Figure 2.17 Joplin FIRMette A

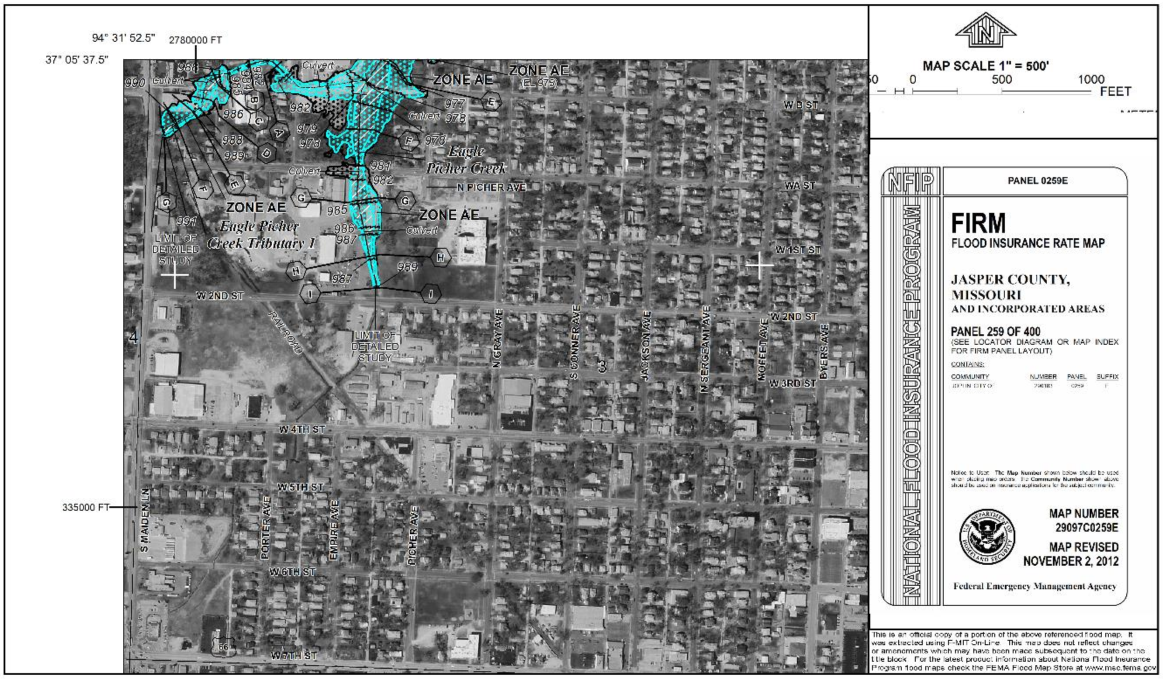


Figure 2.18 Joplin FIRMette B

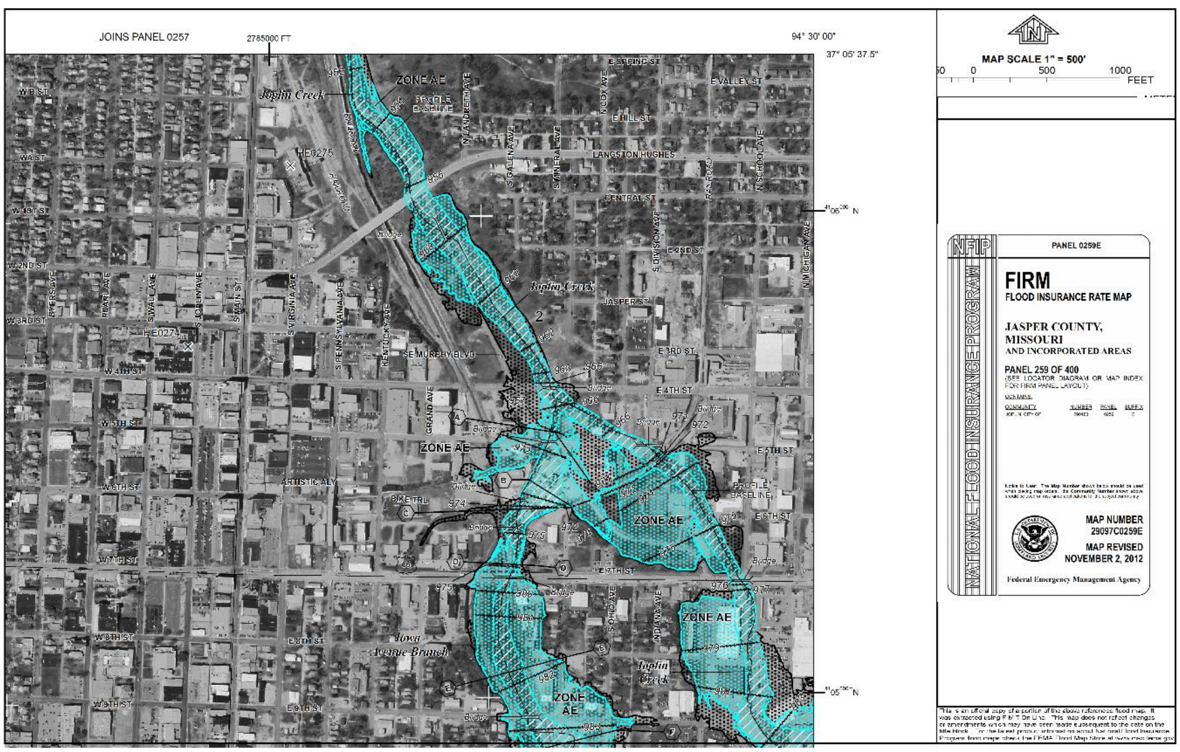


Figure 2.19 Joplin FIRMette C

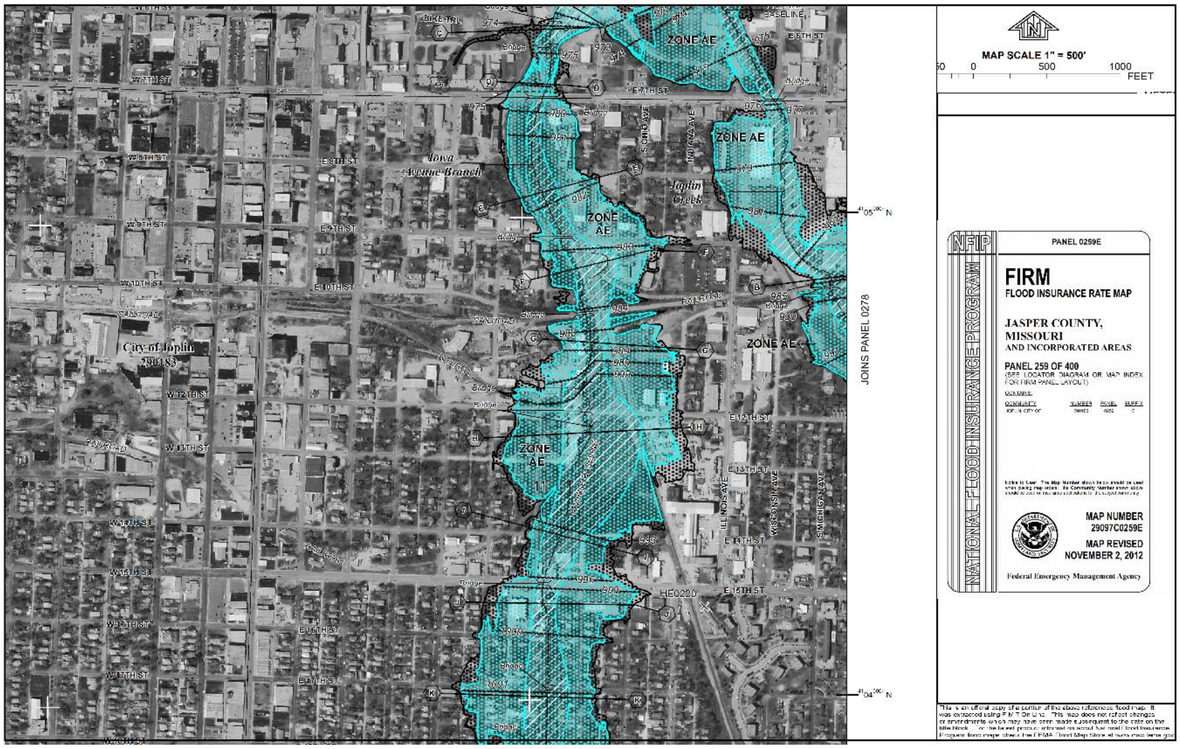


Figure 2.20 Joplin FIRMette D

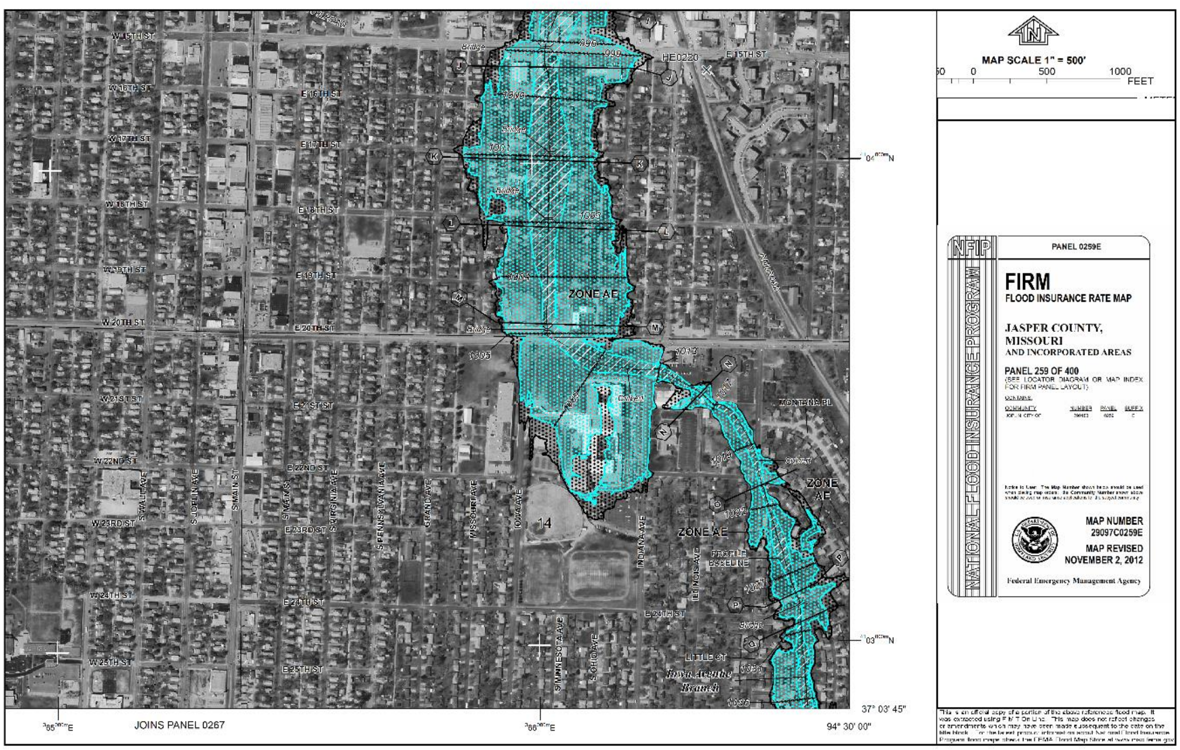


Figure 2.21 Joplin FIRMette E

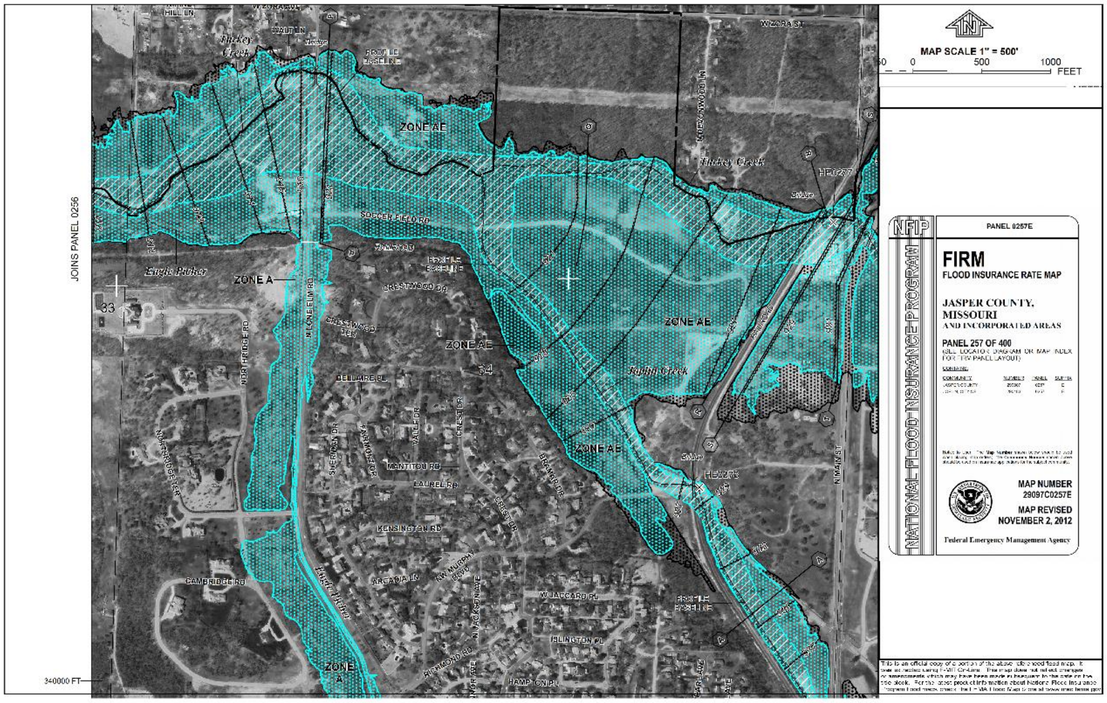


Figure 2.22 Joplin FIRMette F

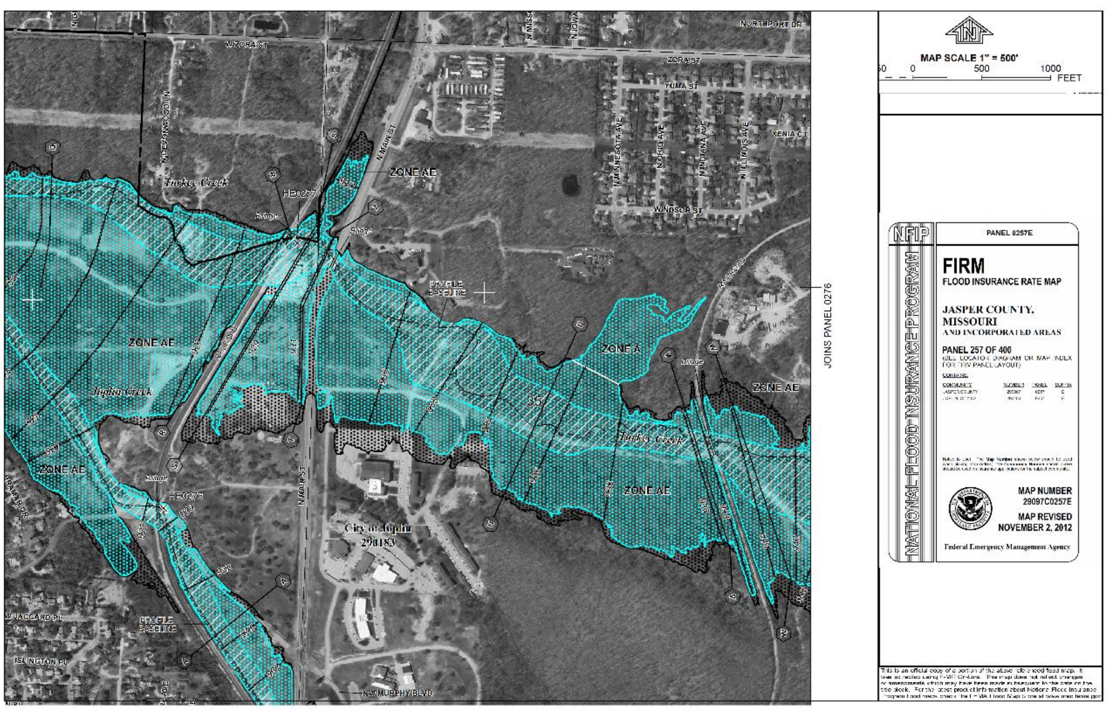


Figure 2.23 Joplin FIRMette G

Figure 2.24 Joplin FIRMette H

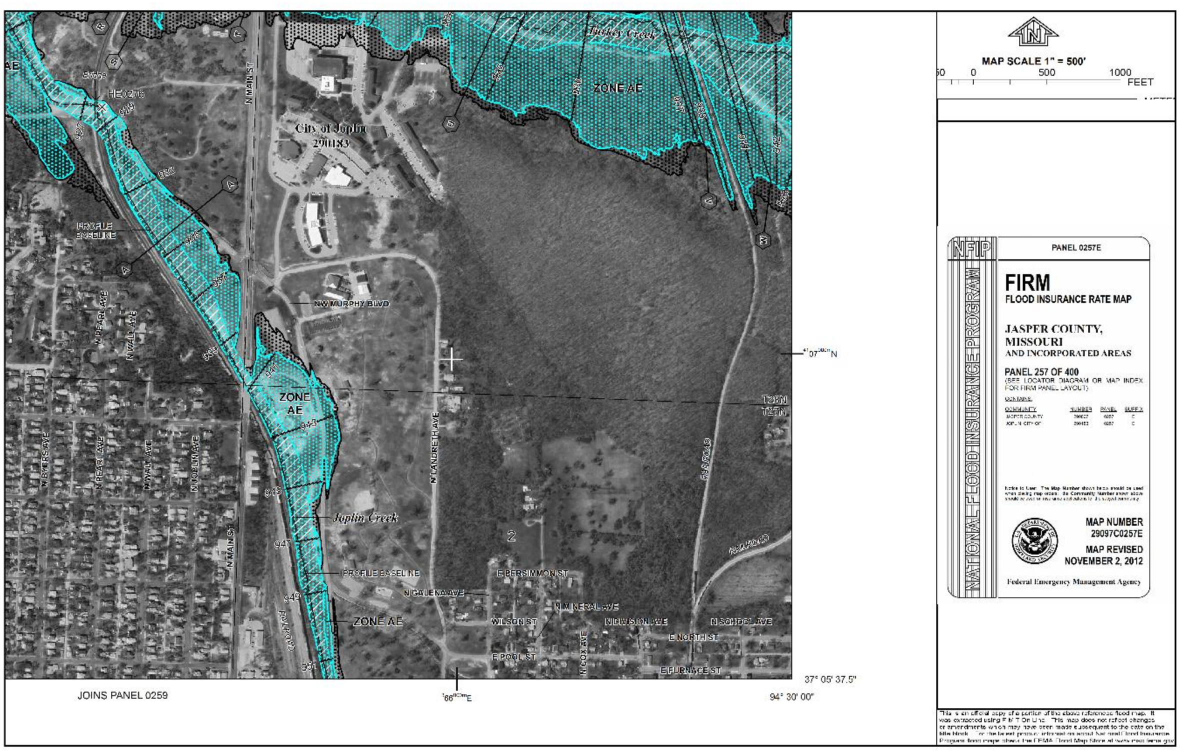


Figure 2.25 Loma Linda FIRMette

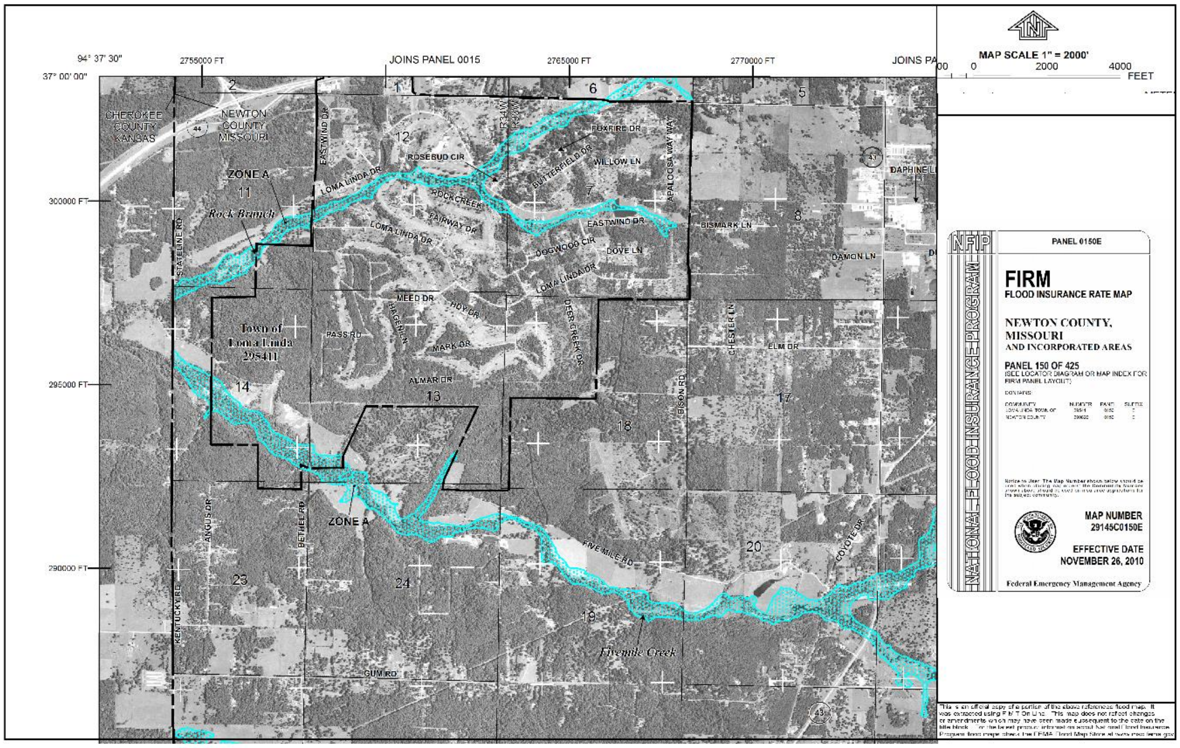


Figure 2.26 Neosho FIRMette A

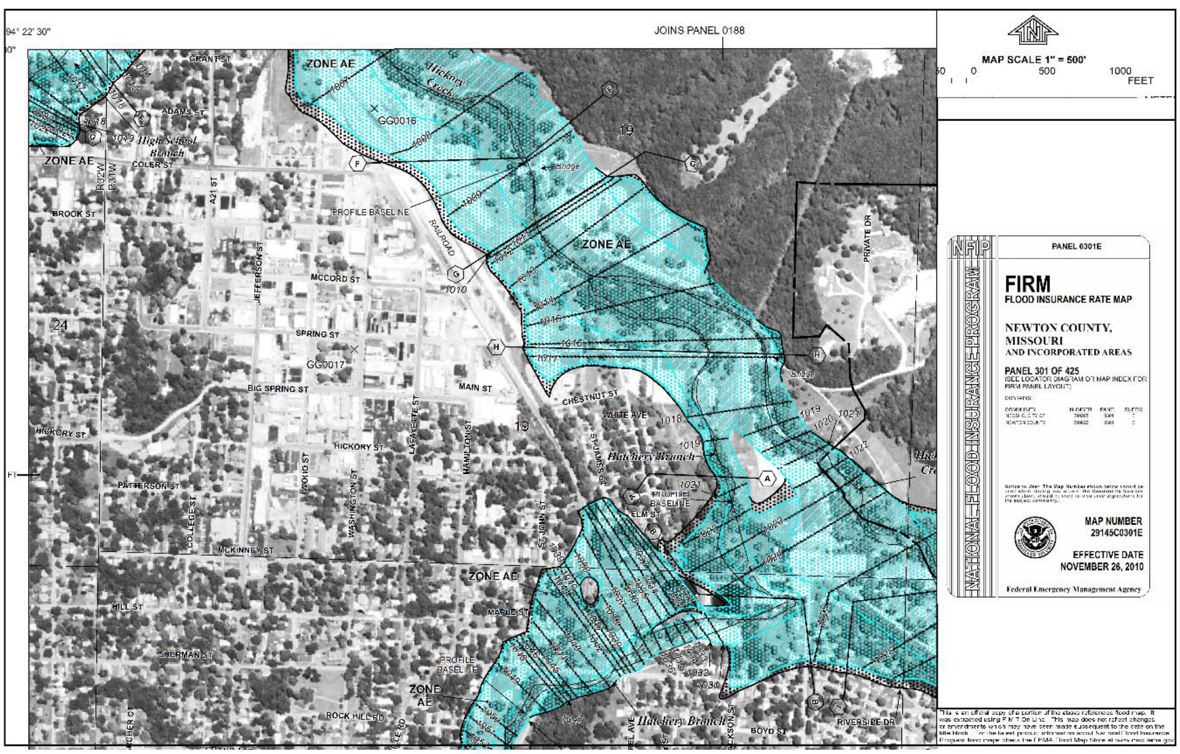


Figure 2.27 Neosho FIRMette B

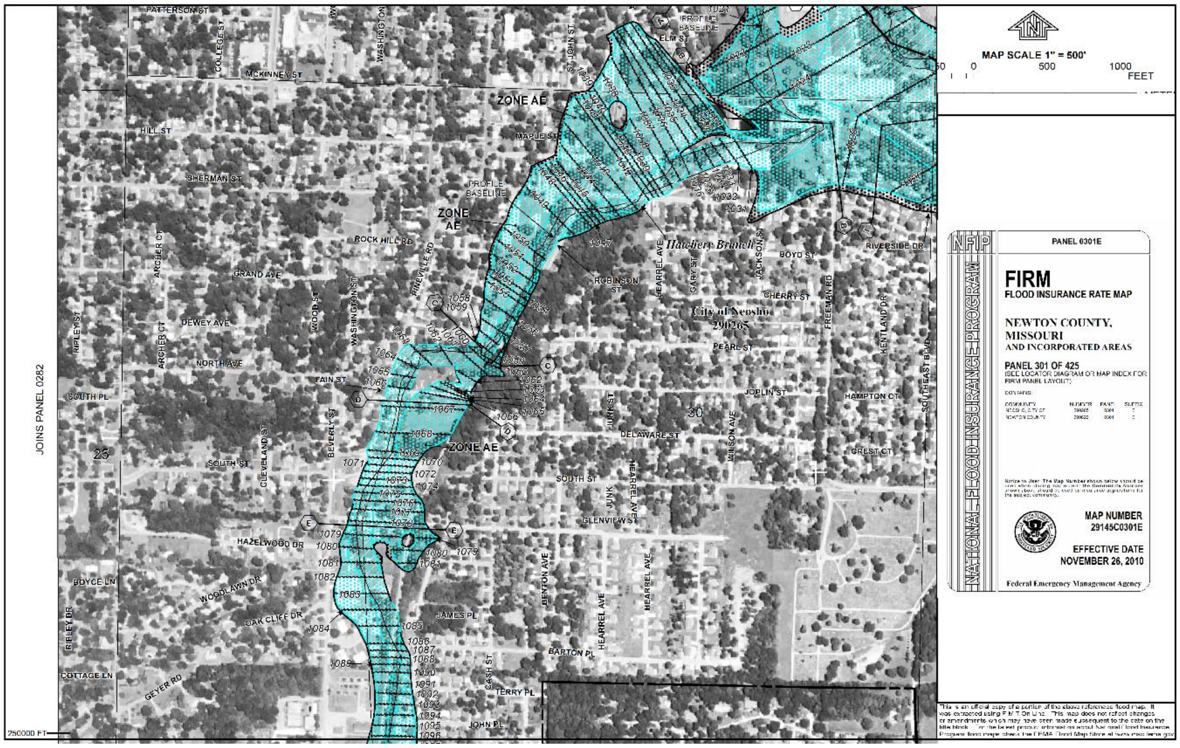


Figure 2.28 Neosho FIRMette C

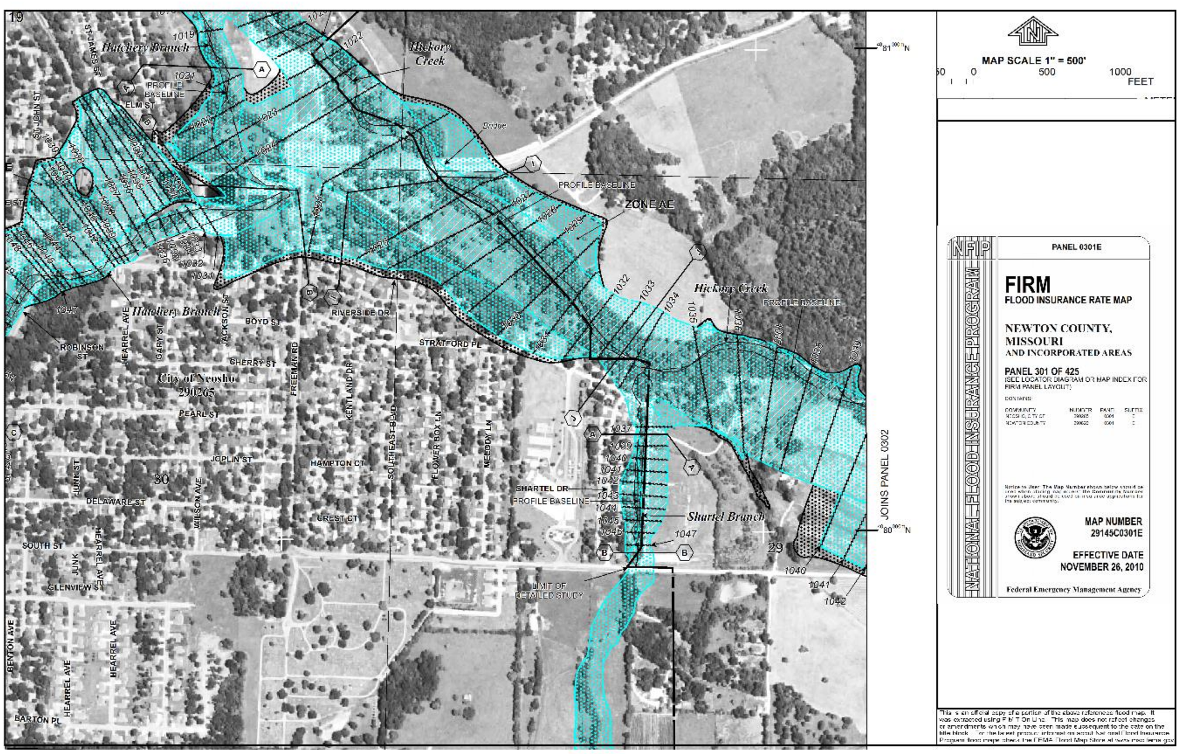


Figure 2.29 Neosho FIRMette D

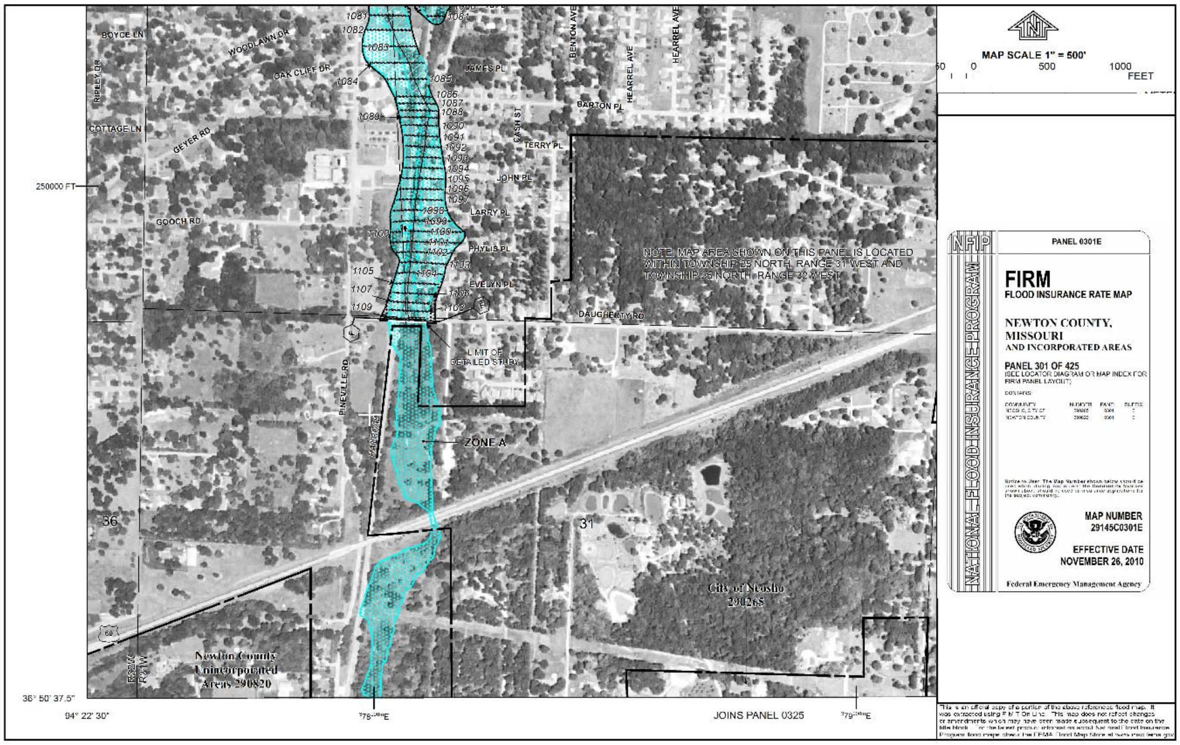


Figure 2.30 Neosho FIRMette E

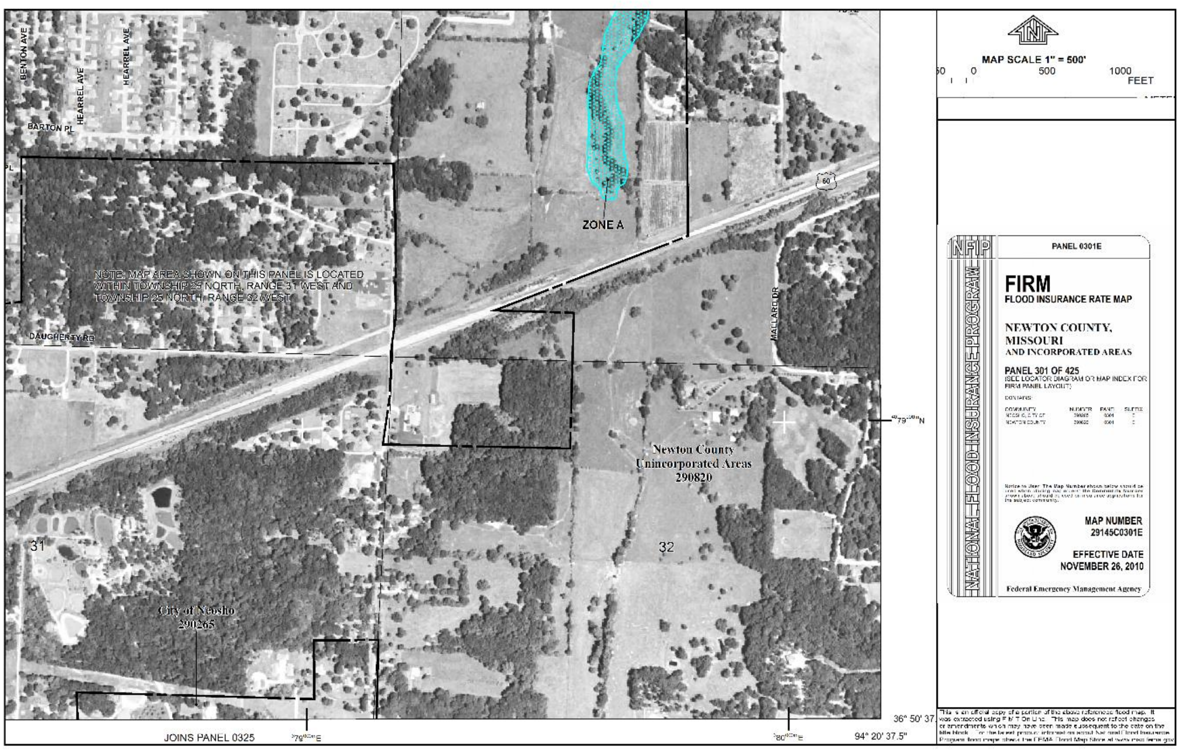


Figure 2.31 Oronogo FIRMette A

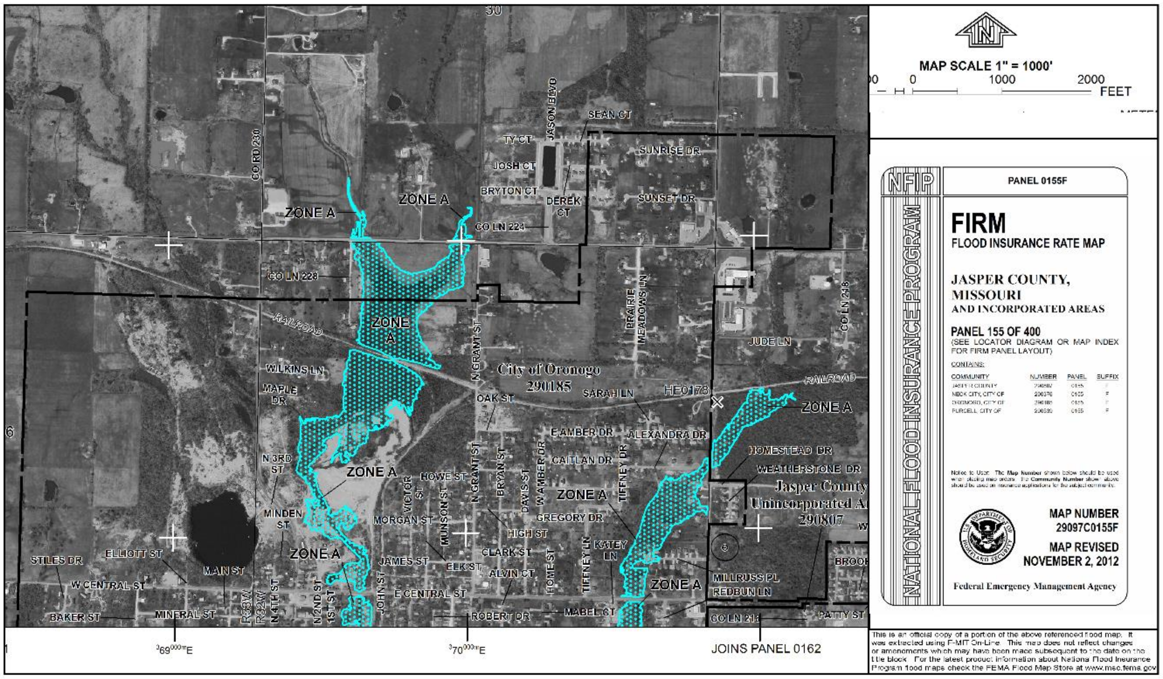


Figure 2.32 Oronogo FIRMette B

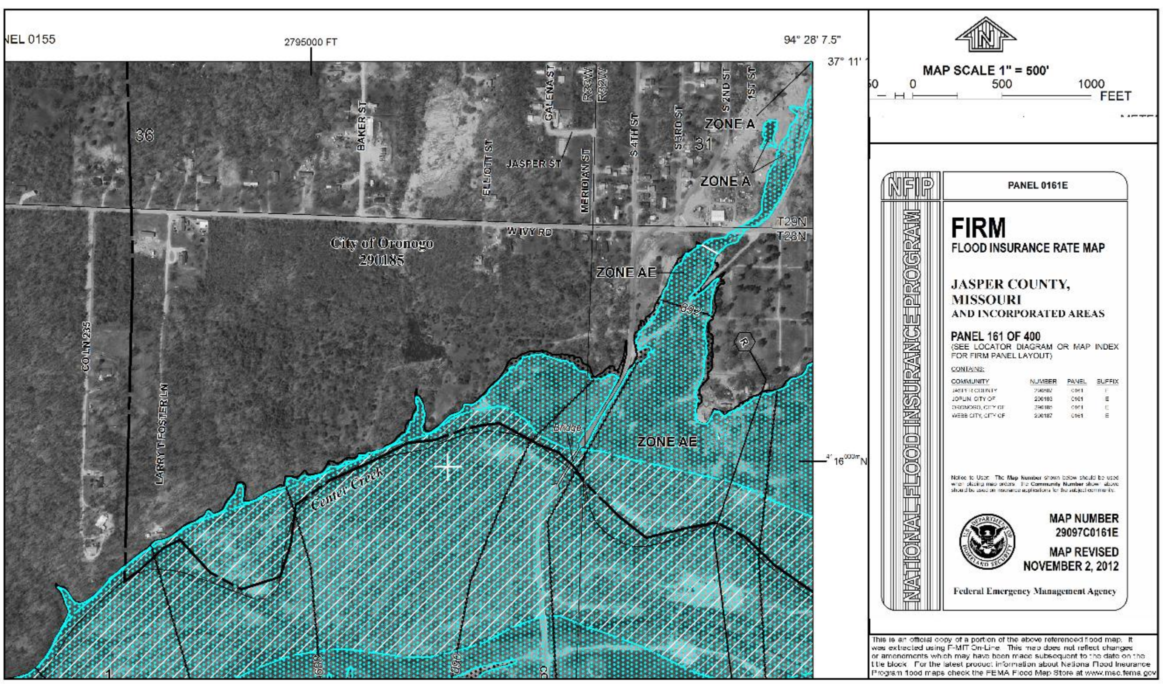


Figure 2.33 Oronogo FIRMette C

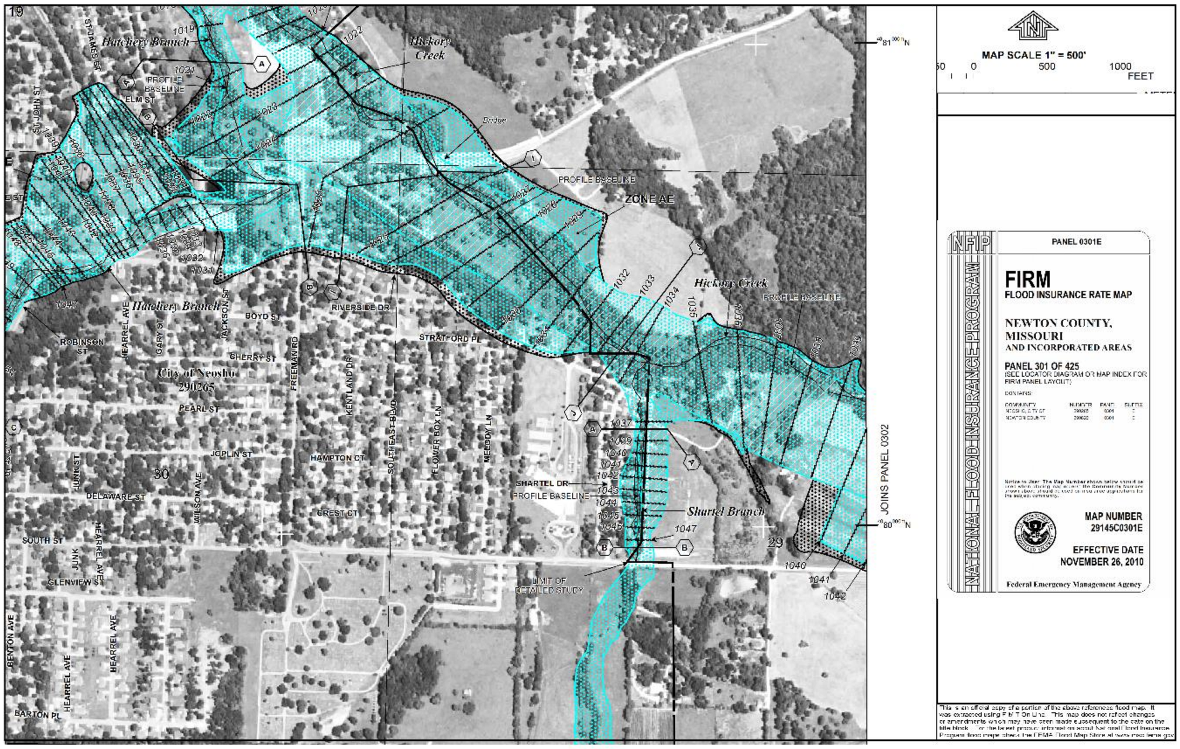


Figure 2.34 Redings Mill FIRMette

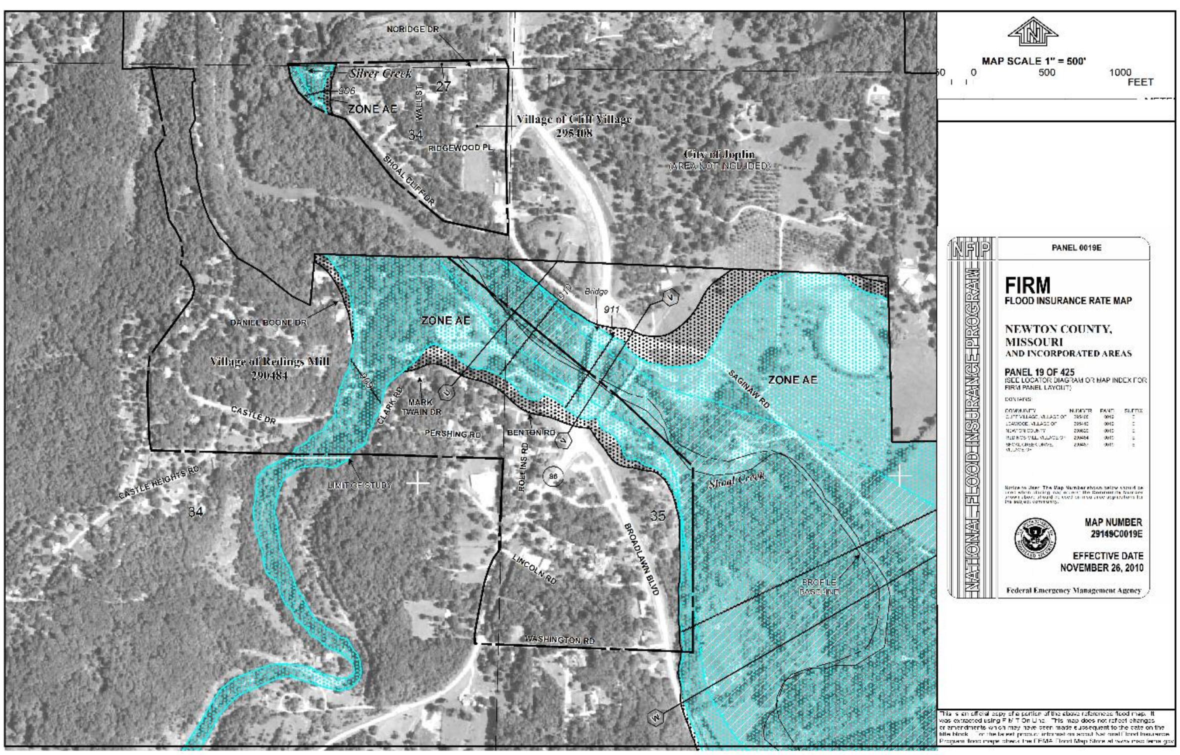


Figure 2.35 Saginaw FIRMette A

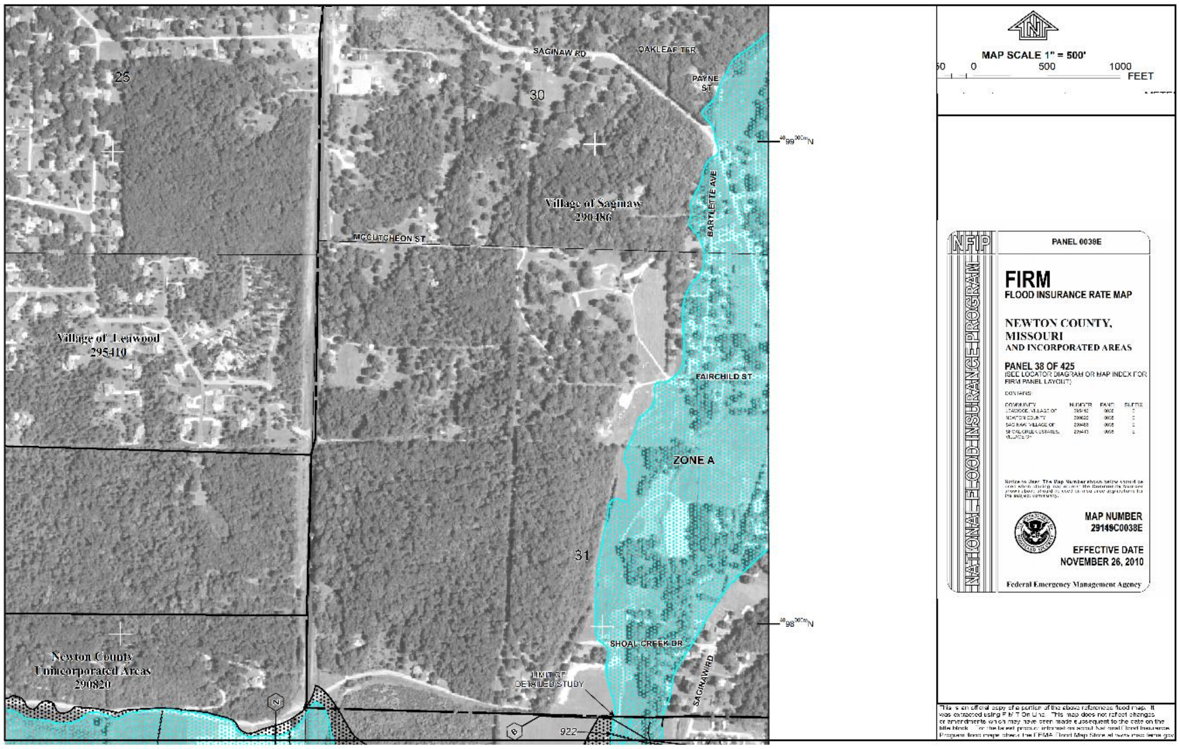


Figure 2.36 Saginaw FIRMette B

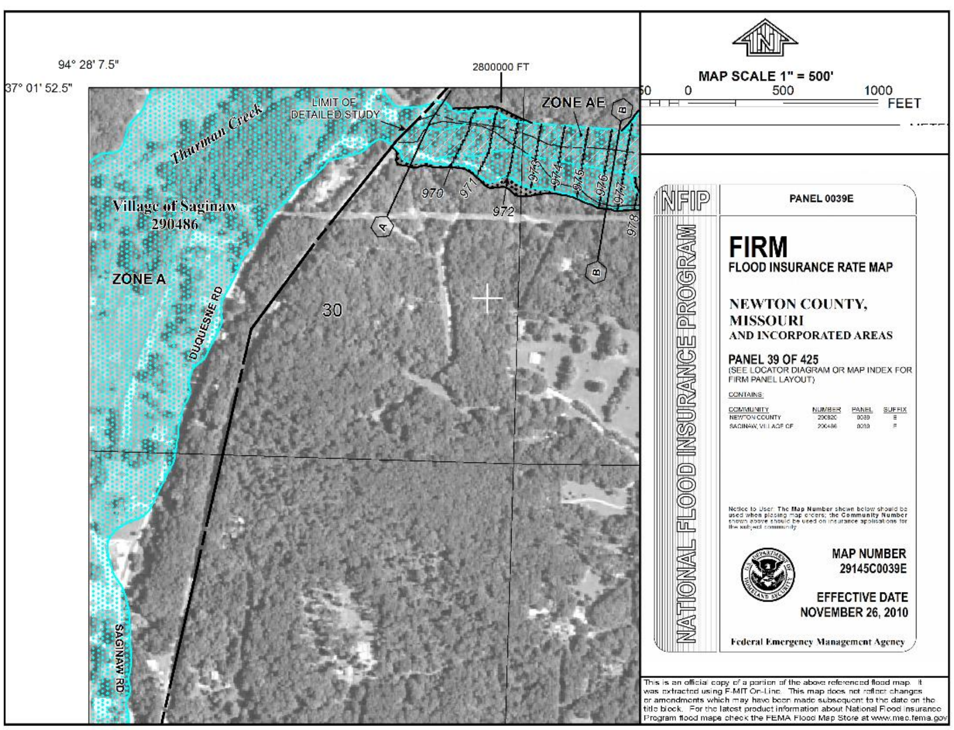


Figure 2.37 Sarcoxie FIRMette

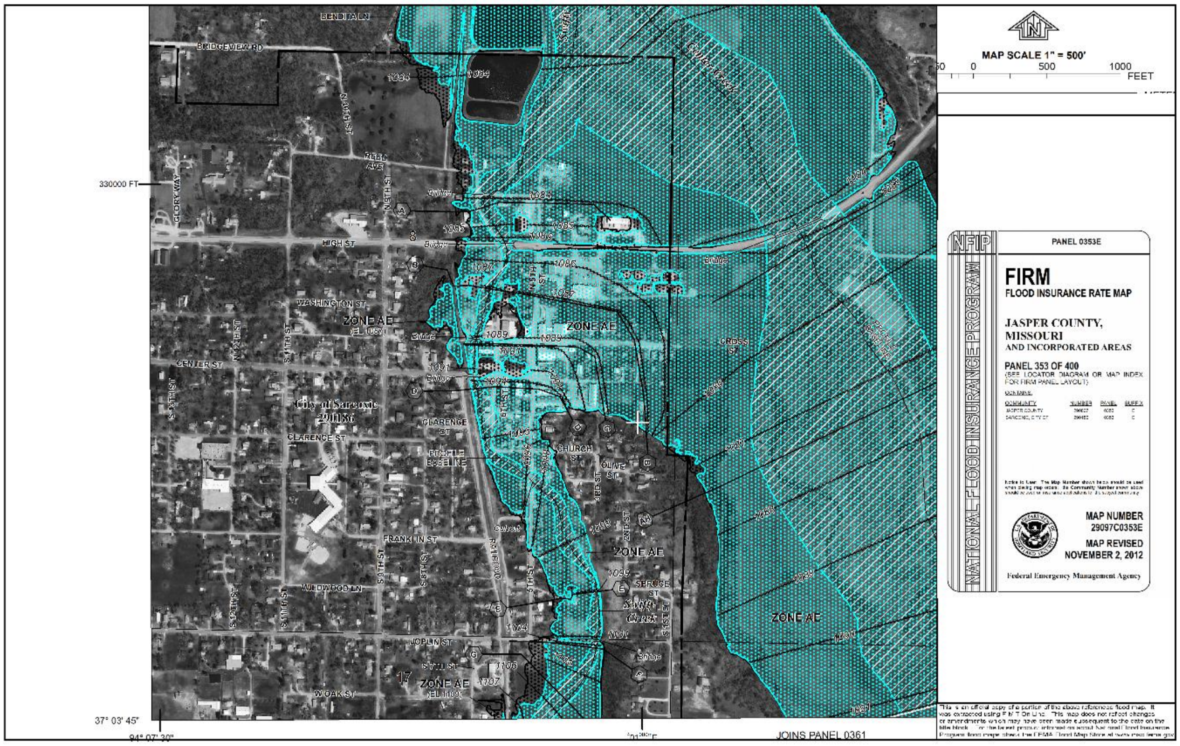


Figure 2.38 Seneca FIRMette

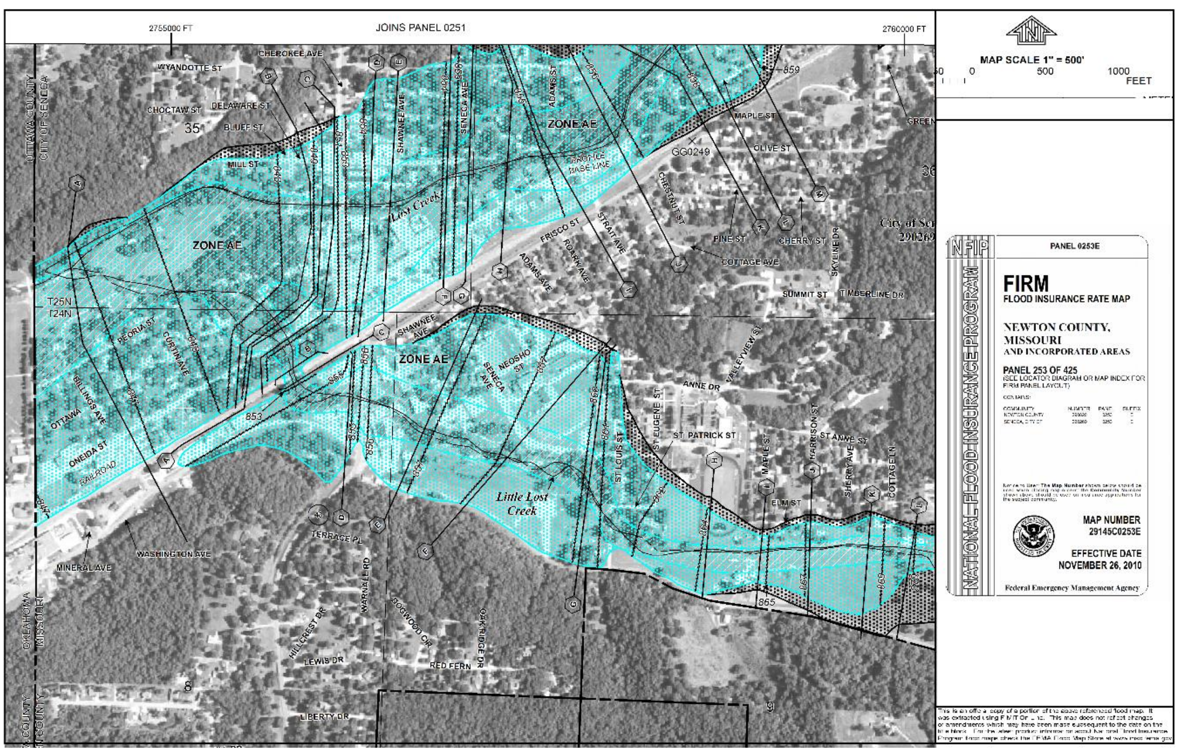


Figure 2.39 Webb City FIRMette A

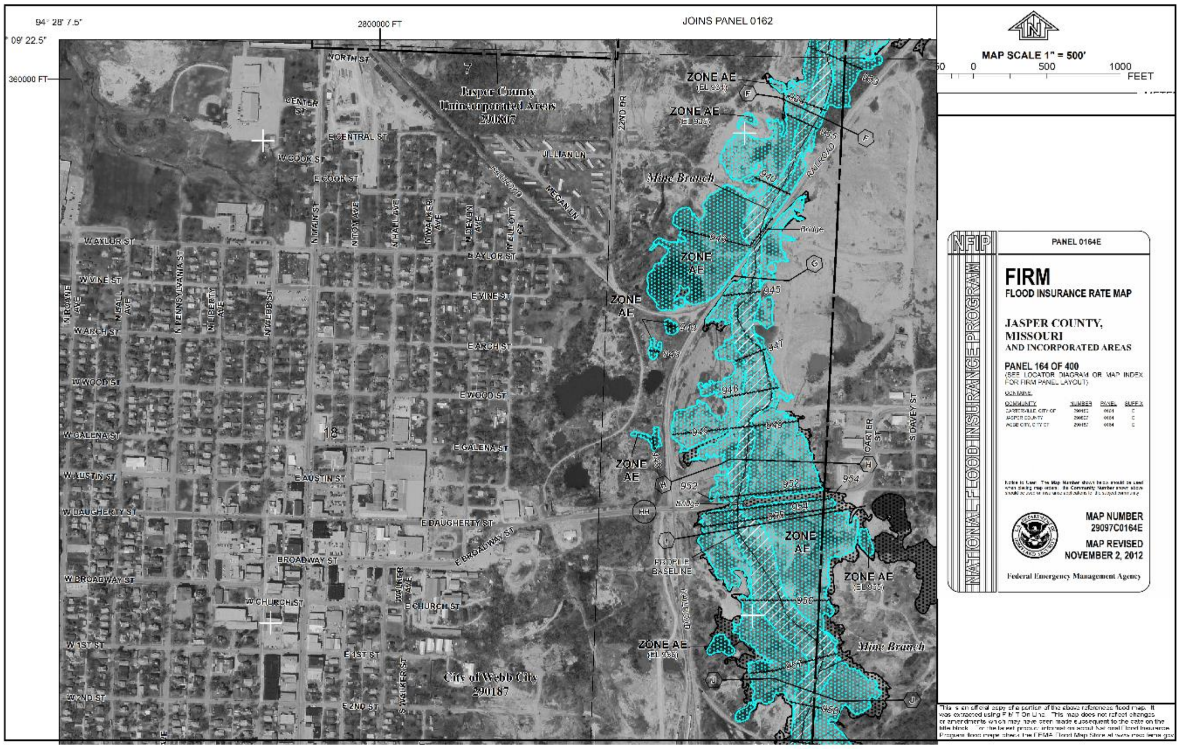
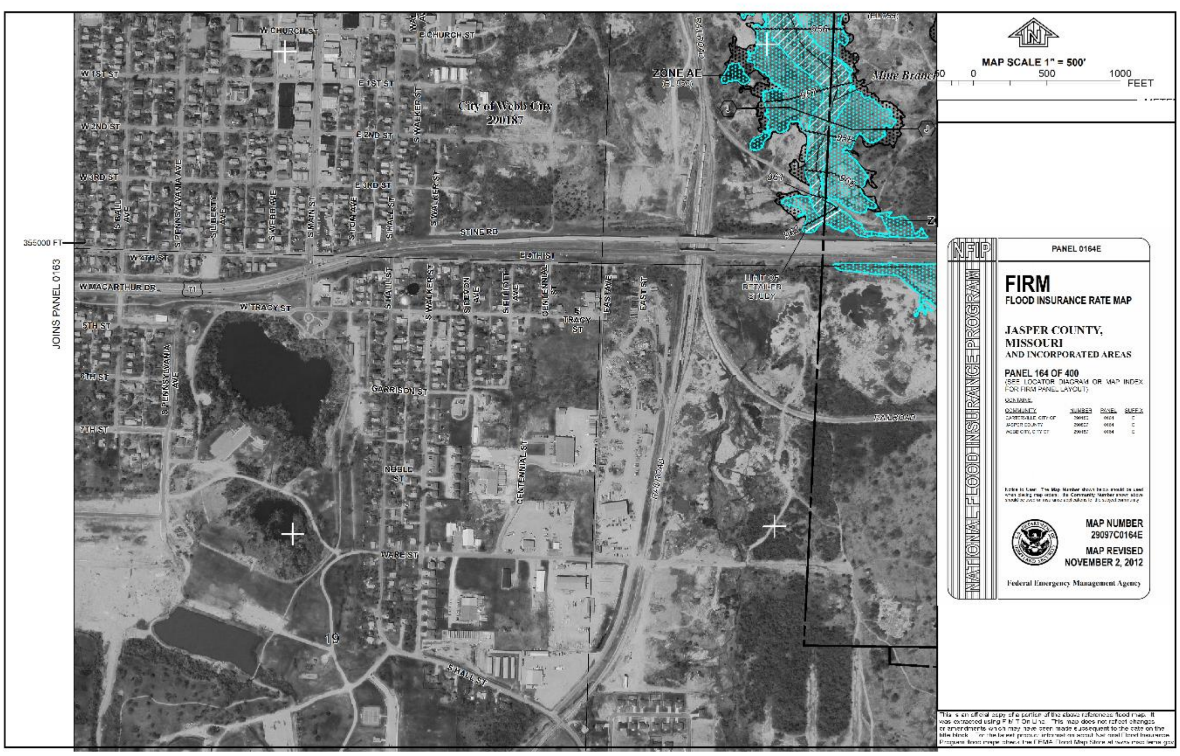


Figure 2.40 Webb City FIRMette B



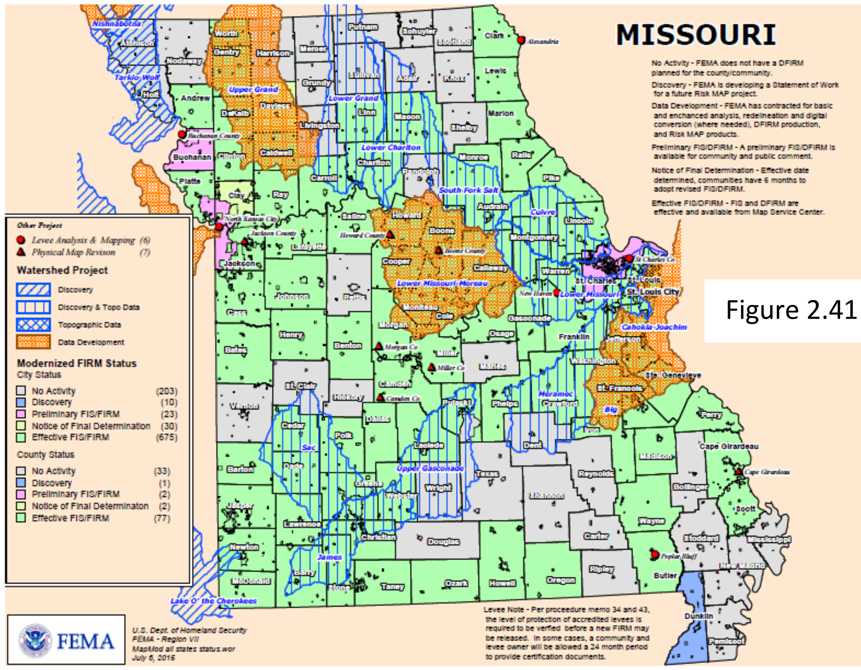


Figure 2.41

As previously stated, jurisdictions within 100 year floodplains have the highest risk of flood-related damage. In the case of a flood event, significant portions of the previously identified jurisdictions and unincorporated portions of the county may be at risk for flood-related damage in a 100 year event based upon existing floodplains throughout the county. HAZUS data suggests that 26% of buildings in Jasper County and 28% of buildings in Newton County within the floodplain may sustain damage of some variety during a 100-year event. Risk Mapping, Assessment, and Planning (RiskMAP) is the Federal Emergency Management Agency (FEMA) program that provides communities with flood information and tools they can use to enhance their mitigation plans and take action to better protect their citizens. Through collaboration with State, Tribal, and local entities, RiskMAP delivers quality data that increases public awareness and leads to action that reduces risk to life and property. This data is not yet available for either county, though Newton County is presently in the Discovery Phase of the project. (Figure 2.41)

Since the adoption of the 2010 plan, significant changes in building development and population shifts have taken place in nearly every jurisdiction. However, because of the existence of floodplain regulations, no new development has taken place in the floodplains without elevation certificates and building permits. As such, damages to future structures have been eliminated from consideration.

Severe Winter Weather (Snow, Ice, and Extreme Cold)

