when a tree fell into a house. After this storm moved out of the area a follow-up bow pushed through the same area producing pockets of strong winds that were recorded up to nearly 80 mph at more than one ASOS. Winds of around 70 to 80 mph occurred in Garden City as a strong, decaying thunderstorm moved into that area. While the storm was severe, the winds in and around Garden City were somewhat unique to the event and the damage across the city indicated some enhanced winds, probably associated with a significant downburst. While the official estimate is around 70 to 80 mph winds, it's plausible that faster winds were experienced in that area with this event solely based on the damage.

Kansas City Downtown Airport December 15, 2021

On December 15, 2021, a large-scale weather event rolled through the Central Plains and Upper Midwest bringing tornadoes, dust storms, wildfires, and snow across several central and northern states. Record high temperatures were set across the region including Kansas City, with the Kansas City International Airport tying its all-time December high temperature. Non-convective winds both ahead and behind the thunderstorms were quite strong. Several locations around the area reported wind gusts above 50 MPH with Lees Summit peaking at 53 MPH, St. Joseph reached 52 MPH, and Johnson County Executive Airport in Olathe, KS reached 60 MPH. Once the line of storms arrived, several areas reported winds in excess of 75 MPH. The Kansas City Downtown Airport reached a peak gust of 77MPH. This resulted in the roof damage to a few airport buildings. Numerous trees and power poles fell across much of eastern Kansas and western Missouri. Areas in far northwest Missouri observed winds of 80-90 MPH as the thunderstorms moved through. Several homes and buildings were damaged across northern Missouri including missing shingles, peeled siding, and blown out windows. While a local reporter was on the air covering the strong winds a roof was ripped off of a hangar at Kansas City Downtown Airport. While this happened, the ASOS measured 77 mph wind at the location

Oak Grove – July 2020
During the early morning hours of July 1, a strong thunderstorm complex came out of southeast Nebraska, into far northwest Missouri. This complex brought 70-80 mph winds and caused a swatch of damage from northwest Missouri, into north central Missouri. Most of the damage was to tree limbs and non-permanent structures. A large fireworks tent was destroyed.

Edgerton – July 2020
During the early morning hours of July 1, a strong thunderstorm complex came out of southeast Nebraska, into far northwest Missouri. This complex brought 70-80 mph winds and caused a swatch of damage from northwest Missouri, into north central Missouri. Most of the damage was to tree limbs and non-permanent structures. There were several tree limbs and at least one tree down in the Edgerton area. One of these tree limbs fell on the roof of a home and punctured through the roof and ceiling. There were no reported injuries.

Clay – May 18, 2019
A storm brought some strong winds to Platte County. A person was injured by lightning. The exact situation and extent of the injury is unknown.

Smithville – August 19, 2000
Thunderstorm winds estimated at 80 mph tore through the Smithville Lake area. Extensive damage was done to a marina, where 40 to 45 boats were damaged, and two of four docks were damaged. A nearby campground was also hit hard, as approximately 20 camping trailers were damaged. Two campers were hospitalized, including one who was inside an RV that rolled over. The severe thunderstorms developed ahead of a warm front in northeastern Kansas and moved east into northwest Missouri. The strongest storm crossed the Missouri River near Atchison, Kansas and caused extensive wind damage as it moved eastward to Richmond. The hardest hit area was in northern Clay County from Smithville Lake to Excelsior Springs. Property damages were estimated at $800,000.

Garden City – August 21, 2003
Severe thunderstorm winds estimated at 70 mph destroyed two mobile homes and caused two injuries. One of the victims later died from injuries sustained in the storm. One house had major damage with one injury. Numerous trees were downed or damaged along with outbuildings. Property damage was estimated at $150,000.

Leeds – June 15, 2017
On the afternoons of June 15 through June 17 multiple rounds of severe storms raked through western and central Missouri causing widespread wind damage and large hail. A tornado occurred in Lafayette County after dark, causing minor damage to rural areas north of Bates City. Lightning strike caused a tree to catch fire which then fell on to a house and resulted in a house fire.

Lake Winnebago and Garden City – July 19, 2018
On July 19, significant severe weather occurred in two distinct but consecutive rounds. The first round was a line of supercells that formed over the eastern Kansas City metro, produced significant hail up to baseball size, and drifted south southeast with time; the second was a Mesoscale Convective System (a complex of thunderstorms that organize as one) dropping southeast and producing straight-line winds across southwestern portions of the area. Caused $10,000 in damage.

Kansas City – August 28, 2018
On August 28, several thunderstorms affected the area with hail and wind. The winds ranged from 60 to 70 mph and did damage to trees, power lines, and some structures. Hail sizes ranged from penny to half-dollar sized. $50,000 in damage was reported. Broadcast media reported a couple were trapped in their home when a large tree fell onto it. The extent of the damage to the home is otherwise unknown.

4.7.2 Probable Locations

Magnitude 10%- 25%

Severe thunderstorms can occur anywhere in the Kansas City metro area. According to NOAA, the greatest severe weather threat in the U.S. extends from Texas to southern Minnesota. Severe Thunderstorm events often affect smaller portions of a county area. Therefore, all counites were given a 10%-25% magnitude rating.

4.7.3 Impact

Like tornadoes, the urban and suburban areas of Cass, Clay, Jackson, Platte and Ray counties are more susceptible to the damaging effects of thunderstorms than the rural portions of these jurisdictions due to larger populations and greater concentration of homes, commercial structures, public facilities, utilities and infrastructure. Nevertheless, thunderstorms can still impact rural portions of the Kansas City region. People may be injured or killed in rural as well as urban areas, though in lesser numbers due to lower population density; livestock may be killed, and crops damaged in rural areas. The costs associated with losses in rural areas may be significant, although generally lower than damage costs in urban areas. Rural residents may also tend to rely more on NOAA weather radios in addition to media broadcasts. More use of mass communication and notification systems in urban areas provide timely alerts and updates to residents in harms' way.

Table 4.7.10 – Table 4.7.12[viii] summarize all thunderstorm wind events more than 57 mph and the impact on each of the five counties in the planning area.

Table 4.7.10: Cass County Thunderstorm Wind Events (1950-2018) (>57 mph)

Wind Speed (mph)	Events	Deaths	Injuries	Property Damage $	Crop Damage $
57-67	108	0	0	47,500	0
68-81	52	1	4	357,000	0
82-100	6	0	0	0	0
Total	166	1	4	404,500	0

Table 4.7.11: Clay County Thunderstorm Wind Events (1950-2018) (>57 mph)

Wind Speed (mph)	Events	Deaths	Injuries	Property Damage $	Crop Damage $
57-67	158	0	0	387,000	0
68-81	69	0	2	17,030,000	0
82-100	7	0	0	68,000	0
Total	234	0	2	17,485,000	0

Table 4.7.12: Jackson County Thunderstorm Wind Events (1950-2018) (>57 mph)					
Wind Speed (mph)	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
57-67	251	0	3	1,310,750	0
68-81	115	0	0	1,604,000	2,000
82-100	18	0	0	10,005,000	0
Total	384	0	3	12,919,750	2,000

Table 4.7.13: Platte County Thunderstorm Wind Events (1950-2018) (>57 mph)					
Wind Speed (mph)	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
57-67	112	0	0	59,500	0
68-81	53	0	1	431,500	0
82-100	5	0	0	0	0
Total	170	0	1	491,000	0

Table 4.7.14: Ray County Thunderstorm Wind Events (1950-2018) (>57 mph)					
Wind Speed (mph)	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
57-67	40	0	0	30,000	0
68-81	22	0	0	249,000	0
82-100	2	0	0	200,000	0
Total	64	0	0	479000	0

Table 4.7.15 – Table 4.7.19[ix] summarize all thunderstorm wind events more than 57 mph and the impact on each of the five counties in the planning area between May 2019 and November 2024.

Table 4.7.15: Cass County Thunderstorm Wind Events (5/19- 11/24) (>57 mph)					
Wind Speed (kts. EG)	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
57-67	7	0	0	$100,000	$0
68-81	1	0	0	$20,000	$0
82-100	0	0	0	$0	$0
Total	**8**	**0**	**0**	**$120,000**	**$0**

Table 4.7.16: Clay County Thunderstorm Wind Events (5/19- 11/24) (>57 mph)					
Wind Speed (kts. EG)	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
57-67	10	0	0	$25,000	$0
68-81	5	0	0	$0	$0
82-100	0	0	0	$0	$0
Total	**15**	**0**	**0**	**$25,000**	**$0**

Table 4.7.17: Jackson County Thunderstorm Wind Events (5/19- 11/24) (>57 mph)					
Wind Speed (kts. EG)	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
57-67	21	0	0	$7,000	$0
68-81	4	0	0	$0	$0
82-100	0	0	0	$0	$0
Total	**25**	**0**	**0**	**$7,000**	**$0**

Table 4.7.18: Platte County Thunderstorm Wind Events (5/19- 11/24) (>57 mph)					
Wind Speed (kts. EG)	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
57-67	5	0	0	$0	$0
68-81	0	0	0	$0	$0
82-100	0	0	0	$0	$0
Total	**5**	**0**	**0**	**$0**	**$0**

Table 4.7.19: Ray County Thunderstorm Wind Events (5/19- 11/24) (>57 mph)					
Wind Speed (kts. EG)	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
57-67	1	0	0	$0	$0
68-81	0	0	0	$0	$0
82-100	0	0	0	$0	$0
Total	**1**	**0**	**0**	**$0**	**$0**

Table 4.7.20 – Table 4.7.16 summarize hail events at least one inch in diameter and the impact on each of the five counties in the planning area.

Table 4.7.20: Cass County Hail Events (1950-2018) (>1")					
Hail Size	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
1-1.5	140	0	0	0	0
1.75-2.5	80	0	0	3,550,000	250,000
>2.75	5	0	0	4,000	0
Total	225	0	0	3,554,000	250,000

Table 4.7.21: Clay County Hail Events (1950-2018) (>1")					
Hail Size	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
1-1.5	146	0	0	0	0
1.75-2.5	98	0	0	2,535,500	55,000
>2.75	15	0	0	2,500,000	0
Total	259	0	0	5,035,500	55,000

Table 4.7.22: Jackson County Hail Events (1950-2018) (>1")					
Hail Size	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
1-1.5	215	0	0	3,000	0
1.75-2.5	111	0	0	14,330,000	0
>2.75	13	0	0	1,000,000	0
Total	339	0	0	15,333,000	0

Table 4.7.23: Platte County Hail Events (1950-2018) (>1")					
Hail Size	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
1-1.5	100	0	0	20,000	0
1.75-2.5	53	0	0	1,325,000	0
>2.75	6	0	0	40,000	0
Total	159	0	0	1385000	0

Table 4.7.24: Ray County Hail Events (1950-2018) (>1")					
Hail Size	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
1-1.5	35	0	0	0	0
1.75-2.5	30	0	0	5,000	0
>2.75	2	0	0	0	0
Total	67	0	0	5,000	0

Table 4.7.25 – **Table 4.7.29** summarize hail events at least one inch in diameter and the impact on each of the five counties in the planning area between May 2019 and November 2024.

Table 4.7.25: Cass County Hail Events (5/19- 11/24) (>1")					
Hail Size	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
1-1.5	9	0	0	$0	$0
1.75-2.5	3	0	0	$0	$0
>2.75	1	0	0	$0	$0
Total	**4**	**0**	**0**	**$0**	**$0**

Table 4.7.26: Clay County Hail Events (5/19- 11/24) (>1")					
Hail Size	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
1-1.5	24	0	0	$0	$0
1.75-2.5	4	0	0	$0	$0
>2.75	0	0	0	$0	$0
Total	**28**	**0**	**0**	**$0**	**$0**

Table 4.7.27: Jackson County Hail Events (5/19- 11/24) (>1")					
Hail Size	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
1-1.5	37	0	0	$0	$0
1.75-2.5	9	0	0	$0	$0
>2.75	0	0	0	$0	$0
Total	**46**	**0**	**0**	**$0**	**$0**

Table 4.7.28: Platte County Hail Events (5/19- 11/24) (>1")					
Hail Size	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
1-1.5	22	0	0	$0	$0
1.75-2.5	1	0	0	$0	$0
>2.75	0	0	0	$0	$0
Total	**23**	**0**	**0**	**$0**	**$0**

Table 4.7.29: Ray County Hail Events (5/19- 11/24) (>1")					
Hail Size	**Events**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
1-1.5	5	0	0	$0	$0
1.75-2.5	1	0	0	$0	$0
>2.75	0	0	0	$0	$0
Total	**6**	**0**	**0**	**$0**	**$0**

Historical statistics associated with the occurrence of severe thunderstorms in the region are presented in **Table 4.7.30** and based on wind gusts and hail size. The table provides an indication of the probable severity of a thunderstorm in the Kansas City region. The severity impact was calculated by taking the average of two percentages. The percentage of storms that have a respective hail size and the percentage of storms that have a respective wind gust speed. For example, a future severe thunderstorm has a 57% chance of having 1-1.5 inch. hail and 57-67 mph wind gusts, most likely causing a limited impact.

Table 4.7.30: Probable Future Severe Thunderstorm Severity		
Hail Size (inches)	**Wind Gusts (mph)**	**Probable Future Severity (Catastrophic, Critical, Limited or Negligible)**
1-1.5	57-67	57% — Limited
1.75-2.5	68-80	29% — Critical
>2.75	81-118	5% — Catastrophic

Based on the 69-year history of severe thunderstorm events across the region, **Table 4.7.31** presents the likely adverse impact of future Kansas City metropolitan area severe thunderstorm and related events.

Table 4.7.31: Estimated Categories of Impact				
Effects of Thunderstorms	**Life**	**Property**	**Emotional**	**Financial**
Without mitigation measures	Limited	Critical	Limited	Critical
With mitigation measures	Negligible	Limited	Negligible	Limited

Hail and wind events commonly occur in the Kansas City planning area. Mitigation measures can reduce the adverse impact of damaging winds, hail and heavy rains associated with severe thunderstorms, helping to save lives, prevent injuries and lessen property damage. Measures include public education and awareness programs and public use of enhanced warning and mass communication systems.

4.7.4 Probability of Future Occurrence: 93%

Although the likelihood of severe thunderstorms is greatest during the spring and early summer, they can occur anywhere in the region, at any time of the year and at any hour of the day or night. A review of historical statistics, summarized in **Table 4.7.32**, indicates the likelihood of a severe thunderstorm occurring anywhere in the Kansas City area based on hail size and wind gusts. For example, a future severe thunderstorm that has 1-1.5 inch. hail and 57-67 mph wind gusts are likely to happen in a given year.

Table 4.7.32: Probability of Future Severe Thunderstorm Events		
Hail Size (inches)	**Wind Gusts (mph)**	**Probability (Highly Likely, Likely, Possible, or Unlikely)**
1-1.5	57-67	57% — Likely
1.75-2.5	68-80	29% — Possible
>2.75	81-118	5% — Unlikely

4.7.5 Extent

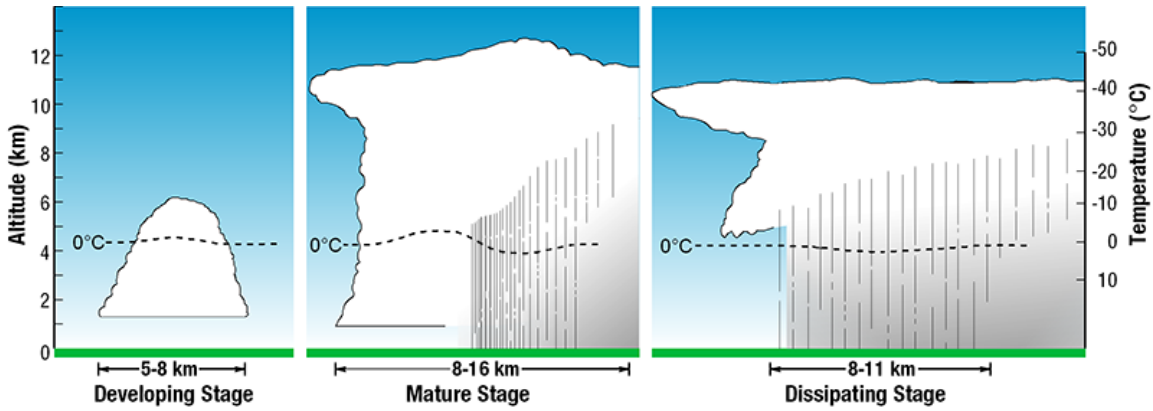
Watches and Warnings
NOAA meteorologists constantly monitor weather patterns, both nationally and locally, and issue watches and warnings as needed.

Severe Thunderstorm Watches are issued by NOAA Storm Prediction Center meteorologists who monitor the entire U.S. for weather conditions that are favorable for severe thunderstorms. A watch can cover parts of one or more states. The purpose of the watch is to encourage people to prepare for severe weather and stay alert to when warnings are issued.

Severe Thunderstorm Warnings are issued by local NOAA National Weather Service Forecast Office meteorologists who monitor a designated area for severe weather that has been reported by spotters or indicated by radar. Warnings mean there is a serious threat to life and property to those in the path of the storm. The purpose of the warning is to encourage people to act immediately to find safe shelter. A warning can cover parts of counties or several counties in the path of danger.

The Thunderstorm Life Cycle

Thunderstorms can look like tall heads of cauliflower or they can have "anvils." An anvil is the flat cloud formation at the top of the storm. An anvil forms when the updraft (warm air rising) has reached a point where the surrounding air is about the same temperature or even warmer. The cloud growth abruptly stops and flattens out to take the shape of an anvil. (**See Figure 4.7.1)**



Source: NOAA Website, online data

Figure 4.7.1: The Thunderstorm Life Cycle

Thunderstorm Types

Single-cell thunderstorms are small, brief, weak storms that grow and die within an hour or so, typically driven by heating on a summer afternoon. Single-cell storms may produce brief heavy rain and lightning.

Multi-cell storms are common thunderstorms in which new updrafts form along the leading edge of rain-cooled air (the gust front). Individual cells usually last 30 to 60 minutes, while the system may last for many hours. Multi-cell storms may produce hail, strong winds, brief tornadoes, and/or flooding.

Squall line refers to a group of storms arranged in a line, often accompanied by "squalls" of high wind and heavy rain. Squall lines tend to pass quickly and are less prone to produce tornadoes than supercells. They can be hundreds of miles long but are typically only 10 or 20 miles wide.

Supercell thunderstorms are long-lived (lasting more than one hour) and highly organized storms that feed off an updraft (a rising current of air) that is tilted and rotating. This rotating updraft — which can be as large as 10 miles in diameter and up to 50,000 feet tall — can be present as much as 20 to 60 minutes before a tornado forms. Scientists call this rotation a mesocyclone when it is detected by Doppler radar. The tornado is a very small extension of this larger rotation. Most large and violent tornadoes come from supercells.

Bow echo refers to the radar signature of a squall line that "bows out" as winds fall behind the line and circulations develop on either end. A strongly bowed echo may indicate high winds in the middle of the line, where the storms are moving forward most quickly. Brief tornadoes may occur on the leading edge of a bow echo. Often the north side of a bow echo becomes dominant over time, gradually evolving into a comma-shaped storm complex.

Mesoscale Convective System (MCS) is a collection of thunderstorms that act as a system. An MCS can spread across an entire state and last more than 12 hours. On radar, one of these monsters might

appear as a solid line, a broken line, or a cluster of cells. This all-encompassing term can include any of the following storm types:

- **Mesoscale convective complex (MCC)—**A particular type of MCS, an MCC is a large, circular, long-lived cluster of showers and thunderstorms identified by satellite. It often emerges out of other storm types during the late-night and early-morning hours. MCCs can cover an entire state.
- **Mesoscale convective vortex (MCV)—**A low-pressure center within an MCS that pulls winds into a circling pattern, or vortex. With a core only 30 to 60 miles wide and 1 to 3 miles deep, an MCV is often overlooked in standard weather analyses. But an MCV can take on a life of its own, persisting for up to 12 hours after its parent MCS has dissipated. This orphaned MCV will sometimes then become the seed of the next thunderstorm outbreak. An MCV that moves into tropical waters, such as the Gulf of Mexico, can serve as the nucleus for a tropical storm or hurricane.

Derecho refers to a widespread, long-lived wind storm that is associated with a band of rapidly moving showers or thunderstorms. Although a derecho can produce destruction like that of tornadoes, the damage typically is directed in one direction along a relatively straight swath. As a result, the term "straight-line wind damage" is sometimes used to describe derecho damage. By definition, if the wind damage swath extends more than 240 miles (about 400 kilometers) and includes wind gusts of at least 58 mph (93 km/h) or greater along most of its length, the event may be classified as a derecho.

Seasonal Pattern: In general, severe thunderstorms may affect Greater Kansas City anytime; however, weather is most likely during the spring and summer months. But as historical records indicate, it is possible for severe thunderstorms to affect the region early or late in the season.

4.7.5a Probable Duration: Thunderstorms can strike so quickly and with little if any warning. The entire thunderstorm life cycle from the growing cumulus cloud to the dissipated storm can take only 30 minutes. Thunderstorms range between 5 and 25 miles in diameter making them much localized storms.[x]

Potential speed of onset (probable amount of warning time):

- ■ Minimal (or no) warning
- ■ 6 to 12 hours warning
- ☐ 12 to 24 hours warning
- ☐ More than 24 hours warning

4.7.6 Vulnerability Analysis

Vulnerable Assets

People: Death and injury can be sustained by fallen trees onto houses or cars, downed power lines, etc., due to damaging winds, or traffic accidents on rain-slick roads caused by heavy rains. People who remain in mobile homes are at tremendous risk. Roads may become blocked by tree limbs or downed power lines and inhibit the ability of emergency services and medical personnel to travel and assist people who are injured or in harm's way, posing a secondary hazard to life. Loss of electricity for extended periods of time in the heat of summer could cause heat exhaustion. Large crowds at outdoor venues are also at a higher risk for injury and death unless nearby shelter is accessible.

Property: Damaging winds and hail can break branches or topple an entire tree, knocking down power and telephone lines, disrupting power and telephone service, causing property damage to vehicles, homes, commercial buildings and other structures. Flooded basements and backed up sewers can also damage property.

Transportation Infrastructure and Services: Rain-slick roads may result in traffic accidents. Roads may also be blocked, and traffic disrupted by downed trees, tree limbs and power lines. Heavy rain may reduce visibility and can temporarily disrupt or slow traffic.

Utilities: Fallen trees and branches can break and fall onto above-ground power and telecommunications lines, damaging the lines and disrupting power and service to customers. Utility poles and telecommunications towers may also be toppled by damaging winds.

Commerce and Essential Services: The costs associated with property damage, power restoration and debris removal can be low or high depending on the storm. Storms can delay surface, air and rail transportation by disrupting the temporary flow of goods and services. Commuters can be delayed or stranded causing a loss of business productivity. Downed power and telecommunications lines can interfere with businesses' ability to power equipment, communicate or execute financial transactions. Essential services such as law enforcement, fire protection and EMS may be hampered by road conditions.

Natural Environment: Damaging wind and hail events can cause considerable damage to trees and other vegetation, like severe winter storms. Trimming and removal efforts, though necessary in most cases, can exacerbate this problem.

All critical facilities are susceptible to the hazard. Refer to the supplemental hazard-specific information in Appendix C: Maps and References.

4.7.7 Problem Statements

Vulnerability statements, such as those below, can support development of mitigation strategies for severe thunderstorms:

- Severe thunderstorms with damaging winds and hail are frequent events within the Kansas City region and will likely continue to impact large areas.
- Cascading impacts of severe thunderstorms can have lasting, cross-jurisdictional impacts. Normal mutual-aid partners or regional resources may be unavailable or unable to support response.
- Mitigation measures to protect property tend to be expensive with cost-benefit ratio being challenging.
- As with tornadoes, current public information efforts have likely plateaued in their effectiveness.
- New warning technologies have created the potential for uncoordinated warnings (or conversely, oversaturation) leading to residents not taking appropriate protective actions.

[i] NOAA Web Site, http://www.nssl.noaa.gov/education/svrwz101/thunderstorms/

[ii] NOAA Storm Events Database

[iii] FEMA Web Site, https://www.ready.gov/thunderstorms-lightning
[iv] Missouri State Hazard Analysis, Annex A
[v] Missouri State Hazard Analysis, Annex A
[vi] NWS Preliminary US Flood Fatality Statistics, NOAA, https://www.weather.gov/arx/usflood
[vii] NOAA Web Site
[viii] NOAA NCDC Web Site, https://www.ncdc.noaa.gove/stormevents
[ix] NOAA NCDC Web Site, https://www.ncdc.noaa.gove/stormevents
[x] NOAA Web Site, http://www.erh.noaa.gov/lwx/swep/Spotting.html

SEVERE WINTER WEATHER

Severe winter storms may include snow, sleet, freezing rain, or a mix of these wintry forms of precipitation. Severe winter weather can down trees, cause widespread power outages, damage property, and cause fatalities and injuries.

4.8 Severe Winter Weather

Severe winter weather, including snow storms, ice storms and extreme cold, may affect any part of Cass, Clay, Jackson, Platte and Ray counties any given winter season. Although the annual snowfall amount in the Kansas City area is moderate — generally around 20 inches — the area may be affected by a full range of snowy conditions, including blizzards, blowing snow, snow squalls, snow showers and snow flurries.[i] These snowy conditions are defined as follows:

Blizzard – Winds of 35 mph or more with snow and blowing snow reducing visibility to less than one-quarter mile for at least three hours.

Snow Squalls – Brief intense snow showers accompanied by strong, gusting winds; accumulation may be significant.

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 Showers – Snow falling at varying intensities for brief periods of time. Some accumulation is possible.

Drifting Snow – Uneven distribution of snowfall caused by strong surface winds. Drifting snow does not reduce visibility.

Snow Flurries – Light snow falling for short durations with little or no accumulation.

Source: *Winter Storms, The Deceptive Killers*, 2001, NWS Web site
Winter Weather Glossary, USA Today Web site

Ice storms may also affect the Kansas City area during the winter months. In ice storms, damaging accumulations of ice occur during a period of freezing rain.[ii] According to the NWS, significant accumulations of ice are defined as one-quarter inch or more of ice.[iii] Other icy conditions that may affect the Kansas City area include freezing rain and sleet. Freezing rain or freezing drizzle occurs when rain or drizzle freezes on surfaces, such as roads, bridges, cars and trees, forming a coating or glaze of ice.[iv] In freezing rain or freezing drizzle situations, air temperatures are warm enough for rain to form, but surface temperatures are below 32 degrees (i.e., below freezing), causing rain or drizzle to freeze on contact with surfaces.[v] Sleet is raindrops that freeze and form ice pellets before reaching the ground.[vi] Like hail, sleet may “bounce” when it hits the ground or other surface instead of sticking and forming a coating.[vii] Sleet, however, may accumulate like snow.[viii] sleet is the accumulation of half an inch or more of sleet.[ix]

4.8.1 Historical Occurrences

Severe winter weather is virtually an annual occurrence in the Kansas City area. Whether it is a snow storm, ice storm, freezing rain, sleet, period of extreme cold or combination of these conditions, citizens of the Kansas City area will normally experience some type of severe weather event each winter. Occurrences of severe winter weather spanning from 2014 to 2018 are depicted in Table 4.8.1. Historical occurrences occurring between May 2019 and November 2024 are depicted in **Table 4.8.2** Each

historical occurrence contains the beginning date of the severe winter weather event, the affected counties in the Kansas City area and a description of the damaging events.

Table 4.8.1 Historical Occurrences, Severe Winter Weather (2014- February 2019)

County	Date	Event Type	Deaths	Injuries	Property Damage $	Crop Damage $
Cass, Clay, Jackson, Platte, Ray	1/6/2014	Cold/Wind Chill	0	0	0	0
Cass, Clay, Jackson, Platte, Ray	2/4/2014	Heavy Snow	0	0	0	0
Cass, Clay, Jackson, Platte, Ray	3/1/2014	Winter Storm	0	0	0	0
Jackson	1/3/2015	Winter Weather	0	0	10,000	0
Clay	11/27/2015	Winter Weather	0	0	0	0
Platte	12/27/2015	Winter Storm	0	0	0	0
Platte	1/13/2017	Winter Weather	0	0	0	0
Jackson	1/12/2018	Cold/Wind Chill	1	0	0	0
Cass, Clay, Jackson, Platte, Ray	2/20/2018	Ice Storm	0	0	0	0
Cass	11/12/2018	Winter Weather	0	0	100,000	0
Cass, Clay, Jackson, Platte, Ray	11/25/2018	Blizzard	0	0	0	0
Cass, Clay, Jackson, Platte, Ray	1/11/2019	Winter Storm	0	0	0	0
Cass, Clay, Jackson, Platte, Ray	2/6/2019	Ice Storm	0	0	0	0
Jackson, Cass	2/15/2019	Winter Weather	0	0	1,500,000*	0

Source: NOAA NCDC Web site

*Jackson county reported $1,000,000 in property damage and Cass county reported $500,000 in property damage

Table 4.8.2 Historical Occurrences, Severe Winter Weather (2019- November 2024)						
County	**Date**	**Event Type**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
CASS (ZONE)	2/14/21	Extreme Cold/wind Chill	0	0	$0	$0
CASS (ZONE)	2/15/21	Extreme Cold/wind Chill	0	0	$0	$0
CASS (ZONE)	2/16/21	Extreme Cold/wind Chill	0	0	$0	$0
CASS (ZONE)	12/22/22	Extreme Cold/wind Chill	0	0	$0	$0
CASS (ZONE)	1/12/24	Extreme Cold/wind Chill	0	0	$0	$0
CASS (ZONE)	03/10/2022	Heavy Snow	0	0	$0	$0
CASS (ZONE)	01/17/2020	Ice Storm	0	0	$0	$0
County	**Date**	**Event Type**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
CLAY (ZONE)	2/14/21	Extreme Cold/wind Chill	0	0	$0	$0
CLAY (ZONE)	2/15/21	Extreme Cold/wind Chill	0	0	$0	$0
CLAY (ZONE)	2/16/21	Extreme Cold/wind Chill	0	0	$0	$0
CLAY (ZONE)	12/22/22	Extreme Cold/wind Chill	0	0	$0	$0
CLAY (ZONE)	1/12/24	Extreme Cold/wind Chill	0	0	$0	$0
CLAY (ZONE)	03/07/2022	Winter Weather	0	0	$0	$0
CLAY (ZONE)	01/17/2020	Ice Storm	0	0	$0	$0
County	**Date**	**Event Type**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
JACKSON (ZONE)	2/14/21	Extreme Cold/wind Chill	0	0	$0	$0
JACKSON (ZONE)	2/15/21	Extreme Cold/wind Chill	0	0	$0	$0
JACKSON (ZONE)	2/16/21	Extreme Cold/wind Chill	0	0	$0	$0
JACKSON (ZONE)	12/22/22	Extreme Cold/wind Chill	0	0	$0	$0
JACKSON (ZONE)	1/12/24	Extreme Cold/wind Chill	0	0	$0	$0
JACKSON (ZONE)	03/10/2022	Heavy Snow	0	0	$0	$0
JACKSON (ZONE)	3/6/22	Winter Weather	0	0	$0	$0
JACKSON (ZONE)	11/15/22	Winter Weather	1	0	$10,000	$0

JACKSON (ZONE)	01/17/2020	Ice Storm	0	0	$0	$0
County	**Date**	**Event Type**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
PLATTE (ZONE)	2/14/21	Extreme Cold/wind Chill	0	0	$0	$0
PLATTE (ZONE)	2/15/21	Extreme Cold/wind Chill	0	0	$0	$0
PLATTE (ZONE)	2/16/21	Extreme Cold/wind Chill	0	0	$0	$0
PLATTE (ZONE)	12/22/22	Extreme Cold/wind Chill	0	0	$0	$0
PLATTE (ZONE)	1/12/24	Extreme Cold/wind Chill	0	0	$0	$0
PLATTE (ZONE)	04/20/2021	Winter Weather	1 (indirect)	0	$200,000	$0
PLATTE (ZONE)	01/17/2020	Ice Storm	0	0	$0	$0
County	**Date**	**Event Type**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
RAY (ZONE)	2/14/21	Extreme Cold/wind Chill	0	0	$0	$0
RAY (ZONE)	2/15/21	Extreme Cold/wind Chill	0	0	$0	$0
RAY (ZONE)	2/16/21	Extreme Cold/wind Chill	0	0	$0	$0
RAY (ZONE)	12/22/22	Extreme Cold/wind Chill	0	0	$0	$0
RAY (ZONE)	1/12/24	Extreme Cold/wind Chill	0	0	$0	$0

Narratives from events with property damage are stated below.

January 3, 2015 – Jackson County
The Kansas City area had a period of mixed precipitation. Rain preceded snow and the warm pavement melted the snowfall instantly. When a cold front came through the moisture froze to the pavement, causing slick conditions. An NWS employee was on their way to the office when they lost control of their vehicle on Highway 150, just west of the intersection with Highway 7. The car slid off the road and flipped in the ditch. The person was hospitalized for a short time before being released later that day.

November 15, 2022 – Jackson County
Overnight through the morning of November 15th some light snow fell, which accumulated on roadways causing a few automobile accidents. At least one of these accidents caused a fatality. Per MHP crash report, a eastbound pickup truck on Highway 150 just east of Highway 7 started sliding on the roadway, crossed the center, and collided head on with a small car traveling westbound. The driver of the of the car passed at the scene.

MHP Crash Report:
https://www.mshp.dps.missouri.gov/HP68/AccidentDetailsAction?ACC_RPT_NUM=220602365

November 12, 2018 – Cass County
Light snow began falling early in the morning on November 12. While the snow was generally light - moderate at times - 1 to 3 inches of snow fell across the area which caused area roads to become icy, and numerous vehicle accidents ensued. Up to 10 injuries had been reported, and 2 fatalities occurred as a result of the icy roads.[x] One such accident that resulted in a fatality occurred along I-49 (Mile Marker 160.2) in Cass County near the town of Archie around 10:00 am, when a vehicle slid off the road, struck a guardrail, and came back onto the road, where it was subsequently hit by a 18 wheeler. The driver of the vehicle died on the scene and the passenger was transported to a local hospital with minor injuries.[xi]

February 15, 2019 – Cass and Jackson Counties
Light to moderate snow began falling across the region in the mid to late morning hours on Friday February 15, 2019. By the early afternoon heavy snow had been falling for a couple hours and area roads became impassible. Around 3 to 4 inches accumulated on local roads, including I-70 just east of Kansas City. Reduced visibility due to the heavy snow prevented vehicles already on local roads from seeing hazards in their path, which resulted in several injury accidents. The reduced visibility caused a massive pile up at the Oak Grove exit on WB I-70. Several injuries occurred in this accident and one fatality occurred in the carnage that ensued. The pile up received high profile coverage on national media as a trucker caught up in the wreck took video from inside his cab. That video can be found at the following link. ||https://twitter.com/Dantej21/status/1096550488714170368 Another pile up occurred on I-49 between Belton and Peculiar. Most injuries in this accident were considered moderate and non-life threatening.

April 20, 2021 – Platte County
With slick roads causing accidents across the Kansas City Metro one such accident proved fatal, just on the Missouri side of the Missouri River along I-635 near where it intersects with Horizons Parkway. Icy roads have not been determined officially as the cause, but with icy roads that day it's strongly plausible as a contributor to the accident. An accident along I-635 just north of the Missouri River was fatal for one motorist. Icy roads have not been determined officially as the cause, but with 2 to 4 inches of snow on the roads causing slick conditions that morning it's strongly plausible as a contributor to the accident. A vehicle was travelling south along I-635 and crashed head on into a semi. This took place south of Horizons Parkway along I-635, but north of the Missouri River.

4.8.2 Probable Locations

Magnitude >50%

Severe winter weather events tend to be regional in scope. Therefore, the entire Kansas City metro area including Cass, Clay, Jackson, Platte and Ray counties may be affected. Therefore, all counites were given a >50% magnitude rating.

4.8.3 Impact

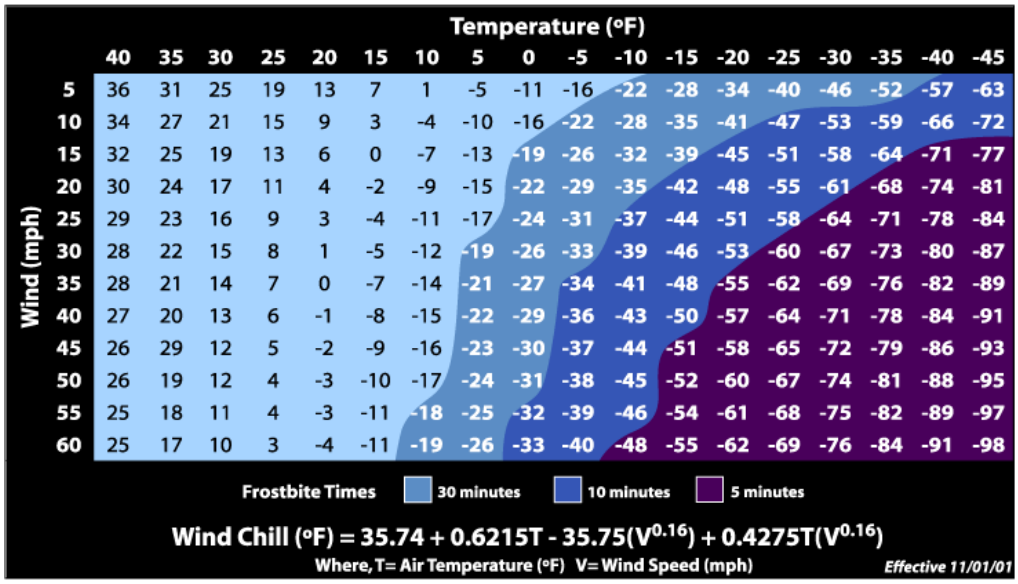
Historical occurrences have shown the impact severe winter weather can have on the Kansas City area. Winter storms have caused injuries and loss of life, traffic accidents, property damage, power outages, transportation and telecommunications disruptions, and economic losses. One of the most glaring examples of the impact severe winter weather can have on the Kansas City area is the ice storm of January 29-31, 2002, in which each of the five counties experienced many adversities. The damage costs associated with this severe winter storm were enormous — $61.9 million in federal public assistance alone — making it the second-costliest disaster in Missouri's history.

On average, Missouri counties north of the Missouri River receive annual snowfall of 18 to 22 inches; counties south of the Missouri River receive 8 to 12 inches. The events often involve borderline conditions of freezing rain, ice and high winds, causing high unpredictability. Besides snow and ice, extremely cold temperatures can produce problems. The wind chill is determined by factoring cold temperatures and wind speed. See **Figure 4.8.3**. The situation can be dangerous to people outdoors because their bodies can experience rapid heat loss, resulting in hypothermia (abnormally low body temperature).

Accidental poisonings and deaths are also more likely to occur in colder months. Carbon monoxide poisoning is one indirect winter hazard that can occur. Improperly vented gas and kerosene heaters or the indoor use of charcoal briquettes create dangerous levels of carbon monoxide. In Missouri, due to weather-related power outages there were 16 fatal cases and 52 non-fatal cases of non-fire carbon monoxide poisoning from 2006-2015. There is no current data for the 2015 – 2019 Plan period.[xii]

People: Winter storms are deceptive killers because many of the deaths and injuries that occur are indirectly related to the storm. Indirect causes of death and injury include traffic accidents on snow-covered or icy roads and heart attacks due to overexertion from shoveling snow and related activities. According to the NWS, about 70 percent of injuries related to ice and snow are the result of vehicle accidents, about 25 percent occur to people outdoors in a storm, and most happen to males more than 40 years old. Ice- or snow-covered roads, or roads blocked by tree limbs or power lines, may also inhibit the ability of emergency services and medical personnel to travel and assist people who are injured or in harm's way, posing a secondary hazard to life. Other, though less common, causes of injury and death indirectly related to severe winter weather include pedestrians slipping and falling on icy walkways, carbon monoxide poisoning from improperly vented heaters, and electrocutions and fires from downed power lines.

The most direct causes of injuries and death from severe winter weather are frostbite and hypothermia. Frostbite occurs when body tissue is damaged by extreme cold. (See **Figure 4.8.1**) Frostbite usually affects the body's extremities, such as fingers, toes, ear lobes and the tip of the nose, and causes a loss of feeling and a white or pale appearance. Hypothermia is a potentially deadly condition that occurs when body temperature drops to less than 95 degrees. Hypothermia can cause lasting kidney, liver and pancreas problems for those who survive the condition. Early symptoms of hypothermia include uncontrollable shivering, memory loss, disorientation, incoherence, slurred speech, drowsiness and exhaustion. According to the NWS, approximately 50 percent of injuries related to cold temperatures occur in people more than 60 years old, more than 70 percent happen to men, and about 20 percent occur at home. The elderly, infants, the poor and the homeless may be particularly susceptible to extremely cold conditions.



Source: National Weather Service

Figure 4.8.3: 2001 NWS Wind Chill Index

Property: Residential and commercial property in the Kansas City area is susceptible to severe winter weather. Snow and ice may accumulate on trees, breaking branches or toppling the entire tree. Falling trees and branches can knock down power and telephone lines, disrupting power and telephone service. Falling trees and branches can also damage homes, commercial buildings and other structures. Ice can accumulate on power and telephone lines, causing them to break. Heavy accumulations of snow can cause roofs to collapse. Extremely cold temperatures may injure or kill unprotected pets and livestock, and damage or destroy crops. Extreme cold can also cause water lines in houses and commercial property to freeze and break.

Transportation Infrastructure and Services: Transportation infrastructure and services in the Kansas City area are highly susceptible to severe winter weather. Snow-covered and/or icy roads may result in traffic accidents. Bridges and overpasses are particularly susceptible to icy conditions because they tend to freeze sooner than other roadways. Roads may also be blocked, and traffic disrupted by downed trees, tree limbs and power lines. Heavy snow, ice, freezing rain, high winds and reduced visibility can close airports, disrupt barge traffic on the Missouri River and disrupt or slow rail traffic.

Utilities: Above-ground power and telecommunications lines in the Kansas City area are highly susceptible to severe winter weather. Heavy accumulations of snow and ice on trees can cause trunks and branches to break and fall on power and telecommunications lines, damaging the lines and disrupting power and service to customers. Utility poles and telecommunications towers may also be toppled by heavy accumulations of ice. The October 22-23, 1996, snow storm and the January 29-31, 2002, ice storm caused widespread power and telecommunications outages across the region. Older and more rural parts of the Kansas City area are generally more likely to experience service disruptions due to severe winter weather because they tend to have more above-ground power and

telecommunications lines than newer areas where those utilities are often underground. Extremely cold temperatures may cause main water lines to break, disrupting the supply of water to communities.

