Figure 3.4. City of Warrenton

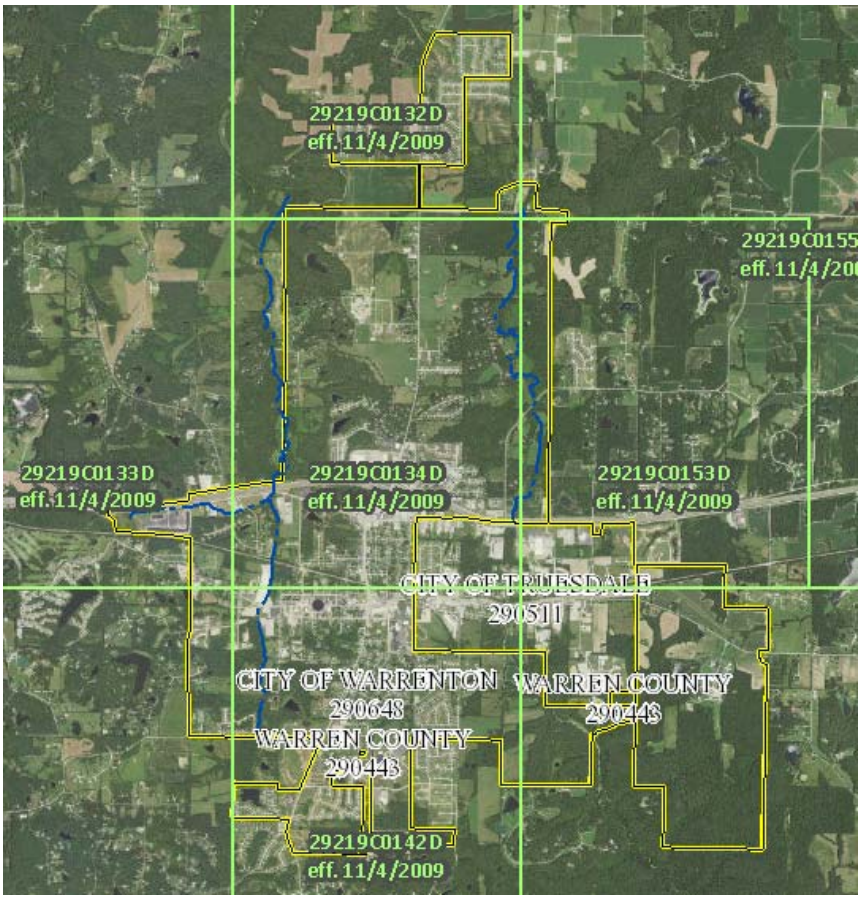


Figure 3.5. City of Truesdale

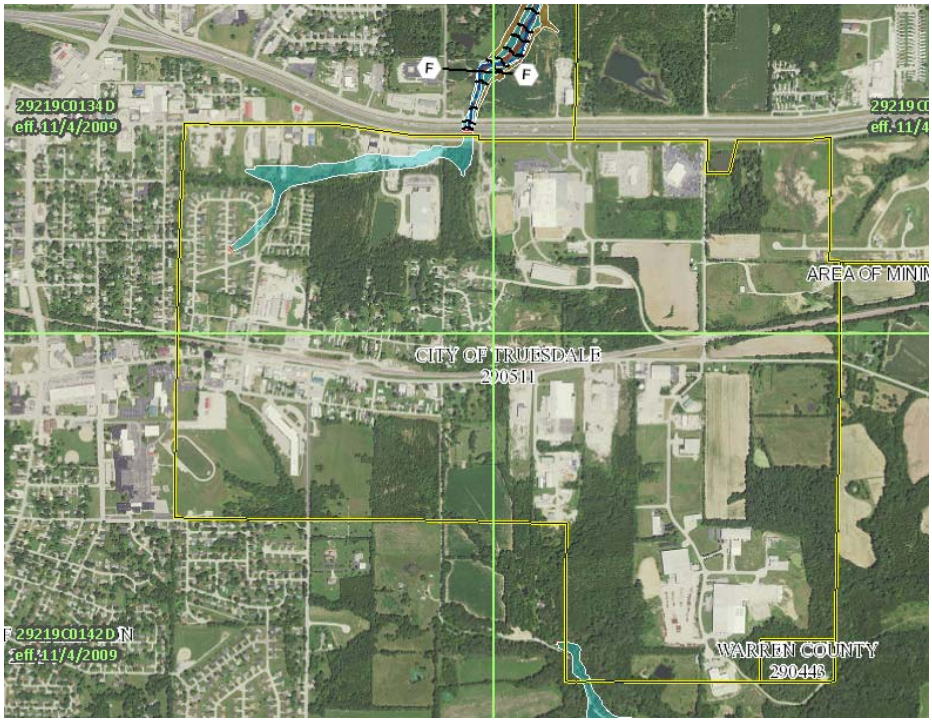


Figure 3.6. City of Wright City

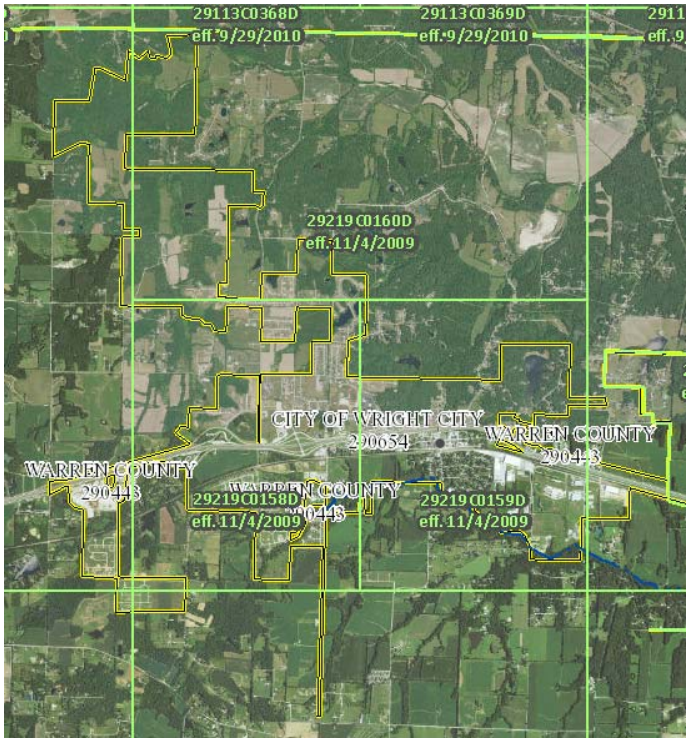
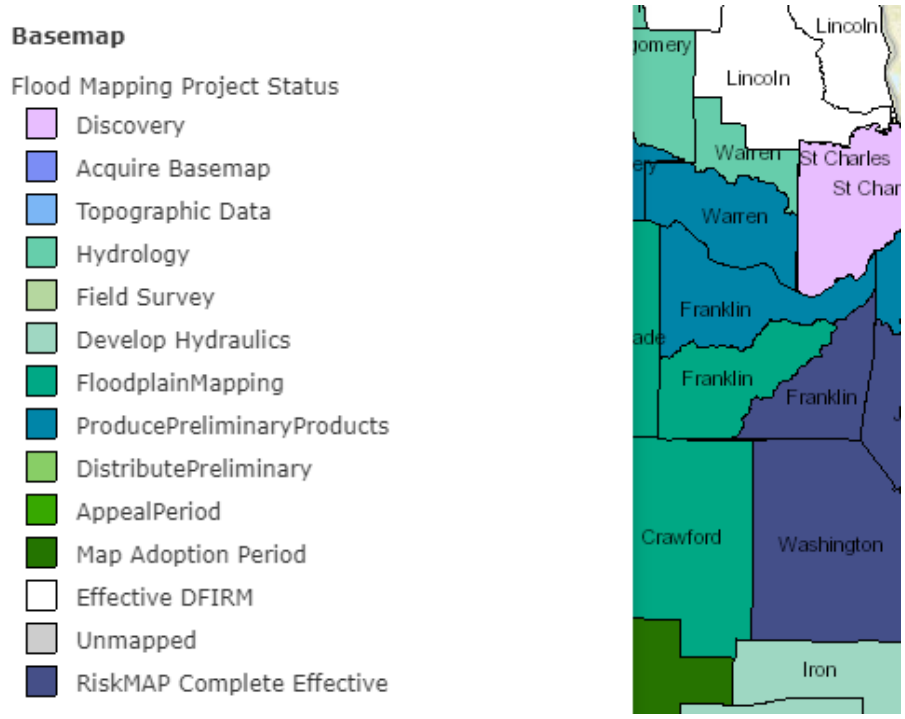