Like thunderstorms, severe winter weather events tend to occur over wide geographic areas, encompassing an entire county or a large group of counties. Severe winter weather events such as snow, ice storms and extreme cold can cause injuries, deaths and property damage in a variety of ways. Winter storms are considered deceptive killers because most deaths are not obviously related to the storm. Causes of death range from traffic accidents during adverse driving conditions to heart attacks caused by overexertion while shoveling snow. Hypothermia or frostbite may be considered the most direct cause of death and injuries attributed to winter storms and/or severe cold.

Economic costs are difficult to measure. Heavy accumulations of ice can bring down trees, electric power lines and poles, telephone lines and communications towers. Crops, trees and livestock can be killed or injured due to deep snow, ice or severe cold. Buildings and automobiles may be damaged from falling tree limbs, power lines and poles. Local governments, homeowners, business owners, and power companies can cumulatively spend millions of dollars for restoration of services, debris removal and landfill hauling. Severe winter weather events that caused damage from 1993-2014 for Jasper and Newton counties are detailed in Table 2.19.

Previous Events

Based upon Jasper and Newton County's event history and the risk indicators, severe winter weather events are likely to have limited impact. Since 1993, according to the NCDC, severe winter weather in the two-county region has:

- Occurred primarily in the months of December and January;
- Occurred as late as the month of March;
- Caused one death;
- Damaged property valued at $500,000.

Severe winter weather events which caused damage for the two county region are detailed in Table 2.19.

Table 2.19	Jasper - Newton County Severe Winter Weather Damage-Causing Events 1998-2014							
Location or County	Date	Time	Type	Magnitude	Deaths	Injuries	Property Damage	Crop Damage
Jasper County	01/01/1999	0500	Winter Storm	N/A	0	0	125K	0
Newton County	03/13/1999	1500	Winter Storm	N/A	0	0	25K	0
Jasper County / Newton County	11/30/2006	1200	Winter Storm	N/A	0	0	250K	0
Jasper County / Newton County	01/08/1997	1200	Heavy Snow	N/A	0	0	65K	0
Jasper County	12/12/2000	2100	Heavy Snow	N/A	0	0	10K	0
Newton County	02/01/2011	0000	Blizzard	N/A	1	0	25K	0

In Newton County, one death occurred in 2011 during a February blizzard. In 2006, a winter storm resulted in $250,000 in property damages in the two counties. When much of the state of Missouri was contending with devastating ice storms in 2007 and 2008, Newton and Jasper County largely escaped these impacts. Of 22 regional events and 5 individual county events, only six resulted in property damages. However, those four (extreme cold, ice, and heavy snow) warrant ratings of limited for future probable severity due the extent of households affected.

Excessive winter weather can prove devastating. Primary concerns include the potential loss of heat, power, telephone service and a shortage of supplies if storm conditions continue for more than a day. Further, employees may be unable to get to work due to icy conditions, unplowed roadways or facility damage.

Winter weather warnings are organized by stages of severity by the National Weather Service. These stages are shown below.

WINTER WEATHER ADVISORY:
Winter weather conditions are expected to cause significant inconveniences and may be hazardous. If caution is exercised, these situations should not become life- threatening. The greatest hazard is often to motorists.

WINTER STORM WATCH:
Severe winter conditions, such as heavy snow and/or ice, are possible within the next day or two.

WINTER STORM WARNING:
Severe winter conditions are imminent in the warned area.

BLIZZARD WARNING:
Snow and strong winds will combine to produce a blinding snow (near zero visibility), deep drifts, and life-threatening wind chill. Seek refuge immediately.

FROST/FREEZE WARNING:
Below freezing temperatures are expected during the growing season and may cause significant damage to plants, crops, or fruit trees. In areas unaccustomed to freezing temperatures, people who have homes without heat need to take added precautions.

In addition to snow, the effects of temperature and wind chill increase the severity of a winter storm. Wind blowing across exposed skin drives down the skin temperature and eventually the internal body temperature. The faster the wind blows, the faster the heat is carried away, the greater the heat loss and the colder it feels. Exposure to low wind chills can be life threatening to humans and animals.

To use the Wind Chill Temperature Index (Figure 2.42), find the air temperature along the top of the table and the wind speed along the left side.

Figure 2.42

Wind Chill Chart

Temperature (°F)

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

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

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

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

Effective 11/01/01

Probability of Occurrence

Based upon the county's event history and the risk indicators discussed above, severe winter weather events are likely to be fairly limited for the two county region. Overall, there is a likely risk of impacts due to winter weather, based upon the counties' history and number of events by month of occurrence. Historical records indicate that snow events of significance are rare, given that the average annual snowfall is approximately 12 inches for the City of Joplin. In addition, ice events and periods of extreme cold temperatures are also possible, though rarely occur. From 1993 to 2014, a total of 27 events occurred in 21 years. Therefore, the probability for any severe winter weather event in any given year for the two county region y is 100%. (27 events / 21 years * 100 = 128.5%) Of these 27 events, 6 severe winter weather events caused damage to the included jurisdictions between 1993 and 2014. A damage-causing severe winter weather event is statistically likely to occur in any given year (6 damage-causing events / 21 years * 100 = 28.6%).

Extent / Severity

Winter weather certainly occurs in Jasper and Newton County. Often, however, these events are regional in scope and affect all jurisdictions within the county. Because of advanced weather forecasting, warnings in excess of 24 hours are usually provided to citizens. However, the destructive and disruptive power of winter weather is beyond the control of humankind. Severity, risk of death and/or injuries, and property damages will continue to occur due to the reduction in access to basic services caused by such storms. Six events in 21 years have caused approximately $500,000 in damages, for an average damage cost per event of approximately $18,666, as well as one death. Based on previous occurrences, the committee estimates that future severity could range from light to moderate damage.

Vulnerability

All jurisdictions within the county (municipalities, educational institutions, and unincorporated areas) are equally susceptible to damage stemming from severe winter weather, particularly snow and ice events. In the event of a severe winter storm, 26-50% of any given jurisdiction may be at risk for damage, with damages estimated to range from light (less than 10%) to moderate (up to 25%) for structures. Since the adoption of the 2010 plan, significant development and population shifts have taken place in nearly every jurisdiction. This means a greater number of people and structures are vulnerable and the risk for damage has increased accordingly. In the case of extreme cold temperatures, special consideration must be given to the potential impact upon the young, disabled, and elderly populations.