Commerce and Essential Services: By damaging property, hampering transportation and disrupting utility services, severe winter weather can have an adverse impact on the economy of a community. As an example, the costs associated with property damage, power restoration and debris removal following the January 29-31, 2002, ice storm were so high for local governments in the Kansas City area that Missouri received a Presidential Disaster Declaration. Cass, Clay, Jackson, Platte and Ray counties were among the 26 Missouri counties eligible for both federal Individual and public assistance programs because of this winter storm event. Severe winter weather can impact surface, air and rail transportation systems by disrupting the flow of goods and services into and out of the metro area. Similarly, commuters can be delayed or stranded, causing a loss of business productivity. Downed power and telecommunications lines can interfere with business' ability to power equipment, communicate or execute financial transactions. Essential services such as law enforcement, fire protection and EMS may be hampered by icy and hazardous road conditions. Area schools are routinely closed due to snow-covered or icy roads and extremely cold temperatures. In addition, beneficial programs for the elderly and/or persons with disabilities, such as home-delivered meals for home-bound senior citizens, may be temporarily curtailed due to the hazardous driving conditions snow-covered or icy roads.

Natural Environment: The early snow storm of October 22–23, 1996, and the ice storms of December 6, 1994, and January 29–31, 2002, caused considerable damage to the environment in the Kansas City area. Thousands of trees and other vegetation in both natural and developed areas were seriously damaged or destroyed by the storm. Trimming and removal efforts, though necessary in most cases, exacerbated this problem. In addition, air quality may have been affected due to the permitted burning of storm debris in some communities. All critical facilities are susceptible to the hazard. Refer to the supplemental hazard-specific information in Appendix C: Maps and References.

4.8.4 Probability of Future Occurrence: 92%

It is likely that some or all of the Kansas City metro area will experience some form of severe winter weather each year. At any hour of the day or night, snow, ice, freezing rain, sleet and/or extreme cold may affect the region in the wintertime (generally between November and April). As a result, the entire region is at risk from severe winter weather, with at 92 percent change of a winter storm including an ice storm, blizzard, extreme cold, heavy snow, freezing fog, or frost/freeze.

Some of the adverse effects of severe winter weather may be reduced, however, through certain mitigation measures, such as public education campaigns that stress winter safety; proper tree-trimming (to keep branches away from power lines); and programs to reduce, eliminate or defer home heating costs for low-income and at-risk residents.

Seasonal Pattern: In general, severe winter weather may affect Greater Kansas City between November and April; severe winter weather is most likely during the months of December, January and February. But, as historical records indicate, it is possible for severe winter weather to affect the region early in the season, such as October snow storms. Similarly, it is not uncommon for the Kansas City area to receive severe winter weather late in the season, such as snow or freezing rain in March.

4.8.5 Extent

In the winter, the Kansas City area's normal low temperatures are 22.5 degrees in December, 17.8 degrees in January and 23.2 degrees in February.[xiii] However, the area may also experience periods of extreme cold in the wintertime. For example, the lowest temperature on record for the Kansas City area was minus 23 degrees on Dec. 22–23, 1989.[xiv] The winter of 1978–79 had the lowest average seasonal temperature for the Kansas City metropolitan area: 21.5 degrees.[xv]

Exacerbating wintertime cold air temperatures is wind chill. Wind chill is not the actual air temperature, but rather how cold and wind feel on exposed skin.[xvi] As the wind velocity increases, heat is carried away from the body at an accelerated rate, lowering the body temperature.[xvii] People and animals' outdoors are affected by wind chill, a situation that can be dangerous, because hypothermia can result from loss of body heat.

The extent of severe weather storms can be characterized by advisories, watches, and warnings provided by NWS in advance of severe winter weather. These include:

Winter Weather Advisory – Winter weather conditions are expected to cause significant inconveniences and may be hazardous. However, if caution is exercised, these situations should not become life-threatening. In conditions warranting a winter-weather advisory, the greatest hazard is often to motorists.

Winter Storm Watch – A significant winter storm may affect the area, but its occurrence, location and timing are uncertain. A winter storm watch is issued to provide 12 to 36 hours' notice of the possibility of severe winter weather. A watch will often be issued when neither the path of a developing winter storm nor the consequences of the event are well-defined. A winter storm watch may be upgraded to a warning when the nature and location of the developing weather event becomes more apparent.

Winter Storm Warning – A winter storm warning is issued when hazardous winter weather is occurring, imminent or likely. A warning is used for winter weather conditions that may be a threat to life and property. Winter storm warnings are usually issued for heavy snow approaching or exceeding 6 inches, ice accumulations, dangerous wind chills or a combination of these conditions. Warnings can be issued for lesser amounts of snow, 3 to 6 inches, for example, if the snow occurs with strong winds more than 20 miles per hour and/or significant sleet or heavy ice accumulations from freezing rain. In the Central Plains, expected snow accumulation during a winter storm warning is 4 inches or more in 12 hours or 6 inches or more in 24 hours.

Wind Chill Warning – A wind chill warning is issued when life-threatening wind chills reach minus 50 degrees or below.

Ice Storm Warning – An ice storm warning is issued when a significant coating of ice, a quarter of an inch or more, is expected.

Heavy Snow Warning – A heavy snow warning is issued when snow accumulations are expected to approach or exceed 6 inches in 12 hours but will not be accompanied by significant wind. A heavy snow warning could also be issued if 8 inches or more of snow accumulation is expected in a 24-hour period. Sleet and freezing rain are not expected during a heavy snow warning.

Blizzard Warning – A blizzard warning is issued when sustained winds or frequent gusts of 35 mph may occur in combination with considerable falling and/or blowing snow for a period of at least three hours. In a blizzard warning, visibilities will frequently be reduced to less than one-quarter mile, and temperatures will often be extremely cold.

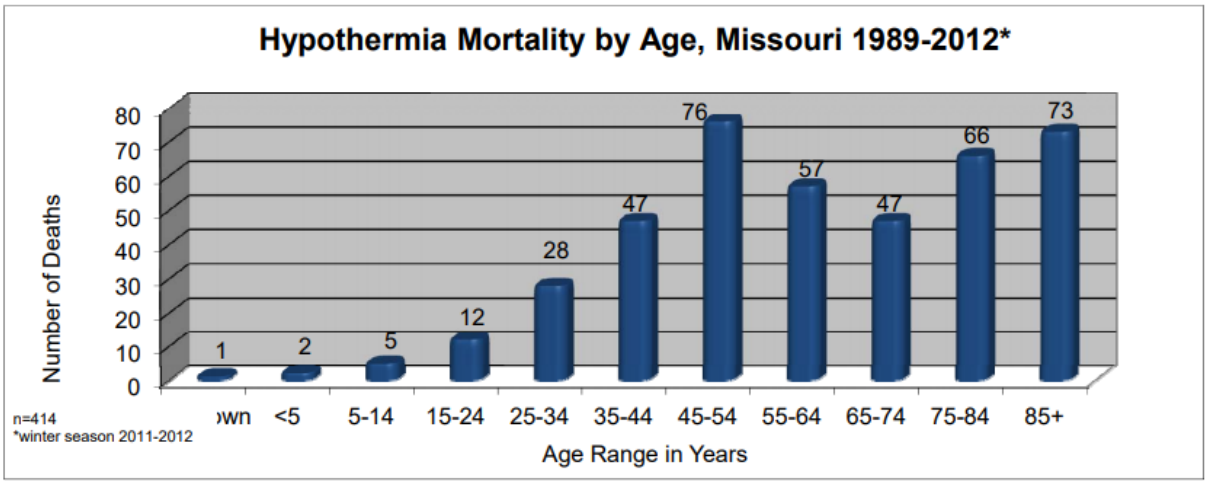
4.8.5a Probable Duration: The dangerous conditions associated with severe winter weather, such as accumulation of snow and ice or extremely low temperatures, can occur within a few hours. Snow and ice may be present for several days; extreme cold may also persist for several days. The cascading effects of severe winter weather, such as utility outages, can also last for several days. In the aftermath of the January 29–31, 2002, ice storm, some parts of the Kansas City area were without electrical power for more than a week.

Potential Speed of Onset (probable amount of warning time):

- ☐ Minimal (or no) warning
- ■ 6 to 12 hours warning
- ☐ 12 to 24 hours warning
- ☐ More than 24 hours warning

4.8.6 Vulnerability Analysis

Winter weather often affects the whole planning area at once. Only a few degrees may be the difference between rain, ice, or snow.[xviii] Vulnerable populations are more susceptible to extreme and winter weather. For instance, senior citizens without proper heating, can find it hard to keep body temperatures up. Figure 4.8.2 is graph created by the Missouri Department of Health and Senior Services showing larger quantities of death by hypothermia in the older age ranges.[xix] Additionally, icy road conditions could cause detrimental slipping and falling. Other vulnerable communities include low-income, children, and the homeless populations. See Planning Profile Appendix for maps of these vulnerable populations.



Source: Missouri Department of Health and Senior Services, Data and Statistical Reports | Note: This data represents the most current data available by the state.

Figure 4.8.2: Hypothermia Mortality by Age, 1989-2012

4.8.7 Problem Statements

Listing vulnerabilities, such as below, can support development of mitigation strategies for severe winter weather:

- Cascading impacts of severe winter weather can have lasting, cross-jurisdictional impacts. Normal mutual-aid partners or regional resources may be unavailable or unable to support response.
- Many critical facilities don't have emergency backup power or rely on generators that will need to be refueled in 24–72 hours.
- Economic impacts from extreme, long-duration winter storms will stress local government resources.
- Debris management/snow removal will likely be a tremendous challenge; many jurisdictions don't have approved debris management plans.
- Vulnerable populations may need assistance with transportation for essential trips or to move to shelter with heat.

[i] NCDC, online data; NWS Winter Storms Preparedness Guide, online document
[ii] USA Today Winter Weather Glossary, online data
[iii] USA Today Winter Weather Glossary, online data
[iv] USA Today Winter Weather Glossary, online data
[v] USA Today Winter Weather Glossary, online data
[vi] USA Today Winter Weather Glossary, online data
[vii] USA Today Winter Weather Glossary, online data
[viii] USA Today Winter Weather Glossary, online data
[ix] USA Today Winter Weather Glossary, online data
[x] News story: https://www.kshb.com/news/local-news/one-killed-in-henry-county-crash-caused-by-slick-roads
[xi] Missouri Highway Patrol Accident Report, https://www.mshp.dps.missouri.gov/HP68/AccidentDetailsAction?ACC_RPT_NUM=180680656
[xii] Missouri Carbon Monoxide Poisoning Surveillance pg. 11, <https://health.mo.gov/living/environment/carbonmonoxide/pdf/co-statistical-report.pdf>
[xiii] NOAA NCDC, online data
[xiv] NWS Kansas City/Pleasant Hill Web site, online data
[xv] NWS Kansas City/Pleasant Hill Web site, online data
[xvi] NWS Winter Storms Preparedness Guide, online document; SEMA State Hazard Analysis, C-1
[xvii] NWS Winter Storms Preparedness Guide, online document
[xviii] SEMA Hazard Mitigation Plan, pg. 354
[xix] Missouri Department of Health and Senior Services, Data and Statistical Reports, https://health.mo.gov/living/healthcondiseases/hypothermia/surveillance.php

FLOODING

FLASH FLOODS, RIVERINE FLOODS, LEVEE FAILURES, & DAM FAILURES

A flood is the partial or complete inundation of normally dry land. The various types of flooding include riverine flooding, coastal flooding, and shallow flooding. Common impacts of flooding include damage to personal property, buildings, and infrastructure; bridge and road closures; service disruptions; and injuries or even fatalities.

4.9 Flooding

Note: Floodplain maps for individual jurisdictions can be found in Appendix C: Maps and References.

With the exception of fires, floods are the most common and widespread of all-natural disasters. Most communities have experienced some type of flooding.[i] Flooding occurs when normally dry areas of land are partially or completely inundated by water.[ii] Floods are caused by a number of conditions, including widespread and/or intense rainfall; runoff from deep snow cover (usually a combination of heavy rain, rapid warming and rapidly melting snow); over-saturated soil (the ground cannot absorb any more water); frozen soil that cannot absorb as much water as soil that is not frozen; high river, stream or reservoir levels preceding heavy or extended rains; ice jams in rivers and streams (these can flood upstream locations and, when they break, downstream locations); and urbanization (large amounts of pavement and buildings inhibit water absorption by the soil and cause rainwater to flow into sewers and drainage ditches and overflow them).[iii] These same conditions that cause flooding have the potential to lead to levee failures and dam failures, resulting in even more extensive flooding. ***Levee Failures*** **and** ***Damn Failures*** are now included in the hazard category of "Flooding" in the 2020 Plan Update.

Several types of flooding have adversely affected the Kansas City area in the past and are expected to put the region at risk in the future: riverine floods, flash floods and sheet floods. Riverine flooding occurs when rivers, streams, lakes, reservoirs or drainage systems overflow due to excessive rainfall, rapid snowmelt or ice jams.[iv] According to FEMA, riverine floods can be either slow- or fast-rising, but generally occur over a period of days, inundating adjacent areas of land.[v] The low, relatively flat land adjoining rivers and streams is known as a floodplain. Floodplains are natural reservoirs for floodwaters, created over thousands of years by floods and the flow of a river or stream's waters.[vi] Floodplains are important components of basins, the land drained by a river and its tributaries. The Kansas City area, along with most of the northern and central parts of the state, lies within the Missouri River Basin. As a result, a significant portion of the region lies within floodplains.[vii]

Common nomenclature associated with riverine floods and floodplains include the terms "10-year flood," "50-year flood," "100-year flood," and "500-year flood." These terms describe the probability of flooding in any given year and are primarily used to determine flood insurance rates in flood hazard areas.[viii] A 10-year flood, for example, has a 10 percent chance of occurring in any given year; a 50-year flood has a 2 percent chance of occurring; a 100-year flood has a 1 percent chance of occurring; and a 500-year flood has a 0.2 percent chance of occurring. Because these terms are measures of probability, an event such as a 100- or 500-year flood has the same chance of occurring each year, regardless of when floods of similar magnitude have occurred, even if the occurrence was the previous year.[ix]

Although riverine floods are more damaging to property, flash floods are the most dangerous type of flooding that may affect the Kansas City area. Flash floods are generally caused by heavy rainfall over a short period of time, though they can also be caused by the breaching or overtopping of dams.[x] According to SEMA, flash flooding frequently impacts small rivers, creeks, streams, canals and drainage ditches and is characterized by a rapid accumulation or runoff of surface water from any source. Most flood-related deaths are the result of flash floods, which are likely to occur with little or no warning and can reach full peak in minutes.[xi]

Sheet floods may also affect portions of the Kansas City area. Sheet flooding is caused by a combination of excessive rainfall or snowmelt, over-saturated ground and inadequate drainage. Sheet flooding is a byproduct of urbanization and development and may occur in areas that are not within a floodplain. In

sheet flooding, water spreads out across the surface of the ground toward areas of lowest elevation, rather than flowing into a defined stream channel.[xii] Large amounts of pavement (e.g., roads and parking lots) and buildings facilitate the flow of rainwater into areas of low elevation and into drainage systems that cannot properly carry and disburse the tremendous amount of water produced by intense storm events. In this type of flooding, water may back up into residential and commercial property, particularly the basements of these structures, damaging mechanical systems, floors, walls, furniture and fixtures, and creating public health and safety problems.[xiii]

The average number of flood deaths in the United States has increased in recent years. From 1998-2018, an average of 86 people died in floods each year. From 2008-2018, the average rose to 95 fatalities each year. From 2015-2018, the average rose to over 100 fatalities each year due to flooding.[xiv] The Weather Chanel states that as climate change increases, the risk of heavy rainfall will increase. Causing the average number of flood deaths to increase.[xv]

The plan narrative and GIS maps provide information on specific locations within the region's cities and counties where past riverine and flash floods have resulted in human casualties or property damage. The information also provides location-specific information on areas subject to future flooding, including identification of 100-year and 500-year flood-prone areas.

The NWS provides advisories, watches, warnings and related products in advance of flooding. These include[xvi]:

Flash Flood Warning – Urban and small-stream flash flooding is imminent or is in progress and is life threatening.

Flood Warning – Major river flooding is imminent or in progress.

Flash Flood/Flood Watch – A threat of flash flooding or flooding exists, but an occurrence is not yet certain or imminent. A watch is usually issued with six or more hours of lead time.

Small-Stream Flood Warning – Small-stream flooding is imminent or in progress. Flooding is not life threatening but is causing property damage.

Urban Flood Warning – Urban flooding is imminent or in progress. Flooding is not life threatening but is causing property damage.

Urban and Small-Stream Flood Warning – Urban and small-stream flooding is imminent or in progress. Flooding is not life threatening but is causing property damage.

Urban and Small-Stream Flood Advisory – Urban and/or small-stream flooding is a significant inconvenience. Flooding is not life threatening or causing property damage.

Flash Flood Statement – Issued to provide more information on a Flash Flood Watch or Warning, or to cancel all or part of those products.

Flood Statement – Issued to provide more information on a Flood Watch, Warning or Advisory, or to cancel all or part of those products.

Local Storm/Spotter Report – Issued to report flash flooding or other types of flooding by time, location and effect, e.g., damage, deaths or injuries; also, includes the information source.

4.9.1 Historical Occurrences

Unfortunately, the Kansas City area has a long history of flooding. Several of the region's largest and most destructive riverine floods include the Flood of 1844, Flood of 1903, Flood of 1951 and the Great Midwest Flood of 1993. Examples of some of the most significant flash floods to affect the Kansas City area include the Sept. 12, 1977 Flash Flood and the Oct. 4, 1998 Flash Flood. Table 4.9.1 depicts flooding events between 2014-2019. Table 4.9.2 depict flooding events by county occurring during 2019-2024.

Table 4.9.1: Kansas City Area Flood Events by County (2015- April 2019)

County	Location	Date	Event Type	Deaths	Injuries	Property Damage $	Crop Damage $	Cause
Cass	FREEMAN	5/30/2016	Flash Flood	0	0	0	0	Heavy Rain
Cass	AVON	7/27/2017	Flash Flood	0	0	0	0	Heavy Rain
Cass	FREEMAN	7/27/2017	Flood	0	0	0	0	Heavy Rain
Cass	PLEASANT HILL	7/27/2017	Flood	0	0	0	0	Heavy Rain
Cass	HARRISONVILLE	8/22/2017	Flash Flood	0	0	0	0	Heavy Rain
Cass	STRASBURG	8/22/2017	Flash Flood	0	0	0	0	Heavy Rain
Cass	BELTON VILLNAVE ARPT	8/22/2017	Flash Flood	0	0	0	0	Heavy Rain
Cass	PLEASANT HILL ARPT	3/26/2018	Flash Flood	0	0	0	0	Heavy Rain
Cass	PLEASANT HILL	3/26/2018	Flash Flood	0	0	0	0	Heavy Rain
Cass	AVON	4/30/2019	Flash Flood	0	0	0	0	Heavy Rain
County	**Location**	**Date**	**Event Type**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**	**Cause**
Clay	GLENAIRE	5/16/2015	Flash Flood	0	0	0	0	Heavy Rain
Clay	LIBERTY	5/16/2015	Flash Flood	0	0	0	0	Heavy Rain
Clay	PRATHERSVILLE	5/17/2015	Flash Flood	0	0	0	0	Heavy Rain
Clay	KEARNEY	5/17/2015	Flash Flood	0	0	0	0	Heavy Rain
Clay	EXCELSIOR SPGS	6/3/2015	Flash Flood	0	0	0	0	Heavy Rain
Clay	EXCELSIOR SPGS ARPT	6/3/2015	Flash Flood	0	0	0	0	Heavy Rain

Clay	ARLEY	6/4/2015	Flash Flood	0	0	0	0	Heavy Rain
Clay	MOSBY	6/4/2015	Flash Flood	0	0	0	0	Heavy Rain
Clay	KEARNEY	6/21/2015	Flash Flood	0	0	0	0	Heavy Rain
Clay	EXCELSIOR SPGS	6/21/2015	Flash Flood	0	0	0	0	Heavy Rain
Clay	MOSBY	6/26/2015	Flash Flood	0	0	0	0	Heavy Rain
Clay	STOCKDALE	4/26/2016	Flash Flood	0	0	0	0	Heavy Rain
Clay	NORTH KANSAS CITY	5/23/2016	Flash Flood	0	0	0	0	Heavy Rain
Clay	GASHLAND	5/23/2016	Flash Flood	0	0	0	0	Heavy Rain
Clay	PRATHERSVILLE	7/3/2016	Flash Flood	0	0	0	0	Heavy Rain
Clay	KEARNEY	8/26/2016	Flash Flood	0	0	0	0	Heavy Rain
Clay	BIGHAM HGT	8/26/2016	Flash Flood	0	0	0	0	Heavy Rain
Clay	MOSBY	8/27/2016	Flood	0	0	0	0	Heavy Rain
Clay	OAKWOOD	7/26/2017	Flash Flood	0	0	0	0	Heavy Rain
Clay	GASHLAND	7/26/2017	Flash Flood	0	0	0	0	Heavy Rain
Clay	GLADSTONE	7/26/2017	Flash Flood	0	0	0	0	Heavy Rain
Clay	NORTH KANSAS CITY	8/5/2017	Flash Flood	0	0	0	0	Heavy Rain
Clay	GASHLAND	8/5/2017	Flash Flood	0	0	0	0	Heavy Rain
Clay	NASHUA	8/21/2017	Flood	0	0	0	0	Heavy Rain
Clay	KEARNEY	8/21/2017	Flood	0	0	0	0	Heavy Rain
Clay	NASHUA	8/21/2017	Flood	0	0	0	0	Heavy Rain
Clay	MOSBY	8/21/2017	Flash Flood	0	0	0	0	Heavy Rain
Clay	LIBERTY	8/21/2017	Flash Flood	0	0	0	0	Heavy Rain
Clay	SMITHVILLE	8/21/2017	Flash Flood	0	0	0	0	Heavy Rain
Clay	NORTH KANSAS CITY	10/8/2018	Flash Flood	0	0	0	0	Heavy Rain
Clay	NORTH KANSAS CITY	4/1/2019	Flood	0	0	0	0	Heavy Rain
County	**Location**	**Date**	**Event Type**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**	**Cause**
Jackson	KANSAS CITY	5/16/2015	Flash Flood	0	0	0	0	Heavy Rain

Jackson	RED BRIDGE	5/16/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY DWTN	5/17/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	5/17/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY DWTN	5/17/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	RED BRIDGE	6/3/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY DWTN	6/3/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	DODSON	6/3/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	DODSON	6/3/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	RAYTOWN	6/3/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	LEEDS	6/3/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	LEEDS	6/3/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	SOUTH LEE	7/1/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	BELVIDERE	7/1/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	SOUTH LEE	7/1/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	GREENWOOD	7/1/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	BELVIDERE	7/1/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY HEART AR	7/6/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	LEEDS	7/20/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	9/10/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	9/10/2015	Flash Flood	0	0	0	0	Heavy Rain
Jackson	BLUE SPGS	5/26/2016	Flash Flood	0	0	0	0	Heavy Rain
Jackson	OAK GROVE	7/3/2016	Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	8/26/2016	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY DWTN	3/6/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	7/27/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	7/27/2017	Flash Flood	0	0	0	0	Heavy Rain

Jackson	LEEDS	7/27/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	DODSON	7/27/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	DODSON	7/27/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	DODSON	7/27/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	HOLMES PARK	7/27/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	8/5/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	8/5/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	LEEDS	8/5/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	8/5/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	SUGAR CREEK	8/5/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	8/5/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	8/5/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KNOBTOWN	8/5/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	8/5/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	8/5/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	DODSON	8/5/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	GRAIN VLY	8/6/2017	Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	8/21/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	8/21/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	8/21/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	8/21/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	8/22/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	(GVW)RICHARDS-GEBAUR	8/22/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	DODSON	8/22/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	RED BRIDGE	8/22/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	LEEDS	8/22/2017	Flash Flood	0	0	0	0	Heavy Rain

Jackson	MARTIN CITY	8/22/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	RED BRIDGE	8/22/2017	Flash Flood	0	0	0	0	Heavy Rain
Jackson	SNI MILLS	3/26/2018	Flash Flood	0	0	0	0	Heavy Rain
Jackson	FAIRMONT	5/25/2018	Flood	0	0	0	0	Heavy Rain
Jackson	SUGAR CREEK	10/8/2018	Flash Flood	0	0	0	0	Heavy Rain
Jackson	DODSON	10/8/2018	Flash Flood	0	0	0	0	Heavy Rain
Jackson	HOLMES PARK	4/30/2019	Flood	0	0	0	0	Heavy Rain
Jackson	UNITY VLG	4/30/2019	Flood	0	0	0	0	Heavy Rain
County	**Location**	**Date**	**Event Type**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**	**Cause**
Platte	FARLEY	6/3/2015	Flash Flood	0	0	0	0	Heavy Rain
Platte	HAMPTON	6/3/2015	Flash Flood	0	0	0	0	Heavy Rain
Platte	RIDGELY	7/6/2015	Flash Flood	0	0	0	0	Heavy Rain
Platte	WESTON	7/6/2015	Flash Flood	0	0	0	0	Heavy Rain
Platte	WESTON	7/6/2015	Flash Flood	0	0	0	0	Heavy Rain
Platte	EDGERTON	7/6/2015	Flash Flood	0	0	0	0	Heavy Rain
Platte	LINKVILLE	9/10/2015	Flash Flood	0	0	0	0	Heavy Rain
Platte	TIFFANY SPGS	9/10/2015	Flash Flood	0	0	0	0	Heavy Rain
Platte	PARKVILLE	4/26/2016	Flash Flood	0	0	0	0	Heavy Rain
Platte	EDGERTON	4/26/2016	Flash Flood	0	0	0	0	Heavy Rain
Platte	FERRELVIEW	5/26/2016	Flash Flood	0	0	0	0	Heavy Rain
Platte	RIVERSIDE	5/26/2016	Flash Flood	0	0	0	0	Heavy Rain
Platte	WALDRON	7/3/2016	Flash Flood	0	0	0	0	Heavy Rain
Platte	PARKVILLE	7/3/2016	Flood	0	0	0	0	Heavy Rain
Platte	RIVERSIDE	8/5/2017	Flash Flood	0	0	0	0	Heavy Rain
Platte	WALDRON	8/5/2017	Flash Flood	0	0	0	0	Heavy Rain
Platte	PLATTE WOODS	8/5/2017	Flash Flood	0	0	0	0	Heavy Rain

Platte	BARRY	8/21/2017	Flash Flood	0	0	0	0	Heavy Rain
Platte	PARKVILLE	8/21/2017	Flash Flood	0	0	0	0	Heavy Rain
Platte	RIVERSIDE	8/21/2017	Flash Flood	0	0	0	0	Heavy Rain
Platte	RIVERSIDE	8/21/2017	Flash Flood	0	0	0	0	Heavy Rain
Platte	NORTHMOOR	8/22/2017	Flash Flood	0	0	0	0	Heavy Rain
Platte	BEAN LAKE	3/14/2019	Flood	0	0	100,000	100,000	Heavy Rain/Snow Melt
Platte	BEAN LAKE	4/1/2019	Flood	0	0	0	0	Heavy Rain
County	**Location**	**Date**	**Event Type**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**	**Cause**
Ray	LAWSON	6/3/2015	Flash Flood	0	0	0	0	Heavy Rain
Ray	VIBBARD	6/3/2015	Flash Flood	0	0	0	0	Heavy Rain
Ray	FLEMING	6/3/2015	Flash Flood	0	0	0	0	Heavy Rain
Ray	LAWSON	6/4/2015	Flash Flood	0	0	0	0	Heavy Rain
Ray	RICHMOND	6/21/2015	Flash Flood	0	0	0	0	Heavy Rain
Ray	UNION	9/14/2016	Flood	0	0	0	0	Heavy Rain
Ray	FLOYD	4/1/2019	Flood	0	0	0	0	Heavy Rain

Source: NOAA NCDC Web site

Table 4.9.2: Kansas City Area Flood Events by County (May 2019- November 2024)

County	Location	Date	Event Type	Deaths	Injuries	Property Damage $	Crop Damage $	Cause
Cass	HARRISONVILLE	5/24/19	Flash Flood	0	0	0	0	Heavy Rain
Cass	EAST LYNNE ARPT	7/4/19	Flash Flood	0	0	0	0	Heavy Rain
Cass	PLEASANT HILL	7/4/19	Flash Flood	0	0	0	0	Heavy Rain
Cass	STRASBURG	7/5/19	Flash Flood	0	0	0	0	Heavy Rain
Cass	HARRISONVILLE	9/28/19	Flash Flood	0	0	0	0	Heavy Rain
Cass	PECULIAR	5/28/20	Flash Flood	0	0	0	0	Heavy Rain

Cass	PECULIAR	4/28/21	Flash Flood	0	0	0	0	Heavy Rain
Cass	HARRISONVILLE	4/28/21	Flash Flood	0	0	0	0	Heavy Rain
Cass	FREEMAN	4/28/21	Flash Flood	0	0	0	0	Heavy Rain
Cass	WEST LINE	4/28/21	Flash Flood	0	0	0	0	Heavy Rain
Cass	CREIGHTON	5/27/21	Flash Flood	0	0	0	0	Heavy Rain
Cass	EAST LYNNE ARPT	5/27/21	Flash Flood	0	0	0	0	Heavy Rain
Cass	GARDEN CITY	6/25/21	Flash Flood	0	0	0	0	Heavy Rain
Cass	LISLE	6/28/21	Flash Flood	0	0	0	0	Heavy Rain
County	**Location**	**Date**	**Event Type**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**	**Cause**
Clay	NORTH KANSAS CITY	5/24/19	Flash Flood	0	0	0	0	Heavy Rain
Clay	MOSBY	5/24/19	Flash Flood	0	0	0	0	Heavy Rain
Clay	SMITHVILLE	5/28/19	Flash Flood	0	0	0	0	Heavy Rain
Clay	ARLEY	9/27/19	Flash Flood	0	0	0	0	Heavy Rain
Clay	NORTH KANSAS CITY	5/28/20	Flash Flood	0	0	0	0	Heavy Rain
County	**Location**	**Date**	**Event Type**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**	**Cause**
Jackson	KANSAS CITY	5/24/19	Flash Flood	0	0	0	0	Heavy Rain
Jackson	BLUE SUMMIT	5/24/19	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	6/21/19	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	6/21/19	Flash Flood	0	0	0	0	Heavy Rain
Jackson	EAST INDEPENDENCE	6/21/19	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	6/21/19	Flash Flood	0	0	0	0	Heavy Rain
Jackson	SOUTH LEE	7/4/19	Flash Flood	0	0	0	0	Heavy Rain
Jackson	OAK GROVE	7/4/19	Flash Flood	0	0	0	0	Heavy Rain
Jackson	LAKE LOTAWANA	7/4/19	Flash Flood	0	0	0	0	Heavy Rain

Jackson	GRANDVIEW	7/4/19	Flash Flood	0	0	0	0	Heavy Rain
Jackson	TARSNEY LAKES	9/5/20	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	5/16/21	Flash Flood	0	0	0	0	Heavy Rain
Jackson	KANSAS CITY	7/1/24	Flash Flood	0	0	$5,000	$1,000	Heavy Rain
Jackson	KANSAS CITY	7/1/24	Flash Flood	0	0	$5,000	$1,000	Heavy Rain
County	**Location**	**Date**	**Event Type**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**	**Cause**
Platte	WALDRON	04/28/2021	Flash Flood	0	0	0	0	Heavy Rain
County	**Location**	**Date**	**Event Type**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**	**Cause**
Ray	VIBBARD	06/25/2021	Flood	0	0	0	0	Heavy Rain

June 28, 2021 – Cass County
Heavy rain produced some marginal flash flooding in Miami County Kansas and nearby Bates County Missouri. MODOT reported that HWY 18 was closed due to flooding.

May 28, 2020 – Clay County
On the morning of May 28 there was some minor flash flooding, causing some roads in the area to shut down briefly. There was flooding on the ramp of Briarcliff and Southbound HWY 9.

July 1, 2024 – Jackson County
During the morning and early afternoon hours of July 1st, heavy rainfall yielded flash flooding across much of the southern two thirds of Jackson County. A swath of 3 to 6 of rain with isolated locations up to 7 fell within about a 3 hour time period from about 930 am to 1230 pm. Up to 6 inches of rain fell across portions of Jackson County within a span of a couple hours, causing widespread flash flooding across much of Jackson County. Major roadways were flooded and closed down, with several water rescues.

April 28, 2021 – Platte County
After heavy rain moved through the Kansas City Metro several local roadways were inundated with running water. After 1-2 inches of rain fell over a short period of time there was flooding along Jones-Myer Road and Hillsboro Road near Waldron.

June 25, 2021 – Ray County
Late in the afternoon, and through the evening hours on June 24 a cluster of storms over southeast Nebraska congealed into a line of thunderstorms that focused across northern Missouri. Most notably within this line of storms was a cluster of QLCS tornadoes that formed in Grundy County. There may have been other tornadoes associated with circulations that were noted on radar, but emergency management confirmed damage consistent with tornadoes near Trenton and Laredo Missouri. Most of the damage was minor, but some grain bins being blown off their foundation was the highlight of the damage in the area. Rainfall was the other big story with this event as some areas received 6 to 10

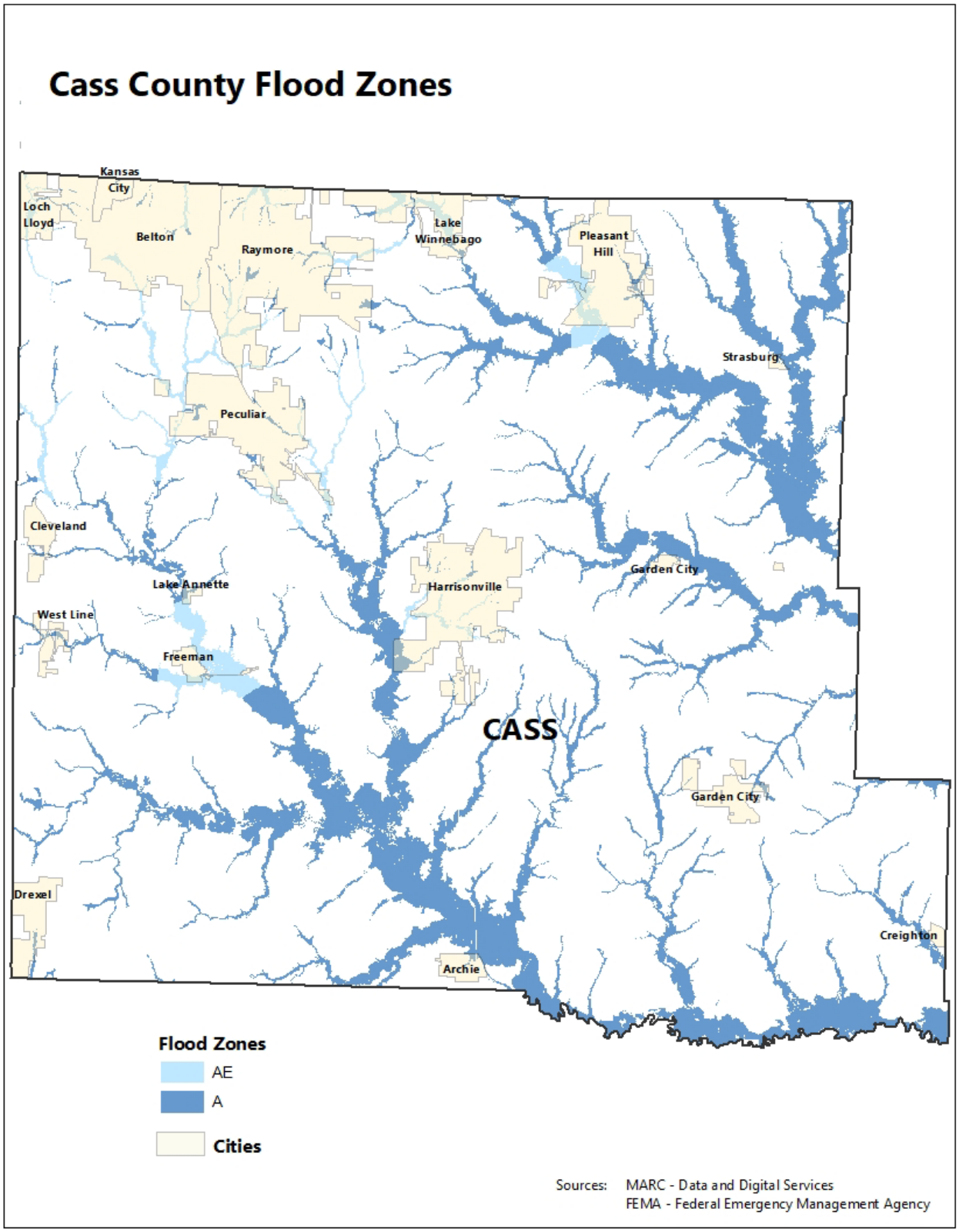
inches of rain. Despite the excessive rain, the flash flooding was rather minor, however there were still numerous roads closed, and areas near Excelsior Springs were especially hard hit as the Fishing River rose out of its banks. Another semi-dramatic event occurred along I-29 just north of St. Joseph, where a crane that was being used to do road construction became unbalanced and tipped. Numerous water rescues occurred across Ray County.

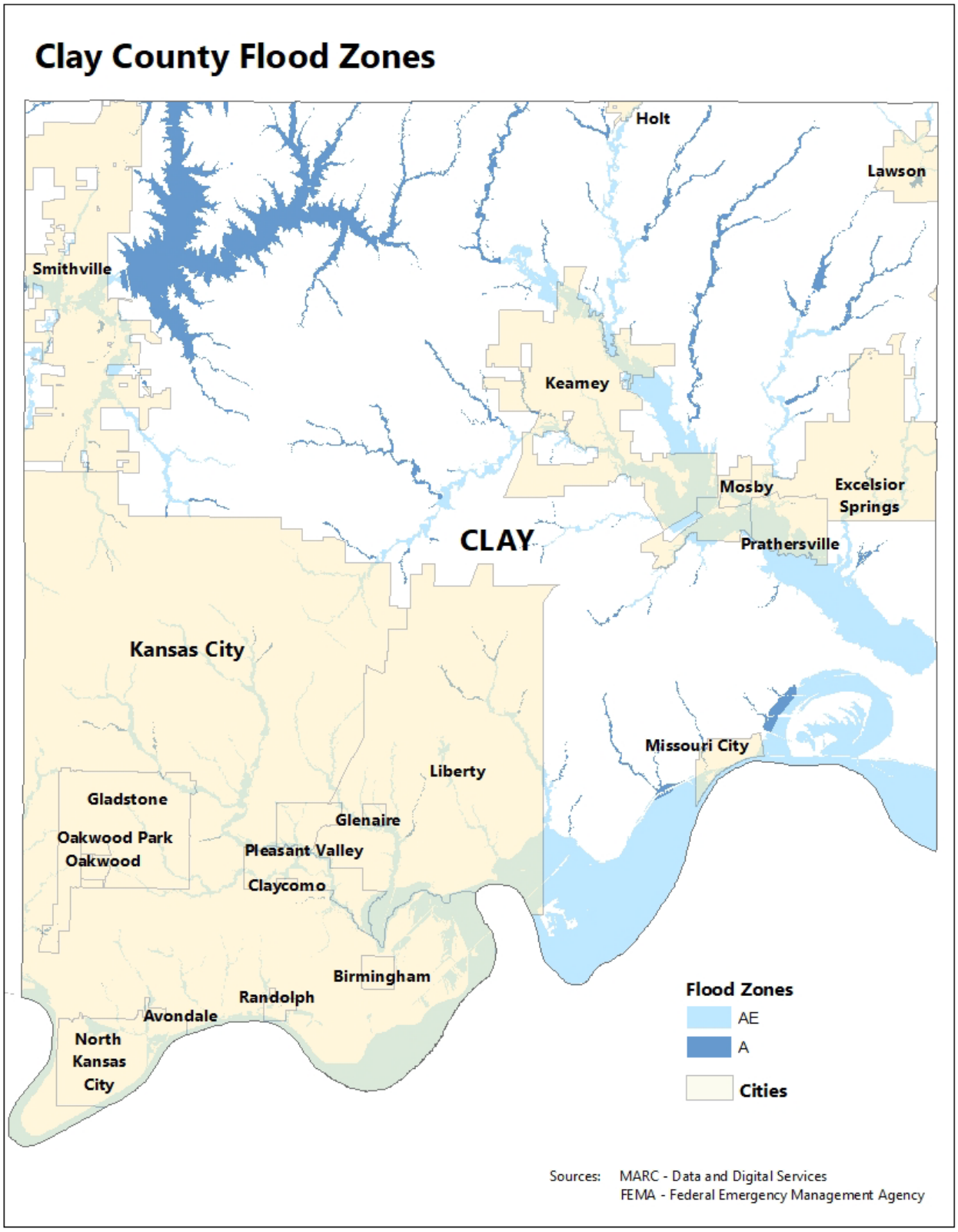
4.9.2 Probable Locations

Magnitude 25%- 50%

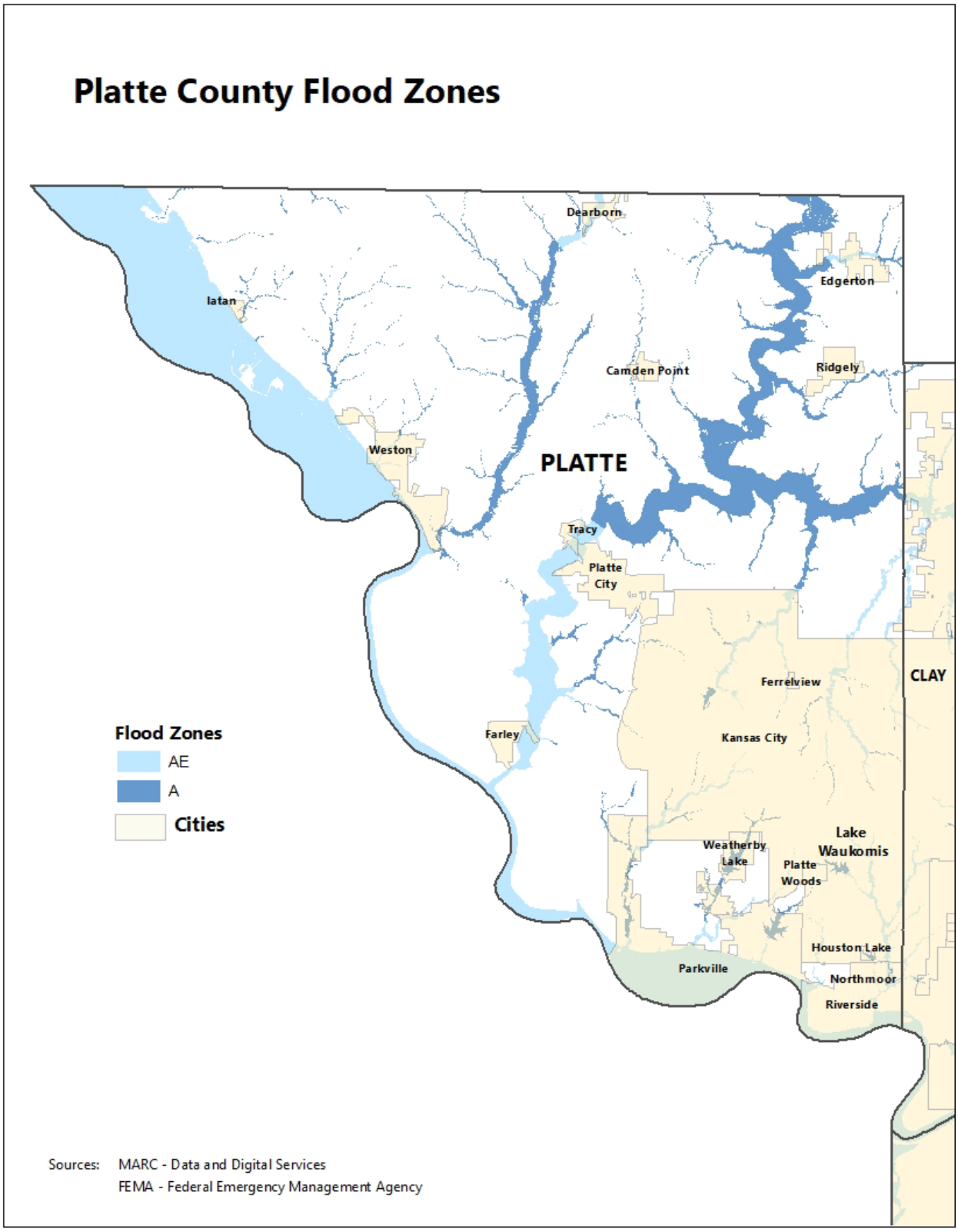
Areas in the Kansas City area most susceptible to flooding continue to include the Missouri River floodplain; areas near the Blue River in South Kansas City; Indian Creek near Red Bridge Road; portions of Martin City and South Kansas City near Red Bridge Road; the Brush Creek Basin near Highway 71; the intersection of I-35 and I-70 and adjacent surface streets; areas in the northeast, such as 9th Street, Hardesty, Gardner and Chouteau Trafficways; Southwest Boulevard and surrounding areas; State Line Road and 95th Street; Turkey Creek near 31st Street; Fairmont; and Westport. Due to flooding happening along rivers and in the floodplain, all counties were given a 35% - 50% magnitude rating.