Figure 3.7. Warren County Flood RISK MAP



Source:https://mosema.maps.arcgis.com/apps/MapJournal/index.html?appid=c95675c3892c4b1aa870f202158d3098

The following National Centers for Environmental Information table shows just four flood events from the last 20 years. Twenty years of history is generally adequate for a trend analysis. Although only four events are recorded for Warren County during the past 20 years, this is considered adequate to establish risk in Warren County.

Table 3.15. Warren County NCEI Flash Flood Events by Location, 2000-2020

Location	# of Events
Countywide	12
Marthasville	1
Truesdale	1
Warrenton	2
Pendleton	1
Wright City	1

Special Flood Hazard Areas (SFHAs) are the land areas covered by the floodwaters of the base flood (a flood with a 1% annual chance of occurrence) is the Special Flood Hazard Area (SFHA) on NFIP maps. The SFHA is the area where the National Flood Insurance Program's (NFIP's) floodplain management regulations must be enforced and the area where the mandatory purchase of flood insurance applies." Therefore, all areas shaded in blue on the city and county FIRMs are SFHAs.

Strength/Magnitude/Extent

Missouri has a long and active history of flooding over the past century, according to the 2018 State Hazard Mitigation Plan. Flooding along Missouri's major rivers generally results in slow-moving disasters. River crest levels are forecast several days in advance, allowing downstream communities sufficient time to take protective measures, such as sandbagging and evacuations. Nevertheless, floods exact a heavy toll in terms of human suffering and losses to public and private property. By contrast, flash flood events in recent years have caused a higher number of deaths and major property damage in many areas of Missouri.

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

National Flood Insurance Program (NFIP) Participation

NFIP participation for the communities in the planning area is shown below and a second table shows the number of policies in force, amount of insurance in force, number of closed losses, and total payments for each jurisdiction, where applicable. Information in the charts was taken between January 1, 1978 and September 30, 2018. Sanctioned (S) communities are those communities that are not currently participating in the NFIP and where a Flood Hazard Boundary Map or Flood Insurance Rate Map has been issued.

Table 3.16 NFIP Participation in Warren County

Community ID Number	Community Name	NFIP Participant (Y / N)	Current Effective Map Date	Regular-Emergency Program Entry Date
290284	Village of Innsbrook	Y	11/04/2009	07/14/2010
290444	City of Marthasville	Y	11/042009	09/14/1983
290511	City of Truesdale	Y	11/04/2009	12/29/2000
290443	County of Warren	Y	11/04/2009	04/03/1985
290648	City of Warrenton	Y	11/04/2009	05/16/1983
290654	City of Wright City	Y	11/04/2009	03/26/2008

Source: NFIP Community Status Book, 2021; http://www.fema.gov/national-flood-insurance-program/national- flood-insurance-program-community-status-book; M= No elevation determined – all Zone A, C, and X: NSFHA = No Special Flood Hazard Area; E=Emergency Program

Table 3.17 NFIP Policy and Claim Statistics as of 8/21/2020

Community Name	Policies in Force	Insurance in Force	Total losses Paid
Village of Innsbrook	1	$140,000	Not available
City of Marthasville	13	$2,850,900	$524,359.93
City of Warrenton	7	$4,614,800	$672,059.27
City of Wright City	1	$42,000	Not available
Unincorporated County	51	$12,079,200	$852,351.57

Source: NFIP Community Status Book, [insert date]; http://bsa.nfipstat.fema.gov/reports/reports.html; *Closed Losses are those flood insurance claims that resulted in payment. Loss statistics are for the period from January 1, 1979 to August 21, 2020.

Repetitive Loss/Severe Repetitive Loss Properties

Repetitive Loss Properties are those for which two flood insurance payments are at least $1,000 or more in a 10 year period. According to the Flood Insurance Administration, jurisdictions included in the planning area have a combined total of eleven repetitive loss properties. As of November, 2020- one property has been mitigated, leaving ten un-mitigated repetitive loss properties.

Severe Repetitive Loss Properties (SRL)

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

Due to Federal restrictions on data sharing, the state was unable to provide full Repetitive Loss data or current Severe Repetitive Loss data.

Repetitive Loss properties and the Severe Repetitive Loss data, which was obtained from the 2018 MO State Hazard Mitigation Plan, does not specify if the properties are mitigated or non-mitigated. There is one validated Severe Repetitive Loss property in Warren County. The property is located in the City of Marthasville with four paid NFIP claims, $50,096.46 in total paid losses and $14,774.12 average payment.

The table below provides a summary of the repetitive loss properties in the planning area.

Table 3.18 Warren County Repetitive Loss Properties

Jurisdiction	# of Properties	# Mitigated	Building Payments	Content Payments	Total Payments	Average Payment	# of Losses
City of Marthasville	4	0	$203,224.6	$21,314.11	$206,277.7	$73,033.9	11
Warren County	7	1	$285,990.4	$14,132.55	$300,123.0	$1,43,820	15

Source: SEMA, November 2020

Previous Occurrences

The largest disaster to impact Warren County in recent years was the Great Flood of 1993. Flash flooding was responsible for a woman's death as her home was swept downstream. Loss of agricultural lands, homes, businesses, and infrastructure, as well as the temporary closing of some local businesses, contributed to economic losses. Areas hardest hit by the flooding were along the Missouri River in southern Warren County. Typical, flooding of the Missouri River affects only the agricultural area of Warren County adjacent the Missouri River floodplain.

It should be noted that flooding of major rivers in Warren County is known well in advance and impacts sparsely populated farmland with few structures. Flash flooding, on the other hand, can impact life and property nearly anywhere in the county at a moment's notice.