Drought

The impacts of drought are not limited to agriculture, but can intensify to encompass the whole economy. Impacts can adversely affect a small town's water supply, the corner grocery store, commodity markets or a large municipality's tourism. On average, droughts negatively impact the U.S. economy by seven to nine billion dollars a year, according to the National Drought Mitigation Center.[14] While there are no cost estimates for the drought events of 1999-2000 and 2011-2012 that gripped Missouri and much of the nation, losses from the severe drought event of the 1988-1989 were assessed at $39 billion.

The drought impact on society results from the interplay between a natural event (less precipitation than expected resulting from natural climatic variability) and the demand development places on groundwater reservoirs. A drought situation often is exacerbated by development practices that decrease the percolation of surface water into groundwater reservoirs. The resulting economic and environmental impacts associated with recent droughts have underscored society's vulnerability to this hazard.

The dictionary definition of drought is a period of prolonged dryness. Current drought literature commonly distinguishes between three categories of drought:

- Agricultural drought, defined by soil moisture deficiencies;
- Hydrological drought, defined by declining surface water and groundwater supplies; and
- Meteorological drought, defined by precipitation deficiencies.

Agricultural drought is the type most likely to wreak economic losses in the two-county region.

The most commonly used indicator of drought and drought severity is the Palmer Drought Severity Index (PDSI), published jointly by NOAA and the United States Department of Agriculture.[15] The PDSI measures the departure of water supply (in terms of precipitation and stored soil moisture) from demand (the amount of water required to recharge soil and keep rivers, lakes, and reservoirs at normal levels). The result is a scale from +4 to -4, ranging from an extremely moist spell to extreme drought. By relating the PDSI number to a regional index, one can compile data that reflects long-term wet or dry tendencies.

Table 2.20 Palmer Drought Severity Index

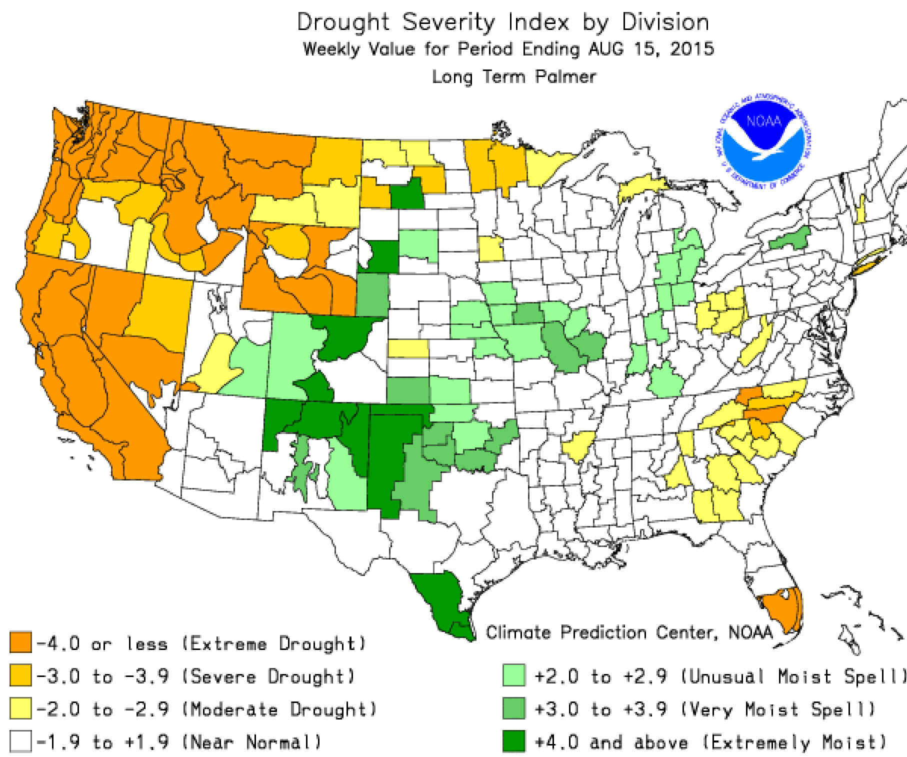
Rating	Description
Above 4.0	Extreme Moist Spell
3.0 to 3.9	Very Moist Spell
2.0 to 2.9	Unusually Moist Spell
1.0 to 1.9	Moist Spell
0.5 to 0.9	Incipient Moist Spell
0.4 to -0.4	Near Normal Conditions
-0.5 to -0.9	Incipient Drought
-1.0 to -1.9	Mild Drought
-2.0 to -2.9	Moderate Drought
-3.0 to -3.9	Severe Drought
Below -4.0	Extreme Drought

Regional indicators such as the PDSI are limited in that they respond slowly to deteriorating conditions. On the other hand, observing surface conditions and

[14] http://drought.unl.edu/AboutUs/CurrentResearch/EstimatingtheImpactsofComplexClimaticEvents.aspx
[15] http://www.drought.unl.edu/whatis/indices.htm

groundwater measurements may provide only a snapshot of a limited area. Therefore, the use of a variety of drought indicators is essential for effective assessment of drought conditions, with the PDSI being the primary drought severity indicator. The PDSI regions and severity scale are shown in Table 2.20.