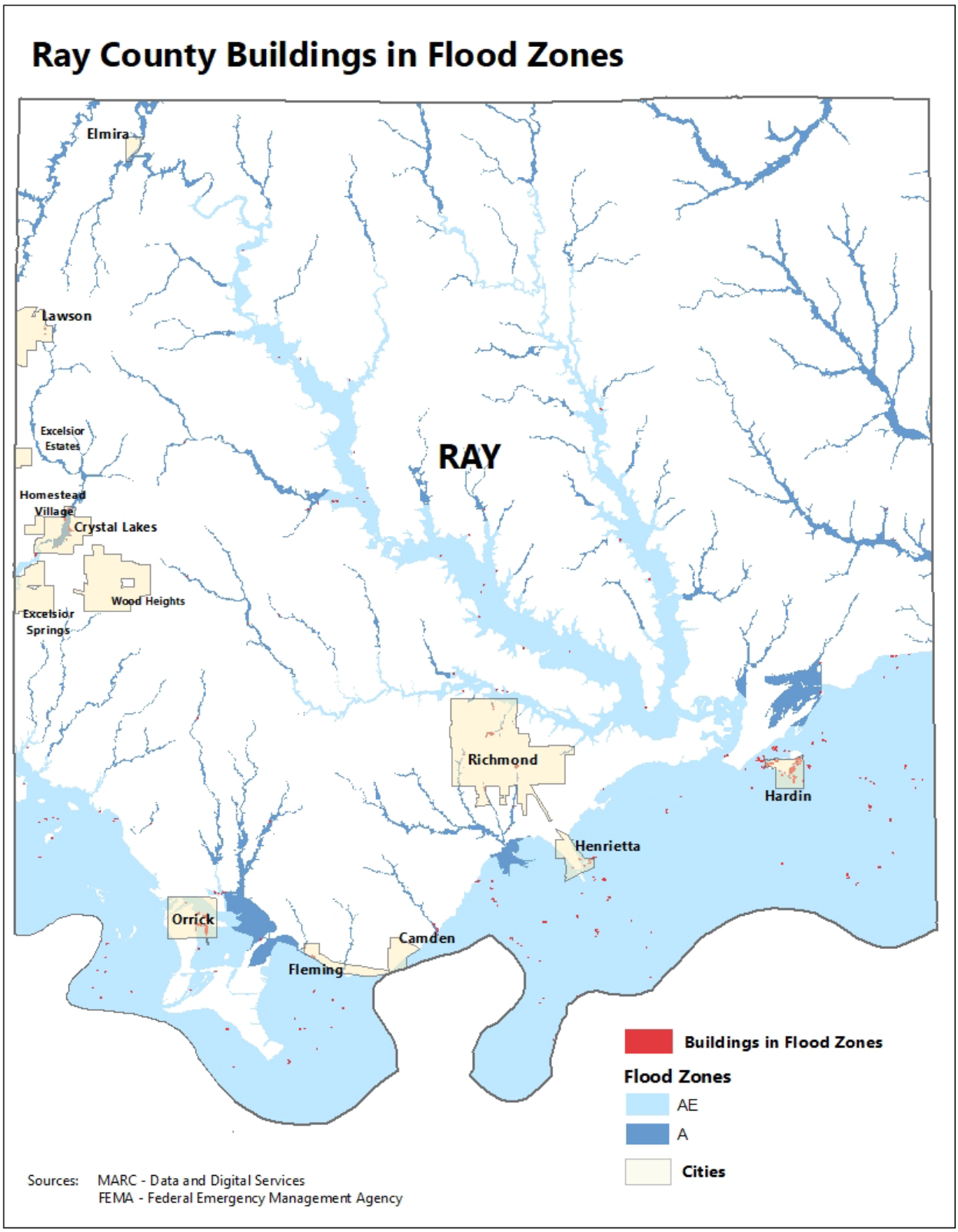
The maps below depict the flood zones in each county.


Cass County Flood Zones
Kansas City
Loch Lloyd
Belton
Raymore
Lake Winnebago
Pleasant Hill
Strasburg
Peculiar
Cleveland
Lake Annette
West Line
Freeman
Harrisonville
Garden City
CASS
Garden City
Drexel
Creighton
Archie
Flood Zones
AE
A
Cities
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency


Clay County Flood Zones
Holt
Lawson
Smithville
Keamey
Mosby
Excelsior Springs
CLAY
Prathersville
Kansas City
Missouri City
Liberty
Gladstone
Glenaire
Oakwood Park
Oakwood
Pleasant Valley
Claycomo
Birmingham
Randolph
Avondale
North Kansas City
Flood Zones
AE
A
Cities
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency


Jackson County Flood Zones
River Bend
Sugar Creek
Sibley
Buckner
Levasy
Independence
JACKSON
Kansas City
Blue Springs
Lake Tapawingo
Grain Valley
Oak Grove
Raytown
Unity Village
Lake Lotawana
Lee's Summit
Grandview
Lone Jack
Greenwood
Flood Zones
AE
A
Cities
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency


Platte County Flood Zones
Dearborn
Edgerton
Iatan
Camden Point
Ridgely
Weston
PLATTE
Tracy
Platte City
CLAY
Ferrelview
Farley
Kansas City
Lake Waukomis
Weatherby Lake
Platte Woods
Houston Lake
Parkville
Northmoor
Riverside
Flood Zones
AE
A
Cities
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency


Ray County Buildings in Flood Zones
Elmira
Lawson
Excelsior Estates
RAY
Homestead Village
Crystal Lakes
Wood Heights
Excelsior Springs
Richmond
Hardin
Henrietta
Orrick
Camden
Fleming
Buildings in Flood Zones
Flood Zones
AE
A
Cities
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency

4.9.3 Impact

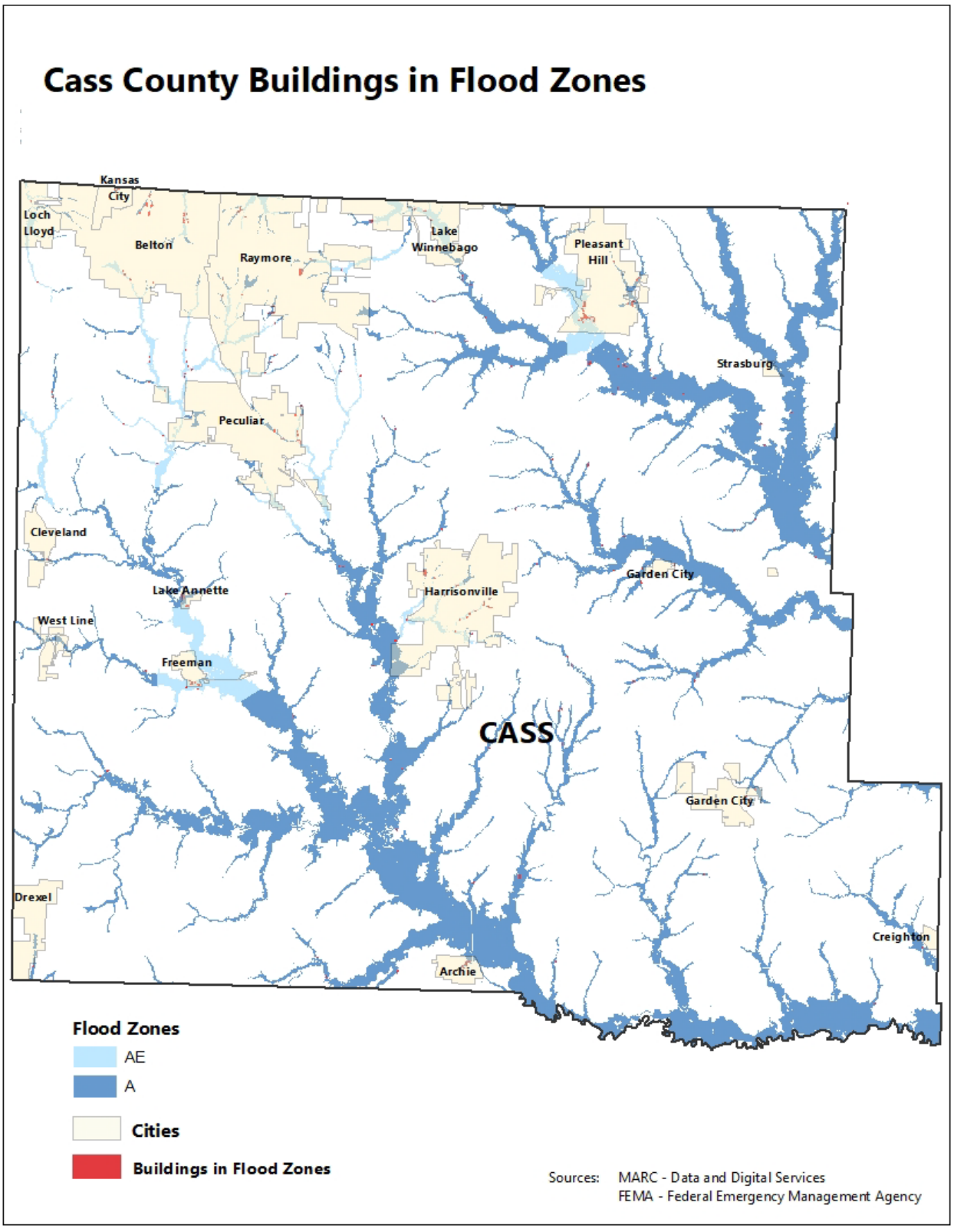
Although most flooding events cause little to no damage, there is the potential for massive loss of life and property. Since 1993, the region has suffered a cumulative total 11 deaths, $1.6 million in crop damages, and over $32 million in property damage as a result of floods, according to the National Center for Environmental Information. The damage values are estimates from the Storm Events Database and only show values that are reported. Property and crop damage values are most likely much higher than reported values.

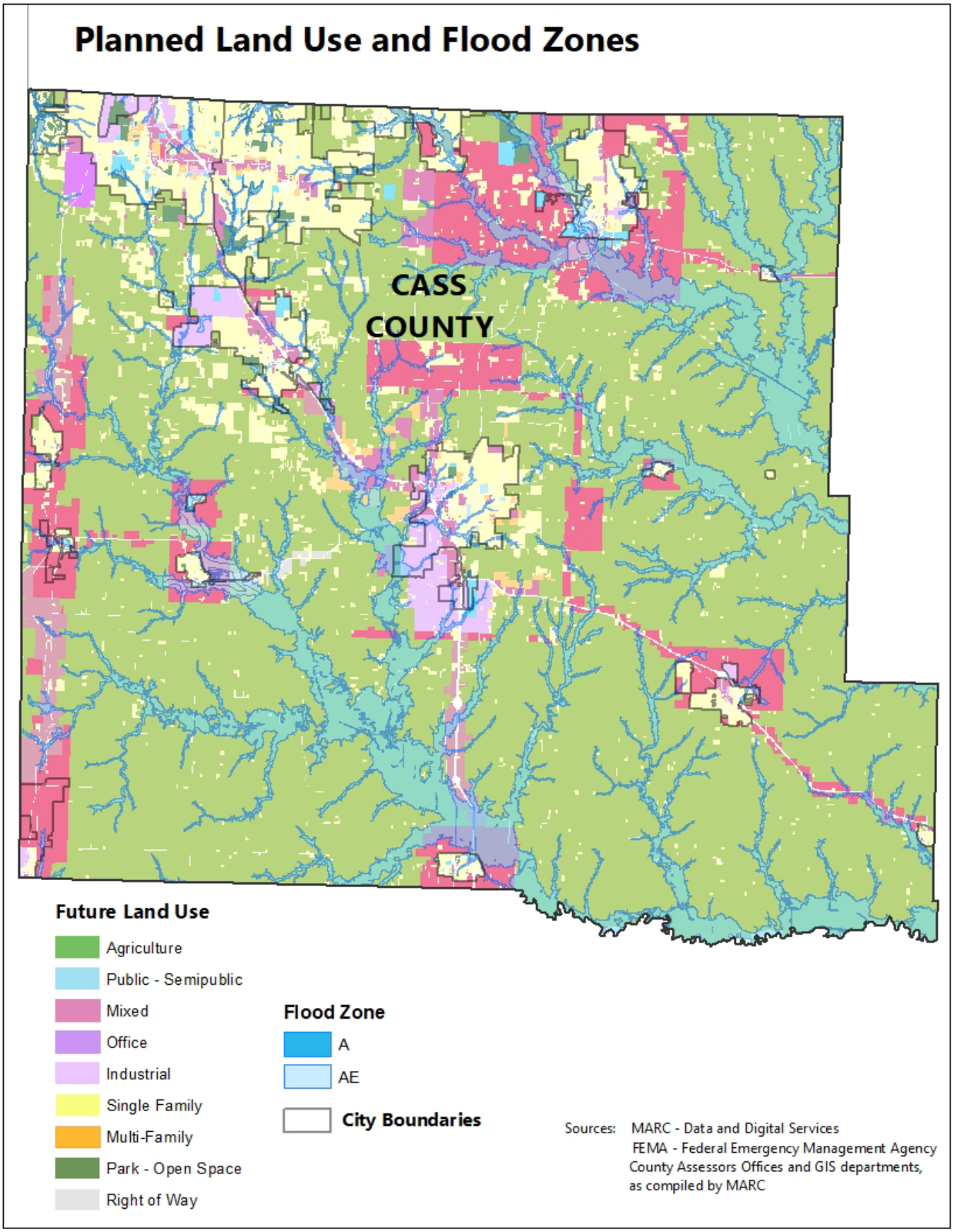
All facilities are susceptible to the hazard. Table 4.9.3 below summarizes the number and type of facilities for all counties in the floodplain.

Table 4.9.3: Number and Type of Facilities in the Floodplain

County	Buildings in Floodplain	Commercial Buildings in Floodplain	Residential Buildings in Floodplain	Other Buildings in Floodplain	Hazardous Materials in Floodplain	Types of Critical Facilities in Floodplain
Cass County	313	15	271	27	2	Dams, hazardous materials facilities, municipal buildings, police station
Clay County	663	74	313	276	72	Airports, childcare centers, dams, fire/EMS facilities, hazardous materials facilities, municipal building, police station, schools, college, nursing home
Jackson County	188	7	60	121	132	Hazardous materials facilities, fire/EMS facilities, dams, colleges, childcare centers, municipal building, police station
Platte County	262	14	131	117	26	Airports, dams, fire/EMS facilities, hazardous materials facilities, municipal building
Ray County	562	25	504	33	4	Airport, hazardous materials facilities, police station, schools, dams

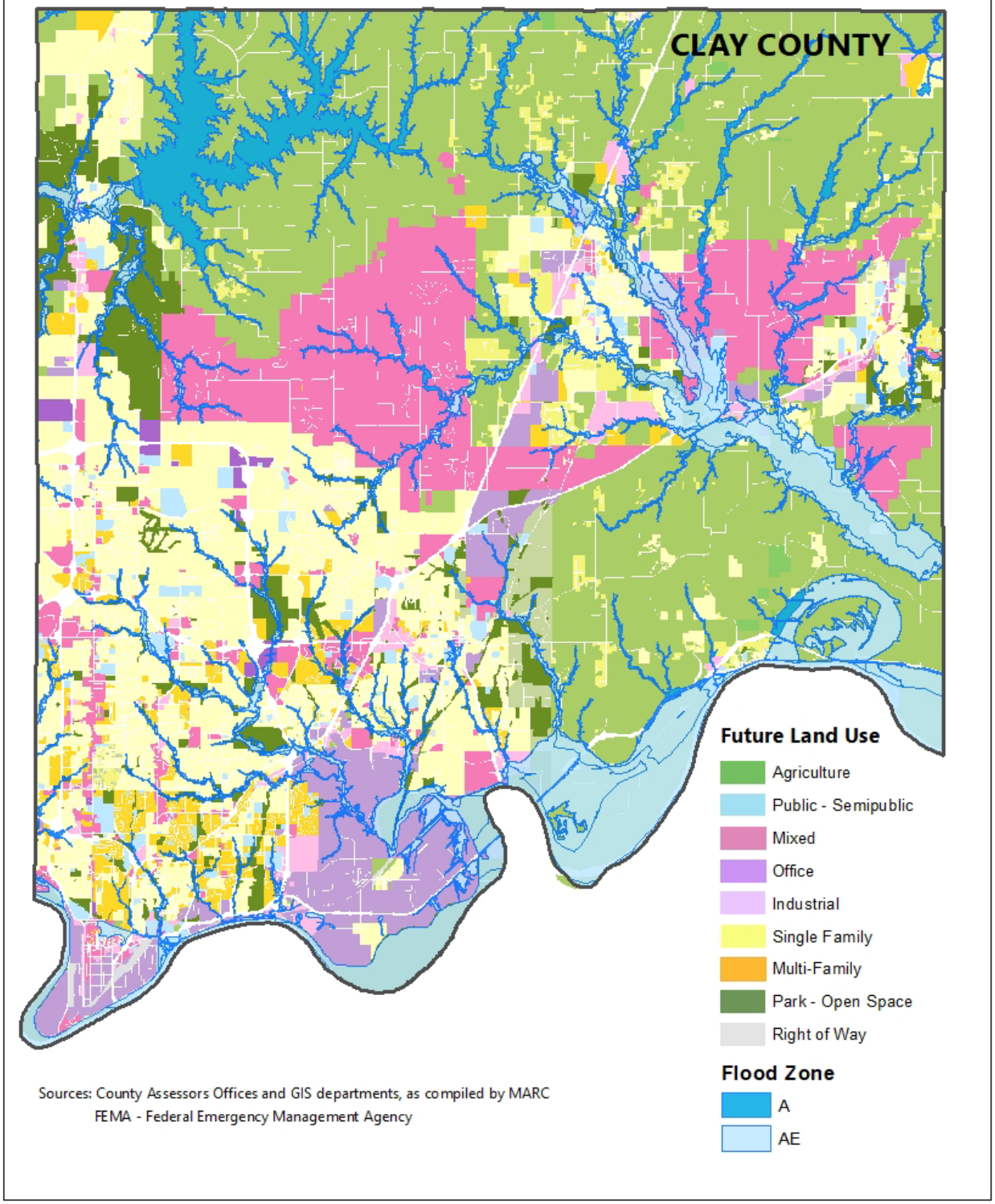
The maps below depict the buildings in the flood zone and future land use areas that are in the flood zone in each county. The future land use areas represent the impact of flooding on future development.



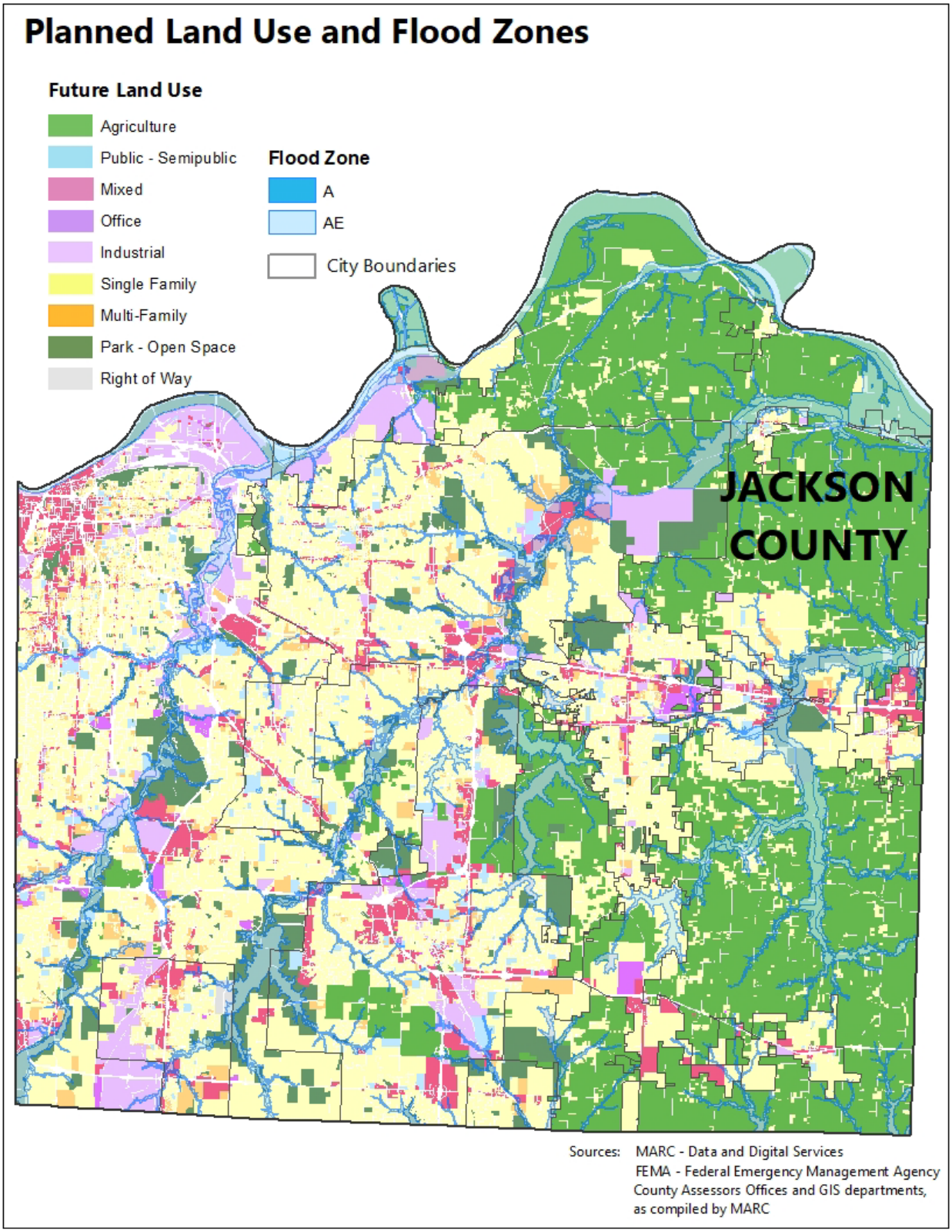

Planned Land Use and Flood Zones
CASS
COUNTY
Future Land Use
Agriculture
Public - Semipublic
Mixed
Office
Industrial
Single Family
Multi-Family
Park - Open Space
Right of Way
Flood Zone
A
AE
City Boundaries
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency
County Assessors Offices and GIS departments,
as compiled by MARC

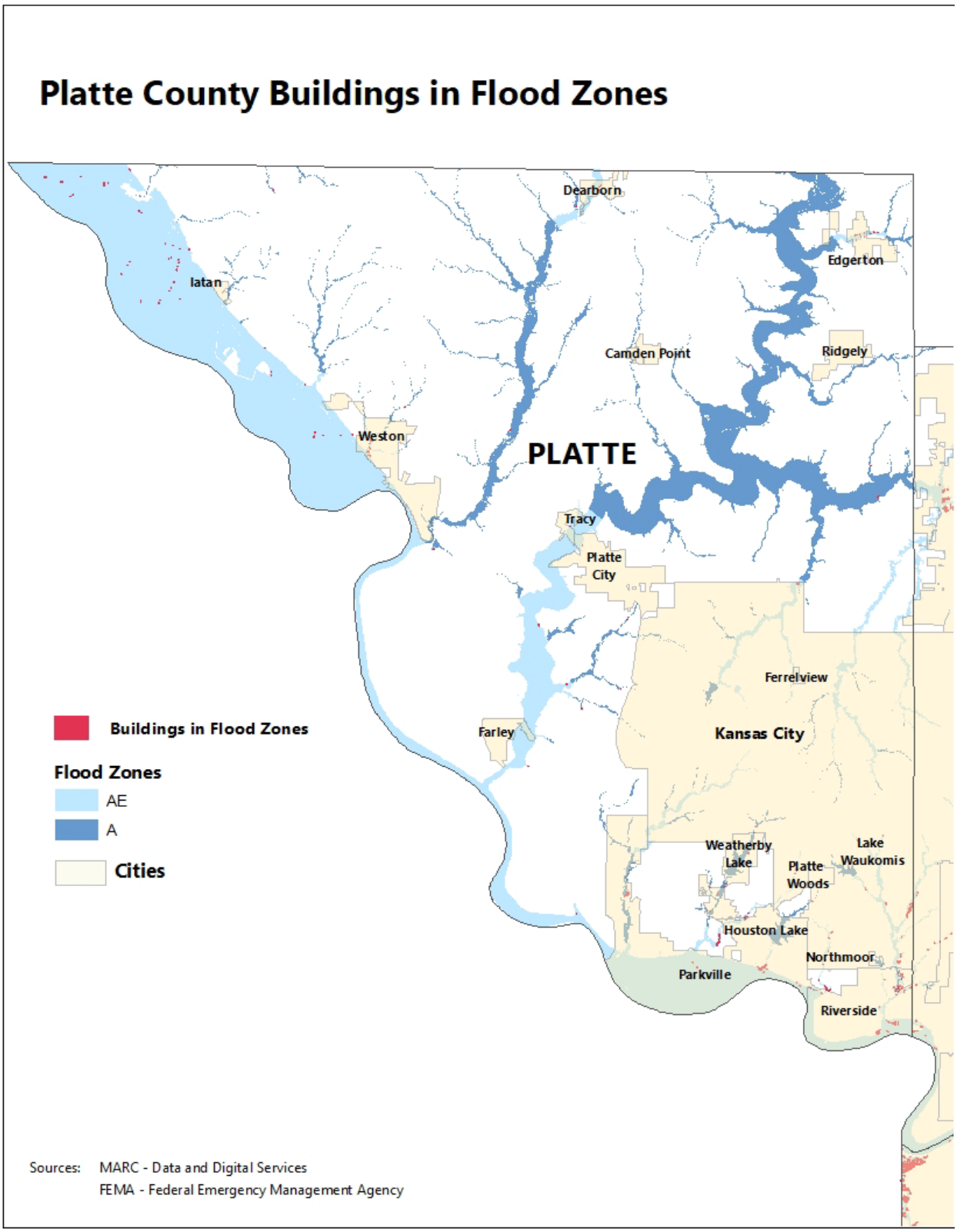

Clay County Buildings in Flood Zones
Holt
Lawson
Smithville
Kearney
Mosby
Excelsior Springs
CLAY
Prathersville
Kansas City
Missouri City
Liberty
Gladstone
Glenaire
Oakwood Park
Oakwood
Pleasant Valley
Claycomo
Birmingham
Randolph
Avondale
North Kansas City
Flood Zones
AE
A
Cities
Buildings in Flood Zones
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency

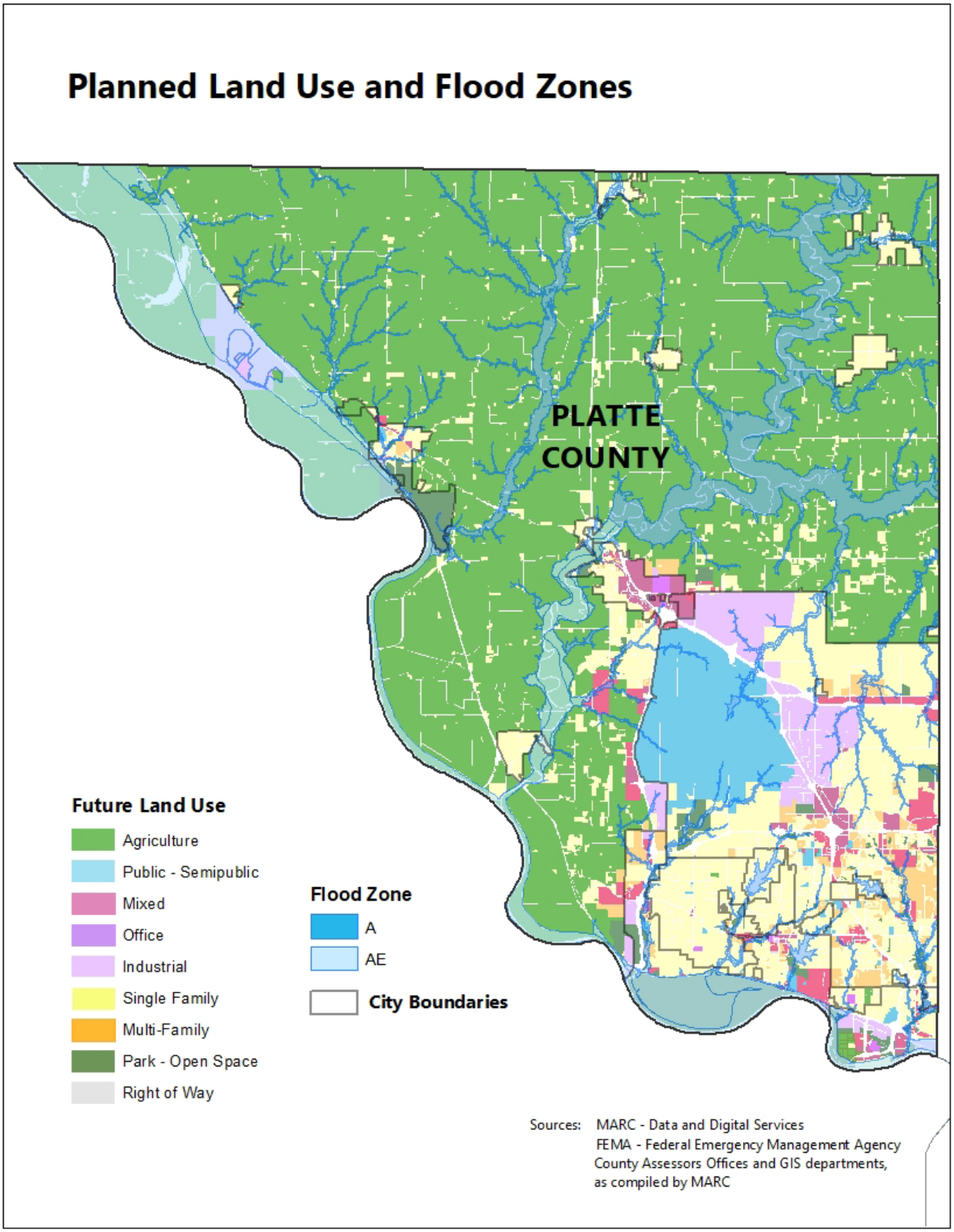
Planned Land Use and Flood Zones

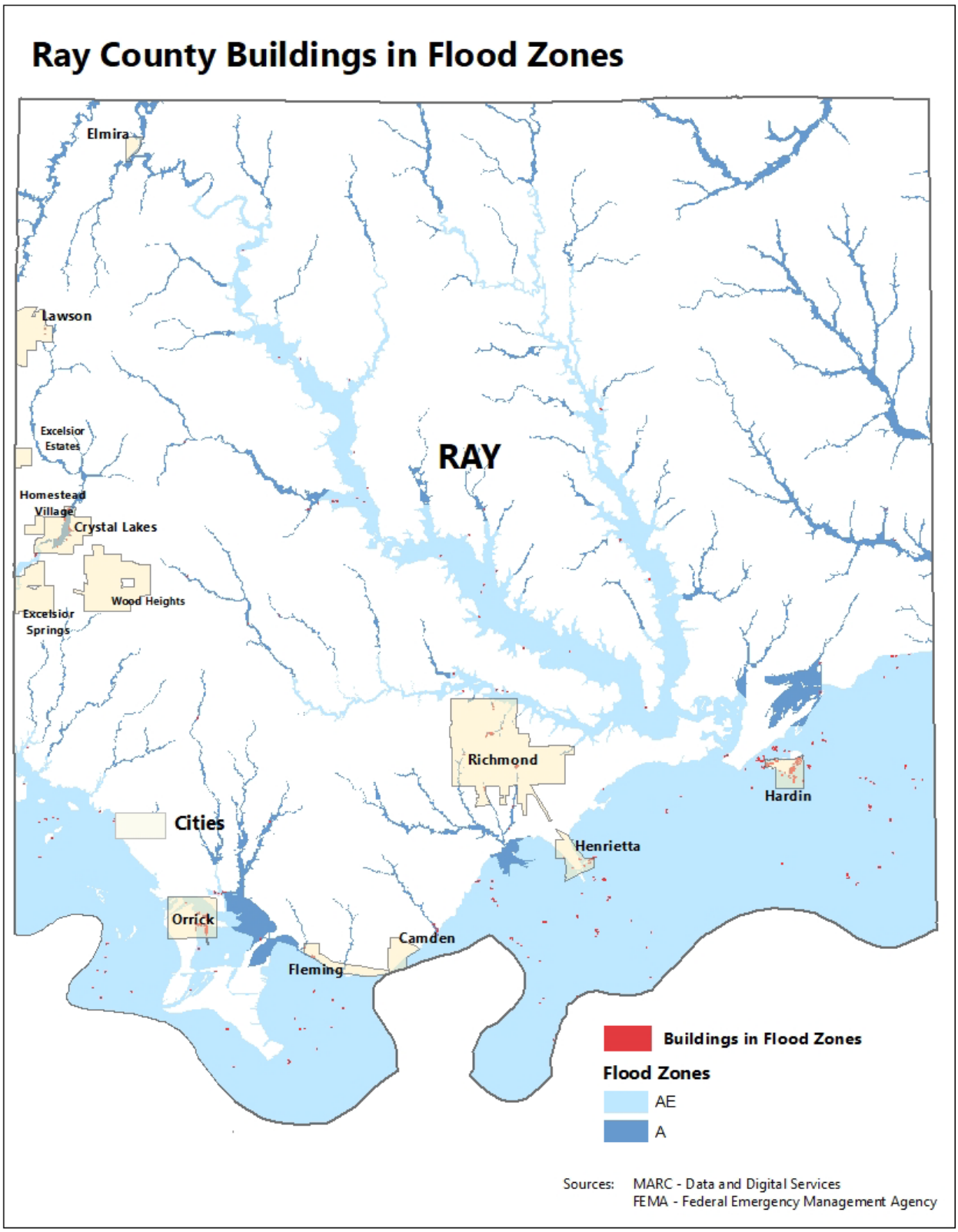


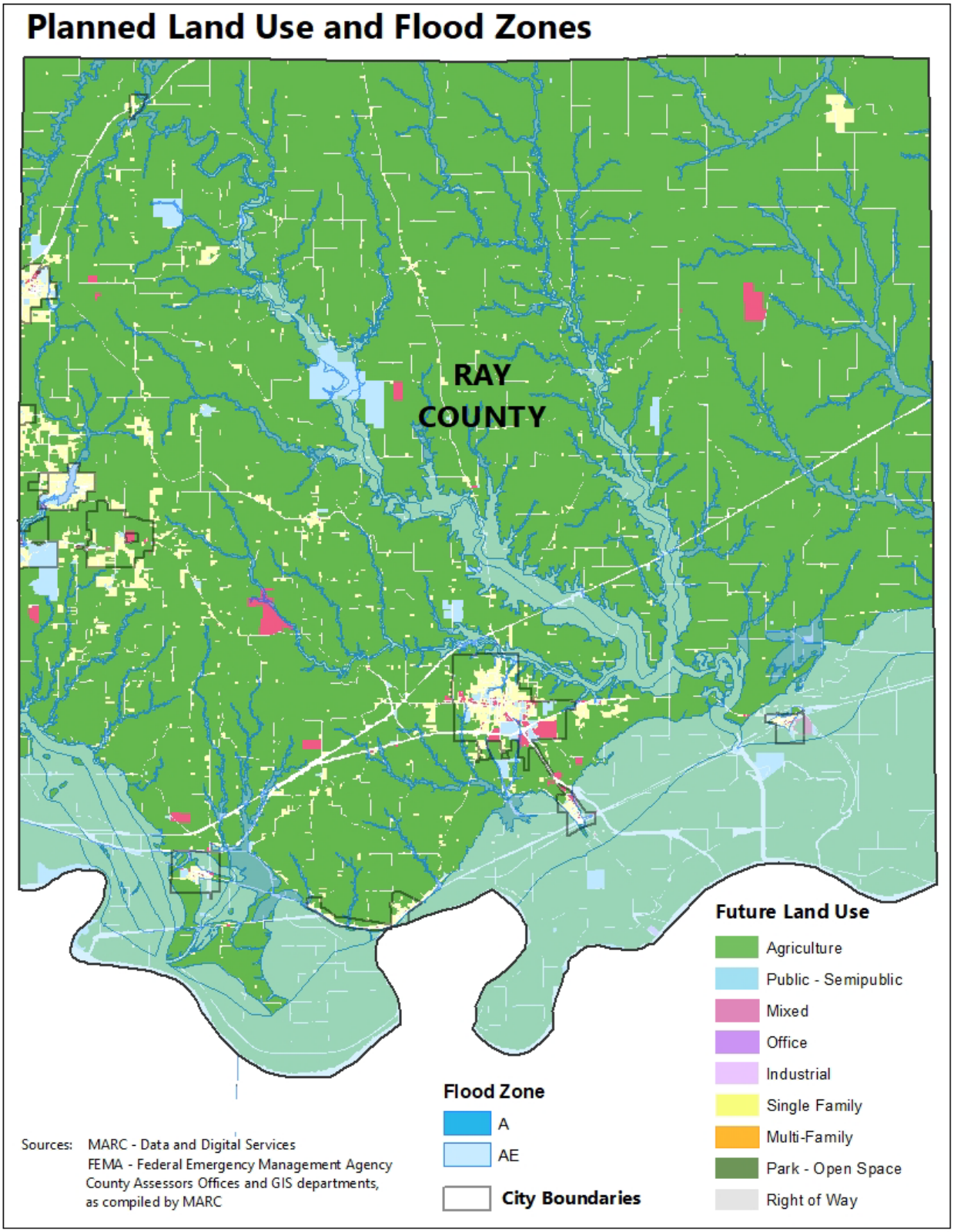

Jackson County Buildings in Flood Zones
Rive
Bend
Sugar
Creek
Sibley
Buckner
Levasy
Independence
JACKSON
Kansas City
Blue Springs
Lake
Tapawingo
Grain
Valley
Oak
Grove
Raytown
Unity Village
Lake
Lotawana
Lee's Summit
Grandview
Lone Jack
Greenwood
Flood Zones
AE
A
Cities
Buildings in Flood Zones
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency


Planned Land Use and Flood Zones
Future Land Use
Agriculture
Public - Semipublic
Mixed
Office
Industrial
Single Family
Multi-Family
Park - Open Space
Right of Way
Flood Zone
A
AE
City Boundaries
JACKSON COUNTY
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency
County Assessors Offices and GIS departments, as compiled by MARC


Platte County Buildings in Flood Zones
Dearborn
Edgerton
Iatan
Camden Point
Ridgely
Weston
PLATTE
Tracy
Platte City
Ferrelview
Buildings in Flood Zones
Farley
Kansas City
Flood Zones
AE
A
Cities
Weatherby Lake
Lake Waukomis
Platte Woods
Houston Lake
Northmoor
Parkville
Riverside
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency


Planned Land Use and Flood Zones
PLATTE COUNTY
Future Land Use
Agriculture
Public - Semipublic
Mixed
Office
Industrial
Single Family
Multi-Family
Park - Open Space
Right of Way
Flood Zone
A
AE
City Boundaries
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency
County Assessors Offices and GIS departments,
as compiled by MARC


Ray County Buildings in Flood Zones
Elmira
Lawson
Excelsior Estates
RAY
Homestead Village
Crystal Lakes
Wood Heights
Excelsior Springs
Richmond
Hardin
Cities
Henrietta
Orrick
Camden
Fleming
Buildings in Flood Zones
Flood Zones
AE
A
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency


Planned Land Use and Flood Zones
RAY
COUNTY
Future Land Use
Agriculture
Public - Semipublic
Mixed
Office
Industrial
Single Family
Multi-Family
Park - Open Space
Right of Way
Flood Zone
A
AE
City Boundaries
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency
County Assessors Offices and GIS departments,
as compiled by MARC

4.9.4 Probability of Future Occurrence: 100%*

*It is unrealistic to assure a 100 percent chance of any hazard happening in a given year. However, based on occurrences in the past 28 years, there has been a flood or flash flood every year.