Table 3.19 NCEI Warren County Flood events and Flash Flood Events Summary, 2000 to 2020

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
2000	1	0	0	0	0
2002	3	0	0	0	0
2003	1	0	0	0	0
2004	1	0	0	0	0

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
2008	2	0	0	0	0
2009	2	0	0	0	0
2010	1	0	0	0	0
2013	1	0	0	0	0
2015	2	0	0	0	0
2019	1	0	0	0	0
2020	3	0	0	0	0

Source: NCEI, data accessed December 2020

Table 3.20 NCEI Warren County Riverine Flood Events Summary, 2000 to 2020

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
2000	1	0	0	0	0
2001	1	0	0	0	0
2007	1	0	0	0	$5,000
2010	1	0	0	0	0

Source: NCEI, December 2020

Probability of Future Occurrence

For flooding events, flash flooding is the most likely to occur. The flash flood chart above shows 18 flash floods occurred during the 21-year period between 2000 and 2020. Expressed mathematically, this is 18 floods divided into 21 years for one flood per year, or a 85% probability of a flash flood occurring somewhere in Warren County during any given year. This probability is just a measurement tool, as you can see in the chart, some years had several flash floods while other years had none.

The above riverine flooding table shows 4 flooding events over a 21-year period. Applying the same formula used above, this would be a 19% probability of a riverine flood occurring somewhere in Warren County during a 12-month period.

Changing Future Conditions Considerations

Warren County should begin to consider the possibility that traditional climate patterns are changing. According to the 2018 State Plan, if departure from normal with respect to increased precipitation intensity continues, frequency of floods in Missouri is likely to increase as well. Over the last half century, average annual precipitation in most of the Midwest has increased by 5 to 10 percent. But rainfall during the four wettest days of the year has increased about 35 percent, and the amount of water flowing in most streams during the worst flood of the year has increased by more than 20 percent.

It is likely (66-100% probability) that the frequency of heavy precipitation or the proportion of total rainfall from heavy storms will increase in the 21st century across the globe. More specifically, it is “very likely” (90-100% probability) that most areas of the United States will exhibit an increase of at least 5% in the maximum 5-day precipitation by late 21st century. As the number of heavy rain events increase, more flooding and pooling water can be expected.

The expected increases in rainfall frequency and intensity are likely to put additional stress on natural hydrological systems and community storm water systems. Heavier snowfalls in the winter will lead to intensified spring flooding, and groundwater levels will remain high even in non-floodplain areas. Such changes in climate patterns can lead to the development of compounding events that interact to create extreme conditions. Flooding caused by high groundwater levels typically recedes more slowly than riverine flooding, slowing the response and recovery process. Groundwater-fed rivers and streams are also likely to experience heightened flooding when groundwater levels are high. Jurisdictions updating or installing storm water management systems should consider potentially larger future discharge amounts when sizing culverts and drainage ways; storage

capacity can also be increased by building retention basins to hold excess storm water. Communities already prone to flooding should be prepared for a potential increase in facility closures and/or damages, as well as an increase in public demand for flood response and assistance. Natural features that experience repeated flooding may manifest changes in the form of stream bank instability and changing shoreline, floodplain, and wetland boundaries. Communities may also wish to plan for the potential loss of cropland and damage to both private property and public infrastructure such as bridges.

The environmental impacts of flooding include erosion, surface and groundwater contamination, and poor quality water. The threat of more frequent flood events may thus be a concern particularly for communities who depend on lakes, rivers, or trout streams for tourism. Rural communities may experience increases in well contamination and road washouts, while urban areas may be particularly vulnerable to flash flooding as heavy rain events quickly overwhelm the ability of a more impermeable environment to absorb excess storm water.

More climate information is available from the following sources:

- 2018 State Plan, see Chapter 3, Section 3.3.1, Changing Future Conditions Considerations, page 3.100
- US Climate Resilience Toolkit; https://toolkit.climate.gov/tools/climate-explorer
- National Climate Assessment; https://nca2014.globalchange.gov/

Vulnerability

Vulnerability Overview

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

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

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

For Warren County, according to the 2018 State Plan, this can mean building exposure for a 100-year flood to range between $500K and $305M and impact as many as 589-1678 buildings and up to 750 residents.

Potential Losses to Existing Development

The Missouri River Floodplain remains agricultural in nature with family farms sparely distributed within them. Portions of the Village of Innsbrook, the City of Marthasville, and areas of the Gasconade R-I School District lie within the Missouri's Floodplain and are frequently at risk of flooding.

Critical facilities at risk include the Washington Regional Airport just inside Warren County north of the City of Washington on MO 47. Missouri highways 47 and 94 in Warren County are also vulnerable to washout and closure due to Missouri River flooding. Warren County sections of MO 47 have been closed three times between May 2008 and January 2016 due to flooding. Likewise, MO 94 has been closed 11 times during the same period.

Impact of Previous and Future Development

Development upstream, in the form of additional levees, creates the greatest impact to Missouri River flooding in Warren County due to channeling additional water into waterways. The county regulates development within incorporated areas located in the floodplain of the Missouri River. Flash floods will continue to impact residents choosing to live in rural areas where low water crossings are required to access their homes. There is anticipated to be little or no increase in run off created by potential development.

Hazard Summary by Jurisdiction

Warren County faces two major risk factors for flooding. The land that forms Warren County is included in the Missouri River basin that drains most of the northern and central part of the state. The Missouri River flows east along the county's southern boundary and joins the Mississippi River some 50 miles east of the county. The southern rim of the county lies directly in the Missouri River floodplain where most the 1993 flood damage occurred. While flooding in southern Warren County will continue, loss of life and property, outside of that of crops, will remain unlikely. Flooding, particularly flash flooding, in the planning area's rivers and creeks will continue to be an issue due to the geography.

City of Marthasville recently initiated a buy-out of remaining properties located in the floodplain. Most of the major roads are raised to avoid flooding. Some bridges in the county are being rehabilitated to avoid future flooding events.

Village of Innsbrook has lots of creeks and therefore flooding, particularly flash flooding, in the creeks will continue to be an issue due to the geography.

Gasconade County R-I School District which serves part of Warren County doesn't have school buildings in the planning area. Due the geography and location of major roads, flooding is a concern.

School District of Washington which serves part of Warren County doesn't have school buildings in the planning area. Due the geography and location of major roads, flooding is a concern.

Problem Statement

Risk to Warren County due to flash floods and riverine floods are relatively insignificant due to geography. During the past 18 years, there are four recorded riverine flood events. During the same period, there were 18 flash flood events, one of which records damages of $5,000. There is one validated Severe Repetitive Loss property in Warren County. There is one mitigated repetitive loss property and ten un-mitigated repetitive loss properties. These repetitive losses could be reduced or eliminated by development of more restrictive flood plain ordinances.

3.4.2 Levee Failure

Hazard Profile

Hazard Description

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

Levees can be small agricultural levees that protect farmland from high-frequency flooding. Levees can also be larger, designed to protect people and property in larger urban areas from less frequent flooding events such as the 100-year and 500-year flood levels. For purposes of this discussion, levee failure will refer to both overtopping and breach as defined in FEMA's Publication "So You Live Behind a Levee" (http://mrcc.isws.illinois.edu/1913Flood/awareness/materials/SoYouLiveBehindLevee.pdf).

Following are the FEMA publication descriptions of different kinds of levee failure.

Overtopping: When a Flood Is Too Big

Overtopping occurs when floodwaters exceed the height of a levee and flow over its crown. As the water passes over the top, it may erode the levee, worsening the flooding and potentially causing an opening, or breach, in the levee.

Breaching: When a Levee Gives Way

A levee breach occurs when part of a levee gives way, creating an opening through which floodwaters may pass. A breach may occur gradually or suddenly. The most dangerous breaches happen quickly during periods of high water. The resulting torrent can quickly swamp a large area behind the failed levee with little or no warning.

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

cause a loss of soil strength, weakening a levee and possibly resulting in failure. Seismic activity can also cause levees to slide or slump, both of which can lead to failure.

