3 RISK ASSESSMENT

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

The risk assessment process identifies and profiles relevant hazards and assesses the exposure of lives, property, and infrastructure to these hazards. The goal of the risk assessment is to estimate the potential loss in Vanderburgh County, including loss of life, personal injury, property damage, and economic loss, from a hazard event. The risk assessment process allows communities in Vanderburgh County to better understand their potential risk to natural hazards and provides a framework for developing and prioritizing mitigation actions to reduce risk from future hazard events.

A Multi-Hazard Mitigation Plan was completed for Vanderburgh County in September 2004. Therefore, this risk assessment is an update to the risk assessment previously prepared. There are, however, several improvements:

1) Hazards to include were evaluated and refined;
2) HAZUS-MH MR5 and parcel data provided by the HMPC was utilized to determine assets at risk; and
3) HAZUS-MH MR5 results assessed vulnerability and loss estimates for earthquake, flooding, and levee failure.

The risk assessment for Vanderburgh County and its jurisdictions followed the methodology described in the FEMA publication 386-2, *Understanding Your Risks: Identifying Hazards and Estimating Losses* (2002), which includes a four-step process:

- Identify Hazards
- Profile Hazard Events
- Inventory Assets
- Estimate Losses

This chapter is divided into four parts: hazard identification, hazard profiles, vulnerability assessment, and Summary of Key Issues.

- **Section 3.1 Hazard Identification** identifies the hazards that threaten the planning area and describes why some hazards have been omitted from further consideration.
- **Section 3.2 Hazard Profiles** discusses the threat to the planning area and describes previous occurrences of hazard events and the probability of future occurrence.

- **Section 3.3 Vulnerability Assessment** assesses the County's total exposure to natural hazards, considering critical facilities and other community assets at risk, and assessing growth and development trends. Hazards that vary geographically across the planning area are addressed in greater detail. This section includes steps 3 and 4 from above.
- **Section 3.4 Summary of Key Issues** provides a summary of the key issues or problems identified in the Risk Assessment.

3.1 Hazard Identification

Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the type…of all natural hazards that can affect the jurisdiction.

3.1.1 Disaster Declaration History

One method used by the HMPC to identify hazards was to examine events that triggered federal and/or state disaster declarations. Federal and/or state declarations may be granted when the severity and magnitude of an event surpasses the ability of the local government to respond and recover. Disaster assistance is supplemental and sequential. When the local government's capacity has been surpassed, a state disaster declaration may be issued, allowing for the provision of state assistance. Should the disaster be so severe that both the local and state governments' capacities are exceeded, a federal emergency or disaster declaration may be issued allowing for the provision of federal assistance.

The federal government may issue a disaster declaration through FEMA, the U.S. Department of Agriculture (USDA), and/or the Small Business Administration. FEMA also issues emergency declarations, which are more limited in scope and do not include the long-term federal recovery programs of major disaster declarations. Determinations for declaration type are based on scale and type of damages and institutions or industrial sectors affected.

Table 3.1 lists federal disaster declarations through FEMA received by Vanderburgh County. Each of the disaster events affected multiple counties; estimated damages reflect total losses to all counties.

Table 3.1 Disaster Declaration History in Vanderburgh County, 1965-Present

DR #*	Declaration Date	Disaster Description	Counties Included for Public Assistance	Counties Included for Individual Assistance	Public Assistance ($)	Individual Assistance ($)
Major Disaster Declarations						
1997	6/23/2011 (4/19 – 6/6/2011	Severe Storms, Tornadoes, Straight-Line Winds, and Floodign	Benton, Clark, Clay, Crawford, Daviess, Dearborn, Dubois, Floyd, Franklin, Gibson, Harrison, Jackson, Jefferson, Jennings, Knox, Lawrence, Martin, Monroe, Ohio, Orange, Parke, Perry, Pike, Posey, Putnam, Ripley, Scott, Spencer, Starke, Sullivan, Switzerland, Vanderburgh, Vermillion, Warrick, Washington, and Wayne.	None	$826,926	None
1828	3/5/2009 (1/26-28/2009)	Severe Winter Storm	Clark, Crawford, Dubois, Floyd, Gibson, Harrison, Jackson, Jefferson, Jennings, Lawrence, Ohio, Orange, Perry, Posey, Ripley, Scott, Spencer, Switzerland, Vanderburgh, Warrick, and Washington	None	$11,643,357	None
1795	9/23/2008 (9/12-10/6/2008)	Severe Storms and Flooding (primary impact to Vanderburgh County was severe storms)	Clark, Crawford, Daviess, Dearborn, Decatur, Dubois, Fayette, Floyd, Franklin, Gibson, Harrison, Jackson, Jefferson, Jennings, La Porte, Lake, Lawrence, Martin, Newton, Ohio, Orange, Perry, Pike, Porter, Ripley, Vanderburgh, Scott, Spencer, Switzerland, Union, Vanderburgh, Warrick, Washington, and Wayne.	Clark, Crawford, Dearborn, Floyd, Franklin, Gibson, Harrison, Jackson, Jasper, Jefferson, Jennings, Knox, La Porte, Lake, Lawrence, Martin, Ohio, Orange, Perry, Pike, Porter, Posey, Ripley, Saint Joseph, Scott, Spencer, Switzerland, Vanderburgh, Warrick, and Washington.	$24,555,126	$36,964,929
1662	10/6/2006 (9/12-9/14/2006)	Severe Storms and Flooding	None	Lake, Vanderburgh, and Warrick.	None	$12,105,107
1612	11/8/2006 (11/6/2006)	Tornado and Severe Storms	Vanderburgh, and Warrick	Vanderburgh and Warrick.	$2,507,109	$885,608

DR #*	Declaration Date	Disaster Description	Counties Included for Public Assistance	Counties Included for Individual Assistance	Public Assistance ($)	Individual Assistance ($)
1573	1/21/2005 (1/1-2/11/2005)	Severe Winter Storms and Flooding	Adams, Allen, Bartholomew, Blackford, Boone, Clinton, Daviess, Dearborn, Delaware, Fayette, Fountain, Franklin, Gibson, Grant, Greene, Henry, Howard, Huntington, Jay, Jefferson, Knox, Lawrence, Madison, Martin, Montgomery, Owen, Perry, Pike , Posey , Putnam , Randolph , Vanderburgh , Starke , Sullivan , Tippecanoe , Tipton , Union , Vermillion , Vigo , Warren , Wayne , and Wells .	Adams, Allen, Bartholomew, Benton, Blackford, Boone, Brown, Carroll, Cass, Clark, Clay, Clinton, Crawford, Daviess, De Kalb, Dearborn, Decatur, Delaware, Dubois, Elkhart, Fayette, Floyd, Fountain, Franklin, Fulton, Gibson, Grant, Greene, Hamilton, Hancock, Harrison, Hendricks, Henry, Howard, Huntington, Jackson, Jasper, Jay, Jennings, Johnson, Knox, Kosciusko, La Porte, Lake, Lawrence, Madison, Marion, Marshall, Martin, Miami, Monroe, Montgomery, Morgan, Newton, Noble, Orange, Owen, Parke, Pike, Porter, Posey, Pulaski, Putnam, Randolph, Ripley, Vanderburgh, Saint Joseph, Scott, Shelby, Starke, Sullivan, Tippecanoe, Tipton, Union, Vanderburgh, Vermillion, Vigo, Wabash, Warren, Warrick, Washington, Wayne, Wells, White, and Whitley.	$18,239,754	$12,352,135
1520	6/3/2004 (5/25-6/25/2004)	Severe Storms, Tornadoes, and Flooding	Benton, Clark, Crawford, Floyd, Fountain, Greene, Harrison, Martin, Miami, Orange, Owen, Perry, Spencer, Tippecanoe, Union, Warren, Warrick, and Washington.	Adams, Allen, Benton, Boone, Brown, Carroll, Cass, Clark, Clay, Clinton, Crawford, De Kalb, Dearborn, Decatur, Delaware, Dubois, Floyd, Fountain, Franklin, Fulton, Gibson, Grant, Greene, Hamilton, Hancock, Harrison, Hendricks, Henry, Howard, Huntington, Jackson, Jasper, Jefferson, Jennings, Johnson, Kosciusko, Lake,	$4,154,202	$5,034,664

DR #*	Declaration Date	Disaster Description	Counties Included for Public Assistance	Counties Included for Individual Assistance	Public Assistance ($)	Individual Assistance ($)
				Lawrence, Madison, Marion, Martin, Miami, Monroe, Montgomery, Morgan, Newton, Noble, Ohio, Orange, Owen, Perry, Pike, Putnam, Ripley, Scott, Shelby, Spencer, Switzerland, Tippecanoe, Tipton, Vanderburgh, Wabash, Warren, Warrick, Washington, Wells, White, and Whitley.		
1476	7/11/2003 (7/4-8/6/2003)	Severe Storms, Tornadoes, and Flooding	Adams, Allen, Carroll, Cass, Clay, Fountain, Greene, Howard, Huntington, Jasper, Jay, Kosciusko, Madison, Miami, Newton, Owen, Parke, Tippecanoe, Tipton, Union, Wabash, Warren, Wells, and White .	Adams, Allen, Benton, Blackford, Boone, Carroll, Cass, Clay, Clinton, Delaware, Fountain, Fulton, Grant, Hamilton, Hancock, Henry, Howard, Huntington, Jasper, Jay, Kosciusko, Lake, Madison, Marion, Miami, Montgomery, Morgan, Newton, Noble, Parke, Porter, Pulaski, Randolph, Tippecanoe, Tipton, Vanderburgh, Vigo, Wabash, Warren, Wayne, Wells, White, and Whitley.	$6,936,605	$13,386,838
1433	9/25/2002 (9/20-9/20/2002)	Severe Storms and Tornadoes	Johnson, Knox, Madison, Marion, Monroe, Morgan, and Posey.	Bartholomew, Blackford, Brown, Daviess, Decatur, Delaware, Fayette, Franklin, Gibson, Grant, Greene, Hamilton, Hancock, Hendricks, Henry, Jay, Johnson, Knox, Lawrence, Madison, Marion, Monroe, Morgan, Owen, Pike, Posey, Randolph, Vanderburgh, Shelby, Sullivan, Tipton, and Vanderburgh.	$3,579,584	Not Avail.
1165	3/6/1997 (2/28-3/31/1997)	Severe Storms/ Flooding	Clark, Crawford, Dearborn, Floyd, Harrison, Jefferson, Ohio, Perry, Posey, Spencer, Switzerland,	Clark, Crawford, Dearborn, Floyd, Harrison, Jefferson, Ohio, Perry, Posey, Spencer,	Not Avail.	Not Avail.

DR #*	Declaration Date	Disaster Description	Counties Included for Public Assistance	Counties Included for Individual Assistance	Public Assistance ($)	Individual Assistance ($)
			Vanderburgh, and Warrick.	Switzerland, Vanderburgh, and Warrick.		
1125	7/3/1996 (4/28-5/25/1996)	Flooding	Brown, Crawford, Daviess, De Kalb, Dearborn, Dubois, Franklin, Gibson, Jefferson, Knox, Martin, Montgomery, Ohio, Orange, Perry, Pike, Posey, Putnam, Ripley, Steuben, Sullivan, Switzerland, Union, Vanderburgh, Warrick, Washington, and Whitley.	Crawford, Dearborn, Franklin, Harrison, Lawrence, Martin, Montgomery, Orange, Posey, Vanderburgh, Warrick, and Washington.	Not Avail.	Not Avail.
891	1/5/1991 (12/28-1/22/1991)	Flooding, Severe Storm	Adams, Allen, Bartholomew, Benton, Brown, Clark, Clinton, Daviess, Dearborn, Fayette, Franklin, Gibson, Grant, Greene, Hamilton, Howard, Jefferson, Jennings, Knox, La Porte, Lake, Madison, Marion, Marshall, Martin, Montgomery, Morgan, Newton, Owen, Parke, Perry, Pike, Posey, Pulaski, Vanderburgh, Saint Joseph, Shelby, Starke, Steuben, Sullivan, Tippecanoe, Vanderburgh, Vermillion, Vigo, Warren, and Wells.	Adams, Allen, Bartholomew, Benton, Blackford, Boone, Brown, Carroll, Clark, Clinton, Daviess, De Kalb, Dearborn, Decatur, Delaware, Elkhart, Fayette, Floyd, Fountain, Franklin, Fulton, Gibson, Grant, Greene, Hamilton, Hancock, Harrison, Henry, Howard, Huntington, Jasper, Jay, Jefferson, Jennings, Johnson, Knox, Kosciusko, La Porte, Lake, Madison, Marion, Marshall, Martin, Miami, Monroe, Montgomery, Morgan, Newton, Noble, Owen, Parke, Perry, Pike, Porter, Posey, Pulaski, Randolph, Saint Joseph, Scott, Shelby, Spencer, Starke, Steuben, Sullivan, Switzerland, Tippecanoe, Tipton, Vanderburgh, Vermillion, Vigo, Warren, and Wells .	Not Avail.	Not Avail.
Emergency Declarations						
EM-3238	9/10/2005 (8/29-10/1/2005)	Hurricane Katrina Evacuation	Statewide-All Counties	None	$2,130,479	None

DR #*	Declaration Date	Disaster Description	Counties Included for Public Assistance	Counties Included for Individual Assistance	Public Assistance ($)	Individual Assistance ($)
EM-3197	1/11/2005	Snow	Bartholomew, Blackford, Brown, Clark, Crawford, Daviess, Dearborn, Decatur, Delaware, Dubois, Fayette, Floyd, Franklin, Gibson, Greene, Hamilton, Hancock, Harrison, Henry, Jackson, Jay, Jefferson, Jennings, Johnson, Knox, Lawrence, Madison, Marion, Martin, Monroe, Morgan, Ohio, Orange, Owen, Perry, Pike, Posey, Randolph, Ripley, Vanderburgh, Scott, Shelby, Spencer, Sullivan, Switzerland, Union, Vanderburgh, Warrick, Washington, and Wayne .	None	$5,819,086	None

Source: Federal Emergency Management Agency, www.fema.gov; *DR # = Disaster Number; Note: Incident dates are in parentheses.

It is also important to note that the federal government may issue a disaster declaration through the U.S. Department of Agriculture and/or the Small Business Administration, as well as through FEMA. The quantity and types of damage are the factors that determine whether such declarations are issued.

The U.S. Department of Agriculture (USDA) provides assistance to farmers and other rural residents, as the result of natural disasters. Agricultural-related disasters are quite common. One-half to two-thirds of the counties in the United States have been designated as disaster areas in each of the past several years. Agricultural producers may apply for low-interest emergency loans in counties named as primary or contiguous in a disaster designation.

USDA Secretarial disaster designations must be requested of the Secretary of Agriculture by a governor or the governor's authorized representative, or by an Indian Tribal Council leader. From 2005-2010, Vanderburgh County has had two primary and five contiguous USDA Secretarial disaster designations as summarized in Table 3.2.

Table 3.2 USDA Disaster Declarations in Vanderburgh County 2005-2010

Designation Number	Description	Primary or Contiguous Designation	Start Date	End Date
S3229	Severe Storms, excessive rainfall, and severe flooding	Contiguous	4/17/2011	Continuing
S3087	Drought	Primary	08/01/2010	12/31/2010
S3045	Drought	Contiguous	08/01/2010	Continuing
S2657	Drought	Primary	06/05/2007	11/07/2007
S2594	Drought	Contiguous	02/01/2007	01/31/2008
S2587	Below Normal Temperature, Winter Storm	Contiguous	04/04/2007	04/10/2007
S2522	Below Normal Temperature, Winter Storm	Contiguous	04/05/2007	04/10/2007
S2221	Drought	Contiguous	05/01/2005	08/31/2005

Source: http://www.rurdev.usda.gov/rd/disasters/

The Small Business Administration provides disaster assistance to families and businesses through their Disaster Assistance Program. The mission of this program is to offer financial assistance to those who are trying to rebuild their homes and businesses in the aftermath of a disaster. By offering low-interest loans, the SBA is committed to long-term recovery efforts. SBA is also committed to mitigation, and has additional loan programs to help reduce future losses.

An SBA declaration may be requested by State Governor. When the Governor's request for assistance is received, a survey of the damaged area(s) is conducted with State and local officials, and the results are submitted to the Administrator for a decision. When the

Administrator of SBA declares an area, both primary and adjacent counties are eligible for the same assistance.

SBA Declarations Including Vanderburgh County:

- August 1, 2010-December 31, 2010— Small businesses were eligible for federal disaster loans from the Small Business Administration for financial loss due to drought from August 1, 2010 through the end of the year. The declaration made small businesses, small agricultural cooperatives, and nurseries eligible for loans through the Economic Injury Disaster Loan program.
- June 1, 2008-January 8, 2009—Small businesses in Indiana are eligible for federal disaster loans from the Small Business Administration for financial loss due to drought and strong winds since June 1, 2008
- June 5, 2007-January 31, 2008—Small businesses in 84 Indiana counties are eligible for federal disaster loans from the Small Business Administration for losses in revenue due to drought from June 5, 2007 through November 7, 2007
- April 1, 2003-July 15, 2003--#9Y28 – Excessive rainfall and cool temperatures that occurred from April 1, 2003 through July 15, 2003.
- July 4, 2003-August 6, 2003--#3526/9W29 – Severe storms, tornadoes and flooding that occurred July 4, 2003 through August 6, 2003.

3.1.2 Research Additional Sources

Additional data on the past impacts of hazards in the planning area was collected from the following sources:

- Indiana State Hazard Mitigation Plan (November 2008)
- Evansville-Vanderburgh County Community Comprehensive Hazard Analysis (2010)
- Evansville-Vanderburgh County Stormwater Master Plan
- National Weather Service Weather Forecast Office, Paducah, Kentucky
- Vanderburgh County Flood Insurance Study (March 17, 2011)
- Information on past hazard events from the Spatial Hazard Event and Loss Database (SHELDUS), a component of the University of South Carolina Hazards Research Lab that compiles county-level hazard data for 18 different natural hazard event types
- Information on past extreme weather and climate events from the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center
- Disaster declaration history from the Federal Emergency Management Agency (FEMA), the Public Entity Risk Institute, and the USDA Farm Service Agency Disaster Declarations
- The National Drought Mitigation Center Drought Reporter
- Information provided by members of the Hazard Mitigation Planning Committee
- Various articles and publications available on the internet
  (sources are indicated where data is cited)

3.1.3 Review of Existing Mitigation Plans

The Hazard Mitigation Planning Committee (HMPC) reviewed data and discussed the impacts of each of the hazards included in the 2004 Vanderburgh County Hazard Mitigation Plan, as well as the State of Indiana Hazard Mitigation Plan. Table 3.3 below provides a comparison of the hazards included in these two plans:

Table 3.3 Hazards Included in 2004 Plan and State Plan

2004 Vanderburgh County Hazard Mitigation Plan	State of Indiana Hazard Mitigation Plan
Drought / Wildfires	Not Included
Earthquake / Liquefaction and Ground Motion Amplification	Earthquakes
Extreme Temperatures	Not Included
Flood / Dam and Levee Failure	Flooding/Dam and Levee Safety
Infestations	Not Included
Mine Subsidence	Not Included
Severe Weather	
- Extreme Temperatures	Not Included
- Thunderstorms / High Winds	Combined with Tornado
- Tornadoes	Tornadoes/Straight-line Winds
Winter Storms	Winter Storms

3.1.4 Hazards Identified

After a careful review of the previous disaster declarations, the State of Indiana Hazard Mitigation Plan, and additional sources, the HMPC determined that they would make the following modifications to the hazards included in the 2004 plan:

- Wildfires would be addressed separately from drought;
- Dam and Levee Failure will be analyzed separate from flood and separate from each other;
- Infestations will include the Emerald Ash Borer; and
- Manmade Hazards will continue to not be profiled in this plan as they are addressed in the Comprehensive Emergency Management Plan.

Therefore, the HMPC identified 13 natural hazards that significantly affect the planning area. These hazards are listed below with an "X" indicating the affected jurisdictions in Table 3.4. Each of these hazards is profiled in further detail in the next section.

Table 3.4 Hazards Identified for Each Participating Jurisdiction

Hazard	Vanderburgh County	Darmstadt	Evansville	Evansville-Vanderburgh School Corporation
Drought	X	X	X	X
- Wildfires	X	X	X	X
Earthquake	X	X	X	X
Flood	X		X	X
- Dam Failure	X		X	X
- Levee Failure	X		X	X
Infestation				
- West Nile	X	X	X	X
- Emerald Ash Borer	X	X	X	X
Mine Subsidence	X		X	X
Severe Weather				
- Extreme Temperatures	X	X	X	X
- Thunderstorms/High Winds	X	X	X	X
- Tornadoes	X	X	X	X
- Winter Storms	X	X	X	X

Multi-Jurisdictional Risk Assessment

For this multi-jurisdictional plan, the risk assessment assesses each jurisdiction's risks where they deviate from the risks facing the entire planning area. Vanderburgh County is 235.74 square miles and is fairly uniform in terms of climate and topography as well as construction characteristics and development trends. Accordingly, overall risk to hazards does not vary greatly across the planning area for hazards that do not have geographically-specific hazard boundaries. Weather-related hazards, such as drought, extreme temperature, thunderstorms/high winds, tornadoes, and winter storms, affect the entire planning area. In addition, Emerald Ash Borer has the potential to affects the entire planning area.

The hazards that do have specific geographic risk areas and the potential to vary across the planning area include: dam failure, earthquake, flood, levee failure, mine subsidence, and wildfires. In Section 3.2, Hazard Profiles, the Geographic Location section discusses how the hazard varies among jurisdictions across the planning area. The Previous Occurrences section lists the best available data on where past events have occurred and the associated losses to particular jurisdictions. Section 3.3.2, Community Asset Inventory, describes critical facilities and other community assets by jurisdiction. Section 3.3.3, Vulnerability by Hazard, identifies structures and estimates potential losses by jurisdiction where data is available and hazard areas are identified for hazards of moderate and high planning significance.

The previous chapter, Chapter 2 Planning Area Profile and Capabilities, discussed the existing mitigation capabilities of each jurisdiction, such as plans and policies, personnel, and financial resources, which are or could be used to implement measures to reduce hazard losses.

3.2 Hazard Profiles

Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the…location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

Methodology

Each hazard identified in Section 3.1 Hazard Identification is profiled individually in this section. The level of information presented in the profiles varies by hazard based on the information available. With each update of this plan, new information will be incorporated to provide for better evaluation and prioritization of the hazards that affect Vanderburgh County.

The sources used to collect information for these profiles include those mentioned in Section 3.1.1 as well as those cited individually in each hazard section.

Detailed profiles for each of the identified hazards include information categorized as follows:

Hazard Description

This section consists of a general description of the hazard and the types of impacts it may have on a community.

Geographic Location

This section describes the geographic extent or location of the hazard in the planning area. Where available, maps are utilized to indicate the areas of the planning area that are vulnerable to the subject hazard. The geographic location was assigned a rank as defined in the following manner:

- **Extensive**—50-100 percent of planning area affected.
- **Significant**—10-50 percent of planning area affected.
- **Limited**—less than 10 percent of planning area affected.

Previous Occurrences

This section includes information on historic incidents and their impacts based upon the sources described in Section 3.1 Hazard Identification and the information provided by the Hazard Mitigation Planning Committee.

Probability of Future Occurrence

The frequency of past events is used to gauge the likelihood of future occurrences. Where possible, the probability or chance of occurrence was calculated based on historical data. Probability was determined by dividing the number of events observed by the number of years and multiplying by 100. This gives the percent chance of the event happening in any given year. An example would be three droughts occurring over a 30-year period, which suggests a 10 percent chance of a drought occurring in any given year. The probability was assigned a rank as defined in the following manner:

- **Highly Likely**—Near 100 percent chance of occurrence next year or happens every year.
- **Likely**—10-100 percent chance of occurrence in next year or has a recurrence interval of 10 years or less.
- **Occasional**—1-10 percent chance of occurrence in the next year or has a recurrence interval of 11 to 100 years.
- **Unlikely**—Less than 1 percent chance of occurrence in next 100 years or has a recurrence interval of greater than every 100 years.

Magnitude/Severity

The magnitude of the impact of a hazard event (past and perceived) is related directly to the vulnerability of the people, property, and the environment it affects. This is a function of when the event occurs, the location affected the resilience of the community, and the effectiveness of the emergency response and disaster recovery efforts.

The magnitude of each profiled hazard is classified in the following manner:

- **Catastrophic—**Multiple deaths; property destroyed and severely damaged; and/or interruption of essential facilities and service for more than 72 hours.
- **Critical—**Isolated deaths and/or multiple injuries and illnesses; major or long-term property damage that threatens structural stability; and/or interruption of essential facilities and services for 24-72 hours.
- **Limited—** Minor injuries and illnesses; minimal property damage that does not threaten structural stability; and/or interruption of essential facilities and services for less than 24 hours.
- **Negligible—**No or few injuries or illnesses; minor quality of life loss; little or no property damage; and/or brief interruption of essential facilities and services.

3.2.1 Drought

Description

A drought is a period of drier-than-normal conditions that result in water-related problems. Precipitation (rain or snow) falls in uneven patterns across the country. The amount of precipitation at a particular location varies from year to year but, over a period of years, the average amount is fairly constant. The average monthly precipitation for Evansville, Vanderburgh County, is presented in Table 3.5 below.

Table 3.5 Precipitation Summary (inches), 1971-2000 National Climatic Data Center Normals

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Evansville Museum	3.14	3.27	4.50	4.54	4.78	4.21	4.11	3.10	3.17	2.96	4.30	3.68	45.76
Evansville Regional Airport	2.91	3.10	4.29	4.48	5.01	4.10	3.75	3.14	2.99	2.78	4.18	3.54	44.27

Source: Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1971 – 2000, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data and Information Service, National Climatic Data Center, Asheville, NC, http://cdo.ncdc.noaa.gov/climatenormals/clim81/INnorm.pdf

When no rain or only a very small amount of rain falls, soils can dry out and plants can die. When rainfall is less than normal for several weeks, months or years, the flow of streams and rivers declines and the water levels in lakes reservoirs and wells fall. If dry weather persists and water-supply problems develop, the dry period can become a drought. Lower river levels can also cause transportation interruptions on navigable streams.

The beginning of a drought is difficult to determine. Several weeks, months, or even years may pass before people recognize that a drought is occurring. The end of a drought can occur as gradually as it began. Dry periods can last for 10 years or more. The first evidence of drought usually is seen in records of rainfall. Within a short period of time, the amount of moisture in soils can begin to decrease. The effects of a drought on flow in streams and rivers or on water levels in lakes and reservoirs may not be noticed for several weeks or months. Water levels in wells may not reflect a shortage of rainfall for a year or more after a drought begins.

In 1994, the Indiana Department and Natural Resources prepared Indiana's Water Shortage Plan. In July 2009, this plan was revised incorporating input from a variety of stakeholders that comprise the Water Shortage Task Force. The plan includes triggers to identify the onset of a water shortage and appropriate response actions, including water use priorities and conservation tools.

The Water Shortage Plan establishes nine “Water Shortage Identification Regions” that correspond to the nine climate divisions determined by the National Weather Service. As shown in Figure 3.1, Vanderburgh County is in Water Shortage Identification Region Seven.

Figure 3.1. Water Shortage Identification Regions

Source: Indiana's Water Shortage Plan, June 2009, http://www.in.gov/dnr/files/watshplan.pdf

The Water Shortage Plan also establishes "Water Shortage Stages": Normal, Watch, Warning and Emergency. These stages are based on 3 variables: (1) Standardized Precipitation Index (SPI), the U.s. Drought Monitor, and below normal percentiles of regionalized monthly average streamflow.

Standardized Precipitation Index (SPI): For the purposes of Indiana's Water Shortage Plan, a monthly SPI value is computed for each of the State's nine climatic regions. The Standardized Precipitation Index was developed in 1993 and is a simple index that is calculated for any location based on the long-term precipitation record (typically 30 years or greater). This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero. Positive SPI values indicate greater than median precipitation (i.e. wet conditions), and negative values indicate less than median precipitation (i.e. dry conditions). Values of the SPI normally range from +2 to -2. An index of +2.0 or greater indicates extremely wet conditions; +1.99 to +1.50, very wet conditions; +1.49 to 1.00, moderately wet; +0.99 to -0.99, near normal to abnormally dry; -1.0 to -1.49, moderately dry; -1.50 to -1.99, severely dry; and -2 and less, extremely dry. Standardized Precipitation Index values for Indiana are prepared for each of the nine climatologic divisions on a monthly basis.

U.S. Drought Monitor: The U.S. Drought Monitor began in 1999 and is a synthesis of multiple climate monitoring tools as well as the informed judgments of its authors and federal, state, and academic reviewers across the country. The U.S. Drought Monitor Map is produced weekly and summarizes information onto a single, easy-to-read colored map. The Drought Monitor Map identifies general drought areas, labeling droughts by intensity, with D1 being the least intense and D4 being the most intense.The data cutoff for Drought Monitor maps is Tuesday at 7 a.m. Eastern Standard Time. The maps, which are based on analysis of the data, are released each Thursday at 8:30 a.m. Eastern Time. The map released the first Thursday of the month will be used as a drought indicator for the previous month's water shortage stages.

Sreamflow: The U.S. Geological Survey, in cooperation with the Department of Natural Resources and a number of other Federal, State and Local agencies, maintains a network of approximately 190 gaging stations in Indiana. Twenty-eight of these stations are used to monitor drought conditions. There are four stations in climate division 7 that includes Vanderburgh County. They are: Wabash River at Riverton, East Fork White River at Shoals, White River at Petersburg, and Wabash River at Mt. Carmel. Streamflow at the 25th percentile means that streamflow is only 25% of the historical average streamflow for that particular month. Lower percentiles correspond to increasingly lower streamflow and drought conditions.

The stage is defined as Normal if no more than one indicator is outside the normal range. The stages and associated criteria are provided in Table 3.6.

Table 3.6 Water Shortage Stages and Criteria

Water Shortage Stages	1-Month Standardized Precipitation Index	U.S. Drought Monitor (Conditions)	Streamflow As Percentile of Normal (Average Streamflow)
Normal	+0.99 to -0.99	None to D0	Greater than or equal to 25
Watch	-1.00 to -1.49	D1	10 to 24
Warning	-1.50 to -1.99	D2	6 to 9
Emergency	-2.00 or less	D3 to D4	5 or less

Source: Indiana's Water Shortage Plan, June 2009, http://www.in.gov/dnr/files/watshplan.pdf

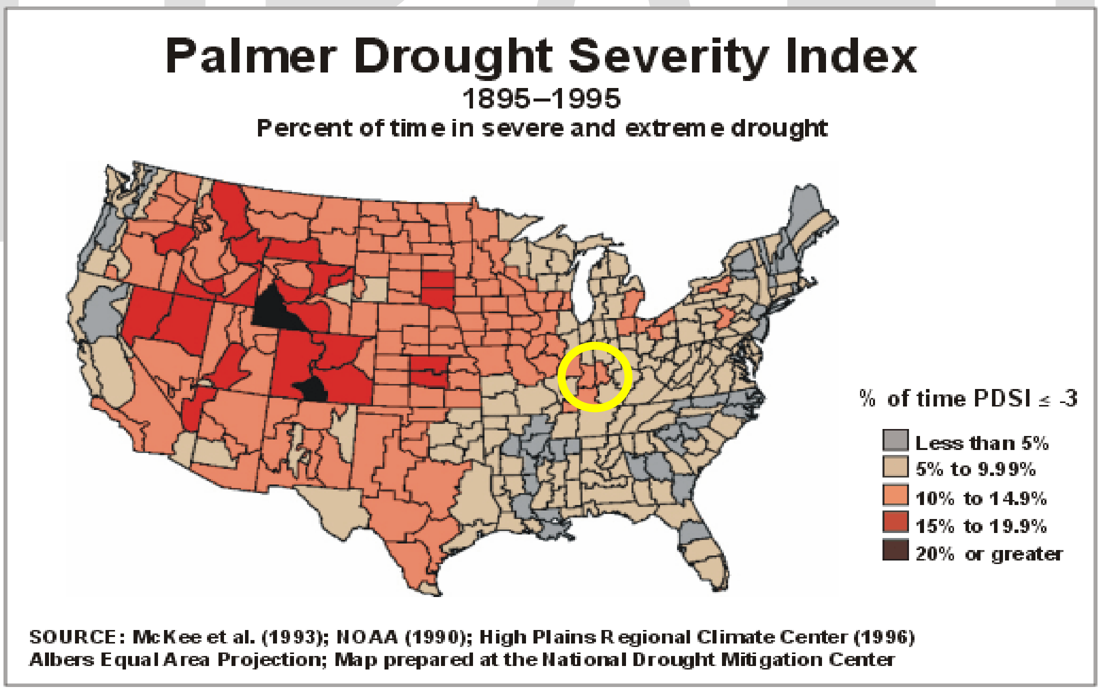
Another common indicator of drought is the Palmer Drought Severity Index (PDSI). The PDSI is a soil moisture algorithm calibrated for relatively homogeneous regions. It is used by many U.S. government agencies and states to trigger drought relief programs. It was also the first comprehensive drought index developed in the United States. The classifications of the PDSI are presented in Table 3.7 below.