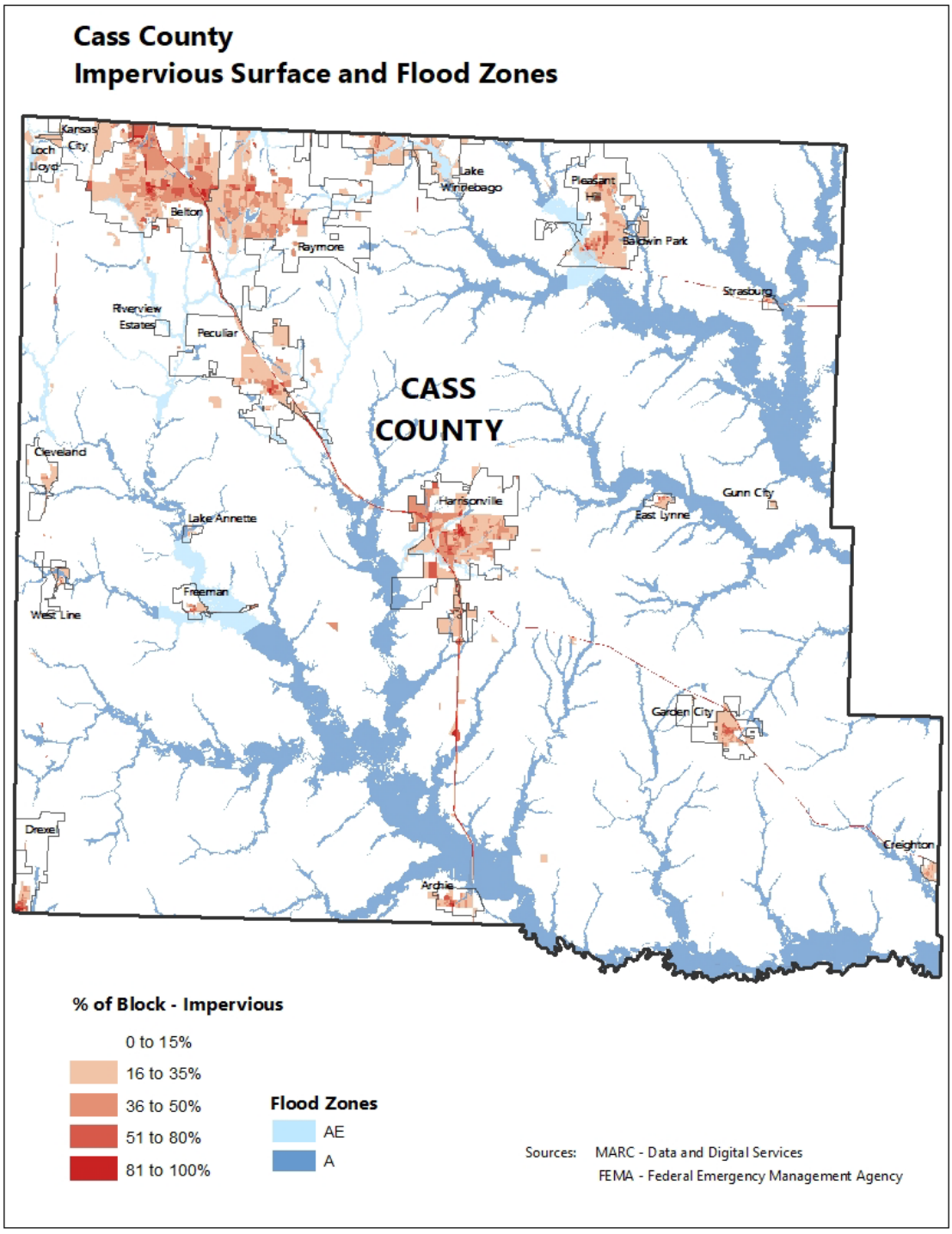
Seasonal Pattern: The most likely cause of flooding is heavy rainfall. In the Kansas City area, May, June, July and September receive the highest average monthly rainfall amounts. Consequently, the risk of flooding may be greatest in these months.

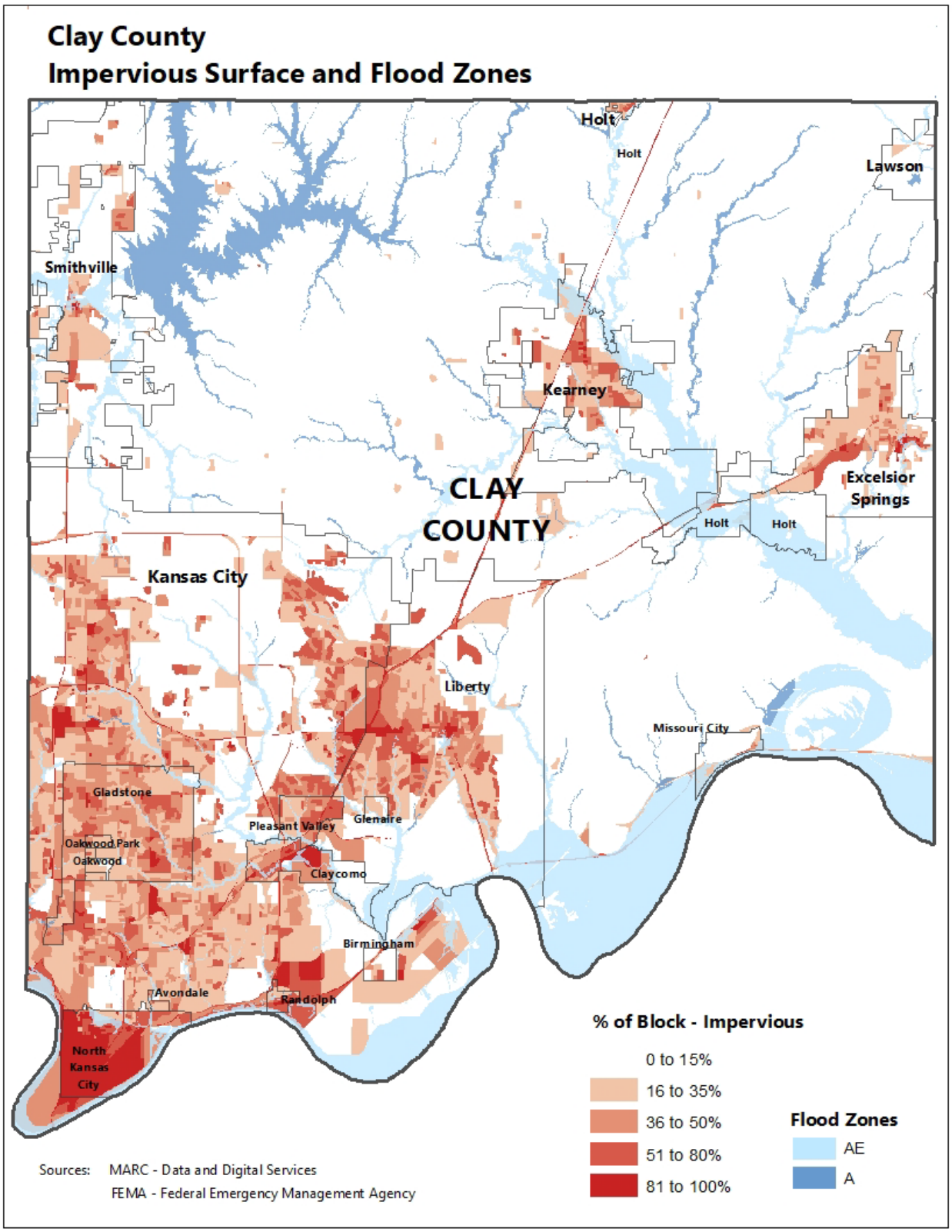
A recent study by Anderson and Walker found that recent and projected increases in annual precipitation for Kansas City are substantial, with concentrated seasonal rainfall during extreme events for both spring and fall, while the length of consecutive dry days will increase substantially in summer months.

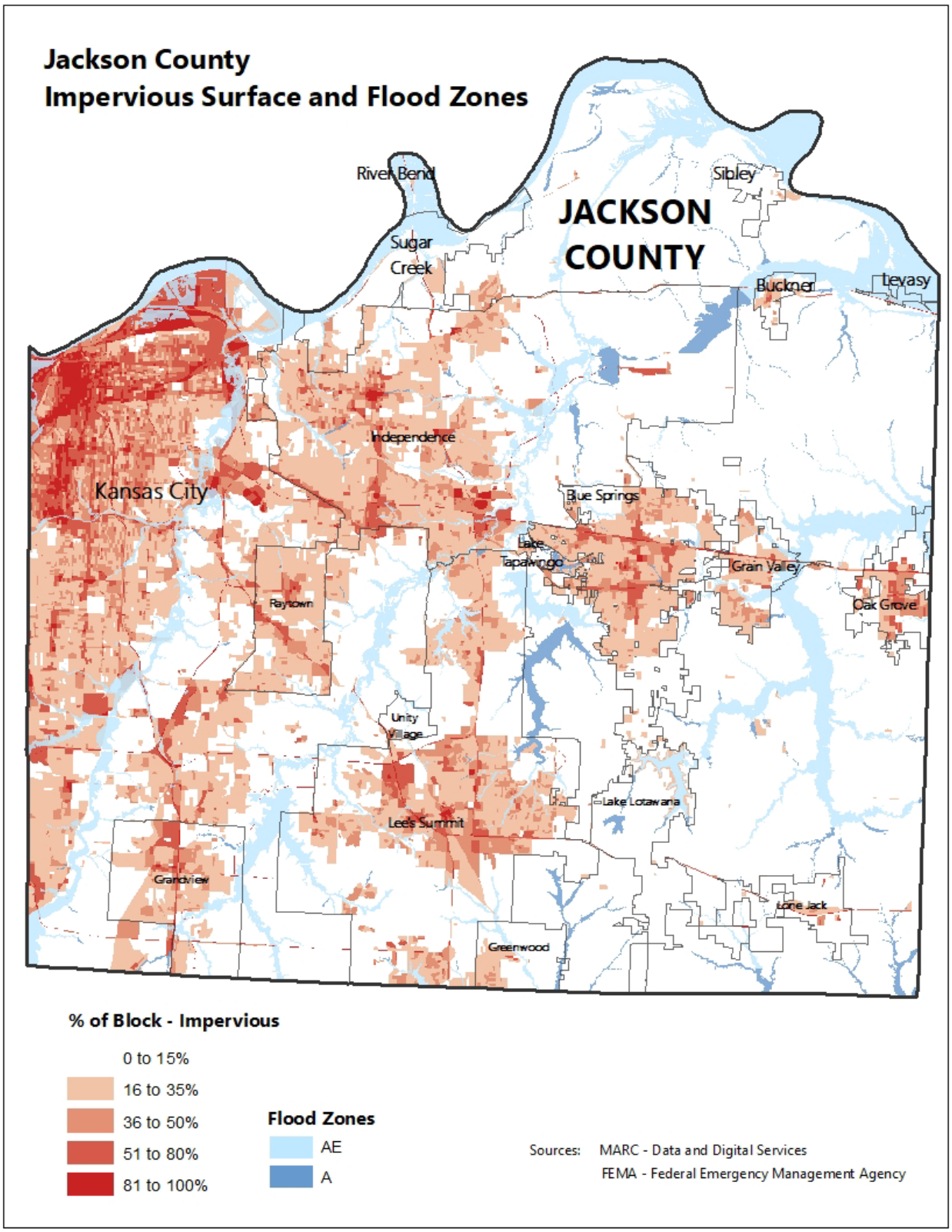
- Average annual precipitation will increase from 38.8 to 44.6 inches/year.
- Maximum precipitation occurring over one day will increase from 3.4 to 4.0 inches. Increases for the maximum five- and 15-day precipitation will be from 5.5 to 7.0 inches and from 7.5 to 10.4 inches, respectively.
- The number of days with more than 1.5” of precipitation will increase from 5.0 to 9.3.
- The maximum number of consecutive dry days will increase from 30.9 days/year to 39.5 days/year.

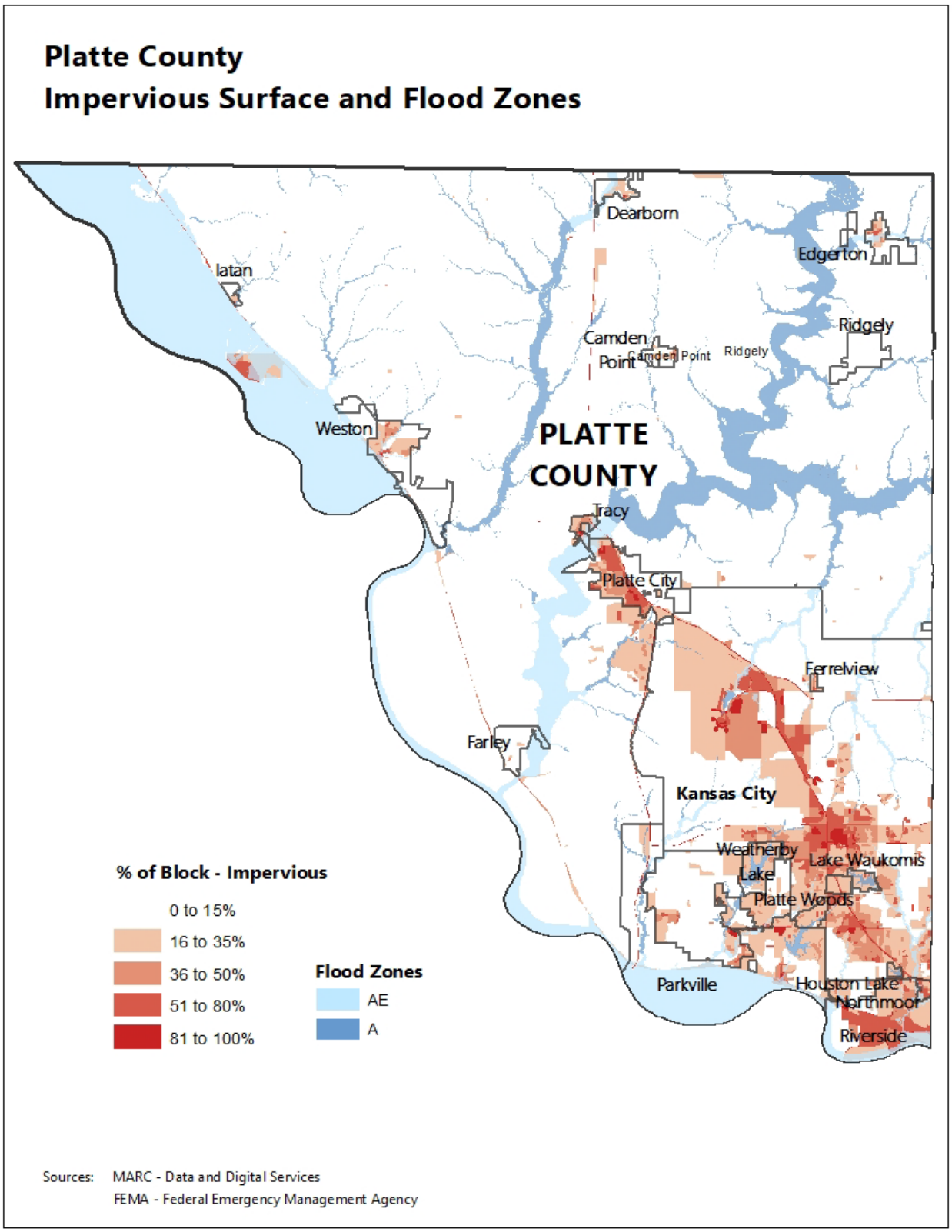
4.9.5 Vulnerability Analysis and Potential Loss Estimates by County

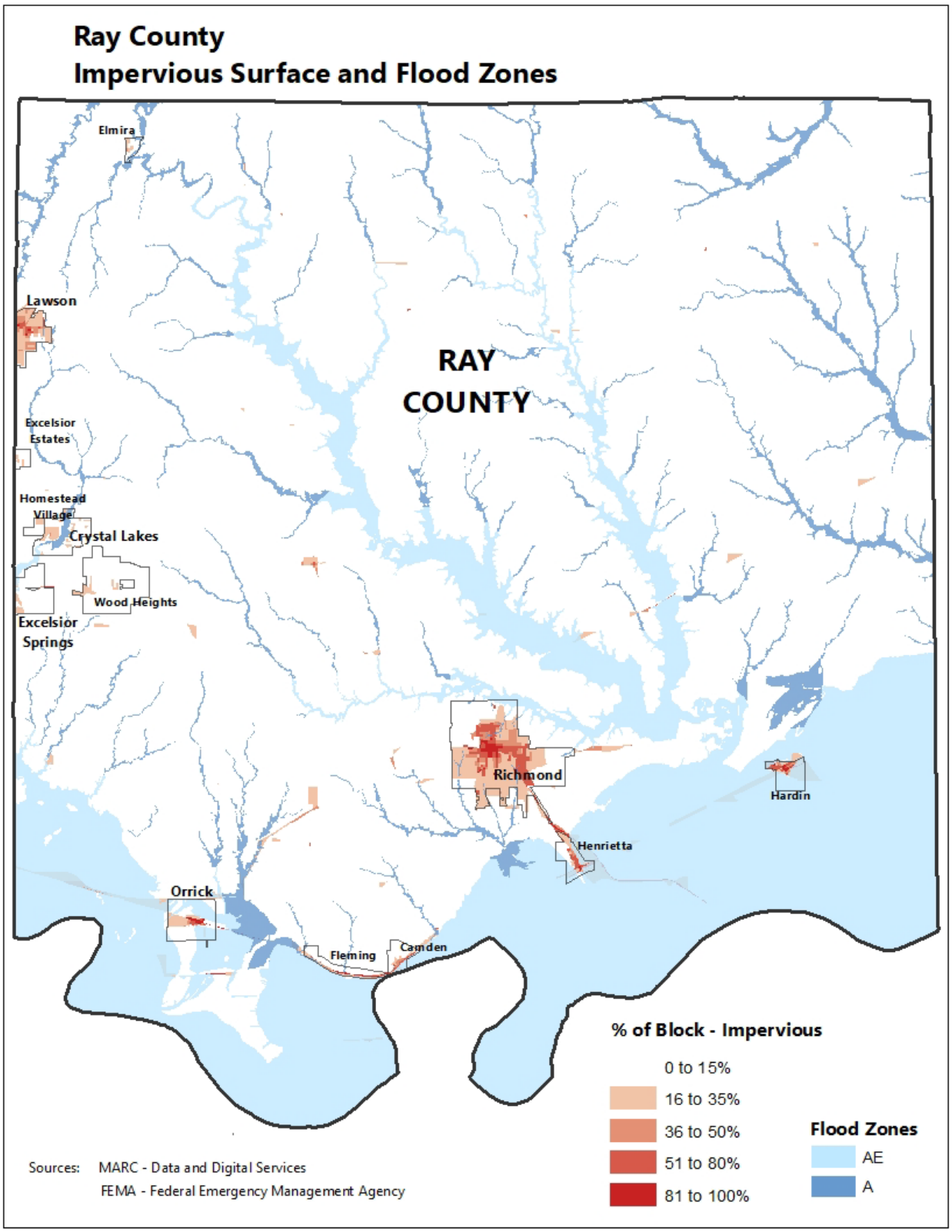
As cities grow and more development occurs, the natural landscape is replaced by roads, buildings, housing developments, and parking lots. Studies have shown that as development and the amount of impervious surfaces increases in a watershed, severe flood events happen more often. The following map depict the impervious areas in each county in the planning area.




Clay County
Impervious Surface and Flood Zones
Holt
Holt
Lawson
Smithville
Kearney
CLAY
COUNTY
Excelsior
Springs
Holt
Holt
Kansas City
Liberty
Missouri City
Gladstone
Pleasant Valley
Glenaire
Oakwood Park
Oakwood
Claycomo
Birmingham
Avondale
Randolph
North
Kansas
City
% of Block - Impervious
0 to 15%
16 to 35%
36 to 50%
51 to 80%
81 to 100%
Flood Zones
AE
A
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency


Jackson County
Impervious Surface and Flood Zones
JACKSON COUNTY
River Bend
Sibley
Sugar Creek
Buckner
Levasy
Independence
Kansas City
Blue Springs
Lake Tapawingo
Gran Valley
Oak Grove
Raytown
Unity Village
Lake Lotawana
Lees Summit
Grandview
Lone Jack
Greenwood
% of Block - Impervious
0 to 15%
16 to 35%
36 to 50%
51 to 80%
81 to 100%
Flood Zones
AE
A
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency


Platte County
Impervious Surface and Flood Zones
Dearborn
Edgerton
Iatan
Camden Point
Ridgely
Weston
PLATTE COUNTY
Tracy
Platte City
Ferrelview
Farley
Kansas City
Weatherby Lake
Lake Waukomis
Platte Woods
Parkville
Houston Lake
Northmoor
Riverside
% of Block - Impervious
0 to 15%
16 to 35%
36 to 50%
51 to 80%
81 to 100%
Flood Zones
AE
A
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency


Ray County
Impervious Surface and Flood Zones
RAY
COUNTY
Elmira
Lawson
Excelsior
Estates
Homestead
Village
Crystal Lakes
Wood Heights
Excelsior
Springs
Richmond
Hardin
Henrietta
Orrick
Fleming
Camden
% of Block - Impervious
0 to 15%
16 to 35%
36 to 50%
51 to 80%
81 to 100%
Flood Zones
AE
A
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency

In 2023, the state of Missouri (SEMA) updated their 2019 Hazard Mitigation Plan assessing hazards and risk for all counties in Missouri. Data for flooding was produced and provided by SEMA. SEMA's methodology estimation for the 2023 Missouri State Hazard Mitigation Plan is excerpted below. Table 4.9.4 and 4.9.5 show the total direct building loss and income loss for Cass, Clay, Jackson, Platte, and Ray. Table and figure numberings have been changed to correspond to sequencing in this Plan.

State Estimates of Potential Losses[xvii]

The intent of this analysis was to enable the State to estimate where flood losses could occur and the degree of severity using a consistent methodology. The statewide analysis used best available data; that is, digital effective FIRM data coupled with LiDAR derived building footprints. The computer models help quantify risk along known flood-hazard corridors such as along the Mississippi and Missouri Rivers. In addition, flood losses are estimated for certain lesser streams and rivers where the flood hazard may not have been previously studied.

The Hazus analysis provides the number of buildings impacted, estimates of the building repair costs, and the associated loss of building contents and business inventory. Building damage can also cause additional losses to a community as a whole by restricting a building's ability to function properly. Income loss data accounts for losses such as business interruption and rental income losses as well as the resources associated with damage repair and job and housing losses. These losses are calculated by Hazus using a methodology based on the building damage estimates.

Flood damage is directly related to the depth of flooding. For example, a two-foot-deep flood generally results in about 20 percent damage to the structure (which translates to 20 percent of the structure's replacement value). Hazus takes into account flood depth when modeling damage (based on FEMA's depth damage functions). Hazus reports capture damage by occupancy class (in terms of square footage impacted) by damage percent classes. Occupancy classes in Hazus include agriculture, commercial, education, government, industrial, religion, and residential. Damage percent classes are grouped by 10 percent increments: 1-10 percent, 11-20 percent, etc., up to 50 percent. Buildings that sustain more than 50 percent damage are considered to be substantially damaged.

The displaced population is based on the inundation area. Individuals and households will be displaced from their homes even when the home has suffered little or no damage either because they were evacuated (i.e., a warning was issued) or there was no physical access to the property because of flooded roadways. Displaced people using shelters will most likely be individuals with lower incomes and those who do not have family or friends within the immediate area. Age plays a secondary role in shelter use in that there are some individuals who will go to a public shelter even if they have the financial means to go elsewhere. These will usually be younger, less established families and elderly families (Hazus User's Manual). Hazus does not model flood casualties given that flood-related deaths and injuries typically do not have the same significant impact on the medical infrastructure as those associated with earthquakes.

- **Direct building losses** are calculated within Hazus from US Census data.

Loss ratio of the direct building losses compared to overall building inventory - The loss ratio of the direct building losses compared to overall building inventory per county gives an indication of the severity of impacts on community sustainability. While a large urban area may have the greatest dollar losses, it may be able to absorb the impact better than a more rural area where a flood could impact a significant amount of the infrastructure in the entire county.

- **Count of Residential Buildings Exposed to Flooding (MSDIS)** – To determine the number of residential buildings exposed to the 1-percent annual chance flood event, the MSDIS dataset was intersected with the depth grids outside of the Hazus environment. This provides an indication of the potential magnitude of a flood event. This exposure count was updated for 18 counties using the draft datasets available from the SEMA CTP Mapping Program.

- **Count of Residential Buildings Potentially Damaged by Flooding (Hazus)** – To determine the number of damaged residential structures, the analysis performed within Hazus utilized US Census data to estimate the number of residential structures which are at risk of damage and the number expected to receive substantial damage during a 1-percent annual chance flood event. Note, there are instances where the Hazus analysis predicted a greater number of damaged buildings than were identified with the exposed MSDIS points. This is due a fundamental premise of the Hazus Level 1 flood loss methodology that the buildings are uniformly distributed within census blocks.

- **Income losses, Population displaced by the flood, and Shelter** needs – all computed within Hazus from US Census data.

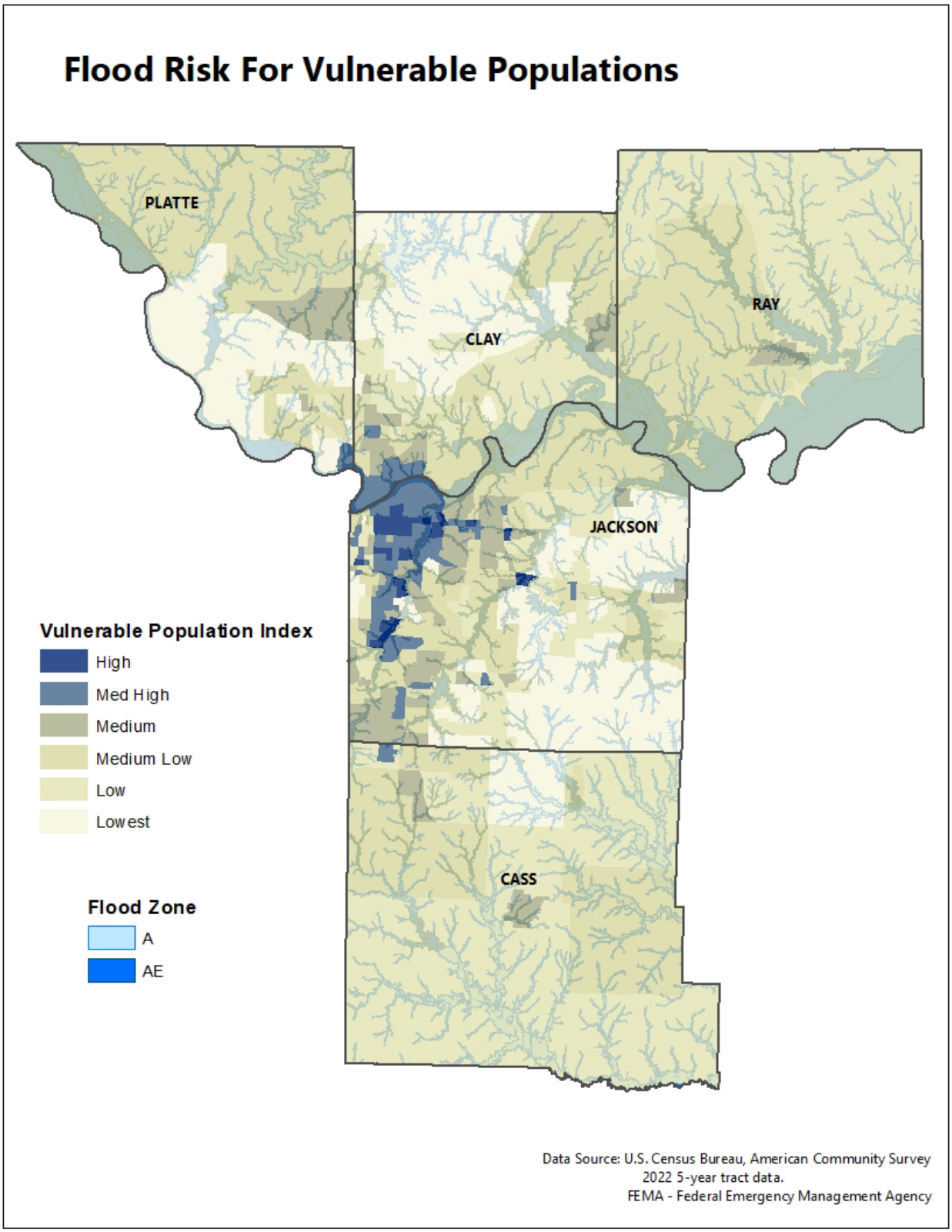
Table 4.9.4: Direct Building Loss and Income Loss					
	Cass	**Clay**	**Jackson**	**Platte**	**Ray**
Countywide Building Exposure	$13, 279, 914, 156	$33,542,252,386	$108,581,199,794	$13,811,465,341	$3,084,500,793
Structural Damage	$65,030,858	$201,154,453	$896,418,928	$92,964,620	$42,510,964
Loss Ratio	0.49%	0.60%	0.83%	0.67%	1.38%
Contents Loss	$46,918,167	$161,383,856	$1,269,692,575	$90,962,230	$34,319,039
Inventory Loss	$1,107,576	$3,393,242	$64,894,690	$3,351,906	$761,078
Total Direct Loss	$113,056,600	$365,931,551	$2,231,006,194	$187,278,755	$77,591,081
Total Income Loss	$173,857	$842,536	$13,666,583	$741,626	$218,840
Total Direct and Income Loss	**$113,230,457**	**$366,774,087**	**$2,244,672,777**	**$188,020,381**	**$77,809,922**
#Hazus UDF damaged structures	239	695	1,264	255	289
# Substantially Damaged	1	204	380	15	0
# Displaced People	2,878	4,992	7,075	1,709	2,034
# Shelter Needs	897	2,989	4,426	794	712

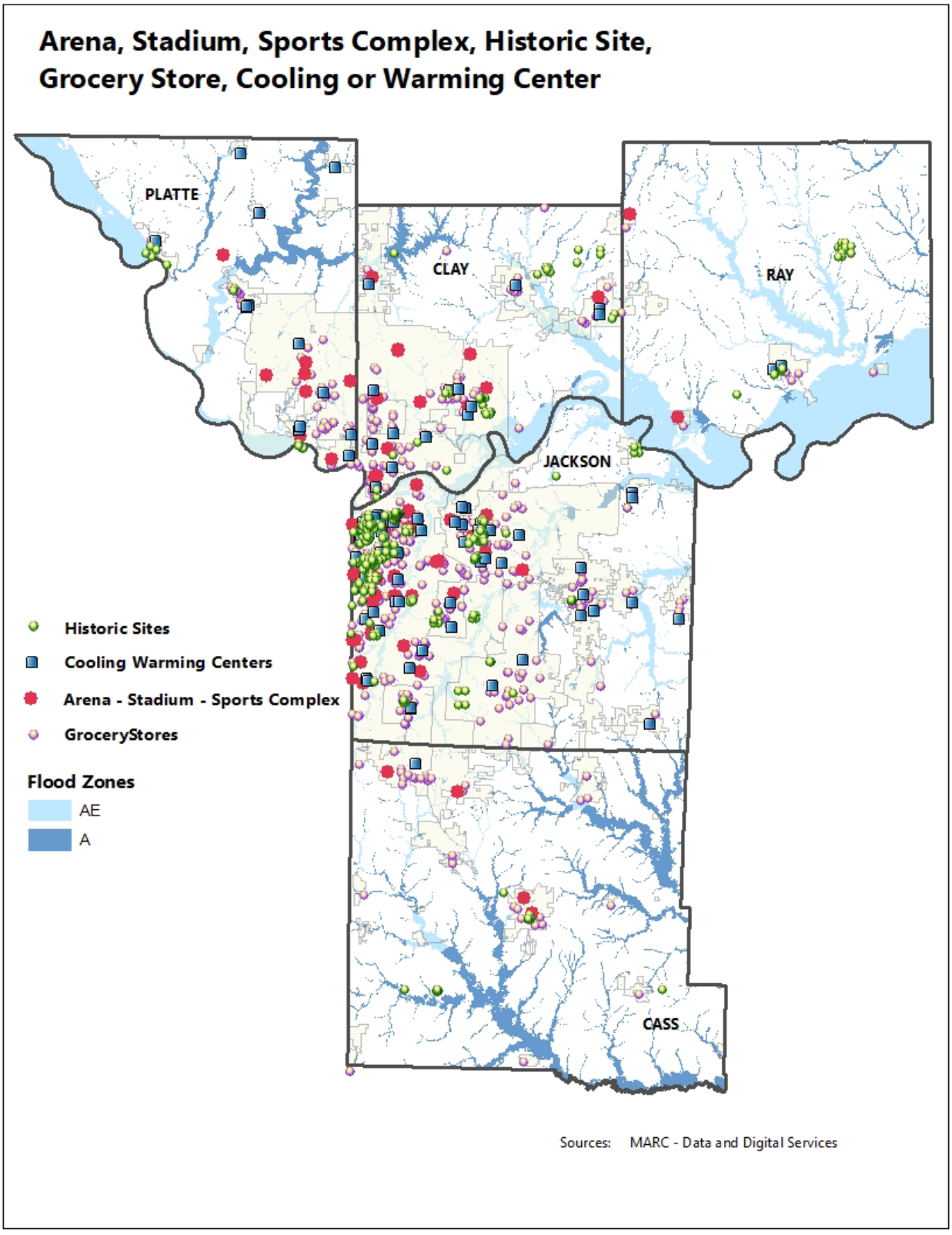
Note: Column headers in dark blue refer to computation within Hazus; column headers in light blue refer to computations performed outside of the Hazus environment.
Source: MO State hazard Mitigation Plan, Flooding, page 3.69-3.71

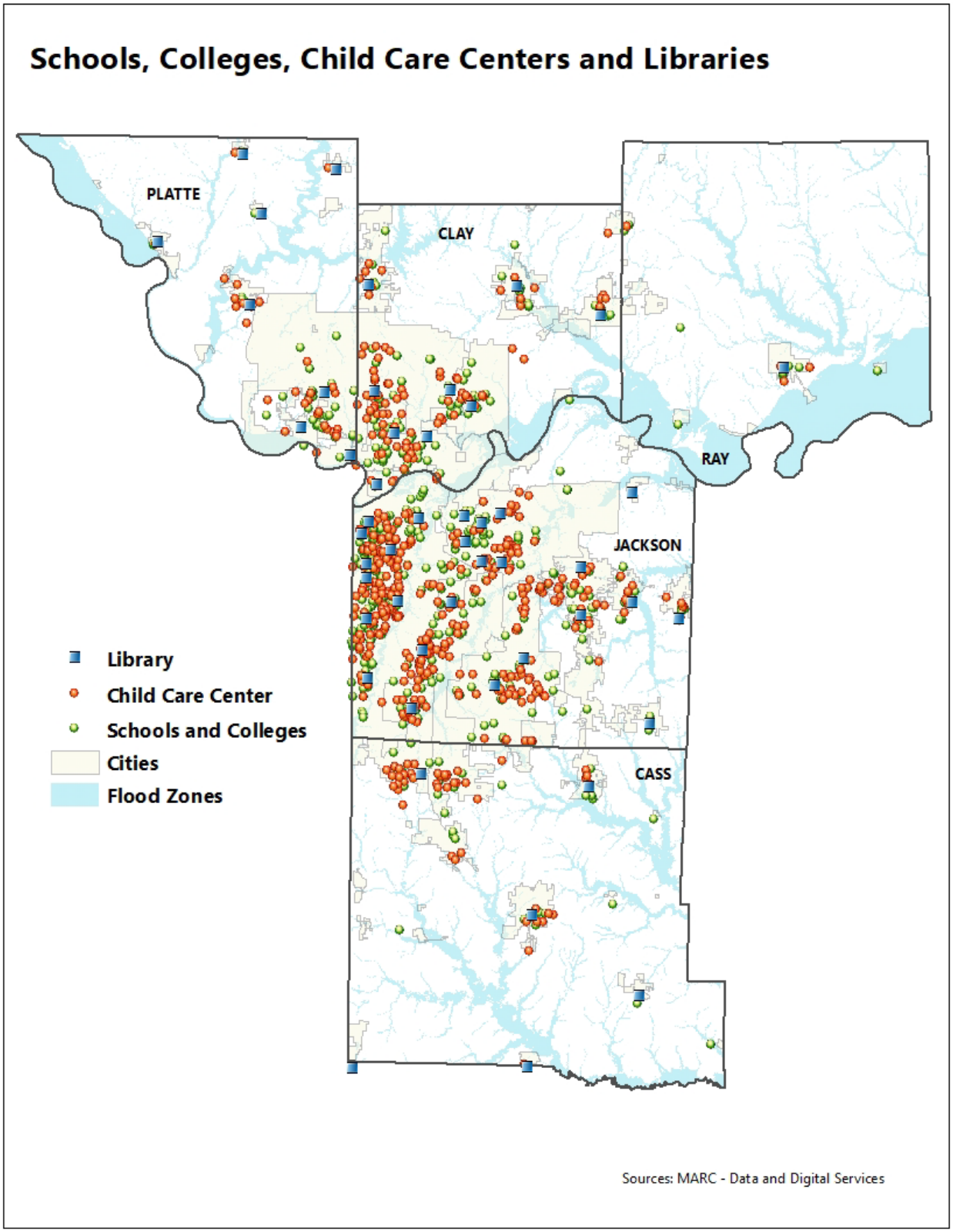
Table 4.9.5: Direct Building Loss and Income Loss						
		Cass	**Clay**	**Jackson**	**Platte**	**Ray**
Residential	# Residential Structures	162	551	1,123	181	318
	Total $$ of Loss	$50,718,733	$183,637,947	$361,402,825	$67,728,912	$87,699,243
Agriculture	# Agriculture Structures	264	192	218	109	502
	Total $$ of Loss	$86,846,275	$54,891,063	$76,983,335	$33,047,061	$222,315,498
Commercial	# Commercial Structures	67	143	1,095	82	22
	Total $$ of Loss	$44,417,950	$183,668,088	$1,479,301,745	$86,757,405	$14,868,684
Education	# Education Structures	0	1	2	0	0
	Total $$ of Loss	$0	$2,345,440	$5,403,213	$	$0
Government	# Government Structures	0	14	1	26	4
	Total $$ of Loss	$0	$19,085,373	$1,738,437	$37,513,793	$3,378,321
$10,671,314Industrial	# Industrial Structures	27	65	598	42	11
	Total $$ of Loss	$14,971,689	$88,084,432	$865,030,631	46,042,048	$10,671,314
Total # Population Affected		**418**	**1,449**	**2,684**	**460**	**811**
Total Loss- Hazus Layer		**$196,954,647**	**$531,712,343**	**$2,789,860,185**	**$271,089,219**	**$338,933,060**

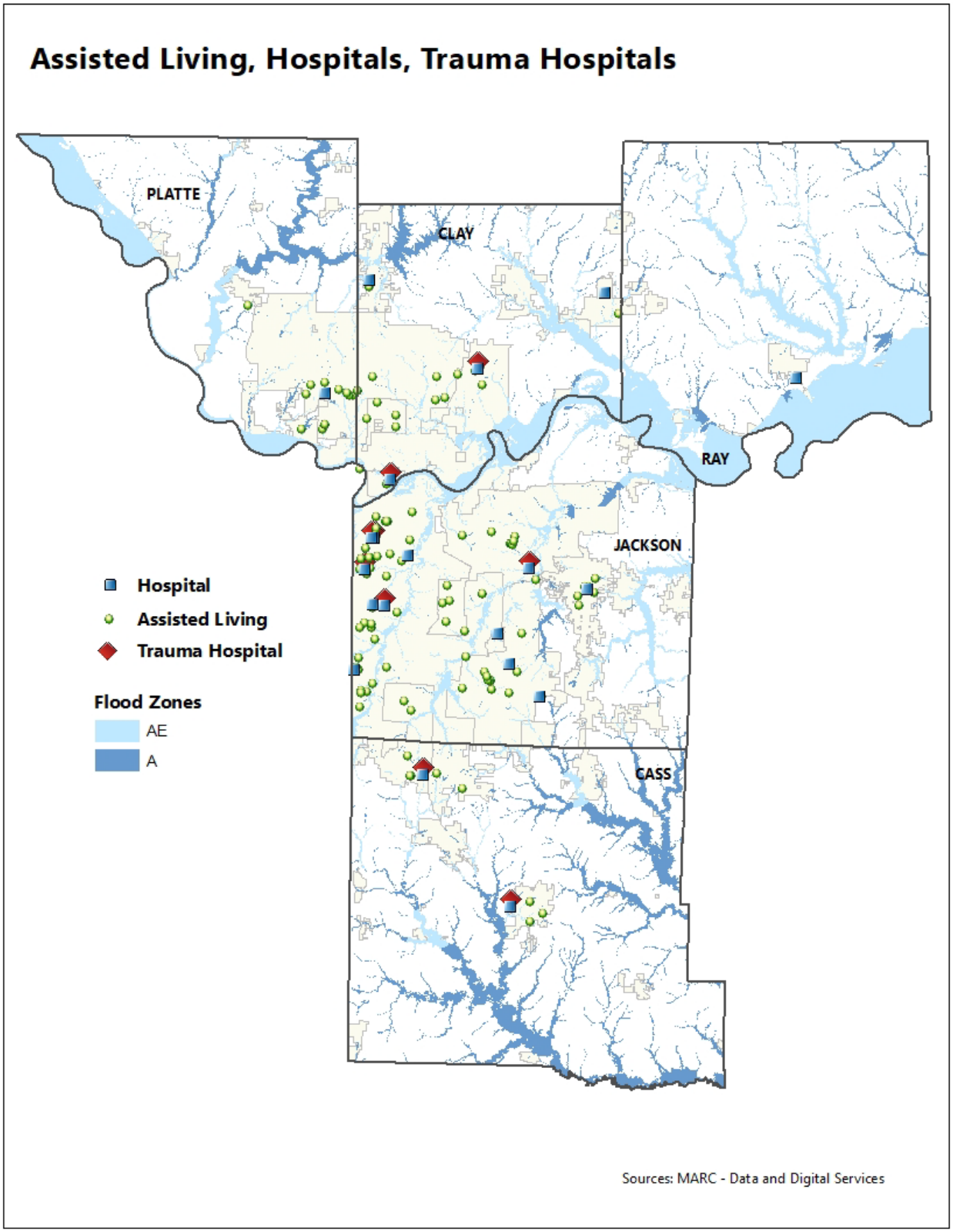
Source: Missouri State Hazard Mitigation Plan, pg. 3.72-3.75

The following maps depict the key assets, including vulnerable populations, that may be vulnerable to flooding in the region.