Geographic Location

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

There are two concurrent nation-wide levee inventory development efforts, one led by the United State Army Corps of Engineers (USACE) and one led by Federal Emergency Management Agency (FEMA). The National Levee Database (NLD), developed by USACE, captures all USACE related levee projects, regardless of design levels of protection.

The Midterm Levee Inventory (MLI), developed by FEMA, captures all levee data (USACE and non-USACE) but primarily focuses on levees that provide 1% annual-chance flood protection on FEMA Flood Insurance Rate Maps (FIRMs).

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

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

Warren County has 5 levee districts which are shown in the following figure: Mo Valley, Tuque Creek, Augusta Bottom and Dutzow Bottom, Mo Valley (Charette Bottom), and Tri-County.

Figure 3.8. County Levees Shown on DFIRM as Providing Protection from

the 1-Percent Annual Chance Flood

Source: https://levees.sec.usace.army.mil/#/; December 2020

Mo Valley Sec 1- The Missouri Valley Levee District Section 1 levee system reduces flood risk to approximately 8,270 acres of Missouri River floodplain in Warren County, Missouri. The levee system includes 15.6 miles of earthen levee along the Missouri River. This levee was not designed or constructed by the U.S. Army Corps of Engineers (USACE). The levee is owned, operated, and maintained by the Missouri Valley Levee District. The 2015 USACE levee screening estimated the leveed area population to approximately 104 people, the property value to be approximately $13.9 Million, and the agricultural product value to be approximately $4.3 Million.

Tuque Creek- The Tuque Creek Levee is a levee system that reduces flood risk to approximately 1,678 acres of Missouri River floodplain in Warren County, Missouri. The levee system includes 9.2 miles of earthen levee along the Missouri River. This levee was not designed or constructed by the U.S. Army Corps of Engineers (USACE). The levee is owned, operated and maintained by the Tuque Creek Levee District. The 2015 USACE levee screening estimated the property value to be less than $1 Million and the agricultural product value to be approximately $6.1 Million.

Augusta Bottom and Dutzow Bottom- The Augusta Bottom and Dutzow Bottom Levee System reduces the risk of flooding from the Missouri River to properties in St. Charles County, Missouri. The system is located near the communities of Augusta and Dutzow, Missouri. The system was locally constructed and is owned and operated by the nonfederal Sponsors: Augusta Bottom Levee Association and Dutzow Bottom Levee District. The levee system was constructed in the 1920s to the 1980s and consists of approximately 17.2 miles of earthen embankment that runs along Charrette Creek on the west, Missouri River on the south and, Bigelow Creek on the east. Within the 7,300-acre leveed area are agricultural bottomlands, a small population within scattered farmsteads, the Washington Memorial regional airport, several oil/gas pipelines, and a portion of the Katy Trail bike trail. No towns or villages are located within the leveed area. The Augusta Bottom and Dutzow Bottom levee system has prevented the St. Charles County properties from flooding during numerous flood events and provides benefits to nearly 100 residents and employees and over $7 million in property value. The levee overtopped and breached in 1993 and 1995.

Mo Valley (Charette Bottom)- The MO Valley L.D. Sec 2 (Charrette Bottom) levee system reduces flood risk to approximately 434 acres of Missouri River floodplain in Warren County, Missouri. The levee system includes 2.9 miles of earthen levee along the Missouri River. This levee was not designed or constructed by the U.S. Army Corps of Engineers (USACE). The levee is owned, operated, and maintained by the Missouri Valley Levee District. The 2015 USACE screening level risk assessment estimated the leveed area population to be less than 10, the property value to be approximately $2.3 Million, and the agricultural products value to be approximately $192,500.

Tri County Levee District Section 1 - The Missouri Valley Levee District Section 1 levee system reduces flood risk to approximately 8,270 acres of Missouri River floodplain in Warren County, Missouri. The levee system includes 15.6 miles of earthen levee along the Missouri River. This levee was not designed or constructed by the U.S. Army Corps of Engineers (USACE). The levee is owned, operated, and maintained by the Missouri Valley Levee District. The 2015 USACE levee screening estimated the leveed area population to approximately 104 people, the property value to be approximately $13.9 Million, and the agricultural product value to be approximately $4.3 Million.

Strength/Magnitude/Extent

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

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

Previous Occurrences

A one-day closure of Missouri Route 47 in 1990 resulted from flash flooding of Tuque Creek. The road has been closed three times since 1990 (twice in 1993 and once in 1995) when the Missouri River levees failed. Both Tuque Creek and Lake Creek are tributaries to Charrette Creek, which lies between Route 47 and the Missouri River. Tuque Creek and Lake Creek join with Charrette Creek so near the Missouri River they are susceptible to combined backwater effects during Missouri River and other significant flooding events. The jurisdiction close to the Missouri river is the City of Marthasville.

Probability of Future Occurrence

Mo Valley Section 1: USACE evaluates risk as a combination of the flood hazard frequency, the anticipated levee performance, and the potential consequences. The 2015 USACE screening level risk assessment estimated the likelihood of a flood overtopping this levee in any given year at approximately 5%, or a 1 chance in 20. This levee was overtopped in 1993, and 1995. In 1993 and 1995 water flowing over the top of the levee eroded the slope and lead to a breach of the levee. Although the screening found overtopping to be the highest risk driver, it also noted that the condition of drainage pipes in the levee is unknown because they have not been video inspected. Aging or damaged pipes increase the chance of a levee breaching prior to water reaching the top.

Warning times for breaches that happen prior to water reaching the top of the levee are often shorter than for water overtopping the levee. Flooding of the levee could lead to flood depths up to 15 feet, which could result in life loss and economic consequences. As per USACE, this levee is rated as “low” meaning there is likelihood of inundation due to breach and/or system component malfunction in combination with loss of life, economic, or environmental consequences results in low risk.

Tuque Creek: The levee was significantly loaded in 2002, 2001, and 1998 but did not overtop. Although the screening found overtopping to be the highest risk driver, it also noted that the condition of drainage pipes in the levee is unknown because they have not been video inspected. Aging or damaged pipes increase the chance of a levee breaching prior to water reaching the top. Warning times for breaches that happen prior to water reaching the top of the levee are often shorter than for water overtopping the levee. Flooding of the levee could lead to flood depths up to 15 feet, which could result in life loss and economic consequences. The area behind the levee is predominately agricultural. There is no permanent population in the leveed area. The 2015 USACE levee screening estimated the property value to be less than $1 Million and the agricultural product value to be approximately $6.1 Million. As per USACE, this levee is rated as “low” meaning there is likelihood of inundation due to breach and/or system component malfunction in combination with loss of life, economic, or environmental consequences results in low risk.

Augusta Bottom and Dutzow Bottom: A risk assessment was completed on the Augusta Bottom and Dutzow Bottom levee system in 2015. The overtopping probability is relatively high, with a chance of occurring approximately once every ten years. The levee is likely to breach when it is overtopped. There is some uncertainty regarding how the levee may perform during an extended flood event due to a history of water seeping beneath the levee that may damage the foundation and the aged and possibly deteriorated pipes passing through the system. The consequences of levee overtopping or failure was determine to be low due to the sparsely populated area and good opportunities to egress in the event of a levee failure and overtopping, though there is no evacuation planning in the community A levee failure could result in flooding of depths of 11 feet, loss of property and productive agricultural land, and potential loss of life, if residents and employees are not evacuated. Depths would be greatest on the east side of the leveed area due to natural topography of the area. As per USACE, this levee is rated as “low” meaning there is likelihood of inundation due to breach and/or system component malfunction in combination with loss of life, economic, or environmental consequences results in low risk.