Figure 2.43



Previous Events

In Missouri, minor droughts happen regularly, and extreme drought occurs occasionally. The 1999-2000 droughts began in July of 1999 and developed rapidly into a widespread drought just three months later. The entire state was placed under a Phase I Drought Advisory level by the Missouri Department of Natural Resources (DNR) and the Governor declared an Agricultural Emergency. In October, the U.S. Agriculture Secretary declared a federal disaster, making low-interest loans available to farmers in Missouri and neighboring states. The NCDC reported the driest month on record for Jasper and Newton County in April of 2000. By June of 2000, the entire state was under a Phase II Alert for drought conditions.

Most recently, the impacts of drought ravaged Midwestern states, including Missouri from 2012-2013, with PDSI ratings of -4.0, or Extreme Drought. The 2012 Missouri harvest saw a 27.5% reduction in corn and a 7% reduction in soybeans. 54% of pastures were rated poor or very poor. As a result, livestock were placed on feed earlier than normal. Livestock were also subject to heat stress, raising feed costs, and reduced inventories, particularly in poultry and hogs. These costs were then passed on to the regular consumer as the price of groceries was impacted, especially for dairy and meat products. Drought affected not only agricultural production in the county, but also threatened the water supplies of local. To date, the economic impacts of this drought continue to be collected as impacts beyond agriculture are considered.

Crops are the first to show the impact of drought. As a drought intensifies,livestock water supplies become scarce and, finally, deep wells begin to fail. When good water becomes a scarce commodity and people must compete for the available supply, the importance of drought severity and duration increases dramatically. According to the Missouri Drought Plan, Jasper County and Newton County have "abundant groundwater resources, making [them] less susceptible to problems caused by prolonged periods without rain. The agricultural needs for water… are not typically as great in this region … because row-crop farming is not extensive in southern Missouri."[16] However, increased seasonal use due to tourism combined with rapid residential and commercial growth in the region does cause concern over depletion of region aquifers. The population growth of the past decade in the two-county region has a potential impact on local water resources.

Precipitation-related impacts on time scales ranging from a few days to a few months can include effects on wildfire danger, non-irrigated agriculture, topsoil moisture, pasture conditions, and unregulated stream flows. Lack of precipitation over a period of several months or years adversely affects reservoirstores,irrigated agriculture, groundwater levels, and well water depth. Groundwater resources in the county are adequate to meet domestic and municipal water needs, but should be monitored as the population continues to grow.

The Missouri Department of Natural Resources' drought response system has four phases. Phase 1 begins when water monitoring analysis indicates anticipated drought consequences. The situation moves into Phase 2 when the PDSI reads -1 to -2 and the stream flow, reservoir levels, and groundwater levels are below normal over a period of several months. Phase 3 is based on a PDSI between -2 to -4 and various other factors. Phase 4, or activation of drought emergency procedures, generally begins when the PSDI exceeds -4. (Figure 2.43)

Therefore, using the Department of Natural Resources' drought response system, the probable severity levels of a future drought could be:

Phase:	**Probable Severity:**
Phase 1, Advisory	negligible
Phase 2, Alert	limited
Phase 3, Conservation	critical
Phase 4, Emergency	critical

[16] Missouri Department of Natural Resources, *Missouri Drought Plan, Water Resources Report Number 69*, http://www.dnr.mo.gov/pubs/WR69.pdf , 12.

Probability of Occurrence

It is possible for the two-county region to experience drought in any given year. Predicting droughts and the severity of each occurrence, however, is difficult as it is largely dependent upon regional climatic conditions but does not conform to any historical pattern. Additionally, local and historical data for drought is still in development, resulting in a limited risk assessment. Agricultural and meteorological drought are often linked, but agricultural drought is the most likely type to significantly impact the region. From 1999 until 2013, six years included drought designations of varying severity. Therefore, the probability for a drought event in any given year for the two-county region is 42.8%. (6 events / 14 years = 42.8%) To date, there is no method available to determine the probability of a damage-causing effect.

Extent / Severity

As stated previously, drought data for local jurisdictions is limited and still under development. However, the majority of drought impact lies in agricultural business. For the most part, both residents and buildings of the two-county region are not directly affected by agricultural drought to any measurable extent. As such, the extent of a potential agricultural drought lies largely in the number of acres dedicated to agricultural use. Based on information from the Jasper and Newton County Assessors, local USDA representatives, and the Hazard Mitigation Committee, the committee assumes that any given drought may result in light damages, largely focused on crops and livestock, but may also impact the availability of local water resources as well.

Vulnerability

All jurisdictions within the county are susceptible to potential damages stemming from drought, particularly in phases 3 and 4 in dealing with water availability. Agricultural land, however, is most vulnerable to the impacts of long term drought. Most municipalities do not encompass agricultural land. Unincorporated Jasper and Newton counties, however, are largely composed of such. As of 2013, Jasper County had 70,122 acres involved in crop production, while Newton County had 12,307 acres involved in crop production. These numbers do not take into account land used for pasture or left unplanted. In the event of a severe drought, 26-50% of all agricultural land in use may be at risk for damage. Since the adoption of the 2010 plan, local agricultural producers have been encouraged to research and implement steps which reduce water usage in the event of a drought. Municipalities have also been encouraged to consider total usage, both seasonal and constant, in order to address issues as they may occur. The committee assumes that damages would be moderate, ranging from 10-24% of all agricultural production.

Heat Wave

According to NOAA, heat is the number two killer among natural hazards; only the cold temperatures of winter take a greater toll.[17] In contrast to the visible, destructive, and violent nature of floods, hurricanes, and tornadoes, a heat wave is a silent killer. Heat kills by overloading the human body's capacity to cool itself. In the disastrous heat wave of 1980, more than 1,250 people died nationwide. In a normal year, about 175 Americans succumb to the bodily stresses of summer heat.

Air temperature is not the only factor to consider when assessing the likely effects of a heat wave. High humidity, which often accompanies heat in Missouri, can increase the harmful effects. Relative humidity must also be considered, along with exposure, wind, and activity. The Heat Index devised by the National Weather Service (NWS) combines air temperature and relative humidity. Also known as the apparent temperature, the Heat Index is a measure of how hot it actually feels. For example, if the air temperature is 102 degrees, and the relative humidity is 55%, then it feels like 130 degrees; 28 degrees hotter than the actual ambient temperature. To find the Heat Index from Figure 2.44, find the air temperature along the top of the table and the relative humidity along the left side of the chart. Where the two intersect is the Heat Index for any given time of day.

Temperature (°F)

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

Figure 2.44

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

[17] http://www.nws.noaa.gov/om/heat/index.shtml

Previous Events

The National Climatic Data Center reports eleven regional heat events which have included Jasper and Newton counties between 1999 and 2014. These heat waves resulted in the following regional impacts:

- 4 deaths;
- Property damage valued at $324,000.

No deaths, injuries, or property damage have taken place in either Jasper County or Newton County as a result of heat wave. This, however, does not remove the possibility of similar effects. Heat events affecting the two-county region from 1999 to 2013 are noted in Table 2.21.

Table 2.21 Jasper County and Newton County Heat Events, 1994-2012							
Location or County	**Date**	**Type**	**Magnitude**	**Deaths**	**Injuries**	**Crop Damage**	**Property Damage**
Regional	7/23/1999	Excessive Heat	N/A	3	0	0	0
Regional	08/01/1999	Excessive Heat	N/A	0	0	0	0
Regional	08/27/2000	Excessive Heat	N/A	0	0	0	0
Regional	09/01/2000	Excessive Heat	N/A	0	0	0	0
Regional	07/17/2001	Excessive Heat	N/A	0	0	0	0
Regional	08/01/2001	Excessive Heat	N/A	1	0	0	0
Regional	08/01/2011	Excessive Heat	N/A	0	0	0	0
Regional	08/03/2011	Excessive Heat	N/A	0	0	0	$324K
Regional	06/01/2012	Excessive Heat	N/A	0	0	0	0
Regional	07/01/2012	Excessive Heat	N/A	0	0	0	0
Regional	08/01/2012	Excessive Heat	N/A	0	0	0	0

Probability of Occurrence

In Jasper and Newton counties, days with temperatures of 90 degrees and above generally occur during the summer months of June, July and August. Based on NWS historical records, an extended heat wave (7 or more consecutive days with temperatures near 100 degrees) may occur only once or twice per decade. A review of climatic data reveals the county's risk of experiencing heat waves, shown below according to Heat Index severity levels.

Index:	**Probable Severity:**
Caution	highly likely
Extreme Caution	likely
Danger	possible
Extreme Danger	unlikely

A review of the data for 1999-2013 shows the two-county region could experience a brief heat wave every year. However, on average, only three instances could qualify as extended heat waves—dependent upon the relative humidity during those times. During this period of time, three events occurred in 15 years. Therefore, the probability for a meteorologically defined heat wave event in any given year for Jasper and Newton counties is 20%. (3 events / 15 years *100 = 20%) All three heat events caused damage to the included jurisdictions between 1999 and 2013. A damage-causing flood event is possible in any given year (3 damage-causing events / 15 years * 100 = 20%).

Extent / Severity

The levels of severity, by Heat Index apparent temperature, are:

> EXTREME DANGER:
> Heat stroke or sunstroke highly likely at 130ºF or higher.
>
> DANGER:
> Sunstroke, muscle cramps, and/or heat exhaustion likely at 105ºF to 129ºF.
>
> EXTREME CAUTION:
> Sunstroke, muscle cramps, and/or heat exhaustion possible at 90ºF to 104ºF.
>
> CAUTION:
> Fatigue possible at less than 90ºF.

The NWS uses these levels in weather warning messages to alert the public to the dangers of exposure to extended periods of heat, especially when high humidity acts along with the high temperatures to reduce the body's ability to cool itself.

Although most heat-related deaths occur in cities, residents of rural areas are at risk due to factors that can include age, outdoor activities, or lack of air conditioning. While heat- related illness and death can occur due to exposure to intense heat in just one afternoon, heat stress on the body has a cumulative effect. The persistence of a heat wave increases the danger. Excessive heat can lead to illnesses and other stresses on people with prolonged exposure to these conditions.

In addition to the human toll, the Midwestern Climate Center notes other possible impacts such as electrical infrastructure damage and failure, highway damage, crop damage, water shortages, livestock deaths, fish kills, and lost productivity among outdoor-oriented businesses.

Jasper and Newton counties are most likely to see a direct affect from meteorologically-defined heat waves in risks to its population and agricultural livestock. Though possible, damage to buildings and infrastructure is unlikely based upon historical data. The committee assumes that any damages associated with this type of hazard event will be light.

3 heat events from 1999 - 2013 were responsible for $324,000 worth of property damage and four death, for an average damage cost per event of $108,000 in property damage and 1.33 lives.

Vulnerability

All jurisdictions (municipalities, educational institutions, and unincorporated areas) within the county are susceptible to damage stemming from a heat wave as these types of events tend to be regional in nature. In the event of a heat wave, the HMP planning committee determined that 25% of any given jurisdiction's population may be at risk for injury. Both Jasper County and Newton County utilize mitigation strategies which include the opening of cooling centers in case of a severe heat event, but up to 10% of all jurisdictions' populations may still be susceptible to the effects of heat wave. As with extreme cold temperatures, special consideration must be given to the potential impact upon the young, disabled, and elderly populations. Since the adoption of the 2010 plan, significant population growth has occurred. While this growth does not directly affect the potential impact of a heat wave, it presents a potential need for additional county services like cooling centers. Both counties utilize a registry process which allows the elderly and disabled or their families to place these individuals on a list for emergency responders which includes information related to medications, oxygen use, and other data. This allows emergency responders and law enforcement to have sufficient knowledge of individual needs and their location to provide aid during extreme heat or cold events.

Earthquakes

The Earth's crust is made up of gigantic sections, commonly referred to as tectonic plates. These plates form what is known as lithosphere and vary in thickness from 6.5 miles (beneath oceans) to 40 miles (beneath mountain ranges) with an average thickness of 20 miles. These plates "float" over a partly melted layer of crust called the athenosphere. The plates are in motion and where one plate joins another, they form boundaries. Stress is built up and stored at the boundary of these tectonic plates, and the sudden release of stress is often felt as an earthquake. The duration can be from a few seconds up to five minutes, while a period of tremors and shocks can last up to several months. The larger shocks can cause ground failure, landslides, uplifts, liquefaction (disintegration of alluvial soils), and sand blows.[18]

The Richter scale is one of the most commonly mentioned intensity scales. Developed in 1935 by Dr. Charles F. Richter, this scale is used to compare the size of earthquakes by measuring seismic waves. "The Richter Scale is not used to express damage. An earthquake in a densely populated area which results in many deaths and considerable damage may have the same magnitude as a shock in a remote area that does nothing more than frighten the wildlife. Large-magnitude earthquakes that occur beneath the oceans may not even be felt by humans."[19]

Another scale is needed to describe the potential of a fault event to cause damage. The Mercalli Intensity Scale gets far less attention, but is a better representative of the impact an event can have upon an area (Table 2.22). Damages from earthquakes occur from one of several causes. Ground shaking is the most common phenomenon. Different kinds of seismic waves propagate outward in all directions from the focus, with the frequency of any given wave ranging from 0.1 to 30 Hertz. Buildings vibrate because of ground shaking, and damage takes place if the buildings cannot withstand these vibrations. Depending on the type of waves, the motion may be horizontal, vertical, or a mixture of the two. Because the different types of waves have different frequencies of vibration, they are weakened differently as they pass through the ground. High frequency waves arrive before the others, which leads observers to notice different ground motions at different times. Low-frequency waves tend to travel farther, arrive later, and are more likely to cause tall buildings to vibrate. Buildings are more susceptible to damage from horizontal motion than from vertical motion, so more damage may come from one type of wave than from another. Also, different frequencies affect buildings differently.

Surface faulting is the second cause of earthquake damage. This phenomenon is described as the offset or tearing of the earth's surface by a differential movement across a fault. Structures built across the fault tend to be damaged if the fault is active. Surface faulting may be an issue in Missouri as faults in the southeast region are considered to be active.

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[18] http://sema.dps.mo.gov/docs/programs/Logistics,%20Resources,%20Mitigation%20&%20Floodplain/mitigation/MO%20State%20HMP.pdf

[19] http://earthquake.usgs.gov/learn/topics/richter.php

Table 2.22 Abbreviated description of the 12 levels of Modified Mercalli intensity.[20]

Intensity	Description
I	Not felt except by a very few under especially favorable conditions.
II	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do notrecognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of atruck. Duration estimated.
IV	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Felt by nearly everyone; many awakened. some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rail bent.
XI	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII	Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Previous Events

Jasper and Newton counties are located near the middle of the North America, far away from mountains, volcanoes, and historic earthquake zones, resulting in many people incorrectly assuming that its communities are not subject to the risk of an earthquake. While very infrequent and usually only barely detectable, earthquakes can, do, and will occur in the two-county area.

Jasper and Newton counties are located in between the NeMaha Fault (which runs roughly from Oklahoma City, Oklahoma north to Lincoln, Nebraska) and the New Madrid Fault (which runs through the southeast corner of Missouri as well as portions of Arkansas, Illinois, and Indiana). In 1993, the NeMaha fault produced a discernable earthquake, rating a 2.9 on the Richter Scale of Earthquake Intensity. Additional quakes took place February 11, 1995 (3.1 rating); July 16, 2004 (3.5 rating); March 23, 2003 (3.1 rating).

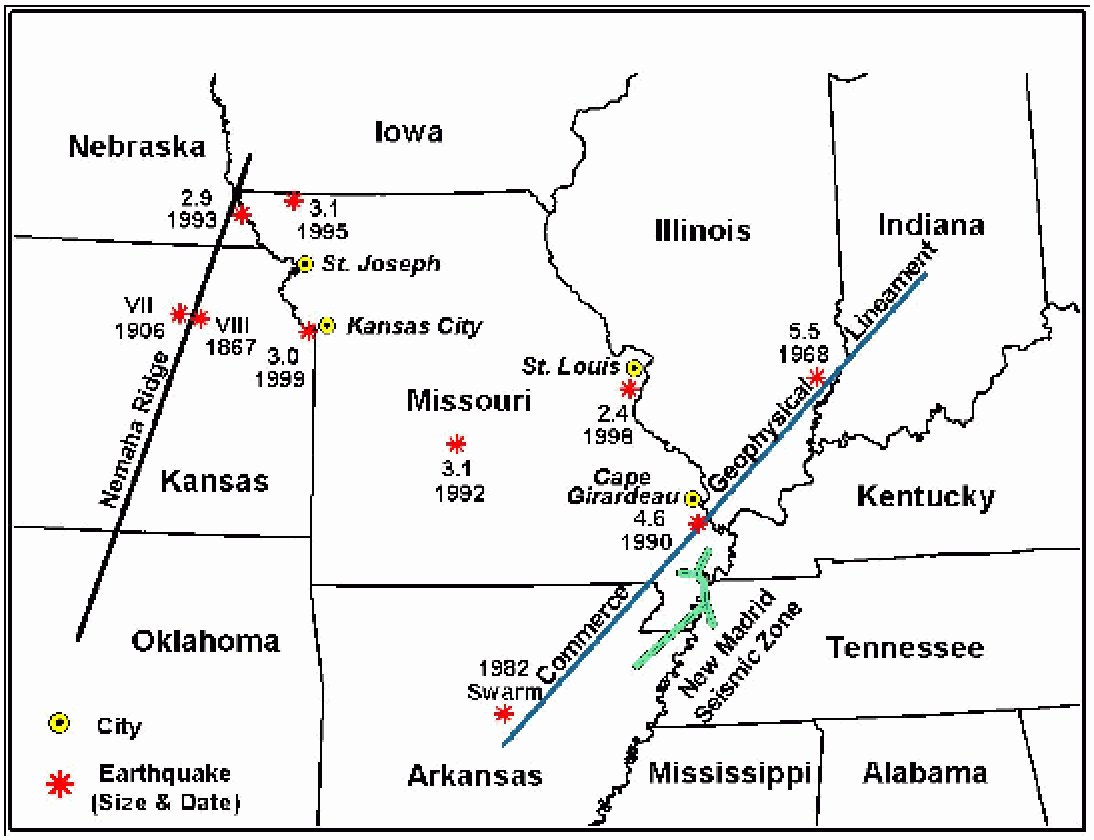
[20] http://pubs.usgs.gov/gip/earthq4/severitygip.html

More recently, an earthquake rating 3.6 was recorded on December 17, 2009. Although relatively quiet most of the time, the NeMaha fault nonetheless has the potential to produce an earthquake which could negatively impact the two-county region.[21]

In addition, the region is subject to effects of the New Madrid Fault located in extreme southeast Missouri, which has, according to many experts, the potential to produce the largest earthquakes in North America. Undoubtedly, this fault has the potential to affect the two-county region and the infrastructure that serves it (gas lines, electricity, highways, etc.). In addition, there have been several small, virtually undetectable earth movements in the region in recent history, which may or may not be attributed to the aforementioned fault lines or other, very small faults located nearby.