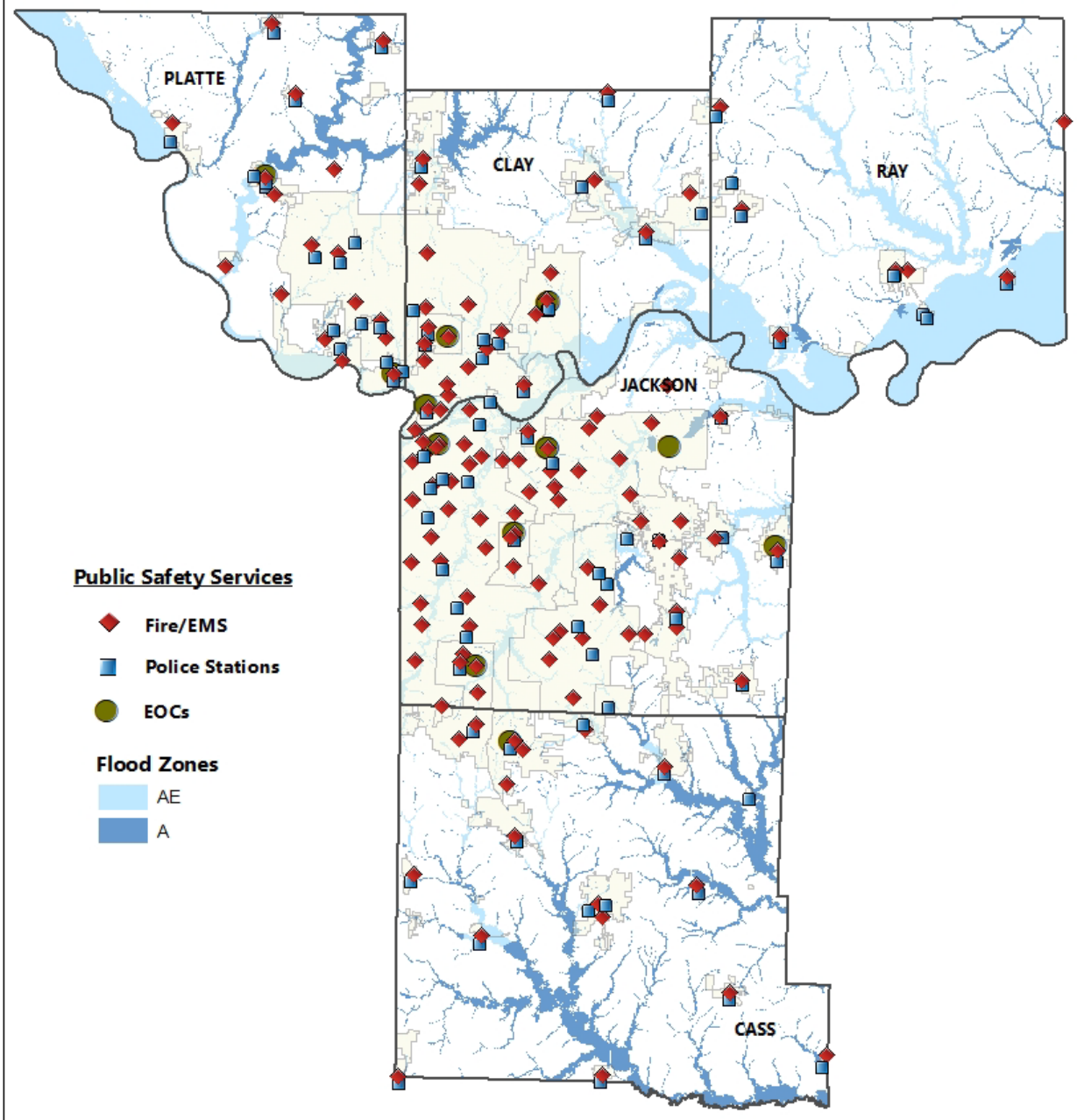


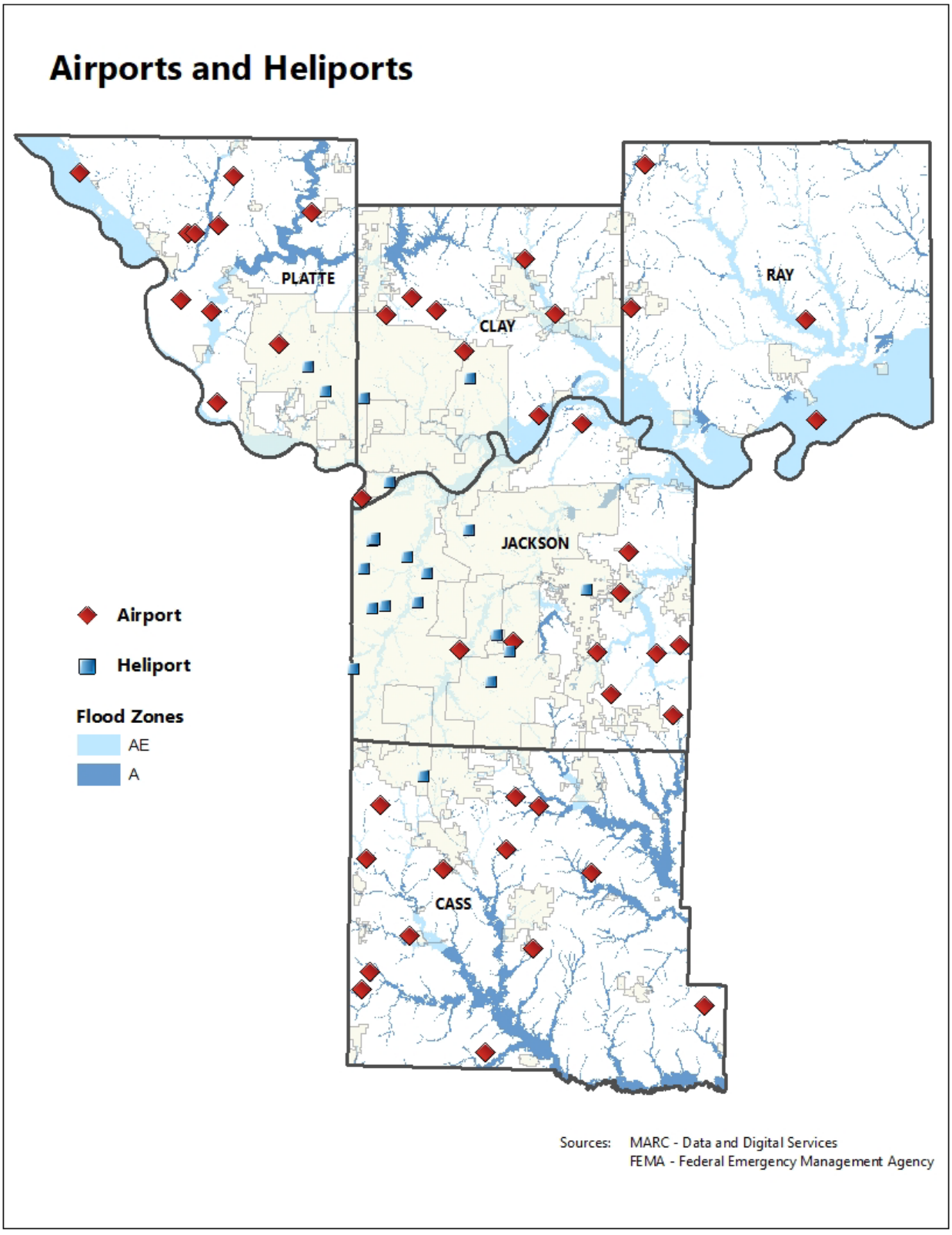

Arena, Stadium, Sports Complex, Historic Site,
Grocery Store, Cooling or Warming Center
PLATTE
CLAY
RAY
JACKSON
CASS
Historic Sites
Cooling Warming Centers
Arena - Stadium - Sports Complex
GroceryStores
Flood Zones
AE
A
Sources: MARC - Data and Digital Services

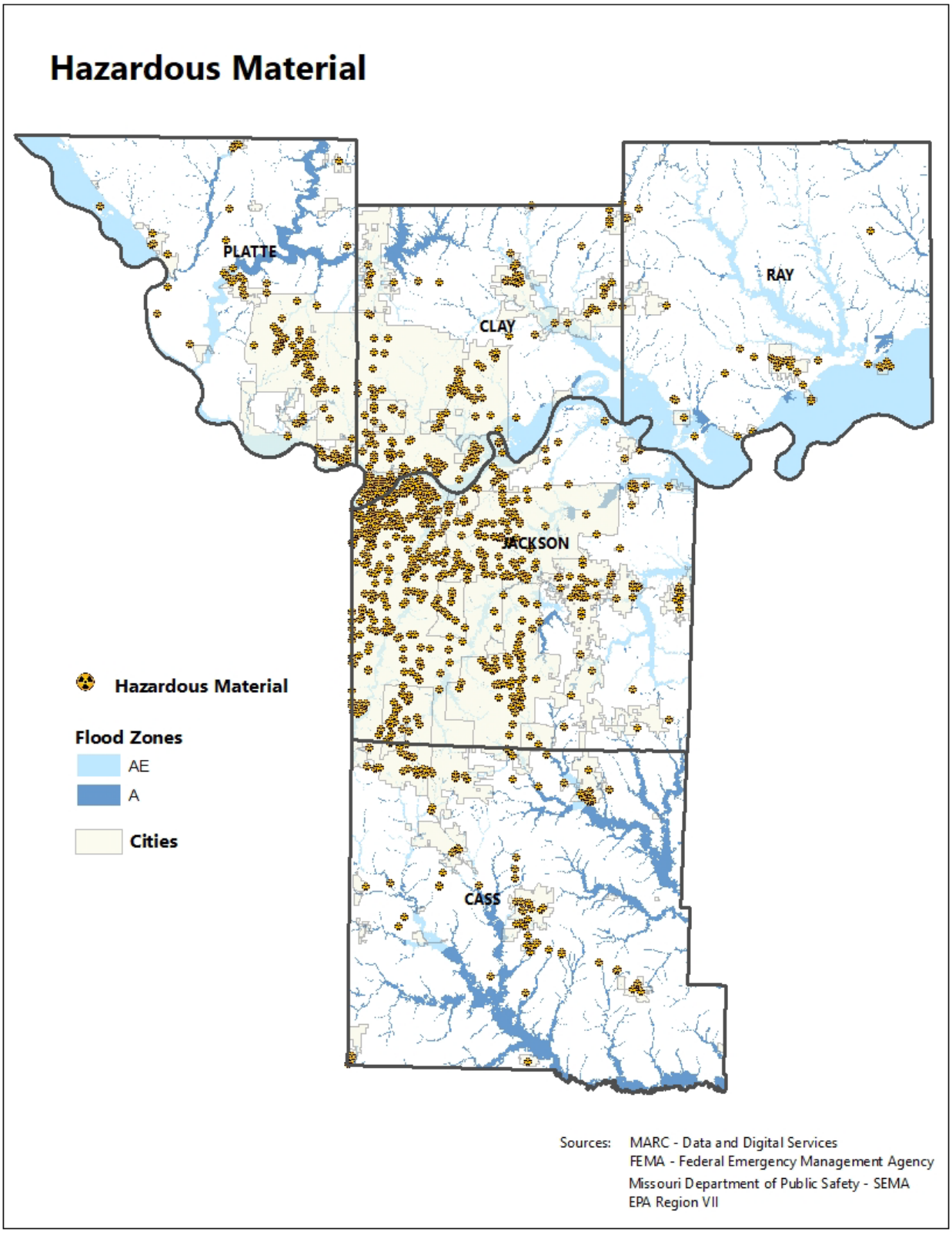

Schools, Colleges, Child Care Centers and Libraries
PLATTE
CLAY
RAY
JACKSON
CASS
Library
Child Care Center
Schools and Colleges
Cities
Flood Zones
Sources: MARC - Data and Digital Services


Assisted Living, Hospitals, Trauma Hospitals
PLATTE
CLAY
RAY
JACKSON
CASS
Hospital
Assisted Living
Trauma Hospital
Flood Zones
AE
A
Sources: MARC - Data and Digital Services

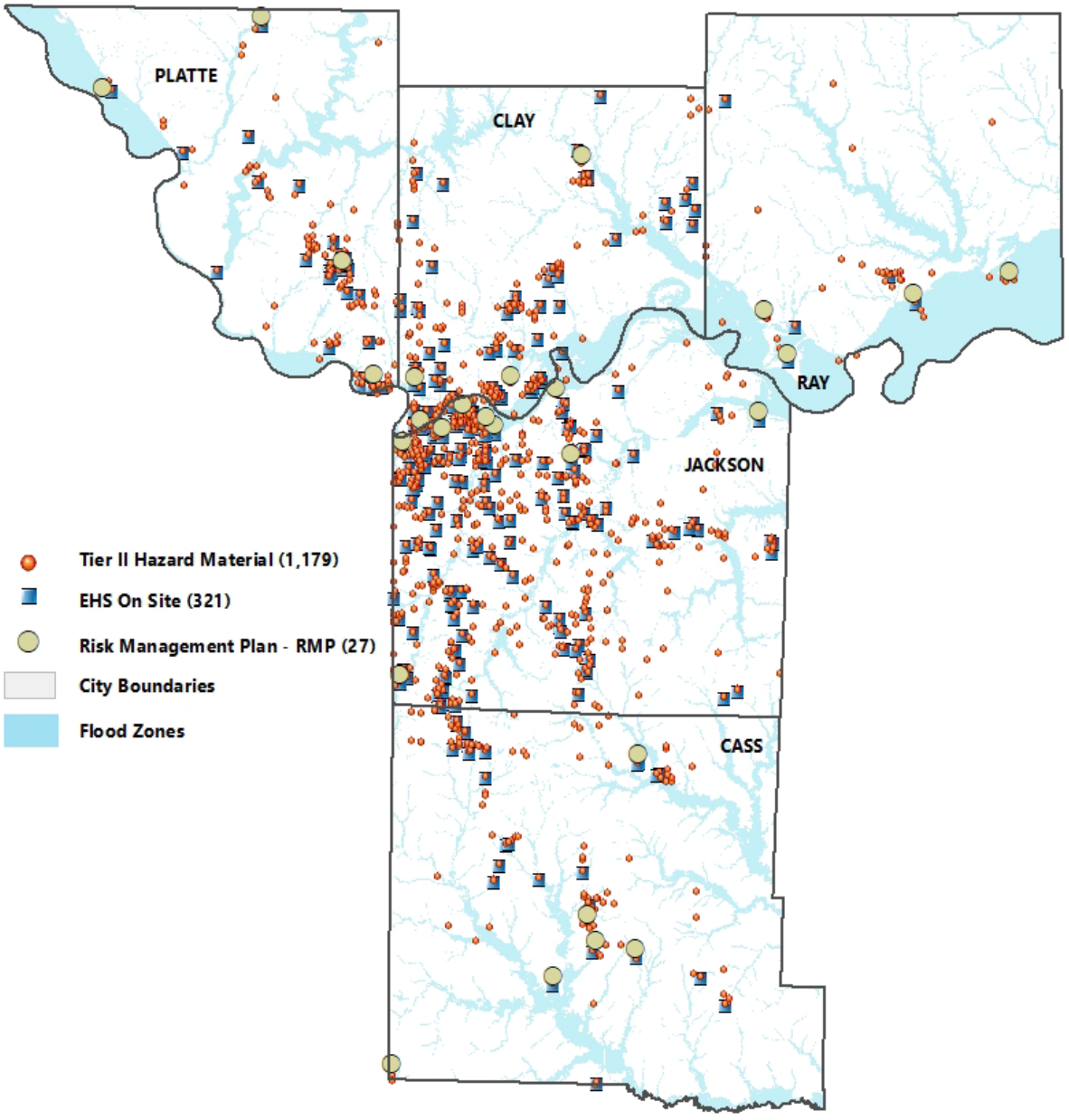
Fire - Police Stations and Emergency Operation Centers




Airports and Heliports
PLATTE
CLAY
RAY
JACKSON
CASS
Airport
Heliport
Flood Zones
AE
A
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency


Hazardous Material
PLATTE
CLAY
RAY
JACKSON
CASS
Hazardous Material
Flood Zones
AE
A
Cities
Sources: MARC - Data and Digital Services
FEMA - Federal Emergency Management Agency
Missouri Department of Public Safety - SEMA
EPA Region VII

Tier II and RMP Facilities



Note: Federal law requires industrial facilites that use large amounts of Extremely Hazardous Substances (EHSs) to file a Risk Management Plan (RMP)

Source: Missouri Department of Public Safety - SEMA
EPA Region VII
MARC - Data and Digital Services

4.9.6 Problem Statements

Vulnerability statements, such as those below, can support development of mitigation strategies for flooding:

- Buildings and critical infrastructure (including hazardous materials sites) within each county are vulnerable to flood damage.
- Many homeowners and business owners may not understand changes to the National Flood Insurance Program (NFIP) from the Homeowner Flood Insurance Affordability Act of 2014 and how it impacts them.
- In some cases, flood control actions taken by one jurisdiction or community can negatively impact downstream or neighboring jurisdictions.
- Fewer programs and grants exist to support flood mitigation efforts than in the past.
- Mitigation efforts that could be most effective include flood buyouts, implementation of the Federal Flood Insurance Program and the adoption of stream setback ordinances to keep development further from area streams and floodplains. Other efforts might include partnerships with agencies to provide temporary shelter/housing for those displaced.
- Changing weather patterns can increase the frequency and severity of flash floods and will be exacerbated by city design/development.

4.10 Levee Failures

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 surfaces are stressed beyond their capabilities to withstand floods, levee failure can result in loss of life and injuries as well as damages to property, the environment, and the economy. Levees are usually engineered to withstand a flood with a computed risk of occurrence. In Missouri, there are an estimated 1,926 miles of levees, many of which were largely constructed to protect agricultural land and are not built to design standards established to protect people and property.[xviii] Their presence can, in some cases, generate a false sense of security. If a larger flood occurs, that structure will likely be compromised. In the event of a levee failure, the water behind it can be released as a flash flood. Failed levees can create floods that are catastrophic to life and property, in part because of the tremendous energy of the released water. **See Figure 4.10.1.**

Source: Jackson County, MO Sheriff's Office[xix]

Figure 4.10.1: Breached Levee in Levasy, Missouri

For the purposes of this plan, the term levee failure will refer to both overtopping and breach of a levee.[xx] 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. A levee breach occurs when part of the levee gives way, creating an opening through which floodwaters may pass. **See Figure 4.10.2 – Figure 4.10.3.**

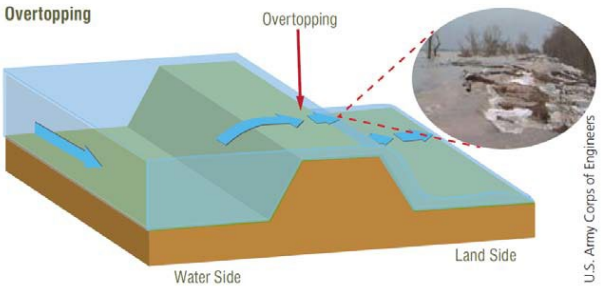


Figure 4.10.2: Overtopping of a Levee

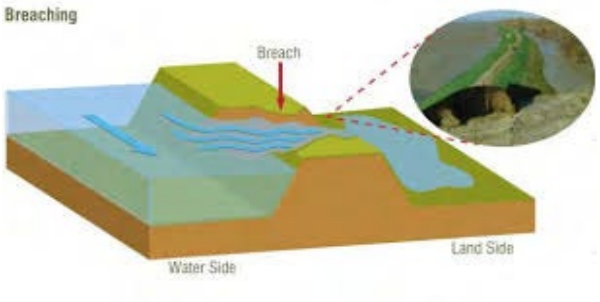


Figure 4.10.3: Breaching of a Levee

Source: Missouri State Hazard Mitigation Plan 2013

Earthen levees can be damaged in several ways. **Figure 4.10.4** presents a few inundation scenarios. 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. Seismic activity can also cause levees to slide or slump, both of which can lead to failure.

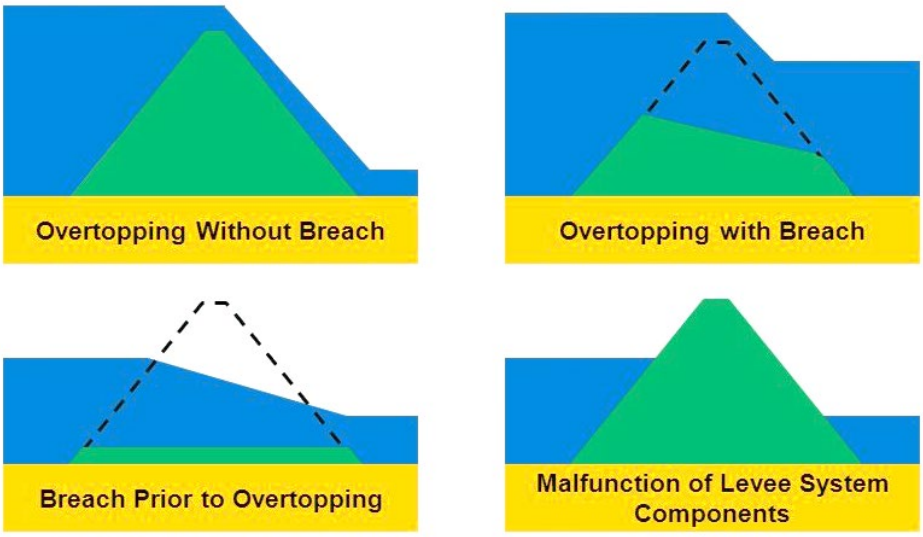


Figure 4.10.4: Inundation Scenarios

Source: Missouri State Hazard Mitigation Plan 2013

Three categories of levees are discussed in the Levee Failure profile:

1. Levees in the USACE Levee Safety Program
2. FEMA Accredited Levees
3. Levees that are both in the USACE Levee Safety Program and Accredited by FEMA

Levees in the USACE Levee Safety Program

The Levee Safety Program (LSP) was created by the USACE in 2006 to assess the integrity and viability of levees and to make sure levee systems that do not present unacceptable risk to the public, property and environment. Under this program, the USACE conducts levee inspections that are used to rate levee systems and determine compliance with operation and maintenance requirements, understand the overall levee condition, and determine eligibility for federal rehabilitation assistance under PL84-99.[xxi]

According to the National Levee Database managed by USACE, there are currently 36 levees in the Kansas City region included in the Levee Safety Program, of which one is rated acceptable, 18 are rated minimally acceptable, and 15 are not reported. Eleven of the 34 levees are federally constructed and turned over to the public sponsor for operations and maintenance. All other levees are locally constructed, operated and maintained.

See **Table 4.10.1** for specific levees in the USACE LSP as of December 31, 2014[xxii]

Table 4.10.1: USACE Levees in Cass, Clay, Jackson, Platte, and Ray Counties

County	NAME	Public Sponsor	Length (Miles)	Leveed Area Acreage	Levee Safety Action Classification	People at Risk	Structures at Risk	Property Value
Clay	Birmingham Unit	Birmingham Drainage District	10.84	4,990	Low	1,113	209	$489M
Clay	North Kansas City Levee Unit	City of Kansas City, Missouri, North Kansas City Levee Unit	8.70	2,909	Moderate	26,703	1,658	$4.4B
Clay, Jackson	Northeast Birmingham Unit	Undefined	0.84	435	Not Screened	0	0	$0
Clay, Ray	Egypt L&D District Tri-County Ray Clay Jack	Egypt Levee & Drainage District, Tri-County of Ray, Clay, Jackson, MO	13.31	4,526	Low	0	0	$0

Jackson	East Bottoms Unit	City of Kansas City, Missouri	9.15	4,335	Moderate	16,539	751	$5.6B
Jackson	FIRE PRAIRIE CREEK - LEVASY	Undefined	2.66	344	Not Screened	4	2	$700K
Jackson	FIRE PRAIRIE CREEK LEVEE 1	City of Levasy	0.61	187	Not Screened	12	4	$1.4M
Jackson	FIRE PRAIRIE CREEK LEVEE 2	City of Levasy	1.73	342	Not Screened	570	228	$88.4M
Jackson	FIRE PRAIRIE CREEK LEVEE 3	City of Levasy	2.71	578	Not Screened	14	8	$2.66M
Jackson	GSA Bannister Complex	Department of Energy	1.66	289	Not Screened	6,573	276	$1.69B
Jackson	Lake City AAP	Lake City AAP	4.26	2,061	Not Screened	188	6	$4.91M
Jackson	LAKE CITY AAP	Lake City AAP	3.74	1,435	Not Screened	0	0	$0
Jackson	Liberty Bend Cutoff Levee Left Bank	Liberty Bend Non-Project , USACE	0.82	802	Not Screened	128	24	$25.4M
Jackson	Liberty Bend Cutoff Levee Right Bank	Liberty Bend Non-Project , Liberty Bend Right Bank Non-Project Segment Upstream, USACE	1.02	635	Not Screened	4	12	$7.88M
Jackson	MRLS 351-R	Atherton Levee District, Atherton-Blue Mills Levee District	16.00	8,154	Low	245	140	$80.4M
Jackson, Wyandotte	CID, Central Industrial District	City of Kansas City, Missouri, Kaw Valley Drainage District	1.84	950	Moderate	7,494	287	$967M

Jackson, Wyandotte	Turkey Creek RB Levee, Tunnel and Walled Channel	United Government of Wyandotte County	0.54	194	Not Screened	1,394	219	$424M
Platte	MRLS 385-L Quindaro Bend	Riverside Quindaro Bend Levee District	4.04	1,446	Low	1,367	42	$310M
Platte	MRLS 385-L Riverside	Riverside Quindaro Bend Levee District	1.22	139	Low	438	54	$90.2M
Platte	MRLS 400-L	Waldron Levee District	7.33	3,821	Low	66	41	$9.28M
Platte	MRLS 400-L Ring Levee	Waldron Levee District	0.14	3	Low	2	2	$105K
Platte	MRLS 408-L	Farley-Beverly Drainage District	12.19	9,827	Low	222	127	$41.6M
Platte	Platte County Drainage Dist 1 sec. 2, Bean Lake	Bean Lake Levee Association, Platte County Drainage District	9.40	6,674	Low	304	425	$45M
Platte	Sugar Creek Levee 1	Undefined	0.78	232	Not Screened	4	2	$830K
Platte, Buchanan	Platte County Drainage District No. 1 Section 1	Platte County Drainage District, Rushville-Sugar Lake	12.18	9,136	Low	304	425	$45M
Ray	HENRIETTA-CROOKED RIVER L&D DIST, SEC 2 B	Undefined	1.21	58	Not Screened	2	2	$760K
Ray	MO VALLEY D&L DIST OF RAY CO. MO, SECTION 1 A	Undefined	1.98	1,273	Not Screened	14	9	$2.55M
Ray	MO VALLEY D&L DIST OF RAY CO. MO, SECTION 1 B	Undefined	1.97	525	Not Screened	210	86	$30.3M

Ray	MO VALLEY D&L DIST OF RAY CO. MO, SECTION 2	Undefined	1.70	576	Not Screened	0	2	$390K
Ray	MO Valley D&L Dist. of Ray Co. MO, Section 2	MO Valley D&L Dist. of Ray Co. MO	1.96	277	Low	0	0	$22.2K
Ray	MO Valley D&L Dist. of Ray Co. MO, Section 3	MO Valley D&L Dist. of Ray Co. MO	2.66	287	Low	0	0	$49.1K
Ray	RAY-LAFAYETTE LEVEE DIST. NO. 2	Undefined	1.69	511	Not Screened	0	0	$0
Ray, Carroll	The Ray-Carroll Levee District of Ray County, Missouri	The Ray-Carroll Levee District of Ray County, Missouri	21.86	13,575	Low	627	372	$77.7M
Ray, Lafayette	MO Valley D&L Dist. of Ray Co. MO, Section 1	MO Valley D&L Dist. of Ray Co. MO	13.65	9,928	Low	78	104	$14.4M
Ray, Lafayette	RAY-LAFAYETTE LEVEE DIST. NO. 1	Undefined	5.25	8,044	Not Screened	32	20	$9.9M
Ray, Lafayette	Ray-Lafayette Levee Dist. No. 1	Henrietta-Crooked Section 1, Ray-Lafayette		29,693	Low	399	239	$48.8M

FEMA Accredited Levees

Many levees shown on the effective Flood Insurance Rate Maps (FIRM) were mapped in the 1970s and 1980s and have never been remapped by FEMA. Prior to 1986, levees were shown on FIRMs as providing protection from base flood when they were designed and constructed in accordance with sound engineering practices. Since 1986, levees have been shown as accredited on FIRMs only when they meet the requirements of 44 CFR 65.10 “Mapping Areas Protected by Levee Systems,” including certification by a registered professional engineer or a federal agency with responsibility for levee design.

Levees that do not meet the requirements of 44 CFR 65.10 cannot be shown as accredited on a FIRM. Furthermore, floodplain areas behind the levee are at risk to base flood inundation and are mapped as high-risk areas subject to FEMA’s minimum floodplain management regulations and mandatory flood insurance purchase requirement.

In 2004, as it initiated work under the Flood Map Modernization Initiative (Map Mod), FEMA determined that analysis of the role of levees in flood risk reduction would be an important part of the mapping efforts. A report issued in 2005 noted that the status of the nation's levees was not well understood and the condition of many levees and floodwalls had not been addressed since their original inclusion in the NFIP. As a result, FEMA established policies to address existing levees.

For the remainder of this discussion, FEMA Accredited Levees will be discussed in two main types: those mapped on Digital Flood Insurance Rate Maps (DFIRM) since the Flood Map Modernization Initiative and those that are mapped prior to the initiative and not mapped on DFIRMs.

FEMA Accredited Levees Mapped on DFIRMS

As DFIRMs are developed, levees fall under one of the three following categories:

Accredited Levee – With the exception of areas of residual flooding (interior drainage), if the date and documentation specified in 44 CFR 65.10 is readily available and provided to FEMA, the area behind the levee will be mapped as moderate-risk areas. There is no mandatory flood insurance purchase requirement in a moderate-risk area, but flood insurance is strongly recommended.

Provisionally Accredited Levee (PAL) – If data and documentation is not readily available, and no known deficiency precludes meeting requirements of 44 CFR 65.10, FEMA can allow the party seeking recognition up to two years to compile and submit full documentation to show compliance with 44 CFR 65.10. During this two-year period of provisional accreditation, the area behind the levee will be mapped as moderate-risk with no mandatory flood insurance purchase requirement.

De-Accredited Levees – If the information established under 44 CFR 65.10 is not readily available and provided to FEMA, and the levee is not eligible for the PAL designation, the levee will be de-accredited by FEMA. If a levee is de-accredited, FEMA will evaluate the level of risk associated with each non-accredited levee through its Levee Analysis Mapping Procedures (LAMP) criteria to consider how to map the floodplain and which areas on the dry side of the levee will be shown as high risk. The mapping will then be updated to reflect this risk.

Table 4.10.2 shows the status of accredited levees within the region. The table distinguishes between USACE program levees and non-USACE program levees.

Table 4.10.2: Levee Accreditation Status in DFRIM Counties in the Kansas City Region				
County	**Primary Community**	**Levee Owner**	**USACE Program Levee**	**Levee Status**
Clay	Kansas City, MO	Birmingham Drainage District	Yes	PAL
Clay	Kansas City, MO; North Kansas City, MO	City of Kansas City, MO	Yes	Accredited
Clay	North Kansas City	North Kansas City Levee District	Yes	PAL
Jackson	Kansas City, MO	City of Kansas City, MO	Yes	PAL
Jackson	Jackson County Unincorporated Areas	Atherton Levee District	Yes	PAL
Jackson	Jackson County Unincorporated Areas	Atherton- Blue Mills Levee District	Yes	PAL
Jackson	Kansas City, MO	GSA	Yes	Accredited
Jackson	Levasy	Northeast Industrial District (East Bottoms)	Yes	Not PAL Eligible
Platte	Platte County Unincorporated Areas	Waldron Levee District	Yes	PAL
Platte	Platte County Unincorporated Areas	Farley-Beverly Levee District	Yes	PAL
Platte	Riverside	Riverside- Quindaro Bend Levee District	Yes	PAL
Platte	Riverside	Riverside- Quindaro Bend Levee District	Yes	PAL
Ray	None Identified			

4.10.1 Historical Occurrences

Data Limitation: The damage years for levees in the five-county area are unknown. The Missouri State Hazard Mitigation Plan provides an example of levee damage history (1942–1993) for southeastern Missouri. A similar history can provide the extent and probability for the Kansas City area. For example, Ray County has received 13 federal disaster declarations for flooding.[xxiii]

The historical narratives below provide an overview of significant floods in recent years relative to levee failure mainly due to spring thaw and storms.

Flood of 1993 Summary

Known as the "Great Flood of 1993," this flood is considered to be among the most expensive ever in the United States, with total damages of over $15 billion and an overall death toll of 50, of which at least 13 took place in Missouri. This flood evolved from a series of heavy rain events along the Missouri and Mississippi Rivers, culminating with a crest of 49.58 feet and a flow of 1.08 million cubic feet per second on August 1 on the Mississippi River at St. Louis. The areas of record flooding extended well upstream on both the Missouri and Mississippi Rivers within Missouri, including western Illinois, western Wisconsin, southern Minnesota, southeastern South Dakota, eastern Nebraska, and much of Kansas, Missouri and Iowa. Months of heavy rainfall followed a winter of near- to above-average snowfall to produce significant spring flooding over much of Missouri. For the first seven months of 1993, United States

Department of Agriculture/Agriculture Stabilization and Conservation Service county offices reported more than 50 inches of rainfall in Osage, Sullivan and Worth Counties — more than twice their normal totals. In June and July, the rainfall intensified as mainly nocturnal thunderstorms affected much of the lower Missouri and middle Mississippi River basins.

Throughout the Midwest, at least 75 towns were completely inundated, an estimated 54,000 people were evacuated, and about 50,000 homes were damaged or destroyed by the flooding. And personal impacts extended well beyond flooded structures. In Iowa, for example, tens of thousands of people were unable to work due to a lack of public water supplies needed for sanitation, firefighting, and routine operation of businesses. Transportation was severely affected throughout Missouri. At one point in July, all road bridges between St. Louis and Burlington, Iowa, were closed due to flooding. On Friday, July 16, only 5 of 28 bridges connecting Missouri with Illinois were open. At one point, all bridges crossing the Missouri River between St. Louis and Kansas City were closed, along with sections of Interstates 29, 35, and 70 across Missouri, all at considerable cost to the trucking industry. Along the Mississippi River, barge traffic was halted for over a month, costing the barge industry between $3–4 million each day. The rail industry suffered losses of over $300 million, with more than $100 million in losses in Missouri alone. Damages to locks and dams and levee systems were staggering. Over a thousand levee systems, including 40 federal levees, were damaged or destroyed.

The agriculture industry also experienced huge losses. More than 600 billion tons of topsoil were removed by the flood and deposited downstream. Over a million acres were flooded, much of it farmland. All of this was a complete loss at harvest time, resulting in a total agricultural loss of $1 billion.

According to SEMA, this flood brought issues related to levees to the forefront.[xxiv] The flood approached or exceeded the 100-year threshold on most major rivers and resulted in overtopping or failure of large numbers of levees, most of them agricultural levees that provided various levels of damage/risk reduction. As a result of this flooding, 840 of Missouri's estimated 1,456 levees were damaged. A number of flood-level records were broken in 1993. In the USACE St. Louis and Kansas City Districts, 867 of 947 federal and non-federal levees failed or were overtopped, greatly contributing to the flooding. (See Table 4.10.3) The Missouri River, normally no more than a half-mile wide, expanded to 5–6 miles wide north of St. Joseph and 8–10 miles wide east of Kansas City.

Table 4.10.3 Number of Failed or Overtopped Federal and Non-Federal Levees – 1993 Flood

USACE District	Federal	Non-Federal
Kansas City	6 of 48	810 of 810

Source: Missouri State Hazard Mitigation Plan

2011 Flooding Summary[xxv]

On July 25, 2011, a major disaster declaration was requested due to flooding during the period of June 1 to August 1, 2011 (See Figure 4.10.5). The governor requested a declaration for individual assistance for 11 counties, public assistance for 22 counties and hazard mitigation for the entire state of Missouri. During the period of July 18–22, 2011, joint federal, state, and local PDAs were conducted in the requested counties and are summarized below.

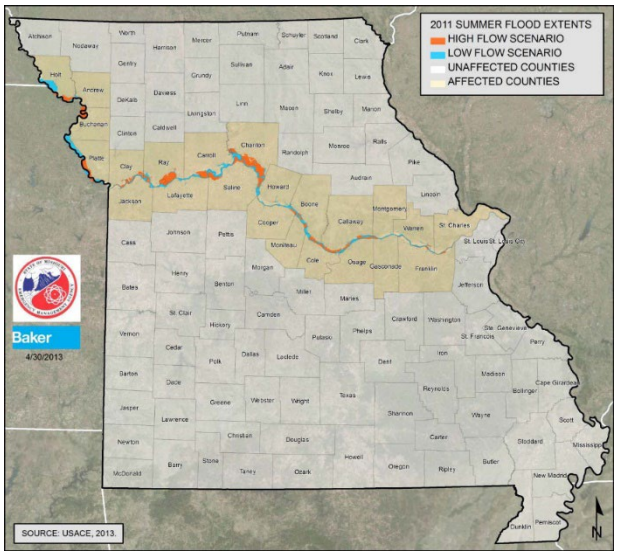


Figure 4.10.5: Summer Flood Extents (Missouri)[xxvi]

Flooding 2017

Cass, Clay, Jackson, Platte, and Ray counties did not receive federal disaster declaration in 2017. However, a period of flooding occurred during the months of July and August. On the evening of July 26, a line of thunderstorms formed roughly along the Interstate 70 corridor. The storms remained over Kansas City and surrounding areas for several hours, causing some extreme flash flooding. Some of the heaviest rain hit some of the most vulnerable parts of the city, namely Indian Creek near the Kansas and Missouri state line. The Kansas City area received 5 to 7 inches of rain fall over a roughly 3-hour period, causing Indian Creek at State Line Road to rise to 27.96 feet, a new record for that location. The result was businesses in that area becoming inundated with several feet of running water. Numerous car dealerships saw much of their merchandise go underwater at that location. A strip mall consisting of a restaurant among other businesses had water at least 6 feet deep.[xxvii]

From August 21st through the 22nd, multiple rounds of heavy rain fell, with some of the highest totals observed over the southwestern portions of the Kansas City metro area and other locations south of Kansas City. Widespread amounts of 4 to 6 inches were recorded, with isolated reports of 8 to nearly 10 inches. In addition to numerous roads and some schools closed due to widespread flooding, record crests were made on Indian Creek at State Line Road. Several water rescues were made overnight on August 21 2017, due to flooding.[xxviii]

2019 Flooding

On May 21, 2019 FEMA announced that federal disaster assistance has been made available to the state of Missouri to supplement state and local recovery efforts in the areas affected by severe storms, straight-line winds, and flooding on March 11 to April 16, 2019.[xxix] Platte and Ray counties were included in this declaration to receive funding for emergency work and repair or replacement of facilities due to severe storms, straight-line winds, and flooding.[xxx]

Bean Lake is a levee system that runs seven miles in Platte County, Missouri. It was breached on March 20, 2019 as well as during the flood of 1993. It's operated by two agencies, the Platte City Drainage District (Platte County Section 2 segment) and the Bean Lake Levee Association (Bean Lake segment). It was inspected in June 2012. The Corps' 2016 risk assessment said that the "likelihood of a flood

overtopping this levee in the next year has been estimated at 2 percent, (one chance in 50)." Extrapolated out, that equaled a 45 percent "likelihood of water overtopping the levee over the life of a typical 30-year mortgage."[xxxi]

Rushville Sugar Lake is a 10.2-mile levee running across Buchanan and Platte counties in Missouri and operated by the Rushville Sugar Lake Levee District. It was breached around March 22, 2019. It was last inspected in June 2012. The likelihood of a flood overtopping this levee was estimated at 5 percent, or a one-in-20 chance, the assessment said. That equaled a 79 percent "likelihood of water overtopping the levee over the life of a typical 30-year mortgage."[xxxii]

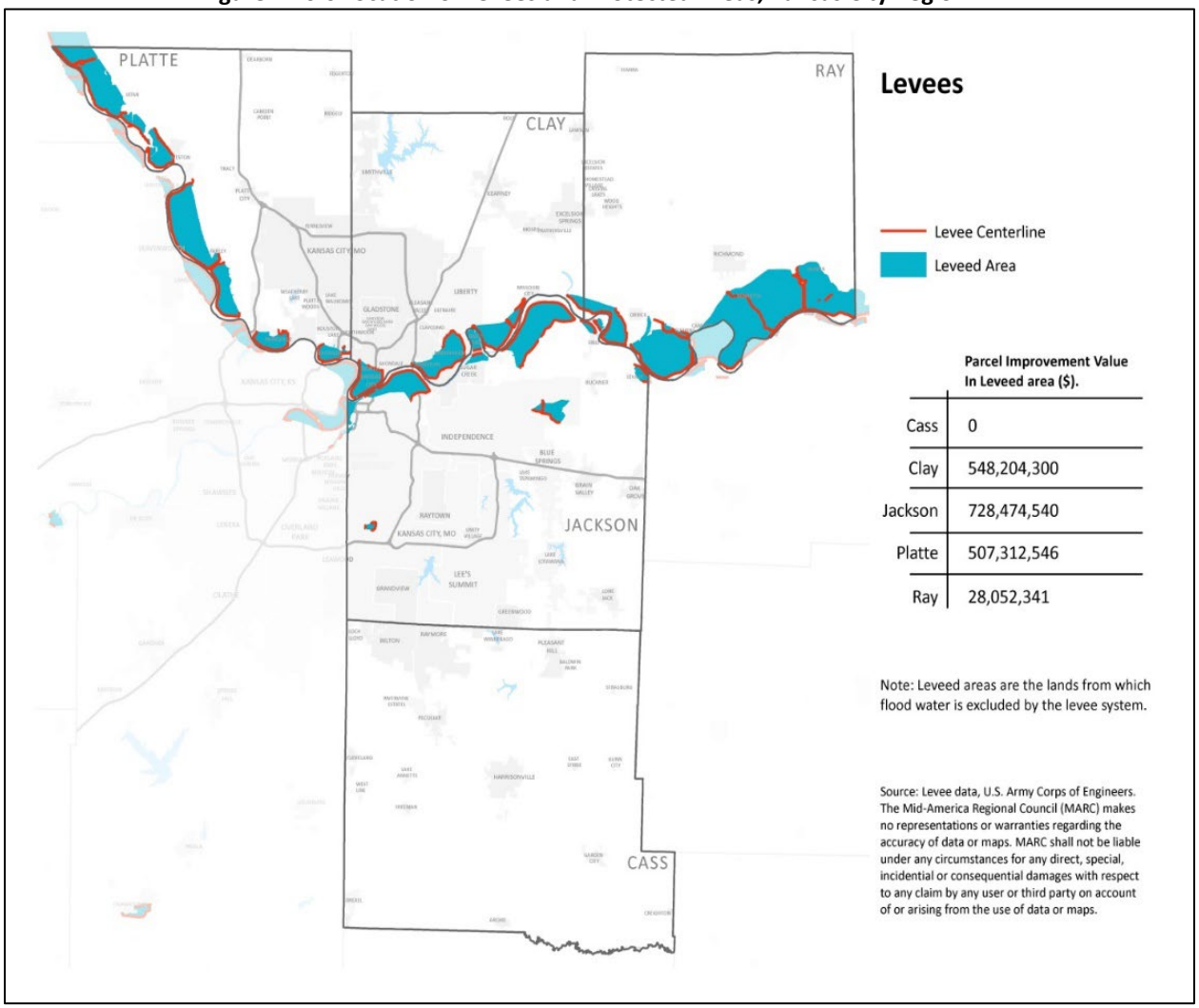
On June 24, 2019 Governor Mike Parson, Lt. Governor Mike Kehoe requested the President Donald Trump issue a major disaster declaration for flood, storm, and tornado damage beginning on April 29th, 2019. This declaration request involved 41 counties, Jackson and Platte among them. The Governor's request stated $25 million in qualifying expenses that had already been identified.[xxxiii] "Governor Parson said joint Preliminary Damage Assessments, conducted by the **State Emergency Management Agency**, **U.S. Small Business Administration**, **Federal Emergency Management Agency**, and local officials, examined 1,650 primary homes, of which 953 had been destroyed or sustained major damage. The assessments also showed that 125 of 251 businesses that were examined had been destroyed or sustained major damage"

4.10.2 Probable Locations

Magnitude 10%-15%

Figure 4.10.6 below is the Location of Levees and Protected Areas within the Kansas City Region. A magnitude rating of 10%-15% was given to all counties except Cass, because only the portions of the county near levee locations will be affected in the event of a levee failure.