Table 3.7 Palmer Classifications

Palmer Classifications	
4.0 or more	extremely wet
3.0 to 3.99	very wet
2.0 to 2.99	moderately wet
1.0 to 1.99	slightly wet
0.5 to 0.99	incipient wet spell
0.49 to -0.49	near normal
-0.5 to -0.99	incipient dry spell
-1.0 to -1.99	mild drought
-2.0 to -2.99	moderate drought
-3.0 to -3.99	severe drought
-4.0 or less	extreme drought

The PDSI indicates that for the period of 1895 through 1995 the southwestern portion of Indiana was in a severe to extreme drought 10 to 15 percent of the time (Figure 3.2). During periods of drought, the Governor has called for a ban of open burning in an effort to reduce the risk of wildfire (see Wildfire).

Figure 3.2. Palmer Drought Severity Index, 1895-1995



Geographic Location

Drought tends to affect broad regions and the entire planning area is subject to drought occurrence at roughly equal probability. The impacts of prolonged drought are most significant in agricultural areas of the County. According to the 2007 Census of Agriculture, 71,927 acres in Vanderburgh County are used for agricultural purpose. This translates to nearly 48% percent of all land in the county.

Additionally, drought can severely limit public water supplies due to depletion of natural water sources and greatly increased demand. Problems due to limited treatment capacity or limited distribution system capacity are an additional concern.

Therefore, the geographic location of this hazard is **extensive,** 50-100 percent of planning area is affected.

Previous Occurrences

Historical information on previous periods of drought and drought impacts was obtained from three primary sources, the USDA Secretarial disaster designations for drought, University of Nebraska's National Drought Mitigation Centers Drought Impact Reporter and the National Oceanic Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC).

Previous drought impacts in Vanderburgh County, Indiana are summarized below:

- **August 1-December 31, 2010**—The U.S. Department of Agriculture designated 52 counties in Indiana as natural disaster areas because of losses caused by drought. Vanderburgh County was included in this declaration as a primary county (S3087).
- **October 2010**—Drought conditions triggered the state's Water Shortage Plan into effect. Twenty-six counties were under a water shortage warning and Twenty-two counties, including Vanderburgh County were in a water shortage watch. In addition, 72 counties, including Vanderburgh County, were placed under outdoor burning restrictions (Drought Impact Reporter).
- **June 5, 2007-November 7, 2007**—The U.S. Department of Agriculture designated 84 counties in Indiana as natural disaster areas because of losses caused by drought. Vanderburgh County was included in this declaration as a primary county (S2675).
- **May 5, 2005-August 31, 2005**—The U.S. Department of Agriculture designated portions of the State a natural disaster area due to losses caused by drought. Vanderburgh County was included in this declaration as a contiguous county (S2221).
- **September 22, 2004**—This was the driest September on record for southwest Indiana. At Evansville, the monthly rainfall was only 0.09 inch, which broke the old September record of 0.25 inch set in 1928. This was the third driest month on record at Evansville, where records extend back to 1897. The dry weather turned lawns and fields brown. The dry weather set in too late to harm crops. In fact, the timing of the dry weather helped farmers harvest a bountiful crop (NCDC).

- **September 1, 2002**—A prolonged summer drought gradually worsened, becoming severe by early September. Many parts of southwest Indiana received little or no measurable rainfall during August. At Boonville, only 0.08 inch was measured in August. Evansville reported an August total of 0.63 inch. Rainfall was highly variable during the summer, and Evansville reported more rain than many other sites. The main effect of the drought was on agriculture. Crop loss estimates totaled around 70 million dollars. The corn crop, which was especially susceptible to the combined effects of heat and drought, took the biggest hit. About 50 million dollars in corn was lost in southwest Indiana. Another 20 million dollars was lost in soybean production. Some trees and shrubs died in the drought, especially newly planted ones with shallow root systems. However, the effect of this drought on trees, shrubs, and wildfire danger was considerably less than the drought of 1999. The remnants of Tropical Storm Isidore provided very heavy rainfall late in September. One to three inches of rain fell over most of southwest Indiana, which greatly eased the drought.
- **August 1, 2002**—Moderate drought conditions developed over southwest Indiana during August as a result of persistent dryness that began in June. At Boonville, which is about 15 miles east of Evansville, total rainfall during the month of August was 0.08 inches. Evansville reported 0.63 inches during the month, compared to a normal of 3.14 inches. This dry period came on the heels of a very wet first half of the year, when 24.90 inches fell from January through May. The main effect of the drought was on agriculture. Farmers anticipated substantial crop losses at harvest time. Heavy spring rains delayed planting of many crops until late May, which made them especially susceptible to the summer drought.
- **December 1, 1999**—Moderate drought conditions continued to plague southwest Indiana into early winter. Heavy rainfall during mid month, up to 4 inches in some places, brought significant relief. Until then, wildfire danger was especially high. The Christmas tree crop was damaged by the long-term drought. Most tree seedlings died, but the larger trees fared remarkably well.
- **November 1, 1999**—The unseasonably warm and dry fall allowed drought conditions to worsen. The Palmer Drought Index fell deeper into the moderate drought category during the month. Total rainfall for the month of November at Evansville was 0.51 inches, which is 3.22 inches below normal. Since the official growing season was over, crop damage was no longer a major concern. As a result of temperatures in the 70s, gusty winds, and low humidity, wildfire activity was well above normal. Upon receiving a recommendation from the governor of Indiana, most counties in Southwest Indiana banned outdoor burning. Two of the largest fires occurred in rural Warrick and Spencer Counties, east of Evansville. These fires were near Elberfeld in Warrick County and near Gentryville in Spencer County. The fire near Gentryville consumed about 100 acres and required assistance from Warrick County firefighters.
- **October 1, 1999**—The moderate to severe summer-long drought was greatly alleviated by heavy rain on October 8th and 9th, when 2 to 4 inches of rain fell during a 24-hour period. Unfortunately, no more rain occurred during the rest of October, which rekindled drought concerns. Before the heavy rain, a couple of wildland fires occurred in Spencer County

during the first week of October. They were both field fires and were under control within several hours. The governor of Indiana lifted the burning ban once rainy conditions began.

- **September1, 1999**—The moderate summer drought took a considerable toll on crops across Southwest Indiana. Rainfall at Evansville for the three-month period from July through September was about 3 inches. This compares to a 3-month average of around 10 inches. Evansville received 0.39 inches in September, which was 3 inches below normal. The soybean crop suffered the greatest effects from the drought, with average yields estimated only about 20 percent of normal. Corn yields were much closer to normal, mainly due to heavy rains in June and early July, when the corn crop matures. The fire danger reached extreme levels at times. The governor of Indiana declared a total burning ban across all of Southwest Indiana. A wildland fire in mid-September scorched several hundred acres near Chandler, which is in Warrick County. A field fire early in the month occurred near Evansville at the junction of Interstate 164 and U.S. Highway 41. Although no evacuations were required, the westbound lanes of Interstate 164 were closed briefly due to smoke. A wildfire on September 27 burned about 150 acres just west of Owensville in Gibson County. Fire departments from throughout Gibson County and parts of Posey County worked to extinguish this fire.
- **August 1, 1999**—After one of the wettest Junes on record, the rest of the summer was very dry. By the end of August, Southwest Indiana was in a moderate drought, according to the Palmer Drought Index. Total rainfall at Evansville from July 1 through the end of August was around 2.5 inches, which is less than one third of the normal rainfall. Effects on crop yields were mild. The greatest effect was on soybeans, which mature relatively late. The corn crop fared relatively well, mainly due to heavy spring rains, which allowed it to mature before the drought set in. In those areas where drinking water supplies were taken from the Ohio River, a degradation in water quality occurred. This degradation was due to nearly stagnant river flows, which contributed to algae buildups that gave the water a poor taste and appearance. The dry weather raised fire danger into the high category at times. A number of brush and field fires occurred, including one near the junction of Interstate 64 and U.S. 41. A couple of bean and corn field fires scorched 5 to 10 acres each.
- **1999**—Palmer Index within report places Vanderburgh County in the worst drought since 1952 to 1957 episode. Bans on burning were issued in both 2002 and 1999.
- **1988**—Most of the State of Indiana was under extreme temperatures and prolonged periods of little or no rain. Several hundreds of thousands of dollars in crops and agricultural losses.
- **1986-1988**—Nationwide attention. Affecting agriculture, water supply, and electric-power generation
- **April 1962-November 1966**—Streamflow less than 7-day, 10-year value. Floods occurred in 1963 and 1964 in central and southern Indiana.
- **April 1952-March 1957**—Streamflow less than 7-day, 10-year value. Broken in northern Indiana in Oct. 1954 by floods.
- **May 1939-January 1942**—Central Indiana severely affected. Most streams had less flow than 7-day, 10-year value

- **June 1933-September 1936**—Streamflow less than 7-day, 10-year value in central and northern Indiana
- **March 1930-August 1931**—Began decade of low-flow conditions. Streamflow generally greater than 7-day, 10-year value in central and northern Indiana.

According to the USDA's Risk Management Agency, insured crop losses in Vanderburgh County as a result of drought conditions from 2001 to 2010 totaled $1,231,487. As of 2009, 71 percent of insurable crop acreage was insured. Crop insurance claims as a result of drought are detailed in Table 3.8 below.

Table 3.8 Claims Paid in Vanderburgh County for Crop Loss as a Result of Drought (2001-2010)

Year	Crop	Hazard	Claims Paid
2010	Corn	Drought	$259,592
2010	Soybeans	Drought	$84,020
2008	Corn	Drought	$94,181
2008	Soybeans	Drought	$34,672
2007	Corn	Drought	$110,511
2007	Soybeans	Drought	$354,833
2006	Corn	Drought	$11,530
2005	Corn	Drought	$12,119
2004	Corn	Drought	$1,371
2003	Corn	Drought	$9,422
2002	Corn	Drought	$122,754
2002	Soybeans	Drought	$129,723
2001	Soybeans	Drought	$5,624
2008	Soybeans	Failure Irrigation Supply	$1,135
	Total		**$1,231,487**

Source: USDA Risk Management Agency, 2011

Probability of Future Occurrences

Lack of precipitation for a given area is the primary contributor to drought conditions. Since precipitation levels cannot be predicted in the long term, it is difficult to determine the probability of future occurrences of drought. Figure 3.2 shows the Palmer Drought Severity Index for the U.S. from 1895-1995. Vanderburgh County is in a region of central Indiana that experienced severe and extreme drought 10-15 percent of the time during that 100-year period. Considering this historical data as well as more recent periods of drought, the HMPC determined the probability of future occurrence of drought to be **likely,** 10-100 percent chance of occurrence in next year or has a recurrence interval of 10 years or less.

Magnitude/Severity

Drought impacts are wide-reaching and may be economic, environmental, and/or societal. The most significant impacts associated with drought in Indiana are those related to agriculture. A prolonged drought could have severe economic impacts.

Drought conditions can also cause soil to compact and not absorb water well, potentially making an area more susceptible to flooding. An ongoing drought may also leave an area more prone to wildfires.

The magnitude/severity for this hazard is **negligible**, no or few injuries or illnesses; minor quality of life loss; little or no property damage; and/or brief interruption of essential facilities and services.

3.2.2 Wildfire

Description

Heavily wooded or forested areas cover approximately 12 percent of Vanderburgh County's total land area. However, when the conditions are right, these areas become vulnerable to devastating wildfires. Also, in the last few decades, the risks associated with Vanderburgh County's wildfire hazard have increased dramatically due to the increase in wildland-urban interface (areas where development occurs within or immediately adjacent to wildlands, near fire-prone trees, brush, and/or other vegetation), more and more structures and people are at risk. On occasion, ranchers and farmers intentionally ignite vegetation to restore soil nutrients or alter the existing vegetation growth. These fires have the potential to erupt into wildfires. But the main culprit of wildfires in the County is caused by careless or unintentional activities of people. These fires start in or near where people live or where people choose to do recreational activities.

Generally, there are three major factors that sustain wildfires and allow for predictions of a given area's potential to burn. These factors include:

- Fuel;
- Topography; and
- Weather.

Fuel is the material that feeds a fire and is a key factor in wildfire behavior. Fuel is generally classified by type and by volume. Fuels sources are diverse and include everything from dead tree needles, twigs, and branches to dead standing trees, live trees, brush, and cured grasses. Man-made structures and other associated combustibles are also to be considered as a fuel source. The type of prevalent fuel directly influences the behavior of wildfire. Light fuels such as grasses burn quickly and serve as a catalyst for spreading wildfires.

An area's topography (terrain and land slopes) affect its susceptibility to wildfire spread. Fire intensities and rates of spread increase as slope increases due to the tendency of heat from a fire to rise via convection. The natural arrangement of vegetation throughout a hillside can also contribute to increased fire activity on slopes

Weather components such as temperature, relative humidity, wind, and lightning also affect the potential for wildfire. High temperatures and low relative humidity dry out the fuels that feed the wildfire creating a situation where fuel will more readily ignite and burn more intensely. Wind is the most treacherous weather factor. The issue of drought conditions contributes to concerns about wildfire vulnerability.

Geographic Location

In general, Indiana has two fire seasons a year: in the spring when the leaf litter on the ground dries out and before young herbaceous plants start to grow and cover the ground (green up); and in the fall after the leaves come down and before they are wetted down by the first heavy snow.

With 12-percent of the total land area heavily wood, the geographic location was assigned a rank of s**ignificant,** 10-50 percent of planning area affected.

Previous Occurrences

According to the data supplied to the Indiana Department of Natural Resources, Division of Forestry, Fire Control Headquarters, Vanderburgh County had 91 rural fires that burned 141.7 acres. The rural and volunteer fire districts that submitted data were the: Scott Township Fire Department, Scott Township Volunteer Fire Department, Perry Township Volunteer Fire Department, German Township Volunteer Fire Department, and Knight Township Volunteer Fire Department. The main cause of the wildfires were from debris burning, followed by smoking, sparks by the railroad line, equipment, and three from lightning strikes. Table 3.9 below details wildfire occurrences in Vanderburgh County from 1994-2008.

Table 3.9 Wildfires, Vanderburgh County, 1994-2008

Year	# Fires	Acres Burned
1994	1	10
1995	8	4.75
1996	6	29
1997	12	3.5
1998	*	*
1999	3	18.35
2000	15	5.2
2001	5	1.7
2002	*	
2003	*	
2004	*	
2005	*	
2006	11	2.5
2007	10	2.5
2008	19	64.2
Totals	**91**	**141.7**

Source: Indiana Department of Natural Resources, Division of Forestry, Fire Control Headquarters
* No wildfires reported.

Also the City of Evansville Environmental Protection Agency has the authority to issue bans on open burning in the area of its jurisdiction (City of Evansville and six miles out in the County) when conditions warrant the ban. Then the County Commissioners will order a ban on open burning for the remainder of the County at the same time.

Probability of Future Occurrences

Wildfires occur in Vanderburgh County on an annual basis. The average number of wildfires per year for the 15-year period from 1994-2009 was 6. The planning committee anticipates that this rate of occurrence is likely to continue. Future occurrences of this hazard are likely to increase if development in wildland-urban interface areas increases. The probability was assigned a rank of **occasional,** 1-10 percent chance of occurrence in the next year or has a recurrence interval of 11 to 100 years.

Magnitude/Severity

Wildfires occur on an annual basis and are mainly caused by humans from debris burning, followed by smoking, sparks by the railroad line, equipment, and only three from a natural occurrence such as lightning strikes. Historically, the magnitude has been minimal with the largest wildfire being 25 acres. The magnitude was classified as **limited,** minor injuries and illnesses; minimal property damage that does not threaten structural stability; and/or interruption of essential facilities and services for less than 24 hours.

3.2.3 Earthquake

Description

An earthquake is a shaking or trembling of the earth's surface caused by the lifting, shifting, breaking, or slipping of a fault line. Stresses in the earth's outer layer push the sides of the fault together. Stress builds up and the rocks slip suddenly, releasing energy in waves that travel through the earth's crust and cause the shaking that is felt during an earthquake. Evansville and Vanderburgh County are subject to earthquakes because of the close proximity of two seismic zones: the New Madrid and the Lower Wabash Valley.

Geographic Location

The New Madrid Seismic Zone (NMSZ) extends from west-central Mississippi northward past Cape Girardeau, Missouri. The center of this seismic zone is in New Madrid, Missouri, which is approximately 160 miles southwest of Evansville. It is the major source of seismic activity east of the Rocky Mountains. Although activity in the New Madrid Seismic Zone is less frequent than that along the West Coast, when tremblers do occur, the destruction covers over more than 20 times the area of an equivalent West Coast earthquake because of the underlying geology. The largest earthquake in continental United States, according to the U.S. Geological Survey (USGS), occurred on the New Madrid fault in 1811.

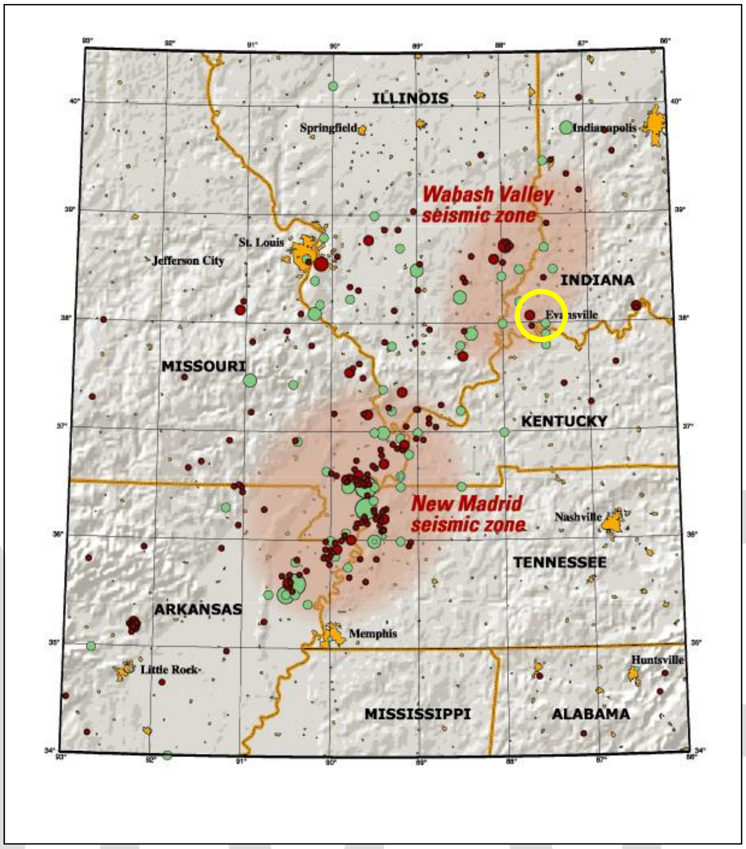
The Lower Wabash Valley Seismic Zone generally follows the Wabash River from the Ohio River north to Terre Haute, Indiana. It extends to southeastern Illinois, southwestern Indiana and parts of western Kentucky. The Wabash Valley Fault System is probably the best-documented fault system in the eastern United States due to past petroleum exploration in the area. However, seismologically it is poorly understood. This zone is considered a source of strong earthquakes with geological evidence of prehistoric earthquakes of up to magnitude 7.5. One of the largest seismic events instrumentally recorded for the Wabash Valley Seismic Zone occurred in April 2008 of at a magnitude of 5.4.

Figure 3.3 indicates the locations of the New Madrid and Lower Wabash Seismic Zones. This U.S. Geological Survey map shows earthquakes as circles. Red circles indicate earthquakes that occurred from 1974 to 2002 with magnitudes larger than 2.5. Green circles denote earthquakes that occurred prior to 1974. Larger earthquakes are represented by larger circles.

All these central United States earthquakes are being monitored and researched by multiple sources such as the U.S. Geological Survey, Center for Earthquake Research and Information at the University of Memphis, Central United Stated Earthquake Consortium, Indiana Geological Survey, Indiana University, St. Louis University, and the University of Kentucky.

Locally, Harrison High School and New Harmony School have seismic monitors installed at their schools. This seismic information is then transmitted on the Princeton Earth Physics project (PEPP) network to Indiana University for research (http://www.indiana.edu/~pepp/index.html).

Figure 3.3. New Madrid and Lower Wabash Valley Seismic Zones Earthquakes 1974-2002.



Source: U.S. Geological Survey, USGS FS-131-02. Yellow circle indicates approximate location of Evansville, Indiana.

Several methods have been developed to quantify the strength of an earthquake. The most recognized methods for measuring earthquake strength are:

Richter Magnitude is a measure of earthquake strength or the amount of energy released. This scale was originally developed by Charles Richter in 1935. Magnitude is expressed in whole numbers and decimals, with each succeeding whole number representing a tenfold increase in the energy released. There is only one Richter value calculated for the epicenter of a specific earthquake. (The epicenter is the location on the surface of the earth directly above where an earthquake originates. It is determined by measuring the amplitudes of ground motion on seismograms.)

Modified Mercalli Intensity Scale is an evaluation of the severity of ground motion at a given location measured relative to the effects of the earthquake on people and property. This scale was developed by Wood and Nueman in 1931, based on Mercalli's 1902 original version. Intensity is expressed in Roman numerals I – XII. The Mercalli scale is the most effective means of determining the approximate magnitude of a quake that occurred in historic time prior to the advent of uniform seismic detection devices and the Richter Scale.

Table 3.10 provides a comparison of the Richter Magnitude and Modified Mercalli Intensity Scales.

Table 3.10 Comparison of Richter Magnitude and Modified Mercalli Intensity Scales

Richter Magnitude	Modified Mercalli Scale	Effects
2	I – II	Usually detected only by instruments
3	III	Felt Indoors
4	IV – V	Felt by most people; slight damage
5	VI – VII	Felt by all; damage moderate
6	VII – VIII	Damage moderate to major
7	IX – X	Major damage
8+	X - XII	Total and major damage

Liquefaction

When strong earthquakes release energy, the resultant violent shaking motions may cause underground layers of saturated sandy soil to behave like a fluid under pressure. This process is called liquefaction. When the pressure forces liquefied sand to move up through cracks in the overlying soil and flow out over the surface a feature called sandblow is created. Liquefaction may cause landslides, the collapse of earthen dams, and the shifting and settling of buildings and other structures.

A diagram of a sandblow is presented in the Figure 3.4 (A). The photo in Figure 3.4 (B) shows a cross-sectional view of an ancient sandblow exposed in the bank of the Wabash River near Vincennes. After the sandblow formed, it was covered by layers of silt deposited during floods.

Figure 3.4. Example of Liquefaction Feature of Sandblow

Source: Central U.S. Earthquake Consortium

This major liquefaction feature, along the east bank of the Wabash River, was discovered in the mid 1980s. At the time of the earthquake that formed this feature, sand and gravel from a buried terrace of the Wabash River was ejected onto the surface and simultaneously captured part of a tree that had been growing along the river bank at the time. Using radio carbon dating methods, the tree was discovered to be 6,100 years old, thus the liquefaction feature is also approximately 6,100 years old. It is estimated that it would have taken at least a magnitude 7 earthquake to produce the Vincennes liquefaction feature. From field evidence at this and other sites in southwestern Indiana, it is concluded that the Lower Wabash Valley is capable of producing large and potentially damaging earthquakes. Loose soils susceptible to liquefaction are found throughout Vanderburgh County.

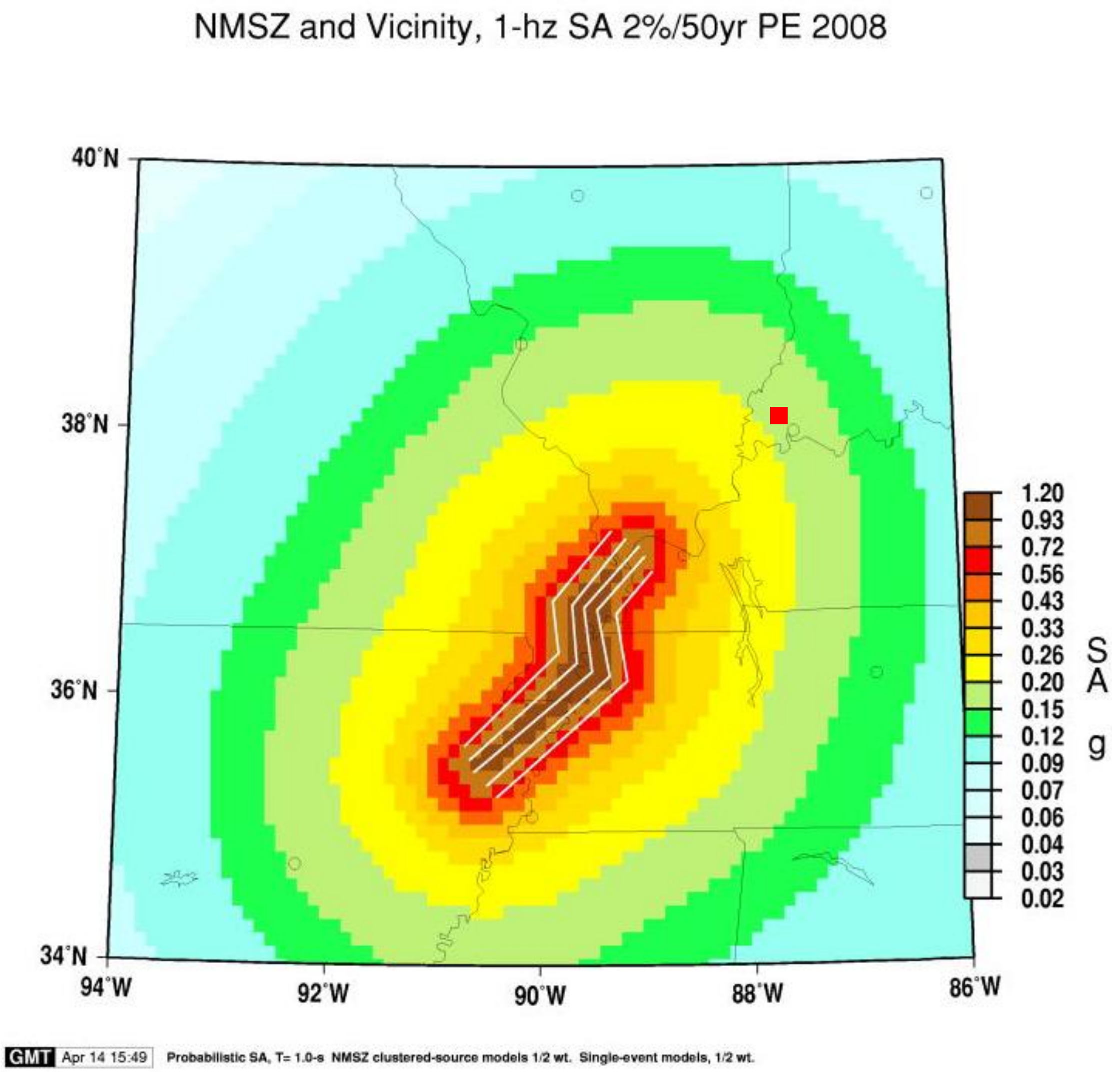
Ground Motion Amplification

Ground motion is the movement of the earth's surface due to earthquakes or explosions. It is produced by waves generated by a sudden slip on a fault or sudden pressure at the explosive source and travels through the earth and along its surface. Ground motion is amplified when surface waves of unconsolidated materials bounce off of or are refracted by adjacent solid bedrock. The New Madrid Seismic Zone hazard area is shown in Figure 3.5 which uses contour values to indicate the earthquake ground motions that have a common probability of being exceeded in 50 years.

In developing Figure 3.6, the ground motions being considered at a given location are those from all future possible earthquake magnitudes at all possible distances from that location. The ground motion coming from a particular magnitude and distance is assigned an annual probability equal to the annual probability of occurrence of the causative magnitude and distance.

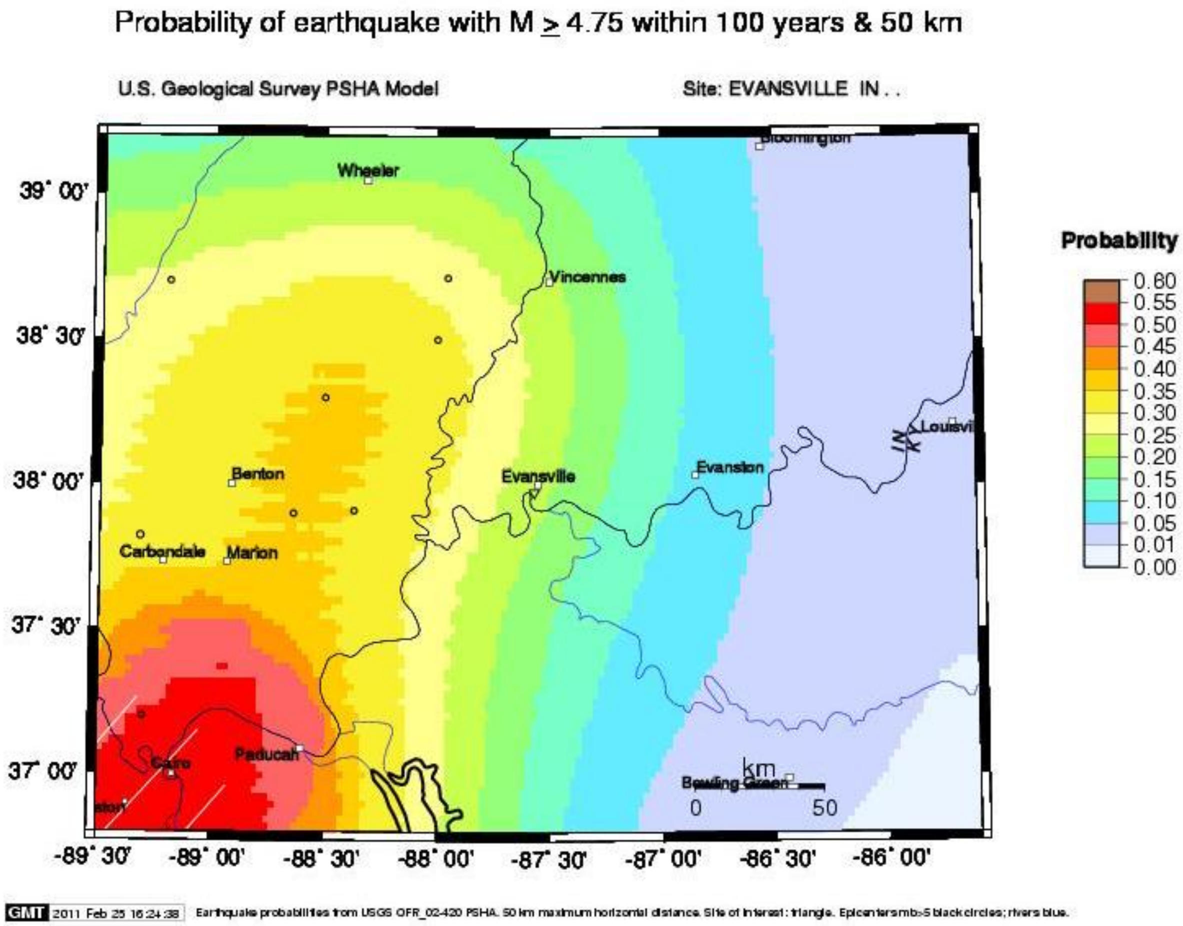
The method assumes a reasonable future catalog of earthquakes, based upon historical earthquake locations and geological information on the recurrence rate of fault ruptures.
When all the possible earthquakes and magnitudes have been considered, a ground motion value is determined such that the annual rate of its being exceeded has a certain value. Therefore, as presented on Figure 3.6, for the given probability of exceedence, two percent, the locations shaken more frequently will have larger ground motions.

Figure 3.5. New Madrid Seismic Zone Map—2 Percent Probability of Exceedence in 50 Years



Source: U.S. Geological Survey, http://earthquake.usgs.gov/hazards/products/conterminous/2008/maps/
Note: Red square shows the approximate location of Vanderburgh County.

Figure 3.6. Seismic Hazard Map—Probability of Magnitude 4.75 or Greater



Source: U.S. Geological Survey, http://eqint.cr.usgs.gov/eqprob/2002/index.php

The geographic location was assigned a rank of **extensive,** 50-100 percent of planning area affected.