Scientists from the U.S. Geological Survey (USGS) and the Center for Earthquake Research and Information at the University of Memphis (CERI) recently estimated the probability of a magnitude 6.0 or greater earthquake from the New Madrid Fault is 25-40% through the year 2053. These percentages, when considered on a year-by-year basis, reflect a 0.5% - 0.8% chance in any given year. Based on available data, the probability of an earthquake event is rated as unlikely and the severity is rated as low.

Figure 2.45

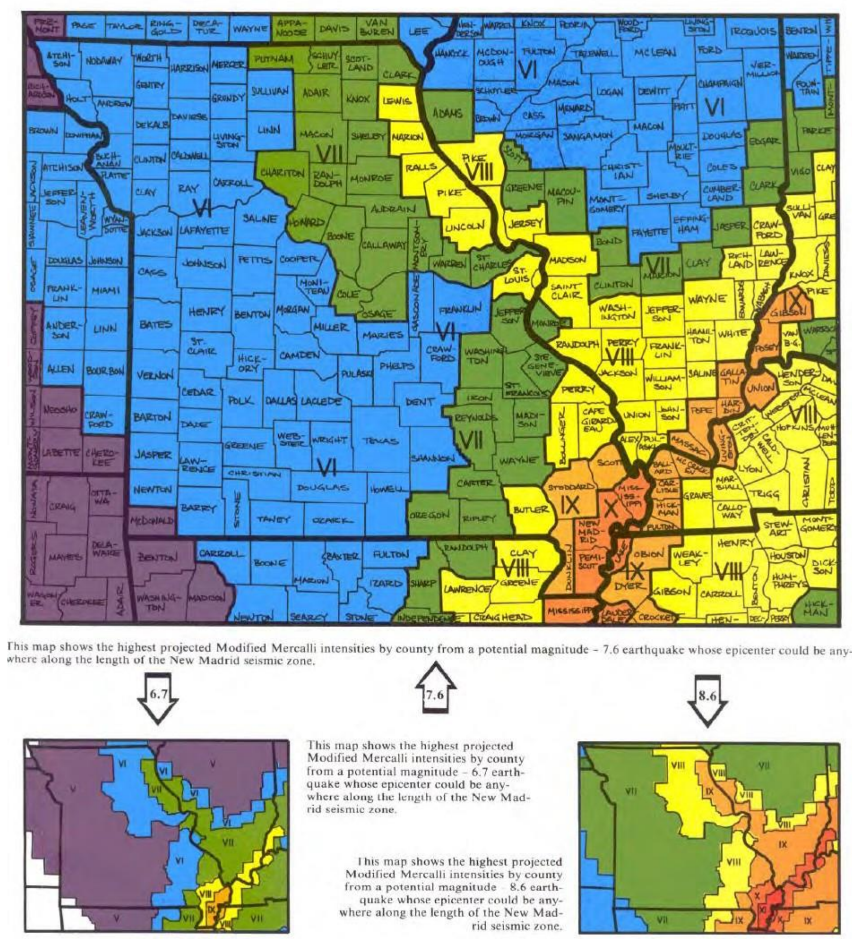


[21] http://earthquake.usgs.gov/earthquakes/eqarchives/epic/

New Madrid earthquake damage covers more than 20 times the area of the typical California earthquake because of the Midwest's underlying geology. Ground shaking affects structures close to the earthquake epicenter and also those at greater distances. Certain types of buildings at a significant distance from the earthquake epicenter may be damaged. Unreinforced masonry structures are specifically susceptible to any large earthquakes. Owners of these structures should be aware of potential damage from seismic activity.

According to SEMA, both Jasper and Newton counties are at risk for a Level V impact on the Modified Mercalli Intensity Scale for a 6.7 magnitude earthquake along the New Madrid Fault; Level VI for a 7.6 magnitude earthquake; and Level VII in the event of an 8.6 magnitude earthquake (Figure 2.46).[22]

Figure 2.46



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

Indirect hazards may also occur at great distances from large earthquakes. Liquefaction, landslides, and life-line disruptions will most affect areas closest to the epicenter, but may occur at significant distances. Subsurface conditions of the Mississippi and Missouri River valleys tend to amplify earthquake ground shaking. As a result, much of Missouri is at risk from earthquakes.

The impact on the general public, small-to medium-size businesses, life-line services, and the infrastructure may be radically lessened if precautions are undertaken at multiple levels. Increased education, concern, and subsequent action can reduce the potential effects of earthquakes, and this can be done in conjunction with preparations for other natural hazards. A program that recognizes the risk of flooding, landslides, and other dangers, incorporating earthquake issues will be the most beneficial to citizens of the two-county region.

Individuals and all levels of government have roles in reducing earthquake hazards. Individuals can reduce their own vulnerability by taking some simple and inexpensive actions with their own households. Local government can take action to lower the threat through the proper regulation of certain sites, assuring that vital or important structures (police, fire, and school buildings) resist hazards, and developing infrastructure in a way that decreases risk. State agencies and the legislature can provide education and assistance to minimize earthquake effects.

Probability of Occurrence

To date, zero earthquake events have impacted either Jasper or Newton County. While the NeMaha fault is still active, historical records demonstrate the limited impact of said earthquakes with no quakes to date exceeding a 5.5 on the Modified Mercalli Scale. Its cascading effects have been largely restricted to more localized regions, but even then the damage caused has been minimal. By contrast, the New Madrid fault has the potential to cause devastating effects throughout the state of Missouri and beyond. Scientists from the U.S. Geological Survey (USGS) and the Center for Earthquake Research and Information (CERI) at the University of Memphis recently estimated the probability of a magnitude 6.0 or greater earthquake from the New Madrid Fault is 25-40 percent through the year 2053, for an estimated 0.5% - 0.8% per year. Based on information from the CERI, the probability of an earthquake event is rated as unlikely and the severity is rated as low. Most likely, aftershocks are the biggest potential threat to the two-county region.

Historical data from the USGS National Earthquake Information Center reports zero measured earthquake events in the southwest Missouri area from 1973-2010. No earthquakes have been reported in the two-county region, nor have small regional earthquakes of less than a 5.0 magnitude had any impact. However, in spite of the fact that no earthquake impacts have been reported, it does not negate the possibility of such an occurrence. As such, the probability of occurrence has been set at 1% in any given year for Jasper and Newton counties.

Extent / Severity

The impact on the general public, small- to medium-size businesses, life-line services, and the infrastructure may be radically lessened if precautions are undertaken at multiple levels. Increased education, concern, and subsequent action can reduce the potential effects of earthquakes, and this can be done in conjunction with preparations for other natural hazards. A program that recognizes the risk of flooding, landslides and other dangers and which incorporates earthquake issues will be the most beneficial to Jasper County and Newton County citizens. Based on USGS projections, Jasper and Newton counties are most at risk for Modified Mercalli Level VI as likely adverse impacts which include slight damage. HAZUS-MH direct economic losses were completed for every Missouri county in 2013. Table 2.23 summarizes the findings for the two-county region.

Table 2.23 HAZUS Direct Economic Losses for Buildings - Earthquake

	Capital Stock Losses				
County	Cost Structural Damage	Cost Non-structural damage	Cost Contents Damage	Inventory Loss	Loss Ratio
Jasper	$46,000	$120,000	$36,000	$1,000	0.00
Newton	$25,000	$63,000	$19,000	$1,000	0.00
	Income Losses				
	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	
Jasper	$33,000	$11,000	$16,000	$12,000	
Newton	$19,000	$6,000	$10,000	$6,000	
	Total Losses				
Jasper	$ 275,000				
Newton	$ 148,000				

Vulnerability

As evidenced by the HAZUS data, any associated damages with an earthquake event would be minimal in the two-county region. All jurisdictions (municipalities, educational institutions, and unincorporated areas) within the county are potentially susceptible to damage stemming from an earthquake, though the potential vulnerability is limited in comparison to other regions of the state. In the event of an earthquake, less than 10% of any given jurisdiction may be at risk for damage based upon data and predicted scenarios. Since the passage of the 2010 plan, significant population growth and building construction have taken place. While building codes in the two counties and their associated jurisdictions have been altered to include tornado resistance, very few earthquake protection measures are included.

Dam Failure

A dam is defined by the National Dam Safety Act as an artificial barrier that impounds or diverts water and (1) is at least 6 feet high, and stores at least 50 acre-feet of water, or (2) is at least 25 feet high and stores at least 15 acre-feet. Of the 80,000-plus dams in the United States, less than 5% are under the control of the federal government.

In the state of Missouri, 4,100 dams come under the regulation of the state. The Missouri Department of Natural Resources (MoDNR) – Water Resources Division is the regulating authority for these dams. MoDNR regulates the design, construction, and maintenance of these non-federal, non-agricultural dams that are at least 35 feet high. Dam owners have primary responsibility for the safe design, operation, and maintenance of their dams. They are responsible for providing early warning of problems at the dam, for developing an effective emergency action plan, and for coordinating that plan with local officials.

Dams can fail for a variety of reasons. The following are the most common causes of dam failure:

- ***Overtopping*** – inadequate spillway design, debris blockage of spillways, or settlement of the dam crest;
- ***Piping Failure*** - piping failures are usually caused by embankment leakage, foundation leakage, and/or the deterioration of structures on the dam.
- ***Erosion Failure*** - erosion of dams is generally caused by the inadequate capacity of a spillway, resulting in overtopping of the dam or flow erosion and/or inadequate slope protection.
- ***Structural Failure*** - structural failures of dams may be caused by an earthquake, slope instability, or poor construction.

Dam failures are typically related to, and can cascade from, other natural events. Flash floods, earthquakes, and landslides can cause a dam failure, or accelerate the failure of an already weakened structure. Dam failures can result in the loss of crops, livestock, structures, homes, life, and property. Many communities use dams for the storage of drinking water, recreation, and natural habitat. The loss of a dam could have a significant negative impact upon a community.

Previous Events

Thousands of people have been injured, many killed, and billions of dollars in property damaged by dam failures in the United States. The problem of unsafe dams in Missouri was underscored by dam failures at Lawrenceton in 1968, Washington County in 1975, Fredericktown in 1977, Taum Sauk in 2005, and a near failure in Franklin County in 1978. There have been 26 recorded dam failures in Missouri over the last 100 years. One drowning is recorded among all of these disasters. There are no known instances of dam failure in the two-county region which caused injury, loss of life, or imposed a considerable cost. See Table 2.24 for a list of regulated dams, Table 2.25 for a list of non-regulated dams, and Figures 2.47 and 2.48 for the locations of dams in Jasper and Newton counties. All data stems from the Missouri Department of Natural Resources Dam Safety Program and NID.

Missouri DNR has defined three levels of hazard classes as accepted by the Interagency Committee on Dam Safety. The definitions are:

- **Class 1 –** Downstream of the dam contains at least 10 or more permanent dwellings or any public building.
- **Class 2** – Downstream of the dam contains 1 to 9 public dwellings or 1 or more campgrounds with permanent water, sewer and electrical services or 1 or more industrial buildings.
- **Class 3** – No lives, campgrounds, public dwellings, public buildings or industrial buildings are threatened from a dam failure.

The NID has defined three levels of hazard classes. The definitions are:

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

The NID consists of dams meeting at least one of the following criteria:

1) High hazard classification – loss of one human life is likely if the dam fails
2) Significant hazard classification – possible loss of human life and likely significant property or environmental destruction
3) Equal to or exceeds 25 feet in height and 15 acre-feet in storage
4) Equal to or exceeds 50 acre-feet storage and exceeds 6 feet in height.

Presently there is no direct correlation between the state's hazard classification and the NID classifications. However, most dams considered to be classes 1 and 2 are considered NID high hazard dams.

Missouri DNR and the National Inventory of Dams (NID) consider seven Newton County dams to be Class 1, or High Hazard dams, three being unregulated, and two Jasper County dams to be Class 1, both unregulated. In the event of a breach, very few households would be impacted, though farm ground may flood.

According to Missouri DNR's Dam Safety Division, Jasper County currently has 14 dams according listed in the National Inventory of Dams, none of which are presently regulated by the state and five of which are considered high hazard. Newton County now has 23 dams according to the same data, seven of which are presently regulated by the state and 14 of which are considered high hazard. The mean dam height is 30.7 feet in Newton County and 17 feet in Jasper County. All unregulated dams in the two-county region are less than 35 feet high. Because there are no base requirements for unregulated dams, people living downstream of these smaller unregulated dams are virtually at the mercy of the dam owner's construction and maintenance practices.

Table 2.24 **Regulated Dams in Newton County, Missouri**

Dam Name	ID Number	Year Completed	Height (ft)	Dam Rating*	Hazard Class
Limberlost Dam	MO20219	1957	42	H	2
Lost Creek B-2	MO20730	1980	35	L	3
Lost Creek D-1	MO20731	1980	37	H	2
Lost Creek E-1	MO20511	1977	46	H	1
Lost Creek F-3	MO20514	1977	39	H	1
Lost Creek Watershed Site A-1	MO20781	1992	49	H	1
Lost Creek Watershed Site C-2	MO20782	1992	55	H	1

* Dam Ratings are labeled as H(High), Significant (S), and L(Low).

Table 2.25 **Non-regulated Dams in Jasper and Newton Counties, Missouri**

Dam Name	County	ID Number	Year Completed	Height In Feet	Dam Rating*	Hazard Class
Asbury Fams Dam	Jasper	MO20088	1965	12	L	3
Barker Lake Dam	Jasper	MO20441	1800	15	H	2
Bemear	Newton	MO50194	No data	No data	L	N/A
Blackberry Hay Farm Dam	Jasper	MO20196	1965	20	H	1
Doran Lake Dam	Jasper	MO20272	1954	15	L	3
Elliot Lake Dam	Jasper	MO20202	1968	22	H	2
Grand Falls Dam	Newton	MO20006	1920	15	L	3
Hargis Lake Dam	Newton	MO11820	1977	20	L	3
Herr Lake Dam	Jasper	MO20278	1967	15	H	2
Hickory Creek Structure H-1A	Newton	MO51152	2003	21	H	N/A
Hickory Creek Structure H-2A	Newton	MO51159	2003	25	H	2
Hickory Creek Structure H-9A	Newton	MO51148	2000	34	H	2
Hickory Creek Structure H-10D	Newton	MO51150	2002	26	H	N/A
Hickory Creek Structure H-11	Newton	MO51149	2000	34	H	2
Kellogg Lake Dam	Jasper	MO20009	1953	10	L	3
Lake Mintahama Dam	Newton	MO20280	1971	25	H	1
Maple Lane Farms Lake Dam	Jasper	MO20268	1972	20	L	3
MONoName40	Newton	MO20108	1950	15	L	3
MONoName 654	Jasper	MO20277	1958	5	L	3
Newton County Structure F-1 Dam	Newton	MO20512	1977	30	H	1
Newton County Structure F-2 Dam	Newton	MO20513	1977	30	H	1
Newton Lake Dam	Newton	MO31747	No data	No data	L	N/A
Oscie Ora Acres Lake Dam	Jasper	MO20276	1968	15	L	3
Pepper Lake Dam	Newton	MO20223	1965	20	L	3
Rainey Lake Dam	Jasper	MO20267	1952	14	H	1
Scroggs Lake Dam	Jasper	MO20087	1955	30	L	3
Shelton Lake Dam	Jasper	MO20017	1956	25	L	3
Smith, Raymond Dam	Jasper	MO20269	1965	20	L	3
Stuffle Dam	Newton	MO20107	1969	18	L	3

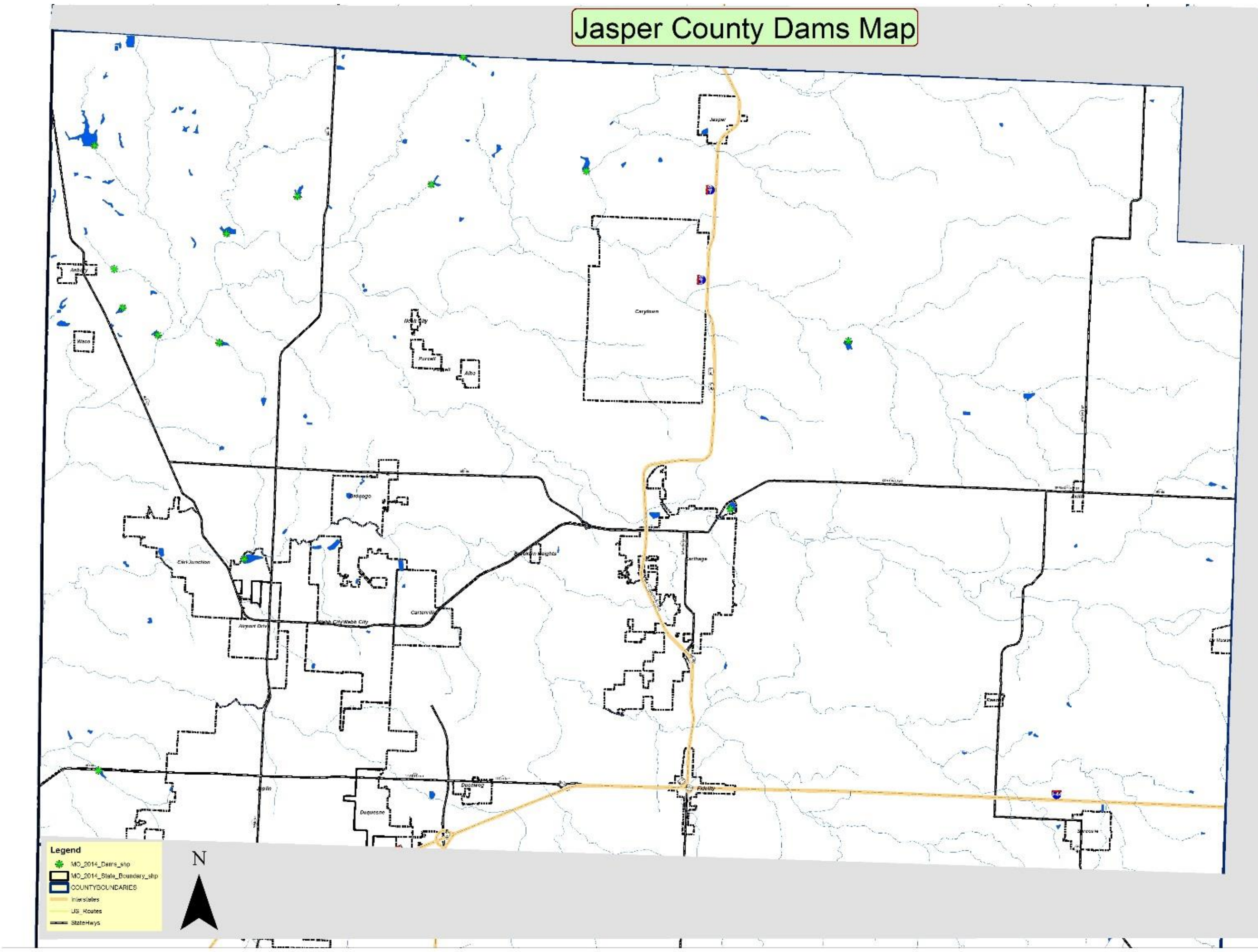

Jasper County Dams Map
Legend
MO_2014_Dams_shp
MO_2014_State_Boundary_shp
COUNTYBOUNDARIES
Interstates
US_Routes
StateHwys
N