Figure 4.10.6 Location of Levees and Protected Areas, Kansas City Region



4.10.3 Impact

"Levees in the state of Missouri that are accredited against the 0.2 percent and 1 percent annual chance of flooding provide protection for close to 2,200 square miles of land. The majority of privately constructed and maintained levees provide protection for an even greater expanse of agricultural land. Should major flood events like the 1993 flood strike, the severity of damage to human lives and properties from all levee failures is expected to be high. While the U.S. Army Corps of Engineers has done major levee reconstruction for levees that are in the PL84-99 program following the 1993 flood, proper inspection, diligent maintenance and timely repair are key to controlling the severity of levee failure damage in the event of another catastrophic flood.

The magnitude of levee failure during a flooding event can be very similar to a dam failure in that the velocity of the water caused by sudden release. A levee breach can result in a flood surge or flood wave that can cause catastrophic damages. If the levee is overtopped due to flood waters more than that of the levee design, impacts are similar to flood impacts."

4.10.4 Probability of Future Occurrence: Low (500-year Event) to High (100-year Event)

Given the numerous levee systems constructed along the main stems and tributaries of the Missouri River, the Kansas City region is highly susceptible to catastrophic levee failure and/or overtopping. Not counting the great flood of 1993, for the 70-year period from 1942 to 2012 for which levee failure statistics are available, over 100 levee failures/over toppings were recorded. In the Flood of 1993 alone, 840 levees — over 55 percent of the levees in the state of Missouri — sustained significant damages. This translates to an overall high probability of 1 percent (100-year event) annual chance flood levee failure in any given year. The probability of a 0.2 percent (500-year event) annual chance flood levee failure has been defined as low for this plan update.[xxxv]

4.10.5 Vulnerability Analysis and Potential Loss Estimates

Flooding is the most common hazard associated with levee failure, breach or overtopping. A levee failure, breach or overtopping can result not only in loss of life, but also considerable loss of capital investment, loss of income and property damage. As discussed in the introduction to this section, extreme flooding conditions have the potential to result in levee failures. Since levee failure is an area-specific hazard, potential loss estimates could be tied directly to the hazard area by jurisdiction. Table 4.10.4 below is the resultant potential loss estimates for jurisdictions within the levee protected areas (*asterisks indicate the community is a current plan participant).

Table 4.10.4 Potential Loss Estimates for County/City Structures and Land Protected by Levees

City	Total Building Value	Total land Value	Total Value	City	Total Building Value	Total land Value	Total Value
Cass County	No risk			**Clay County***	$548,204,300	$281,844,500	$830,048,800
Jackson County*	$728,474,540	$205,133,266	$933,607,806	**Platte County***	$507,312,546	$63,719,224	$571,031,770
Ray County*	$28,052,341	$27,726,259	$55,778,600	**Liberty***	$46,700	$1,771,200	$1,817,900
Birmingham	$26,280,600	$4,640,500	$30,921,100	**Missouri City**	$1,164,500	$463,700	$1,628,200
Camden	$0	$63,680	$63,680	**North Kansas City***	$345,595,200	$207,965,200	$553,560,400

Table 4.10.4 Potential Loss Estimates for County/City Structures and Land Protected by Levees							
City	**Total Building Value**	**Total land Value**	**Total Value**	**City**	**Total Building Value**	**Total land Value**	**Total Value**
Farley*	$1,101,561	$4,403,306	$5,504,867	**Parkville***	$10,967	$1,148,209	$1,159,176
Fleming	$0	$468,040	$468,040	**Randolph**	$2,217,800	$4,104,300	$6,322,100
Harden	$16,600,690	$593,120	$17,193,810	**Riverbend**	$0	$98,900	$98,900
Henrietta	$6,281,660	$437,210	$6,718,870	**Riverside***	$204,336,624	$36,368,504	$240,705,128
Independence*	$25,332,006	$13,217,713	$38,549,719	**Sugar Creek**	$9,742,229	$1,361,080	$11,103,309
Kansas City*	$875,002,623	$248,542,150	$1,123,544,773	**Weston***	$20,855	$136,407	$157,262

Data limitations: Since no good modeling exists to more accurately determine potential loss of the levee systems, the loss estimates below assume a total loss of all buildings within the leveed area. While this may be slightly extreme, it is not unrealistic to assume a total levee failure would cause massive if not catastrophic damage to the protected area.

4.10.6 Problem Statements

Vulnerability statements, such as those below, can support development of mitigation strategies for Levees:

- Several local levees don't have public sponsors identified; upkeep and maintenance for these levees is unclear.
- Unregulated private levees, or those installed without the coordination of a levee district may have negative downstream impacts.
- Property owners may be unaware of public information resources about levee safety.

4.11 Dam Failures

The National Dam Safety Act defines a dam as "an artificial barrier which impounds or diverts water and: (1) is more than 6 feet high and stores 50-acre feet or more [of water] or (2) is 25 feet or higher and stores more than 15 acre-feet [of water]." Dam construction varies widely, ranging from small earthen dams containing farm ponds to large structures of reinforced concrete used for hydroelectric power. Between these two extremes are larger earthen dams reinforced with a core of concrete or asphalt. Most dams in Missouri, including those in the Kansas City metropolitan area, are of earthen construction.[xxxvi]

Dam failures are most likely to happen for the following reasons[xxxvii]:

- **Piping** – Piping is caused when seepage through a dam is not properly filtered and soil particles continue to progress, and form sink holes in the dam. Piping failures are usually caused by embankment leakage, foundation leakage and/or the deterioration of structures on the dam.
- **Structural Failure** – Structural failure of materials used in dam construction may be caused by an earthquake, slope instability or poor construction.
- **Cracking** – Cracking of dams may be caused by movement, such as the natural settling of a dam, or by earthquakes.
- **Overtopping** – Overtopping is water spilling over the top of a dam. This condition can deteriorate dams made of earth, rock or mine tailings.
- **Inadequate maintenance and upkeep** – Inadequate maintenance and upkeep can result in one or more of the aforementioned problems, causing failure of the dam.
- **Erosion** – Erosion of dams is generally caused by inadequate capacity of a spillway, resulting in overtopping of the dam, flow erosion or inadequate slope protection.[xxxviii]

These types of failures may be interrelated. Erosion, for example, may weaken the dam and lead to structural failure. Similarly, structural failure of a dam may shorten the seepage path and lead to a piping failure. Many of the region's dams are old, and with age come a greater likelihood of deterioration and the failure of a dam's structure and systems.[xxxix]

Structural failure is the most common cause of dam failure, and flooding is the most common hazard that interacts with dam failure. According to SEMA, "prolonged rains and flooding can saturate earthen dams . . . producing much the same breaching effect as that which occurs with earthen levees. Flooding can also result in overtopping of dams when the spillway and reservoir storage capacities are exceeded by the excess water. A large slide may develop in either the upstream or downstream slope of the embankment and threaten to release the impounded water." Other natural hazards, such as earthquakes or tremors, can also severely damage dams, including complete structural collapse.[xl]

In the 1970s, three major dam failures occurred within a 15-month period, prompting the development of a national dam safety program. Among the most catastrophic were the failures of the Teton Dam in Idaho in 1976, which killed 14 people and caused more than $1 billion in damage, and the Kelly-Barnes Dam in Georgia in 1977, which left 39 dead and $30 million in property damage. In Missouri, dam failures occurred in Lawrenceton in 1968, Washington County in 1975, Fredricktown in 1977, and on December 14, 2005, with the collapse of the Upper Reservoir of Ameren UE's Taum Sauk hydroelectric complex in Reynolds County. Many of Missouri's smaller dams are becoming a greater hazard as they continue to age and deteriorate. Hundreds of dams are in need of rehabilitation; however, a lack of funding and questions of ownership have made it difficult to implement the necessary maintenance.[xli]

The Missouri Department of Natural Resources (MDNR) Water Resources Center is responsible for ensuring that all new and existing non-agricultural, non-federal dams 35 feet or higher meet the minimum safety standards established by the Dam and Reservoir Safety Law. The MDNR has three classifications for all state-regulated dams:

- ***Class 1*** – The area downstream from the dam that would be affected by inundation contains 10 or more permanent dwellings or any public building. Inspection of these dams must occur every two years.
- ***Class 2 –*** The area downstream from the dam that would be affected by inundation contains one to nine permanent dwellings, or one or more campgrounds with permanent water, sewer and electrical services, or one or more industrial buildings. Inspection of these dams must occur once every three years.
- ***Class 3 –*** The area downstream from the dam that would be affected by inundation does not contain any of the structures identified for Class I or Class II dams. Inspection of these dams must occur once every five years.

4.11.1 Historical Occurrences

There are no historical occurrences of dam failures in Cass, Clay, Platte, Jackson or Ray counties.

4.11.2 Probable Locations

Magnitude <10%

The National Inventory of Dams (NID),[xlii] developed and maintained by the U.S. Army Corps of Engineers (USACE), and distributed by the Missouri Office of Dam Safety, includes 269 dams in the Kansas City metropolitan area, with 123 of those classified as *high hazard* and 46 classified as *significant hazard*. One high-hazard dam and three significant-hazard dams were included in the 2017 inventory. Lake Deanna Dam and Grand Oaks Dam are both State-regulated and classified as significant-hazard dams. 36601 Jim Owings is a private dam classified as high-hazard. Lake Lotawana Sediment Pond Dam is a private dam classified as significant-hazard. Table **4.11.1** summarizes the 269 dams in Cass, Clay, Jackson, Platte and Ray counties.

Each county was given the lowest magnitude rating of <10% due to no historical dam failure events.

Table 4.11.2 summarizes the 42 dams in the five-county planning area regulated by the state of Missouri by class and hazard. Table 4.11.3 lists all 42 state-regulated dams with select characteristics. The MDNR inventory of dams contains additional information on area dams that is not included in this table due to space limitations. Information from the MDNR inventory of dams is available from the Missouri Department of Natural Resources, Water Resources Program, P.O. Box 250, Rolla, MO 65401, (573) 368-2175.[xliii] As a mitigation measure, stakeholders are encouraged to review the MDNR information on local dams to develop and implement mitigation measures.

Table 4.11.1: Dams by Hazard Level, Owner Type and Height by County						
Owner Type	**High Hazard**	**>35'**	**Significant**	**> 35'**	**Low Hazard**	**>35'**
Cass County						
Local Government	5	1	0	0	3	0
Private	23	4	3	2	36	0
Clay County						
Federal	1	1	0	0	0	0
State	1	1	0	0	1	1
Local Government	0	0	0	0	3	1
Private	13	2	0	0	19	0
Jackson County						
Federal	3	2	0	0	4	0
State	3	1	0	0	8	0
Local Government	5	3	0	0	1	0
Private	40	14	1	0	18	2
Platte County						
Local Government	1	1	0	0	0	0
Private	16	4	0	0	13	0
Ray County						
Local Government	4	2	1	0	10	0
Private	8	3	5	0	20	1
Total						
Federal	4	3	0	0	4	0
State	4	2	0	0	9	1
Local Government	15	7	1	0	17	1
Private	100	27	9	2	106	3
Total	**123**	**39**	**10**	**2**	**136**	**5**

Table 4.11.2: MDNR Regulated Dams by County (Class and Hazard Level)						
County	Regulated Class			Hazard Level		
	Class 1	Class 2	Class 3	High	Significant	Low
Cass	5	2	0	5	2	0
Clay	2	1	2	3	0	2
Jackson	15	3	2	18	0	2
Platte	5	0	0	5	0	0
Ray	1	4	0	5	0	0
Total	**28**	**10**	**4**	**36**	**2**	**4**

Data limitation: The Emergency Action Plans (EAP) for High-Hazard Potential (HHP) dams have been completed and approved for each of the five counties as of the last 2015 Plan update.[xliv] An EAP is a plan of action to reduce potential property damage and loss of lives in an area affected by a dam failure and should include a map of the potential inundation area along with procedures and information for warning downstream emergency management authorities. The process for rolling out EAPs to county officials has been staggered. As of this Plan update, only Jackson County inundation pathways were available for inclusion into this risk assessment.

Table 4.11.3: Missouri State- Regulated Dams in the Five County Planning Area											
County	Name	Class	Hazard	Owner Type	Height (Feet)	Storage (Acre-Ft.)	Primary Purpose	Dam Type	River	Nearest City	Distance (Miles)
CASS	GRAND OAKS FARMS LAKE DAM	2	NUID	Private	35.4	91	-	-	TRIB EAST CREEK	BELTON	3
CASS	HARRISONVILLE CITY LAKE DAM	1	High	Local Govt.	55	13520	Recreation and Water Supply	Earth	TR MIDDLE BIG CREEK	PLEASANT HILL	4
CASS	LAKE DEANNA DAM	2	Signficant	Private	67	1876			HARDING CREEK	NA	0
CASS	LAKE WINNEBAGO DAM	1	High	Private	64	7150	Recreation	Earth	MIDDLE BIG CREEK	LATOUR	21
CASS	LAKE WINNEBAGO DAM EXPANSION, NOT BLT	1	High	Private	63	13700	-	Earth		CITY OF LAKE WINNEBAGO	0
CASS	MILL CREEK DAM	1	High	Private	62	3850	Recreation	Earth	MILL CREEK	BELTON	0
CASS	RAINTREE LAKE DAM	1	High	Private	55	7220	Recreation	Earth	MIDDLE BIG CREEK	PLEASANT HILL	8
CLAY	HELVEY PARK DAM	3	Low	Local Govt.	36	203	Recreation and Water Supply	Earth	TR WILKERSON CREEK	SMITHVILLE	1
CLAY	HOLLY LAKE DAM	1	High	Private	40	140	Recreation	Earth	TR-LITTLE SHOAL CREEK	LIBERTY	0
CLAY	MEADOW LAKE ESTATES DAM	2	High	Private	47	400	-	-	-	-	0
CLAY	WATKINS MILL STATE PARK DAM	1	High	State	55	2600	Flood Control, Storm Water Management, and Recreation	Earth	TR-WILLIAMS CREEK	PRATHERSVILLE	-
CLAY	WILLIAMS CREEK #4 DAM	3	Low	State	46	598	Flood Control, Storm Water Management, and Recreation	Earth	TR TO WILLIAMS CREEK	MOSBY	-
JACKSON	ADAMS DAIRY PARKWAY DAM	2	High	Local Govt.	48	876	Flood Control and Storm Water Management	Earth	TRIB BLUE BRANCH	GRAIN VALLEY	3
JACKSON	BARBER LAKE DAM	1	High	Private	57	2186	Irrigation and Recreation	Earth	TR TO WEST FORK SNI-A-BAR CRK	LAKE LOTAWANA	
JACKSON	CARP LAKE DAM	3	Low	Private	45	83	Recreation	Earth	TR-LITTLE BLUE RIVER	LEES SUMMIT	1
JACKSON	COMMANDEER LAKE DAM	3	Low	Private	42	56	Recreation	Earth	TR-E FK LITTLE BLUE RIVER	INDEPENDENCE	1
JACKSON	DOUTT LAKE DAM	1	High	Private	38	86	Water Supply and Other	Rockfill and Earth	TRIB TO ROCK CREEK	INDEPENDENCE	0
JACKSON	LAKE JACOMO DAM	1	High	Local Govt.	74	38620	Recreation	Earth	EAST FORK LITTLE BLUE RIVER.	LEES SUMMIT	0
JACKSON	LAKE LOTAWANA DAM	2	High	Private	58	11568	Recreation	Earth	WEST FORK SNI-A-BAR CREEK	TARSNEY LAKES	3
JACKSON	LAKE TAPAWINGO DAM	1	High	Private	55	2000	Recreation	Earth	TR EAST FORK OF LITTLE BLUE R	INDEPENDENCE	0
JACKSON	LAKEWOOD-EAST DAM	1	High	Private	75	4810	Recreation	Earth	WEST FORK OF MAY BROOK	LEES SUMMIT	1
JACKSON	LAKEWOOD-WEST DAM	1	High	Private	84	6000	Recreation	Earth	WEST FORM OF MAY BROOK	LEES SUMMIT	1
JACKSON	LONE JACK LAKE DAM	2	High	State	47	660	Flood Control and Storm Water Management	Earth	TRIB TO THE SNI-A-BAR	LONEJACK	25
JACKSON	PRAIRIE LEE LAKE DAM	1	High	Local Govt.	69	6000	Recreation	Earth	EAST FORK LITTLE BLUE RIVER	BLUE SPRINGS	0
JACKSON	ROSENFELT DAM	1	High	Private	57	400	Recreation	Earth	UNNAMED TRIB TO BLUE RIVER	GRANDVIEW	1
JACKSON	TOM SMITH LAKE -EAST DAM	1	High	Private	55	127	Recreation	Earth	TR-BLUE RIVER	KANSAS CITY	3
JACKSON	TOM SMITH LAKE WEST	1	High	Private	50	302	-	Earth	TRIB. BLUE RIVER	STANLEY, KS	5
JACKSON	TOM SMITH SOUTH LAKE DAM	1	High	Private	57	650.8	-	Earth	TRIB. BLUE RIVER	STANLY, KS	5
JACKSON	UNITY #1 DAM	1	High	Private	48	285	Recreation and Water Supply	Buttress	TR-LITTLE CEDAR CREEK	UNITY VILLAGE	0
JACKSON	UNITY #2 DAM	1	High	Private	52	618	Recreation and Water Supply	Earth	TR-LITTLE CEDAR CREEK	KANSAS CITY	2
JACKSON	VIEW HIGH LAKE DAM	1	High	Private	37	148	Recreation	Earth	TR-LITTLE BLUE RIVER	KANSAS CITY	1
JACKSON	WHISPERING HILLS LAKE DAM	1	High	Private	40	190	Recreation	Earth	TR ROUND GROVE CREEK	KANSAS CITY	0
PLATTE	INTERNATIONAL AIRPORT DAM	1	High	Local Govt.	45	1670	Flood Control and Storm Water Management	Earth	TR TODD CREEK	PLATTE CITY	16
PLATTE	LAKE WAUKOMIS DAM	1	High	Private	68	2292	Recreation	Earth	TR LINE CREEK	LAKE WAUKOMIS	0
PLATTE	RISS LAKE DAM	1	High	Private	93	7720	Recreation	Earth	WHITE ALOE BRANCH	PARKVILLE	1
PLATTE	THOUSAND OAKS DAM	1	High	Private	70	190	-	Earth			0
PLATTE	WEATHERBY LAKE DAM	1	High	Private	84	5750	Recreation	Earth	RUSH CREEK	PARKVILLE	3
RAY	CRYSTAL LAKE DAM	1	High	Private	54	2846	Recreation	Earth	FISHING RIVER	EXCELSOR SPRINGS	1
RAY	HEDGES LAKE DAM	2	High	Private	43	115	Irrigation, Fire Protection, Stock, or Small Farm Pond, and Recreation	Earth	TR-SHACKELFORD BRANCH	ORRICK	0
RAY	HIDDEN VALLEY LAKE DAM	2	High	Private	52	454	Recreation	Earth	TR TO ROCKY FORK	HARDIN	0
RAY	LAWSON CITY LAKE DAM	2	High	Local Govt.	45	380	Recreation and Water Supply	Earth	BRUSHY CREEK	ELMIRA	11
RAY	WILLOW CREEK WTRSHD SITE A-1	2	High	Local Govt.	42	2000	Flood Control and Storm Water Management	Earth	WILLOW CREEK	HENRIETTA	-

4.11.3 Impact

There are 123 *high-hazard* dams plus ten *significant-hazard* dams located in the five-county area. The majority of these are privately owned and, if they were to fail, would not cause widespread damage. Dam owners are required to notify MDNR of any problem for *inspection*. Problems deemed a serious nature require the *notification* of emergency personnel. Problems deemed immediate require *evacuation*. The transition between those of a serious nature to immediate can either be a slow or rapid transition. At all three reporting levels, efforts are made to save and repair the dam.

Although unlikely, the failure of one of the USACE's six main stem dams on the Upper Missouri River Basin may also impact the Kansas City metropolitan area. These dams with their respective reservoirs and storage capacity include[xlv]:

- Fort Peck Dam and Lake (18.7 million acre-feet of water) near Glasgow, Montana
- Garrison Dam and Lake Sakakawea (23 million acre-feet of water) near Bismarck, North Dakota
- Oahe Dam and Lake (23.5 million acre-feet of water) near Pierre, South Dakota
- Big Bend Dam and Sharpe Lake (1.9 million acre-feet of water) near Fort Thompson, South Dakota
- Fort Randall Dam and Lake Francis Case (nearly 5.5 million acre-feet of water) near Wagner, South Dakota
- Gavins Point Dam and Lewis and Clark Lake (492,000 acre-feet of water) near Yankton, South Dakota

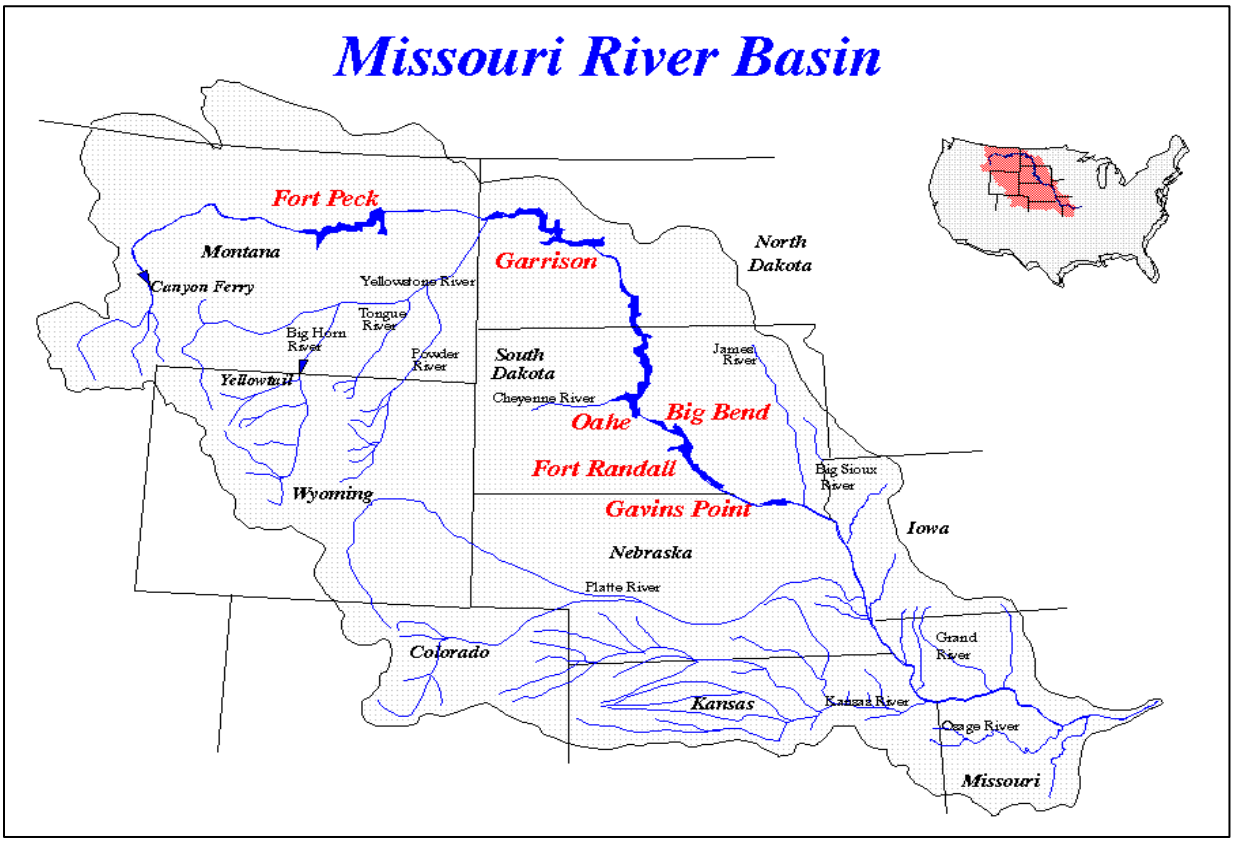
Map 4.11.1 depicts the locations of the six main stem dams on the Upper Missouri River Basin. Each of these dams holds back large bodies of water — Lake Sakakawea and Oahe Lake are two of the largest reservoirs in the nation — and a sudden release of water from one of these reservoirs due to dam failure could have a cascading effect. Water might have to be released from downstream reservoirs to accommodate the additional water received from an upstream dam failure, increasing the flow and level of water in the Missouri River and contributing to the potential for flooding at downstream locations, such as the Kansas City metropolitan area.

Probable Duration
Potential speed of onset (probable amount of warning time):

☐ Minimal (or no) warning
☐ 6 to 12 hours warning
☐ 12 to 24 hours warning
■ More than 24 hours warning

Community Assets
The rise and fall of rushing water can have disastrous impacts on life, property, the economy and the environment. Steps to prevent the loss of life and injuries in the event of a dam failure are similar to those for a tornado. However, instead of seeking shelter underground, evacuation for a dam failure requires people to seek high ground. Persons with disabilities, the elderly, and low-income individuals with limited means would be at a greater disadvantage.

A dam failure would result in damage to residential and commercial structures; critical infrastructure, including transportation and utility service interruptions; and economic losses to agricultural land and businesses. The natural environment could also be impacted by the force of the water damaging or destroying trees and vegetation.



Source: US Army Corps of Engineers, Missouri River Basin Water Management Division

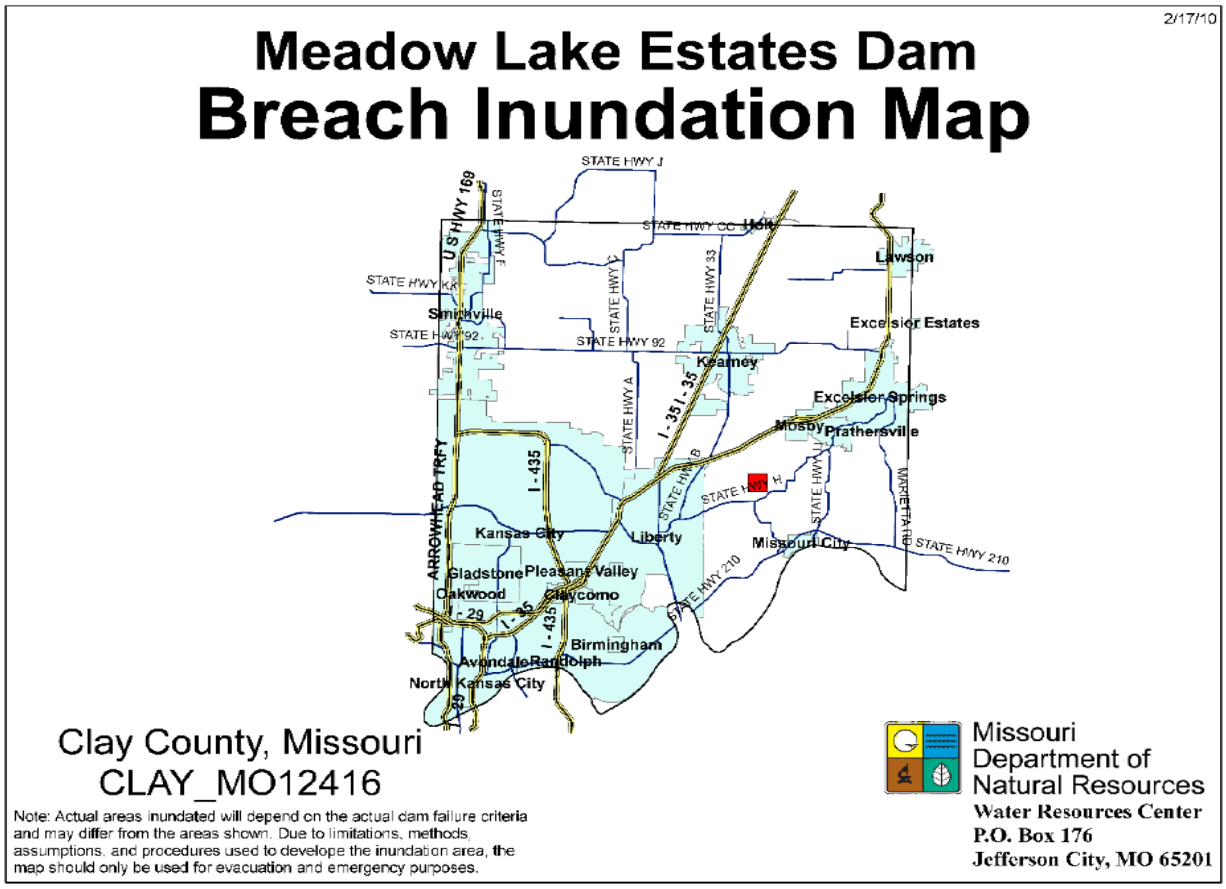
Map 4.11.1: USACE Main Stem Dams in the Upper Missouri River Basin

4.11.4 Probability of Future Occurrence

A probability percentage is unavailable because there no recorded events of dam failure in the five county area. However, the most likely cause of dam failure is heavy rainfall. In the Kansas City metropolitan area, May, June, July and September receive the highest average monthly rainfall amounts. Consequently, the risk of dam failure may be greatest in these months. Although less likely, dam failure may also be caused by a strong earthquake. Earthquakes, however, are not affected by climatic conditions and may occur at any time of the year. The Kansas City metro area is not at high risk for earthquakes (Missouri SEMA New Madrid zone outside KC metro area). Older dams, particularly those holding back large amounts of water, may pose significant risk to downstream populations and structures.

4.11.5 Vulnerability Analysis and Potential Loss Estimates

The Missouri Dam Safety Program reports that all high-hazard dams in the five-county area have approved Emergency Action Plans with inundation maps. As a part of the EAP, dam owners are required to have an evacuation plan and make inundation maps available to the local jurisdiction. See **Map 4.11.2** for a sample map. The state has completed inundation maps for 76 percent of these dams. Once the project is complete, inundation maps will be provided to each respective county in the state for planning and training purposes.[xlvi] Inundation maps are currently available for Jackson County.



Map 4.11.2: Sample Inundation Map (Meadow Lake Estates Dam)

Because inundation pathways are not largely available, the statistical risk assessment methodology was used to estimate loss for dam failures. Table 4.11.4 provides the results of the inundation area analysis with the numbers and values of various types of structures, and populations within the mapped areas for state-regulated dams. The table that follows (Table 4.11.5) provides the same analysis of the inundation area analysis of available USACE dams.

Table 4.11.4. Estimated Numbers and Values of Structures and Population Vulnerable to Failure of State-Regulated Dams with Available Inundation Areas				
County	Category	Number of Structures	Value of Structures	Population
Cass	Agriculture	59	$19,408,826	0
	Commercial	33	$21,877,498	0
	Residential	58	$18,158,559	150
Clay	Agriculture	7	$2,001,237	0
	Commercial	50	$64,219,612	0
	Government	1	$1,363,241	0
	Residential	75	$24,996,090	197
Jackson	Agriculture	33	$11,653,441	0
	Commercial	862	$1,164,527,949	0
	Education	4	$10,806,427	0
	Residential	914	$294,142,638	2,184
Platte	Agriculture	8	$2,425,473	0
	Commercial	56	$59,248,958	0
	Education	1	$2,061,764	0
	Government	2	$2,885,677	0
	Industrial	2	$2,192,478	0
	Residential	106	$39,664,446	269
Ray	Agriculture	3	$1,328,579	0
	Commercial	7	$4,730,945	0
	Residential	2	$551,568	5

Source: Missouri State Hazard Mitigation Plan, 2023

Table 4.11.5. Estimated Numbers and Values of Structures and Population Vulnerable to Failure of USACE Dams with Available Inundation Areas				
County	Category	Number of Structures	Value of Structures	Population
Cass	N/A	N/A	N/A	N/A
Clay	Agriculture	335	$95,773,470	0
	Commercial	666	$855,405,224	0
	Education	9	$21,108,963	0
	Government	38	$51,803,156	0
	Industrial	451	$611,170,441	0
	Residential	2298	$765,880,223	5,975
Jackson	Agriculture	510	$180,098,625	0
	Commercial	807	$1,090,225,121	0
	Education	11	$29,717,673	0
	Government	24	$41,722,484	0
	Industrial	1,875	$2,712,261,594	0
	Residential	4,085	$1,314,630,934	9,967
Platte	Agriculture	600	$181,910,427	0
	Commercial	434	$459,179,431	0
	Education	14	$28,864,695	0

	Government	40	$57,713,527	0
	Industrial	311	$340,930,409	0
	Residential	1,886	$705,727,785	4,640
Ray	Agriculture	899	$398,130,741	0
	Commercial	92	$62,178,136	0
	Education	20	$70,482,819	0
	Government	7	$5,912,062	0
	Industrial	46	$37,760,036	0
	Residential	989	$272,750,163	2,601

Source: Missouri State Hazard Mitigation Plan, 2023

4.11.6 Problem Statements

Vulnerability statements, such as those below, can support development of mitigation strategies for dam failures:

- 134 high-hazard dams (more than 35 feet) that could cause significant damage in inundation pathways exist throughout the planning area. Many of these are unregulated.
- While government and private owners of high-hazard dams have inundation pathways and completed Emergency Action Plans (EAP), these may not have been shared with local officials and potential affected parties.
- Local jurisdictions have little ability to require privately-owned dam owners to adequately maintain dams.
- There may be a need for regular training and exercising of evacuation plans in the vicinity of high-hazard dams.

[i] FEMA Website, Floods and Flash Floods Fact Sheet
[ii] SEMA State Hazard Analysis, Annex B
[iii] USA Today, online data
[iv] SEMA State Hazard Analysis, Annex B
[v] FEMA Web site, Floods and Flash Floods Fact Sheet, online document
[vi] USACE Walla Walla District, online data
[vii] SEMA State Hazard Analysis, Annex B
[viii] BCN Web site, online data
[ix] PBS, online data
[x] FEMA Web site, Floods and Flash Floods Fact Sheet, online document
[xi] FEMA Web site, Floods and Flash Floods Fact Sheet, online document
[xii] Pima County Flood Control District Web site, online data
[xiii] SEMA State Hazard Analysis, Annex B
[xiv] Linda Lam, "A Concerning Trend: Flooding Deaths Have Increased in the U.S. the Last Few Years," *The Weather Channel*, November 8, 2018, https://weather.com/safety/floods/news/2018-11-08-flood-related-deaths-increasing-in-united-states
[xv] Linda Lam, "A Concerning Trend: Flooding Deaths Have Increased in the U.S. the Last Few Years," *The Weather Channel*, November 8, 2018, https://weather.com/safety/floods/news/2018-11-08-flood-related-deaths-increasing-in-united-states
[xvi] NWS Missoula Web site, online data
[xvii] Missouri State Hazard Mitigation Plan, State Estimates of Potential Loss, pg. 3.108-3.109
[xviii] Missouri State Hazard Mitigation Plan, http://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan_2013.pdf_

[xix] Jackson County, MO Sheriff's Office, https://www.kshb.com/news/local-news/water-rescue-in-levasy-as-levee-breaches
[xx] FEMA Web site, "So You Live Behind a Levee," http://content.asce.org/ASCELeveeGuids.html
[xxi] National Committee on Levee Safety, Recommendations for a National Levee Safety Program, http://www.leveesaftey.org/lv_links.cfm
[xxii] Missouri State Hazard Mitigation Plan
[xxiii] Missouri State Hazard Mitigat6ion Plan
[xxiv] Missouri Stat Hazard Mitigation Plan
[xxv] FEMA Local Planning Guide
[xxvi] Narratives from NOAA Storm Events Database
[xxvi] Narratives from NOAA Storm Events Database
[xxvi] FEMA, https://www.fema.gov/news-release/2019/05/21/president-donald-j-trump-approves-major-disaster-declaration-missouri
[xxvi] FEMA, https://www.fema.gov/news-release/2019/05/21/president-donald-j-trump-approves-major-disaster-declaration-missouri
[xxvi] Peggy Lowe, "10 Failed Levees In Midwest Flood Zone Were Not Inspected By Federal Government," KCUR, https://www.kcur.org/post/10-failed-levees-midwest-flood-zone-were-not-inspected-federal-government#stream/0
[xxvi] Peggy Lowe, "10 Failed Levees In Midwest Flood Zone Were Not Inspected By Federal Government," KCUR, https://www.kcur.org/post/10-failed-levees-midwest-flood-zone-were-not-inspected-federal-government#stream/0
[xxvi] Missouri Governor Michael L. Parson, https://governor.mo.gov/press-releases/archive/missouri-requests-second-federal-disaster-declaration-year-response-flooding
[xxvi] Missouri Governor Michael L. Parson, https://governor.mo.gov/press-releases/archive/missouri-requests-second-federal-disaster-declaration-year-response-flooding
[xxvi] USGS, Geological Survey Professional Paper 1183, Online, http://pubs.usgs.gov/pp/p1183/pp1183.html
[xxvi] SEMA State Hazard Analysis, Annex G, http://sema.dps.mo.gov/newspubs/publications/hazard_analysis.php
[xxvi] American Association of Dam Safety Officials; http://www.damsafty.org/news/?p=c0fdade4-ab98-4679-be22-e3d7f14e124f
[xxvi] SEMA State Hazard Analysis, Annex G
[xxvi] SEMA State Hazard Analysis, Annex G
[xxvi] SEMA State Hazard Analysis, Annex G
[xxvi] SEMA State Hazard Analysis, Annex G
[xxvi] Missouri Office of Dam Safety/USACE National Inventory of Dams Webb site, http://nid.usace.army.mil
[xxvi] http://dnr.mo.gov/env/wrc/dam-safety/statemap.htm
[xxvi] Glenn Lloyd, Missouri Dam Safety Program, Phone Interview, May 21, 2015
[xxvi] USACE Omaha District Web site, http://www.nwo.usace.army.mil/Missions/DamandLakeProjects/MissouriRiverDams.aspx
[xxvi] Glenn Lloyd, Phone Interview, 2015
[xxvi] Narratives from NOAA Storm Events Database
[xxvi] Narratives from NOAA Storm Events Database
[xxvi] FEMA, https://www.fema.gov/news-release/2019/05/21/president-donald-j-trump-approves-major-disaster-declaration-missouri
[xxvi] FEMA, https://www.fema.gov/news-release/2019/05/21/president-donald-j-trump-approves-major-disaster-declaration-missouri
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[xxvi] Peggy Lowe, "10 Failed Levees In Midwest Flood Zone Were Not Inspected By Federal Government," KCUR, https://www.kcur.org/post/10-failed-levees-midwest-flood-zone-were-not-inspected-federal-government#stream/0

[xxvi] Missouri Governor Michael L. Parson, https://governor.mo.gov/press-releases/archive/missouri-requests-second-federal-disaster-declaration-year-response-flooding
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[xxvi] SEMA State Hazard Analysis, Annex G, http://sema.dps.mo.gov/newspubs/publications/hazard_analysis.php
[xxvi] American Association of Dam Safety Officials; http://www.damsafty.org/news/?p=c0fdade4-ab98-4679-be22-e3d7f14e124f
[xxvi] SEMA State Hazard Analysis, Annex G
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[xxvi] SEMA State Hazard Analysis, Annex G
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[xxvi] http://dnr.mo.gov/env/wrc/dam-safety/statemap.htm
[xxvi] Glenn Lloyd, Missouri Dam Safety Program, Phone Interview, May 21, 2015
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[xxvi] SEMA State Hazard Analysis, Annex G, http://sema.dps.mo.gov/newspubs/publications/hazard_analysis.php
[xxvi] American Association of Dam Safety Officials; http://www.damsafty.org/news/?p=c0fdade4-ab98-4679-be22-e3d7f14e124f
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[xxx] FEMA, https://www.fema.gov/news-release/2019/05/21/president-donald-j-trump-approves-major-disaster-declaration-missouri
[xxxi] Peggy Lowe, “10 Failed Levees In Midwest Flood Zone Were Not Inspected By Federal Government,” KCUR, https://www.kcur.org/post/10-failed-levees-midwest-flood-zone-were-not-inspected-federal-government#stream/0
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[xxxiv] American Association of Dam Safety Officials; http://www.damsafty.org/news/?p=c0fdade4-ab98-4679-be22-e3d7f14e124f
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[xxxiv] http://dnr.mo.gov/env/wrc/dam-safety/statemap.htm
[xxxiv] Glenn Lloyd, Missouri Dam Safety Program, Phone Interview, May 21, 2015
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[xxxviii] SEMA State Hazard Analysis, Annex G
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[xl] SEMA State Hazard Analysis, Annex G
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[xliii] http://dnr.mo.gov/env/wrc/dam-safety/statemap.htm
[xliv] Glenn Lloyd, Missouri Dam Safety Program, Phone Interview, May 21, 2015
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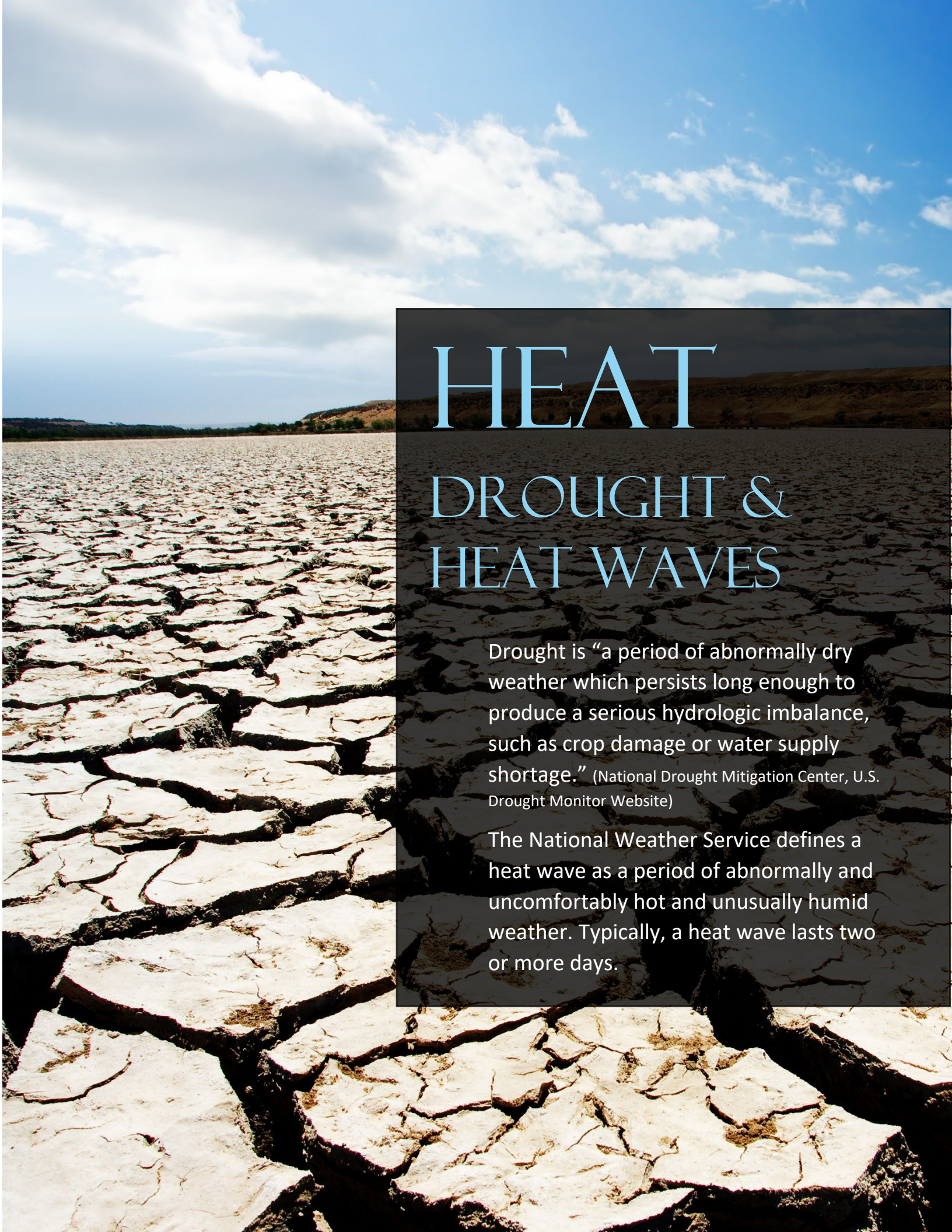


HEAT

DROUGHT & HEAT WAVES

Drought is “a period of abnormally dry weather which persists long enough to produce a serious hydrologic imbalance, such as crop damage or water supply shortage.” (National Drought Mitigation Center, U.S. Drought Monitor Website)

The National Weather Service defines a heat wave as a period of abnormally and uncomfortably hot and unusually humid weather. Typically, a heat wave lasts two or more days.