Previous Occurrences

There have been 52 recorded earthquakes within a 50-mile radius of Evansville since 1827. Identified fault lines and earthquake epicenters are presented in the following figure. The following list shows the major events sited from the Evansville-Vanderburgh County Community Comprehensive Hazard Analysis 2010, U.S. Geological Survey's Earthquake Hazards Program, and the Evansville Courier:

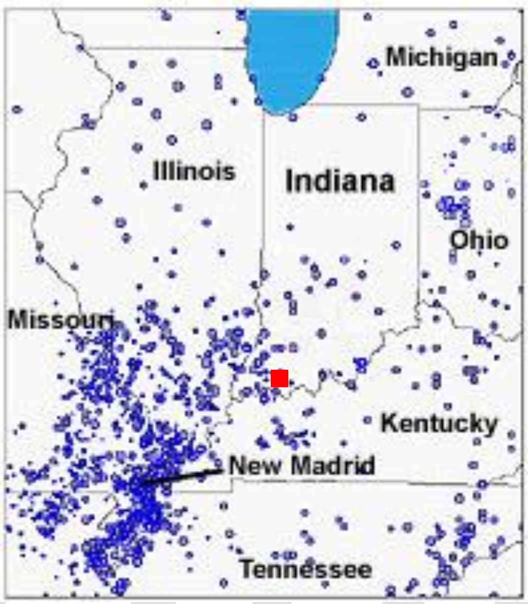
- **April 18, 2008. Richter Magnitude 5.4. Wabash Valley Seismic Zone.** The earthquake struck near Mt. Carmel, Illinois and was felt in at least 16 states, by more than 40,000 people. Fortunately, there were no serious injuries or fatalities, only non-structural damage reported.

- **January 2, 2006. Richter Magnitude 3.6. Wabash Valley Seismic Zone.** It occurred near Equality, Illinois about 45 miles west of Evansville, Indiana.
- **September 12, 2004. Richter Magnitude 3.6.** It was centered near Shelbyville in Shelby County that sent tremors through the earth. No injuries were reported by the quake did cause minor damage to some structures.
- **June 6, 2003. Richter Magnitude 4.5.** It occurred near Bardwell in western Kentucky.
- **January 3, 2003. Richter Magnitude 2.9.** The epicenter was in Gallatin County, Illinois, less than one-half mile west of the Indiana state line. It was the third earthquake to be felt in southwestern Indiana in the last two years.
- **June 18, 2002. Richter Magnitude 5. Wabash Valley Seismic Zone.** Five miles northwest of Evansville "Initial confusion was a common theme around Evansville and surrounding towns after the magnitude 5.0 earthquake. The temblor struck at 12:37 p.m., was felt for a few seconds and left behind very little damage. The quake's epicenter was eventually established nine miles northwest of Evansville and six miles west-southwest of Darmstadt, Ind." Broken glass, fallen chimneys. "It was the largest quake to rumble through the Tri-State since 1987, when a magnitude 5.0 temblor struck near Lawrenceville, Illinois. The strongest earthquake to occur in the last 100 years in the Wabash Valley region happened on Nov. 9, 1968, in south-central Illinois. It had a magnitude of 5.4 and was felt in 23 states."
- **January 3, 2002. Richter Magnitude 2.9. New Madrid Seismic Zone.** Occurred 40 miles west of Evansville.
- **December 7, 2000. Richter Magnitude 3.9. New Madrid Seismic Zone.** Occurred five miles west of Evansville.
- **June 10, 1987. Richter Magnitude 5.1. Wabash Valley Seismic Zone.** Occurred east of Olney, in Richland County, Illinois. Ground shaking probably felt in Evansville.
- **November 9, 1968. Richter Magnitude 5.5. Wabash Valley Seismic Zone.** Occurred south of McLeansboro, in Hamilton County, Illinois. Evansville probably experienced a VI-VII on the Mercalli scale. This was the strongest felt earthquake in southern Illinois since the 1895 Missouri event. Property damage in the area consisted mainly of fallen bricks from chimneys, broken windows, toppled television aerials, and cracked or fallen plaster. In the epicentral area, near Dale, Hamilton County, Illinois intensity VII was characterized by downed chimneys, cracked foundations, overturned tombstones, and scattered instances of collapsed parapets. Most buildings that sustained damage to chimneys were 30 to 50 years old. A large two-story brick house near Dale, Illinois, sustained several thousand dollars damage. About 10 kilometers west of Dale, near Tuckers Corners, a concrete and brick cistern collapsed. A large amount of masonry damage occurred at the City Building at Henderson, Kentucky, 80 kilometers east-southeast of the epicenter. Moderate damage to chimneys and walls occurred in several towns in south-central Illinois, southwest Indiana, and northwest Kentucky. Felt over all or parts of 23 States: from southeast Minnesota to central Alabama and Georgia and from western North Carolina to central Kansas.

- **November 9, 1968. Richter Magnitude 5.4. New Madrid Seismic Zone.** Property damage in the area consisted mainly of fallen bricks from chimneys, broken windows, toppled television aerials, and cracked or fallen plaster.
- **April 27, 1925. Richter Magnitude 4.8. Wabash Valley Seismic Zone.** Wabash River Valley, near Princeton, Indiana (38.2N 87.8W) Chimneys were downed at Princeton and at Carmi, Illinois, 100 km southwest; chimneys were broken at Louisville, Kentucky. Crowds fled from the theaters at Evansville. The felt area includes parts of Indiana, Illinois, Kentucky, Missouri, and Ohio.
- **September 27, 1909. Richter Magnitude 5.1. Wabash Valley Seismic Zone.** Occurred near Terra Haute, Indiana. Estimated magnitude of 5.1 and Evansville likely experienced a V on the Mercalli scale. The NEIC lists this as the strongest earthquake with an epicenter in Indiana. At Terre Haute (Vigo County), two chimneys were thrown down, plaster was cracked, and pictures were shaken from walls. At Covington, north of Terre Haute in Fountain County, a few chimneys were downed and windows were broken. Chimneys were "jarred loose" south of Vincennes at Princeton, Indiana, one chimney was shaken to pieces at Olivette, Missouri (a suburb of St. Louis), and a brick wall was shaken down at St. Louis, Missouri. Also reported felt in Arkansas, Illinois, Iowa, Kentucky, Ohio, and Tennessee.
- **April 29, 1899. New Madrid Seismic Zone.** Rated intensity VI to VII on the Modified Mercalli Scale. It was strongest at Jeffersonville and Shelbyville; at Vincennes, chimneys were thrown down and walls cracked. It was felt over an area of 40,000 square miles.
- **July 27, 1891. Richter Magnitude 4.1. New Madrid Seismic Zone.** A strong local earthquake damaged a wall on a hotel, broke dishes, and overturned furniture at Evansville. The shock also was strong near Evansville at Mount Vernon and Newburgh, Indiana, and at Hawesville, Henderson, and Owensboro, Kentucky.
- **February 6, 1887. Richter Magnitude 4.6. New Madrid Seismic Zone.** This centered near Vincennes and was felt over 75,000 square miles. This shock was strongest in southwest Indiana and southeast Illinois. Plaster was shaken from walls at Vincennes, Ind., and west of Terre Haute, at Martinsville, Illinois; a cornice reportedly fell from a building at Huntington, Indiana. It was felt distinctly at Evansville, Indiana, but only slightly in the outskirts of St. Louis, Missouri. Also reported felt at Louisville, Kentucky.
- **1895. Richter Magnitude 6.7. New Madrid Seismic Zone.** Occurred at Charleston, Missouri. This damaged buildings in Evansville and other parts of southwestern Indiana.
- **August 7, 1827. Richter Magnitude 4.8. New Madrid Seismic Zone.** Occurred in Southern Illinois.
- **July 5, 1827. Richter Magnitude 4.8. New Madrid Seismic Zone.** Epicenter near New Harmony, Indiana. The earthquake cracked a brick store at New Harmony, Indiana, and greatly alarmed some people. It was described as violent in New Madrid, Missouri, and severe in St. Louis. It also alarmed many in Cincinnati, Ohio, and Frankfort, Kentucky.
- **December 16, 1811 two occurred. January 23, 1812, and February 7, 1812. Richter Magnitude 8. New Madrid Seismic Zone.** A series of four earthquakes centered on New Madrid, Missouri. They were estimated magnitudes of 8 plus. These shock waves rippled through the earth with such force that buildings collapsed, trees topples, and the

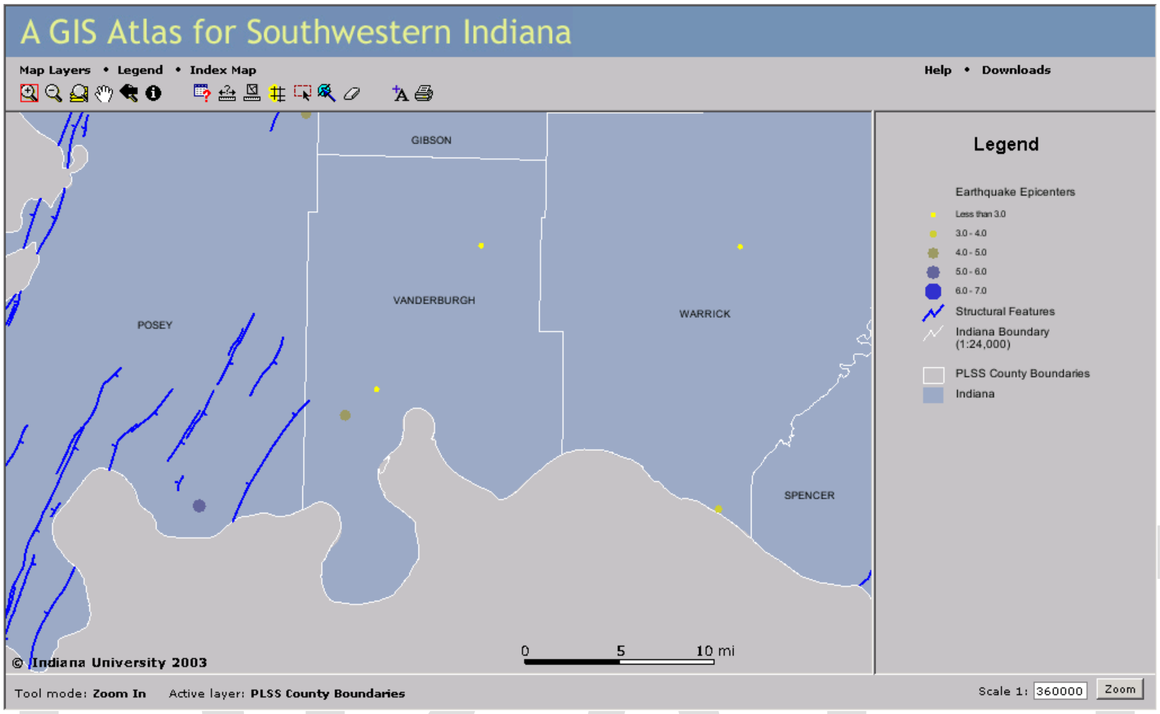
Mississippi River changed course. The explosive force that shattered the stillness of that serene setting was one of the most powerful earthquakes ever recorded in North America. During the next two months, the area was rocked by three more quakes as powerful as the first (one just six hours after the first) and hundreds of smaller ones. Evansville probably experienced a VII to VIII on the Mercalli scale (equal to a six on the Richter).

Figure 3.7. Earthquake Epicenters in Indiana and surrounding states from 1800 to 1995.



Source: Indiana Geological Survey, http://igs.indiana.edu/geology/earthquakes/eqinindiana/index.cfm
Note: Red square shows the approximate location of Vanderburgh County

Figure 3.8. Fault Lines and Earthquake Epicenters



Probability of Future Occurrences

The New Madrid Fault is an active fault, averaging more than 180 events per year measuring 1.0 or more on the Richter scale. This is equivalent to 15 events per month. Events measuring 2.5-3.0 on the Richter scale include tremors large enough to be felt and are noted annually. Every 18 months the New Madrid Fault releases a shock of 4.0 or more, capable of local minor damage. Magnitudes of 5.0 or greater occur approximately once per decade, can cause significant damage and can be felt in several states. A damaging earthquake in the New Madrid area (6.0 or greater) occurs about every 80 years (the last one in 1895).

A major earthquake in the New Madrid area (7.5 or greater) happens every 200-300 years (the last one in 1812). It is predicted that there is a 25 percent chance of disaster by 2040. A New Madrid Fault rupture this size would be felt throughout half the United States and damage is expected in 20 states or more. Events measuring 6.0-7.6 have more significant probabilities in the near future. Recent field work has shown that a major earthquake has already happened in the Wabash Valley fault zone in the past several thousand years. According to the U.S. Geological Survey and Figure 3.5 there is a 25 percent chance that a 4.75 or greater earthquake will occur in the next 100 years. Approximately 30 counties in Missouri, Illinois, Indiana and Kentucky could be affected with potential for serious damage to unreinforced buildings.

The Lower Wabash Valley Fault System is also an active fault with recent events on April 18, 2008 near Mt. Carmel, Illinois, and on January 2, 2006, 45 miles west of Evansville. These events measured 5.4 and 3.6 on the Richter scale, respectively. These recent events along with the identified large liquefaction features suggest the possibility that the region is capable of producing very large earthquakes.

Figure 3.5 indicates that there is a 20 percent probability of an earthquake exceeding a peak acceleration of four percent gravity in the next 50 years in the Vanderburgh County planning area. The probability was assigned a rank of **likely,** 10-100 percent chance of occurrence in next year or has a recurrence interval of 10 years or less.

Magnitude

The City of Evansville and Vanderburgh County have been preparing for an epic earthquake. This includes constructing critical facilities such as schools, hospitals, dams, and bridges to survive the maximum level of shaking likely to occur at the site. Evansville is currently requiring structure designs that will withstand a magnitude 7 earthquake. They are also developing a plan for coordinating activities among emergency response agencies, developing plans of action for schools, businesses, and homes; and educating everyone about earthquakes and what can be done to lessen their potential effects.

The Indiana Geological Survey has worked with the City of Evansville to estimate the shaking potential in sections of the City and therefore where best to locate critical facilities.

The magnitude was classified as **critical**, isolated deaths and/or multiple injuries and illnesses; major or long-term property damage that threatens structural stability; and/or interruption of essential facilities and services for 24-72 hours.

3.2.4 Flood

Description

Floods are among the most frequent and costly natural disaster in terms of human hardship and economic loss. There are several different types of likely flood events in Indiana including flash, riverine, and urban stormwater. Regardless of the type of flood, the cause can almost always be attributed to excessive rainfall, either in the flood area or upstream reach.

The term "flash flood" describes localized floods of great volume and short duration. In contrast to riverine flooding, flash flooding usually results from a heavy rainfall on a relatively small drainage area. Precipitation of this sort usually occurs in the spring and summer.

Riverine flooding is defined as an event when a watercourse exceeds its “bank-full” capacity and is the most common type of flood event. Riverine floods result from precipitation over large areas. This type of flood occurs in river systems whose tributaries may drain large geographic areas and include many independent river basins. Riverine flooding generally occurs as a result of prolonged rainfall, or rainfall that is combined with soils already saturated from previous rain events. The duration of riverine floods may vary from a few hours to many days. Factors that directly affect the amount of flood runoff include precipitation, intensity and distribution, the amount of soil moisture, seasonal variation in vegetation, snow depth, and water-resistance of the surface areas due to urbanization. The area adjacent to a river channel is its floodplain. In its common usage, "floodplain" most often refers to that area that is inundated by the 100-year flood, the flood that has a 1 percent chance in any given year of being equaled or exceeded. The 1 percent annual flood is the national standard to which communities regulate their floodplains through the National Flood Insurance Program.

Urban flood events result as land loses its ability to absorb rainfall as it is converted from fields or woodlands to roads, buildings, and parking lots. Urbanization increases runoff two to six times over what would occur on undeveloped terrain. During periods of urban flooding, streets can become swift moving rivers.

All flood events may result in upstream flooding due to downstream conditions such as channel restriction and/or high flow in a downstream confluence stream. This type of flooding is known as backwater flooding.

Geographic Location

The major sources of flooding in the Evansville and Vanderburgh County are the Ohio River and Pigeon Creek. The Ohio River forms 28 miles of the City and County southern border. Pigeon Creek, originating in neighboring Warrick County, flows in a southwesterly direction through the southeastern corner of Vanderburgh County and Evansville to discharge into the Ohio River, near downtown Evansville. Damage from flooding along Pigeon Creek in the planning area occurs when the Ohio River reaches a stage great enough to back water up Pigeon Creek, or when Pigeon Creek headwater becomes sufficiently high enough to overflow the channel. Because of continued development in the unprotected areas, flood problems are not considered greater than at the time of the 1937 flood. The flooding problem now consists principally of overflow from Pigeon Creek onto the agricultural lands in the eastern part of Vanderburgh County and residential sections northeast of Evansville.

Suffering the greatest damage in more recent headwater floods on Pigeon Creek were the homes and farm buildings in the North Green River Road area. In addition to flooding on Pigeon Creek, floods on the Ohio River cause extensive overflow in the southeastern corner of the county. Because of the meandering nature of the river, this portion of the county lies almost entirely in the floodplain of the river. Backwater flooding from Pigeon Creek aggravates the flood problems on Mill Road Tributary. While there is also potential backwater flooding on both Schlensker Ditch and Greenbriar Hills Tributary, it is not as significant as that on Mill Road Tributary.

Following the major flood event of 1937 on the Ohio River, the City of Evansville, in conjunction with the Louisville District of the U.S. Army Corps of Engineers, initiated flood protection projects. Portions of the riverfront area are now protected from severe flooding by levees, floodwalls, and large pumps. There is also a levee system to help control flooding on

Pigeon Creek. These provide protection to the City of Evansville and portions of the unincorporated areas east of the City from a repetition of the 1937 flood, which had a recurrence interval greater than 500 years. Although related to flood hazard, levee failure is discussed separately in Section 3.2.7.

As a part of the National Flood Insurance Program (NFIP), floodplains and floodways on the Ohio River, Pigeon Creek, and many local streams have been established and are regulated by the local floodplain management ordinance. The most recent Flood Insurance Study (FIS) for Vanderburgh County unincorporated and incorporated areas has an effective date of March 17, 2011. The FIS and associated Digital Flood Insurance Rate Maps (DFIRMs) present the adopted floodplains, floodways, and flood profiles for streams in the planning area. Table 3.11 presents the Vanderburgh County Flooding Sources that were studied by Detailed Methods in the FIS.

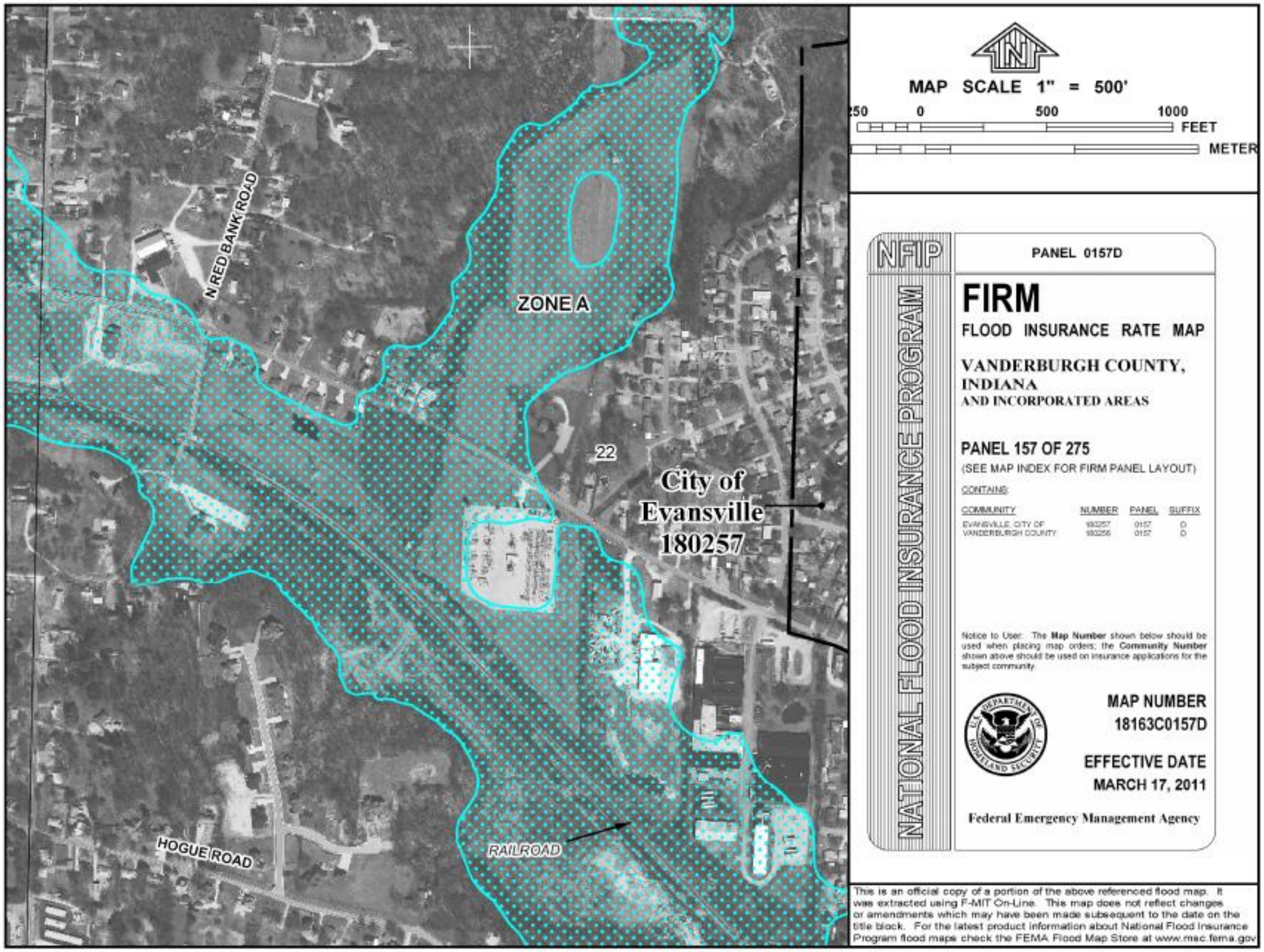
Table 3.11 Flooding Sources Studied by Detailed Methods

Bluegrass Creek	Nurenbern Ditch
Boesche Ditch	Ohio River
Crawford-Brandeis Ditch	Pigeon Creek
Dry Run Lower	Pond Flat Ditch
Dry Run Upper	Pond Flat Ditch Lateral “A”
Greenbriar Hills Tributary	Pond Flat Ditch Lateral “B”
Harper Ditch	Pond Flat Ditch Lateral “C”
Harper Ditch Overflow	Rusher Creek
Hirsch Ditch	Pond Flat Ditch Lateral “D”
Little Pigeon Creek	Pond Flat Ditch Lateral “E”
Locust Creek	Schlensker Ditch
Lockwood Ditch	Schlensker Ditch Tributary
Mill Road Tributary	Stockfleith Ditch

Source: Vanderburgh County Flood Insurance Study, March 17, 2011

Error! Reference source not found. provides an example of the geographic location of the known flood hazard areas as identified by FEMA digital flood insurance rate maps (DFIRM) for Vanderburgh County. The geographic location was assigned a rank of **significant**, 10-50 percent of planning area affected.

Figure 3.9. Excerpt of Floodplain on Carpenter Creek from DFIRM 18163C0157D



National Flood Insurance Program (NFIP) Participation

Vanderburgh County and the City of Evansville are currently participating in the National Flood Insurance Program (NFIP). Both Vanderburgh County and Evansville are a rated Class 8 in the Community Rating System. This class rating results in a 10% reduction in flood insurance premiums for NFIP policy holders. Darmstadt does not participate in the NFIP and was sanctioned on February 1, 1981. Table 3.12 provides additional details on NFIP participation as well as flood insurance policies and claims.

Table 3.12 Community Participation in the National Flood Insurance Program in Vanderburgh County

Jurisdiction	Status/Date	Effective FIRM Date	Policies in Force	Insurance in Force ($)	Number of Paid Losses	Total Losses Paid($)	Substantial Damage Claims Since 1981
Vanderburgh County	Participating Regular-2/1/1980 Emergency 6/25/1971	3/17/2011	775	$158,864,200	153	$1,470,490	14
Darmstadt	Not Participating Sanctioned 2/1/1981	3/17/2011	N/A	N/A	N/A	N/A	N/A
Evansville	Participating Regular-10/15/1981 Emergency 6/25/1971	3/17/2011	597	$116,820,200	356	$2,610,927	18

Source: http://bsa.nfipstat.com/reports/1011.htm#COT

All streams within Evansville and Vanderburgh County, as previously identified, are subject to flooding and backwater flooding. Backwater flooding is defined as upstream flooding caused by downstream conditions such as channel restriction and/ or high flow in a downstream confluence stream. The primary effect of flooding on these streams appears to be inundation, although velocities will become significant to persons and structures under more extreme flooding situations. Calculated floodplain velocities range from 0.2 to 6.5 feet per second (fps). Velocities greater than 5.0 fps which is considered to be of dangerous magnitude. Table 3.13 outlines the critical depths and velocities that will harm residents and structures during a flood event.

Table 3.13 Critical Flood Depths and Velocities

Depth (threat to life)	In stagnant backwater areas (zero velocity), depths in excess of about 1m (3.3ft) are sufficient to float young children, and depths above 1.4m (4.6ft) are sufficient to float teenage children and many adults.
Velocity (threat to life)	In shallow areas, velocities in excess of 1.8m/s (5.9 ft/s) pose a threat to the stability of many individuals.
Depth and Velocity (threat to life)	The hazards of depth and velocity are closely linked as they combine to effect instability through an upward buoyant force and a lateral force. A product of less than or equal to 0.4m2/s (43 ft2/s) defines a low hazard provided the depth does not exceed 0.8m (2.6ft) and the velocity does not exceed 1.7m/s (5.6 ft/s).
Vehicular access (emergency access)	Most automobiles will be halted by flood depths above 0.3-0.5m (1.0-1.7ft). A maximum flood velocity of 3m/s (9.8 ft/s) would be permissible, providing that flood depths are less than 0.3m (1.0ft). A depth of 0.9-1.2m (2.9-3.9 ft) is the maximum depth for rapid access of large emergency vehicles.
Structural Integrity (structures above ground)	A depth of 0.8m (2.6ft) is the safe upper limit for the above ground/super structure of conventional brick veneer, and certain types of concrete block buildings. The structural integrity of elevated structures is more a function of flood velocities (e.g. Erosion of foundations, footings or fill) than depth. The maximum velocity to maintain structural stability depends on soil type, vegetation cover, and slope but ranges between 0.8-1.5m/s (2.6-4.9 ft/s)
Fill (stability)	In general, fill may become susceptible to erosion/instability at depths of 1.8-2.4m (5.9-7.9ft).

Source: Technical Guide - River and Stream Systems: Flooding Hazard Limit, Ontario Ministry of Natural Resources, 2002

Identified Problem Areas

Approximately 30 chronic flooding areas within Evansville have been identified in the 2007 Stormwater Master Plan Update for the City of Evansville (Appendix C, Figure C.1). The problem areas are categorized as follows:

- Neighborhood flooding;
- Combined sewer related flooding; and
- Channel cleanout/stream system flooding.

Neighborhood flooding problems refer primarily to street flooding (primarily in residential areas) caused by undersized storm sewers and roadside ditches. Combined sewer related flooding includes street and property flooding caused by back up of the combined sewer system. Channel cleanout and stream system flooding refers to areas where natural streams exceed their channel banks or back up at bridges or culverts and flood adjacent property. Because of the extensive levee system in Evansville, stream system flooding is not a major problem. The channel cleanout problems also refer to stream systems which have major debris blockages or are heavily overgrown, causing capacity and back up problems.

A total of 15 neighborhood, 10 combined sewer, and 2 channel cleanout/stream system project areas were identified to alleviate flooding. A name was assigned to each problem area. The names were based on nearby major streets and are meant to represent the general vicinity of flooding problems, not the location of a specific problem. Table 3.14 identifies the flooding problem areas.

Table 3.14 Inventory of Flooding Problem Areas Identified

Flooding Problem Classification	Inventory of Flooding Project Areas Identified
Neighborhood	Eastview Terrace Lauderdale Subdivision Blueridge Drive Addition Greencove Avenue Stockwell Road Ditch Red Bank Road and Nolan Avenue Fulton Avenue and Columbia: South Old Booneville Highway and Crawford Brandeis Ditch Lincoln and Kirkwood Ray Becker and Bristol Myers Kratzville Road and Allens Lane Bonnie View Ditch Fulton Avenue and Columbia: North Hesmer Road Ditch Sixth Avenue and Nester Street
Combined Sewer	Diamond Avenue Phases I-IV (already designed) Southeast Boulevard, Brookside Drive and Covert Outfall Cass Avenue St. Joseph Laterals Akin Park State Hospital Grounds Boeke Road Outfall Jeanette and Cass Addition Weinback & Boeke Lateral (already designed) Weinback & Keck Lateral (already designed)
Channel Cleanout/Stream System Flooding	Rollett Lane and Red's Creek Carpentier Creek Cleanout

Repetitive Loss Structures

The Federal Emergency Management Agency (FEMA) has identified 48 structures in Evansville (7 mitigated) and 23 structures in Vanderburgh County (1 mitigated) that have been paid two flood insurance claims of $1,000 or more within a 10-year period since 1978. This is an increase in the number of repetitive loss structures since the original Multi-Hazard Mitigation Plan. The additional flood claims are primarily due to the disaster declaration events DR 1662 (10/6/2006) and DR 1795 (9/23/2008). These repetitive loss properties do not reflect the total number of homes that have flooded in Evansville and Vanderburgh County, but rather the number of insured properties that have filed for an insurance claim repeatedly.

Location maps of the repetitive loss structures are presented in Appendix C. The common cause of repetitive flooding of these structures is the inadequacy of the low lying areas to drain following a storm event. Several of the repetitive loss structures coincide with the floodprone areas defined in the Stormwater Master Plan. The direct causes of flooding in these areas are neighborhood flooding, combined sewer related flooding, and channel cleanout/stream system flooding.

Repetitive Loss Areas

Repetitive loss areas, which encompass a repetitive loss structure along with other properties in the immediate vicinity, identified as being subject to a similar flood risk, have been further identified in 14 locations. Location maps of the repetitive loss areas are presented in Appendix C.

1) **Bosse Avenue** - This repetitive loss area is located within one of the flooding problem areas identified in the Stormwater Master Plan, Red Bank Road and Nolan Avenue. There are 6 structures located within this repetitive loss area, including one repetitive loss structure. The area is located within the 100-year floodplain and is also subject to neighborhood flooding. See Figure C.2 in Appendix C.

2) **East Columbia Street** - This repetitive loss area is located within one of the flooding problem areas identified in the Stormwater Master Plan, North Weinbach. There are 7 structures located within this repetitive loss area, including one repetitive loss structure. The area is located within the 500-year floodplain and is subject to combined sewer related flooding. There are no positive overland flow routes for stormwater. Thus, when the combined sewer system cannot accommodate additional stormwater, the area is flooded. See Figure C.3 in Appendix C.

3) **Johnson Lane** - This repetitive loss area is located south of Bayou Creek. There are 9 structures located within this repetitive loss area, including one repetitive loss structure. Flooding in this area is due to stream system flooding when Bayou Creek overflows its channel banks and/or backs up at bridges or culverts and floods adjacent property. This repetitive loss area is located within the 100-year floodplain. See Figure C.4 in Appendix C.

4) **Peacock Lane** - This repetitive loss area is located within the 100-year floodplain adjacent to Crawford Brandies Ditch. The area is not currently identified in the Stormwater Master Plan as a flooding problem area. There are 6 structures located within this repetitive loss area, including one repetitive loss structure. See Figure C.5 in Appendix C.

5) **Rheinhardt Avenue** - This repetitive loss area is identified in the Stormwater Master Plan as a low-lying area below the Ohio River flood stage elevation, Kenwood Avenue and K2. There are 12 structures located within this repetitive loss area, including two repetitive loss structures. The area is subject to neighborhood flooding. The lots of the repetitive loss structures are located below street grade. A culvert located under the residential driveway is undersized and can become overloaded, flooding the front yard. See Figure C.6 in Appendix C.

6) **Twin Lakes Drive** - This repetitive loss area is located within the 100-year floodplain of Pigeon Creek. The area is not currently identified in the Stormwater Master Plan as a flooding problem area. There are 4 structures located within this repetitive loss area, including one repetitive loss structure. See Figure C.7 in Appendix C.

7) **Wedeking Avenue** - This repetitive loss area is located within one of the flooding problem areas identified in the Stormwater Master Plan, Diamond Avenue. There are 9 located within this repetitive loss area, including one repetitive loss structure. The area is subject to combined sewer related flooding. There are no positive overland flow routes for stormwater. Thus, when the combined sewer system cannot accommodate additional stormwater, the area is flooded. See Figure C.8 in Appendix C.

8) **Broadway Avenue** - The repetitive loss area is located at the base of a large hill that drains into an un-named tributary of Bayou Creek. There are 5 structures located within this repetitive loss area, including one repetitive loss structure. Flooding occurs on this property when excessive run-off from the surrounding hill converges at the low lying area near the intersection of Broadway and Alta Vista Drive. See Figure C.9 in Appendix C.