Mo Valley (Charette Bottom): The 2015 USACE screening level risk assessment estimated the likelihood of a Missouri River flood overtopping this levee in any given year at approximately 10%, or a 1 chance in 10. This levee was overtopped in 1993 and 1995 . The levee did not breach from overtopping during either of those flood events. This levee did not overtop in 2011 or 2019. This levee also lowers the risk of flooding from Charrette Creek and Tuque Creek. The loading and performance of the levee from these sources is not well documented. Tuque Creek did damage the levee in 2013 and those damages have since been repaired. Although the screening found overtopping to be the highest risk driver, it also noted that the condition of drainage pipes in the levee is unknown because they have not been video inspected. Aging or damaged pipes increase the chance of a levee breaching prior to water reaching the top. Warning times for breaches that happen prior to water reaching the top of the levee are often shorter than for water overtopping the levee. Flooding of the levee could lead to flood depths up to 6 feet, which could result in life loss and economic consequences. As per USACE, this levee is rated as “low” meaning there is likelihood of inundation due to breach and/or system component malfunction in combination with loss of life, economic, or environmental consequences results in low risk.

Tri-County: The 2015 USACE screening level risk assessment estimated the likelihood of a Missouri River flood overtopping this levee in any given year at approximately 10%, or a 1 chance in 10. This levee was overtopped in 1993 and 1995 . The levee did not breach from overtopping during either

of those flood events. This levee did not overtop in 2011 or 2019. This levee also lowers the risk of flooding from Charrette Creek and Tuque Creek. The loading and performance of the levee from these sources is not well documented. Tuque Creek did damage the levee in 2013 and those damages have since been repaired. Although the screening found overtopping to be the highest risk driver, it also noted that the condition of drainage pipes in the levee is unknown because they have not been video inspected. Aging or damaged pipes increase the chance of a levee breaching prior to water reaching the top. Warning times for breaches that happen prior to water reaching the top of the levee are often shorter than for water overtopping the levee. Flooding of the levee could lead to flood depths up to 6 feet, which could result in life loss and economic consequences. As per USACE, this levee is rated as "low" meaning there is likelihood of inundation due to breach and/or system component malfunction in combination with loss of life, economic, or environmental consequences results in low risk.

Changing Future Conditions Considerations

If we accept the climate change scenario that forecasts more dramatic periods of precipitation, we can then infer that more stress will be placed upon levees and that levees will be more prone to failure. Couple that with an infrastructure of aging, perhaps poorly maintained levees, and we have the makings of a serious problem.

Vulnerability

Vulnerability Overview

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

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

Both Routine and Periodic Inspections result in a rating for operation and maintenance. Each levee segment receives an overall segment inspection rating of Acceptable, Minimally Acceptable, or Unacceptable. Both the levee segments in Warren County have been inspected and rated as Acceptable.

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

Potential Losses to Existing Development

All the 5 levees are rated as “low” meaning there is likelihood of inundation due to breach and/or system component malfunction in combination with loss of life, economic, or environmental consequences results in low risk.

The Missouri River Floodplain remains agricultural in nature with family farms sparely distributed within them. Portions of the City of Marthasville lie within the Missouri’s Floodplain and are frequently at risk of flooding due mainly to levee failure or overtopping. Critical facilities at risk include the Washington Regional Airport just inside Warren County north of the City of Washington on MO 47. That highway is also vulnerable to washout and closure from Missouri River flooding. Losses associated with overtopping or failure are included as flood losses in the Flood Section of this plan.

Impact of Previous and Future Development

Development upstream, in the form of additional levees, creates the greatest impact to Missouri River flooding in Warren County due to channeling additional water into waterways. The county regulates development within unincorporated areas located in the floodplain of the Missouri River. Flash floods and levee failures will continue to impact residents choosing to live in rural areas where low water crossings are required to access their homes. There is anticipated to be little or no increase in run off created by potential development.

Hazard Summary by Jurisdiction

Warren County- the agricultural areas of lower Warren County are prone to levee failure.

City of Marthasville- Bridges and roads would be impacted due to levee failure.

Village of Innsbrook has lots of creeks and therefore flooding, particularly flash flooding, in the creeks will continue to be an issue due to the geography.

Gasconade County R-I School District which serves part of Warren County doesn’t have school buildings in the planning area. Due the geography and location of major roads, flooding is a concern.

School District of Washington which serves part of Warren County doesn’t have school buildings in the planning area. Due the geography and location of major roads, flooding is a concern. In addition, the Washington Regional Airport and MO 47 / MO 94 highways are vulnerable to closure and erosion during levee failure.

Problem Statement

Flooding and potential levee breach will remain a concern for those choosing to live in or near alluvial plains. Care must be taken to ensure existing levees are well maintained and that emergency evacuation plans are in place that provide sufficient warning in the event of a pending levee breach.

3.4.3 Dam Failure

Hazard Profile

Hazard Description

A dam is defined by the National Dam Safety Act as an artificial barrier that impounds or diverts water and is at least 6 feet high and stores at least 50 acre-feet of water; or, is at least 25 feet high and stores at least 15 acre-feet. Missouri's DNR regulates the design, construction and maintenance of 4,100 non-federal, non-agricultural dams that are at least 35 feet high. Regardless of the size of the dam, 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. The state has ultimate responsibility for public safety and many states regulate construction, modification, maintenance, and operation of dams. DNR's Dam Safety Division maintains a database of all dams regardless of federal, state, local or private ownership. Primary Levees are built and maintained by the Army Corps of Engineers while Secondary Levees; i.e., those constructed on secondary rivers and streams, are regulated by the Corps who sets design and construction standards.

The failure of dams can result in injuries, loss of life, and damage to property and the environment. While levees are built solely for flood protection, dams often serve multiple purposes, one of which may be flood control. Severe flooding and other storms can increase the potential that dams and levees will be damaged and fail as a result of the physical force of the flood waters or overtopping. Dams are usually engineered to withstand a flood with a computed risk of occurrence. If a larger flood occurs, then that structure will likely be overtopped. If during the overtopping, the dam fails or is washed out, the water behind is released as a flash flood. Failed dams can create floods that are catastrophic to life and property, in part because of the tremendous energy of the released water. The problem of unsafe dams in Missouri was underscored by dam failures at Lawrenceton in 1968, Washington County in 1975, Fredericktown in 1977, and a near failure in Franklin County in 1978. On December 14, 2005, the Taum Sauk reservoir dam owned by Ameren Missouri failed. A 600-foot breech in the northwest side of the retention facility released 1.5 billion gallons of stored water into the Johnson Shut-Ins State Park in just 10 minutes. The waters destroyed the park and the park superintendent's house and swept the superintendent's family out of their house. All five family members survived. The lower reservoir was overtopped by the flow of the east fork of the Black River. As a precautionary measure, the City of Lesterville evacuated 100-150 people to higher ground. If the dam had failed during the summer months, during the park's peak use, it is likely that many lives would have been lost.

The 2011 floods in Missouri led to the Corps of Engineers having to release record levels of water through the Gavin Point Dam on the upper Missouri. This release caused downstream flooding; however, the reservoirs upstream were at 100% capacity. The difficult choice to release so much water was supported by local officials. In Wyatt, Missouri the Corps had to breach the Bird's Point Levee late at night, in order to reduce pressure on a floodwall protecting the town.