4.12 Drought

A drought's severity is dependent on a variety of factors, including its duration, the degree of moisture deficiency and the size of the affected area. Drought can be exacerbated by other climatic conditions, including high temperatures, high winds and low humidity.

There are five categories of drought, each one relating the occurrence of drought to water shortfall in some component of the hydrological cycle. These categories are operational definitions and help to describe the onset, severity and end of droughts. Each category affects patterns of water and land use and refers to a repetitive climatic condition. The categories include:

Meteorological Drought – is a measure of precipitation's departure from normal over a period of time. This definition of drought is region-specific, i.e., a drought in one area may not be considered a drought in another area. According to the National Drought Mitigation Center (NDMC), meteorological measurements usually provide the first indication of drought.[i]

Agricultural Drought – occurs when there is not enough moisture in the soil to meet the needs of a crop at a particular time. According to the NDMC, agriculture is usually the first economic area to be affected by drought.

Hydrological Drought – occurs when surface and subsurface water supplies are below normal. Hydrological drought is determined by streamflow and by lake, reservoir and groundwater levels. Hydrological indicators do not provide early indications of drought, since there is a delay between periods with little or no precipitation and low levels of surface and groundwater.

***Hydrological Drought and Land* Use –** refers to a meteorological drought in one area that has hydrological impact in another area. For example, a drought in the Rocky Mountains may have a significant impact in Missouri, since the Missouri River and its tributaries are partly dependent upon precipitation upstream and snowmelt.[ii]

Socioeconomic Drought – occurs when a physical water shortage begins to affect people.

4.12.1 Historical Occurrences

Drought has been a recurrent climatic feature of the Kansas City metropolitan area for many years. Residents of the Kansas City area have experienced some of the nation's worst periods of drought, including the 1930s Dust Bowl drought, the drought of 1954–1956, the Great Drought 1988–1989, the drought of 1999–2000, and the drought of 2012, which was one of the worst droughts to impact Missouri in over 30 years.

Historical occurrences occurring between May 2019 and November 2024 are depicted in **Table 4.12.1**. The planning area did not have any occurrences of excessive heat between May 2019 and November 2024.

Table 4.12.1 Historical Occurrences, Drought (5/19 to 11/24)						
Location	**Date**	**Event Type**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
CASS (ZONE)	09/27/2022	Drought	0	0	$0	$0
CASS (ZONE)	10/01/2022	Drought	0	0	$0	$0
CASS (ZONE)	11/01/2022	Drought	0	0	$0	$0
CASS (ZONE)	05/09/2023	Drought	0	0	$0	$0
CASS (ZONE)	06/01/2023	Drought	0	0	$0	$0
CASS (ZONE)	07/01/2023	Drought	0	0	$0	$0
CASS (ZONE)	08/01/2023	Drought	0	0	$0	$0
CASS (ZONE)	10/01/2023	Drought	0	0	$0	$0
Location	**Date**	**Event Type**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
CLAY (ZONE)	09/27/2022	Drought	0	0	$0	$0
CLAY (ZONE)	10/01/2022	Drought	0	0	$0	$0
CLAY (ZONE)	11/01/2022	Drought	0	0	$0	$0
CLAY (ZONE)	12/01/2022	Drought	0	0	$0	$0
Location	**Date**	**Event Type**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
JACKSON (ZONE)	07/19/22	Drought	0	0	$0	$0
JACKSON (ZONE)	08/1/22	Drought	0	0	$0	$0
JACKSON (ZONE)	09/1/22	Drought	0	0	$0	$0
JACKSON (ZONE)	10/1/22	Drought	0	0	$0	$0
JACKSON (ZONE)	11/1/22	Drought	0	0	$0	$0
JACKSON (ZONE)	12/1/22	Drought	0	0	$0	$0
JACKSON (ZONE)	05/9/23	Drought	0	0	$0	$0
JACKSON (ZONE)	06/1/23	Drought	0	0	$0	$0
JACKSON (ZONE)	07/1/23	Drought	0	0	$0	$0

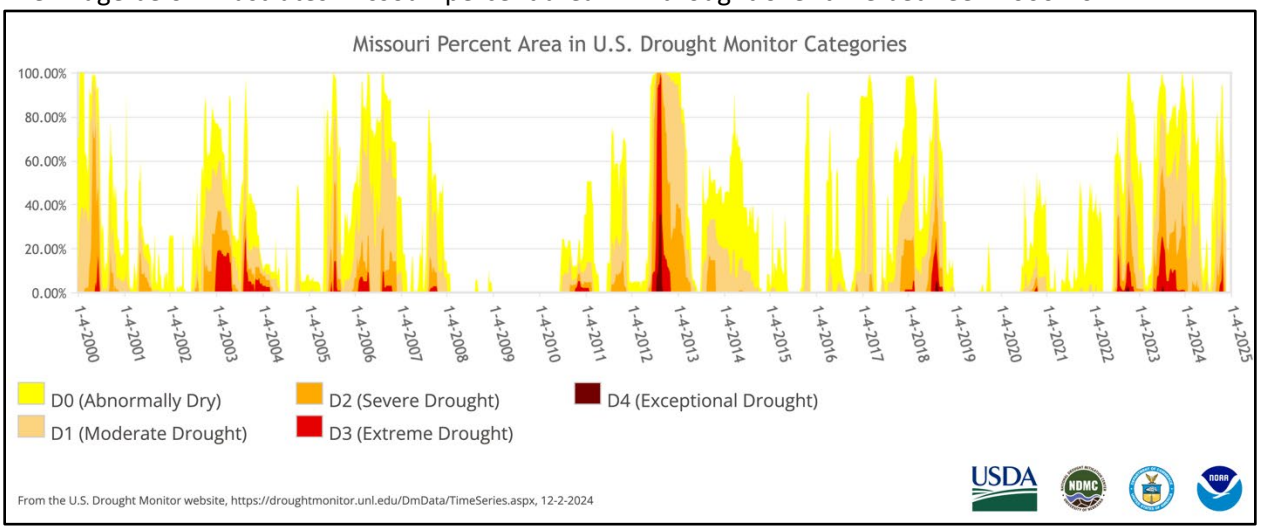
JACKSON (ZONE)	08/1/23	Drought	0	0	$0	$0
JACKSON (ZONE)	10/1/23	Drought	0	0	$0	$0
Location	**Date**	**Event Type**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
PLATTE (ZONE)	9/27/22	Drought	0	0	$0	$0
PLATTE (ZONE)	10/1/22	Drought	0	0	$0	$0
PLATTE (ZONE)	11/1/22	Drought	0	0	$0	$0
PLATTE (ZONE)	12/1/22	Drought	0	0	$0	$0
Location	**Date**	**Event Type**	**Deaths**	**Injuries**	**Property Damage $**	**Crop Damage $**
RAY (ZONE)	9/27/22	Drought	0	0	$0	$0
RAY (ZONE)	10/1/22	Drought	0	0	$0	$0
RAY (ZONE)	11/1/22	Drought	0	0	$0	$0
RAY (ZONE)	6/20/23	Drought	0	0	$0	$0
RAY (ZONE)	7/1/23	Drought	0	0	$0	$0
RAY (ZONE)	8/1/23	Drought	0	0	$0	$0

Source: NOAA NCDC Web site

*the dollar values assigned in storm data are a basic estimate

4.12.2 Historical Trends

The image below illustrates Missouri percent area in in drought over time between 2000-2024.



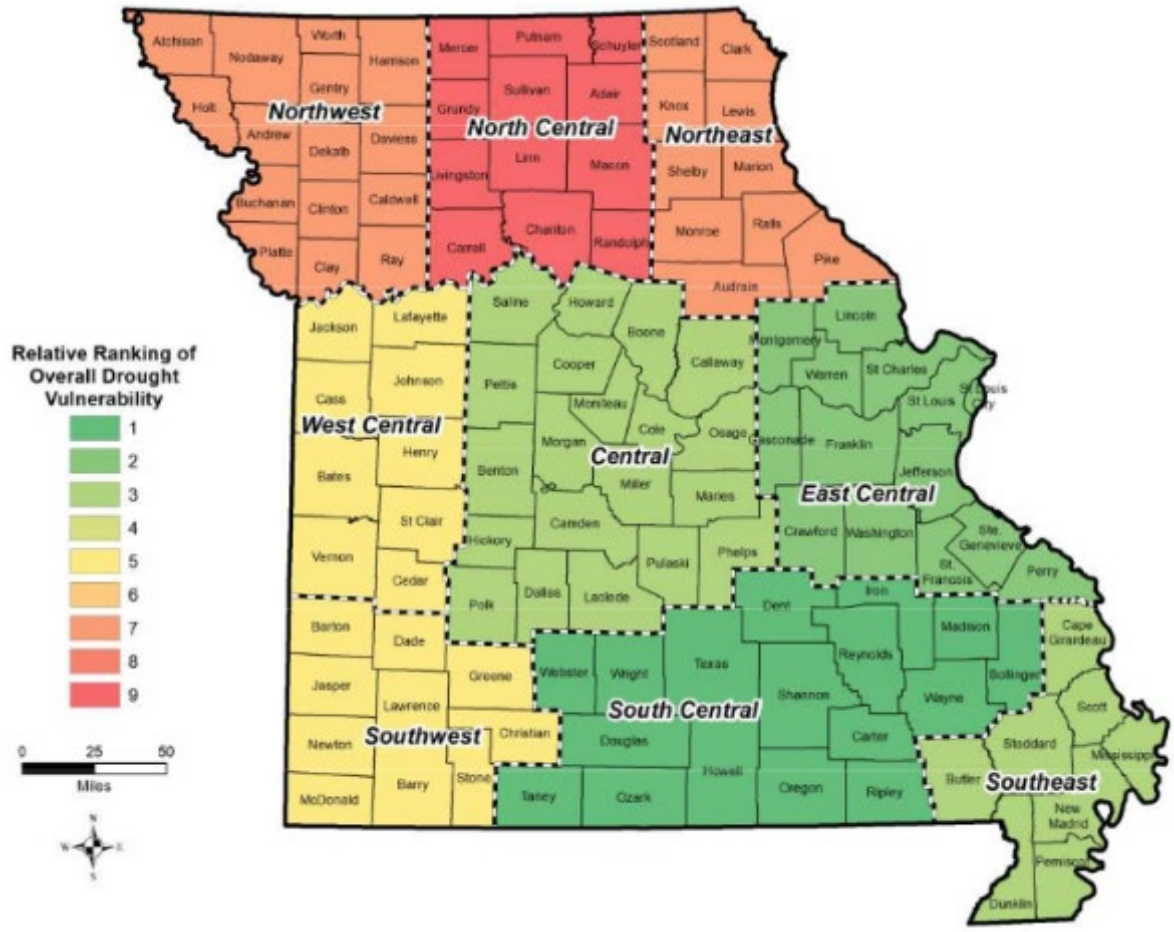
Source: NOAA NCDC Web site

4.12.3 Probable Locations

Magnitude >50%

As in the 2019 Plan, the entire planning area remains susceptible to drought. In its 2023 Missouri Drought Mitigation and Response Plan, MDNR divided the state into multiple regions. These drought regions are depicted in the map below.

The entire Kansas City region is subject to the impacts of drought. Therefore, all counites were given a >50% magnitude rating.



Source: Missouri Drought Mitigation and Response Plan, Missouri Department of Natural Resources

Map 4.12.4: Missouri's Drought Vulnerability Ranking

Specific locations within the regions described above may be susceptible to drought, based on local water supplies and/or patterns of water use. A local area's susceptibility to drought and the severity of drought conditions may also be influenced by a variety of other factors, such as historical occurrences of drought; actual annual and seasonal rainfall amounts; current and projected water demands and uses; sources of available water; water reserves and accessibility to additional water supplies; and current population and projected population trends associated with water use amounts.[iii]

4.12.4 Impact

There is not a consistent national methodology to determine the impact or severity of droughts. In response to this gap, the National Drought Mitigation Center developed the Drought Impact Reporter to fulfill the need for a national drought impact database for the United States. The Drought Impact Reporter is an interactive web-based mapping tool designed to compile and display impact information across the United States in near real-time from a variety of sources such as media, government agencies, and the public. Launched in July 2005, this tool is the only nationwide, multi-source archive of drought impact information.[iv]

Table 4.12.1 shows the number of impact reports received by the National Drought Mitigation Center from various sources. **Table 4.12.2** shows the number of valid impacts determined by the National Drought Mitigation Center using the information from reports. Impacts can be made up of one or more reports.[v]

Table 4.12.1: Drought Reports 05/19- 11/24

County	Report Category								
	Agricultural	Business and Industry	Energy	Fire	Plants and Wildlife	Relief, Response & Restrictions	Society and Public Health	Tourism & Recreation	Water Supply and Quality
Cass	2	0	0	1	4	1	2	0	4
Clay	2	0	0	0	2	4	2	0	4
Jackson	20	1	19	3	42	6	16	4	9
Platte	63	62	59	60	62	54	59	61	65
Ray	2	0	0	0	1	4	2	0	4

Source: National Drought Mitigation Center Website, Drought Impact Reporter

Table 4.12.2: Drought Impacts 05/19- 11/24									
County	Impacts Category								
	Agricultural	Business and Industry	Energy	Fire	Plants and Wildlife	Relief, Response & Restrictions	Society and Public Health	Tourism & Recreation	Water Supply and Quality
Cass	4	1	0	1	3	6	2	1	5
Clay	4	1	0	0	3	5	2	1	5
Jackson	7	3	0	1	6	6	3	1	6
Platte	4	2	0	0	3	6	2	1	6
Ray	4	1	0	0	3	5	2	1	5

Source: National Drought Mitigation Center Website, Drought Impact Reporter

4.12.4a Drought Impact Reporter Categories[vi]

Impacts and reports based on what sectors are involved. A report or an impact can have more than one category.

Agriculture – Drought effects associated with agriculture, farming, aquaculture, horticulture, forestry or ranching. Examples of drought-induced agricultural impacts include damage to crop quality; income loss for farmers due to reduced crop yields; reduced productivity of cropland; insect infestation; plant disease; increased irrigation costs; cost of new or supplemental water resource development (wells, dams, pipelines) for agriculture; reduced productivity of rangeland; forced reduction of foundation stock; closure/limitation of public lands to grazing; and the high cost or unavailability of water for livestock, Christmas tree farms, forestry, raising domesticated horses, bees, fish, shellfish or horticulture.

Business & Industry – This category tracks drought's effects on non-agriculture and non-tourism businesses, such as lawn care, recreational vehicles or gear dealers, and plant nurseries. Typical impacts include reduction or loss of demand for goods or services, reduction in employment, variation in number of calls for service, late opening or early closure for the season, bankruptcy, permanent store closure, and other economic impacts.

Energy – This category concerns drought's effects on power production, rates and revenue. Examples include production changes for both hydropower and non-hydropower providers, changes in electricity rates, revenue shortfalls and/or windfall profits, and purchase of electricity when hydropower generation is down.

Fire – Drought often contributes to forest, range, rural or urban fires, fire danger, and burning restrictions. Specific impacts include enacting or easing burning restrictions, fireworks bans, increased fire risk, occurrence of fire (number of acres burned, number of wildfires compared to average, people displaced, etc.), state of emergency during periods of high fire danger, closure of roads or land due to fire occurrence or risk, and expenses to state and county governments of paying firefighters overtime and paying equipment (helicopter) costs.

Plants & Wildlife – Drought effects associated with unmanaged plants and wildlife, both aquatic and terrestrial, include loss of biodiversity of plants or wildlife; loss of trees from rural or urban landscapes, shelterbelts, or wooded conservation areas; reduction and degradation of fish and wildlife habitat; lack

of feed and drinking water; greater mortality due to increased contact with agricultural producers, as animals seek food from farms and producers are less tolerant of the intrusion; disease; increased vulnerability to predation (from species concentrated near water); migration and concentration (loss of wildlife in some areas and too much wildlife in others); increased stress on endangered species; salinity levels affecting wildlife; wildlife encroaching into urban areas; and loss of wetlands.

Relief, Response & Restrictions – This category refers to drought effects associated with disaster declarations, aid programs, requests for disaster declaration or aid, water restrictions or fire restrictions. Examples include disaster declarations, aid programs, USDA Secretarial disaster declarations, Small Business Association disaster declarations, government relief and response programs, state-level water shortage or water emergency declarations, county-level declarations, a declared "state of emergency," requests for declarations or aid, nonprofit organization-based relief, water restrictions, fire restrictions, National Weather Service Red Flag warnings, and declaration of drought watches or warnings.

Society & Public Health – Drought effects associated with human, public and social health include health-related problems related to reduced water quantity and/or quality, such as increased concentration of contaminants; loss of human life (e.g., from heat stress, suicide); increased respiratory ailments; increased disease caused by wildlife concentrations; increased human disease caused by changes in insect carrier populations; population migration (rural to urban areas, migrants into the United States); loss of aesthetic values; change in daily activities (non-recreational, like putting a bucket in the shower to catch water); elevated stress levels; meetings to discuss drought; communities creating drought plans; lawmakers altering penalties for violation of water restrictions; demand for higher water rates; cultural/historical discoveries from low water levels; prayer meetings; cancellation of fundraising events; cancellation/alteration of festivals or holiday traditions; stockpiling water; public service announcements and drought information websites; protests; and conflicts within the community due to competition for water.

Tourism & Recreation – Drought effects associated with recreational activities and tourism include closure of state hiking trails and hunting areas due to fire danger; water access or navigation problems for recreation; bans on recreational activities; reduced license, permit, or ticket sales (e.g. hunting, fishing, ski lifts, etc.); losses related to curtailed activities (e.g. bird watching, hunting and fishing, boating, etc.); reduced park visitation; and cancellation or postponement of sporting events.

Water Supply & Quality – Drought effects associated with water supply and water quality include dry wells, voluntary and mandatory water restrictions, changes in water rates, easing of water restrictions, increases in requests for new well permits, changes in water use due to water restrictions, greater water demand, decreases in water allocation or allotments, installation or alteration of water pumps or water intakes, changes to allowable water contaminants, water line damage or repairs due to drought stress, drinking water turbidity, change in water color or odor, declaration of drought watches or warnings, and mitigation activities.[vii]

4.12.5 Probability of Future Occurrence: 20%

The onset, duration, and end of droughts are difficult to classify. Using past drought events to predict future probability is insufficient. Therefore, the weekly probability percentage of 20 percent is a very basic estimate based only on data from the National Oceanic and Atmospheric Administration storm events database (2000-2019). The combination of moderate precipitation amounts and relatively short

growing season (compared to other parts of the state), relatively high evaporation rates, deep soils, poor groundwater, reliance on surface water and historical occurrences (including current drought conditions), contribute to the region's vulnerability to drought. In many parts of the region, particularly rural areas within drought susceptibility Region C, drought conditions may have severe economic, environmental and social impacts. Mitigation measures, particularly those involving conservation and water system infrastructure improvements, may reduce the vulnerability of these areas to the effects of drought.

Another tool for monitoring drought is the United States Drought Monitor. This database allows you to download data in various categories for each week of a selected time period and location.[viii] **Table 4.12.3** below shows the probability of a D0-D4 drought occurring in more than half a county on a given week.

Due to **Table 4.12.3** including minor drought classifications like D0 and D1, the probability percentages are much higher than the probability percentage calculated from the NOAA storm events database in the previous paragraph. While many weeks experienced only D0 and D1 droughts and were not mentioned in the storm events database, **Table 4.12.4** shows that droughts at lower classification levels are still capable of damage.

Table 4.12.3 Probability of a D0-D4 Drought Occurring in a Given Week

County	Weeks with >50% of county in D0-D4 Drought	Weeks data on record	Probability
Cass	218	554	39%
Clay	209	554	38%
Jackson	202	554	36%
Platte	196	554	35%
Ray	191	554	34%
Planning Area	1,016	2,770	37%

Source: United States Drought Monitor

4.12.6 Extent

Like *section 4.12.3* mentioned, drought impacts are inherently difficult to quantify. Several methods exist for quantifying the impacts of and economic losses caused by drought in the United States. For ease of comparison, this 2020 Plan update relies on the U.S. Drought Monitoring system classification to describe drought intensity, discussed below. (The U.S. Drought Monitor is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. Map courtesy of NDMC-UNL.)

> "Drought intensity categories are based on five key indicators, numerous supplementary indicators including drought impacts, and local reports from more than 350 expert observers around the country. The accompanying drought severity classification table **(Table 4.12.4)** shows the ranges for each indicator for each dryness level. Because the ranges of the various indicators often don't coincide, the final drought category tends to be based on what most of the indicators show and on local observations. The analysts producing the map also weigh the indices according to how well they perform in various parts of the country and at different times of the year. Additional indicators are often needed in the West, where winter snowfall in the

mountains has a strong bearing on water supplies. It is this combination of the best available data, local observations and experts' best judgment that makes the U.S. Drought Monitor more versatile than other drought indicators."[ix]

Table 4.12.4: Drought Classification							
			Ranges				
Category	**Description**	**Possible Impacts**	**Palmer Drought Severity Index (PDSI)**	**CPC Soil Moisture Model (Percentiles)**	**USGS Weekly Streamflow (Percentiles)**	**Standardized Precipitation Index (SPI)**	**Objective Drought Indicator Blends (Percentiles)**
D0	**Abnormally Dry**	Going into drought: Short-term dryness slowing planting, growth of crops of pastures Coming out of drought: some lingering water deficits pastures or crops not fully recovered	-1.0 to -1.9	21 to 30	21 to 30	-0.5 to -0.7	21 to 30
D1	**Moderate Drought**	Some damage to crops, pastures Streams, reservoirs, or wells low, some water shortages developing or imminent Voluntary water-use restrictions requested	-2.0 to -2.9	11 to 20	11 to 20	-0.8 to -1.2	11 to 20
D2	**Severe Drought**	Crop or pasture losses likely Water shortages common Water restrictions imposed	-3.0 to -3.9	6 to 10	6 to 10	-1.3 to -1.5	6 to 10
D3	**Extreme Drought**	Major crop/pasture losses Widespread water shortages or restrictions	-4.0 to -4.9	3 to 5	3 to 5	-1.6 to -1.9	3 to 5

D4	Exceptional Drought	Exceptional and widespread crop/pasture losses Shortages of water in reservoirs, streams, and wells creating water emergencies	-5.0 or less	0 to 2	0 to 2	-2.0 or less	0 to 2

4.12.7 Vulnerability Analysis

The categories described under section *4.12.3a Drought Impact Reporter Categories* (agriculture, business and industry, energy, fire, plants and wildlife, relief/response, society/public health, tourism/recreation, and water supply/quality) are all vulnerable areas in the region. Severe drought also poses health threats to citizens due to water shortages and can be exacerbated by extreme heat. Particularly vulnerable are children, the elderly, and those with respiratory problems. Contaminated or poor water quality for drinking and sanitation measures can also cause serious illnesses.[x]

4.12.8 Problem Statements

Drought will continue to impact the Kansas City region, most notably in the agricultural sector and areas of the region with high drought susceptibility. Due to the region's general abundance of potable water via the Kansas and Missouri Rivers and alluvial wells, short-term droughts are not likely to have direct, lasting impacts on the entire region, but may have meaningful impacts on individual communities. "Some preparatory measures and policies may help communities and infrastructure assets and systems (especially aging infrastructure) to cope with the impacts."[xi]

Vulnerability statements, such as those below, can support development of mitigation strategies for drought:

- Older infrastructure could be impacted by drought conditions (such as soil or substructure constriction).
- For agricultural communities, inefficient/aging irrigation systems can waste excessive amounts of water and increase the severity of drought impacts.
- Public information campaigns typically don't include water conservation measures.

4.13 Heat Waves

Almost every summer, heat waves affect the Kansas City metropolitan area. Although the entire region is affected by heat waves, the impact of these prolonged periods of heat and humidity tends to be more severe in urban areas because they absorb and retain more heat than rural or natural areas. In addition, elderly, sick and low-income residents — especially those who live in the urban core or other urbanized areas of the Kansas City region — are more susceptible to the hazards of heat waves than those who are young, healthy or have access to adequate air conditioning or ventilation.

4.13.1 Historical Occurrences

Like severe winter weather, heat waves are virtually an annual occurrence in the Kansas City metropolitan area. The region has experienced significant heat waves in the past, including record-setting periods of high temperatures, such as Aug. 4–8, 1934, when the average high temperature was 108 degrees; Aug. 12–15, 1936, with an average high temperature of 110.5 degrees (the region's record high temperature of 113 degrees occurred on Aug.14, 1936); Aug. 22–27, 1936, when the average high temperature was 105.6 degrees; and July 11–14, 1954, with an average high temperature of 110 degrees for the period.[xii] Summarized below in Table 4.13.1 is a listing of heat events from 2010 to 2018. This table includes heat events from the 2019 Plan because there have been no heat events reported to NOAA between 05/19 and 11/24.

Table 4.13.1: Heat Events (2010-2018)

Impacted County	Begin Date	End Date	Deaths	Injuries	Property Damage	Crop Damage	Additional Information
Jackson	August 2, 2010	August 14, 2010	2	0	0	0	A ridge of high pressure aloft caused unseasonably hot and humid weather settled over west central Missouri during the first two weeks of August. Excessive humidity, combined with afternoon high temperatures in the 95 to 104-degree range, caused heat index readings in the 105 to 115-degree range. As a result, an 86-year-old male and a 92-year-old female, died from the excessive heat in their apartments.
Jackson	June 28, 2012	June 30, 2012	0	0	0	0	An upper level ridge of high pressure, over the central plains, dominated the weather with hot and humid conditions, June 27th through June 30th. Afternoon heat indices were in the 100 to 105 degree range.

Clay Jackson Platte Cass	June, 26 2013	June 27, 2013	1	0	0	0	An upper level ridge of high pressure allowed hot and humid conditions to prevail across west central Missouri, on June 26th and 27th, 2013. The combination of heat and humidity caused afternoon heat indices, to be in the 100 to 106 degree range. As a result, one person in Kansas City died from the effects of the heat.
Jackson	June 10, 2015	June 11, 2015	1	0	0	0	June 10 temperatures had heat indices in the upper 90s to middle 100s. An elderly woman died as a direct cause of the heat. While the heat wave lasted only a short duration, the death was pronounced on June 15. The heat related fatality was reported to the office by a Kansas City Health Department official.

4.13.2 Probable Location

Magnitude >50%

The entire Kansas City region is subject to the impacts associated with heat waves. Therefore, all counites were given a >50% magnitude rating.

4.13.3 Impact

Heat kills by taxing the human body beyond its abilities. In a normal year, about 175 Americans succumb to the demands of summer heat. In the planning area, there have been 53 deaths since 1998 due to extreme heat.[xiii] Of all the other natural hazards discussed in this Plan, only extreme cold kills more Americans annually.

According to the NWS, the severity of heat-related disorders tends to increase with age. For example, heat cramps in a 17-year-old can become heat exhaustion for someone in his forties and may result in heat stroke for someone in his sixties.[xiv] **Table 4.13.2** below describes the possible impacts to health from prolonged heat exposure.

Table 4.13.2: Heat Index/Heat Disorders		
Category	**Heat Index**	**Possible heat disorders for people in higher risk groups**
Extreme Danger	130 degrees or higher (54 C or higher)	Heatstroke/sunstroke highly likely with continued exposure.
Danger	105-129 degrees (41-54 C)	Sunstroke, heat cramps or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity.
Extreme Caution	90-105 degrees (32-41 C)	Sunstroke, heat cramps and heat exhaustion possible with prolonged exposure and/or physical activity.
Caution	80-90 degrees (27-32 C)	Fatigue possible with prolonged exposure and/or physical activity.

In addition to heat-related illnesses, heat waves pose several other problems. Pets and livestock may suffer disorders like those experienced by humans due to prolonged exposure to heat and humidity. High demand for electricity for cooling purposes can lead to blackouts or brownouts. The resultant loss of power can lead to an even greater risk of heat-related illnesses and fatalities due to loss of cooling and ventilation. In urban areas, the opening of fire hydrants can result in a system-wide loss of water pressure. Increased water use may result in water shortages and drought-like conditions. (Heat waves commonly take place during actual droughts, as was the case in the Kansas City area and elsewhere during major droughts of the mid-1930s and mid-1950s.) Extreme heat can cause asphalt on roads and parking lots to soften and buckle. If large numbers of people are affected by heat-related illnesses, local EMS systems and hospital emergency rooms may become overwhelmed, affecting the level of care available to people. Finally, studies indicate that civil disturbances, riots and incidents of domestic violence and abuse are more likely to occur during heat waves.[xv]

4.13.4 Probability of Future Occurrence: 60%

Historical occurrences of heat waves, climatological and meteorological data, demographic data and medical statistics associated with heat-related disorders and deaths provide useful information about the people and places vulnerable to the effects of heat waves. The probability percent is based only on historical occurrences since 1998.

While recent changes in temperatures observed in Kansas City have been relatively modest, temperature is projected to increase substantially in all seasons over the remainder of this century. Heat waves will become more frequent and summer overnight lows will become hotter.

A recent study written by Dan Walker and published by MARC shows increasing annual temperatures due to climate changes. By 2100, in Kansas City:

- Average annual temperature will increase from 56.5°F to 64.4°F.
- The number of days/year in which the temperature exceeds 105°F will increase from 0.7 to 21.9.
- The number of cooling degree days, a reflection of the demand for energy needed to cool a building, will nearly double. Conversely, energy demand for heating will decline by 27 percent.

- The last spring frost is projected to be more than two weeks earlier, whereas the first fall frost will occur about 11 days later.

4.13.5 Extent

The National Weather Service defines a heat wave as a period of abnormally and uncomfortably hot and unusually humid weather. Typically, a heat wave lasts two or more days. The NWS will initiate three types of heat alert products, depending on local conditions:

Excessive Heat Outlooks – issued when the potential exists for an excessive heat event in the next 3-7 days. An Outlook provides information to those who need considerable lead-time to prepare for the event.

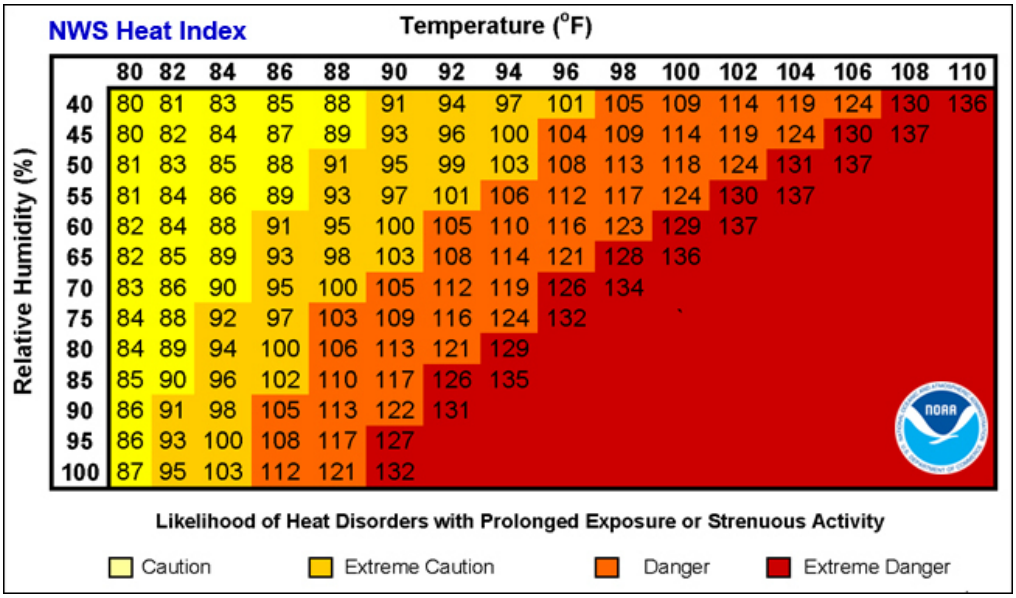
Excessive Heat Watches – issued when conditions are favorable for an excessive heat event in the next 24 to 72 hours. A Watch is used when the risk of a heat wave has increased but its occurrence and timing is still uncertain.

Excessive Heat Warning/Advisories – issued when an excessive heat event is expected in the next 36 hours. These products are issued when an excessive heat event is occurring, is imminent, or has a very high probability of occurring. The warning is used for conditions posing a threat to life. Warnings are issued within 12 hours of the onset of the following criteria: 1) heat index of at least 105 degrees F for more than three hours per day for two consecutive days, or 2) heat index more than 115 degrees F for any period.[xvi]

In the Kansas City metropolitan area, these types of high temperatures generally occur between June and September but are most likely to occur in July and August. Based on data from the High Plains Regional Climate Center covering the past 64 years, from 1948 to 2012, the Kansas City metropolitan area experiences approximately 46.2 days per year above 90 degrees, with a significant number of those days with humidity levels between 50 and 70 percent.[xvii] During this period, July averaged the most days with temperatures above 90 degrees (16.1 days), followed by August with an average of 14.5, June with an average of six, and September with an average of 4.9.[xviii] According to this climatological data, the Kansas City metropolitan area is subject to heat waves during the summer months of any given year.

Heat kills by taxing the human body beyond its abilities. In a normal year, about 175 Americans succumb to the demands of summer heat. Of all the other natural hazards discussed in this Plan, only extreme cold kills more Americans annually.

In the 40-year period from 1936 through 1975, nearly 20,000 people were killed in the United States by the effects of heat and solar radiation. In the disastrous heat wave of 1980, more than 1,250 people died. To provide warning about the potentially devastating effects of heat waves, the NWS devised the "Heat Index" (HI), shown in Figure 4.13.1, which is sometimes referred to as the "Apparent Temperature." The HI, given in degrees Fahrenheit, is an accurate measure of how hot it really feels when the effects of relative humidity (RH) are added to the actual air temperature.[xix]



Source: National Weather Service

Figure 4.13.1: Heat Index Degrees*

*Note: Because HI values were devised for shady, light-wind conditions, exposure to full sunshine can increase HI values by up to 15 degrees. Also, strong winds, particularly with very hot, dry air, can be extremely hazardous.