9) **Green River Road and Heckel Road** – This repetitive loss area is located within the 100-year floodplain of Pigeon Creek. The area is outside of the City of Evansville, and thus not included in the Stormwater Master Plan. There are 39 structures located within this repetitive loss area, including two repetitive loss structures. The area is subject to riverine flooding. See Figure C.10 in Appendix C.

10) **Knight Unincorporated on Ohio River** – The portion of Knight Township directly adjacent to the Ohio River is identified as a repetitive loss area with 11 structures, including 3 repetitive loss structures. Flooding in this area is a direct result of the Ohio River. See Figure C.11 in Appendix C.

11) **Olmstead Road** – This identified repetitive loss area is located within the 100-year floodplain of Pigeon Creek. There are 26 structures located within this repetitive loss area, including one repetitive loss structure. The area is subject to riverine flooding. See Figure C.12 in Appendix C.

12) **Six School Road** - This identified repetitive loss area is located at the upstream limits of the 100-year floodplain of a tributary to Little Creek. There are 2 structures located within this repetitive loss area, including one repetitive loss structure. The area is subject to riverine flooding. See Figure C.13 in Appendix C.

13) **Union Township** - Union Township, located in extreme southwestern Vanderburgh County, has a system of drains comprised of improved sloughs serving solely agricultural lands. The Township is identified as a repetitive loss area, with 241 structures, including 11 repetitive loss structures. Flooding in this area is a direct result of the Ohio River.

In addition to the defined repetitive loss areas, there are two locations in the County with noted flooding problems. Although the structures located in these two locations have not made repetitive flood insurance claims, there is an identified repetitive flooding problem. These areas are located along Elmridge Road (also noted in the 2007 Stormwater Master Plan) and Voight Road. See Figures C.23 and C.24, respectively, in Appendix C.

Previous Occurrences

There are 68 flood events listed in the NCDC database for Vanderburgh County between 1993 and 2010. This database provides information on flooding events back to 1993. In addition, Vanderburgh County received six Presidential disaster declarations for flooding between 1965 and February 2011. (Note: DRs 17945 and 1520 included flooding in the description. However the Vanderburgh County damages were not the result of flooding. The September/October 2008 declaration (DR-1795 was for flooding in northern Indiana. Southern Indiana, including Vanderburgh County had damages primarily from severe storms. Therefore, this declaration is included in the Severe Storms Previous Occurrences Section. The May/June 2004 declaration (DR-1520) impacts in Vanderburgh County were primarily as a result of the tornado that occurred in Darmstadt. Therefore, this declaration is included in the Tornado Previous Occurrences Section.) Historical accounts of flooding events are recorded below. Sources are the NCDC database, FEMA, the National Weather Service Weather Forecast Office in Paducah, Kentucky, and the Evansville-Vanderburgh county Community Comprehensive Hazard Analysis.

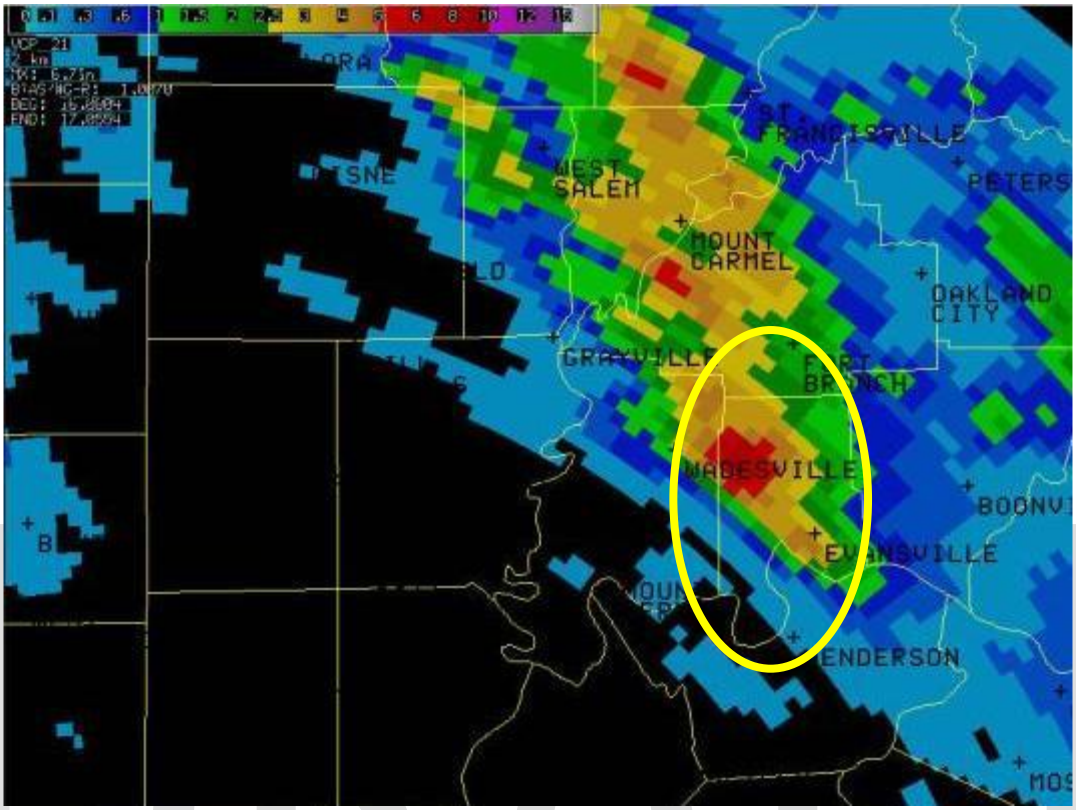
- **November 25, 2010, Flash Flood**—Water was over roads in numerous places in Evansville. The intersection of Indiana 66 and First Avenue was closed due to flooding. On the southeast side of Evansville, a spotter reported 4.6 inches of rain in 36 hours
- **September 5, 2009, Flash Flood**—1.67 inches of rain fell in less than an hour on the southeast side of Evansville. Widespread street flooding caused numerous vehicles to stall out. Police and fire crews were kept busy with vehicle rescues. Water was up to waist-deep on one side street south of downtown. The most affected areas of Evansville were from the downtown area to the southeast side. Garages and basements were flooded in the southeast section of the city. Flooding occurred on the Lloyd Expressway, causing westbound traffic to narrow to one lane that was under water but passable.

- **March 18, 2008, Flood**—Major flooding of Pigeon Creek occurred. Sandbag walls and pumps were placed around a number of residences near the creek, which flows into the Ohio River near Evansville. National Guard troops and firefighters were among those helping with sandbagging. About 100,000 sandbags were filled in this massive flood-fighting effort. Voluntary evacuations were in effect for residents of 194 mobile homes at a mobile home park which was threatened by a weakening levee. Water was about one foot from the top of the levee, and sinkholes formed in the levee. Floodwaters seeping through the levee flooded parts of the mobile home park, but water was not believed to have entered any homes. At least a dozen other homes were threatened by the creek. The Red Cross opened a shelter for evacuees. Access to one home was by boat only. Four teenagers were rescued from an SUV that stalled in floodwaters. In the city of Evansville, the manager of the water and sewer department received 29 reports of storm water in homes. Thirty homes were affected by floodwaters, and a few were heavily damaged. Motorists were stuck in high water on roads near the Evansville Regional Airport. Schools were closed across the county, and a State of Emergency was declared.
- **March 7, 2008, Flood**—Minor flooding of the Ohio River occurred. At the Evansville gage, the river crested at 43.65 feet on March 23. Flood stage there is 42 feet. Basements along the riverfront were flooded. At the Angel Mounds boat ramp, a man in a pickup truck was swept into the Ohio River and then rescued by fire crews 100 yards down the river. Backwater aggravated flooding along Pigeon Creek, a tributary that flows through Vanderburgh County. The river was 3300 feet wide.
- **September 12-14, 2006, Flash Flood (FEMA-1662-DR)**—This event resulted in a Presidential Disaster Declaration that included Vanderburgh County. Major flash flooding inundated sections of Evansville. Based on radar estimates, about one inch of rain fell within 20 minutes of the onset of heavy rain. Flooding occurred within 30 minutes of the onset of heavy rain. The extreme rainfall was very localized. A total rainfall measurement of 4.87 inches was received from the Community Collaborative Rain, Hail, and Snow (CoCoRaHS) Network just east-southeast of Evansville. A total of 248 occupied structures were affected. Of those 248, fifteen were single family homes that sustained major damage, 141 were structures that received minor damage, and 92 others were affected in some way. The totals include three businesses and 40 to 50 apartments. A school cafeteria was flooded with an inch or two of water. The basement wall of a residence collapsed. Thirteen families were displaced, and at least four of those families were placed in hotels by the Red Cross. Over 30 water rescues were conducted from cars stalled in flooded streets. Six persons were rescued from a stranded school bus. The occupants of four flooded residences were rescued by firefighters. Long-time residents reported this was the worst flood in memory. Many roads were barricaded and closed. Persistent and repeated drainage problems occurred on the southeast side of Evansville.
- **March 12, 2006, Flash Flooding**—Many city streets in Evansville were closed due to high water, with water rescues conducted. The county highway department ordered 16 road closures as a result of high water, including heavily-travelled Green River Road. The basement of a vacant house collapsed. Emergency managers provided sandbags to a handful of property owners who requested them. The rainfall total of 2.61 inches at

Evansville broke the daily rainfall record for March 12. The total rainfall for the three rounds of thunderstorms from March 9 to March 12 was 7.90 inches.

- **August 26, 2005, Flash Flood**—Rainfall amounts reported by emergency management officials ranged from 2.2 inches in downtown Evansville to 5 inches on the east side. Numerous city roads and one county road were closed by high water. Residential areas that were affected were mostly limited to three neighborhoods on Evansville's southeast side. Approximately 50 homes and 3 apartment buildings were affected by high water, many with water in the basements. Numerous vehicles were flooded, including those parked on the street, in garages, and driven into high water. At least 17 cars were reportedly flooded in the Dexter neighborhood
- **January/February 2005, Flooding (FEMA-1573-DR)—**This event resulted in a Presidential Disaster Declaration that included Vanderburgh County. Flooding throughout the region was due to a prolonged period of wet weather following the rapid snowmelt from a record late December snowstorm. Rainfall at the Evansville airport for the January 5-6 event was nearly 1.5 inches. On January 5, Pigeon Creek was out of its banks. In northern Vanderburgh County, a vehicle stalled in several feet of water, requiring the assistance of the fire department. Minor to moderate flooding of the Ohio River occurred. A state of emergency was declared in Vanderburgh and Posey Counties. Isolated evacuations of homes in low-lying areas were conducted in both counties. Many roadways in the vicinity of the river were closed. In Vanderburgh County, a total of 20 roads were closed. They were mostly farm roads flooded near the river, outside the Evansville city limits. Most of the flooded roads were south of Interstate 164 in the southeast part of the county and in lowland areas in the southwest part of the county. At Evansville, the Ohio River crest was 44.14 feet; about two feet above flood stage, but lower than the crest of 47.52 in 1997. The Army Corps of Engineers closed the locks on the Ohio River at Newburgh Lock and Dam.
- **July 16, 2004, Flash Flood**—Significant flash flooding occurred over the Evansville area and parts of Wabash County Illinois. Widespread street flooding occurred in Vanderburgh County after 5 to 10 inches of rain fell in a couple of hours. The rain began at Evansville about 10:30 P.M., and by midnight measured 1.47 inches at the Evansville airport. Radar indicated considerably heavier rainfall rates over downtown Evansville and western Vanderburgh County. The Vanderburgh county Emergency Management Agency reported 175 to 200 residential structures were affected by the flooding. In one trailer park alone, 150 homes were evacuated with the water 6 feet deep in places. In the downtown area, 35 homes were affected by the flooding. No dollar damage estimates were available. Figure 3.10 provides a radar image of the "storm-total" rainfall estimate. The shades of red indicate 5-plus inches. Yellow and gold colors indicate 2.5 to 5 inches. Green shades indicate 1 to 2.5 inches. The yellow oval provides the location of Vanderburgh County.

Figure 3.10. July 16, 2004 Flash Flood Storm Total Radar Image



National Weather Service Weather Forecast Office, Paducah, Kentucky,
http://www.crh.noaa.gov/pah/hydro/rainfall/evvflashflood.php

- **May 1, 2004, Flash Flood**—Major flooding occurred in a band extending eastward across the Wabash River into northern Posey, southern Gibson, and northern Vanderburgh Counties. In northern Vanderburgh County, Interstate 64 was flooded west of U.S. Highway 41 (exit 25); with water up to 2 feet deep in spots. At least one vehicle was stranded in deep water near the Gibson/Vanderburgh County line.
- **January 5, 2004, Flood**—The Ohio River rose above flood stage in response to heavy rains from Illinois to Ohio at the end of December and into the first days of January. The river flooding was moderate, consisting of extensive bottomland flooding of fields and woodlands. A number of lesser travelled county roads were closed. Some families in flood-prone areas had to find alternate routes to and from their homes. One man was swept into the floodwaters in southern Vanderburgh County as he tried to walk to dry land. Two men were driving through the flooded area when their pickup truck stalled in waist-deep water. They spent the night in a river camp that they broke into, and then decided to try crossing the floodwaters to dry land. Although one of the men turned back, the second continued into the cold water and was swept away by the current. He was able to grab onto a tree, and he spent three hours wedged between its limbs before he was found. The man was airlifted to a local hospital where he was treated for hypothermia with a body temperature of 90 degrees. The river first rose above flood stage at Newburgh

on the 5th and last fell below flood stage at Mount Vernon on the 17th. At Newburgh, where flood stage is 38 feet, the river crested at 45.0 feet on the 10th. Evansville crested just inches above its 42-foot flood stage. Mount Vernon crested at 42.8 feet on the 12th, nearly 8 feet over flood stage. The river was 3300 feet wide at Evansville. Basements along the riverfront began to fill, and Pigeon Creek was flooded by backwater. Near Evansville, several gravel secondary roads were closed, mostly across from Henderson, KY where there is a bend in the river.

- **November 25, 2003**—Minor flooding of the Ohio River occurred in southwest Indiana. About 30 school children living in the river bottoms of Union Township were picked up at alternate locations on higher ground. No evacuations of residents were required. Among the roads closed included Weinbach Avenue, Happe Road, and Seminary Road.
- **July/August 2003, Flash Flooding (FEMA-1476-DR)**—This event resulted in a Presidential Disaster Declaration that included Vanderburgh County. On July 9, A severe thunderstorm developed over Evansville, producing torrential rain, wind gusts around 60 MPH, and hail up to the size of dimes. Flash flooding of streets occurred in the City of Evansville. Water was reportedly over the tops of cars at the intersection of St. Joseph Road and Franklin Road. Other sections of St. Joseph Road were impassable. Division Street was another problem area, where at least one vehicle stalled out in floodwaters. On July 30, during the incident period for this declaration, an unofficial measurement of 3.0 inches of rain was recorded in downtown Evansville resulting in extensive street flooding. A railroad underpass was closed on Diamond Avenue, and Old U.S. Highway 41 was under water for about a three-quarter mile stretch. An intersection on Becker Parkway was under two feet of water.
- **November 8, 1998, Urban Flooding**—A band of slow-moving thunderstorms produced heavy rain as it sagged south across southwest Indiana. A particularly strong thunderstorm intensified to severe levels as it passed right over Evansville. Dime size hail and copious rainfall amounts between 2 and 4 inches per hour occurred downtown. Serious street flooding took place, with numerous stranded vehicles. Emergency services personnel performed many water rescues due to submerged vehicles. A restaurant was surrounded by water, trapping about 25 people inside the building until the water receded. A school on the north side of Evansville was closed after water came pouring into the building through doors and drains. The 265 students in the school were moved to a church on higher ground.
- **August 1997, Flash Flooding**—Thunderstorms dumped heavy rain estimated between 2 and 3 inches over Evansville within 3 hours. Less than an inch of rain was measured at the Evansville airport. The flooding stranded many motorists in floodwaters around 3 feet deep. Several streets were closed. Firefighters were busy rescuing people stranded in the flooding, including a group of elderly people at Division and Main Streets. The group of six elderly people were stranded in a van, and had to be taken out of the area by a fire truck. Two other people were rescued at the same intersection. The Water Rescue Team was called to a viaduct to rescue two people stranded in a car. No injuries were reported. An official with the city Division of Transportation estimated about 200 cars were stranded by flooding in the city. The Lloyd Expressway was closed for about two hours near the Vann Avenue exit when a Greyhound bus became stranded. The only homes

threatened by flooding were on two city streets that routinely experience flood problems. City pump trucks were sent to that area to help remove the water.

- **March 1997, Flood (FEMA-1165-DR)**—This event resulted in a Presidential Disaster Declaration that included Vanderburgh County. Widespread rainfall amounts around 10 inches in the middle Ohio Valley, from around Louisville to Cincinnati, occurred over a one to three day period. This resulted in a massive flood crest that took a few weeks to travel down the Ohio River. The resultant flood was the worst in about 30 years, and one of the five worst on record. Water from the Ohio River backed up into the Pigeon Creek, which flows through Evansville. About 60 homes were evacuated along Pigeon Creek, and two bridges over the creek were closed. In Warrick County, just a few families were forced from their homes. Numerous roads were closed for days at a time. All barge traffic was halted on the Ohio River upstream from Newburgh. Near Evansville, a few families were evacuated by boat.
- **April/May 1996, Flood (FEMA-1125-DR)**—This event resulted in a Presidential Disaster Declaration that included Vanderburgh County. Over seven inches of rain fell at Evansville in 24 hours. School openings were delayed for two hours because of floodwaters. Damage to county roads and bridges was estimated to be around 150,000 dollars. So much water overloaded the sewer system that officials released raw sewage into the Ohio River.
- **November 14, 1993, Flash Flood**—This flash flood event developed into a widespread major flood event over central and southern Indiana. The heavy rain on November 14 was followed by an additional 1.50 to 2.50 inches of rain from November 16 to November 17. |Flooding in much of central and southern Indiana was reminiscent of the late December 1990 and early January 1991 flood. Flood levels in portions of the state exceeded the late December 1990 and early January 1991 flood, and were the highest experienced in 50 or more years. Over 1,000 people were forced to flee their homes, and the Indiana Department of Natural Resources made numerous rescues of hunters and stranded residents.
- **December 1990/January 1991, Flood (FEMA-891-DR)**—This event resulted in a Presidential Disaster Declaration that included Vanderburgh County. River and small stream flooding occurred in the County.
- **January 29, 1937, Flood**—The precursors to this historic flood event began January 5th with heavy rain, snow, and sleet falling almost continually over the Ohio Valley. The rainfall from Wheeling, West Virginia, to Cairo, Illinois was an average of sixteen to twenty-one inches in eighteen days. The watershed was unable to carry the tremendous volume of water. Rising temperatures in the north began melting snow and it too drained into the raging Ohio. The flooding of low lands along the Ohio River was nothing out of the ordinary, but the rampage of the Ohio River in 1937 was something that no one expected. The flood stage of 35 ft. was reached at Evansville on January 11th. The river continued to rise steadily and more residents were forced out of their homes. The water rose higher and higher, forcing people to flee for their lives. This record flood reached its' crest January 29, 1937, when the Ohio at Evansville reached 53.7 feet. (January 31st in FIS Report) Approximately 7,500 of the 22,000 homes in Evansville were damaged to some extent, and 500 city blocks were inundated. In the Pigeon Creek basin,

approximately 10,000 acres were flooded. The City of Henderson KY had remained relatively dry. Henderson was one of the few towns along the Ohio to remain dry. Evansville, however, had over 300 square blocks under water. The depth of the floodwater at the corner of Washington and Kentucky Avenues on January 31, 1937, was seven feet.

Figure 3.11 1937 Flood in Vanderburgh County

According to the USDA's Risk Management Agency, insured crop losses in Vanderburgh County as a result of flood conditions and excessive moisture from 2001 to 2010 totaled $3,225,383. As of 2009, 71 percent of insurable crop acreage was insured. Crop insurance claims as a result of flooding are detailed in Table 3.15 on the following page.

Table 3.15 Claims Paid in Vanderburgh County for Crop Loss as a Result of Flood and Excessive Moisture (2002-2010)

Year	Crop	Hazard	Claims Paid
2010	Wheat	Excess Moisture/Precip/Rain	$453,852
2010	Corn	Excess Moisture/Precip/Rain	$376,462
2010	Soybeans	Excess Moisture/Precip/Rain	$17,289
2009	Wheat	Excess Moisture/Precip/Rain	$48,463
2009	Corn	Excess Moisture/Precip/Rain	$377,416
2009	Soybeans	Excess Moisture/Precip/Rain	$26,614
2008	Wheat	Excess Moisture/Precip/Rain	$17,821
2008	Corn	Excess Moisture/Precip/Rain	$102,200
2008	Soybeans	Excess Moisture/Precip/Rain	$83,775
2007	Wheat	Excess Moisture/Precip/Rain	$49,738
2007	Corn	Excess Moisture/Precip/Rain	$5,170
2006	Corn	Excess Moisture/Precip/Rain	$26,004
2006	Soybeans	Excess Moisture/Precip/Rain	$31,338
2005	Wheat	Excess Moisture/Precip/Rain	$19,227
2005	Corn	Excess Moisture/Precip/Rain	$42,114
2005	Grain Sorghum	Excess Moisture/Precip/Rain	$361
2005	Soybeans	Excess Moisture/Precip/Rain	$4,663
2004	Wheat	Excess Moisture/Precip/Rain	$1,116
2004	Corn	Excess Moisture/Precip/Rain	$118,313
2004	Soybeans	Excess Moisture/Precip/Rain	$84,907
2003	Wheat	Excess Moisture/Precip/Rain	$575
2003	Corn	Excess Moisture/Precip/Rain	$244,121
2003	Grain Sorghum	Excess Moisture/Precip/Rain	$655
2003	Soybeans	Excess Moisture/Precip/Rain	$72,848
2002	Wheat	Excess Moisture/Precip/Rain	$5,120
2002	Corn	Excess Moisture/Precip/Rain	$7,606
2002	Soybeans	Excess Moisture/Precip/Rain	$405
2001	Soybeans	Excess Moisture/Precip/Rain	$3,361
2010	Corn	Flood	$5,610
2010	Soybeans	Flood	$369
2009	Corn	Flood	$31,202
2008	Corn	Flood	$8,626
2008	Soybeans	Flood	$12,508
2004	Corn	Flood	$766,870
2004	Grain Sorghum	Flood	$5,753
2004	Soybeans	Flood	$84,346
2003	Wheat	Flood	$187
2003	Corn	Flood	$65,445
2003	Soybeans	Flood	$4,989
2002	Corn	Flood	$17,273
2002	Soybeans	Flood	$670
	Total		**$3,225,383**

Source: USDA Risk Management Agency, 2011

Probability of Future Occurrences

The terms "10 year", "50 year", "100 year" and "500 year" floods are used to describe the estimated probability of a flood event happening in any given year. A 10 year flood has a 10 percent probability of occurring in any given year, a 50 year event a 2% probability, a 100 year event a 1% probability, and a 500 year event a 0.2% probability. While unlikely, it is possible to have two 100 or even 500 year floods within years or months of each other.

The potential for flooding can change and increase through various land use changes and changes to land surface. A change in environment can create localized flooding problems inside and outside of natural floodplains through the alteration or confinement of natural drainage channels. These changes can be created by human activities or by other events, such as wildfires, earthquakes, or landslides.

Based on data from NCDC, from 1993 to 2010, there were 68 records of flood or flash flood events over an 18 year period. The average number of flood and flash flood events calculates to 3.7 per year. The probability was assigned a rank of **likely,** 10-100 percent chance of occurrence in next year or has a recurrence interval of 10 years or less.

Magnitude/Severity

The magnitude was classified as **catastrophic**, multiple deaths; property destroyed and severely damaged; and/or interruption of essential facilities and service for more than 72 hours.

3.2.5 Dam Failure

Description

A dam is defined as a barrier constructed across a watercourse for the purpose of storage, control, or diversion of water. Dams are typically constructed of earth, rock, concrete, or mine tailings. A dam failure is the collapse, breach, or other failure resulting in downstream flooding.

A dam impounds water in the upstream area, referred to as the reservoir. The amount of water impounded is measured in acre-feet. An acre-foot is the volume of water that covers an acre of land to a depth of one foot. As a function of upstream topography, even a very small dam may impound or detain many acre-feet of water. Two factors influence the potential severity of a full or partial dam failure: the amount of water impounded, and the density, type, and value of development and infrastructure located downstream.

The failure of dams could result in injuries, loss of life, or damage to property, the environment, and the economy. Dams often serve multiple purposes, one of which may be flood control. Severe flooding and other storms can increase the potential that dams 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 hazard potential for dam failure is classified according to the following definitions accepted by the Interagency Committee on Dam Safety:

- **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 persons, or 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 or service of a utility serving a small number of customers, or inundate recreation facilities, including campground areas intermittently used for sleeping and serving a relatively small number of persons
- **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

Dam failures can result from any one or a combination of the following causes:

- Prolonged periods of rainfall and flooding, which causes most failures;
- Inadequate spillway capacity, resulting in excess overtopping flows;
- Internal erosion caused by embankment or foundation leakage or piping;
- Improper maintenance, including failure to remove trees, repair internal seepage problems, replace lost material from the cross section of the dam and abutments;
- Improper design, including the use of improper construction materials and construction practices;
- Negligent operation, including failure to remove or open gates or valves during high flow periods;
- Failure of upstream dams o the same waterway;
- Landslides into reservoirs, which cause surges that result in overtopping;
- High winds, which can cause significant wave action and result in substantial erosion; and
- Earthquakes, which typically cause longitudinal cracks at the tops of embankments and weaken entire structures.

Geographic Location

According to data from the Indiana Department of Natural Resources, Agriculture, Division of Water Resources, Water Structures Program, Vanderburgh County has 23 total state-regulated dams. Of those, eight are high hazard dams and eight are significant hazard dams. The remaining seven are low hazard dams.

Table 3.16 below summarizes the high and significant hazard dams in Vanderburgh County. All high and significant hazard dams in Vanderburgh County are privately owned and are for recreational purposes as reported by the National Inventory of Dams.

Table 3.16 High and Significant Hazard State-regulated Dams with potential to impact Vanderburgh County

Dam Name	Hazard Class	Last Inspection	Height (Ft.)	Storage (Acre Feet)	River
Bittner Lake Dam	High	1/10/2002	24	76	Unnamed Tributary Maidlow Ditch
Kahre Lake Dam	High	9/25/2009	31	288	Locust Creek
Lloyd Hahn Lake Dam	High	9/3/2008	31	220	Unnamed Tributary Bayou Creek
Mater Dei Provincialate Dam	High	10/17/2008	33	223	Unnamed Tributary Little Creek
North Lake Estates Dam	High	10/22/2008	22	152	Unnamed Tributary Little Creek
Schnacke Lake Dam No. 1	High	10/6/2009	41	230	Unnamed Tributary Locust Creek
University of Southern Indiana Dam	High	3/17/2009	35	135	Unnamed Tributary Bayou Creek
USI Student Residence Complex Lake Dam	High	3/30/2009	31	98	Unnamed Tributary Bayou Creek
Dr. Mok Lake Dam	Significant	5/11/1982	18	0	Unnamed Tributary Carpenter Creek
Edgewater Lake Dam	Significant	3/25/2009	29	172	Big Creek
Lake Shawnee Dam No. 1	Significant	3/9/2009	26	289	Pigeon Creek
Lake Talahi Dam	Significant	3/23/2009	37	259	Unnamed Tributary Pigeon Creek
Ray Nell Lake Dam	Significant	6/23/2009	21	63	Unnamed Tributary Schlensker Ditch
Schnacke Lake Dam No. 2	Significant	¾/2009	40	50	Unnamed Tributary Locust Creek

Dam Name	Hazard Class	Last Inspection	Height (Ft.)	Storage (Acre Feet)	River
Schnacke Lake Dam No. 3	Significant	¾/2009	40	54	Unnamed Tributary Locust Creek
Schnacke Lake Dam No. 4	Significant	¾/2009	40	22	Unnamed Tributary Locust Creek

Source: National Inventory of Dams and Indiana Department of Natural Resources

Previous Occurrences

There have been no reported previous occurrences of dam failure in Vanderburgh County.

Probability of Future Occurrences

Because dam failure is generally a secondary effect of other causes and hazards, calculating probability is difficult. Based on the past performance of these structures during flooding conditions, the HMPC determined that the probability of this hazard is **unlikely,** less than 1 percent chance of occurrence in next 100 years or has a recurrence interval of greater than every 100 years. Additionally, as reflected in Table 3.16, all but two of the high and significant state-regulated dams have been inspected within the last three years. Frequent inspections can identify needed repairs or improvements that may be necessary to prevent failure.

Magnitude/Severity

Although there have been no documented failures of state-regulated dams in Vanderburgh County and the probability of failure is low, if failure were to occur, it could be **catastrophic** for people and structures in the inundation path. According to the Indiana Department of Natural Resources, Emergency Action Plans and Inundation Maps are not required for privately-owned dams. As a result, data is not available to specifically address potential magnitude of failure in quantitative terms. Additionally, if additional development occurs in downstream areas where inundation would occur, the severity of failure would also increase.

3.2.6 Levee Failure

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 loss of life and injuries as well as damages to property, the environment, and the economy.

Levees range from small agricultural levees that protect farmland from high-frequency flooding to large urban areas that protect people and property from larger-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 of a levee as defined in FEMA's Publication "So You Live Behind a Levee" (http://content.asce.org/ASCELeveeGuide.html).

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.

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

1) Accredited Levee – With the except of areas of residual flooding (interior drainage), if the data and documentation specified in 44 CFR 65.10 is readily available and provided to

FEMA, the area behind the levee will be mapped as a moderate-risk area. There is no mandatory flood insurance purchase requirement in a moderate-risk area, but flood insurance is strongly recommended.

2) Provisionally Accredited Levee (PAL) – If data and documentation is not readily available, and no known deficiency precludes meeting requirements of 44 CFR 65.10, FEMA can allow the party seeking recognition up to two years to compile and submit full documentation to show compliance with 44 CFR 65.10. During this two-year period of provisional accreditation, the area behind the levee will be mapped as moderate-risk with no mandatory flood insurance purchase requirement.
3) De-Accredited Levees – If the information established under 44 CFR 65.10 is not readily available and provided to FEMA, and the levee is not eligible for the PAL designation, the levee will be de-accredited by FEMA. The area behind the levee will be mapped as a high-risk area subject to mandatory flood insurance purchase requirement.

Geographic Location

In Vanderburgh County, there is one Provisionally Accredited Levee (PAL) System that provides flood protection for the City of Evansville and portions of unincorporated Vanderburgh County. This levee system is depicted on the Digital Flood Insurance Rate Map (DFIRM) dated March 17, 2011. The area behind the levee is mapped as moderate-risk with no mandatory flood insurance purchase requirement.

There are also several agricultural levees in the county that provide low-level protection to agricultural land during high-frequency flood events. The agricultural levees are not intended to provide protection for development or individuals.

The geographic location was assigned a rank of **significant**, 10-50 percent of planning area affected.