Figure 2.47

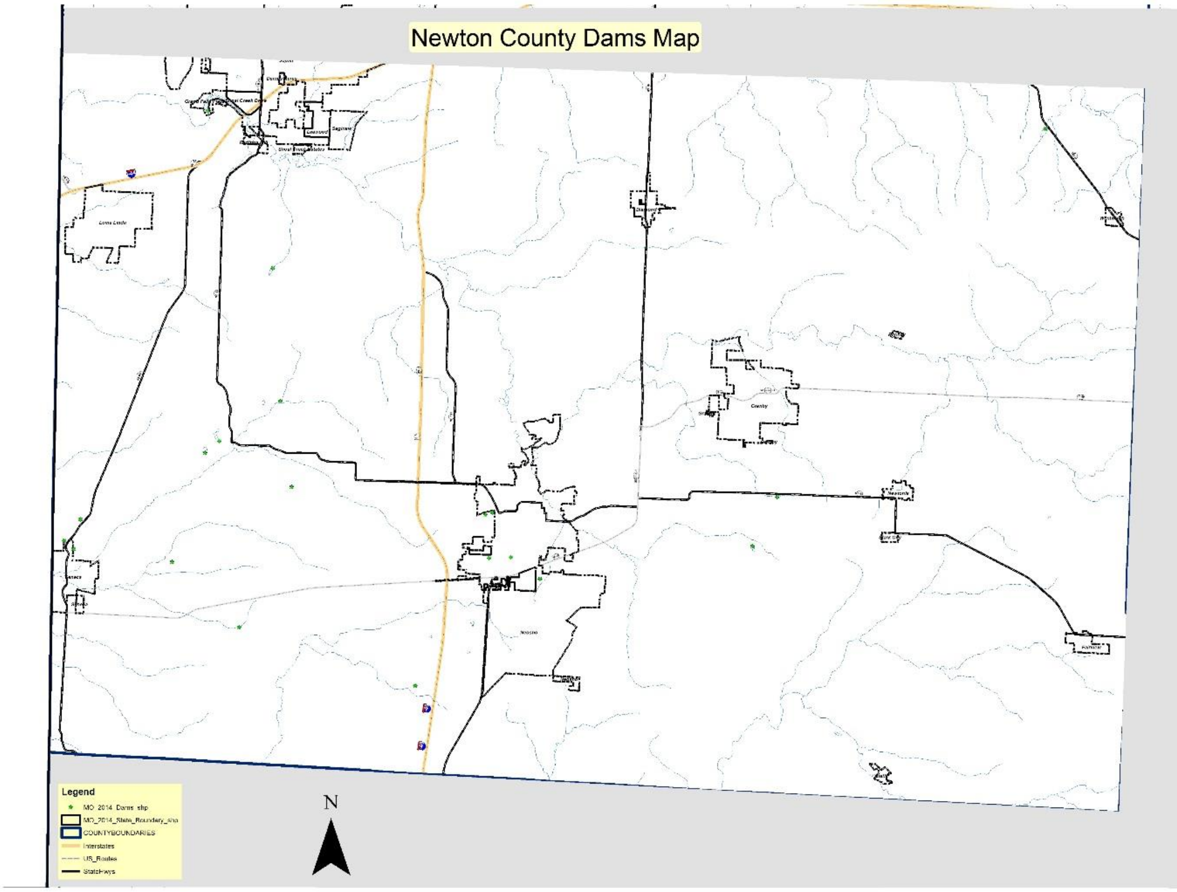

Newton County Dams Map
Legend
MO_2014_Dams_shp
MO_2014_State_Boundary_shp
COUNTYBOUNDARIES
Interstates
US_Routes
StateHwys
N

Figure 2.48

Probability of Occurrence

Of 34 dams in the two-county region, ten are rated by Missouri DNR and the NID as "high" risk. Three of these dams are regulated by the State. High-hazard dams exhibit one or more characteristics: more than 30 years old, high ratio of maximum storage to dam height, and/or high population density downstream. Maps of all existing dams are provided above and in Appendix C. The cities of Carl Junction and Carthage in Jasper County have unregulated dams located near their boundaries. In Newton County, the cities of Grand Falls Plaza, Seneca, and Neosho each have dams within or near their borders as well. The Inundation data, however, is not currently available for any of these dams or the surrounding areas as it still being developed.

The risk of dam failure is shown below according to DNR's classifications.

Hazard Level	**Probable Risk**
Low	unlikely
Significant	unlikely
High	possible

26 dam failures have occurred within the state of Missouri over the past 100 years. However, the two-county region has experienced no such event. Therefore, the probability of a dam failure within Jasper and Newton counties' boundaries remains at 0%. (0 events/100 years= 0% probability). However, for the purposes of this assessment, dam failure and its associated impacts cannot be eliminated from the realm of possibility. In order to allow for a risk assessment, the probability of this event has been included as less than 10%.

Extent / Severity

Based on historical data, the likely adverse impact of disaster occurring due to dam fault in Jasper or Newton County is shown below. The 2013 Missouri State Hazard Mitigation Plan estimates that 487 people and 60 buildings in Newton County are presently at risk from dam failure with regulated dams with an estimated loss of $89,508 per structure, though the type of structures are not identified, and a total potential building loss of $4,544.561. For the purposes of this plan, it has been estimated that 2/3 of the structures affected will be residential, and 1/3 will be agricultural. Jasper County has an estimate of 0 people and 0 buildings due to its lack of unregulated dams, though this does not take into account the failure of unregulated dams.[23] As such, the extent of this type of hazard event would include only light damages of less than 1%.

Vulnerability

The assessment of dam failure impact upon the two-county region and their jurisdictions

[23] *2013 Missouri State Hazard Mitigation Plan*, 3.389-3.390

is significantly limited due to a lack of data concerning inundation. As stated above, the 2013 Missouri State Hazard Mitigation Plan demonstrates an extremely small portion of both the population and area structures are at risk. The cities of Carl Junction, Carthage, Grand Falls Plaza, Neosho, Seneca and Webb City have the greatest potential threat from dam failure. 37 residences exist in the immediate vicinity of the Elliot Lake Dam near Webb City. The majority of dams in the two-county region are located in rural portions of the county. The locations of dams when compared to residential areas and cities do not lend themselves to creation of a significant hazard for most local jurisdictions, but all current information is conjecture until inundation studies are completed. More jurisdiction-specific information is not presently available, but a mitigation strategy has been included to pursue development of such data.

Wildfire

Each year in the United States, about 3,700 wildfires burn more than 55,000 acres of forest and grassland in our state. Unlike Western states that have a summer fire season, Missouri's wildfires season is in the spring and fall. Dead vegetation, combined with the low humidity and high winds typical of these seasons, makes wildfire a greater risk at these times. The majority of wildfires in the world are thought to be started by people. However, the greatest cause of wild land fires is lightning. Eight million lightning strikes occur worldwide each day. One percent of these strikes result in wild land fires. In fact, dry lightning is responsible for 80 percent of all fires in wild land areas. Dry lightning occurs during thunderstorms when the humidity levels are so low that rain evaporates before it reaches the ground. Even though the rain does not reach the ground, the lightning does.[24]

Grass, brush, and forest fires are natural events that have occurred periodically throughout history. There are three major classes of wild land fires; ground fires, surface fires, and crown fires. Ground fires spread across the grass and low-lying vegetation. Surface fires burn the trunks of trees as well as the grass and low-lying vegetation. During crown fires, the flames move across the ground, up the trees, and across the tops of the trees. Crown fires are the most dangerous and destructive class of wild land fires.

Table 2.26 **Fire Danger Categories**

Low Fire Danger	Open burning is usually safe with proper containers and precautions under low fire danger conditions. However, residents should always check on local ordinances that prohibit open burning under any conditions. Escaped fires are easy to extinguish. No fire crew staffing is planned for low fire danger conditions.	**Burning index <20.**
Moderate Fire Danger	Open burning is usually safe with the proper precautions under moderate fire danger conditions. Burning should be done in the early morning and late evening to avoid windier conditions at midday. Escaped fires can be contained with proper fire-fighting equipment. Partial fire crew staffing is planned for moderate fire danger.	**Burning index = 21-30.**
High Fire Danger	Any open burning is discouraged during high fire danger. Windy conditions, low humidity and dry fuels contribute to high fire danger. Fires escape control easily and containment is difficult, endangering human safety and property. Partial or full fire staffing is planned, depending on local burning conditions.	**Burning index = 31-45.**
Extreme Fire Danger	Open burning should not be attempted during extreme fire danger. Local authorities may impose burning bans. High winds and extended dry periods lead to extreme burning conditions. Open fires can quickly escape and are very difficult to control. Spot fires occur ahead of the main fire, and erratic burning conditions make fires difficult to control even for experienced fire fighters. Full fire crew staffing is planned for extreme burning conditions.	**Burning index >45.**

[24] http://sema.dps.mo.gov/docs/programs/Logistics,%20Resources,%20Mitigation%20&%20Floodplain/mitigation/MO%20State%20HMP.pdf

Fire danger is based upon the burning index (BI). The burning index takes into account the fuel moisture, relative humidity, wind speed, temperature, and recent precipitation. The burning index is the basis for fire suppression crew staffing levels. The Missouri Department of Conservation relies upon the local news media to help warn citizens of high fire danger. A set of standardized fire danger adjectives (Table 2.26) has been developed for fire warnings. These adjectives include a brief description of burning conditions, open burning suggestions for homeowners and fire crew staffing levels. Residents should always check with their local fire department or conservationist for local burning conditions.

Previous Events

No Missouri fires are listed among the significant wildfires in the U.S. since 1825. Fires covering more than 300 acres are considered large in Missouri. Missouri averages 3,500 fires a year with 45,000 acres burned, or an average fire size of 12 acres. Both Jasper and Newton County have significant portions of land in urban settlement, but also large areas of rural and agricultural land. Jasper County experienced 297 wildfires from 2004 - 2012, with an average acre impact of 33 acres per incident and a total of 2,298.75 acres. Newton County experienced 1,208 wildfires from 2004 – 2012, with an average acre impact of 134.2 acres per incident and a total of 4.511.29 acres.

Probability of Occurrence

Although there is always a risk of fire in the two-county region, there is little historical precedent for significant wildfires threatening the County on any large scale. Due to the predominantly agricultural nature of the rural portions of Jasper and Newton County, it is likely that small-scale brush fires may occur in the County, but the threat is minimal. Local fire districts reported during the meeting process that the majority of these reported wildfires were more likely controlled burns by local farmers. Controlled burns, however, can potentially result in larger fires. Therefore, the probability of a wildfire event in Jasper and Newton Counties in any given year is near 100% (373 events / 8 years = 4,663%).[25] Fires, by nature, cause damage with every occurrence.

Extent / Severity

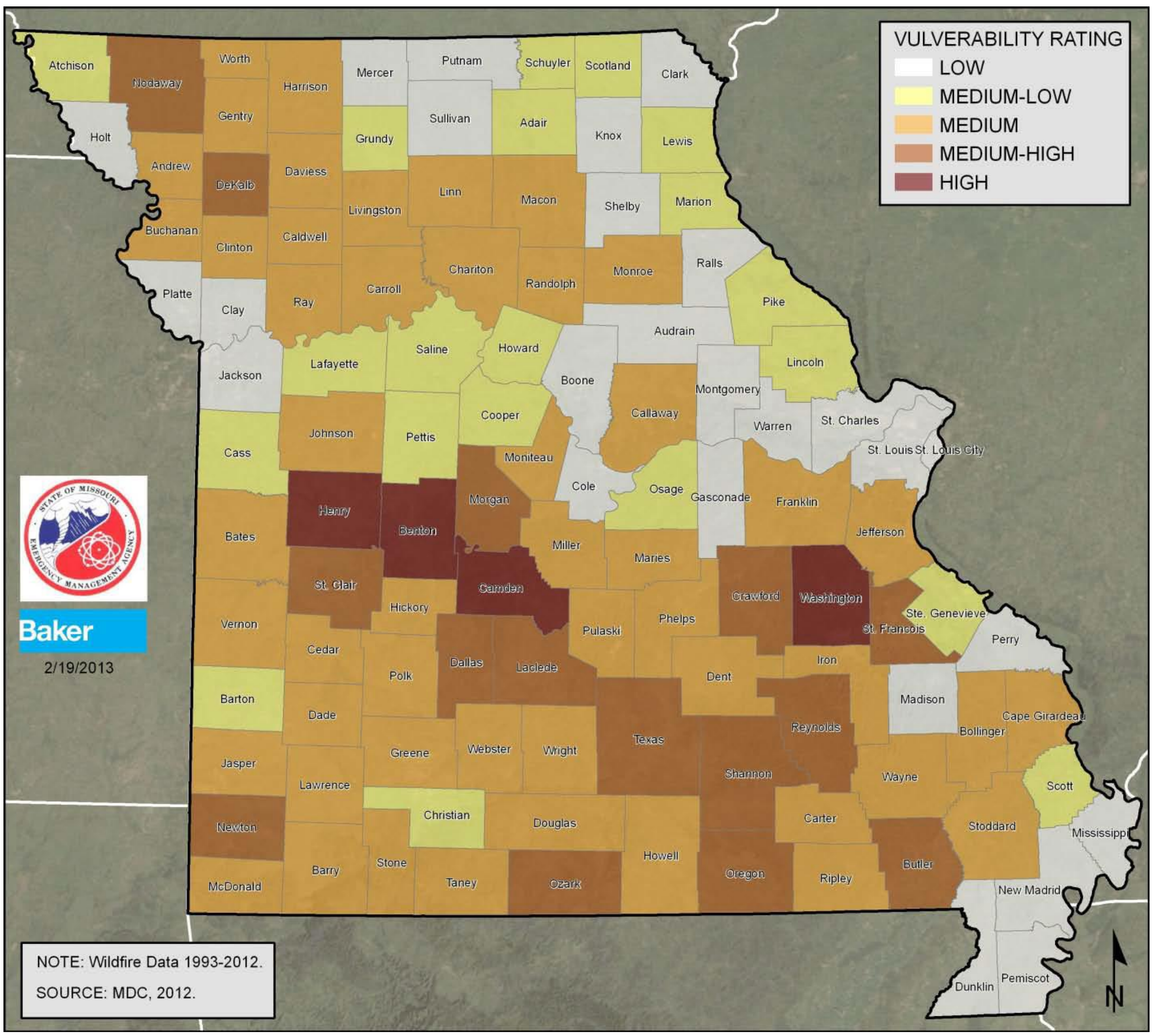
The potential extent of damage caused by wildfire is difficult to determine. Like earthquakes and dam failure, wildfires have had no measurable impact upon Jasper County or Newton County. From 2004-2012, 1,505 fires have burned a total of 6,801.04 acres, for an average of 4.5 acres affected per event. Jasper County sustained damage to 3 buildings related to wildfires during this time period, while Newton County sustained damage to 53 buildings. With an average of 33 acres per fire in Jasper County and 134.2 acres per fire in Newton County, it is unlikely that damage would exceed 1% based upon event location and the unlikeliness of an uncontrollable wildfire. However, for the purposes of this assessment,

[25] 2013 Missouri State Hazard Mitigation Plan, 3.500 – 3.501

wildfire and its associated impacts cannot be eliminated from the realm of possibility. Further study will be required to create a model for damage assessments related to wildfire.

Vulnerability

The risk of wildfire in the two-county region and its jurisdictions is minimal, particularly when compared with other areas of the state and the nation. Jasper County received a rating of Medium vulnerability, while Newton County received a rating of Medium-High in the state hazard mitigation plan. Wildfire is most likely to occur in the unincorporated areas, largely limited to agricultural land. The City of Joplin has some interface of wildfire and urban fire locations without vegetation present, but no wildfires have affected the city to date. The remaining cities and school districts are largely surrounded by agricultural land. The presence of drought may also alter the potential consequences in the region.



The data for wildfire at this time is insufficient to craft a successful loss model. For the purposes of this plan and based on the vulnerability assessment completed by the State of Missouri, it is estimated that less than 5% of any given jurisdiction may be at risk for damage before the fire is contained due to surrounding agricultural land and the potential for lost control during managed burning. Resulting damages would most likely be light, weighing in at less than 10% for any impacted land or structure.

Sinkholes

Land subsidence is sinking of the earth's surface due to the movement of earth materials below the surface. This sinking can be sudden or gradual and is generally attributed to the removal of subsurface water or the draining of organic soils. In Missouri, subsidence is primarily associated with sinkholes. In the case of sinkholes, the rock below the surface is limestone, carbonate rock, salt beds, or some other rock that can be naturally dissolved by circulating ground water. As the rock dissolves, spaces and caverns form, and ultimately the land above the space collapses. In Missouri, sinkholes usually result above openings into bedrock caves which erode and collapse. These collapses are called "cover collapses" and geologic information can be applied to predict the general regions where collapses may occur. Sinkholes range in size from several square yards to hundreds of acres. They may be quite shallow or hundreds of feet deep. In the Joplin area, the bedrock is extensively carbonate and chert overlain with alluvium, soil, and chat. Paleo-sinkholes have formed along a north-northwest line trending dissolutioned joints. These sinkholes are typically in-filled with shale, siltstone, sandstone, limestone, and coal. Lead and zinc ore was also deposited along these sinkholes and near the vertical faults as well as sheet ground deposits (Figure 2.50).

Figure 2.50

Sinkhole formation is most intense where the bedrock is most soluble and has been exposed to extended period of weathering and where surface materials are between 40 and 80 feet in thickness and are composed of relict bedrock formation and sinkhole formation. Both Jasper and Newton counties are in the Springfield Plateau which is a karst subprovince made of carbonate (Figure 2.51). Caves, sinkholes, and losing streams are common in carbonate karst topography.

According to the U.S. Geological Survey, the most damage from sinkholes tense to occur in Florida, Texas, Alabama, Missouri, Kentucky, Tennessee, and Pennsylvania. Fifty-nine percent of Missouri is underlain by thick, carbonate sinkholes which occur naturally in the state's karst regions. They are a common geologic hazard in southern Missouri, but also occur in the central and northeastern parts of the state. While most develop from natural causes, others are the result of human activities. Triggering factors include activities that alter the natural hydrologic conditions. These may include, but are not limited to, the collapse of storm sewers and subsurface mining.