Oversight is extremely valuable to the owners as well as those people living downstream of the dam who could be flooded in the event the dam should fail. Dams can fail for many reasons. The most common are:

Piping	Internal erosion caused by embankment leakage, foundation leakage and deterioration of pertinent structures appended to the dam.
Erosion	Inadequate spillway capacity causing overtopping of the dam, flow erosion, and inadequate slope protection.

Structure Failure	Caused by an earthquake, slope instability or faulty construction.
Overtopping	Inadequate spillway design, debris blockage of spillways or settlement of the dam crest.

These types of failures are often interrelated. For example, erosion; either on the surface or internal to the structure, may weaken the dam or lead to structural failure. Additionally, a structural failure may shorten the seepage path and lead to a piping failure.

The National Inventory of Dams (NID) defines three levels of hazard potential; high, significant, and low, as accepted by the Interagency Committee on Dam Safety. The definitions are:

• **High;** Failure or incorrect operation will probably cause loss of human life.

• **Significant;** Failure or incorrect operation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

• **Low;** Failure results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

Information can be obtained from:

- National Resources Conservation Service: http://www.nrcs.usda.gov
- DamSafetyAction.org: https://damsafety.org/missouri

Data for dams in Warren County has been collected from two sources; a listing by the Missouri Department of Natural Resources (MoDNR) and the National Inventory of Dams (NID). Each has its own system of classifying dams. Neither the MoDNR nor the NID hazard potential classifications references the condition of the dam. For the Risk Analysis, data was used from all MoDNR Class I and NID High Hazard dams.

Table 3.21 MoDNR Dam Hazard Classification Definitions

Hazard Class	Definition
Class I	Represents the most severe threat to public safety, life and property. Contains ten or more permanent dwellings or any public building. Inspections must occur every two years.
Class II	Represents a moderate threat to public safety, life and property. Contains 1-9 permanent buildings or 1 or more campgrounds with permanent water, sewer, and electrical services, or one or more industrial buildings. Inspections must occur every three years.
Class III	Represents the least severe threat to public safety, life and property. Inspections must occur every five years.

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

Table 3.22 NID Dam Hazard Classification Definitions

Hazard Class	Definition
High Hazard	Loss of at least one human life if dam fails
Significant Hazard	Possible loss of human life and likely significant property or environmental destruction

Low Hazard	• Equals or exceeds 25 feet in height and exceeds 15 acre-feet in storage • Exceed 6 feet in height and equal to or exceeds 50-acre feet in storage

Source: National Inventory of Dams

Geographic Location

Dams Located Within the Planning Area

According to the Missouri Department of Natural Resources, Dam and Reservoir Safety, Warren County has 131 dams, of which eight are Class I, or High Hazard Dams. Of these, nine are state regulated.

This contrasts to the National Inventory of Dams; NID, that lists 1278 dams in Warren County, of which 78 are rated High Hazard and 44 are state regulated.

Table 3.23 MoDNR Class I Dams in Warren County

Dam Name	Class	Height (ft)	Drainage area (acre)	State Regulated
Alpine Lake dam	I	118	2,553	Y
Aspenhoff Lake dam	I	29	211	
B & K Lake no.2 dam	I	32	25	
B & K Lake #1 dam	I	26	157	
Boone trail farm lake dam	I	28	310	
Brockfeld dam	I	51	31	
Cedar grove dam	I	32	28	
Cedar knoll farm lake dam	I	26	150	
Deer hollow lake dam	I	78	26	Y
Dirkemeier lake dam-mononame 314	I	33	128	Y
Dr. Courtney dam	I	32	278	
Isley lake dam	I	65	96	Y
Krueger lake dam	I	34	115	
Lake Belle-Ann dam	I	29	128	
Lake Lucern dam	I	30	1140	
Lake Scheffborg dam	I	29	560	
Lake Sherwood dam	I	67	2937	Y
Lakeview estates dam	I	32	160	
Marthasville Mv-5 dam	I	36	678	Y
Mcdaniels. Huelin dam	I	25	442	
Our country place dam	I	64	100	Y
Rogers lake dam	I	25	175	
Siegmund lake dam	I	30	35	
Sky ranch lake dam	I	34	130	
Sugar hollow dam	I	43	974	Y

Dam Name	Class	Height (ft)	Drainage area (acre)	State Regulated
Voelkerding lake dam	I	31	100	
White smith Austin lake dam	I	18	58	
Windy Knoll dam	I	31	45	
Woodridge lake dam	I	64	427	Y

Table 3.24 NID High Hazard Dams in Warren County

Dam Name	River	Nearest City	Owner's name	Dam height (feet)	Normal acre feet storage	EAP	Inspection date	EAP last revised date
REID LAKE DAM	TR SCHLANKER BRANCH	WARRENTON	GLEN ELLEN SUBDIVISION	36	181	Y	10/19/2016	17-DEC-09
DOGWOOD LAKE DAM	TR NORTH FORK CHARRETTE CREEK	WARRENTON	DOGWD LK LOT OWNERS ASSO	42	88	Y	11/14/2017	29-JUN-11
FOREST LAKE DAM	TRIB-INDIAN CAMP CREEK	WRIGHT CITY	Not available	38	341	Y	9/18/2015	29-JUN-11
LAKE SHERWOOD DAM	WOLF CREEK	MARTHASVILLE	LAKE SHERWOOD ESTATES	67	2982	Y	10/19/2016	26-MAY-10
BOULANGER LAKE DAM	TR HICKORY LICK CREEK	OLD MONROE	LILLIAN BOULANGER	33	265	NR		
DUNN LAKE DAM	TR HICKORY LICK CREEK	WARRENTON	MILDRED DUNN	38	93	Y	10/19/2016	26-JAN-09
PALAZZO LAKE DAM	TR INDIAN CAMP CREEK	CHAIN OF ROCKS	FRANK PALAZZO	25	50	NR		
WOODY CREEK DAM	TR-MASSIE CREEK	JONESBURG	WOODY CREEK LLC	64	347	Y	4/25/2017	15-OCT-10
JOHNSON LAKE DAM	TR INDIAN CAMP CREEK	CHAIN OF ROCKS	WM JOHNSON	32	70	NR		
CEDAR KNOLL FARM LAKE DAM	TRIB-PERUQUE CREEK	WRIGHT CITY	RUTH SIMS	26	118	NR	6/9/1980	
BROUSSARD LAKE DAM	TR HICKORY LICK CREEK	CHAIN OF ROCKS	PAUL BROUSSARD	25	44	NR		
SCOFIELD LAKE #3 DAM	TR-MASSIE CR	BERGER	JOHN SCOFIELD	30	56	NR		
PETERSMEYER LAKE DAM	TR-BIG CREEK	WARRENTON	FRED PETERSMEYER	28	50	NR		
PETERSMEYER'S LOWER LAKE	TR BIG CREEK	WARRENTON	FRED PETERSMEYER	28	25	NR		