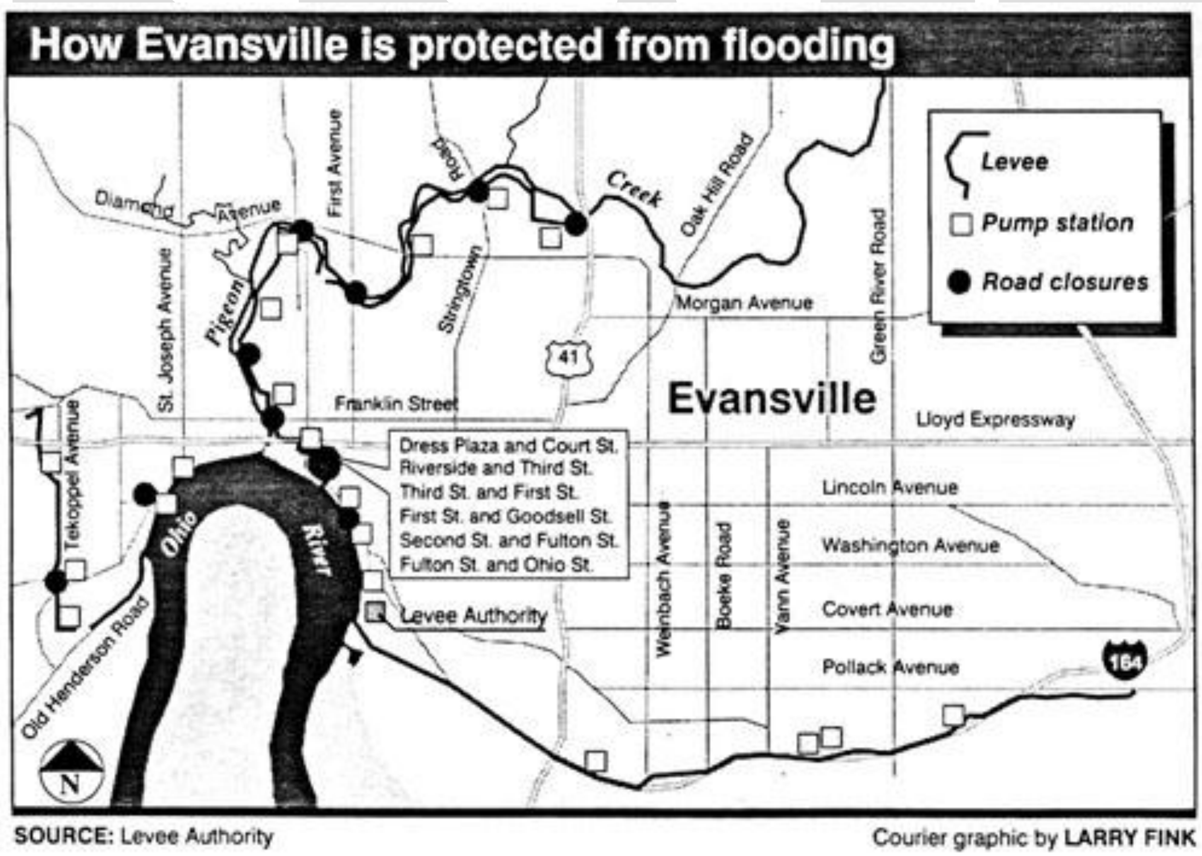
Evansville-Vanderburgh County Levee (PAL Levee)

The city of Evansville, Vanderburgh County, Indiana, is situated in the southwestern part of the state on the right bank of the Ohio River 792 miles below Pittsburgh, Pennsylvania. Following the major flood event of 1937 on the Ohio River, under the general authorization for the Ohio River Basin contained in the Flood Control Act approved August 28, 1937, the City of Evansville, in conjunction with the Louisville District of the U.S. Army Corps of Engineers, initiated the flood protection project. The resulting levee system provides protection to the City of Evansville and portions of the unincorporated areas east of the City from a repetition of the 1937 flood, which had a recurrence interval greater than 500 years. The flood protection system is designed to pump rainwater from the city/county back into the river during high river conditions as well as prevent the river from backing into the sewer system.

The levee system project consists of 79,183 feet of earth levee, 8,175 feet of concrete wall, 1,761 feet of combined wall and highway, 3,160 feet of roadway levee, 20 pumping stations, 24 movable closures, and 15 sandbag closures. The protective works is made up of seven sections along both the Ohio River and Pigeon Creek as follows:

1) A Knight & Howell section began in June 1939 and was completed in 1948.
2) Gatewell construction began in 1976 and was completed in 1979.
3) Pigeon Creek, Unit 1 levee construction began 1964 and completed in 1965. Pump stations began in 1965 and completed 1966.
4) Pigeon Creek, Unit 2, Part 1 began in 1974 and completed in 1985.
5) Pigeon Creek, Unit 2, Part 2 began in 1982 and completed in 1984. Pump stations began in 1988 and completed 1991.
6) Pigeon Creek, Unit 2, Part 3 began in 1988 and completed 1989. Pump stations began in 1988 and completed 1990.
7) Pigeon Creek, Unit 2, Part 4 began in 1992 and completed 1994.

Figure 3.12 Evansville-Vanderburgh County Levee



Source: Evansville-Vanderburgh County Levee Authority, http://www.vanderburghgov.org/index.aspx?page=56

The Evansville-Vanderburgh Levee Authority District (EVLAD) is responsible for operation and maintenance of the levee system. EVLAD is a separate body of the City of Evansville and Vanderburgh County governments and is governed by a three-member board. Funding to maintain this project is provided by local funds per an agreement between federal and local government entities. The EVLAD is partnered with the U. S. Army Corps of Engineers

(Louisville District) who inspects the system annually. Any changes or modifications to the system must have approval by both the local levee district and the Corps of Engineers.

Flood stage at Evansville is 42 feet; zero elevation corresponds to 329.18 feet above sea level at the Court Street Gauge located at Dress Plaza. According to EVLAD, with all road closures in place, and pumps operational, the levee would overtop if the river stage reached 56.7 feet. At a river stage of 26 ft., EVLAD starts working 24 hours day, seven days a week, pumping rain/storm water into the river. After the river rises past 32 ft., a computerized remote control system is activated necessitating three employees per shift trouble-shooting and monitoring the remote control system.

Agricultural Levees

In addition to the Evansville-Vanderburgh County Levee that is provisionally accredited as providing flood protection, there are several agricultural levees in the County that provide minimal protection to agricultural land during high-frequency, low level flooding.

Union Township Levee

The Union Township Levee is located within the southwestern boundaries of Evansville, Indiana and is located approximately 9.25 miles southwest of downtown Evansville. The levee starts at the intersection of Hendricks Lane and Seminary Road in Evansville, Indiana and extends south-southwest for approximately 1.60 miles to the intersection of Old Henderson Road and Golden Rule Road. At the intersection of Old Henderson Road and Golden Rule Road, the levee parallels Old Henderson Road south-southwest for approximately 0.95 miles, terminating at an elevated farmhouse. Total project length is approximately 2.55 miles (all levee embankment).

According to the Louisville District U.S. Army Corps of Engineers, the maximum level of protection of the levee with its current design crest elevation, while maintaining no freeboard, is less than a 98% exceedence frequency (1-year event). The overtopping elevation is 365.5 Feet NGVD, or to stage 36.7 as measured by the Evansville River Gage.

Other Agricultural Levees

There are numerous other agricultural levees in Vanderburgh County that provide low-level protection to agricultural land. These levees are routinely overtopped and are not intended to protect structures or people.

Previous Occurrences

Evansville-Vanderburgh County Levee

Since its construction, the Evansville-Vanderburgh County Levee has not failed or been overtopped. Flood stage at Evansville is 42 ft; zero elevation corresponds to 329.18 feet above sea level at the Court Street gauge located at Dress Plaza. However, as indicated above, according to EVLAD, with all road closures in place, and pumps operational, the levee would overtop if the river stage reached 56.7 feet. In recorded history, the river has never reached this level. The highest the river stage reached in recorded history is 53.7 feet, which was the river stage of the 1937 flood. This flood exceeded the 500-year recurrence interval.

Some high river stages of record at Evansville:

January 29, 1937 53.7 ft.
February 19, 1884 48.8 ft.
February 18, 1883 48.6 ft.
April 5, 1913 48.4 ft.
March 11, 1945 48.2 ft.
March 16, 1964 47.7 ft.
March 10, 1997 47.5 ft.

Since 1940 the Ohio River at Evansville has been above flood stage (42 ft.) 41 times. From 1950, it has been above 30 ft. 138 times.

Agricultural Levees

The Union Township Levee and Drainage Association indicated that the Union Township Levee is overtopped approximately every year, and that adding material to the crown after overtopping is a regular occurrence.

Probability of Future Occurrences

According to events and river stages in recorded history, it is unlikely that the Evansville-Vanderburgh County Levee would be overtopped. The EVLAD has the responsibility to ensure the levee is inspected and maintained to ensure that levee failure does not occur. Although overtopping or failure of this levee is **unlikely**, it remains a risk that could occur due to unprecedented river stages or inspection oversight or lack of maintenance.

It is likely that agricultural levees will continue to be overtopped during low-level high-frequency flood events. In land use and development planning, these levees should not be considered as providing protection for populations or development.

Magnitude/Severity

Although unlikely, the magnitude of an overtopping or failure of the Evansville-Vanderburgh County levee would be **catastrophic** as this levee protects developed, populated areas.

As for agricultural levees, overtopping occurs regularly. The magnitude is negligible and impacts are limited to agricultural losses.

3.2.7 Infestations - Emerald Ash Borer

Description

The HMPC determined that potential infestation of the Emerald Ash Borer (EAB) is of particular concern in the planning area. This pest is a slender, emerald green beetle that is ½ inch long, and responsible for the destruction of approximately 20 million ash trees in Ohio, Michigan, Indiana, Illinois, and Maryland. This exotic beetle feeding on ash trees was discovered in southeastern Michigan in July 2002. On April 21, 2004, Emerald Ash Borer was confirmed in Indiana. Table 3.13 is a photo of an Emerald Ash Borer.

Figure 3.13 Emerald Ash Borer

Source: Indiana Department of Natural Resources, http://www.in.gov/dnr/entomolo/3443.htm

Although ash trees are not necessarily important economically, they are important aesthetically. In addition, the need to remove numerous dead trees throughout the planning area could create problems for residents and local governments.

The Emerald Ash Borer (EAB), *Agrilus planipennis* (Fairmaire) (Coleoptera: Buprestidae), is a pest of ash trees native to Asia and first discovered in North America in 2002 in the Detroit, Michigan area. It has killed millions of ash trees and thousands of ash trees have been removed Since this initial discovery, the core area affected by EAB has expanded. It has been detected in Windsor, Ontario (2003), Ohio (2003), Indiana (2004), Illinois (2006), Maryland (2006), Pennsylvania (2007), West Virginia (2007), Toronto, Canada (2007), Virginia (2008), Wisconsin (2008) and Missouri (2008).

The United States Department of Agriculture restricted the importation and movement of ash nursery stock from Canada into the United States in August 2007 to prevent the spread of Emerald Ash Borer. Illinois, Indiana and Ohio and some counties in Maryland, Missouri, Pennsylvania, West Virginia and Wisconsin are quarantined areas also.

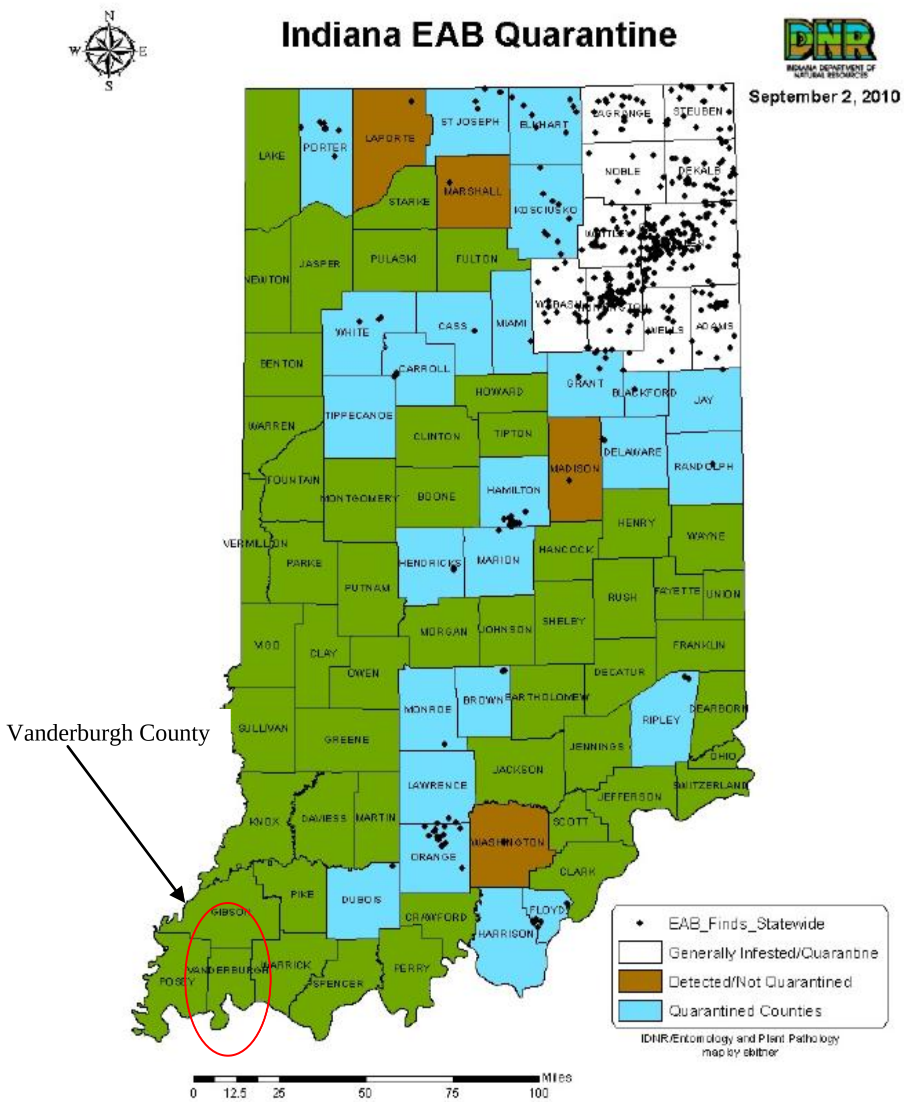
All ash trees native to Indiana are susceptible to infestation by EAB. Trees become infested when adult beetles lay eggs on the bark, which hatch into larvae that bore into the tree. The larvae tunnel in the phloem layer (between bark and wood) and disrupt the movement of water and nutrients, eventually killing the tree. EAB appears to prefer trees under stress, but is capable of killing perfectly healthy trees.

Geographic Location

Table 3.14 provides the currently identified areas of the Indiana where EAB has been confirmed. As this map indicates, the northeast corner is the most heavily infested portion of the State. In May 2010, the Department of Natural Resources has placed purple traps in trees in Vanderburgh County. To date, EAB has not been detected in Vanderburgh County. The pest has been found near Dubois County, to the north east, about 75 miles from Evansville.

A recent audit revealed that of the 10,000 trees in public areas around Evansville, which includes approximately 700 ash trees. The geographic location was assigned a rank of **extensive,** 50-100 percent of planning area affected.

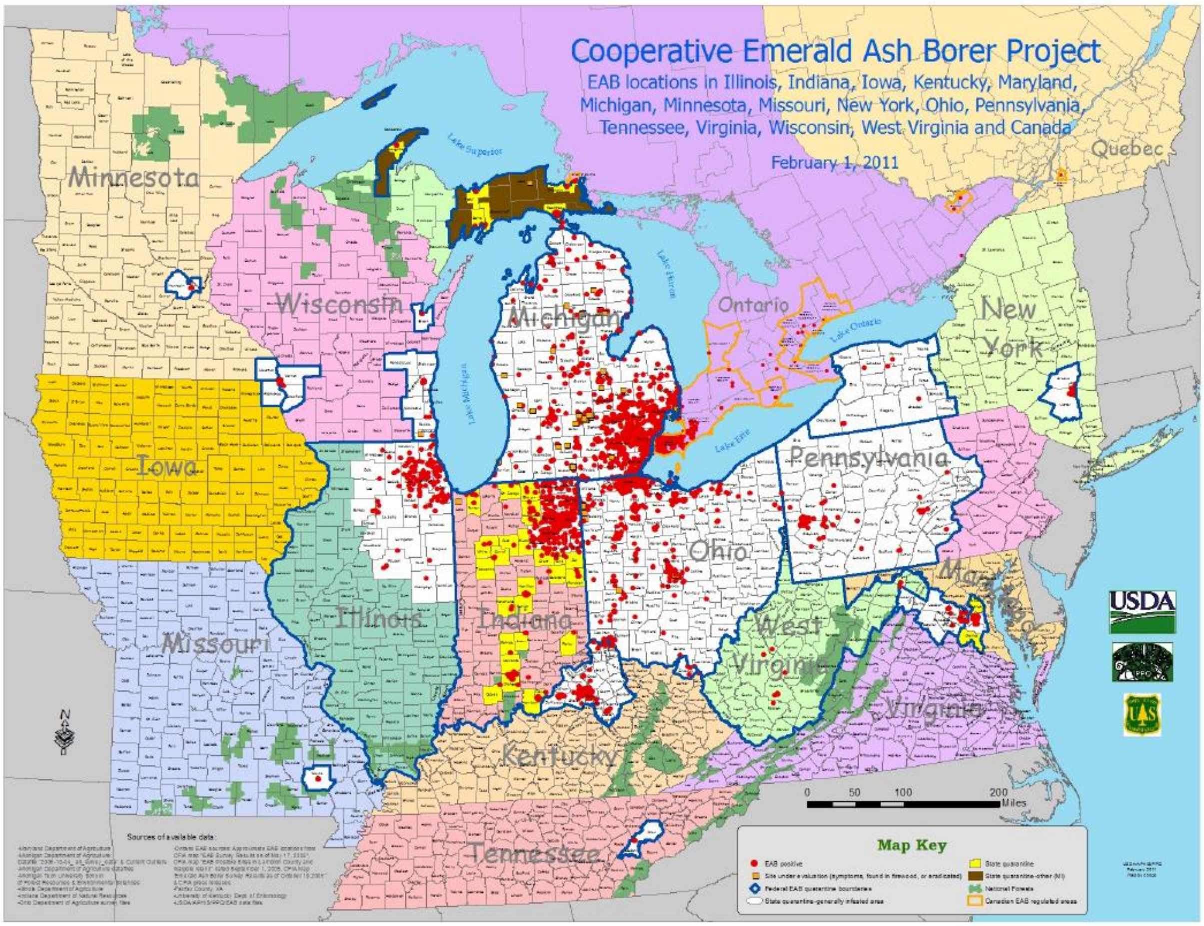
Figure 3.14 Emerald Ash Borer Locations in Indiana



Source: Indiana Department of Natural Resources, http://www.in.gov/dnr/entomolo/files/ep-Indiana_EAB_Quarantine.pdf

Table 3.15 provides the known locations of EAB in the surrounding states.

Figure 3.15   Locations of Emerald Ash Borer in Surrounding States



Source: U.S. Department of Agriculture, http://www.in.gov/dnr/entomolo/files/ep-MultiState_EABpos.pdf

Previous Occurrences

There have been no documented previous occurrences of Emerald Ash Borer in Vanderburgh County.

Probability of Future Occurrences

Arborists and other local officials agree that the chances of sparing local trees from the Emerald Ash Borer's destructive effects are slim to nonexistent. The insect population can travel naturally up to two miles per year. With several major transportation routes going through Vanderburgh County, the natural mobility is increased when, despite prohibitions, individuals transport lumber and firewood. It is estimated that the emerald ash borer will be found in Vanderburgh County within the next one to five years. The probability of future occurrences was assigned a rank of **occasional,** 1-10 percent chance of occurrence in the next year or has a recurrence interval of 11 to 100 years.

To avoid the large cost associated with cleaning up a large number of trees at once, Evansville officials have chosen to cut them down on their own, starting with the weakest ones first. The tree-removal plan was adopted in early 2009. A few ashes in public cemeteries will be saved, as well as a "state champion" tree — the largest of its species in Indiana — in Wesselman Woods Nature Preserve. Ash trees can be protected by injecting them with chemicals, a procedure that must be done as often as once a year to be effective. The need for such regular treatment makes the measure unaffordable on a mass scale.

Magnitude/Severity

It is estimated that Ash trees make up 7 percent of all trees on public ground in Vanderburgh County. If all of them were to die after an infestation by the emerald ash borer, the city would not have the manpower to cut them down. Faced with such a prospect, officials would have to hire the help of tree services, placing a heavy burden on local budgets.

3.2.8 Infestations – West Nile Virus

Description

West Nile Virus (WNV) is one of several mosquito-borne viruses in the United States that can infect people. The virus exists in nature primarily through a transmission cycle involving certain species of mosquitoes and birds. Mosquitoes become infected with WNV when they feed on infected birds.

The West Nile Virus usually causes West Nile fever, a milder form of the illness, which can include fever, headache, body aches, swollen lymph glands, or a rash. A small number of individuals can develop a more severe form of the disease with encephalitis or meningitis and other neurological syndromes, including flaccid muscle paralysis. Health officials report individuals age 50 and over are at greatest risk for serious illness and even death from West Nile virus. However, people of all ages can be and have been infected with the virus.

WNV first struck the northern hemisphere in Queens, N.Y., in 1999 and killed four people. The disease spread from New York to the West Coast in three years. By 2003, all 50 states were warning of an outbreak.

A positive case of West Nile Virus in Vanderburgh County in a bird was first reported in 2001. Since that time, positive cases in humans, horses, and birds have been reported each year. The figure below presents human case data from 2002.

The tenth annual West Nile Virus conference was held in Savannah, Georgia, in February 2009. Conclusions of the conference include:

- WNV has become the most common cause of arboviral neuroinvasivedisease in the U.S.
- WNV activity has also been detected at a lower level in Tropical Americas
- ArboNET, a cooperative surveillance system, was developed in response to WNV introduction
- Non-human activity has helped define the geographic location and spread of WNV
- WNND affects all age groups; causing more deaths and encephalitis in individuals > 50 years
- WNV human disease may have reached endemic level in the U.S.

Geographic Location

The entire planning area is subject to mosquito habitat. The geographic location was assigned a rank of **extensive,** 50-100 percent of planning area affected.

Previous Occurrences

The summer of 2010 was extremely hot and dry in Vanderburgh County. These conditions are of extreme concern due to the biology of the primary West Nile Vector, Culex pipiens. This mosquito breeds in stagnant ditches and catch basins in water with very high organic content. With the drought conditions, the potential for significant numbers of this species and a WNV outbreak was high. The Vanderburgh County Vector Control program focused its efforts on controlling these habitats by treating the catch basins and ditches regularly. Despite the ideal conditions for an outbreak, the Indiana State Health Department conducted periodic adult mosquito surveillance, but numbers of mosquitoes caught were lower than previous years and none tested positive for WNV.

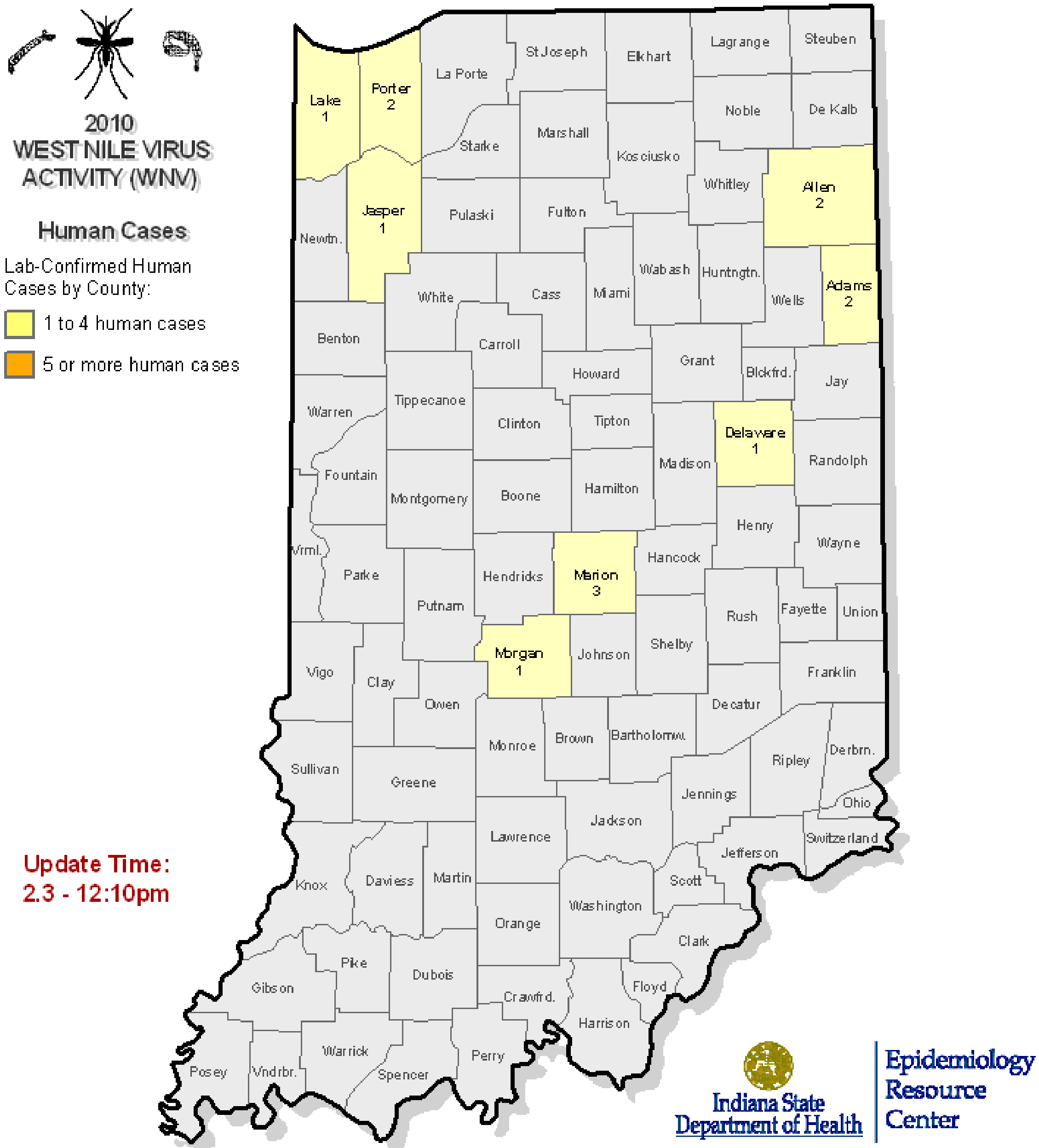
The table below presents the annual number of human disease cases in Vanderburgh County since 2003. Positive human cases of West Nile Virus in Indiana for 2010 are also presented in Figure 3.16.

Table 3.17 WNV Human Disease Cases in Vanderburgh County

Year	2003	2004	2005	2006	2007	2008	2009	2010
WNV Human Disease Cases	0	1	0	1	3	0	0	0

Source: USGS West Nile Virus Historical Maps
http://diseasemaps.usgs.gov/wnv_historical.html

Figure 3.16 Human Disease Cases, 2010

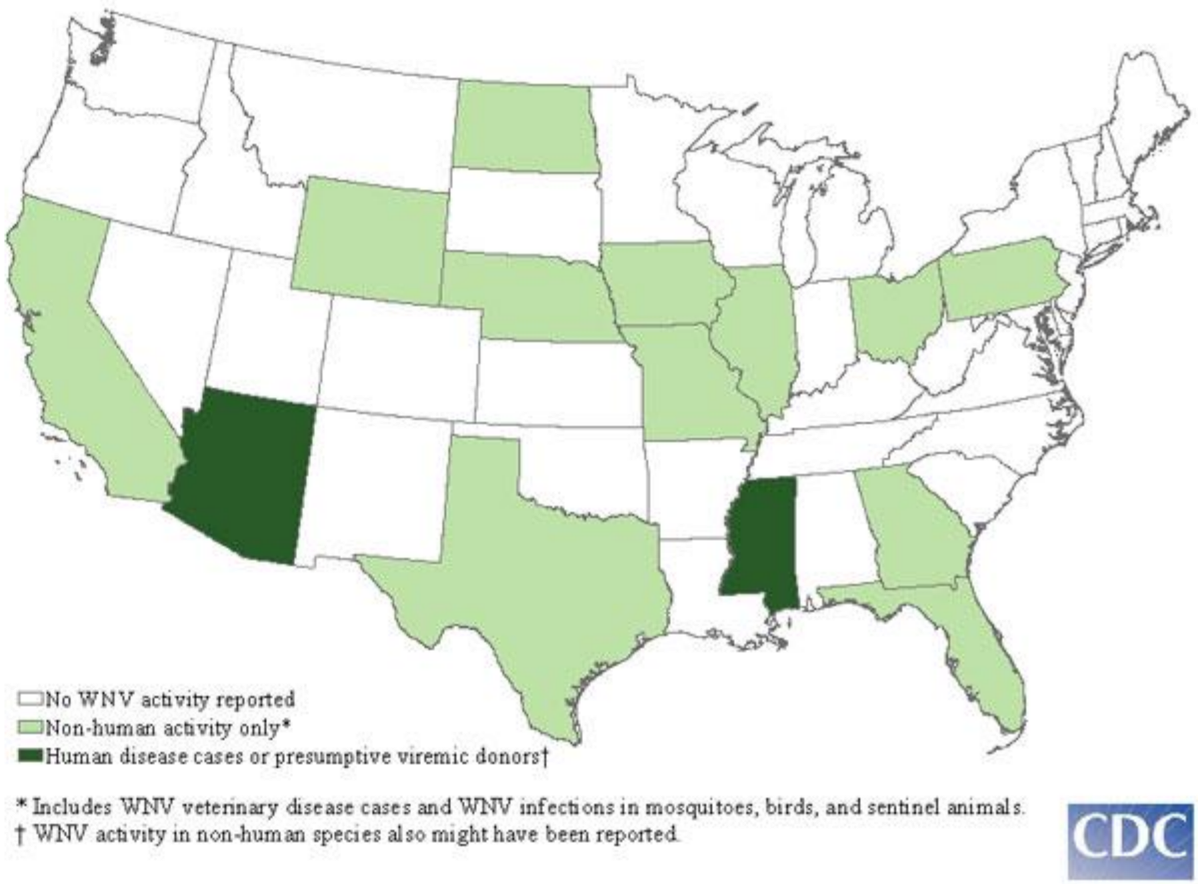


Source: Indiana State Department of Health Arboviral Disease Mapping; http://isdhmaps.isdh.in.gov/apps/pubstat/WNVStat.htm

Probability of Future Occurrences

Since 2003, there have been 5 human disease cases identified in Vanderburgh County. The probability of a future occurrence is **unlikely**, less than 1 percent chance of occurrence in next 100 years or has a recurrence interval of greater than every 100 years. The figure below presents the West Nile activity in the US as of July 5, 2011. No activity had been reported in the State of Indiana at that time.

Figure 3.17 West Nile Activity within the United States, as of July 5, 2011



Source: Center for Disease Control;
http://www.cdc.gov/ncidod/dvbid/westnile/Mapsactivity/surv&control11MapsAnybyState.htm

Magnitude/Severity

The magnitude/severity for this hazard is **negligible**, no or few injuries or illnesses; minor quality of life loss; little or no property damage; and/or brief interruption of essential facilities and services.

3.2.9 Mine Subsidence

Description

Mine subsidence is movement of the ground surface as a result of the collapse or failure of underground mine workings. In active underground mining operations using longwall mining or high extraction pillar recovery methods, subsidence can occur concurrently with the mining operation in a predictable manner. In abandoned mines where rooms and unmined coal pillars are often left in various sizes and patterns, it may be impossible to predict if and when subsidence will occur. Mine subsidence resulting from abandoned room and pillar mines can generally be classified as either sinkhole subsidence or trough subsidence.

Mine subsidence can occur as a result of mining at any depth. As a general rule, the total surface area affected by subsidence increases as the depth of mining increases. This means a structure can be damaged by subsidence even if it is located directly above a pillar or solid block of coal.

Geographic Location

All of Indiana's coal is located in the west-central and southwestern portion of the State in a large geologic structure known as the Illinois Basin. Illinois Basin coal originated from plant material that accumulated in tropical wetlands during the Pennsylvanian Period of geologic time (approximately 300 million years ago).

For more than 150 years, the coal region of west-central and southwestern Indiana has undergone widespread mining and that continues in the present (see 0 3.18). But there are no surface or underground coal mines active in Vanderburgh County now. The now inactive mines are presented in Figure 3.19. Underground (deep) mining was the dominant mining technique until the 1950s when the development of large-scale excavation and transportation equipment made surface (strip) mining more efficient. Most of Indiana's underground mines used a method called room-and-pillar mining, whereby 20 to 50 percent of the coal is left in the mine to support the overlying rock. In instances where the remaining coal pillars are insufficient to bear the weight of the overlying rock, subsidence of the mine roof will occur. Subsidence may occur decades or centuries after an underground mine is abandoned. All undermined areas are at risk of subsidence, but it is not possible to predict when, if ever, subsidence will occur at a given locality.

Common factors causing or affecting mine subsidence include:

- Time elapsed since mining;
- Depth of the mine;
- Water conditions of the mine;
- Type and thickness of rock and sediment overlying the mine; and
- Method of mining and plan shape of the mine.

There are also special factors of importance for transportation agencies. Due to the driving force for subsidence being gravity:

- Added weight of fill, especially at bridge approaches, could accelerate subsidence; and
- Acceleration and amplification of gravity forces from earthquakes could accelerate the subsidence.

About 100,000 acres of southwestern Indiana are undermined, but there are no estimates of the total acreage of subsidence damage. Subsidence is indicated by the formation of sinkholes, ponds, and troughs, alteration of the flow of ground water, and damage to manmade structures. The effects of subsidence, which are long lasting in many places and may not be eliminated by natural processes for decades or centuries, may be difficult to recognize and must be studied in the field and on aerial photographs. The character and areal extent of subsidence, as well as the time elapsed before its formation, depend on the layout of a mine, the methods used in mining, the depth of a mine, the character of the rocks and sediments overlying a mine, the flow of groundwater through the workings, and later human activity, such as surface mining.

Within Vanderburgh County, the area of parcels which overlay with the area of the identified mines is approximately 3-percent of the total planning area. Thus, the geographic location was assigned a rank of **limited,** less than 10 percent of planning area affected.