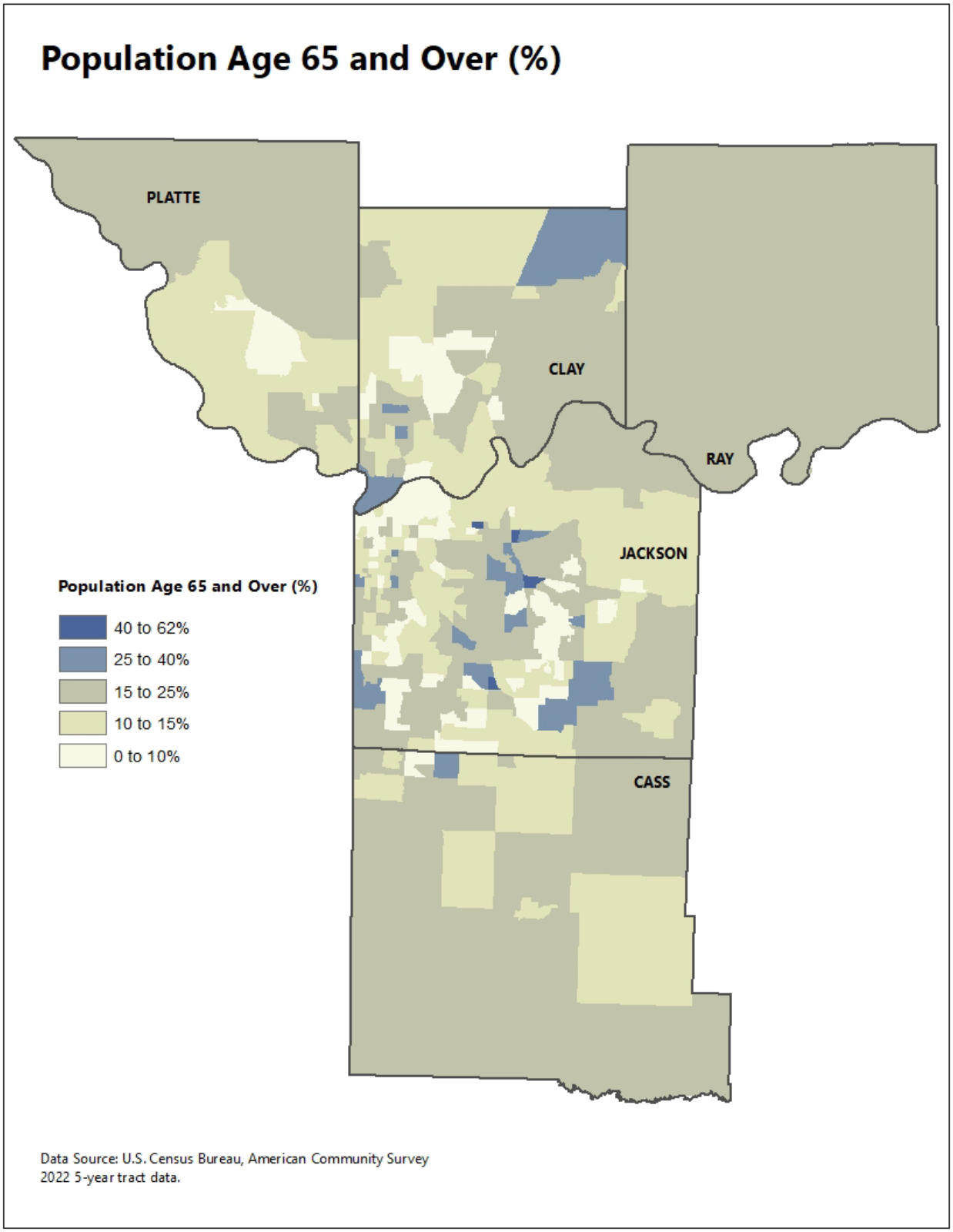
4.13.6 Vulnerability Analysis

The impact of heat waves is generally limited for most of the population in the metropolitan area, although they can be more severe for the urban areas and at-risk groups described in *Section 4.13.3*. Socioeconomic problems associated with certain urban populations exacerbate the hazards of heat waves. Many people in the urban core of Kansas City and elsewhere across the metropolitan area, especially the elderly and poor, do not have air conditioning or do not use their air conditioners because of the high cost of electricity. In addition, some residents in high crime areas, particularly the elderly, may be afraid to open their windows or venture outside to seek cooler locations. People with disabilities or other medical needs may also be more susceptible to the effects of heat waves and tend to live more in urban areas. Because of these conditions and problems, most heat-related deaths occur in cities.[xx]

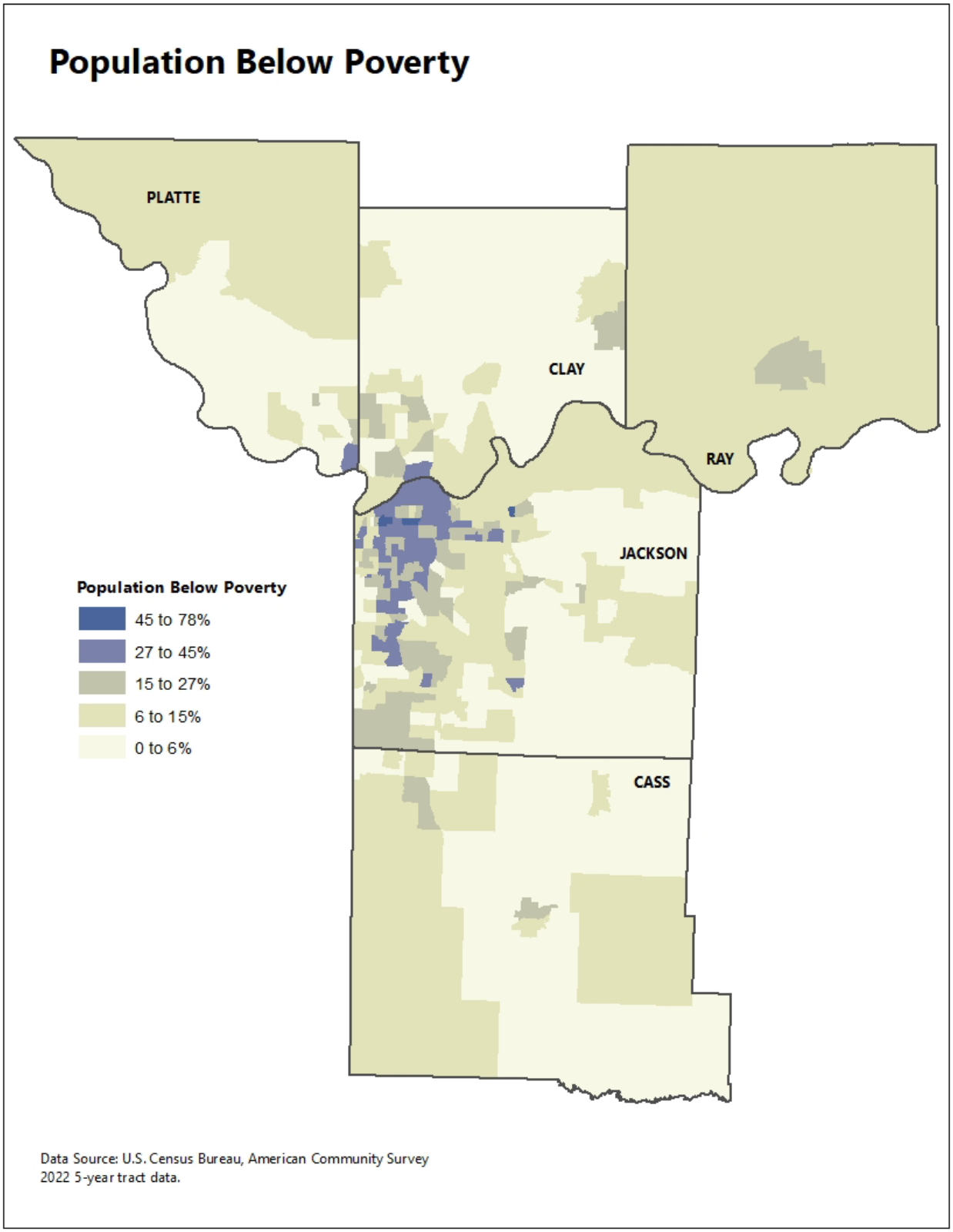
As previously mentioned, at-risk population groups are:

- People with medical/physical conditions or disabilities.
- People who work or conduct leisure activities outside.
- People who are difficult to reach through normal communications.
- People who are elderly.
- People with a lack of access to air-conditioning or other cooling mechanisms due to low incomes.

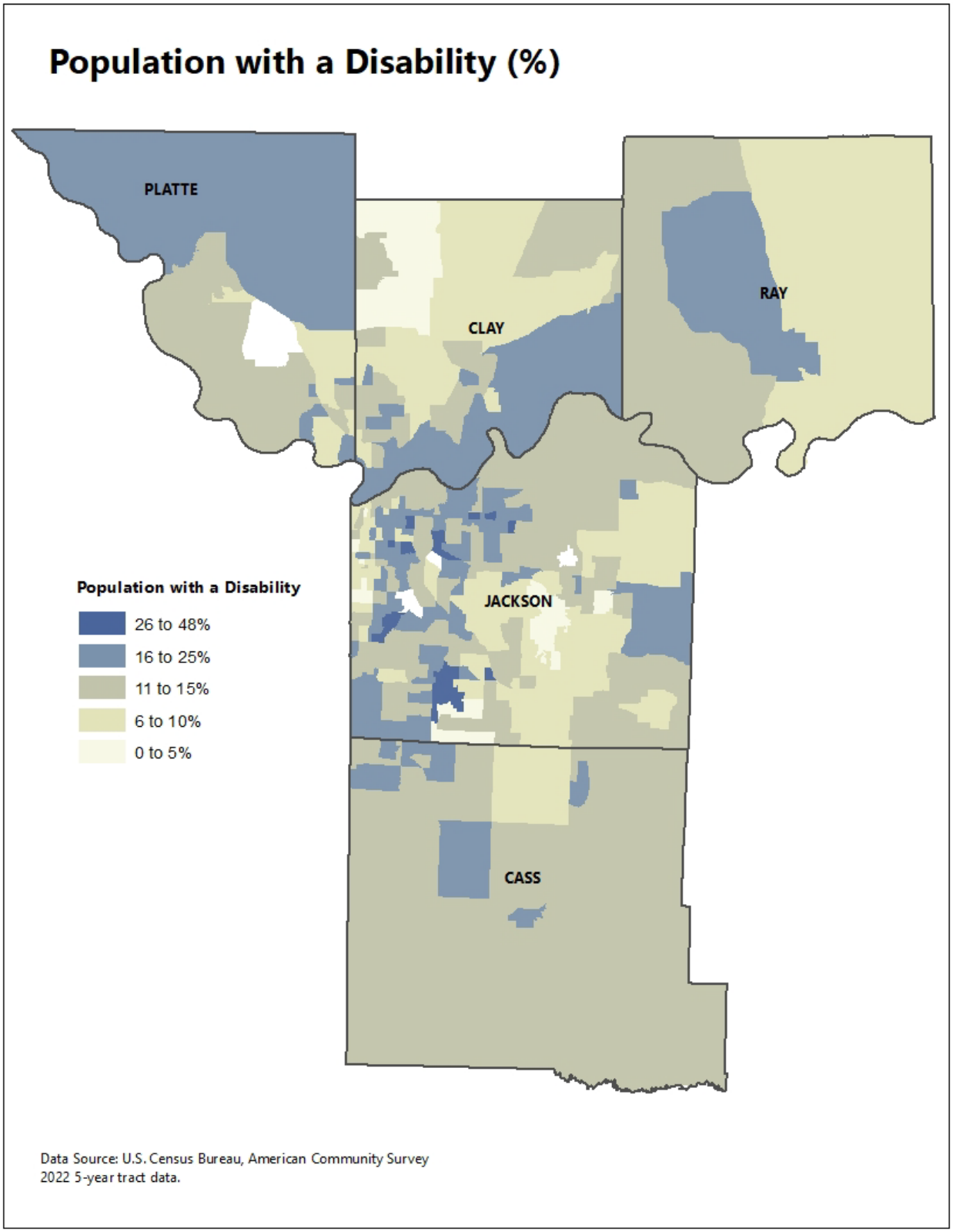
Maps 4.13.1- 4.13.3 illustrate the locations and distribution of three at-risk populations. **Map 4.13.1** depicts the population in the Kansas City metropolitan area over the age of 65. **Map 4.13.2** depicts poverty level. Map 4.13.3 depicts the disabled population in the Kansas City metropolitan area.



Map 4.13.1: Population Over age 65 in the Kansas City Metropolitan Area



Map 4.13.2: Population Below Poverty Kansas City Metropolitan Area



Map 4.13.3: Population with a Disability in the Kansas City Metropolitan Area

4.13.6 Problem Statements

Heat waves can pose a dangerous health threat to the residents of the Kansas City metropolitan area, especially at-risk population groups:

- People with medical/physical conditions or disabilities
- People who work or conduct leisure activities outside
- People who are difficult to reach through normal communications
- People who elderly
- People with a lack of access to air-conditioning or other cooling mechanisms due to low-income

Given the locations and circumstances of these populations, vulnerability statements, such as those below, can support development of mitigation strategies for heat waves:

- If not already identified, cooling centers should be strategically located to maximize coverage for those residents most vulnerable to heat waves.
- Low-income families may not have the ability to acquire or run air conditioning and may need alternative solutions to mitigate the dangers from heat waves (e.g., cooling centers).
- Those most vulnerable to heat waves are often the most difficult to reach with information or warnings about heat waves.

[i] National Drought Mitigation Center, U.S. Drought Monitor Website, http://droughtmonitor.unl.edu/
[ii] Missouri Department of Natural Resources (MDNR) Missouri Drought Mitigation and Response Plan, 2023
[iii] Drought of 2023 Final Report, MDNR Online, https://dnr.mo.gov/document-search/missouri-drought-mitigation-response-plan-2023
[iv] National Drought Mitigation Center
[v] National Drought Mitigation Center Website, Drought Impact Reporter Help Page
[vi] National Drought Mitigation Center Website
[vii] National Drought Mitigation Center Website
[viii] United States Drought Monitor, Data Download, Comprehensive Statistics, https://droughtmonitor.unl.edu/Data/DataDownload.aspx
[ix] United States Drought Monitor
[x] SEMA Hazard Mitigation Plan, pg. 3.252
[xi] Department of Homeland Security, Office of Cyber Infrastructure and Analysis, "Drought Impacts to Critical Infrastructure," April 23, 2015
[xii] Nation Master Website, www.nationmaster.com
[xiii] National Oceanic and Atmospheric Administration, Storm Events Database
[xiv] National Weather Service, Website, http://www.nws.noaa.gov/os/heat
[xv] Nation Master Website, www.nationmaster.com
[xvi] [National Weather Service, Website, http://www.nws.noaa.gov/os/heat/ww.shtml
[xvii] High Plains Regional Climate Center, Website, http://www.hprcc.unl.edu/
[xviii] High Plains Regional Climate Center, Website, http://www.hprcc.unl.edu/
[xix] National Weather Service, Website, http://www.nws.noaa.gov/os/heat
[xx] National Weather Service, Website

CASS COUNTY
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	44,013
Number of Schools	39
Number of Nursing Homes	10
Number of Childcare Centers	41
Number of Apartment Complexes	83
Number of Hazardous Materials locations	129
Tornado events in past 5 years (NOAA)	1

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	13

Floods

Buildings in floodplain	313
Commercial property in floodplain (parcels)	15
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	271
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	2
Dams	30
Flood events in past 5 years (NOAA)	6

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	1
Heat related events in past 5 years (NOAA)	17

CITY OF BELTON
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	10,284
Number of Schools	9
Number of Nursing Homes	4
Number of Childcare Centers	13
Number of Apartment Complexes	37
Number of Hazardous Materials locations	34
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	2

Floods

Buildings in floodplain	94
Commercial property in floodplain (parcels)	6
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	67
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	2
Flood events in past 5 years (NOAA)	1

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	1
Heat related events in past 5 years (NOAA)	17

CITY OF HARRISONVILLE
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	4,357
Number of Schools	5
Number of Nursing Homes	4
Number of Childcare Centers	7
Number of Apartment Complexes	12
Number of Hazardous Materials locations	34
Tornado events in past 5 years (NOAA)	1

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	8

Floods

Buildings in floodplain	47
Commercial property in floodplain (parcels)	10
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	32
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	3
Flood events in past 5 years (NOAA)	1

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	6

Heat

Cooling Centers	0
Heat related events in past 5 years (NOAA)	17

CITY OF LAKE WINNEBAGO
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	512
Number of Schools	0
Number of Nursing Homes	0
Number of Childcare Centers	0
Number of Apartment Complexes	0
Number of Hazardous Materials locations	0
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	0

Floods

Buildings in floodplain	8
Commercial property in floodplain (parcels)	0
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	6
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	2
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	6

Heat

Cooling Centers	0
Heat related events in past 5 years (NOAA)	17

CITY OF PECULIAR
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	2,276
Number of Schools	3
Number of Nursing Homes	0
Number of Childcare Centers	2
Number of Apartment Complexes	4
Number of Hazardous Materials locations	14
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	2

Floods

Buildings in floodplain	37
Commercial property in floodplain (parcels)	0
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	31
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	3
Flood events in past 5 years (NOAA)	1

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	6

Heat

Cooling Centers	0
Heat related events in past 5 years (NOAA)	17

CITY OF PLEASANT HILL
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	3,499
Number of Schools	5
Number of Nursing Homes	0
Number of Childcare Centers	3
Number of Apartment Complexes	10
Number of Hazardous Materials locations	15
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	10

Floods

Buildings in floodplain	98
Commercial property in floodplain (parcels)	20
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	74
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	1
Dams	1
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	6

Heat

Cooling Centers	0
Heat related events in past 5 years (NOAA)	17

CITY OF RAYMORE
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	8,783
Number of Schools	7
Number of Nursing Homes	2
Number of Childcare Centers	11
Number of Apartment Complexes	16
Number of Hazardous Materials locations	7
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	7

Floods

Buildings in floodplain	36
Commercial property in floodplain (parcels)	8
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	27
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	1
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	6

Heat

Cooling Centers	0
Heat related events in past 5 years (NOAA)	17

ARCHIE R-V SCHOOL DISTRICT
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	1,381
Number of Schools	2
Number of Nursing Homes	0
Number of Childcare Centers	3
Number of Apartment Complexes	1
Number of Hazardous Materials locations	3
Tornado events in past 5 years (NOAA)	1

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	2

Floods

Buildings in floodplain	58
Commercial property in floodplain (parcels)	4
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	54
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	5
Flood events in past 5 years (NOAA)	1

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	6

Heat

Cooling Centers	0
Heat related events in past 5 years (NOAA)	17

HARRISONVILLE SCHOOL DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	5,949
Number of Schools	5
Number of Nursing Homes	4
Number of Childcare Centers	7
Number of Apartment Complexes	12
Number of Hazardous Materials locations	35
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	1

Floods

Buildings in floodplain	113
Commercial property in floodplain (parcels)	10
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	85
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	11
Flood events in past 5 years (NOAA)	2

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	6

Heat

Cooling Centers	0
Heat related events in past 5 years (NOAA)	17

PLEASANT HILL R-III SCHOOL DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	4,647
Number of Schools	5
Number of Nursing Homes	0
Number of Childcare Centers	3
Number of Apartment Complexes	9
Number of Hazardous Materials locations	14
Tornado events in past 5 years (NOAA)	1

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	6

Floods

Buildings in floodplain	146
Commercial property in floodplain (parcels)	35
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	102
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	1
Dams	4
Flood events in past 5 years (NOAA)	1

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	6

Heat

Cooling Centers	0
Heat related events in past 5 years (NOAA)	17

RAYMORE-PECULIAR SCHOOL DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	15,089
Number of Schools	10
Number of Nursing Homes	2
Number of Childcare Centers	13
Number of Apartment Complexes	24
Number of Hazardous Materials locations	2
Tornado events in past 5 years (NOAA)	

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	12

Floods

Buildings in floodplain	136
Commercial property in floodplain (parcels)	8
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	118
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	1
Dams	3
Flood events in past 5 years (NOAA)	2

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	6

Heat

Cooling Centers	0
Heat related events in past 5 years (NOAA)	17

SHERWOOD-CASS R-8 SCHOOL DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units

Number of Schools

Number of Nursing Homes

Number of Childcare Centers

Number of Apartment Complexes

Number of Hazardous Materials locations

Tornado events in past 5 years (NOAA)

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)

Floods

Buildings in floodplain

Commercial property in floodplain (parcels)

Commercial property in floodplain (area)

Residential property in floodplain (parcels)

Residential property in floodplain (value)

Residential property in floodplain (area)

Hazardous materials locations in floodplain

Dams

Flood events in past 5 years (NOAA)

Severe Winter Weather

Warming Centers

Severe winter weather in past 5 years (NOAA)

Heat

Cooling Centers

Heat related events in past 5 years (NOAA)

CLAY COUNTY
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	105,571
Number of Schools	80
Number of Nursing Homes	21
Number of Childcare Centers	91
Number of Apartment Complexes	248
Number of Hazardous Materials locations	235
Tornado events in past 5 years (NOAA)	3

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	41

Floods

Buildings in floodplain	663
Commercial property in floodplain (parcels)	74
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	313
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	72
Dams	19
Flood events in past 5 years (NOAA)	3

Severe Winter Weather

Warming Centers	12
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	15
Heat related events in past 5 years (NOAA)	17

CITY OF EXCELSIOR SPRINGS
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	4,368
Number of Schools	6
Number of Nursing Homes	1
Number of Childcare Centers	5
Number of Apartment Complexes	17
Number of Hazardous Materials locations	9
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	4

Floods

Buildings in floodplain	33
Commercial property in floodplain (parcels)	5
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	9
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	0
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	1
Severe winter weather in past 5 years (NOAA)	0

Heat

Cooling Centers	2
Heat related events in past 5 years (NOAA)	17

CITY OF GLADSTONE
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	12,595
Number of Schools	7
Number of Nursing Homes	1
Number of Childcare Centers	9
Number of Apartment Complexes	27
Number of Hazardous Materials locations	12
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	3

Floods

Buildings in floodplain	15
Commercial property in floodplain (parcels)	2
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	8
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	1
Dams	0
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	6

Heat

Cooling Centers	1
Heat related events in past 5 years (NOAA)	17

CITY OF KEARNEY
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	4,228
Number of Schools	7
Number of Nursing Homes	0
Number of Childcare Centers	7
Number of Apartment Complexes	8
Number of Hazardous Materials locations	3
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	4

Floods

Buildings in floodplain	12
Commercial property in floodplain (parcels)	3
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	5
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	0
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	0
Heat related events in past 5 years (NOAA)	17

CITY OF LIBERTY
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	11,749
Number of Schools	16
Number of Nursing Homes	5
Number of Childcare Centers	17
Number of Apartment Complexes	39
Number of Hazardous Materials locations	36
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	5

Floods

Buildings in floodplain	157
Commercial property in floodplain (parcels)	25
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	90
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	1
Dams	5
Flood events in past 5 years (NOAA)	1

Severe Winter Weather

Warming Centers	2
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	3
Heat related events in past 5 years (NOAA)	17

CITY OF NORTH KANSAS CITY
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	3,084
Number of Schools	1
Number of Nursing Homes	1
Number of Childcare Centers	3
Number of Apartment Complexes	24
Number of Hazardous Materials locations	39
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	0

Floods

Buildings in floodplain	68
Commercial property in floodplain (parcels)	0
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	38
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	37
Dams	0
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	1
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	1
Heat related events in past 5 years (NOAA)	17

CITY OF SMITHVILLE
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	3,797
Number of Schools	5
Number of Nursing Homes	1
Number of Childcare Centers	7
Number of Apartment Complexes	8
Number of Hazardous Materials locations	8
Tornado events in past 5 years (NOAA)	1

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	2

Floods

Buildings in floodplain	109
Commercial property in floodplain (parcels)	25
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	49
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	1
Dams	2
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	1
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	1
Heat related events in past 5 years (NOAA)	17

EXCELSIOR SPRINGS SCHOOL DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	6,592
Number of Schools	6
Number of Nursing Homes	1
Number of Childcare Centers	5
Number of Apartment Complexes	17
Number of Hazardous Materials locations	24
Tornado events in past 5 years (NOAA)	1

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	10

Floods

Buildings in floodplain	306
Commercial property in floodplain (parcels)	24
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	180
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	17
Flood events in past 5 years (NOAA)	2

Severe Winter Weather

Warming Centers	1
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	2
Heat related events in past 5 years (NOAA)	17

NORTH KANSAS CITY SCHOOL DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	59,743
Number of Schools	32
Number of Nursing Homes	8
Number of Childcare Centers	47
Number of Apartment Complexes	157
Number of Hazardous Materials locations	28
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	13

Floods

Buildings in floodplain	775
Commercial property in floodplain (parcels)	42
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	625
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	70
Dams	1
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	5
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	6
Heat related events in past 5 years (NOAA)	17

SMITHVILLE R-II SCHOOL DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	5,411
Number of Schools	5
Number of Nursing Homes	1
Number of Childcare Centers	7
Number of Apartment Complexes	8
Number of Hazardous Materials locations	8
Tornado events in past 5 years (NOAA)	2

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	3

Floods

Buildings in floodplain	146
Commercial property in floodplain (parcels)	34
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	77
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	1
Dams	3
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	1
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	1
Heat related events in past 5 years (NOAA)	17

JACKSON COUNTY
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	330,584
Number of Schools	260
Number of Nursing Homes	85
Number of Childcare Centers	350
Number of Apartment Complexes	1,950
Number of Hazardous Materials locations	637
Tornado events in past 5 years (NOAA)	2

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	15

Floods

Buildings in floodplain	188
Commercial property in floodplain (parcels)	7
Commercial property in floodplain (area)	60
Residential property in floodplain (parcels)	121
Residential property in floodplain (value)	5
Residential property in floodplain (area)	132
Hazardous materials locations in floodplain	188
Dams	7
Flood events in past 5 years (NOAA)	60

Severe Winter Weather

Warming Centers	41
Severe winter weather in past 5 years (NOAA)	6

Heat

Cooling Centers	59
Heat related events in past 5 years (NOAA)	17

CITY OF BLUE SPRINGS
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	22,434
Number of Schools	22
Number of Nursing Homes	7
Number of Childcare Centers	27
Number of Apartment Complexes	61
Number of Hazardous Materials locations	31
Tornado events in past 5 years (NOAA)	1

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	7

Floods

Buildings in floodplain	32
Commercial property in floodplain (parcels)	0
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	25
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	2
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	3
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	4
Heat related events in past 5 years (NOAA)	17

CITY OF GRANDVIEW
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	11,897
Number of Schools	7
Number of Nursing Homes	2
Number of Childcare Centers	16
Number of Apartment Complexes	45
Number of Hazardous Materials locations	19
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	2

Floods

Buildings in floodplain	30
Commercial property in floodplain (parcels)	1
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	22
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	0
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	1
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	2
Heat related events in past 5 years (NOAA)	17

CITY OF GREENWOOD
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	14,088
Number of Schools	1
Number of Nursing Homes	0
Number of Childcare Centers	4
Number of Apartment Complexes	2
Number of Hazardous Materials locations	7
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	1

Floods

Buildings in floodplain	0
Commercial property in floodplain (parcels)	0
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	0
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	0
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	0
Heat related events in past 5 years (NOAA)	17

CITY OF GRAIN VALLEY
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units

Number of Schools

Number of Nursing Homes

Number of Childcare Centers

Number of Apartment Complexes

Number of Hazardous Materials locations

Tornado events in past 5 years (NOAA)

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)

Floods

Buildings in floodplain

Commercial property in floodplain (parcels)

Commercial property in floodplain (area)

Residential property in floodplain (parcels)

Residential property in floodplain (value)

Residential property in floodplain (area)

Hazardous materials locations in floodplain

Dams

Flood events in past 5 years (NOAA)

Severe Winter Weather

Warming Centers

Severe winter weather in past 5 years (NOAA)

Heat

Cooling Centers

Heat related events in past 5 years (NOAA)

CITY OF INDEPENDENCE
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	55,913
Number of Schools	45
Number of Nursing Homes	9
Number of Childcare Centers	42
Number of Apartment Complexes	134
Number of Hazardous Materials locations	88
Tornado events in past 5 years (NOAA)	2

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	15

Floods

Buildings in floodplain	894
Commercial property in floodplain (parcels)	37
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	650
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	9
Dams	2
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	7
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	12
Heat related events in past 5 years (NOAA)	17

CITY OF KANSAS CITY, MO
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	241,827
Number of Schools	191
Number of Nursing Homes	52
Number of Childcare Centers	238
Number of Apartment Complexes	1,678
Number of Hazardous Materials locations	536
Tornado events in past 5 years (NOAA)	1

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	55

Floods

Buildings in floodplain	2,287
Commercial property in floodplain (parcels)	263
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	900
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	138
Dams	24
Flood events in past 5 years (NOAA)	5

Severe Winter Weather

Warming Centers	26
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	38
Heat related events in past 5 years (NOAA)	17

CITY OF LEE'S SUMMIT
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	40,716
Number of Schools	32
Number of Nursing Homes	11
Number of Childcare Centers	53
Number of Apartment Complexes	89
Number of Hazardous Materials locations	60
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	24

Floods

Buildings in floodplain	131
Commercial property in floodplain (parcels)	3
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	77
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	1
Dams	8
Flood events in past 5 years (NOAA)	3

Severe Winter Weather

Warming Centers	2
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	2
Heat related events in past 5 years (NOAA)	17

CITY OF LEVASY
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units

Number of Schools

Number of Nursing Homes

Number of Childcare Centers

Number of Apartment Complexes

Number of Hazardous Materials locations

Tornado events in past 5 years (NOAA)

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)

Floods

Buildings in floodplain

Commercial property in floodplain (parcels)

Commercial property in floodplain (area)

Residential property in floodplain (parcels)

Residential property in floodplain (value)

Residential property in floodplain (area)

Hazardous materials locations in floodplain

Dams

Flood events in past 5 years (NOAA)

Severe Winter Weather

Warming Centers

Severe winter weather in past 5 years (NOAA)

Heat

Cooling Centers

Heat related events in past 5 years (NOAA)

CITY OF OAK GROVE
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	6,150
Number of Schools	6
Number of Nursing Homes	1
Number of Childcare Centers	5
Number of Apartment Complexes	49
Number of Hazardous Materials locations	17 (# of Tornado Warnings)
Tornado events in past 5 years (NOAA)	

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	8

Floods

Buildings in floodplain	3
Commercial property in floodplain (parcels)	2
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	3
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	
Dams	0
Flood events in past 5 years (NOAA)	7

Severe Winter Weather

Warming Centers	2
Severe winter weather in past 5 years (NOAA)	8

Heat

Cooling Centers	2
Heat related events in past 5 years (NOAA)	8

CITY OF RAYTOWN
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	13,647
Number of Schools	10
Number of Nursing Homes	4
Number of Childcare Centers	8
Number of Apartment Complexes	54
Number of Hazardous Materials locations	12
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	3

Floods

Buildings in floodplain	23
Commercial property in floodplain (parcels)	12
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	10
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	0
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	1
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	2
Heat related events in past 5 years (NOAA)	17

CENTRAL JACKSON COUNTY FIRE PROTECTION DISTRICT
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	
Number of Schools	25
Number of Nursing Homes	7
Number of Childcare Centers	31
Number of Apartment Complexes	69
Number of Hazardous Materials locations	39
Tornado events in past 5 years (NOAA)	1

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	8

Floods

Buildings in floodplain	240
Commercial property in floodplain (parcels)	20
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	189
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	1
Dams	7
Flood events in past 5 years (NOAA)	1

Severe Winter Weather

Warming Centers	
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	5
Heat related events in past 5 years (NOAA)	17

SNI VALLEY FIRE PROTECTION DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	6,150
Number of Schools	6
Number of Nursing Homes	1
Number of Childcare Centers	5
Number of Apartment Complexes	49
Number of Hazardous Materials locations	14
Tornado events in past 5 years (NOAA)	17 (# of tornado warnings)

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	8

Floods

Buildings in floodplain	12
Commercial property in floodplain (parcels)	
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	
Dams	3
Flood events in past 5 years (NOAA)	7

Severe Winter Weather

Warming Centers	2
Severe winter weather in past 5 years (NOAA)	8

Heat

Cooling Centers	2
Heat related events in past 5 years (NOAA)	8

BLUE SPRINGS SCHOOL DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	36,809
Number of Schools	22
Number of Nursing Homes	9
Number of Childcare Centers	36
Number of Apartment Complexes	83
Number of Hazardous Materials locations	2
Tornado events in past 5 years (NOAA)	2

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	8

Floods

Buildings in floodplain	159
Commercial property in floodplain (parcels)	4
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	123
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	3
Dams	159
Flood events in past 5 years (NOAA)	4

Severe Winter Weather

Warming Centers	3
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	4
Heat related events in past 5 years (NOAA)	17

FORT OSAGE R-1 SCHOOL DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	9,711
Number of Schools	9
Number of Nursing Homes	0
Number of Childcare Centers	3
Number of Apartment Complexes	12
Number of Hazardous Materials locations	0
Tornado events in past 5 years (NOAA)	1

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	4

Floods

Buildings in floodplain	349
Commercial property in floodplain (parcels)	55
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	180
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	12
Dams	10
Flood events in past 5 years (NOAA)	1

Severe Winter Weather

Warming Centers	1
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	2
Heat related events in past 5 years (NOAA)	17

GRAIN VALLEY SCHOOL DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	8,309
Number of Schools	7
Number of Nursing Homes	0
Number of Childcare Centers	7
Number of Apartment Complexes	17
Number of Hazardous Materials locations	4
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	1

Floods

Buildings in floodplain	142
Commercial property in floodplain (parcels)	12
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	106
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	1
Flood events in past 5 years (NOAA)	1

Severe Winter Weather

Warming Centers	1
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	1
Heat related events in past 5 years (NOAA)	17

INDEPENDENCE SCHOOL DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	46,141
Number of Schools	30
Number of Nursing Homes	8
Number of Childcare Centers	36
Number of Apartment Complexes	118
Number of Hazardous Materials locations	65
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	12

Floods

Buildings in floodplain	951
Commercial property in floodplain (parcels)	62
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	813
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	5
Dams	1
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	9
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	14
Heat related events in past 5 years (NOAA)	17

KANSAS CITY SCHOOL DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	113,216
Number of Schools	33
Number of Nursing Homes	37
Number of Childcare Centers	122
Number of Apartment Complexes	1,389
Number of Hazardous Materials locations	78
Tornado events in past 5 years (NOAA)	

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	18

Floods

Buildings in floodplain	1,097
Commercial property in floodplain (parcels)	575
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	436
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	96
Dams	2
Flood events in past 5 years (NOAA)	3

Severe Winter Weather

Warming Centers	17
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	25
Heat related events in past 5 years (NOAA)	17

LEE'S SUMMIT SCHOOL DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	42,826
Number of Schools	29
Number of Nursing Homes	11
Number of Childcare Centers	49
Number of Apartment Complexes	85
Number of Hazardous Materials locations	10
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	25

Floods

Buildings in floodplain	213
Commercial property in floodplain (parcels)	11
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	136
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	26
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	2
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	2
Heat related events in past 5 years (NOAA)	17

OAK GROVE R-VI SCHOOL DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	4,104
Number of Schools	4
Number of Nursing Homes	0
Number of Childcare Centers	6
Number of Apartment Complexes	25
Number of Hazardous Materials locations	8
Tornado events in past 5 years (NOAA)	1

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	3

Floods

Buildings in floodplain	22
Commercial property in floodplain (parcels)	2
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	14
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	22
Flood events in past 5 years (NOAA)	2

Severe Winter Weather

Warming Centers	1
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	1
Heat related events in past 5 years (NOAA)	17

METROPOLITAN COMMUNITY COLLEGES SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units

Number of Schools

Number of Nursing Homes

Number of Childcare Centers

Number of Apartment Complexes

Number of Hazardous Materials locations

Tornado events in past 5 years (NOAA)

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)

Floods

Buildings in floodplain

Commercial property in floodplain (parcels)

Commercial property in floodplain (area)

Residential property in floodplain (parcels)

Residential property in floodplain (value)

Residential property in floodplain (area)

Hazardous materials locations in floodplain

Dams

Flood events in past 5 years (NOAA)

Severe Winter Weather

Warming Centers

Severe winter weather in past 5 years (NOAA)

Heat

Cooling Centers

Heat related events in past 5 years (NOAA)

PLATTE COUNTY
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	45,378
Number of Schools	36
Number of Nursing Homes	12
Number of Childcare Centers	29
Number of Apartment Complexes	110
Number of Hazardous Materials locations	136
Tornado events in past 5 years (NOAA)	1

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	9

Floods

Buildings in floodplain	262
Commercial property in floodplain (parcels)	14
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	131
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	26
Dams	16
Flood events in past 5 years (NOAA)	1

Severe Winter Weather

Warming Centers	9
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	12
Heat related events in past 5 years (NOAA)	17

CITY OF FARLEY
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	91
Number of Schools	0
Number of Nursing Homes	0
Number of Childcare Centers	0
Number of Apartment Complexes	0
Number of Hazardous Materials locations	1
Tornado events in past 5 years (NOAA)	

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	0

Floods

Buildings in floodplain	0
Commercial property in floodplain (parcels)	0
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	0
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	0
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	0
Heat related events in past 5 years (NOAA)	17

CITY OF LAKE WAUKOMIS
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	492
Number of Schools	0
Number of Nursing Homes	0
Number of Childcare Centers	0
Number of Apartment Complexes	0
Number of Hazardous Materials locations	0
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	2

Floods

Buildings in floodplain	0
Commercial property in floodplain (parcels)	0
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	0
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	1
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	0
Heat related events in past 5 years (NOAA)	17

CITY OF NORTHMOOR
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	144
Number of Schools	0
Number of Nursing Homes	0
Number of Childcare Centers	0
Number of Apartment Complexes	0
Number of Hazardous Materials locations	1
Tornado events in past 5 years (NOAA)	

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	0

Floods

Buildings in floodplain	33
Commercial property in floodplain (parcels)	5
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	1
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	0
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	0
Heat related events in past 5 years (NOAA)	17

CITY OF PARKVILLE
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	2,958
Number of Schools	1
Number of Nursing Homes	1
Number of Childcare Centers	2
Number of Apartment Complexes	18
Number of Hazardous Materials locations	8
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	2

Floods

Buildings in floodplain	51
Commercial property in floodplain (parcels)	28
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	4
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	2
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	1
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	2
Heat related events in past 5 years (NOAA)	17

CITY OF PLATTE CITY
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	2,067
Number of Schools	4
Number of Nursing Homes	1
Number of Childcare Centers	8
Number of Apartment Complexes	15
Number of Hazardous Materials locations	12
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	2

Floods

Buildings in floodplain	1
Commercial property in floodplain (parcels)	1
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	0
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	1
Dams	1
Flood events in past 5 years (NOAA)	1

Severe Winter Weather

Warming Centers	2
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	3
Heat related events in past 5 years (NOAA)	17

CITY OF PLATTE WOODS
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	228
Number of Schools	0
Number of Nursing Homes	0
Number of Childcare Centers	2
Number of Apartment Complexes	0
Number of Hazardous Materials locations	0
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	1

Floods

Buildings in floodplain	0
Commercial property in floodplain (parcels)	0
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	0
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	0
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	0
Heat related events in past 5 years (NOAA)	17

CITY OF RIVERSIDE
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	1,667
Number of Schools	1
Number of Nursing Homes	0
Number of Childcare Centers	0
Number of Apartment Complexes	17
Number of Hazardous Materials locations	22
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	0

Floods

Buildings in floodplain	40
Commercial property in floodplain (parcels)	12
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	6
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	18
Dams	0
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	1
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	1
Heat related events in past 5 years (NOAA)	17

CITY OF TRACY
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	84
Number of Schools	0
Number of Nursing Homes	0
Number of Childcare Centers	1
Number of Apartment Complexes	0
Number of Hazardous Materials locations	2
Tornado events in past 5 years (NOAA)	

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	0

Floods

Buildings in floodplain	1
Commercial property in floodplain (parcels)	0
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	1
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	0
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	0
Heat related events in past 5 years (NOAA)	17

CITY OF WEATHERBY LAKE
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	967
Number of Schools	0
Number of Nursing Homes	0
Number of Childcare Centers	0
Number of Apartment Complexes	0
Number of Hazardous Materials locations	0
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	1

Floods

Buildings in floodplain	4
Commercial property in floodplain (parcels)	0
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	3
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	1
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	0
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	0
Heat related events in past 5 years (NOAA)	17

CITY OF WESTON
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	854
Number of Schools	3
Number of Nursing Homes	0
Number of Childcare Centers	0
Number of Apartment Complexes	2
Number of Hazardous Materials locations	6
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	1

Floods

Buildings in floodplain	23
Commercial property in floodplain (parcels)	8
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	6
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	2
Dams	0
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	1
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	1
Heat related events in past 5 years (NOAA)	17

NORTHLAND REGIONAL AMBULANCE DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units

Number of Schools

Number of Nursing Homes

Number of Childcare Centers

Number of Apartment Complexes

Number of Hazardous Materials locations

Tornado events in past 5 years (NOAA)

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)

Floods

Buildings in floodplain

Commercial property in floodplain (parcels)

Commercial property in floodplain (area)

Residential property in floodplain (parcels)

Residential property in floodplain (value)

Residential property in floodplain (area)

Hazardous materials locations in floodplain

Dams

Flood events in past 5 years (NOAA)

Severe Winter Weather

Warming Centers

Severe winter weather in past 5 years (NOAA)

Heat

Cooling Centers

Heat related events in past 5 years (NOAA)

WEST PLATTE FIRE PROTECTION DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	
Number of Schools	3
Number of Nursing Homes	0
Number of Childcare Centers	0
Number of Apartment Complexes	2
Number of Hazardous Materials locations	4
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	3

Floods

Buildings in floodplain	45
Commercial property in floodplain (parcels)	13
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	19
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	2
Dams	0
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	1
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	1
Heat related events in past 5 years (NOAA)	17

NORTH PLATTE R-1 SCHOOL DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	1,757
Number of Schools	4
Number of Nursing Homes	0
Number of Childcare Centers	1
Number of Apartment Complexes	1
Number of Hazardous Materials locations	6
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	5

Floods

Buildings in floodplain	41
Commercial property in floodplain (parcels)	9
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	27
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	4
Dams	0
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	3
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	3
Heat related events in past 5 years (NOAA)	17

PARK HILL SCHOOL DISTRICT
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	32,136
Number of Schools	21
Number of Nursing Homes	7
Number of Childcare Centers	19
Number of Apartment Complexes	80
Number of Hazardous Materials locations	24
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	12

Floods

Buildings in floodplain	427
Commercial property in floodplain (parcels)	86
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	290
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	19
Dams	3
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	4
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	5
Heat related events in past 5 years (NOAA)	17

PLATTE COUNTY R-3 DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	11,401
Number of Schools	7
Number of Nursing Homes	7
Number of Childcare Centers	10
Number of Apartment Complexes	37
Number of Hazardous Materials locations	8
Tornado events in past 5 years (NOAA)	1

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	8

Floods

Buildings in floodplain	40
Commercial property in floodplain (parcels)	3
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	17
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	7
Flood events in past 5 years (NOAA)	1

Severe Winter Weather

Warming Centers	2
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	4
Heat related events in past 5 years (NOAA)	17

WEST PLATTE R-II SCHOOL DISTRICT SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	1,718
Number of Schools	3
Number of Nursing Homes	0
Number of Childcare Centers	0
Number of Apartment Complexes	2
Number of Hazardous Materials locations	10
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	3

Floods

Buildings in floodplain	156
Commercial property in floodplain (parcels)	22
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	75
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	3
Dams	0
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	1
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	1
Heat related events in past 5 years (NOAA)	17

PARK UNIVERSITY
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units

Number of Schools

Number of Nursing Homes

Number of Childcare Centers

Number of Apartment Complexes

Number of Hazardous Materials locations

Tornado events in past 5 years (NOAA)

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)

Floods

Buildings in floodplain

Commercial property in floodplain (parcels)

Commercial property in floodplain (area)

Residential property in floodplain (parcels)

Residential property in floodplain (value)

Residential property in floodplain (area)

Hazardous materials locations in floodplain

Dams

Flood events in past 5 years (NOAA)

Severe Winter Weather

Warming Centers

Severe winter weather in past 5 years (NOAA)

Heat

Cooling Centers

Heat related events in past 5 years (NOAA)

RAY COUNTY
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	9,388
Number of Schools	11
Number of Nursing Homes	2
Number of Childcare Centers	8
Number of Apartment Complexes	11
Number of Hazardous Materials locations	44
Tornado events in past 5 years (NOAA)	1

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	6

Floods

Buildings in floodplain	562
Commercial property in floodplain (parcels)	25
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	504
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	4
Dams	19
Flood events in past 5 years (NOAA)	1

Severe Winter Weather

Warming Centers	1
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	2
Heat related events in past 5 years (NOAA)	17

CITY OF RICHMOND
SUMMARY ASSESSMENT OF RISKS

Tornadoes

Number of Housing Units	2,847
Number of Schools	4
Number of Nursing Homes	2
Number of Childcare Centers	7
Number of Apartment Complexes	9
Number of Hazardous Materials locations	19
Tornado events in past 5 years (NOAA)	0

Severe Thunderstorm

Severe thunderstorms in past 5 years (NOAA)	4

Floods

Buildings in floodplain	45
Commercial property in floodplain (parcels)	7
Commercial property in floodplain (area)	
Residential property in floodplain (parcels)	30
Residential property in floodplain (value)	
Residential property in floodplain (area)	
Hazardous materials locations in floodplain	0
Dams	0
Flood events in past 5 years (NOAA)	0

Severe Winter Weather

Warming Centers	1
Severe winter weather in past 5 years (NOAA)	

Heat

Cooling Centers	2
Heat related events in past 5 years (NOAA)	17