Dam Name	River	Nearest City	Owner's name	Dam height (feet)	Normal acre feet storage	EAP	Inspection date	EAP last revised date
DAM								
B & K LAKE NO. 2 DAM	TR TO LOST CREEK	NEW HAVEN	B&K CONST.CO	32	39	NR	8/20/1979	
NIKO LAKE DAM	SCHLANKER BRANCH	CHAIN OF ROCKS	DR RAYMOND R NIKO	25	65	NR		
LAKEVIEW ESTATES DAM	TRIBUTARY TO BIG CREEK	WARRENTON	MID CENTRAL DEVELOPMT CO	32	192	NR	5/17/1979	
WOODRIDGE LAKE DAM	TR-DRY FORK	WARRENTON	WOODRIDGE LAKE TRUSTEES	64	581	Y	9/13/2016	06-JAN-14
ASPENHOFF LAKE DAM	TR-HOPEWELL CREEK	WARRENTON	ASPENHOFF TRUSTEES	29	88	NR	5/15/1979	
KRUEGER LAKE DAM	TRIBUTARY TO SMITH CREEK	NEW HAVEN	TOM NULL	34	103	NR	5/16/1979	
CEDAR GROVE DAM	TR-LOST CREEK	NEW HAVEN	CEDAR GROVE SUBDIVISION	32	20	NR	6/26/1980	
GETTINGER LAKE DAM	TR NORTH FORK CHARRETTE CREEK	MARTHASVILLE	EDWARD GETTINGER	33	175	NR		
LAKE WANDERFERN DAM	TR CHARETTE CREEK	INNSBROOK	INNSBROOK OWNERS ASSOCIATION	54	1008	Y	9/28/2017	11-AUG-10
HAMBAUCH LAKE DAM	TR LITTLE LOST CREEK	NEW HAVEN	ED HAMBAUCH	26	140	NR		
LAKE INNSBROOK DAM	TRIB CHARRETTE CREEK	INNSBROOK	INNSBROOK OWNERS ASSOCIATION	46	532	Y	11/12/2015	11-AUG-10
DEER HOLLOW LAKE DAM	UNNAMED TRIB TO WILSON'S CRK.	JONESBURG	HOPE ED. & RESEARCH CTR.	78	143	Y	2/8/2016	01-JAN-13
PRIOR LAKE DAM	TR-CHARRETTE CREEK	MARTHASVILLE	ALBERT PRIOR	34	58	NR		
MAPLE WOOD LAKE DAM	INDIAN CAMP CREEK	OLD MONROE	SHERWOOD BUILDERS, INC	42	132	Y	10/19/2016	22-FEB-13
DR. COURTNEY DAM	TR-BIG CREEK	WARRENTON	CARL HELD & BILL REID	30	130	NR	5/17/1979	
VOELKERDING LAKE DAM	TRIB-LAKE CREEK	DUTZOW	W & J VOELKERDING TRUST	31	145	NR	5/20/1980	

Dam Name	River	Nearest City	Owner's name	Dam height (feet)	Normal acre feet storage	EAP	Inspection date	EAP last revised date
B&K LAKE #1 DAM	TR LOST CREEK OFFSTREAM	WARRENTON	B & K CONST	26	74	NR	5/19/1979	
DIRKEMEIER LAKE DAM-MONONAME 314	TR-LOST CREEK	BERGER	HERBERT BIRKEMEIER	33	103	NR	5/19/1979	
MCDANIELS, HUELIN DAM	LOST CREEK	NEW HAVEN	HUELIN MCDANIELS	25	107	NR	5/18/1979	
BOONE TRAIL FARM LAKE DAM	INDIAN CAMP CREEK	OLD MONROE	MATERIAL HAULING CO.	28	206	NR	5/30/1980	
WINDY KNOLL DAM	TRIB-CHARRETTE CREEK	MARTHASVILLE	WILLMARJIM COMPANY	31	63	NR	6/9/1980	
KOEPKE LAKE DAM NORTH	TR CHARRETTE CREEK	INNSBROOK		39	124	Y	10/21/2015	11-AUG-10
LAKE GRENDEL DAM	TR-NORTH FORK CHARRETTE CREEK	INNSBROOK		39	94	Y	8/23/2016	11-AUG-10
SHERMAN LAKE DAM	TR CHARETTE CREEK	MARTHASVILLE	WILLIAM SHERMAN	33	135	NR		
LAKE LUCERN DAM	TRIB CHARRETTE CREEK	MARTHASVILLE	ASPENHOF CORP.	30	338	NR	7/1/1980	
SIEGMUND LAKE DAM	TR CHARRETTE CREEK	WRIGHT CITY	DELORES SIEGMUND	30	44	NR	12/3/1980	
LUCKS LAKE DAM	TR KOCHS CREEK	MARTHASVILLE	THOMAS LUCKS	20	53	NR		
SUGAR HOLLOW DAM	TR-WOLF CREEK	LAKE SHERWOOD ESTATES	LAKE SHERWOOD ESTATES HOA	43	178	Y	4/25/2017	08-APR-11
WHITE,SMITH,AUSTIN LAKE DAM	TR-SCHLANKER BRANCH	HAWK POINT	GERALD SMITH	18	37	NR	5/18/1979	
CASTELENOVO LAKE DAM	TR CHARRETTE CREEK	INNSBROOK		37	109	Y	4/25/2017	11-AUG-10
MONEY SUNK RANCH DAM	TR NORTH FORK CHARRETTE CREEK	MARTHASVILLE	MONEY SUNK RANCH	30	40	NR		
SENG LAKE DAM	TR BEAR CREEK	MCKITTRICK	CHARLES W SENG	30	155	NR		
SUNNY MOUNT CHURCH DAM	TR-MASSIE CREEK	JONESBURG	NEIL VANCE	40	113	N	5/17/2016	
LAKE BELLE-ANN DAM	TR COLLEGE CREEK	MARTHASVILLE	WM & GRACE BEAVER	29	25	NR	5/15/1979	

Dam Name	River	Nearest City	Owner's name	Dam height (feet)	Normal acre feet storage	EAP	Inspection date	EAP last revised date
SKY RANCH LAKE DAM	TR-LOST CREEK	NEW HAVEN	ELMER EDELMANN	34	51	NR	7/9/1980	
OETTING LAKE DAM	TR-LOST CREEK	BERGER	MRS FRITZ OETTING	25	30	NR		
LAKE SCHEFFBORG DAM	TRIB CHARRETTE CREEK	MARTHASVILLE	ASPENHOF CORP.	29	79	NR	7/1/1980	
VATTEROT DAM	TR-CHARRETTE CREEK	MARTHASVILLE	GLEN VATTEROT	30	83	NR		
OWL CREEK ESTATES DAM #1	TR-OWL CREEK	WARRENTON		41	79	Y	7/15/2015	15-DEC-10
LAKE ASPEN DAM	TRIB CHARRETTE CREEK	INNSBROOK	INNSBROOK OWNERS ASSOCIATION	53	2167	Y	9/13/2016	11-AUG-10
MILLER LAKE DAM	TR-CHARRETTE CREEK	INNSBROOK	TOM MILLER	46	54	Y	7/15/2015	24-AUG-10
HUNT LAKE DAM	TR CHARRETTE CR	WASHINGTON	ROGER&BONNIE HUNT	27	81	NR		
ROGERS LAKE DAM	TR CHARRETTE CREEK	WRIGHT CITY	ELLIOTT ROGERS	25	39	NR	12/3/1980	
BUNGE, H. LAKE DAM	TR CHARRETTE CREEK	MARTHASVILLE	HENRY BUNGE	24	44	NR		
ISLEY LAKE DAM	UNNAMED TRIB TO DRY FORK	WARRENTON		65	268	Y	5/17/2016	12-JAN-11
SEEBROOK DAM	TR CHARRETTE CREEK	INNSBROOK	INNSBROOK H/O ASN	41	56	Y	2/28/2017	11-AUG-10
TRINITY LAKE DAM	TR CHARRETTE CREEK	INNSBROOK	INNSBROOK OWNERS ASSOCIATION	44	137	Y	10/21/2015	11-AUG-10
BUMB LAKE #1 DAM	TR LITTLE LOST CREEK	JONESBURG	CLARENCE BUMB	34	385	NR		
BUMB LAKE DAM #2	TR LITTLE LOST CREEK	JONESBURG	CLARENCE BUMB	32	32	NR		
BUMB LAKE DAM #3	TR LITTLE LOST CREEK	JONESBURG	CLARENCE BUMB	32	21	NR		
BUMB LAKE DAM #4	TR LITTLE LOST CREEK	JONESBURG	CLARENCE BUMB	21	21	NR		
LAKE ST. GALLEN DAM	TRIB TO CHARRETTE CREEK	INNSBROOK	INNSBROOK OWNERS ASSOCIATION	57	694	Y	9/13/2016	11-AUG-10