Figure 3.18 Map of Coal Mines in Indiana, 2008

EXPLANATION

- Active Surface Coal Mine
- Active Underground Coal Mine
- 1 Mine ID Number
- Surface Mined Area
- Underground Mined Area
- P Pennsylvanian System (coal-bearing strata)

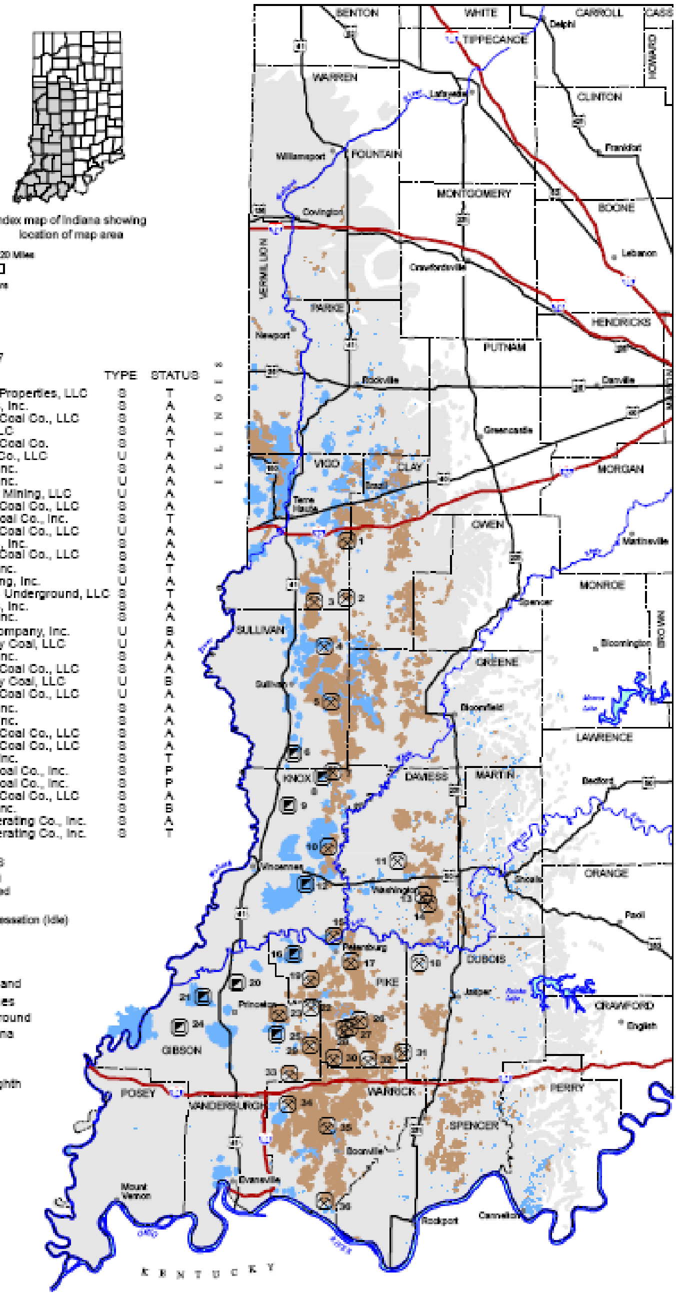
Index map of Indiana showing location of map area

10 5 0 10 20 Miles

10 5 0 10 20 Kilometers

N

Map Scale 1: 1,300,000



ACTIVELY PERMITTED COAL MINES 2007

ID #	MINE NAME	COMPANY	TYPE	STATUS
1	Clayvigo #1 Mine	RLF Chinook Properties, LLC	S	T
2	Lewis Mine	Solar Sources, Inc.	S	A
3	Farmersburg #1 Mine	Black Beauty Coal Co., LLC	S	A
4	J. C. #1 Mine	Jarvis Coal, LLC	S	A
5	Farmersburg,Bear Run East	Black Beauty Coal Co.	S	T
6	Carlisle Mine	Sunrise Coal Co., LLC	U	A
7	Freelandville Mine	Triad Mining, Inc.	S	A
8	Freelandville Underground	Triad Mining, Inc.	U	A
9	Oaktown Fuels #1 Mine	Black Panther Mining, LLC	U	A
10	Miller Creek, Knox Pit	Black Beauty Coal Co., LLC	S	A
11	Antioch Mine	Little Sandy Coal Co., Inc.	S	T
12	Air Quality Mine	Black Beauty Coal Co., LLC	U	A
13	Cannelburg Mine	Solar Sources, Inc.	S	A
14	Viking Mine, Corning Pit	Black Beauty Coal Co., LLC	S	A
15	Pride Mine	B. B. Mining, Inc.	S	T
16	Prosperity Mine	Five Star Mining, Inc.	U	A
17	Charger Mine	Solar Sources Underground, LLC	S	T
18	Shamrock Mine	Solar Sources, Inc.	S	A
19	Flat Creek Mine	Triad Mining, Inc.	S	A
20	Baron Mine	Baron Coal Company, Inc.	U	B
21	Gibson County Mine	Gibson County Coal, LLC	U	A
22	Hurricane Creek Mine	Triad Mining, Inc.	S	A
23	Francisco Mine	Black Beauty Coal Co., LLC	S	A
24	Gibson South Mine	Gibson County Coal, LLC	U	B
25	Francisco Underground Mine	Black Beauty Coal Co., LLC	U	A
26	Augusta Mine	Triad Mining, Inc.	S	A
27	Augusta South Mine	Triad Mining, Inc.	S	A
28	Somerville East Mine	Black Beauty Coal Co., LLC	S	A
29	Somerville #1 Mine	Black Beauty Coal Co., LLC	S	A
30	Log Creek Mine	Triad Mining, Inc.	S	T
31	Hilsmeyer Mine	Little Sandy Coal Co., Inc.	S	P
32	Rhodemaker Mine	Little Sandy Coal Co., Inc.	S	P
33	Discovery/Somerville South	Black Beauty Coal Co., LLC	S	A
34	Five Star #1 Mine	B. B. Mining, Inc.	S	B
35	Cypress Creek Mine	Vigo Coal Operating Co., Inc.	S	A
36	Red Brush Mine	Vigo Coal Operating Co., Inc.	S	T

TYPE CODES
S - Surface Mine
U - Underground Mine

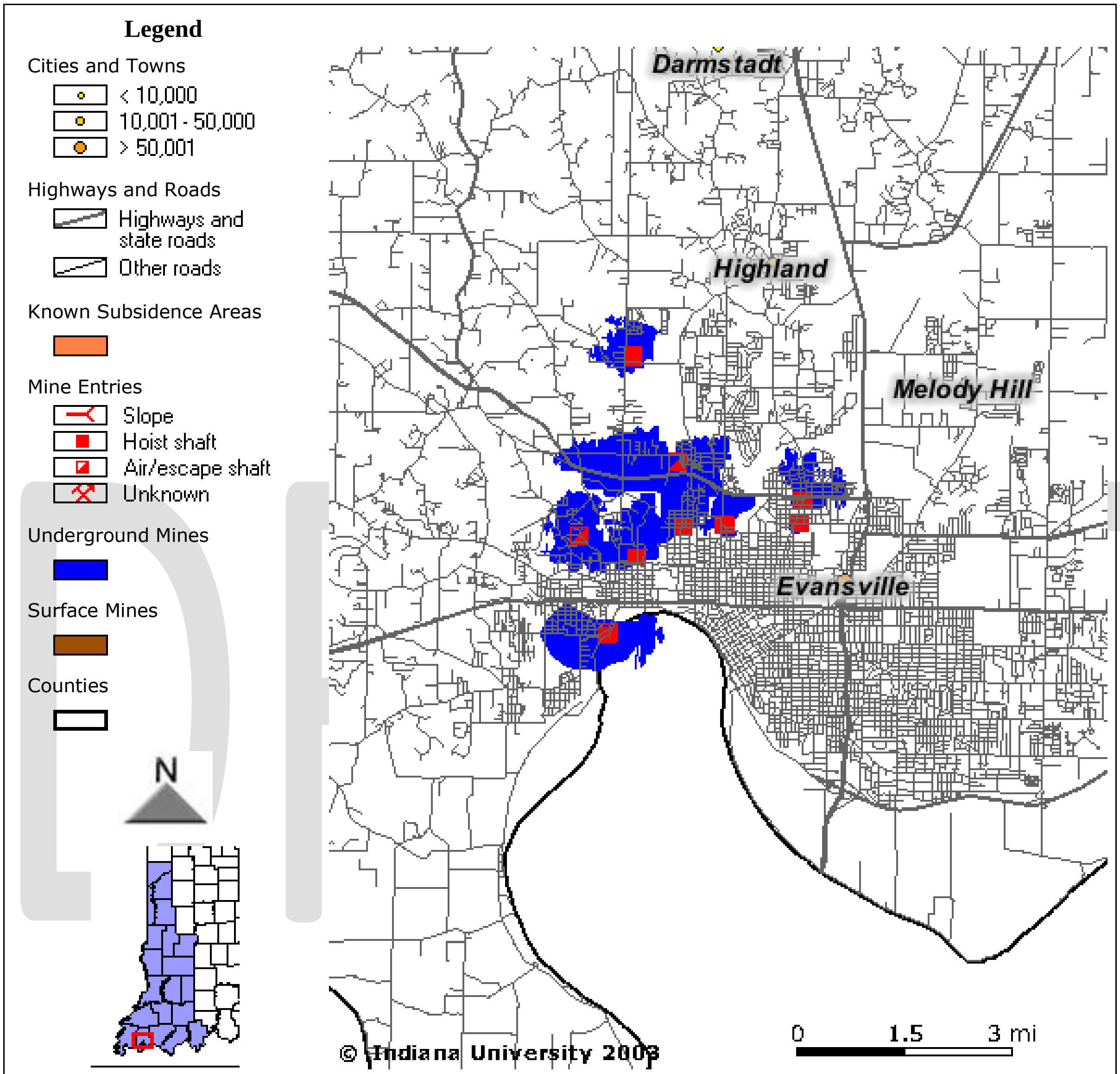
STATUS CODES
A - Active Mining
B - Permit Bonded
P - Pending
T - Temporary Cessation (Idle)

2007 COAL STATISTICS

In 2007, 7 companies operated 18 surface mines and 6 underground mines in Indiana. The surface mines produced 23.4 million short tons while the underground operations produced 10.3 million short tons (Indiana Department of Natural Resources, Division of Reclamation, 2007). With total coal production in excess of 35 million short tons, Indiana ranked eighth out of all coal-producing states in 2007 (U.S. Department of Energy, 2008).

Source: Directory of Coal Mines and Producers in Indiana, 2008

Figure 3.19 Vanderburgh County Coal Mines



DATA AVAILABILITY

The Indiana Geological Survey has additional information for many of the mines shown on this map. Additional information may include detailed maps showing underground mine workings, mine history information, and coal production data. Requests for specific mine information should be directed to the Energy Resources Section:

Indiana Geological Survey
611 N. Walnut Grove
Bloomington, IN 47405
Phone: 812-855-7636
FAX: 812-855-2862
Email: IGSINFO@indiana.edu
URL: http://www.indiana.edu/~igs

Some mine and entry locations are approximate and incomplete. Please provide additions or corrections to Head, Energy Resources Section, Indiana Geological Survey.

DISCLAIMER

This map was compiled by the Indiana Geological Survey, using data believed to be accurate; however, a margin of error is inherent in all maps. This product is distributed "AS-IS" without warranties of any kind, either expressed or implied, including but not limited to warranties of suitability of particular purpose or use. There is no attempt in either the design or production of this map to define the limits or jurisdiction of any federal, state or local government. This map is intended for use only at the scale of 1:24,000 or smaller. A detailed on-the-ground survey and historical analysis of a single site may differ from this map.

Indiana Coal Mine
Information System
Indiana Geological Survey
Indiana University

Table 3.18 Coal Mines in Vanderburgh County

Mine Number	Mine Name	Start Year	End Year	Area (sq.meters)	Permiter (meters)	Mine Type	Source Confidence
810002	Kohler Farm Drift	1858	1898	870	135	A	Secondary
810003	Stevens Farm Drift	1898	1898	882	136	A	Secondary
800117	Unity Mine	1885	1891	4,587,574	14,510	U	Primary
	Sunnyside #2 Mine	1892	1895				
	Unity Mine	1900	1913				
	Crescent #1 Mine	1914	1933	392,382	5,709	U	Secondary
800118	Diamond Mine	1883	1929	1,257,539	10,486	U	Primary
800119	Crescent #2 Mine	1937	1946	854,011	11,955	U	Primary
		1937	1946	346,165	6,343	U	Secondary
800120	Ingleside Mine	1883	1917	727,152	6,339	U	Primary
	Bodium Mine	1858	1882	1,940,885	6,664	U	Secondary
800121	First Avenue Mine	1883	1913	155,051	3,363	U	Primary
		1883	1913	537,170	3,748	U	Secondary
800122	Sunnyside Mine	1883	1936	2,815,621	16,012	U	Primary
		1883	1936	691,801	6,076	U	Secondary
800751	Black Crow Mine	1934	1939	46,532	2,138	U	Primary
	Banner Mine	1939	1939				
802382	Echo Mine	1883	1888	123,410	1,294	U	Secondary
	Cooperative Mine	1891	1895				
	Union Mine	1895	1898				

Mine Number: Indiana Geological Survey Mine ID Number
Year Start: Approximate date that mine opened
Year End: Approximate date that mine closed
Mine Type: A – adit mine, small underground mine; U – underground mine
Primary: Mapped from company mine map
Secondary: Mapped from source other than a company mine map, including IGS publications, field notes and maps of IGS geologists, and Reports of the State Inspector of Mines

Previous Occurrences

There have not been any recorded events of mine subsidence within Evansville and Vanderburgh County. Therefore, it is not a high priority hazard facing Evansville and Vanderburgh County.

Probability of Future Occurrences

Because the initial stages of subsidence are hidden and because so many factors are involved, predicting subsidence above abandoned room-and-pillar mines for a particular locality is impossible. But as more information is gathered, determining probabilities of subsidence for selected sites may be possible. Because there have not been any recorded events within the planning area, the probability of future occurrence is assigned a rank of **unlikely**, less than 1 percent chance of occurrence in next 100 years or has a recurrence interval of greater than every 100 years.

Magnitude/Severity

Due to the parcels and structures located above the noted mines, this hazard is classified as **critical**, isolated deaths and/or multiple injuries and illnesses; major or long-term property damage that threatens structural stability; and/or interruption of essential facilities and services for 24-72 hours.

3.2.10 Severe Weather – Extreme Temperatures

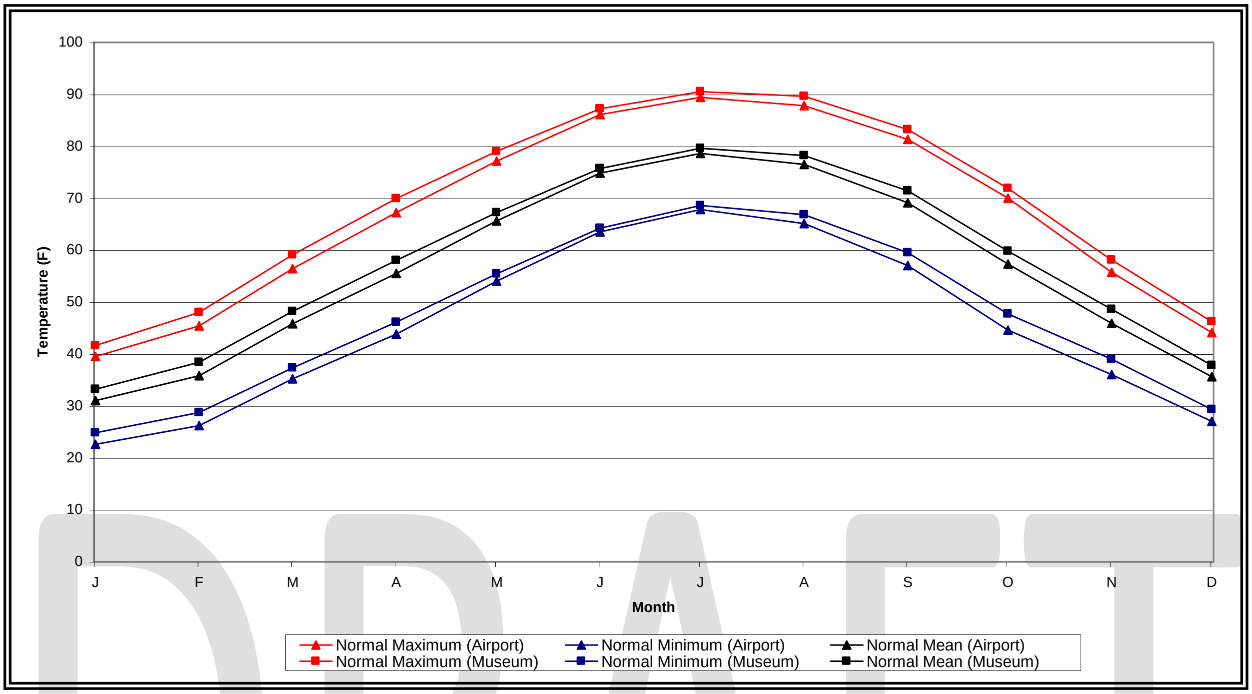
Description

Extreme temperature events, both hot and cold, can have severe impacts on natural ecosystems, agriculture and other economic sectors, human health and mortality. All areas of Evansville and Vanderburgh County have an equal chance of experiencing extreme temperatures in the summer or winter months. The normal monthly temperatures for Evansville are presented Table 3.19 below.

Table 3.19 1971-2000 National Climatic Data Center Normals, Temperature Summary (°F)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Evansville Museum	33.2	38.4	48.2	58.0	67.2	75.7	79.6	78.2	71.4	59.8	48.6	37.8	58.0
Evansville Regional Airport	31.0	35.8	45.8	55.5	65.6	74.8	78.6	76.5	69.1	57.3	45.9	35.6	56.0

Figure 3.20 Comparison of Maximum and Minimum Normal Temperatures

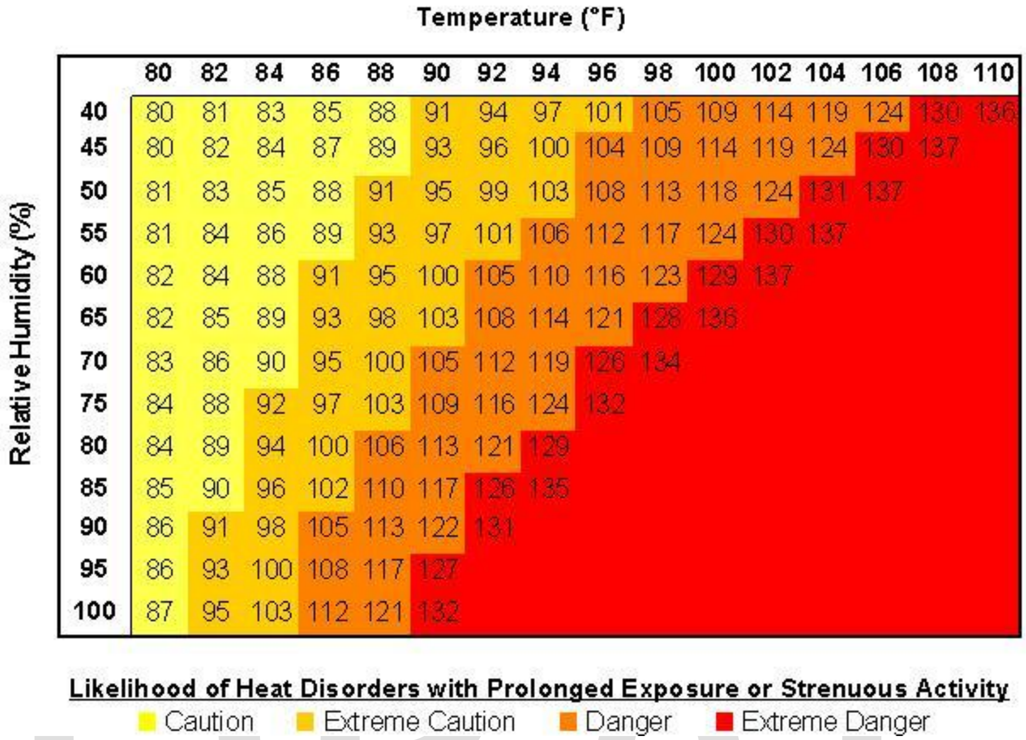


Extreme Heat

Temperatures that remain 10 degrees or more above the average high temperature for the region and last for several weeks are defined as extreme heat by FEMA. Humid or muggy conditions, which add to the discomfort of high temperatures, occur when high atmospheric pressure traps damp air near the ground.

In an effort to alert the public to the hazards of prolonged heat and humidity episodes, the National Weather Service devised the "heat index". The heat index is an accurate measure of how hot it feels to an individual when the affects of humidity are added to high temperature. Figure 3.21 provides the heat index chart demonstrating how the heat index value is determined based on relative humidity. Table 3.20 that follows presents heat index values and their potential physical effects.

Figure 3.21 Heat Index (HI) Chart



Source: National Weather Service (NWS)
Note: Exposure to direct sun can increase Heat Index values by as much as 15°F. The shaded zone above 105°F corresponds to a HI that may cause increasingly severe heat disorders with continued exposure and/or physical activity.

Table 3.20 Heat Index Values and Effects

Heat Index Values Combination of Heat and Humidity	Heat Index Effects
80 to 90 degrees F	Fatigue possible with prolonged exposure and/or physical activity.
90 to 105 degrees F	Sunstroke, heat cramps, and heat exhaustion possible with prolonged exposure and or physical activity.
105 to 130 degrees F	Sunstroke, heat cramps or heat exhaustion likely, and heatstroke possible with prolonged exposure and/or physical activity.
130 degrees and higher F	Heatstroke/sunstroke highly likely with continued exposure.

The National Weather Service will issue a *Heat Advisory* for Evansville-Vanderburgh County when daytime heat indices are at or above 105°F and nighttime heat indices are at or above 80°F. An *Excessive Heat Warning* is issued when the heat index equals or exceeds 115°F for three hours or longer with a minimum heat index of at least 80°F during a 24-hour period. An excessive heat advisory is also issued when heat advisory conditions persist for at least 3 days. In either of these scenarios, the heat becomes dangerous for a large portion of the population. Those at greatest risk for heat-related illness include infants and children up to four years of age, people 65 years of age and older, people who are overweight, and people who are ill or on certain medications. However, even young and healthy individuals are susceptible if they participate in strenuous physical activities during hot weather.

Extreme Cold

Extreme cold can cause hypothermia (an extreme lowering of the body's temperature), frostbite and death. Infants and the elderly are particularly at risk, but anyone can be affected. While there are no firm data on hypothermia (cold) death rates, it is estimated that 25,000 older adults die from hypothermia each year. The National Institute on Aging estimates that more than 2.5 million Americans are especially vulnerable to hypothermia, with the isolated elderly being most at risk. About 10 percent of people over the age of 65 have some kind of temperature-regulating defect, and 3-4 percent of all hospital patients over 65 are hypothermic. Also at risk are those without shelter or who are stranded, or who live in a home that is poorly insulated or without heat. Other impacts of extreme cold include asphyxiation (unconsciousness or death from a lack of oxygen) from toxic fumes from emergency heaters, household fires, and frozen/burst pipes.

In 2001, NWS implemented an updated Wind Chill Temperature (WCT) index. This index was developed by the National Weather Service to describe the relative discomfort/danger resulting from the combination of wind and temperature. Wind chill is based on the rate of heat loss from exposed skin caused by wind and cold. As the wind increases, it draws heat from the body, driving down skin temperature and eventually the internal body temperature.

Specifically, the new WCT index:

- Calculates wind speed at an average height of five feet (typical height of an adult human face) based on readings from the national standard height of 33 feet (typical height of an anemometer);
- Is based on a human face model;
- Incorporates modern heat transfer theory (heat loss from the body to its surroundings, during cold and breezy/windy days);
- Lowers the calm wind threshold to 3 mph;
- Uses a consistent standard for skin tissue resistance; and
- Assumes no impact from the sun (i.e., clear night sky).

Figure 3.22 shows the relationship of wind speed to apparent temperature and typical time periods for the onset of frostbite.

Figure 3.22 Wind Chill Chart

Temperature (°F)

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

Frostbite Times: 30 minutes; 10 minutes; 5 minutes

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

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

Effective 11/01/01

Source: National Weather Service

The National Weather Service will issue a Wind Chill Advisory for Evansville and Vanderburgh County when wind-chill temperatures are expected to reach –4 °F to –20 °F.

Geographic Location

The geographic location was assigned a rank of **extensive**, the entire planning area is subject to extreme temperatures and all participating jurisdictions are affected.

Previous Occurrences

Analysis of daily maximum temperatures recorded at the Evansville Airport Cooperative Weather Station revealed that during the 8-year period from 2000-2007; 279 days had a high temperature exceeding 90 degrees Fahrenheit. This translates to nearly 10 percent of the days during that time period. Six days in this time period, all in August 2007 had a high temperature that exceeded 100 degrees Fahrenheit. The record high temperature at this station occurred on July 28, 1930 with a temperature of 111 degrees Fahrenheit.

Analysis of daily minimum temperatures recorded at the Evansville Airport Cooperative Weather Station revealed that during the 8-year period from 2000-2007; 48 days had a low temperature of ten degrees Fahrenheit or less. Twenty-one days in this time period had a low temperature of zero or below. The record low temperature at this station occurred on February 2, 1951 with a temperature of minus 23 degrees Fahrenheit.

The following section summarizes 23 previous extreme temperature events in Vanderburgh County in the 37-year period from 1974 to 2010. Information on these events came from the National Climatic Data Center and the Evansville - Vanderburgh County Community Comprehensive Hazard Analysis. Of the historical events summarized, 14 were extreme heat events and 9 were extreme cold events.

- **Summer 1974, Extreme Summer Heat**—Summer temperatures reached all time highs in much of the Central and South United States resulting in numerous deaths.
- **January, 1978, Extreme Winter Cold**—The Winter of 1978 was the year that the State of Indian experienced the worst blizzard on record. It hit the region on the 25th through the 27th of January and dumped up to 20 inches of snow onto the central and southern portions of the State. An amazing 40 inches was recorded in the extreme northern portions of Indiana. Even worse were the powerful wind gusts that reached up to 55 mph which caused snow drifting that reached in excess of 10 to 20 feet and deadly wind chills as low as -50. A Federal State of Emergency was declared for this event.
- **January 1979, Extreme Winter Cold**—In January of 1979, significant snows fell again, but ice storms came with it, making the state virtually stand still for two weeks. There were significant power outages, collapsed trees, and commercial and residential property damages all over the state. Damages were estimated at just over 1.5 million dollars. A federal disaster declaration was given to this event to assist in cleaning up.
- **Summer, 1988, Extreme Summer Heat**—In 1988, much of the country was experiencing drought conditions with extremely high temperatures.
- **January 14, 1994, Extreme Cold**—Bitter cold weather settled over Indiana during the third week of January. Many locations recorded daily minimum temperatures below zero each day from January 14 to January 21. The coldest temperatures were recorded on the morning of January 19, when a new record minimum for the state of Indiana was established with a reading of -36 at the National Weather Service cooperative weather station at New Whiteland in Johnson County. Other record low temperatures recorded on the 19th included an all time record low of -27 at Indianapolis, and **record lows for the day of -17 at Evansville**, -18 at Fort Wayne, and -21 at South Bend. Some locations with official temperatures of -30 or colder on the 19th included Cambridge City with -35, Martinsville with -35, Spencer with -33, the Bloomington Airport with -33, Salem with -32, Rushville with -31, and Brookville with -31. **Three people in Vanderburgh County died** as a result of the extreme cold. A 79 year woman died from hypothermia in her home, a 77 year old male man died from exposure while working on his farm, and a 46 year old male froze to death after he passed out in his car.

  Heavy Snow/Ice Storm Southern Indiana. A major winter storm brought heavy snow to central and southern Indiana. In parts of southern Indiana one-quarter to one-half inch of freezing rain accumulated before the precipitation changed to snow. Most of central and southern Indiana received between six and nine inches of snow. However, heavier amounts fell in extreme southern Indiana, with 16 inches being reported over Harrison, Floyd, and Clark Counties, and close to a foot of snow being reported over the southern parts of Spencer and Perry Counties. Many businesses and schools were closed for several days following the storm, with some schools remaining closed for an entire week. Many roads in southern Indiana were impassable for several days following the storm.

- **July 13, 1995, Heat Wave**—Heat wave conditions developed across all of Indiana. High temperatures reached between 95 and 105 degrees with heat indices between 100 and 120 degrees. The Evansville area temperatures reached or exceeded 95 degrees from July 11-17. Nearly all heat related deaths occurred in the sick or elderly populations and most occurred in northwest Indiana. Also, nearly 800,000 baby chickens died at the Rose Acre Farms in Seymour resulting in losses totaling near one million dollars.
- **February 2, 1996, Extreme Cold**—The most severe cold snap of the 1995-96 winter season caused **water pipes to burst and heating systems to malfunction**. The high temperature at Evansville only reached 6 degrees on the 3rd, followed by a low of minus 7 on the 4th.
- **January 10, 1997, Extreme Wind Chill**—Arctic air blew into the region in the wake of a departing snowstorm. A wind chill advisory was issued for wind chills as low as minus 30.
- **July 25, 1997, Excessive Heat**—High temperatures rose into the mid to upper 90s for three consecutive days. High humidity raised the heat index to between 105 and 115 degrees. The potentially hazardous conditions prompted the **issuance of a heat advisory**.
- **February 1, 1998, Abnormal Warmth**—The month of February averaged well above normal. At Evansville, this was the sixth warmest February on record. The mild temperatures provided area residents with unusual opportunities for outdoor recreation. Many trees and plants, such as forsythia and daffodils, blossomed early. Unfortunately, the premature blossoms were vulnerable to late season cold snaps.
- **July 18, 1999, Excessive Heat**—Prolonged heat and humidity set in around mid month and continued through the latter half of July. High temperatures were in the 90s for the last 14 days of the month, including a 98-degree reading on the 30th. High humidity sent afternoon heat indices to between 105 and 115 degrees. **A Heat Advisory was in effect for over a week.** Power usage approached or exceeded record levels. There was a slight increase in emergency room visits for heat exhaustion.
- **December 12, 2000, Extreme Cold**—An invasion of arctic air occurred on December 12. The arctic air became permanently entrenched over the region for the remainder of the month, resulting in the second coldest December on record at Evansville. The average monthly temperature of 23.6 degrees was 11.6 below normal. On the coldest day of the month, the 22nd, the high was 15 and the low was 2. **Unusually high energy prices**, combined with the record cold, caused **homeless shelters to fill to capacity**. The usual problems associated with frigid temperatures, such as frozen pipes and water main breaks, were common during the latter half of the month.
- **January 1, 2001, Extreme Cold**—The prolonged arctic freeze that began during the second week of December finally ended by January 4. During the first few days of the new year, temperatures averaged 15 to 25 degrees below normal. Overnight lows were around zero.
- **January 23, 2003, Extreme Cold/Wind Chill**—Wind chills fell to 12 below zero across southwest Indiana during the morning hours. The extremely cold weather was a factor in the closing of schools in the Evansville area, and homeless shelters were filled beyond capacity. A southwest Indiana power company set a record for winter peak electric demand. This cold

snap was just one of many cases of harsh winter weather during January. After the relatively mild winters of the past several years, the bitter mid-winter cold came as a shock to many. Temperatures fell below zero at some locations for the first time in several years. The low temperature at Evansville was zero, but some outlying areas were colder.