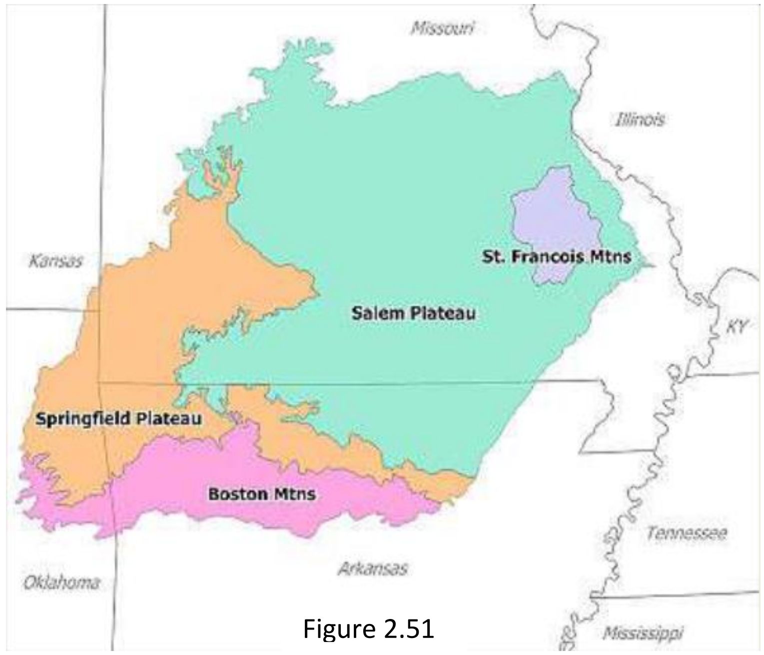


Figure 2.51

Previous Events

Sinkholes are a regular occurrence in Missouri, but usually occur with little significance. There have been occasional damages related to sinkholes. Sinkhole collapses have occurred in sewage lagoons in a number of towns in southern Missouri, but most were abandoned at the time of their collapse. Mining-related collapses have also occurred in the Joplin area where mining for lead and zinc once occurred. Figures 2.52 and 2.53 demonstrate the location of mines in Jasper and Newton counties.

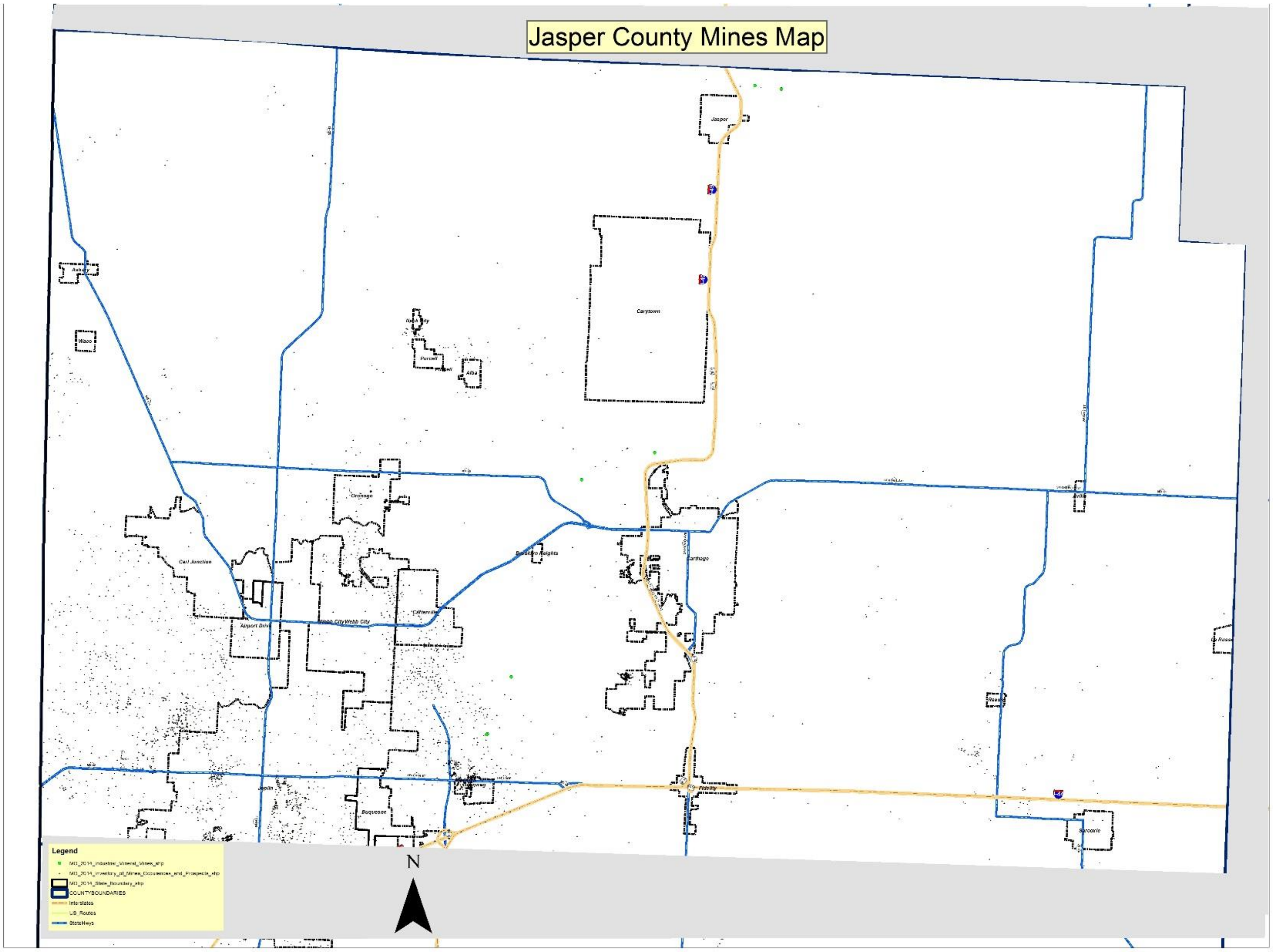

Jasper County Mines Map
Jasper
Carytown
Alba
Waco
Carl Junction
Airport Drive
Carterville
Carthage
Joplin
Duquesne
Sarcoxie
N
Legend
MO_2014_Industrial_Mineral_Mines_shp
MO_2014_Inventory_of_Mines_Occurences_and_Prospects_shp
MO_2014_State_Boundary_shp
COUNTYBOUNDARIES
Interstates
US_Routes
StateHwys

Figure 2.52

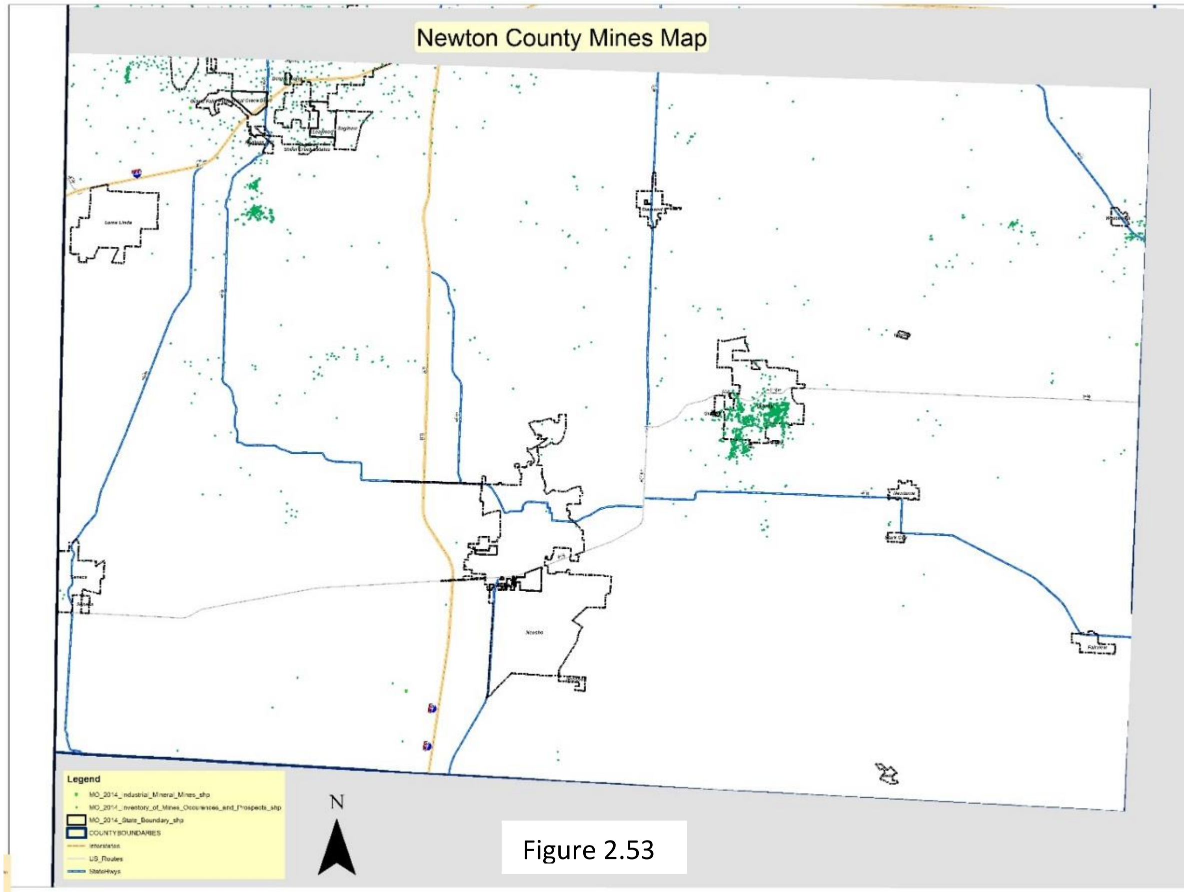


Figure 2.53

Recent events include:

- a 1998 sinkhole in Carterville which destroyed a backyard and damaged the sewer system;
- a sinkhole which drained Lake Chesterfield in St. Louis County in 2004;
- a sinkhole the size of a football field was reported in 2005 in Barry County;
- a sinkhole collapse in Nixa in 2006 which destroyed a residence and vehicle;
- an abandoned and forgotten lead/zinc mind shaft was reopened during a 2007 MoDOT project on Rangeline in Joplin which was permanently with Missouri Land Reclamation funds assistance;
- a sinkhole opened north of the Webb City High School in 2008 which threatened local transportation infrastructure.
- a large sinkhole in Joplin which destroyed a backyard pool in 2009; and
- a collapse near the Springfield-Branson Airport in 2012 which caused damage to the water main following the collapse of the surface concrete;

Previous sinkholes in Jasper and Newton counties have caused little if any damage, but a number have been reported since the 1970s. Figures 2.54 and 2.55 show the locations of reported sinkholes in the two counties.

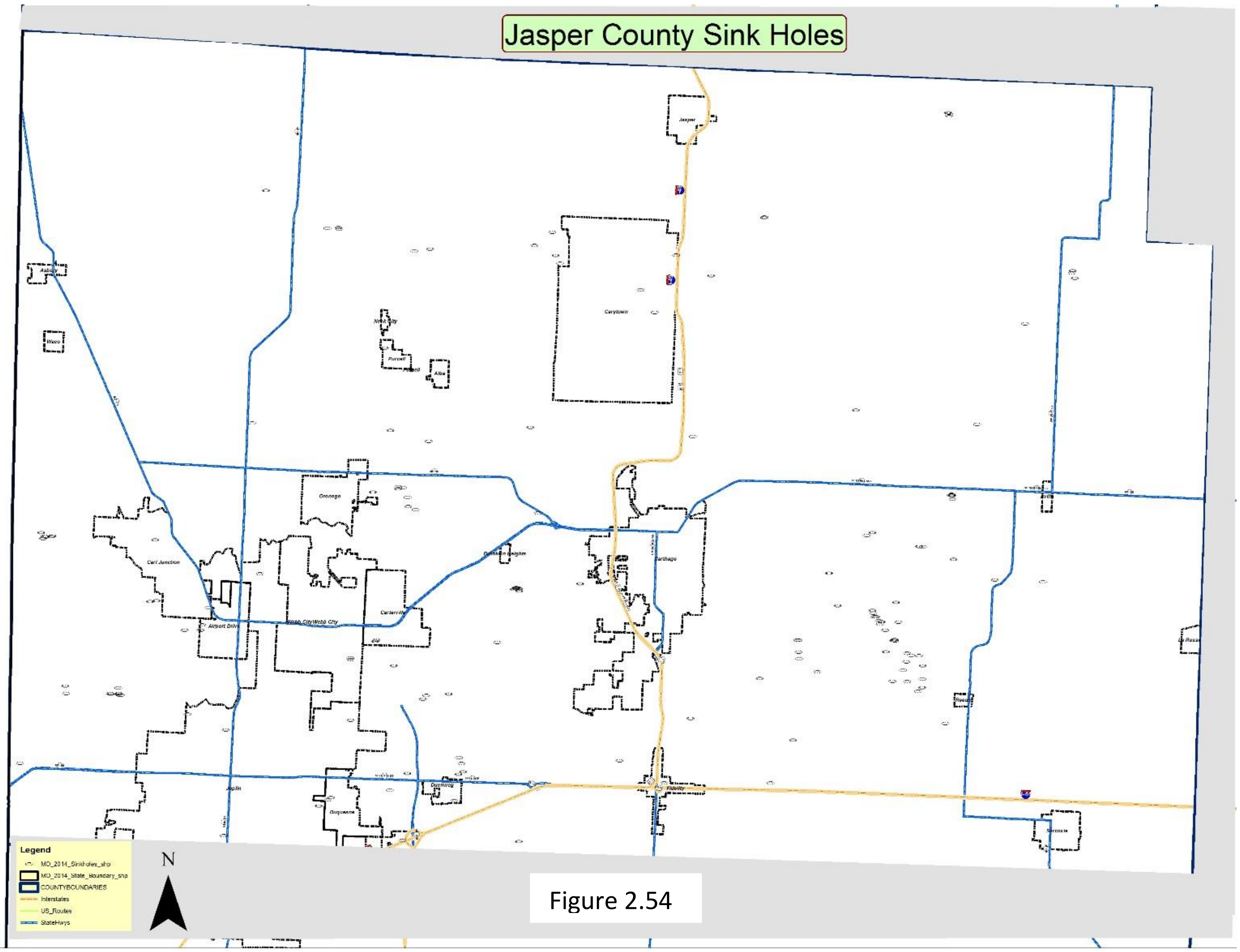

Jasper County Sink Holes
Legend
MO_2014_Sinkholes_shp
MO_2014_State_Boundary_shp
COUNTYBOUNDARIES
Interstates
US_Routes
StateHwys
N
Carthage
Joplin
Carterville
Oronogo
Carl Junction
Duenweg
Duquesne
Sarcoxie
Carytown
Jasper
Airport Drive
Alba
Purcell

Figure 2.54

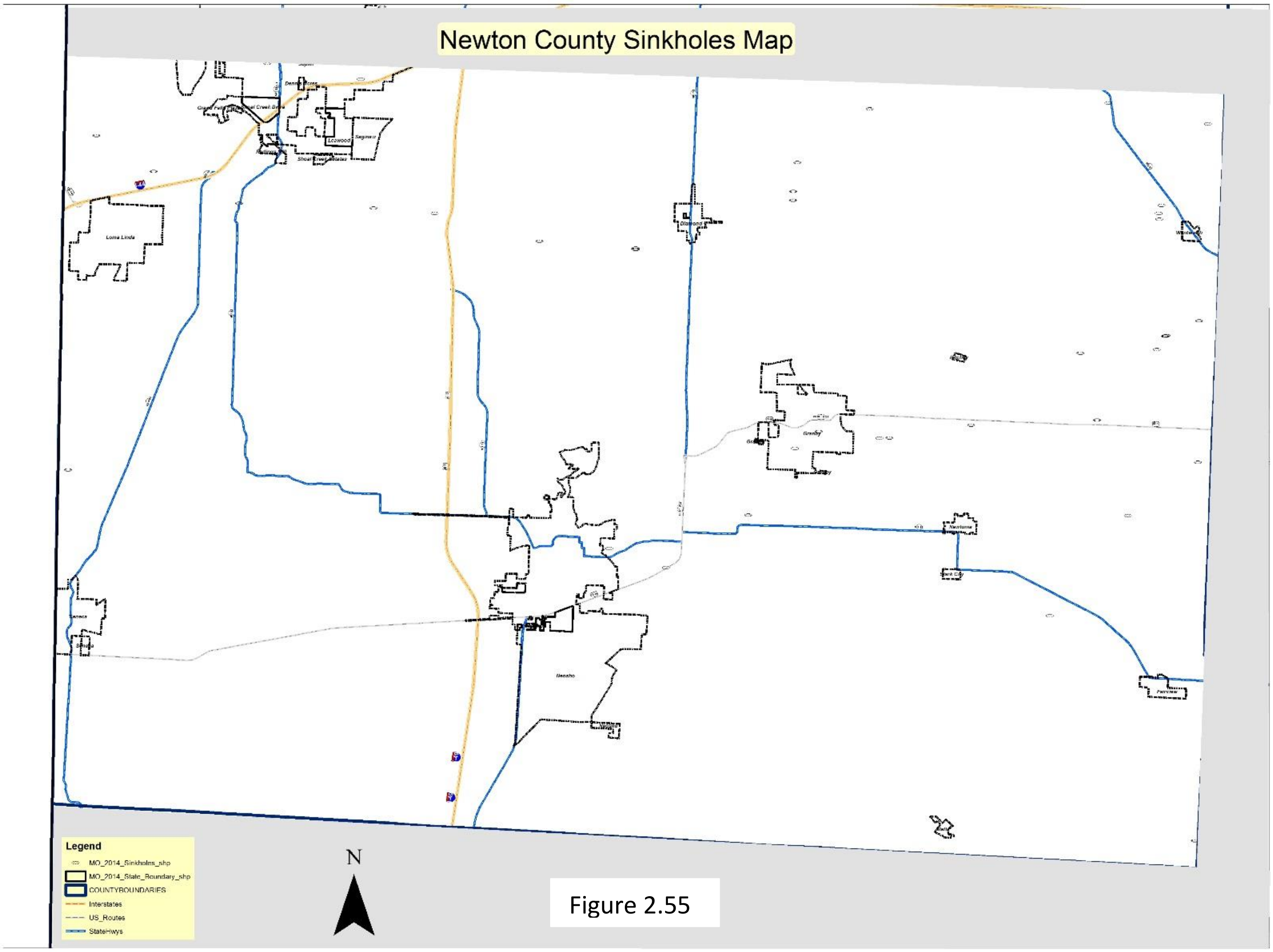


Figure 2.55

Probability of Occurrence

Because of the underlying geography and history of mining in the two-county region, there is always a risk of sinkholes in both Jasper and Newton counties. However, there is little historical precedent for significant impact on life or property. A total of 15,981 sinkholes have been identified in Missouri by the Geological Survey Program.[26] The potential threat of sinkholes is compounded during times of flooding or drought as the hydrologic patterns shift. Due to the mining history and geological makeup of the two-county region, it is likely that sinkholes may occur in the County, but the threat is relatively minimal given that buildings or infrastructure damage is localized with each occurrence. Due to the nature of this hazard, it is extremely difficult to predict future occurrences. While counties may be able to identify potential void spaces to help predict

[26] http://dnr.mo.gov/geology/geosrv/envgeo/sinkholes.htm

future sites, this hazard generally develops over a long period of time and can help jurisdiction make decisions about further development and potential mitigation actions. From 1970 - 2012, Jasper County has experienced 146 reported sinkholes while Newton County has reported 42, for a total of 188 events. Therefore, the probability of a sinkhole event in the two-county region in any given year is 100% (188 events / 45 years = 417%). At this time, data limitations on the damage-causing impact of sinkholes is not readily available.

Extent / Severity

The potential extent or severity of sinkholes in the region is difficult to assess due to a lack of data. Like wildfires and dam failure, sinkholes have had very limited impact upon the two-county region, with no events being publicly associated with any type of damage cost. Since 2004, ten additional mine shafts have opened, increasingly the possibility for potential sinkhole development. However, the existing data insufficiency makes in almost impossible to generate a workable figure for any given sinkhole event, particularly given the fact that sinkholes usually impact single buildings or pieces of infrastructure rather than a large group. For the purposes of this plan, the assumption was made that damage would rarely exceed 1% of any given jurisdiction based upon event location. Further study will be required to create a model for damage assessments related to sinkholes.