Dam Name	River	Nearest City	Owner's name	Dam height (feet)	Normal acre feet storage	EAP	Inspection date	EAP last revised date
SCHMITT LAKE DAM	TRIB TO TUQUE CREEK	MARTHASVILLE	TOM SCHMITT	32	171	NR		
OWL CREEK ESTATES DAM #2	TR-OWL CREEK	WARRENTON		54	48	Y	7/15/2015	15-DEC-10
OWL CREEK ESTATES DAM #3	TR-OWL CREEK	WARRENTON	OWL CREEK ESTATES TRUSTEES	49	19	Y	7/15/2015	15-DEC-10
LAKE KONSTANZ DAM	TRIB. CHARRETTE CREEK	INNSBROOK	INNSBROOK CORPORATION	90	86	Y	1/7/2016	11-AUG-10
ALPINE LAKE DAM	CAVE CREEK	INNSBROOK	INNSBROOK CORPORATION	118	10266	Y	9/28/2017	11-AUG-10
CARDINAL LAKE DAM	TRIB TO CHARETTE	INNSBROOK	INNSBROOK ESTATES	44	96	Y	10/17/2017	11-AUG-10
MARTHASVILLE MV-5 DAM	TRIB TO TUQUE CREEK	MARTHASVILLE	CITY OF MARTHASVILLE	36	117	Y	2/28/2017	24-FEB-11
LAKE KITZBUHL DAM	NORTH FORK CHARRETTE CREEK	INNSBROOK		58	457	Y	9/28/2017	11-AUG-10
SONNENBLICK LAKE DAM	UNAMED TRIB OF CHARRETTE CRK	INNSBROOK		51	47	Y	9/28/2017	11-AUG-10
STIEVEN DAM	TRIB OF MASSEY CREEK	CASE	JOSEPH & MARY STIEVEN TRUSTEES	43.5	737	Y	5/5/2016	26-SEP-13
WHITE-BOVERI DAM	UNNAMED TRIB OF DRY FORK	HOPEWELL		40	142	Y	8/22/2016	09-OCT-13
TYROL LAKE DAM				47	134	Y	7/7/2015	23-FEB-15

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

Strength/Magnitude/Extent

A dam failure could create a critical hazard for the City of Marthasville and the School District of Washington (Marthasville attendance center) because of the concentration of people living or attending school in the inundation area of the city. While Innsbrook also has a high concentration of dams, few people live in the inundation area so the severity is deemed to be limited.

It should be noted that the severity/magnitude of dam failure would be similar in some cases to the impacts associated with flood events (see the flood hazard vulnerability analysis and discussion). Based on the hazard class definitions, failure of any of the High Hazard/Class I dams could result in a serious threat of loss of human life, serious damage to residential, industrial or commercial areas,

public utilities, public buildings, or major transportation facilities. Catastrophic failure of any high hazard dams has the potential to result in greater destruction due to the potential speed of onset and greater depth, extent, and velocity of flooding. Note that for this reason, dam failures could flood areas outside of mapped flood hazards.

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

Previous Occurrences

To determine previous occurrences of dam failure within Warren County, the 2016 Warren County Hazard Mitigation Plan was consulted as well as the 2018 Missouri State Hazard Mitigation Plan. The most recent earthen dam failure in Warren County occurred on May 27, 2008 at Lake Alpine in Innsbrook. Lake Alpine is the largest private man-made lake in the State of Missouri and is about 11 miles at its perimeter and reaches a depth of 90 feet. The incident occurred after a period of heavy rainfall which caused a large diameter spillway pipe to fail, expelling part of the 36-inch pipe from the dam. The pipe feeds an overflow spillway at the center of a quarter mile earthen dam at the south end of the lake. When the force of the water literally tore the section of the pipe from the dam, it created an opening in the dam measuring 40 feet across. At the time of the incident, emergency officials estimated the water level of the lake to be about 3 feet above the drainage pipe. Emergency personnel and officials from DNR took steps to prevent a possible breach in the dam by sealing the spillway and broken pipe with a mixture of rocks and concrete.

Probability of Future Occurrence

Although there is one dam failure in the past, the area impacted is located near a private dam and. few people live in the inundation area so the severity is deemed to be limited. Other than this, there are no recorded dam failures for Warren County dams which make forecasting probability of failure difficult. However, there are two factors that can impact dam failure; regulation and inspection. Regulation requires regular inspections which can determine issues that contribute to failure. Warren County has 131 dams, of which eight are Class I, or High Hazard Dams. Of these, nine are state regulated.

This contrasts to the National Inventory of Dams; NID, that lists 128 dams in Warren County, of which 78 are rated High Hazard and 44 are state regulated. 33 have published Emergency Action Plans. The impact of regular inspection and maintenance significantly reduces the probability of dam failure.

Changing Future Conditions Considerations

If we accept the climate change scenario that forecasts more dramatic periods of precipitation, we can then infer that more stress will be placed upon dams which will be more prone to failure. Couple that with an infrastructure of aging, uninspected, perhaps poorly maintained dams, and we have the makings of a serious problem for those living downstream. Most of Warren County's growth surrounding the Interstate 70, Missouri Route 47 corridors where little additional potential for loss is likely. The only exception would be the areas in and around Marthasville where levee failure and river flooding are currently well documented threats. Refer to the Flooding Section of this document.

Vulnerability

Vulnerability Overview

Vulnerability to dam failure is a factor due to the number of dams in the planning area. As there are no recorded dam failures and most of them are located in unincorporated areas, the planning committee chose only to address high hazard dams when funding becomes available.

Potential Losses to Existing Development:

If any of the state-regulated dams with available inundation areas breach, it could account for loss of 162 farm, 2 commercial and 51 residential structures valued at $11M and potential loss of life for up to 135 people.

Impact of Previous and Future Development

Most of Warren County's growth surrounding the Interstate 70, Missouri Route 47 corridors where little additional potential for loss is likely. The only exception would be the areas in and around Marthasville where levee failure and river flooding are currently well documented threats. Refer to the Flooding Section of this document.

Hazard Summary by Jurisdiction

While a dam break could flood many rural, unpopulated areas of the county, only two areas are vulnerable to potential loss of property to dam failure; the City of Marthasville and the resort community of Innsbrook. It will be helpful for residents near the high hazard dams to get familiarized with the dam's Emergency Action Plan (EAP) and work closely with County EOP & participate in dam emergency exercises.