- **December 23, 2004, Extreme Cold/Wind Chill**—Bitterly cold temperatures arrived in the wake of a paralyzing snowstorm. The low temperature on Christmas morning was 11 degrees below zero at Evansville, which set a record for the date. This was the coldest temperature since January of 1994. It was four degrees shy of the coldest December temperature on record at Evansville, where records date back to 1897
- **July 21, 2005, Excessive Heat**—Several days of excessive heat and humidity caused a significant increase in heat-related illnesses. A local hospital in Gibson County reported treating four people, all of whom were involved in outdoor activities. Statistics from Evansville hospitals were unavailable. The heat index peaked from 100 to 110 degrees each afternoon. True air temperatures reached the lower to mid 90's, with overnight lows in the lower to mid 70's. At Evansville, the heat index topped out at 109 degrees on the 21st, 105 on the 22nd, 98 on the 23rd, 109 on the 24th, 106 on the 25th, and 104 on the 26th. These heat indices were representative of the rest of southwest Indiana. The heat wave was the result of an expansive surface high pressure system extending from the Gulf of Mexico to the Great Lakes. A light southerly wind flow, combined with moist ground from the remnants of Hurricane Dennis earlier in the month, allowed dew points to hover just below 80 degrees at times.
- **August 19, 2005, Excessive Heat**—The heat index topped 105 degrees across most of southwest Indiana on two consecutive afternoons. At Evansville, the official peak heat indices were 106 degrees on the 19th and 107 on the 20th.
- **July 31, 2006, Heat**—Heat indices rose to around 105 degrees during the afternoon hours. At the Evansville airport, the highest observed hourly heat index was 105 degrees.
- **August 1, 2006, Heat**—Heat indices across southwest Indiana rose to 105 degrees or more on the afternoons of August 1st and 2nd. At Evansville, the heat index peaked at 107 degrees on August 1st and 105 degrees on August 2nd. A utility company based out of Evansville set an electricity demand record on August 1st.
- **August 7, 2007, Heat**—Surface high pressure located over the Deep South remained nearly stationary. A persistent hot and humid southwest wind flow around this high brought an extended period of dangerously high heat indices, ranging from 105 to 110 degrees on several afternoons. Four cooling centers were opened in Evansville/Vanderburgh County. 46 people attended the shelters. A count of heat-related illnesses was unavailable from local hospitals.
- **July 21, 2008, Heat** —Hot and humid conditions prevailed as a large upper-level ridge of high pressure covered the south central United States. The heat index peaked around 105 degrees for a few hours at Evansville.
- **August 5, 2008, Heat**—A large and strong high in the upper levels of the atmosphere stretched from the Tennessee Valley to the Plains. This feature contributed to hot and humid weather. Afternoon heat indices peaked near 105 degrees over parts of southwest Indiana, mainly south of Interstate 64.

- **June 20, 2010, Heat**—High temperatures reached the mid to upper 90's during this four-day streak of high heat indices. High humidity produced heat indices locally around 105 degrees on some afternoons. Most counties reached the 105-degree threshold for a Heat Advisory only once or twice. One county never quite reached it. A strong upper-level ridge remained quasi-stationary from the Tennessee Valley to the southern Plains through the period of heat.

According to the USDA's Risk Management Agency, there were no insured crop losses in Vanderburgh County as a result of extreme temperatures from 2001 to 2010.

Probability of Future Occurrences

On average, these events have a recurrence interval of 62 percent in any given year. The probability was assigned a rank of **highly likely**.

Magnitude/Severity

Due to the potential for fatalities and the possibility for the loss of electric power due to increased strain on power generation and distribution for air conditioning, periods of extreme heat can severely affect the planning area. In addition, accompanying drought may compound the problem exacerbating agricultural and economic losses. The impacts of extreme cold in the planning area have been primarily associated with agricultural losses. However, extreme cold can also cause injury such as frostbite or in extreme situations, death.

Although the most common impact of extreme temperatures is losses to crops, the primary concerns expressed by the planning committee for this hazard are the human health and safety issues. The magnitude is classified as **limited**, minor injuries and illnesses; minimal property damage that does not threaten structural stability; and/or interruption of essential facilities and services for less than 24 hours.

3.2.11 Severe Weather - Thunderstorms / High Winds

Description

Thunderstorms are defined as localized storms, always accompanied by hail, lightning, damaging winds, heavy rain causing flash flooding (discussed separately in Section 3.2.x) and sometimes tornadoes (discussed separately in Section 3.2.x). Thunderstorms can produce a strong out-rush of wind known as a down-burst, or straight-line winds which may exceed 120 mph. These storms can overturn mobile homes, tear roofs off of houses and topple trees.

According to the National Oceanic and Atmospheric Administration, approximately 10 percent of the thunderstorms that occur each year in the United States are classified as severe. The typical thunderstorm is 15 miles in diameter and lasts an average of 30 minutes. A thunderstorm is classified as severe when it contains one or more of the following phenomena:

- Hail measuring three quarters of an inch or larger in diameter; and/or
- Winds equal or exceed 58 mph.

A *severe thunderstorm watch* is issued by the National Weather Service when the weather conditions are such that a severe thunderstorm is likely to develop. They are normally issued well in advance of the actual occurrence of severe weather. During the watch, people should review severe thunderstorm safety rules and be prepared to move to a place of safety if threatening weather approaches.

A *severe thunderstorm warning* is issued when a severe thunderstorm has been sighted or indicated by weather radar. At this point, the danger is very serious and it is time to go to a safe place, turn on a battery-operated radio or television, and wait for the "all clear" from authorities.

High Winds

A severe thunderstorm can produce winds that can cause as much damage as a weak tornado and these winds can be life threatening. The damaging winds of thunderstorms include downbursts, microbursts, and straight-line winds. Downbursts are localized currents of air blasting down from a thunderstorm, which induce an outward burst of damaging wind on or near the ground. Microbursts are minimized downbursts covering an area of less than 2.5 miles across. They include a strong wind shear (a rapid change in the direction of wind over a short distance) near the surface. Microbursts may or may not include precipitation and can produce winds at speeds of more than 150 miles per hour. Damaging straight-line winds are high winds across a wide area that can reach speeds of 140 miles per hour.

Figure 3.25 shows the wind zones of the United States based on maximum wind speeds; Indiana is located within wind zone IV, the highest inland categories. All of Vanderburgh County is in zone IV. High winds, often accompanying severe thunderstorms, can cause significant property and crop damage, threaten public safety, and have adverse economic impacts from business closures and power loss.

Hail

Hail can occur when strong rising currents of air within a storm, called updrafts, carry water droplets to a height where freezing occurs. Then the grown ice particles fall to the ground. Severe thunderstorms can produce hail that can be three quarters of an inch or more in diameter and fall at speeds more than 100 mph. Hailstones of this size cause more than $1 billion in damages to properties and crops nationwide annually. Large hail can reach the size of grapefruit.

Based on information provided by the Tornado and Storm Research Organization, Table 3.21 describes typical damage impacts of the various sizes of hail.

Table 3.21 TORRO Hailstorm Intensity Scale

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

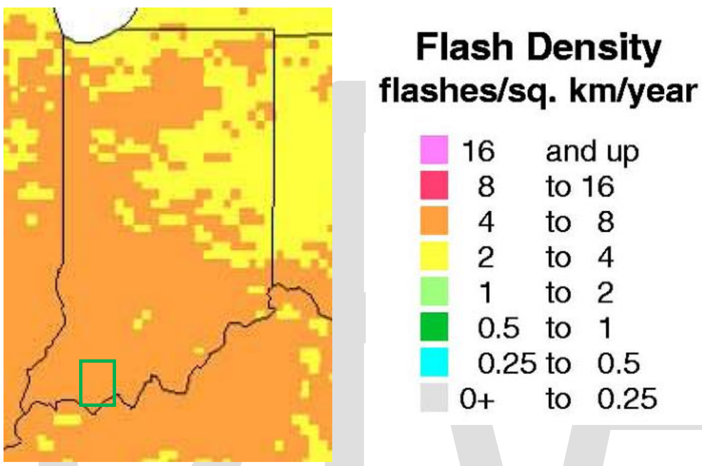
Source: Tornado and Storm Research Organization (TORRO), Department of Geography, Oxford Brookes University
Notes: In addition to hail diameter, factors including number and density of hailstones, hail fall speed and surface wind speeds affect severity.

Lightning

Lightning is defined as any and all of the various forms of visible electrical discharge caused by thunderstorms. Lightning can occur from cloud-to-cloud, within a cloud, cloud-to-ground, or cloud-to-air. It causes an average of about 60 fatalities and 300 injuries each year when people are caught outdoors in the summer months during the afternoon and evening.

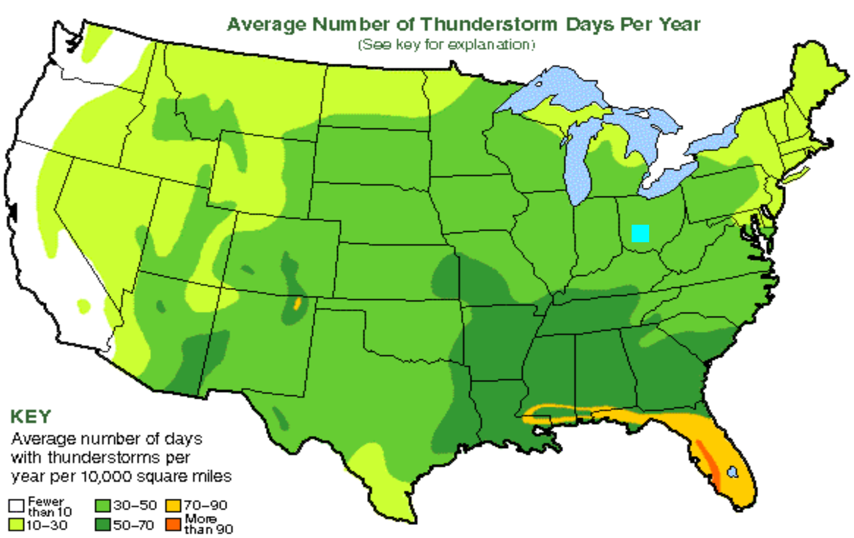
Figures 3.23 and 3.24 show Vanderburgh County located in an area with four to eight lightning strikes per square kilometer per year and with an average of 30-50 days with thunderstorms per year per 10,000 square miles.

Figure 3.23 Annual Frequency of Lightning in Indiana, 1996-2000



Source: National Weather Service, www.lightningsafety.noaa.gov/lightning_map.htm
Note: Green square indicates approximate location of Vanderburgh County

Figure 3.24 Average Number of Thunderstorm Days Per Year



Source: Oklahoma Climatological Survey
Note: Blue square indicates approximate location of Vanderburgh County

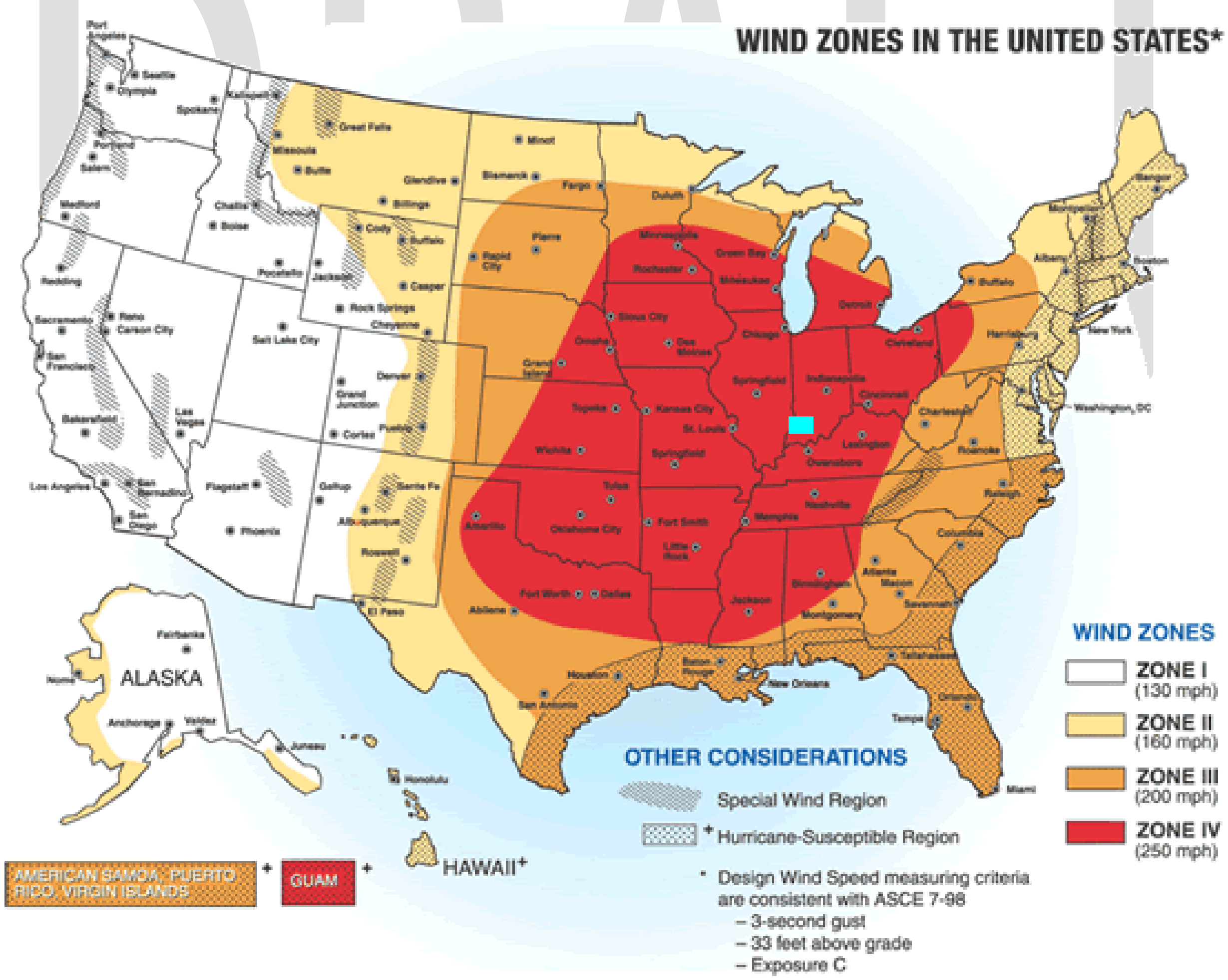
Geographic Location

Thunderstorms and the associated high wind, hail, and lightning impact the entire Vanderburgh County planning area. Thunderstorms over Indiana typically occur between late April and early September, but, given the right conditions, they can develop as early as March. They are usually produced by supercell thunderstorms or a line of thunderstorms that typically develop on hot and humid days.

All of Vanderburgh County is susceptible to high wind events, and all of the participating jurisdictions are vulnerable to this hazard. Figure 3.25 below shows Vanderburgh County (blue square approximates location on map) is in Wind Zone IV. This zone of the United States can experience winds 200 to 250 mph.

The geographic location was assigned a rank of **extensive**, the entire planning area is subject to extreme temperatures and all participating jurisdictions are affected.

Figure 3.25 Wind Zones in the United States



Source: FEMA; http://www.fema.gov/plan/prevent/saferoom/tsfs02_wind_zones.shtm
Note: Blue square indicates approximate location of Vanderburgh County

Previous Occurrences

Vanderburgh County has not been included in any presidential disaster declaration that specifically included high winds. However, generally, the events that included severe storms likely included high winds as well. For reference, the eight declarations that Vanderburgh County received including severe storms are summarized below in Figure 3.22. These events are also discussed separately in the flood and tornado profiles.

Table 3.22 Thunder Storm Disaster Declaration History in Vanderburgh County, 1965-Present

Declaration Number	Declaration Date (incident period)	Disaster Description
1795	9/23/2008 (9/12-10/6/2008)	Severe Storms and Flooding
1662	10/6/2006 (9/12-9/12/2006)	Severe Storms and Flooding
1612	11/8/2005 (11/6-11/6/2005)	Tornado and Severe Storms
1520	6/3/2004 (5/25-6/25/2004)	Severe Storms, Tornadoes, and Flooding
1476	7/11/2003 (7/4-8/6/2003)	Severe Storms, Tornadoes, and Flooding
1433	9/25/2002 (9/20-9/20/2002)	Severe Storms and Tornadoes
1165	3/6/1997 (2/28-3/31/1997)	Severe Storms and Flooding
891	1/5/1991 (12/28-1/22/1991)	Flooding and Severe Storms

Source: FEMA

High Winds

According to the NCDC database, the planning area experienced 145 severe thunderstorms with high winds in excess of 58 miles per hour (50 knots) from 1950 to 2010. Descriptions of the events are only provided from 1993 to 2010 and during this 17 year period there were 72 events causing nearly $3 Million in property damages and three injuries reported.

Summaries of some of the more damaging events are provided below:

- **June 15, 2010.** In Evansville, two people were injured when a tree fell on the bedroom, hallway, and living room of a house. Both were transported to a hospital with non life-threatening injuries. The structural damage to the house was moderate to major. Elsewhere, there were numerous reports of utility lines blown down in McCutchanville. A trampoline blew in front of cars on the Lloyd Expressway in Evansville.
- **June 22, 2009.** A downburst with peak winds estimated near 95 mph affected an area one mile wide and six miles long. The damage started near the Gibson County line not far from

Interstate 64. Many dozens of trees and tree limbs were blown down. Several homes sustained damage, mainly to roofs. Two barns were destroyed. Other farm buildings were damaged. Metal farm bins were partially blown over.

- **August 5, 2008.** Numerous trees and power lines were down throughout Evansville.
- **September 23, 2008-FEMA-1795-DR (period of incident September 12-October 6, 2008).** This federal disaster declaration was made following severe storms and flooding as remnants of Hurricane Ike. It brought high winds to southeast Missouri, southern Illinois, southwest Indiana, and western Kentucky.
- **January 29, 2008.** Numerous buildings around the County sustained mostly minor damage, such as shingles blown off. Several reports of wind gusts from 60 to 75 mph were received. At the Evansville airport, a gust to 71 mph was measured by the automated surface observing system. Sustained winds were clocked at 52 mph. The highest estimated gust was 75 mph in the northwest part of the county, reported by a trained spotter. Numerous trees and power lines were down. A semi was blown over, and roofs were blown completely off two homes. An elementary school sustained considerable roof damage. North of St. Wendel, a pole barn, hay barn, implement shed, and a grain bin were destroyed. Minor damage occurred to tractors and farm equipment. A pole barn in the exact same place was destroyed just a few years earlier, in 2004.
- **October 18, 2007.** Utility poles were down about one half mile east-northeast of the Evansville airport.
- **October 6, 2006-FEMA-1662-DR (period of incident September 12, 2006).** This federal disaster declaration was made following severe storms and major flash flooding inundated sections of Evansville.
- **May 24, 2006.** A wind gust to 61 mph was measured at the Evansville airport. Some minor damage to houses was reported in a subdivision a couple miles southeast of the airport.
- **April 2, 2006.** The roof and porch was blown off a vacant house on North Fulton Avenue. A wind gust to 64 mph was measured at the Evansville airport.
- **March 9, 2006.** Major roof damage occurred to a few homes in Green River Estates, just northeast of the airport. One house was completely unroofed. Windows were broken and siding was stripped off. At the Evansville Regional Airport, a wind gust to 59 mph was measured. Trees and power lines were blown down around the airport.
- **February 16, 2006.** Damage started at Burdette Park, where roofs were blown off and trees were uprooted. About one half to three quarters of a mile to the east of the park, the tops of two pole barns were blown off. Several homes sustained roof damage. Near the end of the damage path, the roof was blown off a garage and into a back yard.
- **November 8, 2005-FEMA-1612-DR (period of incident November 6, 2006).** This federal disaster declaration was made following the destructive tornado and severe thunderstorm that occurred in the early morning hours of November 6, 2006. This F3 tornado has peak winds estimated at 200 mph, the path was approximately 41 miles and 400+yards wide and caused widespread destruction and 23 fatalities.
- **August 28, 2004.** Thunderstorm winds caused damage along and just south of the Gibson County line. The winds knocked down the Indiana State Police communications tower and toppled eight to ten utility poles. The metal communications tower, which was 300 feet high,

was located behind the state police post on U.S. Highway 41 near Interstate 64. The utility poles were knocked down from Stacer Road north almost to Interstate 64. Traffic was backed up for about a mile on U.S. 41 after a power line fell on a truck. The driver was not injured.

- **July 5, 2004.** Wind speeds were estimated from 60 to 70 MPH at downtown Evansville, along the Ohio riverfront. Many trees were blown down across the City. At least a few houses received major damage due to falling trees. A large oak tree crashed through the living room and kitchen of a house, injuring one person inside. The Red Cross opened a temporary emergency shelter for those without power. Police barricaded numerous streets blocked by downed trees, utility poles, and power lines. Falling trees also damaged vehicles. Widespread damaging winds occurred in association with a line of thunderstorms that crossed the Wabash River from southern Illinois, then tracked east-southeast across the Ohio River counties. At its peak, 32,000 utility customers were without power in Posey, Vanderburgh, and Warrick Counties. About 85 percent of those were in Posey and southern Vanderburgh Counties.
- **June 3, 2004-FEMA-1520-DR (period of incident May 25-June 25, 2004).** This federal disaster declaration was made following two different severe storm events. One occurred on May 27th when a line of severe thunderstorms crossed southern Illinois, southwest Indiana, and northwest Kentucky during the evening. Widespread extremely damaging winds of excess of 80 mph caused at least $3 Million in damages. Then on May 30th, there was an outbreak of isolated super cell storms and tornadoes. An F1 with 100 mph winds caused about $1.2 Million in damages near Darmstadt.
- **July 11, 2003-FEMA-1476-DR (period of incident July 4-August 6, 2003).** This federal declaration was from severe thunderstorms that moved across the area on July 28th.
- **April 21, 2002.** Thunderstorm winds downed some trees. About a dozen homes were damaged by falling trees or tree limbs.
- **September 25, 2002-FEMA-1433-DR (period of incident September 20, 2002).** This federal declaration was from severe storms and tornadoes. An F2 tornado struck outside Poseyville, Indiana and then went on to produce many others as it moved northeast across central Indiana.
- **June 20, 2001.** Near Diamond Avenue in Evansville, about a dozen trees were down, including two that fell on houses.
- **August 20, 2000.** Numerous trees were down at the Vanderburgh 4-H Fairgrounds. Elsewhere in the county, several trees were down on power lines, and one tree fell onto a house.
- **May 12, 2000.** Damaging thunderstorm winds affected the west side of Evansville. The hardest hit neighborhood was just off Route 62 about 2 miles west of the Evansville city limits. The main damage was done to an elementary school, which lost a large section of roof. A large tree toppled through a classroom. There was water damage inside the school, and a cinder-block baseball dugout was destroyed. Other damage included many large limbs blown down and privacy fences down. The back deck of a house near the school was heavily damaged. Another nearby house lost part of its roof. About 5,000 electric customers were without power because of fallen tree limbs and utility poles. In the City of Evansville, on the west side of downtown, a few businesses along West Franklin Street received siding and window damage. Trees were blown down in Wesselman Woods Nature Preserve and at the West Side Branch Library.

- **January 3, 2000.** Thunderstorm winds caused extensive damage in a small area, covering approximately a four square block area on the east side of Evansville. About 25 homes were damaged. Most of the damage was due to trees being blown onto roofs. Five homes had to be abandoned due to severe roof damage. Damage to the remainder of the homes was mainly light. A vehicle was damaged by wind-blown fencing. About 30 trees were down.
- **February 27, 1999.** Numerous trees and power lines were down in and around Evansville. Wind speeds were measured to 75 MPH at a television station in Evansville. A few microbursts with estimated wind speeds between 80 and 90 mph occurred in and near Evansville. Two of the most intense microbursts were on the northwest side of Evansville and the east side of Evansville. On the northwest side, shingles were off roofs, some 2 by 4's were blown through a car windshield, and large storage buildings were damaged. This damage path was 1 to 2 miles long and 300 yards wide. Elsewhere in the County, in the McCutchanville area, large doors of a building were shoved in. About 3 miles north of Daylight on Interstate 164, a tractor trailer was overturned. Just east of Evansville, near the junction of Interstate 164 and Route 62, two power poles were downed, and three houses sustained significant roof damage. A light commercial structure that was under construction was blown down.
- **May 20, 1998.** A roof was blown off an industrial building on Diamond Avenue. Debris was scattered across First Avenue, which disrupted traffic. Trees and wires were blown down. About 3,000 Vanderburgh County electric customers were still without power a few hours later.
- **March 6, 1997 FEMA-1165-DR (period of incident February 28-March 31, 1997).**
- **July 14, 1997.** Large trees and power lines were down. About 10,000 Evansville homes were without power due to trees falling on power lines. At least two homes and a van were damaged by falling trees.
- **June 11, 1994.** Numerous trees and utility poles were blown down on Evansville's north side. Several homes and automobiles were damaged. Electrical power was not restored for up to 12 hours in some locations.
- **April 15, 1994.** Trees and power lines were blown down and the roofs were blown from two homes on the west side of Evansville. Two construction site trailers were blown over on Green River Road on Evansville's east side.

Most of the events in the NCDC database included reports of downed trees and tree limbs. Although many of these events did not report damages to property or crops, debris removal and other associated costs are common as a result of the numerous high wind events.

Hail

The NCDC reports 59 hail events in Vanderburgh County between 1962 and 2010. When limiting the list to those events considered destructive magnitude according to the TORRO Hail Intensity scale (1.75 in. diameter or larger), there were 12 events in the same 48 year period causing a reported $20,000 in property damages. Figure 3.23 shows the number of hail events by the size of the hail.

Table 3.23 Vanderburgh County Hail Events Summarized by Hail Size from 1961 to 2010

Hail Size	Number of Events	Property Damages
< 0.88 in	26	0
0.88 in.	6	0
1.00 in.	11	0
1.25 in.	2	0
1.50 in.	2	0
1.75 in.	6	0
2.00 in.	3	0
2.25 in.	1	0
2.75 in.	2	$20,000
Total	**59**	**$20,000**

Source National Climatic Data Center Storm Events Database

According to the USDA Risk Management Agency, insurance payments for damages to crops as a result of hail from 2001-2010 totalled $12,376. Also state-wide in Indiana, 71 percent of the row crops were insured in 2009 according to the USDA's Risk Management Agency.

Table 3.24 Claims Paid in Vanderburgh County for Crop Loss as a Result of Hail

Year	Crop	Hazard	Insurance Paid ($)
2010	Corn	Hail	160
2006	Peaches	Hail	11,866
2004	Soybeans	Hail	350
Total			**12,376**

Source: USDA Risk Management, 2011

Lightning

From 1995 to 2010, the County only experienced two reported lightning events, which is presumed to be a low reported number of lightning events. Lighting events were not reported in NCDC prior to 1994. Therefore a shorter time-period of statistics is available. The following are the events listed in NCDC:

- **July 8, 2010.** A house fire was started by lightning. The fire was mostly limited to the attic and a downstairs wall causing $10,000 in property damage.
- **March 28, 1997.** Lighting struck a house setting it on fire and causing $60,000 in property damage.

Probability of Future Occurrences

According to NCDC, there were 145 wind events in Vanderburgh County between 1950 and 2010 (50 years). Based on this information, the probability that at least one significant wind event with 50 knots or higher will occur in Vanderburgh County in any given year is **highly likely**, 100 percent with an annual average of 2.9 events per year.

Based on the reported 12 events in the NCDC database of hail events with hail 1.75 inches in diameter and larger occur an average of .25 times per year in the planning area from 1962 to 2010.

National Weather Service data indicates that Vanderburgh County is in a region that receives four to eight lightning strikes per square kilometer per year. However, most of these lightning strikes do not result in damages and that is reflected in the small amount of historical data reported in the NCDC database.

Seasonally, thunderstorms are more likely to occur during the summer months of May, June, and July. These rates of occurrence are expected to continue in the future.

Magnitude/Severity

Estimated damages from thunderstorms (including high winds, hail and lightning) in the NCDC database for the 17 year period were reported to be $3.9 Million in property damages. Many damages and costs as a result of such events are often not reported. So, these estimates can be considered to be very conservative. Common types of damages were structural damages caused by falling limbs and debris, roof damages, overturned vehicles and light structures, and downed power poles resulting in some loss of electric service. In addition, clearance of the debris left behind can be costly and is generally not reported in damage estimates in NCDC.

The magnitude for this hazard is classified as **critical**, isolated deaths and/or multiple injuries and illnesses; major or long-term property damage that threatens structural stability; and/or interruption of essential facilities and services for 24-72 hours.

3.2.12 Severe Weather – Tornadoes

Description

The National Weather Service defines a tornado as a “violently rotating column of air extending from a thunderstorm to the ground.” Tornadoes are the most violent of all atmospheric storms and are capable of tremendous destruction. Wind speeds can exceed 250 mph, and damage paths can be more than one mile wide and 50 miles long. In an average year, more than 900 tornadoes are reported in the United States, resulting in approximately 80 deaths and more than 1500 injuries. High winds not associated with tornadoes are profiled separately in this document in Section 3.2.x Thunderstorms/High Winds.

In Indiana, most tornadoes and tornado-related deaths and injuries occur during the months of April, May, and June. However, tornadoes have struck in every month. Similarly, while most tornadoes occur between 3:00 and 9:00 p.m., a tornado can strike at any time.

Prior to February 1, 2007, tornado intensity was measured by the Fujita (F) scale. This scale was revised and is now the Enhanced Fujita scale. Both scales are sets of wind estimates (not measurements) based on damage. The new scale provides more damage indicators (28) and associated degrees of damage, allowing for more detailed analysis, better correlation between damage and wind speed. It is also more precise because it takes into account the materials affected and the construction of structures damaged by a tornado.

Table 3.25 shows the wind speeds associated with the original Fujita scale ratings and the damage that could result at different levels of intensity.

Table 3.25 Original Fujita Scale

Fujita (F) Scale	Fujita Scale Wind Estimate (mph)	Typical Damage
F0	< 73	Light damage. Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
F1	73-112	Moderate damage. Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
F2	113-157	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
F3	158-206	Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
F4	207-260	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
F5	261-318	Incredible damage. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yards); trees debarked; incredible phenomena will occur.

Source: National Oceanic and Atmospheric Administration Storm Prediction Center, www.spc.noaa.gov/faq/tornado/f-scale.html

Talbe 3.26 shows wind speeds associated with the Enhanced Fujita Scale ratings. The Enhanced Fujita Scale's damage indicators and degrees of damage can be found online at www.spc.noaa.gov/efscale/ef-scale.html.

Table 3.26 Enhanced Fujita Scale

Enhanced Fujita (EF) Scale	Enhanced Fujita Scale Wind Estimate (mph)
EF0	65-85
EF1	86-110
EF2	111-135
EF3	136-165

Enhanced Fujita (EF) Scale	Enhanced Fujita Scale Wind Estimate (mph)
EF4	166-200
EF5	Over 200

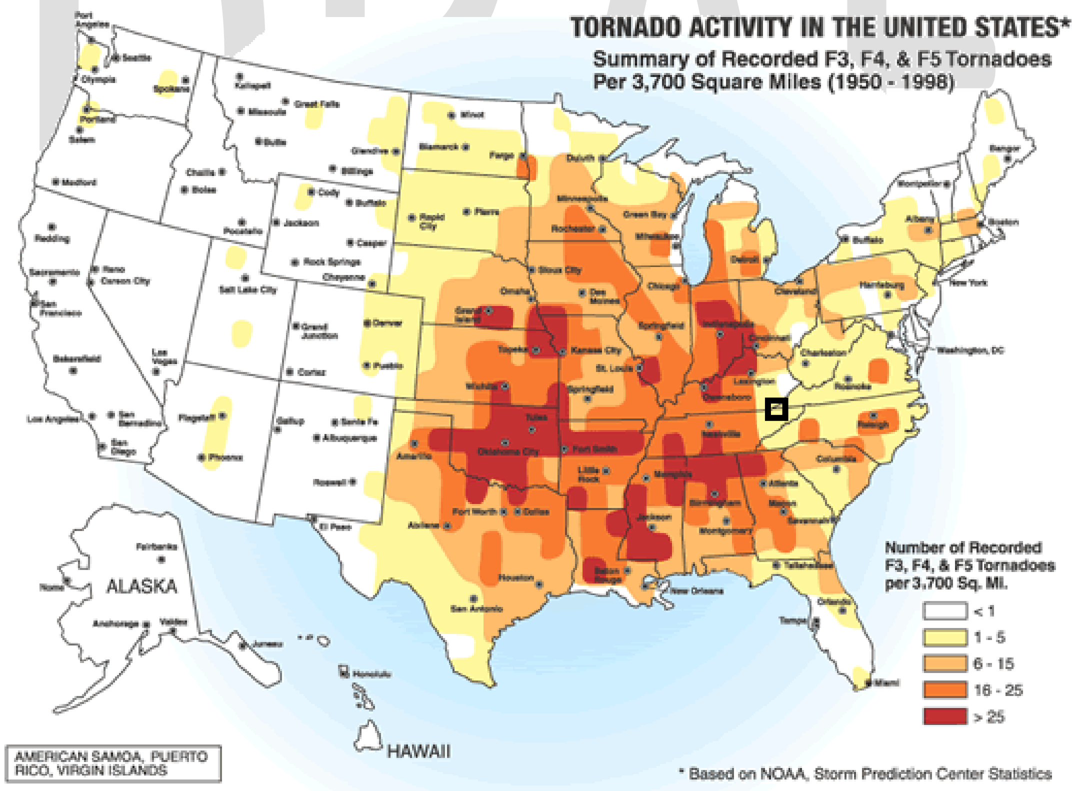
Source: National Oceanic and Atmospheric Administration Storm Prediction Center, www.spc.noaa.gov/faq/tornado/ef-scale.html

Geographic Location

While tornadoes can occur in all areas of the State of Indiana, historically, some areas of the state have been more susceptible to this type of damaging storm. Figure 3.26 illustrates the number of F3, F4, and F5 tornadoes recorded in the United States per 3,700 square miles between 1950 and 1998. Vanderburgh County is in the section shaded medium orange indicating 16-25 tornadoes of this magnitude during this 48-year period. The eastern boundary of the planning area is adjacent to the section shaded dark orange, indicating over 25 events.

The geographic location was assigned a rank of **extensive**, the entire planning area is subject to extreme temperatures and all participating jurisdictions are affected.

Figure 3.26 Tornado Activity in the United States



Note: Black Square is the approximate location of Vanderburgh County

.

Previous Occurrences

According to the NCDC database, there were 19 separate tornado events in Vanderburgh County between January of 1950 and December of 2010 (listings on the same date more than one hour apart or at different locations were considered multiple events). Combined damages of these events were 20 fatalities, 210 injuries, and over $517.9 Million in reported property damages. Of these previous events, 16 were rated F0, five were rated F1, four were rated F2, one was rated F3 and 3 were not rated. Table 3.27 summarizes these events.

Vanderburgh County has been included in four presidential disaster declarations that involved tornadoes since 1955 (see details below under DR-1612, DR-1520, DR-1476, and DR-1433). For the disasters of DR-1476 and DR-1433, the County was included in these disaster designations for other related damages that result from hail, strong winds and flooding. These impacts are discussed separately under those hazards.

Table 3.27 Recorded Tornadoes in Vanderburgh County, 1950-2007.

Location	Date	Magnitude	Fatalities	Injuries	Property Damage ($)
Vanderburgh	15-Nov-55	F3	0	9	250,000
Vanderburgh	26-May-62	F1	0	0	0
Vanderburgh	11-Dec-67	F1	0	0	25,000
Vanderburgh	10-Jan-75	F1	0	0	25,000
Vanderburgh	30-Jun-77	F1	0	1	250,000
Vanderburgh	11-Apr-79	F2	0	0	0
Vanderburgh	28-Jun-80	F1	0	0	0
Vanderburgh	26-May-81	F0	0	0	0
Vanderburgh	15-May-86	F0	0	0	0
Vanderburgh	15-May-86	F2	0	0	250,000
Vanderburgh	19-May-89	F1	0	0	250,000
Vanderburgh	6-Jun-90	F0	0	0	0
Evansville	17-Jun-97	F1	0	0	500,000
Evansville	18-Aug-97	F0	0	0	0
Daylight	7-Aug-98	F0	0	0	5,000
Darmstadt	30-May-04	F1	0	0	1,200,000
Cypress	6-Nov-05	F3	0	0	150,000
Evansville	6-Nov-05	F3	20	200	15,000,000
Darmstadt	10-May-06	F0	0	0	0
Total			**20**	**210**	**$17.905 Million**

Source: National Climatic Data Center

Descriptions of the more damaging events are provided below:

- **November 8, 2006-FEMA-1612-DR (period of incident November 6, 2006).** This federal disaster declaration was made following the destructive tornado and severe thunderstorm that occurred in the early morning hours of November 6, 2006. The tornado crossed into Vanderburgh County from Henderson County, Kentucky a second time near Ellis Park, a horse-racing facility off U.S. Highway 41. The tornado moved rapidly east-northeast at close to 60 mph, staying a mile or less south of Interstate 164 and the southern city limit of Evansville. Twenty people perished at a large mobile home park on the south side of the interstate. Of about 350 mobile homes in the park, 100 were destroyed and another 125 were damaged. Many of the destroyed homes were obliterated. The coroner reported that most of the victims were probably killed instantly, many by spine and skull fractures. Several bodies were carried almost two hundred yards. Several of the fatally injured persons were found in a nearby retention pond that was drained to find victims. An 8-year-old child was found alive in a ditch after being trapped under debris for about 12 hours. One person, who was thrown 150 feet, died of complications from tornado injuries on December 17. The tornado exited into Warrick County at the Angel Mounds State Historic Site, just south of Interstate 164. This was the deadliest tornado in Indiana since April 3, 1974. This tornado tracked a total of 41 miles from Henderson County, Kentucky into Spencer County, Indiana. A total of at least 500 homes and buildings were destroyed or severely damaged. Much of the damage was upper F-2 to lower F-3 intensity. Although the tornado was up to 500 yards wide, the average path width was 275 yards. Of the approximately 230 injuries, 20 were critical, and 63 resulted in hospital admissions.

Figure 3.27 Tornado Damage at the Eastbrooke Mobile Home Park, November 6, 2006

Source: http://www.crh.noaa.gov/pah/?n=evansvilletornado-nov.6,2005#GROUND

- **June 3, 2004-FEMA-1520-DR (period of incident May 25-June 25, 2004).** This federal disaster declaration was made following two different severe storm events. One occurred on May 27th when a line of severe thunderstorms crossed southern Illinois, southwest Indiana, and northwest Kentucky during the evening. Then on May 30th, there was an outbreak of isolated super cell storms and tornadoes. The tornado first touched down on Bromm Road, then tracked east directly across Darmstadt, finally lifting at Browning Road. Hundreds of trees were blown down, including many that landed on houses and power lines. A total of 42 single family homes, 6 commercial structures, and 1 agricultural structure were affected. Peak winds were estimated near 100 mph. Strong gusty winds occurred throughout Vanderburgh County. A gust to 57 mph was measured in Evansville. Widespread damaging winds raked southwest Indiana. Embedded short-lived tornadoes and intense downbursts caused pockets of severe damage. The single most destructive event was an F-2 tornado that struck Newburgh, Indiana. Another tornado in the northern suburbs of Evansville caused over one million dollars damage.

Figure 3.28 Roof Blown Off A House Located In the City of Darmstadt, May 30, 2004

Source: http://www.crh.noaa.gov/pah/storm/may3004/torsummary.php

- **July 11, 2003-FEMA-1476-DR (period of incident July 4-August 6, 2003).** This federal declaration was from severe thunderstorms that moved across the area on July 28th.
- **September 25, 2002-FEMA-1433-DR (period of incident September 20, 2002).** This federal declaration was from severe storms and tornadoes. An F2 tornado struck outside Poseyville, Indiana and then went on to produce many others as it moved northeast across central Indiana, but no tornadoes touched down in Vanderburgh County.
- **June 17, 1997.** This F1 tornado occurred in a densely populated suburban area called North Park, about 2 miles northwest of downtown Evansville. There were many witnesses, so the event was well documented by photographers and eyewitnesses. Although the tornado was unusual in the respect that it developed from a non-severe thunderstorm in a weakly sheared environment, it caused considerable damage in such a populated setting. A survey conducted by National Weather Service personnel determined the damage path was narrow, well defined, and highly convergent. Most of the damage was a result of trees falling on houses (at least a dozen) and causing roof damage and some structural damage. The neighborhood was 40 years old so most trees were full grown. A liquor store, bowling alley, and grocery store suffered primarily roof damage due to winds estimated near 100 mph. About 2,800 people were without power for several hours.
- **June 30, 1977.** This F1 tornado was 15 miles in length and 50 yards wide. It caused approximately $250,000 in property damage.
- **November 15, 1955.** This F3 tornado was two miles in length and 50 yards wide. It caused nine injuries and approximately $250,000 in property damage.

Probability of Future Occurrences start here

Based on NCDC records of 19 tornadoes in a 60-year period, there is a 32 percent probability of a tornado in Vanderburgh County in any given year. Removing the F0 rated events from this calculation, there were 13 tornadoes in the same period resulting in a probability 22 percent probability in any given year, resulting in a rank of **likely,** 10-100 percent chance of occurrence in next year or has a recurrence interval of 10 years or less.

Magnitude/Severity

If a strong tornado did impact the populated portions of Vanderburgh County, the impacts would be **critical**, isolated deaths and/or multiple injuries and illnesses; major or long-term property damage that threatens structural stability; and/or interruption of essential facilities and services for 24-72 hours.

3.2.13 Severe Weather - Winter Storms

Description

Winter storms in Indiana typically involve snow and/or freezing rain (ice storms). These conditions pose a serious threat to public safety, disrupt commerce and transportation, and can damage utilities and communications infrastructure. Winter storms can also disrupt emergency and medical services, hamper the flow of supplies, and isolate homes and farms. Heavy snow can collapse roofs and down trees onto power lines. Direct and indirect economic impacts of winter storms include cost of snow removal, damage repair, increased heating bills, business and crop losses, power failures and frozen or burst water lines.

The National Weather Service describes different types of winter storm conditions as follows:

- **Blizzard**—Winds of 35 mph or more with snow and blowing snow reducing visibility to less than 1/4 mile for at least three hours.
- **Blowing Snow**—Wind-driven snow that reduces visibility. Blowing snow may be falling snow and/or snow on the ground picked up by the wind.
- **Snow Squalls**—Brief, intense snow showers accompanied by strong, gusty winds. Accumulation may be significant.
- **Snow Showers**—Snow falling at varying intensities for brief periods of time. Some accumulation is possible.
- **Freezing Rain**—Measurable rain that falls onto a surface whose temperature is below freezing. This causes the rain to freeze on surfaces, such as trees, cars, and roads, forming a coating or glaze of ice. Most freezing-rain events are short lived and occur near sunrise between the months of December and March.
- **Sleet**—Rain drops that freeze into ice pellets before reaching the ground. Sleet usually

The average monthly/annual snowfall for Evansville is presented in Table 3.28.

Table 3.28 Snowfall Summary (inches) 1941-2002

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Evansville Regional Airport	4.0	3.7	2.7	0.3	---	---	---	---	---	0.1	0.6	2.7	14.1

Source: http://lwf.ncdc.noaa.gov/oa/climate/online/ccd/snowfall.html

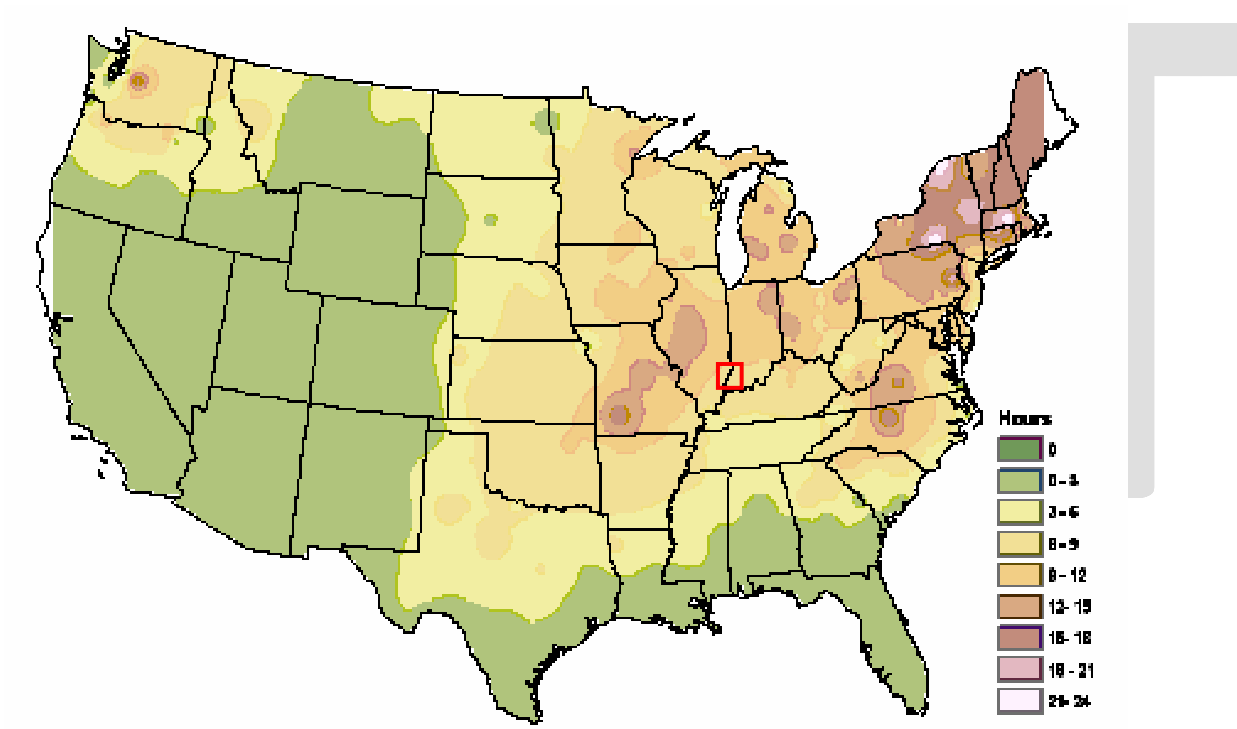
Duration of the most severe impacts of winter storms is generally less than one week, though dangerous cold, snow, and ice conditions can remain present for longer periods in certain cases. Weather forecasts commonly predict the most severe winter storms at least 24 hours in advance, leaving adequate time to warn the public.

Geographic Location

The entire State of Indiana is vulnerable to heavy snow and freezing rain. Northern Indiana receives the greatest average annual snowfall. The southern region of Indiana including Vanderburgh County receives 14.2 of snow during a normal season according to the National Weather Service in Paducah, Kentucky.

Figure 3.29 shows that Vanderburgh County falls in a zone that receives 8-9 hours of freezing rain per year. The geographic location was assigned a rank of **extensive**, the entire planning area is subject to extreme temperatures and all participating jurisdictions are affected.

Figure 3.29 Average Number of Hours per Year with Freezing Rain in the United States



Source: American Meteorological Society. "Freezing Rain Events in the United States." http://ams.confex.com/ams/pdfpapers/71872.pdf.
Note: Red square indicates approximate location of Vanderburgh County

Previous Occurrences

Of the 11 Major Presidential Disaster Declarations and two emergency declarations that have occurred in Vanderburgh County since 1965, three have been related to winter storms. There have also been two USDA Disaster Declarations from 2005 to 2010.

Details of these events are provided in Table 3.29.

Table 3.29 FEMA and USDA Winter Storm Disaster Declaration History in Vanderburgh County, 1965-Present

Declaration Number	Declaration Date	Disaster Description
1828	03/05/2009 (incident period 1/26/2009 – 1/28/2009)	Severe Winter Storm
S2587(USDA)	04/04/2007 – 4/10/2007	Below Normal Temperature, Winter Storm
S2522 (USDA)	04/05/2007 – 4/10/2007	Below Normal Temperature, Winter Storm
EM-3197	01/11/2005 (incident period 12/21/2004 – 12/23/2004)	Snow Storm
1573	1/21/2005 (incident period 1/1/2005 – 2/11/2005)	Severe Winter Storms and Flooding

Source: FEMA and USDA, http://www.fema.gov/dhsusda/search.do

- **March 5, 2009-FEMA-1828-DR (period of incident January 26-28, 2009),** Severe Winter Storm: A major winter storm dumped 6 to 10 inches of sleet and snow north and west of Evansville. In addition to the sleet and snow, up to one-half inch of ice coated objects. This resulted in very difficult driving conditions. Numerous vehicles slid off roadways. Schools were out for several days. Isolated power outages affected a small number of people north and west of Evansville. From Evansville south and east, a major ice storm occurred. About one inch of ice accumulated. This resulted in widespread tree damage and numerous power outages. In the city of Evansville itself, several inches of sleet and snow were combined with nearly an inch of ice. The weight of the ice and snow caused a house roof to collapse in Evansville. Fallen trees and limbs blocked many streets in Evansville and cities to the east. Several ambulances became stranded in snow and ice. The Evansville Fire Department made 275 runs on the second night of the storm, compared to a normal of 10 runs per night. Across the Evansville region, there was an increase in structure fires caused by alternate heating or lighting devices. Red Cross shelters were opened across southwest Indiana. One shelter in the Evansville area housed 150 individuals at one point. The largest utility company serving southwest Indiana reported more than half their customers were without power the day after the storm. This was believed to be one of the largest outages in the utility's history, comparable to the remnants of Hurricane Ike in September of 2008. Power was restored to most residents four to seven days after the storm. Hundreds of utility workers were brought in from other states, including some even before the storm hit. The National Guard was activated to help transport people from their homes to shelters.

Figure 3.30 Photos from Ice Storm in Evansville, January 2009.

Source: www.courierpress.com/photos/galleries/2009/jan/28/evansville-ice-storm/5294/#section_header. Photo on left is showing a thick layer of ice coating a tree near the Old Courthouse taken by Rich Davis and photo on the right was taken of a tree at U.S. 41 and Washington Avenue by Gavin Lesnick.

- **January 11, 2005-FEMA-3197-EM**, **(period of incident 12/21/2004 – 12/23/2004)** Snow Storm: Emergency declaration for 49 counties in Indiana for snow removal and emergency protective measures during that 48-hour period. A record-setting winter storm dumped from 17 to 22 inches of snow across southwest Indiana, closing interstates and shutting down most businesses near the peak of the Christmas shopping season. A 25-mile stretch of Interstate 64 from the Illinois state line to Evansville (the Interstate 164 exit) was closed for about 48 hours. The National Guard was mobilized to assist motorists along the interstate who were stranded in their vehicles overnight. About 100 motorists were transported to emergency shelters, including dozens taken to the Red Cross building in Evansville. Drifts up to 5 feet deep made many roads impassable. States of emergency were declared in Vanderburgh, Warrick, and Gibson Counties, where drivers were urged to stay off the roads. There were reports of plows and even a Humvee disabled in ditches and deep snow drifts. Most travel, including that by police and other emergency workers, was done in four-wheel drive vehicles. Two fatalities in Evansville were indirectly attributed to the snow. In both cases, elderly men suffered fatal heart attacks while shoveling snow. Mail delivery was suspended in most areas for at least one day. Gusty north winds from 15 to 25 MPH caused blowing and drifting. There was a 3-hour lull in the snow during the early afternoon; otherwise visibility was frequently around one-quarter mile for over 24 hours. Snowfall rates averaged an inch per hour, with higher rates observed in thundersnow. The total of 22.3 inches measured at the Evansville Airport established a new 24-hour snowfall record. This single storm total resulted in the second snowiest December on record at Evansville, where records date back to 1897. Preliminary snowfall reports from co-operative observers included 18.5 inches at Boonville (Warrick County) and 16.7 inches at Stendal (Pike County). Recovery efforts were slowed by gusty winds and bitterly cold arctic air, as low as 10 below zero on Christmas morning.
- **January 21, 2005-FEMA-1573-DR, (period of incident 1/1/2005 – 2/1/2005)** Severe Winter Storms and Flooding: Heavy freezing rain occurred over parts of the northern third of

Indiana. Widespread half-inch ice accumulations were reported, with isolated one inch or greater amounts, crippling communities for as much as several days to over one week while cleanup lasted for more than a month. Electricity was knocked out for as many as 150,000 homes in areas affected by the storm. Shelters were opened by the Red Cross and other organizations across the area, with more than 1,000 residents taking advantage of shelters in east central Indiana alone. States of emergency were declared in several counties, and hospitals and other emergency services were forced to go to backup power. Nearly $75 millions of dollars in damage were done to trees, power lines, and structures and the associated cleanup work.

In addition to the events that resulted in Presidential Declarations, the following events occurred in Vanderburgh County between October 1993 and December 2010 and are reported from NCDC records:

- **February 9, 2010.** Three to four inches of snow were measured from Evansville west, and the five to seven inch amounts were east of Evansville into Spencer County.
- **January 29, 2010.** Accumulations across southwest Indiana were generally from 6 to 8 inches south of Interstate 64, including Evansville and Boonville. There was some blowing and drifting of the snow due to gusty winds. Roads were snow-covered and very slippery. Visibility was reduced to around one-half mile in the snow.
- **March 7, 2008.** The four-inch amounts were in Evansville, and amounts increased with eastward extent.
- **December 16, 2007.** The rain changed to snow and accumulated from 1 to 2 inches north and west of Evansville.
- **December 22-23, 2004.** A major snowstorm occurred along the Ohio River Valley with severe impacts over large parts of Illinois, Indiana, Kentucky, and Ohio. Evansville, Indiana received 22.3 inches of snow and then received four days of extremely low temperatures (The Pre-Christmas 2004 Snowstorm Disaster in the Ohio River Valley, Prepared for the Midwestern regional Climate Center, April 2005)
- **December 8, 2005.** The first winter storm of the season produced significant accumulations of sleet and freezing rain, followed by a few inches of snow. The heaviest ice accumulations were from Evansville eastward, where about one-quarter inch of glazing occurred.
- **January 27, 2004.** One to two inches of snow fell across southwest Indiana.
- **January 25, 2004.** Between one quarter and one half inch of ice coated all surfaces. Roads were dangerous and locally impassable. Hundreds of accidents were reported across southwest Indiana, including jackknifed tractor trailers. Some roads were closed. A State of Emergency was declared in Spencer and Pike Counties, which banned all travel except for emergencies. State highway crews were pulled off the roads in Spencer County after three salt trucks overturned on icy roads and a fourth went into a ditch. A fatal accident occurred on Interstate 64 on the Wabash River bridge at the Illinois state line. A van heading eastbound spun out of control on the bridge. Scattered power outages were reported throughout southwest Indiana as brisk winds brought down ice-laden tree limbs. Thousands of homes were without power. About 12,000 customers were without power on the east side

of Evansville for about 90 minutes when ice brought down a transformer line. Another large power outage was in Boonville, where about 2,000 utility customers were affected. Evansville Regional Airport was closed for about three hours. Hospital emergency rooms reported numerous slip-and-fall injuries on the ice.

- **December 13, 2003.** Three to 3.5 inches of snow was reported in Evansville. A daily maximum snowfall record was set.
- **February 23, 2003.** This snowstorm was short but intense. Heavy snowfall rates of up to three inches per hour were reported. Visibility was less than one quarter mile during the heaviest snow bursts. Total snowfall was six inches or more north of Interstate 64, and four to five inches elsewhere.
- **February 15, 2003.** The Evansville Tri-State area received the brunt of a winter storm that began during the evening of February 15th and lasted about 24 hours. The precipitation was mainly in the form of sleet. Several inches of sleet, mixed with freezing rain and snow, resulted in major travel disruptions. Multi-vehicle pileups and highway closures were reported in Evansville near the beginning of the winter storm. A thick layer of ice caused by the compacted sleet and freezing rain mixture made travel difficult at best. The storm occurred on the Presidents Day weekend. The weight of the sleet caused docks at an Evansville marina to start sinking. Three covered boat houses, each holding 40 to 45 boats, were threatened. Some specific reports included 4.3 inches at Evansville (with a liquid equivalent of 1.52 inches).
- **January 22, 2003.** Up to two inches of snow fell across southwest Indiana. Roads became slick and hazardous.
- **January 18, 2003.** Around one inch of snow fell across southwest Indiana. The Indiana State Police investigated 18 vehicle accidents or slide-offs.
- **December 23, 2002.** About two inches of sleet, mixed with some snow, fell south of Interstate 64 during the night of the 23rd. Only an inch or less fell north of the interstate. During the late afternoon and evening of Christmas Eve, an additional 3 inches of snow fell over most of southwest Indiana, except only around an inch in some places along the Ohio River. Emergency officials reported numerous minor accidents and vehicles sliding off roads on Christmas Eve.
- **December 4, 2002.** A winter storm brought significant snow and ice accumulations to southwest Indiana. The precipitation type was mostly snow, but the counties bordering the Ohio River received a significant period of freezing rain and sleet. Around one quarter inch of ice accumulated from Evansville east to Boonville and Rockport. Snow accumulations ranged from 2 to 5 inches. A total of 2.5 inches was measured at the Evansville airport. Travel was heavily impacted by the winter storm. Numerous vehicle accidents occurred, including 25 in the city of Evansville alone. Schools and some businesses were closed. The winter storm began during the morning hours and ended late the following night.
- **December 29, 2001.** The first measurable snow of the season caused some minor traffic problems. About one inch of snow fell across most of southwest Indiana, including Evansville.

- **February 22, 2001.** Several hours of moderate sleet and snow occurred, sometimes accompanied by thunder and lightning. The sleet accumulated to a depth of one inch. The liquid equivalent of the precipitation was 0.25 inch at Evansville.
- **January 26, 2001.** Freezing rain lasted for several hours and amounted to less than a tenth of an inch of precipitation.
- **January 1, 2001.** During the early morning hours, a general one to three inch snowfall blanketed southwest Indiana. The official total at Evansville was 2.3 inches.
- **December 16, 2000.** The snow accumulated from two to three inches across southwest Indiana.
- **December 13, 2000.** A major winter storm produced three to four inches of snow across southwest Indiana, followed by 1/4 to 1/2 inch of ice. The snow began during the mid to late-morning hours, falling at rates near one inch per hour. During the midday hours, the snow changed to freezing rain after a brief period of sleet. Light to occasionally moderate freezing rain fell during the afternoon and early evening hours. Numerous accidents occurred, most of which were minor. In Vanderburgh County, including Evansville, police reported more than 50 accidents. Most schools and some businesses were closed by the storm.
- **December 2, 2000.** Snow began falling during the late afternoon hours. Accumulations ranged from one to two inches before the snow ended late in the evening. Because temperatures were just above freezing at the start, most of the accumulation was on grassy areas. As temperatures fell below freezing late in the evening, ice formed on the wet roads, causing a number of minor vehicle mishaps.
- **January 22, 2000.** Snow began during the morning hours and continued intermittently through the afternoon. Total accumulations averaged about two inches. Roads became very slippery, causing numerous accidents. Indiana State Police reported 28 accidents in southwest Indiana, and 19 of those were on Interstate 64.
- **January 17, 2000.** A period of freezing rain during the evening hours produced a light glaze less than one quarter inch thick.
- **March 14, 1999.** Heavy snow, between four and eight inches, fell over parts of southwest Indiana away from the Ohio River.
- **January 8, 1999.** Freezing rain coated objects with about a quarter of an inch of ice. Roads were ice or slush covered, but no downed tree limbs or power lines were reported.
- **January 1, 1999.** A period of freezing rain coated surfaces with a quarter to a half inch of ice. Roads became icy and dangerous. A few tree limbs were down.
- **December 30, 1998.** A one to two inch snowfall resulted in snow-covered and slippery roads.
- **December 23, 2998.** A light snowfall coated the region with around an inch of the white stuff. Travel was impacted due to very cold road surfaces, which allowed the snow to readily stick to the roads. The wintry precipitation hit right near the evening commute time.
- **December 21, 1998.** Rain during the day changed to sleet and freezing rain during the evening as a sharp cold front passed through the region. The wintry precipitation lasted a few hours, long enough to ice up most roads and walkways. Temperatures plunged from the

upper 50s in the morning to the upper 20s early at night. Numerous skidding accidents were reported.

- **February 4, 1998.** One of the heaviest snowfalls in recent memory blanketed southwest Indiana with a total of 10 to 14 inches of snow. The snow fell in two distinct bursts. The first period of heavy snow from the afternoon of the 4th into the wee morning hours of the 5th produced six to eight inches. Snowfall rates during the peak of this burst were one to two inches per hour. The most intense snowfall occurred during the late afternoon rush hour, which caused major traffic headaches. A motorist was killed in a two-car accident on the Lloyd Expressway around 4 P.M. on the 4th. Countless minor accidents occurred, which slowed traffic to a crawl. A tractor trailer rig overturned on Interstate 164, closing that highway for a couple of hours. Strong wind gusts around 30 MPH caused some problems with snow drifting across roads that had been cleared. Almost every school, college, and university was closed. Some businesses were closed, and many clubs and associations cancelled meetings. The second burst of snow began during the afternoon of the 5th and continued into the wee morning hours of the 6th. Although snowfall rates were not as intense as in the first round of heavy snow, an additional 4 to 5 inches of snow fell. This brought snowfall totals for the two-day period up to a foot across most of southwest Indiana. This storm total was enough to make this the sixth snowiest February on record at Evansville. Despite the heavy snow totals, relatively warm ground temperatures combined with air temperatures right near the melting point helped road crews clear the primary roads fairly easily.
- **December 30, 1997.** An "Alberta Clipper" type of low pressure system produced around four inches of snow across southwest Indiana during the afternoon and evening. Specific snowfall reports included 4 inches in downtown Evansville, 5 inches at the University of Southern Indiana near Evansville, and 3.5 inches at the Evansville. The evening rush hour was a mess, with so many accidents that Evansville Police could only respond to major accidents.
- **January 8, 1997.** A low pressure system moved northeast across the Tennessee River Valley, producing 3 to 4 inches of snow across southwest Indiana.
- **December 16, 1996.** Rain changed to snow across southwest Indiana and accumulated one to three inches. No major problems were reported. Slick roads contributed to a rash of vehicle accidents.
- **March 19, 1996.** A state of emergency was declared in the six southwestern Indiana counties including Vanderburgh. Snowfall accumulations were near a foot, but strong winds created many drifts 4 to 5 feet deep. The heavy wet snow combined with strong winds brought down many tree limbs and power lines. Visibility became so poor that some county highway crews were called off the job. Emergency shelters were set up for people without heat or electricity. Power outages were widespread during the storm. The National Guard was mobilized to help rescue families stranded on impassable roads. Even some National Guard Humvee vehicles became stuck in snow drifts up to 6 feet deep. Nearly a dozen school busses were stranded in ditches after students were released from school early. Numerous secondary roads and a few state roads were impassable for one to three days. Front end loaders and bulldozers were used to clear roads of downed trees, deep snow drifts, and abandoned vehicles.

- **October 29, 1993.** Snow of two to six inches fell across the southern half of Indiana. The snow began in southwest Indiana during the evening of October 29, and spread northeast during the night. The heaviest snow fell in a band from Evansville to near Cincinnati, Ohio, with the greatest amounts of around six inches reported in the southeast corner of the state. Evansville set a new 24 hour snowfall record for October with 4.10 inches from the 29th to the 30th. Evansville also experienced its second snowiest October on record with a total of 4.60 inches. The only October with more snow at Evansville was in 1925, with a total of five inches.

According to the USDA Risk Management Agency, insurance payments for damages to crops as a result of freeze and frost from 2001-2010 totalled $17,256. Also state-wide in Indiana, 71 percent of the row crops were insured in 2009 according to the USDA's Risk Management Agency.

Table 3.30 Claims Paid in Vanderburgh County for Crop Loss as a Result of Cold Wet Weather, Freeze, or Frost.

Year	Crop	Hazard	Insurance Paid ($)
2010	Corn	Cold Wet Weather	8,828
2006	Grain Sorghum	Cold Wet Weather	55
2006	Grain Sorghum	Frost	55
2005	Corn	Cold Wet Weather	742
2005	Soybeans	Cold Wet Weather	3,413
2001	Apples	Freeze	4,163
Total			**17,256**

Source: USDA Risk Management, 2011

Probability of Future Occurrences

With the combined historical information from FEMA declarations, planning committee accounts, and the NCDC database, during an 18-year period from 1993 to 2010 there were at least 38 significant recorded winter storm events in Vanderburgh County resulting in an average of 2 significant winter storms per year. Based on historic frequency, the probability of future occurrence rating for winter storms is **highly likely**, 100 percent in any given year.

Magnitude/Severity

Damages associated with winter storms in Vanderburgh County are usually related to downed power lines and power infrastructure. These damages and the associated losses as a result of disruptions in normal daily operations can be costly.

One significant winter weather event can have multiple impacts including property damage and damages to power lines and infrastructure from falling trees and limbs, prolonged power outages, road damage, road hazards, and road closures, school, government and business closures.

3.2.14 Hazard Profiles Summary

This section summarizes the results of the hazard profiles and assigns a level of overall planning significance to each hazard of low, moderate, or high. Significance was determined based on the hazard profile, focusing on key criteria such as frequency and resulting damage, including deaths/injuries and property, crop, and economic damage. This assessment was used by the HMPC to prioritize those hazards of greatest significance to the planning area; thus enabling the County to focus resources where they are most needed. Those hazards that occur infrequently or have little or no impact on the planning area were determined to be of low significance. Those hazards determined to be of high significance were characterized as priority hazards that required further evaluation in Section 3.3 Vulnerability Assessment.

Table 3.31 Planning Significance of Identified Hazards

Hazard	Geographic Location	Probability	Magnitude	Planning Significance
Drought	Extensive	Likely	Negligible	**Moderate**
- Wildfires	Significant	Occasional	Limited	**Moderate**
Earthquake	Extensive	Likely	Critical	**High**
Flood	Significant	Likely	Catastrophic	**High**
- Dam Failure	Significant	Unlikely	Catastrophic	**Moderate**
- Levee Failure	Significant	Unlikely	Catastrophic	**Moderate**
Infestation				
- West Nile	Extensive	Likely	Negligible	**Moderate**
- Emerald Ash Borer	Extensive	Occasional	Negligible	**Moderate**
Mine Subsidence	Limited	Unlikely	Critical	**Low**
Severe Weather				
- Extreme Temperatures	Extensive	Highly Likely	Limited	**High**
- Thunderstorms/ High Winds/Lightning	Extensive	Highly Likely	Critical	**High**
- Tornadoes	Extensive	Likely	Critical	**High**
- Winter Storms	Extensive	Highly Likely	Critical	**High**

See Section 3.2 for definitions of these factors